

## Assessment of Samarra Barrage Lake Using GIS and Canadian Water Quality Index (CCME)

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DOI: <https://doi.org/10.55145/ajest.2026.05.01.010>

Received December 2025; Accepted January 2026; Available online February 2026

**ABSTRACT:** River water is a fundamental necessity for all aspects of life, especially drinking water. Millions of Iraqis depend primarily on the waters of the Tigris river. The aim of the study is to evaluate the water quality of the Samara Barrage Lake for the period between September 2024 and May 2025. Water samples taken from the lake were analyzed to determine fourteen physical and chemical parameters, namely pH, turbidity, DO, TDS, BOD<sub>5</sub>, TSS, SO<sub>4</sub>, NO<sub>3</sub>, Cl<sup>-</sup>, PO<sub>4</sub>, and ions (Ca, Mg, Na, and K). Ten points were taken within the barrage lake, distributed along its edges and center. Geographic Information Systems (GIS) techniques were used to analyze and map the spatial distribution of the selected indicators. The Canadian Water Quality Index was also used to determine the lake's water quality, and the results revealed that water quality is subject to seasonal fluctuations. In the autumn season (September 2024), the pH, turbidity, and BOD exceeded the limits permitted for drinking water. In contrast, during the winter (January 2025) and spring (May 2025), turbidity and BOD remained above the World Health Organization's permissible limits. This indicates that the Tigris River and Samara lake were subjected to certain conditions, such as erosion, soil degradation, and riverbed disturbance, as well as human activity along the river and even the lake's edges, and water pollution from organic matter due to agricultural and animal waste, in addition to inadequately treated sewage discharged into the river. All other parameters remained within recommended limits throughout the study period. According to the Canadian Water Quality Index (CWQI), the lake's water quality was generally "good," with CWQI values of 81.38 in the autumn, 82.08 in the winter, and 81.8 in the spring. These results highlight the impact of seasonal variations on lake water quality and demonstrate the effectiveness of integrating environmental indicators with GIS-based spatial analysis for surface water monitoring. The results of this study represent a valuable reference for sustainable water resource management and improving water quality in the Samarra barrage lake.

**Keywords:** Lake of Samarra Barrage, Tigris River, CWQI, GIS



### 1. INTRODUCTION

Water is an essential element for all living things, but with increasing environmental pressures due to the rise of various industries and population growth, its quality has begun to deteriorate. This deterioration threatens Aquatic life and the potable water [1]. Surface water is essential for life, but in developing countries, its quality is degraded by untreated waste, industrial activity, and population growth [2]. River pollution is a major 21st-century issue that harms ecosystems, human health, and economic development [3]. One method of water management is dams, which, in addition to controlling floods, help with agriculture, electricity generation, and the provision of drinking water [4]. Human activities, such as the discharge of sewage, pesticides, and agricultural fertilizers, pollute the waters of dam reservoirs as a result of their entry into these water bodies [5]. Water quality analysis includes assessing the state of natural water and its suitability for drinking, farming, household, industrial, and irrigation applications [6]. Surface water quality has steadily deteriorated in recent decades, largely due to its susceptibility to pollution from natural and human sources, such as the disposal of household waste, industrial waste, and agricultural runoff. The global population increase and the accompanying rise in various activities have made the overall increase in pollution a clear phenomenon affecting all natural resources [7]. (CCME) compares data using either a quality-specific or site-specific

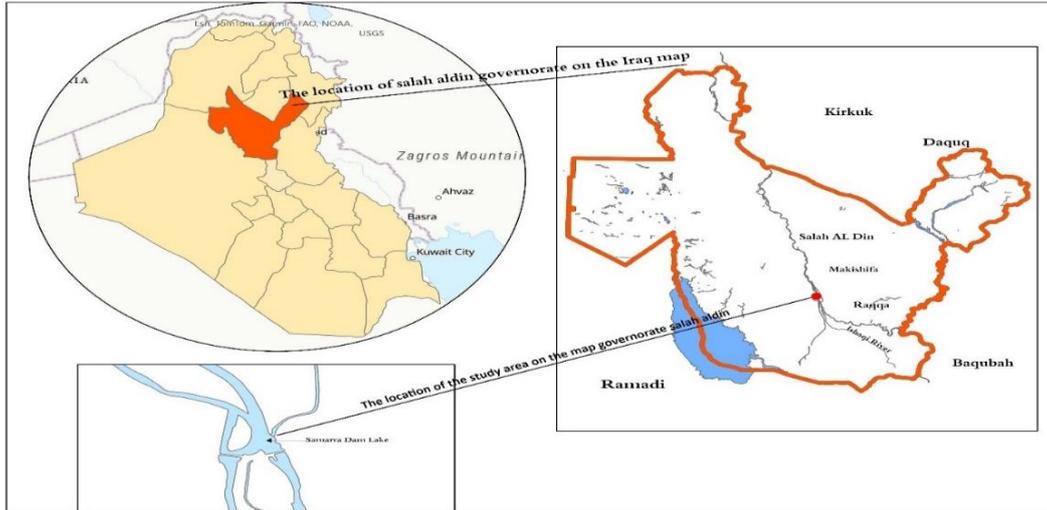
standard and provides clear results that can be a convenient solution to many problems, difficulties, and costs related to monitoring topics, and facilitate their understanding [8,9]. Geographic Information Systems (GIS) allow for experiments involving the analysis of satellite imagery and its comparison with field data, providing a different and more accurate method for identifying parameters. Several researchers have demonstrated the benefits of combining field data and satellite image analysis to assess the accuracy of water quality detection. This approach enables the use of both analytical and visual methods to monitor and evaluate various natural systems, in conjunction with remote sensing and mapping [10,11]. Geographic Information Systems (GIS) have been used in many studies in the field of water management. For example, 63 samples of the Mahi River in India were studied, which facilitated and provided clear information to decision-makers, thus helping to understand water quality management [12]. Another study, conducted locally in Baghdad, used Geographic Information Systems (GIS) in conjunction with a water quality index to examine 96 water samples. The aim was to assess the physical and chemical quality of the Tigris River in Iraq, where some criteria were above the limits and some were within the limits [13]. According to UN-ESCWA (2013), it goes through a transformational journey. The Tigris River has both natural and man-made problems, including mud buildup, plant growth, and water constraint. The water quality in Iraq's inland water bodies has been assessed in numerous studies [14]. A water quality study of the Tigris River in Baghdad was conducted during 2010 at three stations using the CCME WQI. The values were (37-42), indicating severe deterioration due to urban pollutants. The results confirmed the need for better monitoring and management of the river [15]. A study conducted in 2011 on the Duhok Dam lake showed that the nutrients in the lake's water were of medium density in the autumn, while they were rich in these elements in other seasons. It was shown that phosphorus is the limiting factor for algae growth, and that the lake's water was classified as very suitable for irrigation purposes [16]. A local study of the Tigris River in Iraq, covering a length of 1,468 kilometers, examined the dry and wet seasons of 2016. This was done using the WQ and GIS systems. The results showed that water quality in the upper reaches of the river was good, but it deteriorated significantly (from Al-Aziziyah to Al-Qumah, Basra), where the water was classified as poor and unsuitable for direct use due to sources of pollution [17]. In another study conducted on the waters of the Simli Dam in Islamabad/Rawalpindi, in which 12 parameters were identified, it was found that the waters of this lake were of poor quality, with a water quality index (WQI) of 62.79, while the filtered waters of this lake were of good quality, with an index of (WQI) of 49.43. On this basis, it was recommended to conduct continuous and regular monitoring [18]. The Samarra Barrage reservoir is considered water facility controls the flow of water crossing the Tigris River. It also affects the river's water quality through sedimentation and thinning processes. The Tigris River is a vital water source for the cities along its course, where residents use it for various purposes, most importantly drinking water. Many studies concerning the Tigris River have not addressed the impact of the Samarra Barrage on the river's water quality. Therefore, this study will focus on demonstrating this crucial effect of this hydraulic structure on the river's water quality.

This study aims to identify the distribution temporal and spatial of fourteen determinants within the Samarra Barrage Lake using a geographic information systems program, in addition to measuring the water quality index using the Canadian Water Quality Index during a study period between September 2024 and May 2025.

