Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(2): 2739 – 2753 (2025)
www.ejabf.journals.ekb.eg

Evaluation of Tigris River Water Between Hammam Al-Alil and Al-Salamiyah in the South of Mosul City Using the Canadian Water Quality Index (CCME WQI) Model

Rania Raed Najeeb[1], Ahmed Mohamed Taher[2], Raghad Mukdad Mahmood[3], Ibrahim Omar Saeed[4*]

[1]Department of Sensing and Nano Photonics, Laser and Photonics Center, University of Al-Hamdaniya
[2]Ministry of Education, Open College of Education / Nineveh Center, Iraq
[3]Department of Biology, College Education for Pure Science, University of Tikrit, Iraq
[4]Department of Biology, College of Science, University of Tikrit, Iraq

***Corresponding author: dr.ibrahim1977@tu.edu.iq**

ARTICLE INFO

Article History:
Received: Feb. 17, 2025
Accepted: April 24, 2025
Online: April 28, 2025

Keywords:
Tigris River,
CCME WQI,
Physicochemical parameters,
Drinking water standards,
Mosul City,
Total plate count

ABSTRACT

During this study, physical and chemical parameters were measured along the Tigris River in four locations extending between Hammam Al-Alil and Al-Salamiyah for the period of August 2024 to January 2025. This study aimed to evaluate the Tigris River water and its suitability for drinking and human use at sites 1, 2, 3, and 4. Physical, chemical, and biological parameters such as pH, air and water temperature, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity, active phosphate (PO_4), nitrite (NO2), chloride (Cl), active silica (SiO_2), and total platelet count (TPC) were studied. Some of these parameters were tested in the field and others in the laboratory. Most of the tested parameters were found to be compatible with international and Iraqi drinking water specifications, except for the total platelet count (TPC) (especially at station 4), which was significantly high, reaching 48.16 * 10^2 cells/ml. Values of pH and water temperature ranged between 6.23- 7.31 and 7-24°C, respectively, while the electrical conductivity (EC) was 341.16 micro siemens/cm. The average value of total dissolved solids (TDS) was determined at 185.20mg/ L, and dissolved oxygen (DO) at 6.6mg/ L, whereas ranges of the silica value were detected between 1.00-2.1µg/ L; in addition, the effective phosphate rate was 0.11µg /L, and the nitrite value was 0.19µg/ L.

INTRODUCTION

There is no doubt that rivers are one of the most important sources of fresh water for human consumption, which has made people rely on them for drinking, irrigation, and watering animals instead of fish, which has become one of the most important sources of food **(Shambara, 2021)**. The Tigris River flows through Iraq sourced in the neighboring Turkey, reaching the Arabian Gulf. During this time, this river is exposed to many environmental crises, including water scarcity and pollution from oil derivatives or household waste, in addition to fertilizer pollutants from neighboring agricultural lands **(Bream *et al.*, 2019; Al-Shanona *et al.*, 2020)**. This has made the Tigris River vulnerable to pollution, which leads to the emergence of many diseases among users of this river water, such as bacterial and fungal diseases, heavy metal poisoning, diarrhea, intestinal inflammation, and other diseases **(Altemimi & Al-Juhaishi, 2024)**

.

Due to the river's course along the cities it passes through and the factories overlooking it, rivers have become a breeding ground for human waste. Thus, studies have been conducted on rivers to evaluate the quality of their water addressing its characteristics to ensure its suitability for drinking and other uses **(Al-Mandeel *et al*., 2024)**. The physical, chemical, and biological characteristics are among the most important indicators and evidences that can be relied upon in evaluating river and lake water. The Canadian model (CCME WQI) for measuring water quality for drinking is considered one of the most important models currently adopted **(Al-Safawi, 2018)**. It is well known that Iraq is one of the countries that depends on agriculture for its economic resources and that agriculture requires treatments such as fertilizers and pesticides **(Al-Assaf & Alsaffawi, 2024)**, therefore, among the pollutants that threaten surface water, such as rivers and even groundwater, are the fertilizers and pesticides used in agriculture, which are no less dangerous than other pollutants. Recent research has shown the pollution occurring in the waters of the Tigris River, especially in the areas south of Mosul, due to the accumulation of industrial and domestic wastes, thrown randomly into the river **(Alsinjari, 2024)**. The current study aimed to monitor some of the environmental changes frequently occurring in the Tigris River due to human pollutants or as a result of changes in climate and river nature. Monitoring these environmental alterations can help us avoid numerous problems and risks **(Mariam *et al*., 2025)**.

MATERIALS AND METHODS

Study area

The study area (the Tigris River course between the towns of Hammam Al-Alil and Salamiyah) is located south of Mosul City in Iraq, about 21km from Mosul City center. The study was conducted on the eastern bank of the river within coordinates 36°08'45.1"N north, 43°18'06.5"E east, along the river starting from the town of Hammam Al-Alil and ending with the town of Salamiyah. The study area is characterized by the abundance of villages that depend on agriculture and the Tigris River for irrigation, especially the town of Salamiyah, which is famous for agriculture. There is also a sulfur spring near Hammam Al-Alil and reliance on the river course for irrigation and watering animals. It is also characterized by the scarcity of factories and pollutants, except the household waste of the villages overlooking the river course (Fig. 1).

