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Evaluating Water Quality of the Tigris River in the Qayyarah District/ Nineveh/ Iraq Through the Concentrations of Some Heavy metals and Some Limnological Parameters

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ABSTRACT

The current study aimed to evaluate the water of the Tigris River and its suitability for drinking. The physical, chemical, and biological parameters of the Tigris River water in the Qayyarah district were studied. The studied samples were collected for a period of six months from October 2023 to March 2024. The water was divided according to some physical, chemical, and biological factors such as temperature, electrical conductivity (EC), total dissolved solids (TDS), pH, dissolved oxygen (DO), chemical oxygen demand (COD), total alkalinity, chloride (Cl^-), phosphate (PO_4), nitrite (NO_2), silica (SiO_2), heavy metals, and total plate count (TPC). The results of the study showed that numerous samples conformed to Iraqi and international standards for drinking water, except for the total plate count (TPC), which was high and appeared in all samples throughout the study period between 360 and1500 cell/ ml. The water temperature ranged between 9 & 24 degrees Celsius, and the electrical conductivity ranged between 293- 395µS/ cm, and the dissolved oxygen rate recorded 9.26mg/ L. Chemical oxygen demand rate was 1.23mg/ L. Nitrite concentrations were low, ranging between 0.14- 0.35µg/ L. Total alkalinity ranged between 96- 128mg/ L as CaCO3, phosphate ranged between 0.002- 0.067µg/ L, silica ranged between 1.4- 2.15µg/ L, and varying values of heavy metals were recorded: 0.095- 0.887mg/ L for lead, 0.044- 0.059mg/ L for cadmium, and 0.053- 0.177mg/ L for zinc.

INTRODUCTION

The Tigris and Euphrates rivers provide Iraq with an abundance of fresh water, however as a result of industrial development and urbanization that has extended alongside the rivers, sewage and other industrial wastewater have contaminated the country's waters. These sources of pollution are a major source of biotic and abiotic pollution, particularly in areas close to large cities. A specific concentration of pollutants has increased the risk of pollution and toxicity since they have a toxic effect on living things, particularly untreated industrial effluents that end up in rivers **(Alwan & Saeed, 2024)**. Being an oil-producing nation with numerous crude oil refineries, transportation routes to oil depots, gas stations, and electricity stations. Iraq is among the nations facing the risks of pollution, particularly those associated with oil waste in all its forms, which are rich in hydrocarbon compounds. As the most common and extensively utilized fuel, crude oil and its derivatives are the main causes of pollution. According to **Mojiri *et al*. (2019)** and **Najeeb and Saeed (2022)**, oil pollutants are also thought to be the most complicated combination of hydrocarbon molecules that seriously contaminate water and degrade its quality. Due to the significant threats that industrial pollution poses to both the ecosystem and public health as a result of a rise in the amount of pollutants dumped into the water, it is one of the most significant issues that has gained a lot of attention on a local and global scale. One of the main issues that people are currently experiencing is water contamination, and it is imperative that a concerted effort is being made to treat and reduce it, but the issue is complicated by the fact that humans are clearly contributing to its danger because of its various activities that endanger human life and its effects on other living things, which alter the environment's natural balance and its various living and non-living components **(Bream *et al*., 2019)**.

The study aimed to evaluate the water quality of the Tigris River in the Al-Qayyarah district and observe the effect of monthly changes on its water quality characteristics.

MATERIALS AND METHODS

Study area

The current study was carried out at South of Qayyarah district, South Mosul City, on the western side of the Tigris River within the coordinates 35°47'06.79" N, 43°17'22.82" E, following the higher Zab tributary's confluence with the Tigris River at a distance of 13km from the present study site; the conductor is located 60km from Mosul's City center (Fig. 1).

Fig. 1. The studying location

Throughout the study period, water samples were taken every month from October 2023 to March 2024. Laboratory analyses were conducted according to various references depending on the type of test.

Table 1. Methods of analysis

No.	Examination	Unit	Name of the device or tools	Reference
1	Temperature	Celsius	Mercury thermometer	-
2	Electrical conductivity	µS/cm	Electrical conductivity meter	**APHA,2017**
3	Total dissolved solids	mg/L	Multi meter	**APHA,2017**
4	pH	-	(pH Meter) Romanian origin	**APHA,2017**

Total alkalinity

Alkalinity values were measured by following the method described in **ASTM (1984)** for estimating the total alkalinity. A volume of 50ml of water sample was taken, and the indicator Methyl orange was added to it, producing a light yellow color. The sample was then titrated with sulfuric acid at a concentration of 0.02 N until the color changed to orange. The result was expressed in mg/L as $CaCO_3$. The total alkalinity concentration was calculated as follows:

$Total\ Alkalinity = (V\ H_2SO_4 \times N\ H_2SO_4 \times 1000 \times Eq.wt\ of\ Ca\ CO_3) / (V\ Sample).$

Chloride

Chloride was measured in accordance with the procedures outlined in **ASTM (1984)** by taking 50ml of the water sample and placing it in a glass beaker (a capacity 250ml), then adding 1ml of dichromate potassium (K_2CrO_4) reagent solution and mixing well. Then, it was pulverized with a solution of silver nitrate $AgNO_3$ with a concentration of 0.025 N until it changed to an indistinct flesh-red color. The results were expressed in mg/ L, and the chloride ion concentration was calculated as follows:

$Cl^- = (V\ AgNO_3) \times N\ AgNO_3 \times 1000 \times Atomic\ Wt.\ of\ Cl\ / (V\ sample).$

Dissolved oxygen (DO)

Dissolved oxygen was measured using the Winkler method described according to **Mackerath (1963)**. Transparent glass bottles with a capacity of 250ml were filled with water samples, ensuring there were no air bubbles. After 2 to 3 minutes, 2ml of manganese sulfate (MnSO4·H2O) was added, followed by 2ml of basic potassium iodide (KOH + KI). The sample was shaken, and then 2ml of concentrated sulfuric acid (H2SO4) was added. The samples were transported to the laboratory, where 100ml was taken from each and titrated with 0.025N standard sodium thiosulfate (Na2S2O3). The results were expressed in mg/L.