## 2. Materials and Methodology

### 2.1 Study area

Samarra is one of the important and large cities in Iraq, located in Salah Al-Din Governorate. It is located north of the capital, Baghdad. The coordinates of Samarra are latitude 34.197771 and longitude 43.891900 [19]. The 1,200-meter-long Samarra barrage was built in 1951 and completed in 1956. The Samarra Barrage operates with a maximum possible discharge of 7000 cubic meters per second and has three hydroelectric gates, each with a discharge of 980 m<sup>3</sup>/sec. The Samara Dam, built on the Tigris River, is an important hydraulic structure. The Tharthar irrigation canal is connected to the dam regulator via a diversion canal to divert floodwaters to Tharthar lake, where its discharge can be increased to 13,500 m<sup>3</sup>/sec during major floods instead of its current discharge of between 8,500 and 9,000 m<sup>3</sup>/sec, in order to protect Baghdad and the areas adjacent to the river from flooding. At maximum capacity, the barrage lake covers 40 to 50 square kilometers and serves mainly as a flow regulator rather than a long-term storage facility. The dam lake stores approximately 150 Mm<sup>3</sup>. Figure 1 shows the study area location on the map of Iraq in general and Salah Al-Din Governorate in particular. Ten points were identified along the perimeter and center of the Samarra barrage reservoir. Figure 2 shows an aerial photograph of the Samarra barrage reservoir and the study points, while Table 1 shows the coordinates of these points. People Populated areas exist on both sides of the river, and their inhabitants engage in agriculture, livestock breeding, industrial activities, and other pursuits.



**FIGURE 1** The Study area location



**FIGURE 2** Aerial photo of Samarra Barrage lake

**Table 1** Coordinates of points inside Samarra barrage lake

Points	P1	P2	P3	P4	P5
Coordinates	34.198164°	34.202855°	34.209846°	34.210571°	34.205332°
	43.842797°	43.844544°	43.845515°	43.850070°	43.852760°
Points	P6	P7	P8	P9	P10
Coordinates	34.205144°	34.201891°	34.198605°	34.197355°	34.202645°
	43.857811°	43.857935°	43.855016°	43.848248°	43.850070°

## 2.2 Canadian water quality index (CCME-WQI)

The Canadian Council of Environment and Development Water Quality Index (CCME WQI) is a way to simplify and transform complex data into a number that is easier for the public to understand. It converts several variables into a single number and measures how well water meets environmental standards. Its value ranges from 0 to 100, with higher values indicating better water quality. It consists of three components: scope, frequency, and amplitude [20, 21]. It can be calculated using the following relationships (1-7):

F1 (scope): this represents the percentage of parameters that exceeded water quality standards divided by the number of those parameters.

$$F_1 = \left( \frac{\text{Number of failed parameters}}{\text{Total number of parameters}} \right) \times 100 \quad (1)$$

F2 (frequency): it is the repetition rate, which is the failed tests percentage.

$$F_2 = \left( \frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) \times 100 \quad (2)$$

F3 (amplitude): it is the measure that determines the extent to which failed tests deviate from their intended objectives.

"Excursion" is a term that refers to the number of times a given concentration differs from the target value. When the test value is less than the target value, it is calculated as follows:

$$excursion_i = \left( \frac{\text{Failed test value}_i}{\text{Objective}_j} \right) - 1 \quad (3)$$

Or, if the test value is higher, we use Equation (4) to determine the deviation.

$$excursion_i = \left( \frac{\text{Objective}_j}{\text{Failed test value}_i} \right) - 1 \quad (4)$$

The normalized excursions summation (nse) is the excursions summation of each test divided by the test's total number, which is calculated as follows:

$$nse = \frac{\sum_{i=1}^n excursion_i}{\text{No. of tests}} \quad (5)$$

The following relationship is used to calculate F3:

$$F_3 = \left( \frac{nse}{0.01nse + 0.01} \right) \quad (6)$$

The CCME- WQI is then calculated using the following equation:

$$CCME\ WQI = 100 - \left( \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right) \quad (7)$$

Table 2 shows the water quality classification according to the CCME-WQI [21].

<b>Rate of Water Quality</b>	<b>WQI</b>
Excellent	95 – 100
Good	80 – 94
Fair	60 – 79
Marginal	45 – 59
Poor	0 – 44

## 2.3 Sampling

Two-liter water samples were collected from ten selected locations in the lake using clean plastic containers, free from any potential contaminants. Additionally, areas with low water levels and stagnant water were avoided to prevent bias in the results, as these can sometimes be contaminated by the accumulation of pollutants and sluggish water movement. The samples were collected slightly below the surface of the flow to avoid floating debris. Some on-site tests were also conducted using equipment operated according to strict instructions. These samples were then transported directly to the laboratory and stored in a dark, cool environment under optimal conditions. All water sample tests were performed in the laboratories of Tikrit University. The water samples were examined according to standard procedures, and the results for the fourteen locations are listed in Table 3. Water samples were collected from all ten locations and analyzed during the summer, autumn, and winter periods from September 2024 to May 2025. Advanced electronic devices and a variety of laboratory instruments were used in the analysis.

## 2.4 ArcMap GIS

It is a Geographic Information System (GIS) program from Esri that allows data to be entered and then displayed spatially. The program also creates spatial maps of the input data, enabling the production of high-quality maps such as spatial distribution maps, environmental characteristic maps, and water quality maps. It is important in environmental studies [22]. In this study, we used it to map the area within the Samarra Barrage Lake, showing how these parameters were spatially distributed during the study period.

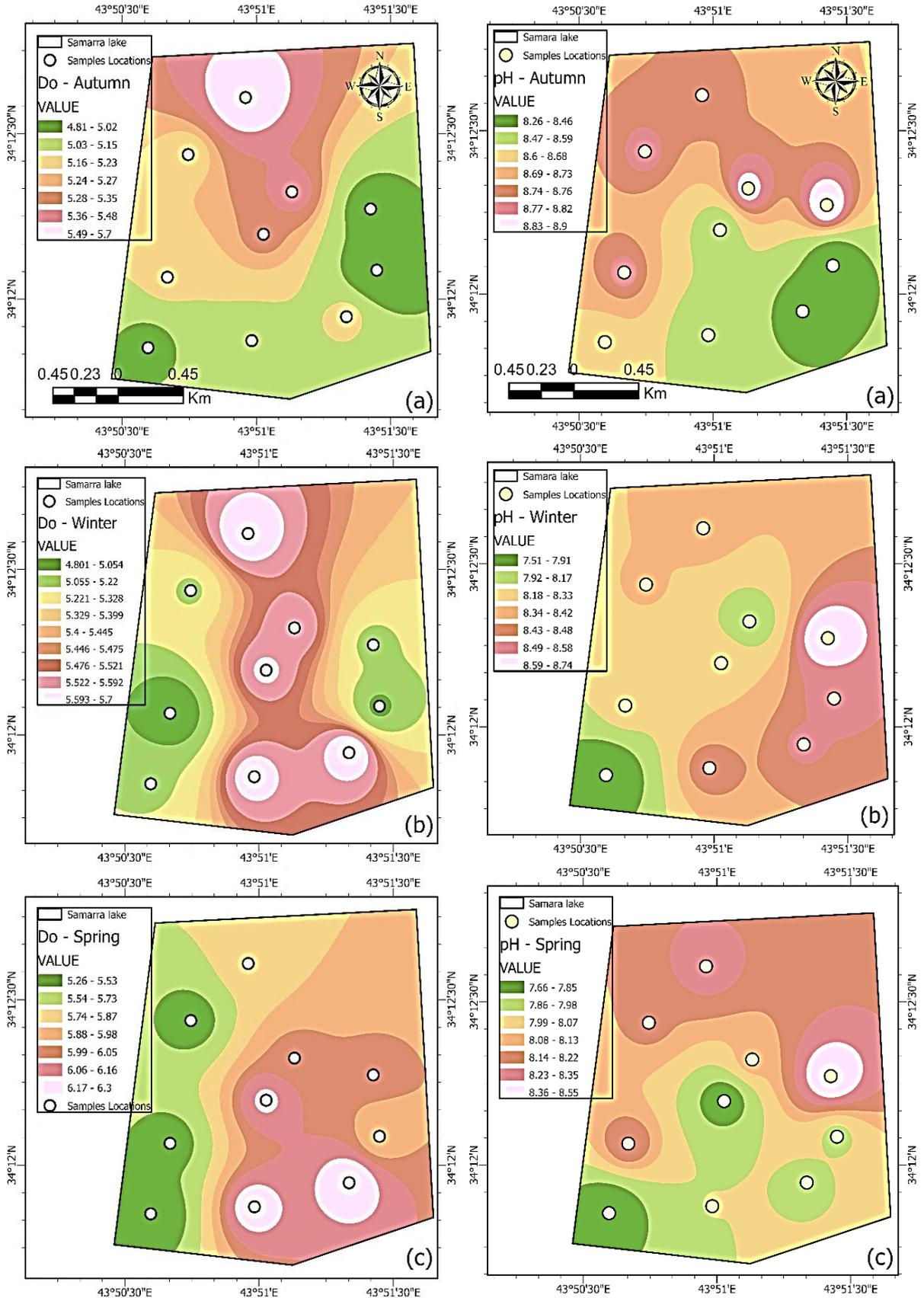
## 3. Results and Discussion

### 3.1 Distribution results of determinants within the lake

All samples taken from Samarra Lake for the three seasons were analyzed to identify their physical and chemical properties as shown in the Table 3. In light of the analysis results, contour maps were drawn for the spatial and temporal distribution of each determinant using the Geographic Information Systems program, as shown in Figures 3 to 16. These figures will show the extent of the distribution of concentrations of each characteristic within the lake, as well as whether they are within the (WHO) limits or deviate from them [23]. It is noted from the analysis results that all the characteristics of Samarra Lake water were consistent with the World Health Organization's specifications for potable water, except for DO, pH, and BOD5.