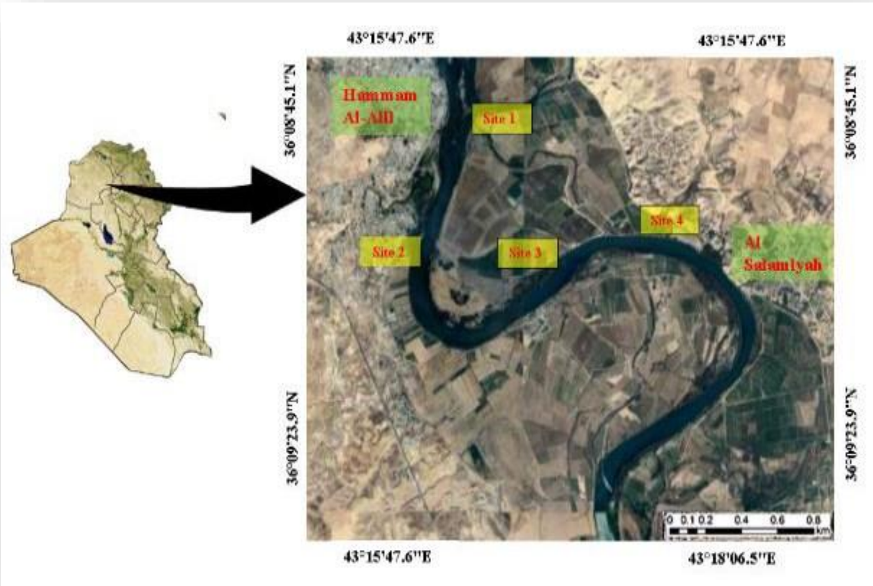

Fig. 1. Map of the studied area showing sites along the Tigris River

The study was conducted from August 2023 to the end of January 2024. The physical and chemical properties as well as a bacteriological study of the water under study were measured once a month for six months, with three replicates. Early in the morning, water samples were collected from the four selected study sites along the Tigris River, from Hammam al-Alil to al-Salamiyah, with a distance of approximately 5.6km between each site (Fig. 1). Special plastic bottles were used, filling them directly from the river water, ensuring that no air bubbles remained. The bottles were labelled with the site numbers and the date of sampling and were transported in special boxes to the laboratory (A side laboratory in the centre of Nineveh Governorate) for testing. Some samples were tested in the field, and different sources were used according to the tests. Water samples were taken from the study sites using sterile bottles for bacteriological purposes in order to perform a series of dilutions and subsequently culture them in the laboratory **(Taher & Saeed, 2022)**.

Total alkalinity

Total alkalinity was measured by taking 50ml of water sample and adding 3 drops of methyl orange indicator, after which it was titrated with 0.02N sulfuric acid according to the guidelines of **APHA (2017)**. The color changed to reddish orange and $CaCO_3$ was expressed in mg/L. Total alkalinity was measured using the following equation: Total alkalinity = (V H_2SO_4 × N H_2SO_4 × 1000 × Eq.wt of $CaCO_3$) / (V Sample).

Chloride

According to the guidelines of the **ASTM (1984)**, 50ml of water was placed in a 250ml beaker. Additionally, potassium dichromate (K_2CrO_4) reagent was added and mixed well, and 0.025 N silver nitrate solution was added until the mixture turned to a pale red color. The chloride results (mg/L) were calculated according to the following equation: $Cl^- = (V\ AgNO3) \times N\ AgNO3 \times 1000 \times$ atomic weight of chlorine / (V sample).

Dissolved oxygen (DO)

According to the method of **Mackerath (1963)**, dissolved oxygen was measured. Glass bottles were filled with water samples from the study sites, gently to prevent air bubbles. 2ml of manganese sulphate was added, followed by 2ml of potassium iodide to stabilize the oxygen. The bottle was turned upside down several times, gently, and the sample was kept away from sunlight. Then, 2ml of concentrated sulfuric acid was added and shaken well. In the laboratory, 100ml of the sample was taken, and the yellow solution, amounting to 203ml, was tittered with sodium thiosulphate ($Na_2S_2O_3$), and expressed in mg/liter.

Chemical oxygen demand (COD)

Chemical oxygen demand (COD) is an indicator of oxygen consumption resulting from the chemical oxidation of organic matter. The chemical oxygen demand was measured using a Wag tech COD device at the four sites over six months, once every two months. The water sample was taken in a special glass bottle, and shaken vigorously, then the Wag tech COD device cover was removed and 2ml of the sample was added. The sample was heated, cooled and digested for two hours at a temperature of 150°C. Afterward, the samples were read using a spectrophotometer at a wavelength of 490nm **(APHA, 1998; APHA, 2017)**.

Reactive silicate

Molybdenum silicate was used when measuring silica. This was done using a spectrophotometer type (CE 1011 CECIL(at a wavelength of 410nm **(APHA, 2017)**. The results were expressed by mg/ L.

Reactive phosphorus

Freshwater is usually rich in phosphorus. To monitor phosphorus dynamics in ecosystems and ensure water quality, reactive phosphorus was measured using the ascorbic acid reduction method **(APHA, 2017)** and spectrophotometrically at a wavelength of 880nm. The reactive phosphorus ratio was measured and expressed in μg/ L.

Nitrite

Using the method of **Strickland and Parsons (1972)**, nitrite was measured by spectrophotometer (CE 1011 CECIL) at a wavelength of 543nm. The results were expressed in μg/ L.

Total plate count (TPC)

Pouring the culture medium into Petri dishes containing 1ml of the study samples, preceded by a series of decimal dilutions, where dilutions 10-1, 10-3, and 10-5 were used at a rate of 3 replicates for each dilution. After incubating the dishes in an incubator at 37°C for 24-48 hours, a colony counter was used to count the growing colonies. The results were multiplied by the inverse of the dilution, and they were expressed in cells/ml (**Sneath *et al*., 1986)**.

Canadian mathematical model

The Canadian mathematical model for water quality is characterized by high accuracy and has been applied to determine the quality of the studied river water and to determine the intended purposes of it such as drinking, watering animals and livestock, and irrigating gardens and plants. The index values were found by calculating three factors as follows **(Keraga *et al*., 2017; Zhu *et al*., 2018)**:

F1 (Scope): represents the percentage of variables exceeding the standard limits compared to the total number of variables (even once during the study period).

$$F1=\left(\frac{number\ of\ failed\ variables}{total\ number\ of\ variables}\right) \times 100 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (1)$$

F2 (*Scope*): the percentage of individual tests exceeding the standard limits over the total number of tests.

$$F2=\left(\frac{number\ of\ failed\ variables}{total\ number\ of\ tests}\right) \times 100 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

F_3 (*Amplitude*): represents the number of exceeded tests and was calculated in two stages:

1- The first stage: The number of times individual concentrations exceed the standard limits and is called Excursion and is calculated as follows:

$$Excursion=\left(\frac{failed\ test\ value}{guideline\ value}\right) - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

2- The second stage: It is the group of exceeded individual tests and was calculated by adding the individual deviations and dividing them by the total number of tests (exceeded and not exceeded). This variable is called the sum of adjusted deviations Normalization of excursion and is symbolized as nse:

$$nse= \frac{\sum_{i=1}^{n} Excursion}{number\ of\ tests} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4)$$

F3 is calculated from the following equation:

$$\mathbf{F3}=\frac{\boldsymbol{nse}}{\mathbf{0.01}\ \boldsymbol{nse}+\mathbf{0.01}} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (5)$$

After finding the three factors, the Canadian index was calculated from the following equation:

$$\boldsymbol{WQI}=100 - \left(\frac{\sqrt{F1^2+F2^2+F3^2}}{1.732}\right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (6)$$

The constant 1.732 is to adjust the result of the index value and make it limited between 0.0-100. Water quality was classified into five sections, as shown in Table (2).

Table 1. CCME WQI categorization schema

Criterion	WQI range
Excellent	95 – 100
Good	80 – 94
Fair	60 – 79
Marginal	45 – 59
Poor	0.0 – 44

RESULTS AND DISCUSSION

Physical properties

From Fig. (2) and Table (2), it is clear that the pH of the Tigris River water ranged between 6.23 and 7.31 during the study period. In August, it was at its highest value at sites 1 and 4, where it reached 7.31 for both sites. In January, it was at its lowest value at site 3, where it reached 6.23. The decrease in pH may be attributed to the high water levels due to rainfall, climate changes, and the increase in the solubility of carbon dioxide, which is inversely related to temperature **(Abdullah *et al*., 2018)**. It is worth noting that the pH ranged within the permissible values of **WHO (2011)**, which is within the range of 6.5 to 8.5. Based on data presented in Fig. (2) and Table it can be noted (2) that the air temperature ranged between 10 to 40 degrees Celsius during the study period. In August, the highest temperature was recorded at the site 1 and the lowest temperature was in January at the site 3. This result is inline with the findings of **Younis and Saeed (2023)**. On the other hand, the water temperature ranged between 7 to 24 degrees Celsius. In August, the highest water temperature was at the site 1, and in January, the lowest temperature was at the site 3. These temperatures are consistent with the permissible values of **WHO (2011)**.

The results also showed that the electrical conductivity is between 287 and 530µS/ cm, as shown in Fig. (2) and Table (2), and that the average electrical conductivity recorded is 341.16µS/ cm for all sites throughout the study period. This is consistent with the findings of **Alsinjari)2024(** upon conducting a study on the Tigris River from the Mushairfa area to the Albusief area. The author argued that the electrical conductivity was somewhat high. The reason for this may be that the riverbed becomes shallower the further south it goes, and because of the pollution sources that the river is exposed to **(Oleiwi & Al-Dabbas, 2024)**.

. Given the information in Table (2) and Fig. (2), the total dissolved solids range between 170 to 230mg/ L. In August, the highest value was recorded at site 1, while the lowest value was at site 2 in December. As is evident, the presence or absence of tributaries of the Tigris River, the flow rate in the riverbed, the geochemical composition of the sediments, and other characteristics of the Tigris River all influence total dissolved solids (TDS) **(Rasheed & Saeed, 2024)**. TDS increases with the amount of agricultural, industrial, and domestic waste **(Zhu *et al*., 2018)**.

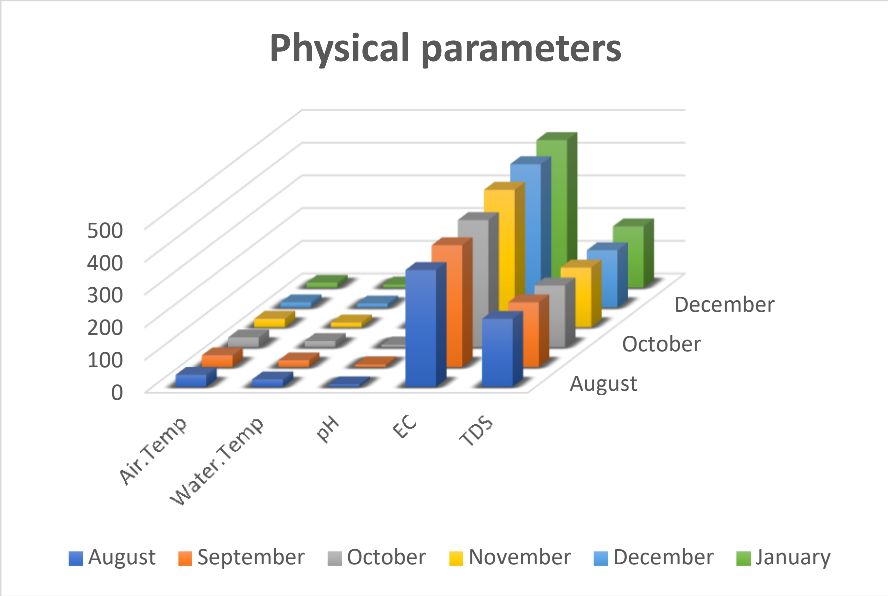

Fig. 2. Monthly changes in the studied physical parameters during the study period