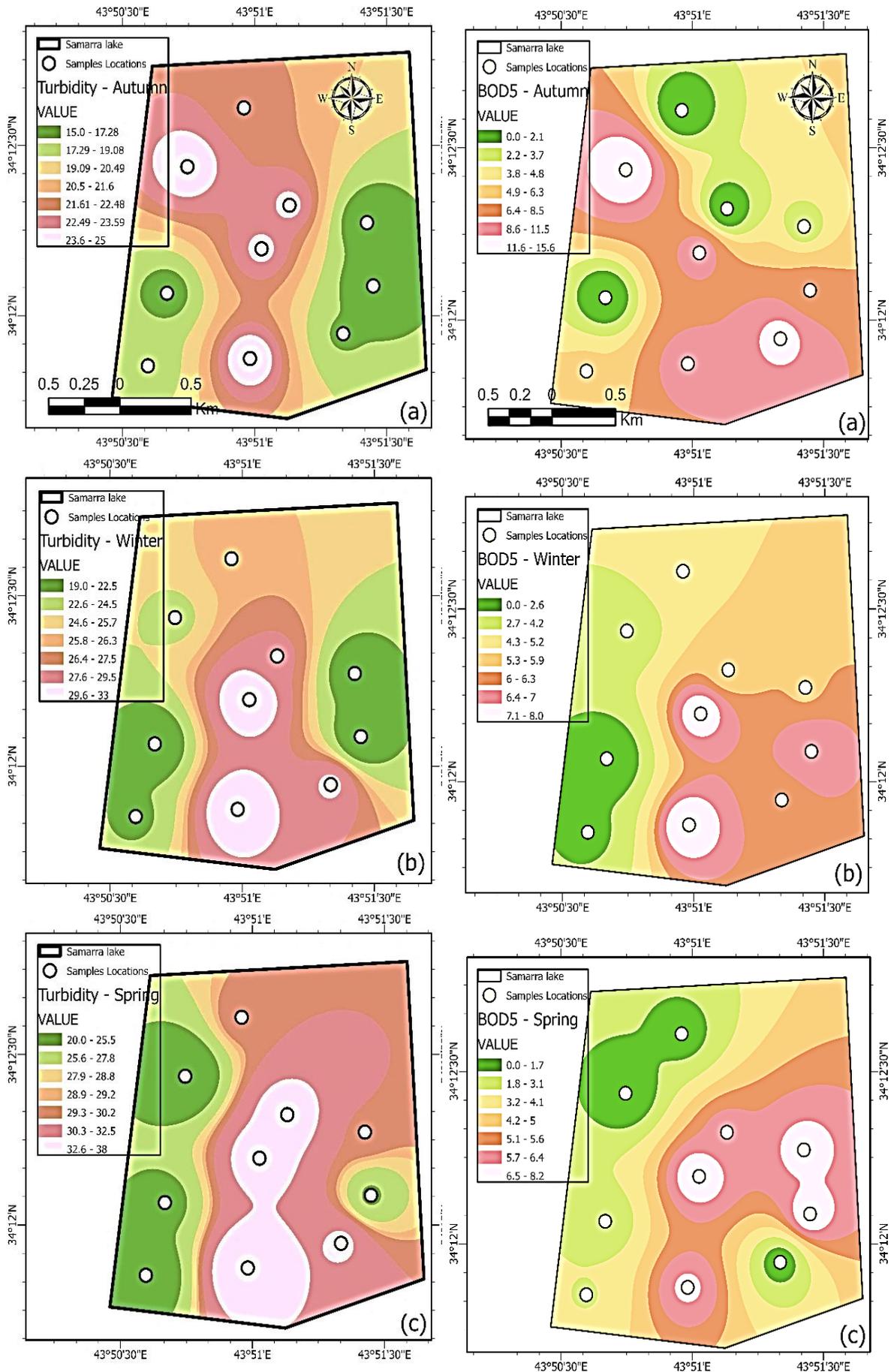
**Table 3 Properties of Samarra lake water samples**

Test	Date	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P 10	Average	WHO Limit
DO	Sep 24	4.95	5.18	5.18	5.7	5.43	4.9	4.8	5.18	5.1	5.3	5.17	>5
	Jan 25	5.2	4.8	5.2	5.7	5.6	5.18	5.01	5.7	5.66	5.62	5.36	
	May25	5.25	5.4	5.38	5.8	6.02	6	5.9	6.3	6.25	6.19	5.84	
pH	Sep 24	8.65	8.78	8.78	8.76	8.85	8.9	8.26	8.38	8.5	8.5	8.63	6.5-8.5
	Jan 25	7.5	8.27	8.34	8.39	7.97	8.74	8.52	8.5	8.49	8.3	8.3	
	May25	7.65	8.2	8.15	8.3	8.1	8.55	7.95	7.95	7.98	7.72	8.05	
TUR	Sep 24	18	16	25	22	24	15	15	17	25	24	20.1	>5
	Jan 25	22	19	24	26	28	20	19	30	33	33	25.4	
	May25	21	24	20	30	35	30	25	33	38	35	29.1	
BOD <sub>5</sub>	Sep 24	4.8	0	15.6	0	0	3	7	13	10	10	6.34	<5
	Jan 25	2	0	3	4.9	6.5	5.8	7.9	6	8	7.7	5.18	
	May25	3.9	2	4.9	1	6.1	7	7.2	8.2	6.7	7.5	5.45	
TDS	Sep 24	465	459	464	460	459	472	470	462	460	468	463	1000
	Jan 25	545	550	532	562	555	523	531	552	530	519	539.9	
	May25	479	466	453	480	492	461	450	477	493	511	476.2	
TSS	Sep 24	0	0	3.3	2.7	5	3.8	0.8	1	7.5	8	3.21	<10
	Jan 25	1	1.9	0	5	7.7	4	2	4.5	8	9	4.31	
	May25	3.8	2	2	4.3	7	0.8	4.3	6	7	5.5	4.27	
SO <sub>4</sub> <sup>2-</sup>	Sep 24	23	23	24	23	25	24	25	26	24	29	24.4	350
	Jan 25	35	39	41	42	45	42	40	40	38	45	40.7	
	May25	31	38	45	47	50	52	54	45	49	53	46.4	
PO <sub>4</sub> <sup>3-</sup>	Sep 24	0.05	0.05	0.13	0.19	0.07	0	0.25	0.08	0.17	0.28	0.12	0.4
	Jan 25	0.05	0.15	0.09	0.12	0.07	0.04	0.03	0.08	0.04	0.02	0.069	
	May25	0.3	0.3	0.25	0.16	0.13	0.19	0.17	0.13	0.11	0.14	0.18	
NO <sub>3</sub> <sup>-</sup>	Sep 24	4.88	5.26	4.86	6.69	5.51	4.43	5.55	5.97	6.03	7.19	5.63	50
	Jan 25	6.99	7.39	6.97	7.54	6.4	6.84	5.88	6.18	5.7	7.9	6.77	
	May25	8.2	8.2	7.99	8.1	8.4	7.8	7.7	8.7	8.8	8.9	8.27	
Cl <sup>-</sup>	Sep 24	36	26	24	26	28	26	26	24	22	30	26.8	350
	Jan 25	45.9	42	39.9	50	52	38	38	37	36	40	41.88	
	May25	33.9	35.2	34.7	35.3	33.9	34.5	37	37.8	38	36.5	35.68	
Ca <sup>+2</sup>	Sep 24	67.3	67.3	68.9	67.5	65	65.7	72.1	64.1	80.1	83	70.08	150
	Jan 25	64	64	68	70	60	65	61	55	50	52	60.9	
	May25	76	79.9	77	83	83	73.5	75	70.1	68	66	75.13	
Mg <sup>+2</sup>	Sep 24	8.7	8.7	5.8	2.9	9.7	5.8	10.7	4.8	14.6	13.7	8.54	100
	Jan 25	19.5	20	19	18.7	20.3	19.2	17.5	17	18.3	17.8	18.73	
	May25	23	23.5	23.9	25	23.1	24.7	23.7	23.4	22.1	21.8	23.42	
Na <sup>+</sup>	Sep 24	31	32	32	30	31	33	31	30	29	29	30.8	200
	Jan 25	26	25	25	28	28	27	29	30	25	27	27	
	May25	38	38	34	35	32	33	37	39	30	32	34.8	
K <sup>+</sup>	Sep 24	2.5	2.44	2.41	2.39	2.42	2.58	2.55	2.4	2.37	2.5	2.45	10
	Jan 25	2.2	2.18	2.09	2.11	2.1	2.07	2	1.98	1.93	1.98	2.06	
	May25	3.5	3.42	3.29	3.19	3.38	3.7	3.7	3.52	3.59	3.43	3.47	