Chemical properties

Based on the results from Fig. (3) and Table (2), the total alkalinity recorded its highest value in August at the site 1 (129.5 mg/L), and its lowest value was recorded in December at the site (3), where it reached 89.9mg/ L. This is because the total alkalinity (temporary hardness) or calcium and magnesium bicarbonates free of alkaline substances in the water, which was released by microorganisms that decompose organic matter in the presence of oxygen, increases with the dissolution of carbon dioxide gas, all of which are inversely related to temperature **(Keraga *et al*., 2017)**.

$$CO_2+H_2O \rightarrow H_2CO_3$$

$$CaCO_3+H_2CO_3 \rightarrow Ca^{+2}+2HCO_3^-$$

$$Ca\text{-}Mg\,(CO_3)_2+2H_2CO_3 \rightarrow Ca\,(HCO_3)_2+Mg\,(HCO_3)_2$$

Since the Tigris River in the studied areas is rich in agricultural lands and natural plants, both wild and aquatic, a decrease was recorded in total alkalinity, as the presence of aquatic plants increases both microorganisms and the chances of releasing carbon dioxide, reducing the production of carbonic acid and thus the total alkalinity **(Lateef *et al*., 2020)**. Fig. (3) and Table (2) illustrate that the chloride values levels ranged between 17.34 - 21mg/ L. It is known that the nature of sedimentary rocks plays a role in the formation of chloride ions, the proximity of homes and their waste, and the seepage of irrigation water and the fertilizers it contains, increasing the percentage of chlorides **(Aljaburi *et al*., 2024)**. Fig. (3) and Table (2) show the percentage of dissolved oxygen (DO) in the study area, which ranged between 5.8 - 7.3mg/ L, where the highest value was in November at Station 3, while the lowest value was in Station 4 in January, which is consistent with previous studies **(Hmoshi *et al*., 2024)**. The speed of the water current and the high temperature may increase the solubility of oxygen, as the speed of the water current distributes the water temperature, which lowers the temperature and thus increases the solubility of oxygen, in addition to the lack of waste in the vast majority of the areas under study through which the Tigris River passes, adding to the lack of homes and factory waste, which reduces organic matter and thus the bacteria's consumption of oxygen. This is evident from the slight increase in bacteria at Station 4, since this area is abundant with plant debris **(Alwan & Saeed, 2024)**. The results in Table (2) and Fig. (3) show that the silica concentration ranged between 1.00-2.1 micrograms/liter. The presence of high and dense algae caused the low silica concentration in the river water at the studied stations, especially at Station 4. Algae, especially Bacillariophyta, consume silica in building their cells, in addition to some diatoms that feed on silica. This was in addition to the nature of the structure and texture of the soil in the study area **(Almoula *et al*., 2021)**.

Based on the results in Fig. (3) and Table (2), it is clear that the effective phosphate concentration ranged between 0.01 - 0.199 micrograms/liter, with the highest value being in January at site 4, while the lowest value was in January at site 2. According to **Taher and Saeed (2023)**, phosphorus is one of the most important sources of active phosphate. The slight increase in active phosphate in rivers is due to low rainfall, climate change, and high phosphorus levels or abundance of its sources, such as rocks, bird droppings, and plant structures and debris that reach water sources. (**Al-Saedi *et al*., 2024**). Fig. (3) and the Table (2) show that the nitrite values ranged between 0.12 - 0.87 micrograms/liter, where the highest value was reached at site 4 in January, and the lowest value was also in January at site 2. The reason for the high nitrite, especially at station 4, is due to the abundance of rain that washes away nitrogen-rich fertilizers and seeps them into the river near the agricultural areas **(Al-Sarraj *et al*., 2014)**.