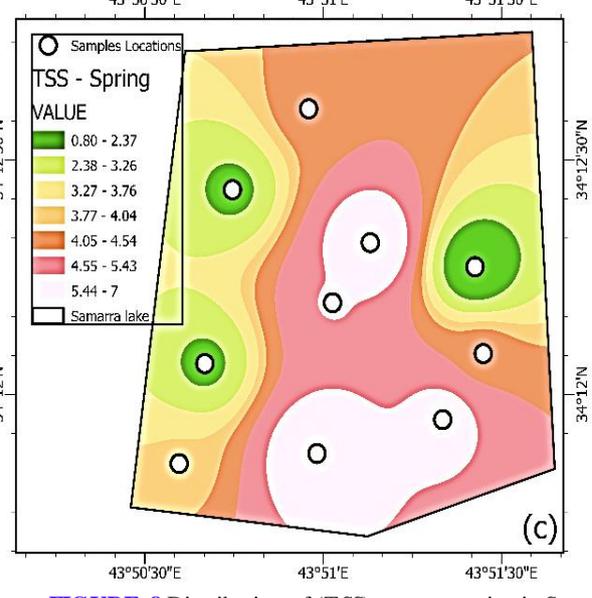
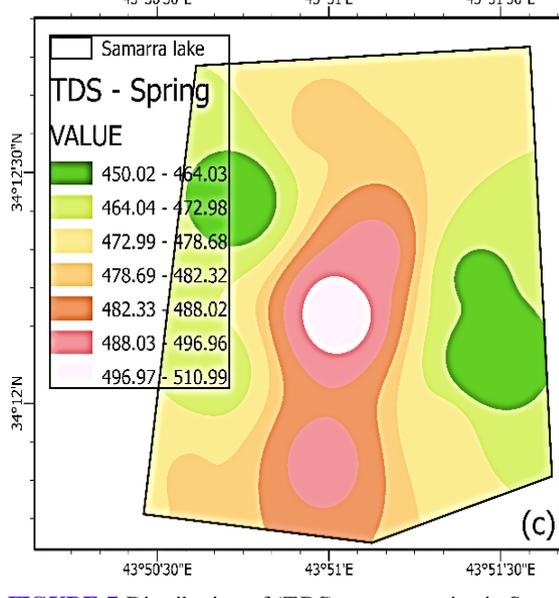
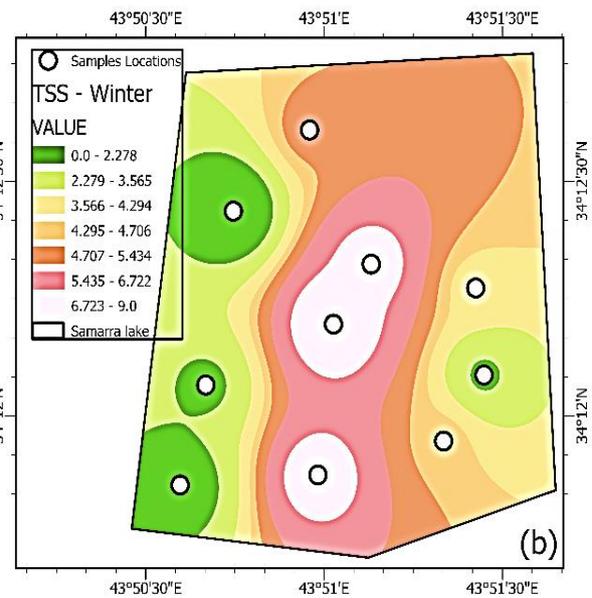
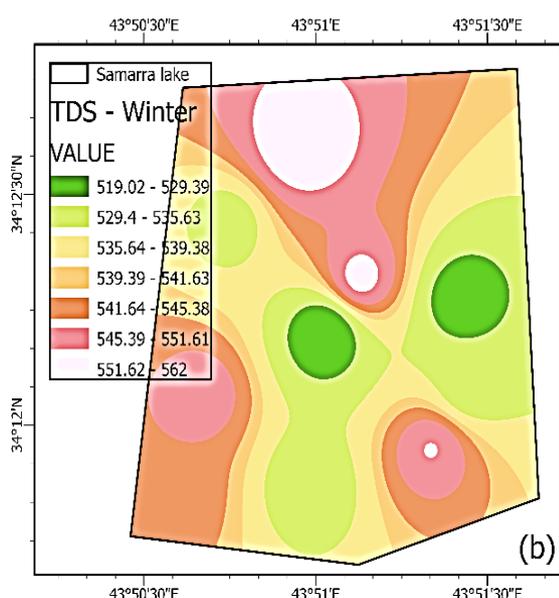
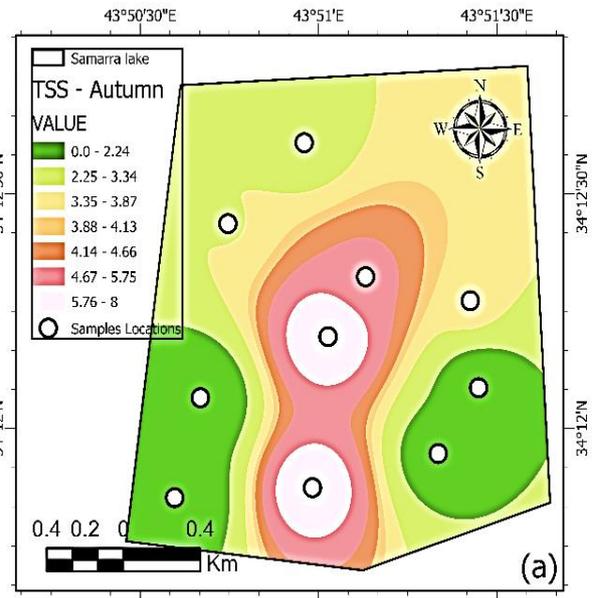
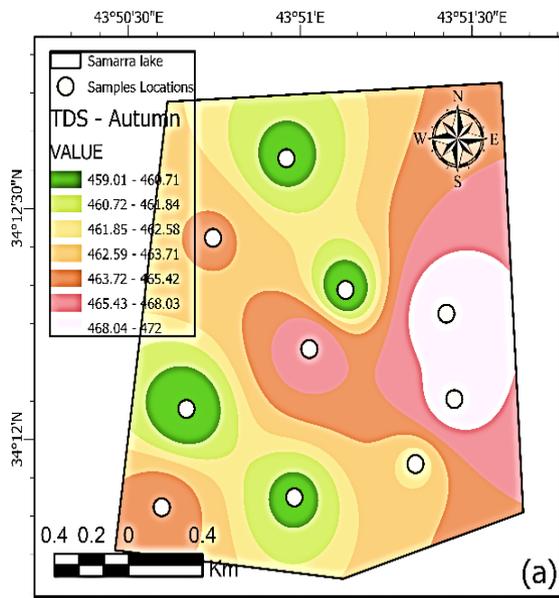
**FIGURE 3** Distribution of (DO) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

**FIGURE 4** Distribution of (pH) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)



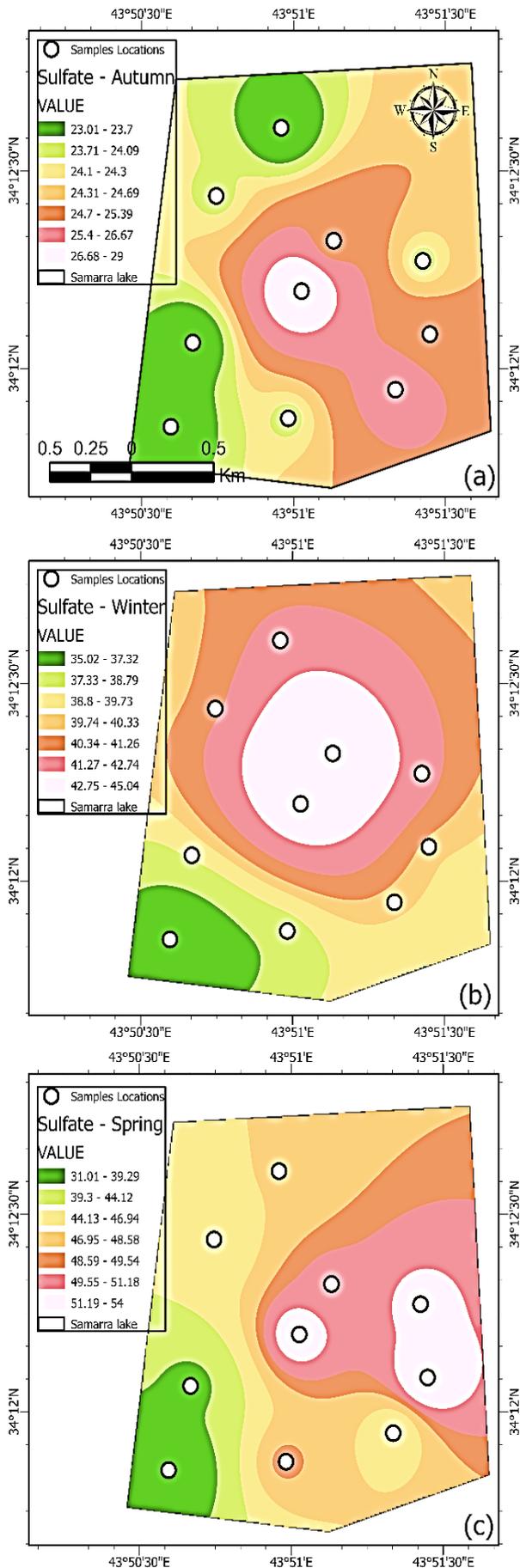
**FIGURE 5** Distribution of (Turbidity) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