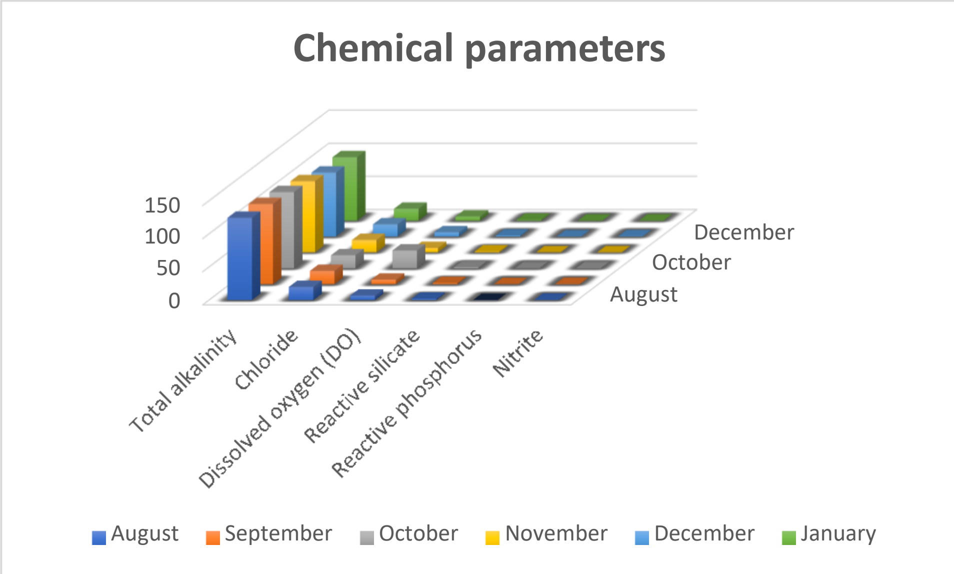

Fig. 3. Monthly changes in the studied chemical parameters during the study period

Fig. (4) shows that the chemical oxygen demand (COD), which was measured once every two months over six months, ranged between 1 - 1.9mg/ L. This is an evidence of the stability of the river's condition and its good flow, which reduces pollutant accumulations. Moreover, there is a decrease in waste, and this is evident through the increase in the percentage of dissolved oxygen **(Tsunatu *et al*., 2016)**.

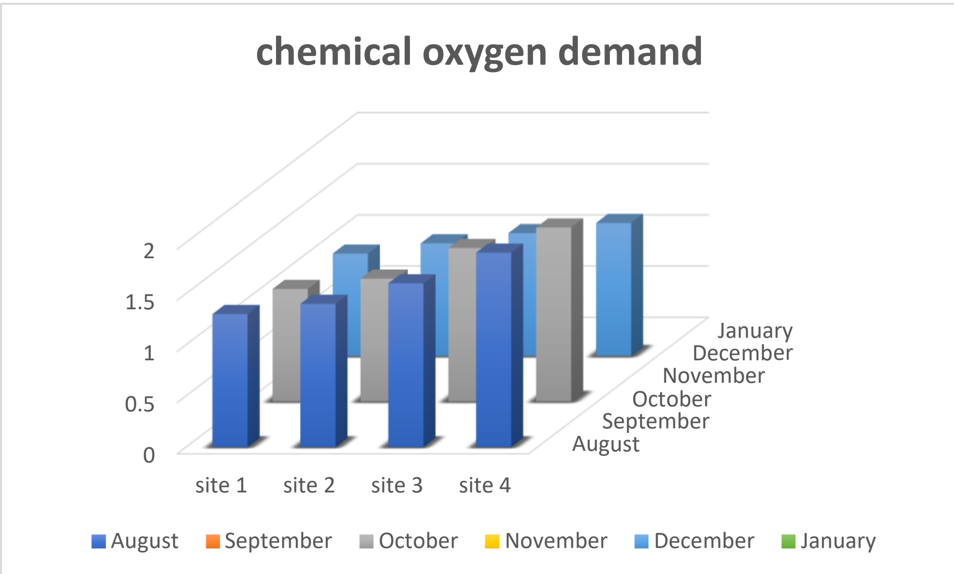

Fig. 4. Monthly changes in chemical oxygen demand studied during the study period.

Fig. (5) shows the numbers and growth of bacteria, from which we can read the total plate count (TPC) in the river, where the highest value was recorded at site 4 in November, at 70 * 10^2 cells/ml, while at site 1 in August the lowest value was recorded at 3 * 10^2 cells/ml.

The study showed that the number of microorganisms was low in September due to the lack of rainfall in the fall. However, they increased significantly with the onset of a somewhat rainy winter, after having been lower in the fall. We should not forget the water current that sweeps away organic matter and dead plant remains. Rivers also experience an abundance of nutrients, especially in Site 4, which provides a greater opportunity for microorganisms to grow **(Al-Jebouri & Edham, 2012; Mallika *et al*., 2017)**.

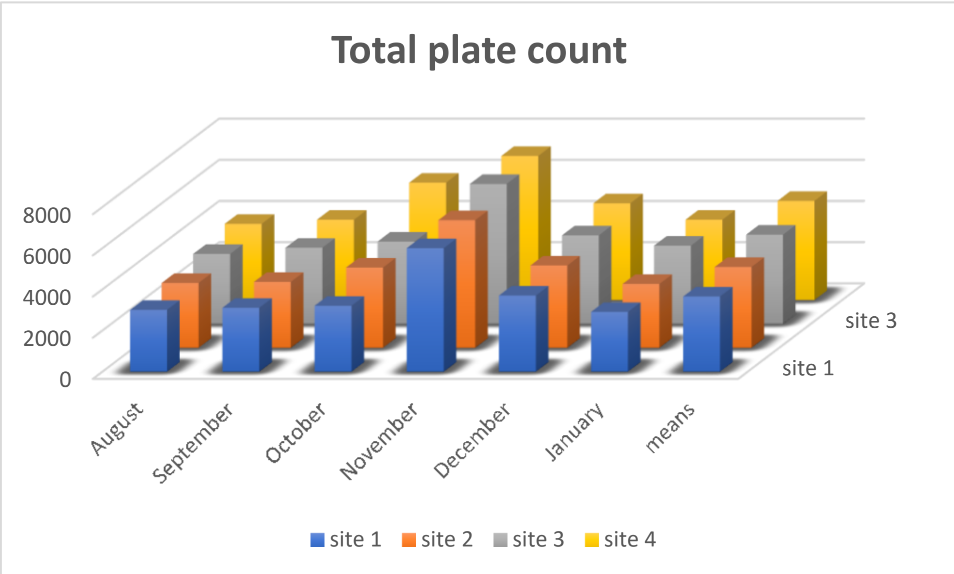

Fig. 5. Monthly changes in total plate count studied during the study period

Table 2. Monthly changes in chemical and physical parameters of the sites during the study period