**FIGURE 6** Distribution of (BOD<sub>5</sub>) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

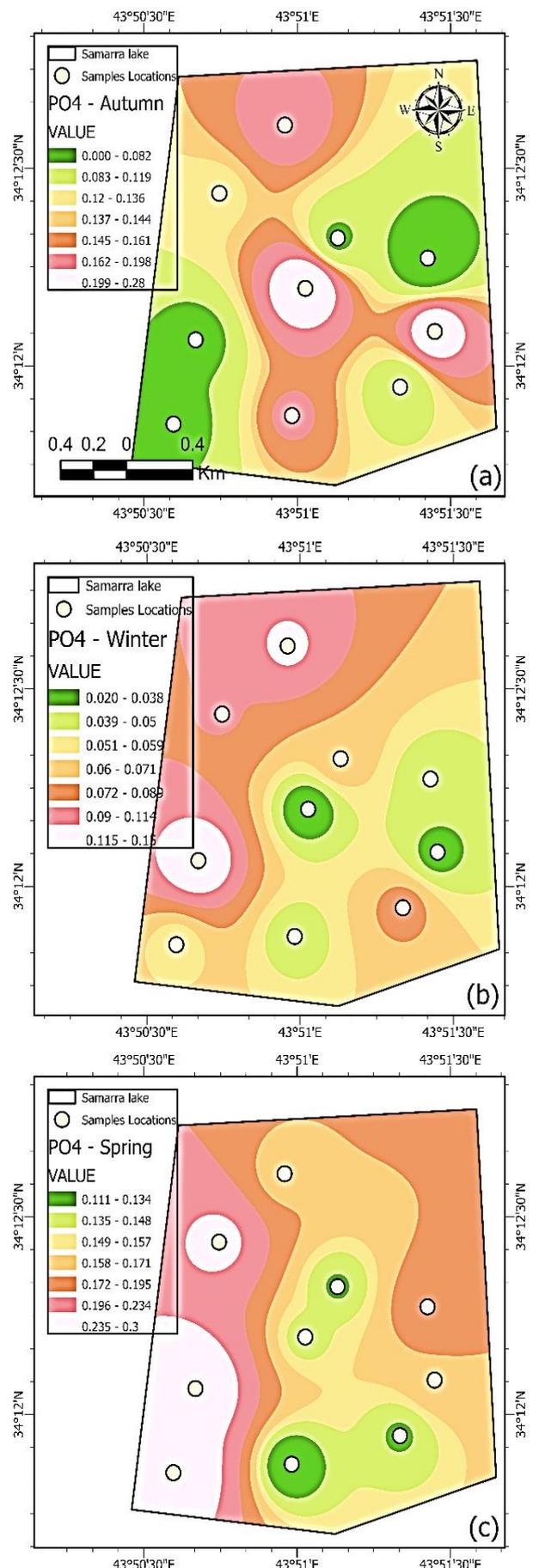


**FIGURE 7** Distribution of (TDS) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

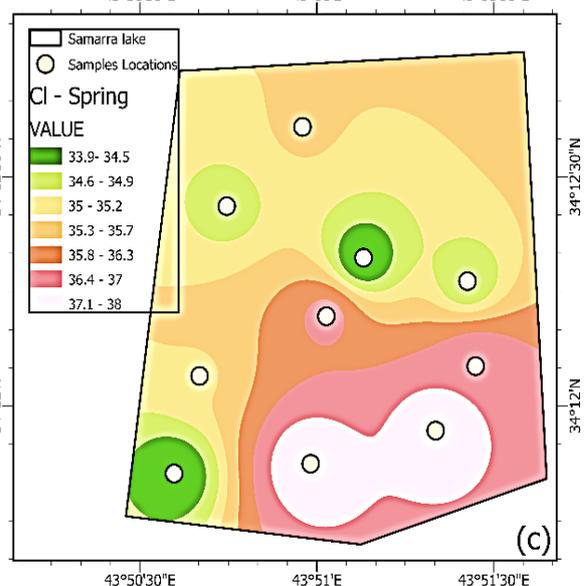
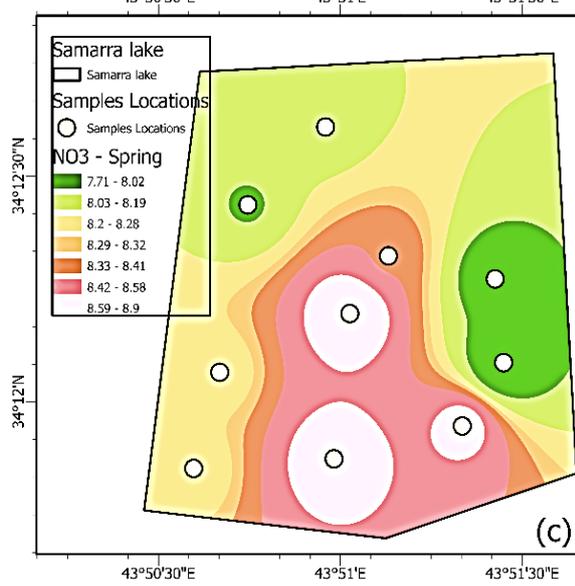
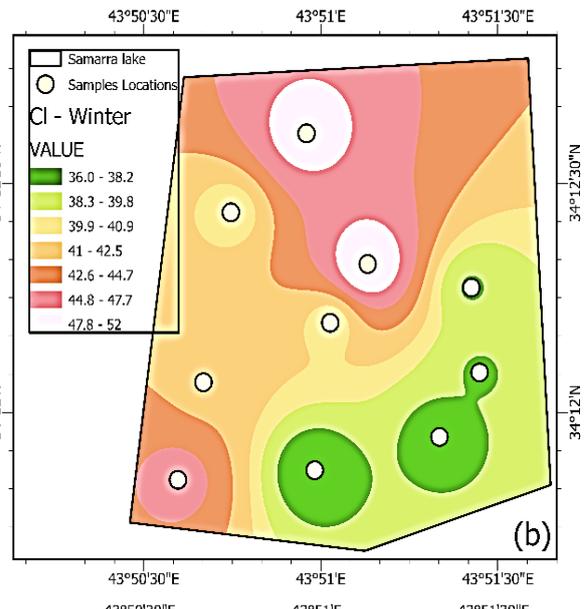
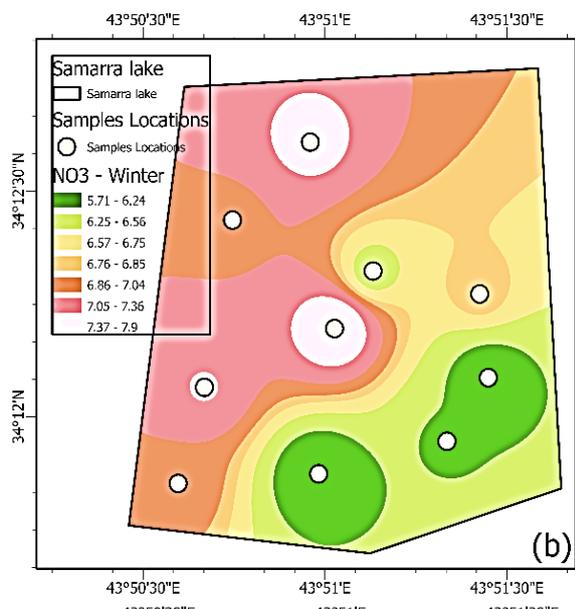
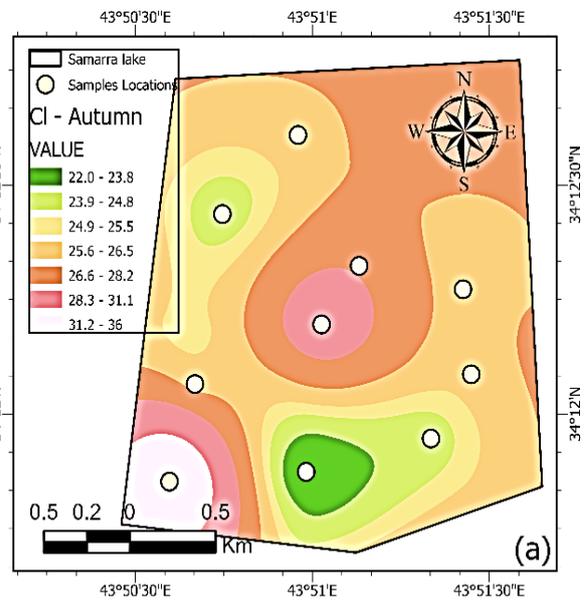
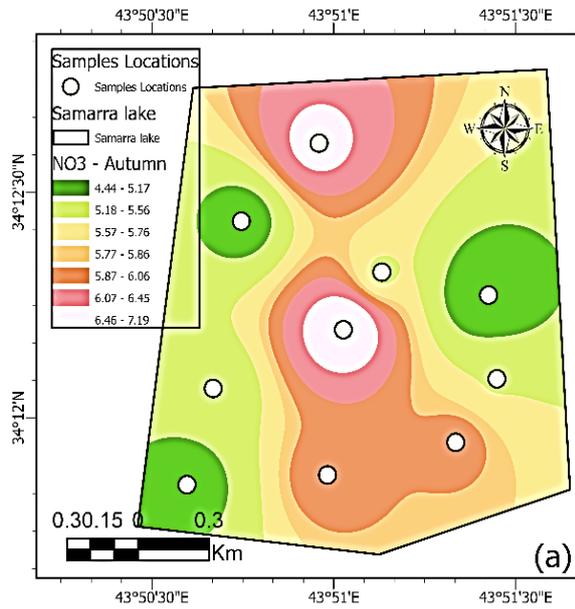
**FIGURE 8** Distribution of (TSS) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)