	Month	pH	EC	TDS	Air Temperature	Water Temperature	Total alkalinity	Chloride	Dissolved oxygen (DO)	Reactive silicate	Reactive phosphorus	Nitrite
Sit1	**August**	7.2	460	230	40	24	129.5	20	7	2.1	0.09	0.34
	September	7.12	480	212.3	38	23	124.7	21	6.7	2	0.08	0.3
	October	7.21	508	200.3	30	20	117	20.78	6.2	1.9	0.07	0.3
	November	7.22	521	190.5	27	17	115	19.16	6	1.8	0.09	0.28
	December	7.23	500	180	17	14	100.01	19	5.9	1.7	0.1	0.22
	January	7.31	530	198.67	16	10	100	18.6	5.89	1.5	0.12	0.19
	Mean	**7.215**	**499.83**	**201.96**	**28**	**18**	**114.3**	**19.7**	**6.36**	**1.8**	**0.09**	**0.27**
Sit2	**August**	7	380	200	38	22	120	20	7	2	0.09	0.31
	September	6.77	397	198	36	18	119	20.7	7.1	1.99	0.1	0.29
	October	6.23	400	189.9	30	17	114	19.89	6.89	1.09	0.089	0.18

	November	7.2	432	179	25	12	112	18.6	6.5	1	0.07	0.16
	December	7.16	460	170	16	10	96.68	18	6.4	1.07	0.08	0.14
	January	7.11	470	187.89	15	9	95.7	17.34	5.9	1	0.01	0.12
	Mean	**6.911**	**423.166**	**187.46**	**26.6**	**14.6**	**109.5**	**19.08**	**6.7**	**1.3**	**0.07**	**0.2**
Sit3	**August**	6.23	300	199	30	20	119.2	19	6	1.99	0.08	0.41
	September	6.34	320	189	29	17	118	18.9	6.45	1.09	0.07	0.34
	October	6.9	332	180.78	26	16	112	18.5	7	1	0.09	0.22
	November	7.2	358.87	178.9	24	11	98	18	7.3	1.07	0.1	0.2
	December	7.23	528	169	10	9	89.9	17.9	7.1	1	0.12	0.18
	January	7	401.76	178	10	7	90.9	17.5	6.5	1	0.1	0.16
	Mean	**6.8166**	**352.105**	**182.44**	**21.5**	**13.3**	**104.6**	**18.3**	**6.7**	**1.1**	**0.09**	**0.25**
Sit4	**August**	7	287	200	37	23.3	128.12	19.9	7	2	0.2	0.8
	September	7.12	290	189	37.5	21	122.67	19.5	6.9	1.9	0.19	0.78
	October	7.2	312	180.7	29.8	19	117	19	6.7	2	0.18	0.67
	November	6.7	367.89	180	26.3	16	105.15	18.9	6.5	1.8	0.19	0.8
	December	6.9	390	179	17	13	100	18	6	1.76	0.189	0.65
	January	7.31	400.1	182.54	15.6	9	96.42	17.9	5.8	1.6	0.199	0.87
	Mean	**7.0383**	**341.16**	**185.20**	**27.2**	**16.8**	**111.5**	**18.8**	**6.6**	**1.8**	**0.19**	**0.76**
Sits Means		**6.995**	**404.067**	**189.27**	**25.8**	**15.7**	**110.03**	**19**	**6.6**	**1.5**	**0.11**	**0.37**

Upon reviewing Tables (1, 3) and Fig. (6), and through the mathematical equations of the Canadian model and the calculation of the CCME WQI, it became clear that Site (1) is marginal for human use in terms of drinking water due to its proximity to the Hammam Al-Alil site and its impact on water quality in terms of household and industrial waste and the presence of a sulfur spring. According to **Al-Safawi (2018)**, sites (2, 3) are considered good in terms of quality due to their distance from pollution sources and their geographical location, which is characterized by the positive aspects of the river bank width, depth, and flow rate. The water at Site (4) is categorized under the moderate quality for drinking water due to its dense agricultural area with local crops, including vegetables, which makes it vulnerable to the leakage of fertilizers and animal waste **(Eslami *et al*., 2019)**.

Table 3. Values and classification of Tigris River water in restricted areas

Site No	F1	F2	F3	CCME WQI	
				Value	Status
1	54.45	55.78	53.41	45.48	Marginal
2	57.41	33.30	48.91	81.28	Good
3	57.51	34.72	47.98	82.02	Good
4	53.60	45.18	47.03	64.31	Fair