**FIGURE 9** Distribution of ( $\text{SO}_4$ ) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

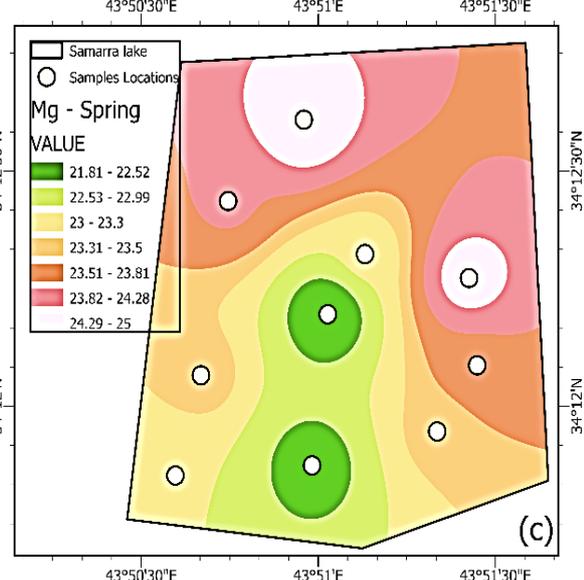
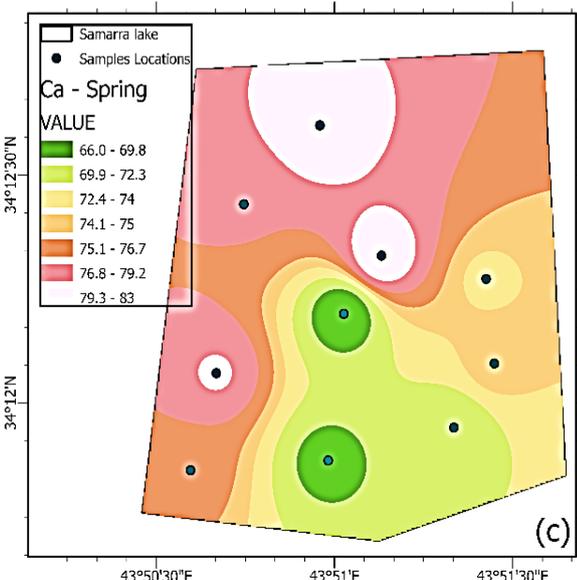
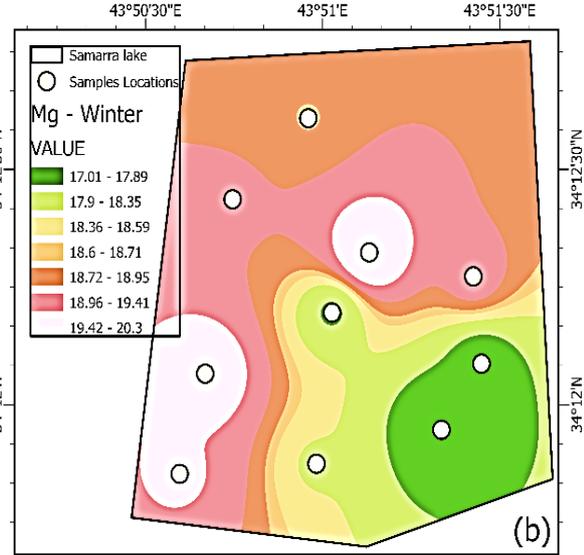
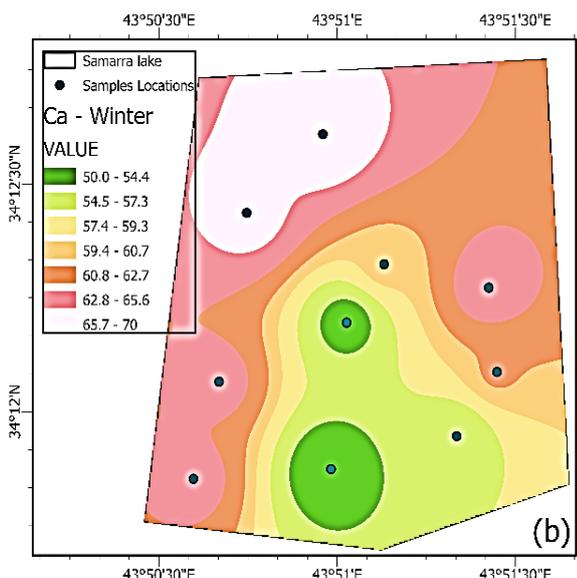
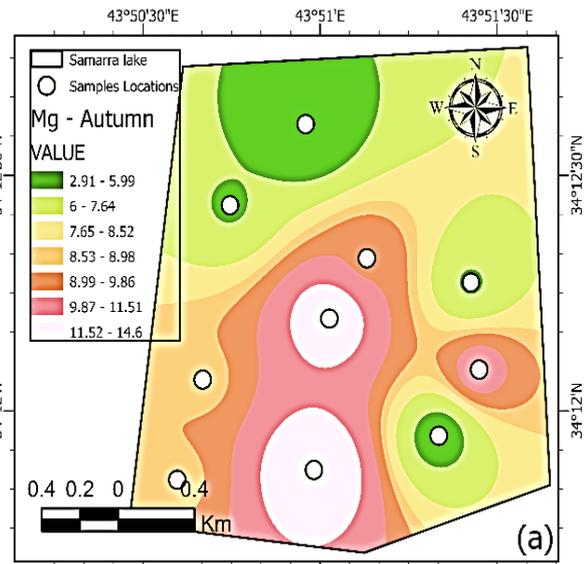
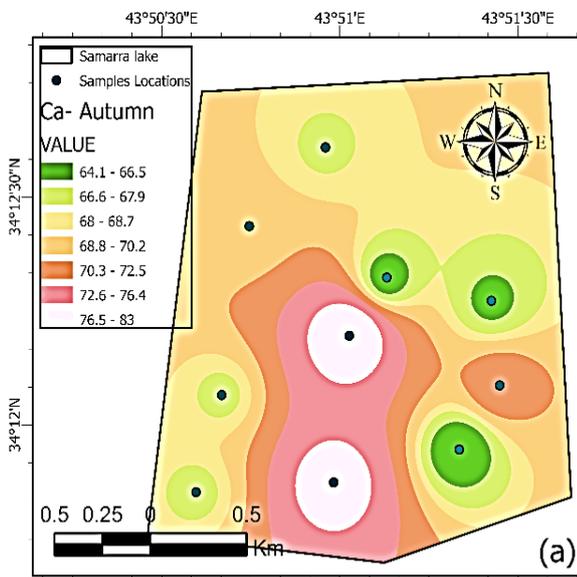


**FIGURE 10** Distribution of ( $\text{PO}_4$ ) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)



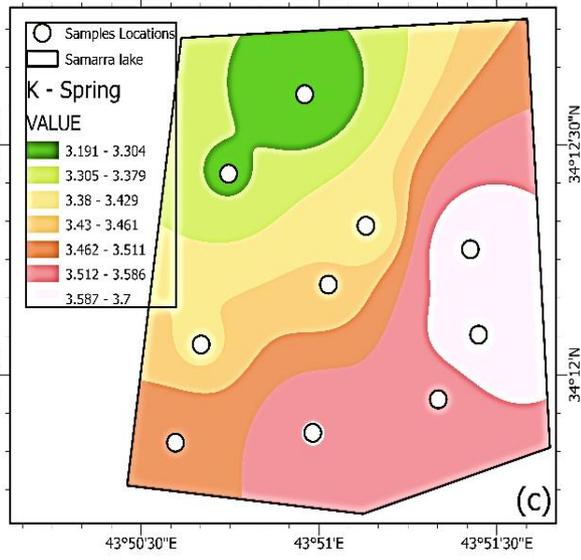
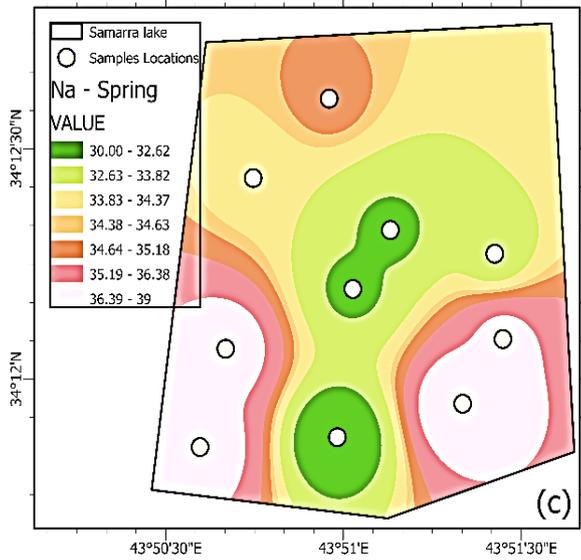
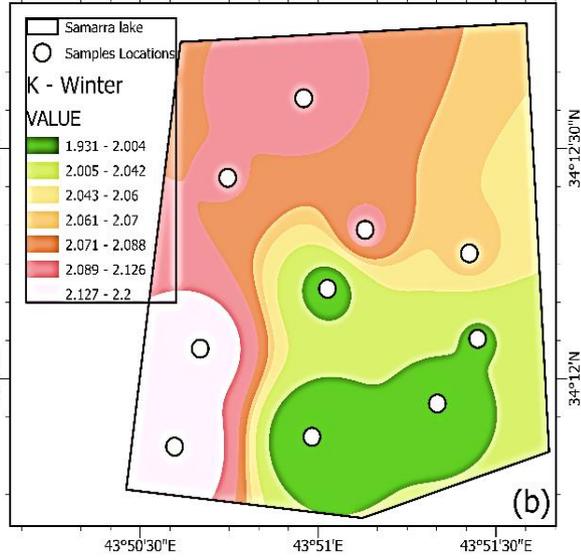
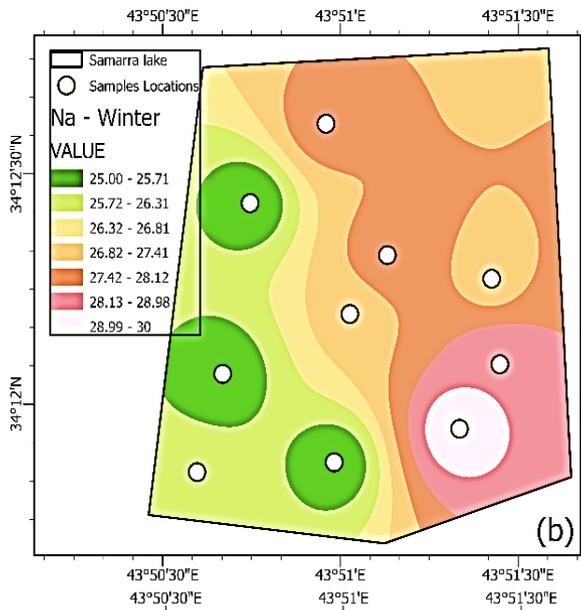
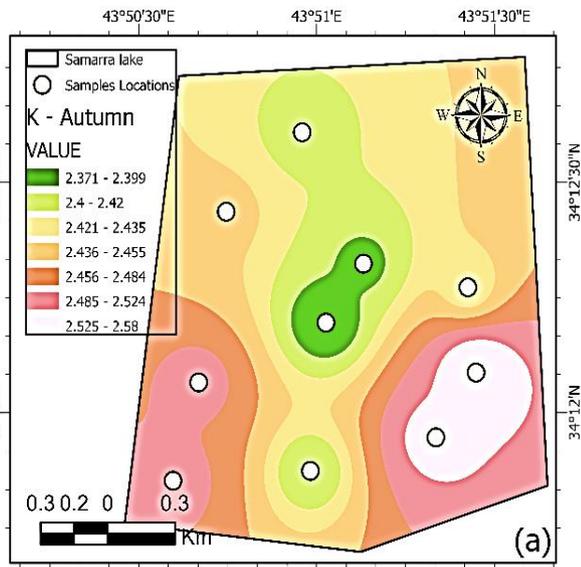
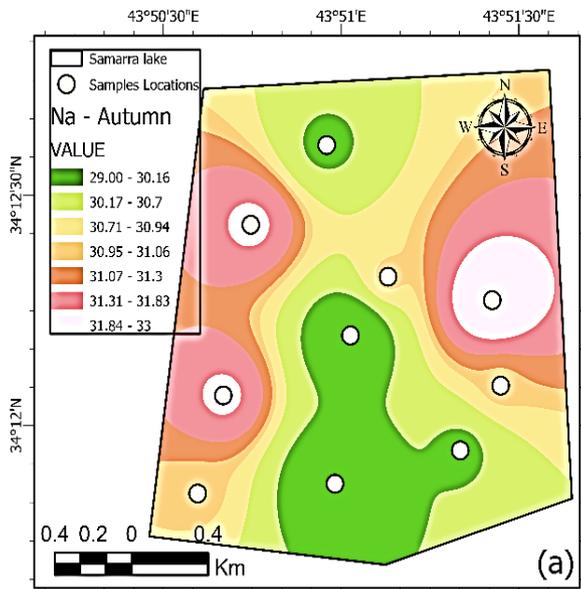
**FIGURE11** Distribution of (NO<sub>3</sub>) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

**FIGURE 12** Distribution of (Cl) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)



**FIGURE13** Distribution of (Ca) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

**FIGURE 14** Distribution of (Mg) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)



**FIGURE 15** Distribution of (Na) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

**FIGURE 16** Distribution of (K) concentration in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

### 3.2 Discussion of factors influencing water quality in Samarra barrage lake

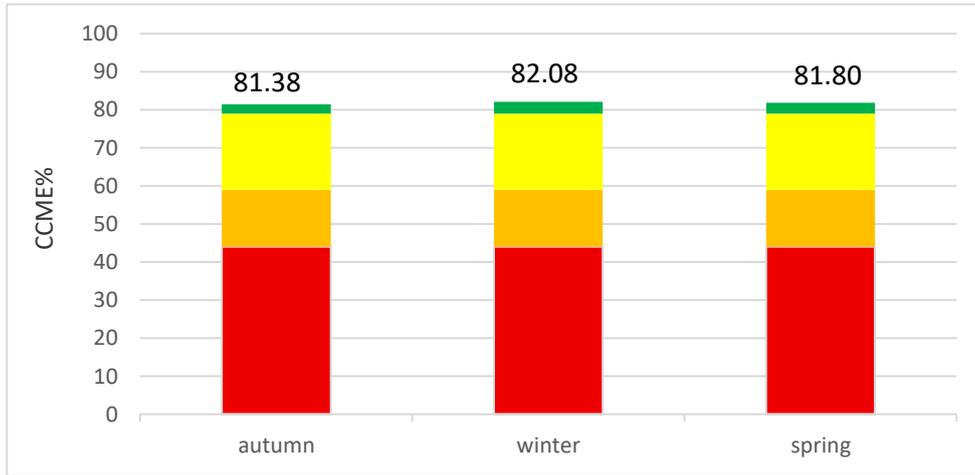
The values of these characteristics may be higher or lower than the standard specifications in some areas of the lake and in one season rather than another. Dissolved oxygen has a significant impact on water quality in general, and its concentration in water is affected by many human and environmental factors. Photosynthesis, the process by which algae and aquatic plants operate, is one of the main environmental sources of dissolved oxygen and its exchange with the atmosphere. Other factors that affect the concentration of dissolved oxygen are water temperature and flow velocity; cold, moving water is able to store more oxygen. Human factors include the decomposition of organic matter from sewage and organic waste discharged into rivers and lakes, which will cause an increase in dissolved oxygen consumption. This may result in a sharp decline in its levels, exposing aquatic life to environmental stress. The results of Table 2 and Figure 3 show that dissolved oxygen levels in points 1, 6, and 7 for September 2024 were below the permissible limit of WHO, reaching 4.95, 4.9, and 4.8, respectively, i.e. it was below 5. The dissolved oxygen value was equal to 4.8 at point 2 for January 2025. Therefore, by referring to the Figure 2, it becomes clear that the main reason for the decrease in dissolved oxygen at the above-mentioned points is that these points are located in areas where the lake water is stagnant or has very little movement, in addition to the high temperatures in September 2024. The remaining points had dissolved oxygen values that were within the WHO's parameters, being above 5, as they were located in areas with relative water movement, in addition to being taken in January and March of 2025, meaning they were modeled within cold seasons. One of the most important indicators of water quality is pH, because it is affected by the chemicals present in the water [24]. Temperature, chemical pollution, Increased biomass of aquatic plants and algae are among the most important factors that may lead to an increase in water pH [25]. The pH range according to (WHO) is between (6.5-8.5). Analysis results for this element showed that it exceeded the permissible limit in most points of the lake during the month of September 2024. On this basis, the increase in pH can be attributed to the fact that the rise in temperature in September leads to an increase in photosynthesis in aquatic plants and algae, in addition to the fact that the heat facilitates the decomposition of organic matter to provide food for these plants. It is worth noting that Lake Samarra suffers from a dense growth of the Nile flower plant, which may be the main reason for the increase in pH, which makes the lake water highly alkaline during hot seasons. It is also noted that the turbidity was outside the permissible limits at all points within the lake and in all seasons, and this is attributed to the flow of Tigris River water into the lake, which is laden with sediments and silt. Biochemical oxygen demand (BOD) is a coefficient it is described as a consuming organic substance that depletes dissolved oxygen in water through aerobic bacteria that feed on it over a specific temperature and time. It is measured in milligrams per liter (mg/L) and is tested during a 5-day incubation period at 20 degrees Celsius. When a water sample is tested and found to contain this substance, it indicates organic pollution in the water, specifically a decrease in dissolved oxygen in the sample that consumed it by weight [26]. BOD5 Water can be contaminated from several sources, such as untreated wastewater (domestic or industrial), decaying plant and animal remains, agricultural and animal husbandry waste, oil spills, and other sources of water pollution., sewage, fattening pens, food processing facilities, malfunctioning sewage systems, and storm water runoff from urban areas. These factors will be sufficient to accelerate the decline in dissolved oxygen levels in rivers and other water bodies, negatively impacting water quality [27]. The analysis results show that BOD5 exceeded the permissible limit of 5 mg/l at many points in the lake and across different seasons. The highest BOD5 value (15.6 mg/l) was recorded in 2024 at point 3