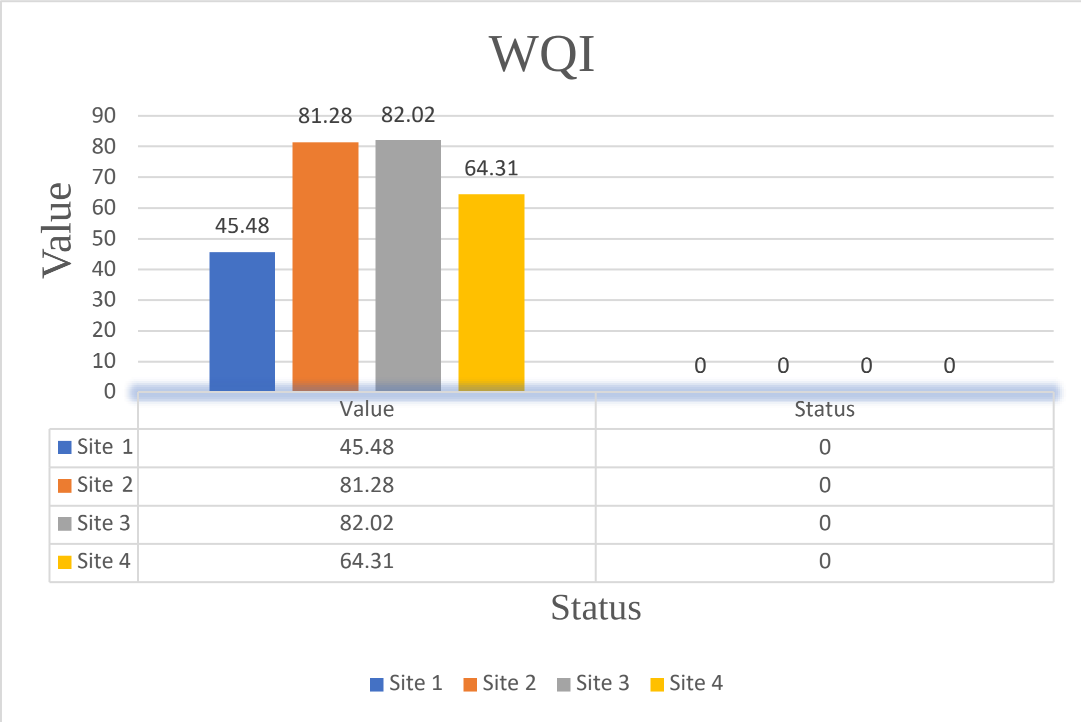

Fig. 6. Water quality assessment in some parts of the Tigris River south of Nineveh Governorate

The most important conclusions of the current study are that the physical and chemical properties of the Tigris River water at the study sites generally align with an increase in the total bacterial count (TPC) at site 4, and that site 1 is marginal, sites (1) and 2 are considered good, while site 4 is classified as fair in terms of water quality according to the Canadian water quality index.

REFERENCES

Abdullah, S. A. G.; Hammadi, N. S. and Ouda, Y. W. (2018). Assessment of the lower reaches of Tigris River by a development of a water quality index (WQI). Research Journal of Science and Technology, 10(1): 1-8.

Al-Assaf, A. Y. R., Alsaffawi, A. Y., & Katib, M. A. (2024). Application of the Canadian Index (CCME WQI) to Assess Water Quality for Aquatic Life: A Case Study of Water Quality for the Khoser and Tigris Rivers in the North of Nineveh Governorate. Egyptian Journal of Aquatic Biology & Fisheries, 28(5):29-42

Aljaburi, M. S.; Alshakeer, Y. M. and Alfakhrii, M. A. (2024). The Effect of the Succession of Seasons on Some Parameters of the Tigris River in Mosul City, Iraq. Egyptian Journal of Aquatic Biology and Fisheries, 28(5):1300-1312.

Al-Jebouri, M. M. and Edham, M. H. (2012). An assessment of biological pollution in certain sector of Lower Al-Zab and River Tigris waters using bacterial indicators and related factors in Iraq. Journal of water resource and protection, 4(1), 32-38. DOI: 10.4236/jwarp.2012.41005

Al-Mandeel, F. A.; May A. Al-Allaf. and Mishal A. Mohamed. (2024). The Evolution of the Al-Qayyarah Refinery's treatment plant's effectiveness and the impact of its discharges on the Tigris River's quality. Egyptian Journal of Aquatic Biology and Fisheries,28(1):156-164.

Almoula, O. A.; Abdulrazzaq, K. A.; Mohammed, A. H. and Alani, R. R. (2021, November). Seasonal and annual variation of Tigris River's water quality using physicochemical parameters within Baghdad city. In AIP Conference Proceedings (Vol. 2372, No. 1). AIP Publishing. https://doi.org/10. 1063/5.0066552.

Al-Saedi, M. S.; Naimi, S. and Al-Sharify, Z. T. (2024). The environmental impact of pollutants and heavy materials on the water quality in the Tigrisriver. Mathematical Modelling of Engineering Problems, 11(2), 290-300. 10.18280/mmep.110202

Al-Safawi, A. Y. T. (2018). Application of the Canadian Index (CCME WQI) to assess the quality of water for drinking purposes: A case study of groundwater quality in the Mahlabiya sub-district / Nineveh Governorate. Al-Rafidain Science Journal, Vol. 27, No. 4 / Special Issue of the Third Scientific Conference on Biology, pp :202-193. http://dx.doi.org/10.33899/rjs. 2018. 159362

Al-Sarraj, E. S.; Jankeer, M. H. and Al-Rawi, S. M. (2014). Some Indicators of Water Quality of the Tigris in Mosul City an Inferential Study. Rafidain journal of science, 25(1A).

Al-Shanona, R. A.; Al-Assaf, A. Y. and Al-Saffawi, A. Y. (2020, March).Assessment of the health safety of bottled drinking water in Iraqi local markets using the WQI model. In AIP Conference Proceedings (Vol. 2213, No. 1). AIP Publishing.

Alsinjari, W. E. (2024). Application of mathematical model to assess the irrigation water quality of the Tigris River in Mosul City, Iraq. SABRAO J. Breed. Genet, 56(5): 2175-2183.

Altemimi, Z., & Al-Juhaishi, M. (2024). Water Quality Evaluation of Tigris River by using Canadian and Horton Water Quality Index. CONSTRUCTION, 4(1): 37-44.

Alwan, I. A. and Saeed, I. O. (2024). Monitoring Pollution Indicators of the Water of the Tigris River in Tikrit and its Suburbs. Egyptian Journal of Aquatic Biology & Fisheries, 28 (2). https://dx.doi.org/10.21608/ejabf.2024.346018

APHA; AWWA and WCPE (1998). "Stand Method for Examination of water and wastewater American public Health Association, 20th ed., Washington DC, USA.

APHA; AWWA and WCPE (2017). "Stand Method for Examination of water and wastewater American public Health Association, 23RD ed., Washington DC, USA.

Eslami, F.; Yaghmaeian, K.; Mohammadi, A.; Salari, M. and Faraji, M. (2019). An integrated evaluation of groundwater quality using drinking water quality indices and hadrochemical characteristics: a case study in Jiroft, Iran. Environmental Earth Sciences, 2(78): 1-10.

Bream, A.S.; El Surtasi, E.I.; Mahmoud, M.A. and Hamza, Y.I. (2019). Industrial Pollution Evaluation through Enzymatic Biomarkers at Different Localities of El-Sadat Industrial City, Menofia, Egypt. Egyptian Academic Journal of Biological Sciences. A, Entomology, 12(3): 19-36.

Hmoshi, R. M.; AL-Saleem, S. and Mohammed, M. I. (2024). Assessment of Natural and Municipal Liquid Wastes Discharged into the Tigris River in Mosul-Iraq. Egyptian Journal of Aquatic Biology & Fisheries, 28(4). 10.21608/ejabf.2024.369171.

Keraga, A.; Kiflie, Z. and Engida, A. N. (2017). Evaluating water quality of Awash River using water quality index. Int. J. Water Res. Environ. Eng. 9(11): 243-253. http://dx.doi.org/10.5897/IJWREE2017.0736

Lateef, Z. Q.; Al-Madhhachi, A. S. T. and Sachit, D. E. (2020). Evaluation of water quality parameters in Shatt Al-Arab, Southern Iraq, using spatial analysis. *Hydrology*, *7*(4), 79. doi: 10.3390/hydrology7040079

Mallika, S.; Umamaheswari, R. and Krishnamoorthy, S. (2017). Physico-chemical parameters and bacteriological study of Vaigai river water Madurai district, Tamilnadu, India. International Journal of Fisheries and Aquatic Studies, 5(1), 42-45.

Mariam, A.I.; Ahmed. M.T.; Ibrahim. O.S. (2025). Evaluating the Water of the Tigris River Between the Cities of Al-Mosul and Al-Badoush Dams in Northern Iraq. *Egyptian Journal of Aquatic Biology and Fisheries*, 29(1), 1519-1531. https://doi.org/10.21608/ejabf.2025.410915

Oleiwi, A. S. and Al-Dabbas, M. (2024). The parameters discharge, salinity and dissolved loads of Tigris River from Mosul to Baghdad, Iraq. Iraqi Journal of Science, 3176-3194.

Rasheed, M. M.; Saeed, I. O. and Ibrahim, O. M. (2024). Study of Pollution by Some Heavy Metals in the Water of the Tigris River in Some Areas of Salah Al-Din Governorate. Egyptian Journal of Aquatic Biology & Fisheries, 28(2). https://doi.org/10.21608/ejabf.2024.348253

Shambara, A. A. (2021). The Impact of Human Activities on Water Pollution of Al-Qassim Stream. Journal of the University of Babylon for Humanities, 29(3). Strickland and Parsons. (1972). U.S. EPA, Aquatic Life Ambient Water Quality Criteria, office of water, Office of Science and Technology.

Shihab, H. F. and Kannah, A. (2023). Using a Number of Environmental Factors to Determine the Water quality of the Tigris River at Wana, Nineveh, Iraq. Egyptian Journal of Aquatic Biology and Fisheries, 27(4), 1107-1116. 10.21608/ejabf.2023.314472

Sneath, P. H.; Mair, N. S.; Sharpe, M. E. and Holt, J. G. (1986). Bergey's manual of systematic bacteriology. Volume 2 (pp. xxiii+-965).

Taher, A.M. and Saeed, I.O. (2022). Bioremediation of Contaminated Soil with Crude Oil Using New Genus and Species of Bacteria. King Abdulaziz University J. Marine.Science.32(2): 13-35. https://doi.org/10.4197/Mar.32-2.2.

Taher, A.M. and Saeed, I.O. (2023). Isolation and identification normal flora bacteria from different areas of Ninava governorate. Nativa J .11(2): 161-165. https://doi.org/10.31413/nativa.v11i2.15434.

Tsunatu, D. Y.; Kurutsi, D. S.; Tickson, T. S. and Bingari, M. S. (2016). Assessment of some physico-chemical parameters of Nukkai River tributaries, Jalingo, Nigeria. FUW Trends Sci Technol J, 1, 427-432.

Younis, B. M. and SAEED, I. O. (2023). Concentration of heavy metals in soil contaminated with crude oil at two Iraquian sites according to environmental indices of pollution. *Nativa*, 11(4). https://doi.org/10.31413/nat.v11i4.16521

Zhu, S.; Mostafaei, A.; Luo, W.; Jia, B. and Dai, J. (2018). Assessing water quality for urban tributaries of the Three Gorges Reservoir, China. J. Wat. Reuse and Desalination (In press): 1-10. http://dx.doi.org/10.2166/wrd.2018.010