### 3.3 Results of water quality index

One practical way to condense multiple water quality data and make it easier for a wider audience to understand is through the Water Quality Index (WQI). In this study, the Canadian Water Quality Index (CCME-WQI) was chosen because it is suitable for assessing the water quality of rivers and surface water. Index values range from 0 to 100, classified as follows: 0-44 poor, 45-59 marginal, 60-79 acceptable, 80-94 good, and 95-100 excellent.[28, 29]. The Water Quality Index (CCME) was calculated for points within the lake, and the average of those points was also calculated., as shown in Table 4 and Figure 17 Each color in the columns within the figure gives a classification category for the index, starting from the lowest to the highest category.

**Table 4 result of (CCME-WQI) for each point at Samarra barrage lake**

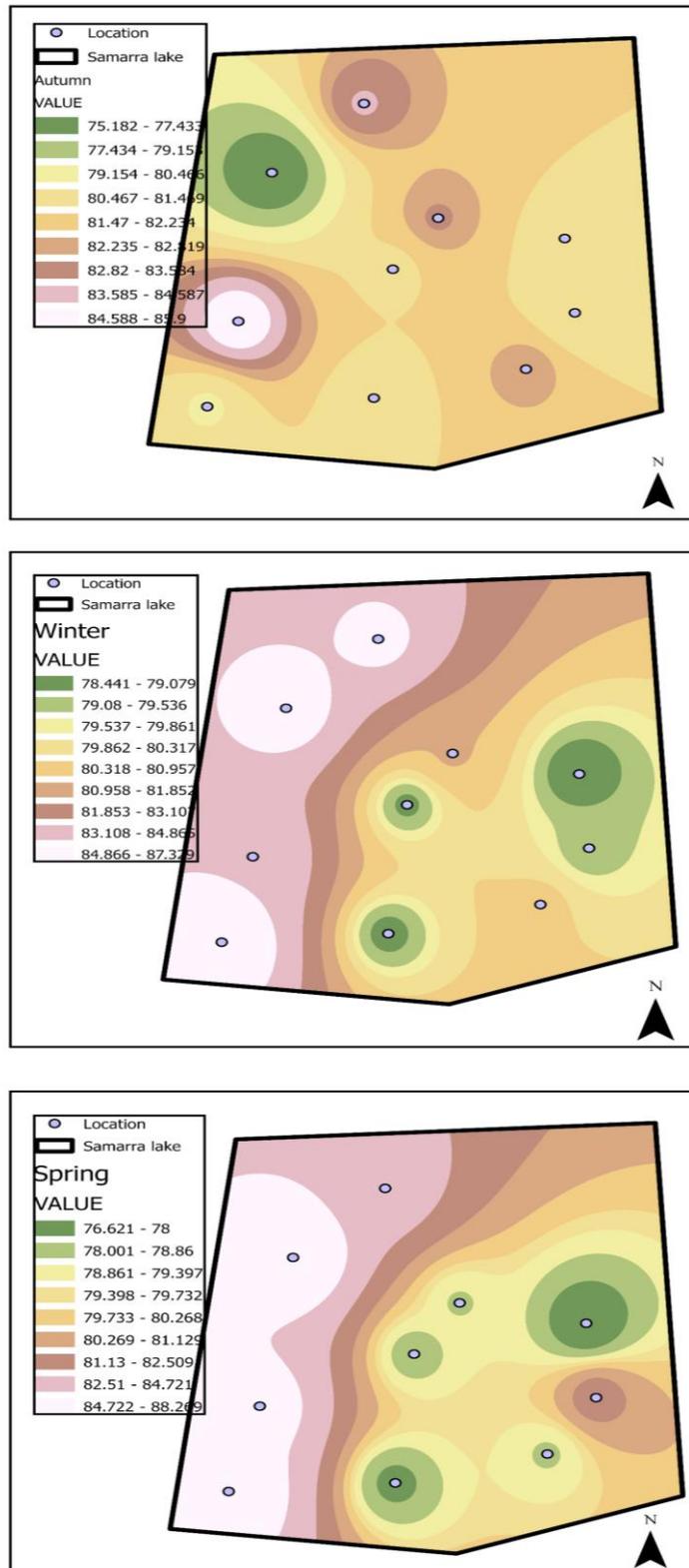
Season	Points										Average
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
(September 2024)	80.28	85.9	75.18	83.72	82.96	81.01	80.52	82.68	80.85	81.22	81.38
(January 2025)	87.33	84.83	86.37	85.46	81.02	78.44	79.22	80.5	78.8	78.9	82.08
g (May 2025)	87.75	86.37	88.27	83.73	78.76	76.62	81.86	78.74	77.6	78.3	81.8



**FIGURE 17** WQI values of Samarra barrage lake during the study period

Based on the above findings, the water quality of Samarra Barrage Lake is classified as good. However, this study revealed high turbidity levels, which remained elevated and consistent across seasons, failing to decrease to acceptable levels compared to previous studies conducted on the same river in this region. On the other hand, the study sites exhibited good and stable water quality throughout the seasons, thanks to the regulating effect of the dam on the lake. The dam regulates and balances the flow of the Tigris River, reduces pollution levels, and mitigates seasonal variations that could cause negative environmental problems, despite the presence of aquatic plants that affect some lake water characteristics. Therefore, the significant improvement in water quality observed in this study, compared to previous studies, can be attributed to the regulating role of the Samarra Dam and the limited impact of human activity.

Based on Table 4, which shows the results of the water quality index for points within the lake, a map was drawn illustrating the values of those points within the lake during the study period, as shown in Figure 18.



**FIGURE 18** Water quality index results in Samarra barrage lake (a-September 2024 b- Jan. 2025 c- May 2025)

## 4. CONCLUSIONS

Based on the results of this current study, the conclusions indicate that:

- The results indicate that DO, pH, and (BOD<sub>5</sub>) values exceeded the limits permitted by the (WHO) drinking water standards during the study period, and that exceeding these standards contributed to the decline in lake water quality.

- The lake's turbidity levels were much higher than the permissible limit for drinking water, due to an increase in suspended particles that reduce water clarity, such as silt, sediment, and other causes of increased turbidity, resulting from soil transformations from stability to erosion, or the activities of people living near the riverbanks and carrying out their various activities that contributed directly or indirectly to increasing turbidity.

- The values of the other parameters were within acceptable limits, as they did not affect the results of this study and remained within acceptable limits, with any increase or decrease remaining within acceptable standards during the period in which the tests were conducted.

- The water quality index values in the study area were generally "good" according to the CCME-WQI classification, which indicates that the Tigris River water is suitable for drinking and most other uses with minimal treatment. It is worth noting that it can be said that the quality of the river water is stable and that the lake has not caused any negative change in that regard.

## FUNDING

None

## ACKNOWLEDGEMENT

The authors would like to thank the anonymous reviewers for their efforts.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest

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