Chemical oxygen demand (COD)

The process of measuring COD in water was carried out using the American-made Wagtech COD testing device in the laboratories of the Ministry of Science and Technology in Baghdad, Al-Jadriya. COD measurements were taken every two months for all study sites. Each sample was placed in a special tube and shaken vigorously to suspend all sediments. The cover of the COD device was then removed, and 2ml of the sample was added using the device's pipette tip (one-time use). The cover was replaced tightly, and the tubes were gently turned to ensure the contents were mixed. During mixing, the tubes became hot due to the heater within the COD device. After ensuring all sediments were suspended, the tubes were marked with marking paper and placed in their special slots, ensuring they were centered. After digesting the tubes for two hours, the device was turned off, and the tubes were left to cool at room temperature. The wavelength of 490 nanometers was selected, and the readings for each sample were recorded in mg/ L **(APHA, 2017)**.

Nitrite

Nitrite was measured according to the method of **Strickland and Parsons (1972)**. It was determined by using the spectrophotometer model (CE 1011 CECIL) at wavelength of 543nm, and results were expressed by µg/ L.

Reactive phosphorus

Ascorbic acid reduction method was used for the determination of reactive phosphorus **(APHA, 2017)**. The reactive phosphorus was determined by using the spectrophotometer model (CE 1011 CECIL) at a wavelength of 880nm, and results were expressed by mg/ L.

Reactive silicate

The molybdosilicate method was used for the determination of reactive silica. Reactive silica was determined by using the spectrophotometer model (CE 1011 CECIL) at wavelength of 410nm **(APHA, 2017)**, and the results were expressed by mg/ L.

Heavy metals (Zinc, lead, and cadmium)

Using an atomic absorption spectrometer SHIMADZU AA-6200, heavy metals were measured in the Chemical Engineering Department's Automated Analysis Laboratory by gathering 500 milliliter plastic bottle water samples from each of the six locations over a six-month period after the bottles were cleaned with the same water sample. Three metals were tested for zinc (Zn), lead (Pb), and cadmium (Cd).

Total plate count (TPC)

The method of pouring culture medium into Petri dishes containing 1ml of studying samples was used after conducting a series of decimal dilutions, where dilutions 10^{-1}, 10^{-3}, and 10^{-5} were used at a rate 3 duplicate for each dilution, then Petri dishes were incubated at $37^{O}C$, for 24- 48 hours, a colony counter was used to count the growing colonies, the results were multiplied by inverted of the dilution, the results were expressed in units of cell/ ml.

RESULTS AND DISCUSSION

The results of the current study showed that the air temperature (Fig. 2) during the study period ranged between 13 & 34 degrees Celsius, while the water temperature ranged between 9 and 24^{o}C. The variation in temperature results from the difference in season and time of measurement **(McCarron, 2023; Rasheed *et al*., 2024)**. It is observed that all water temperatures recorded for all months are less than 35^{o}C, which complies with **WHO (2011)** drinking water standards. Additionally, it was observed that the air temperature has a one-month effect on the water temperature. The statistical analysis, as determined by the Pearson analysis, revealed a positive significant correlation (r=0.780) between the air and water temperatures at a significance level of $P \leq 0.001$ (Table 3). The results of the current study showed that the electrical conductivity of water ranged between 293- 395µS/ cm, as shown in Fig. (2). Moreover, when comparing the conductivity rate, it was 368µS/ cm, consistent with the study of **Abdulqader (2018)** conducted on the water quality at Tikrit University. Since the rate was recorded at 495µS/ cm, it was classified as low, and the reason for its relative decrease may be due to the distance of the study site from densely populated cities and the lack of water pollution in sewage outfalls, in addition to the leakage of chemicals from industrial sources. Changes in water temperature and algae density also increase. This forms a negative effect on the electrical conductivity of water **(Richardden, 2023)**.

According to the current study's results, total dissolved solids had a rate of 174.7mg/ liter for all months, with October recording the lowest value (147.5mg/ L), while the highest value was 197mg/ L for the same month (Fig. 1). The Great Zab River, which empties into the Tigris River north of our study area between the Qayyarah district and the Shura district, may have had an impact on the Tigris River's characteristics, contributing to the moderate percentages of total dissolved salts observed. Additionally, the study site does not experience any household waste flow into the Tigris River, and the amount of rainfall, water flow speed, and land type all affect the total dissolved salt value **(Shihab *et al*., 2022)**. As we move South, the Tigris River's salinity may rise, contributing to an increase in the amount of household and industrial waste as well as the consequences of disposing the agricultural waste (agricultural wastewater) into the river **(Abdel Karim, 2021)**. It has been shown that dissolved solids and electrical conductivity typically have a direct relationship. This relationship is also directly related to salinity, as indicated in Table (3). Statistical analyses using the Pearson correlation coefficient at significant levels of $P \leq 0.001$ and $P \leq 0.01$ confirmed this, with the values obtained being r=0.932 and r=0.534, respectively.

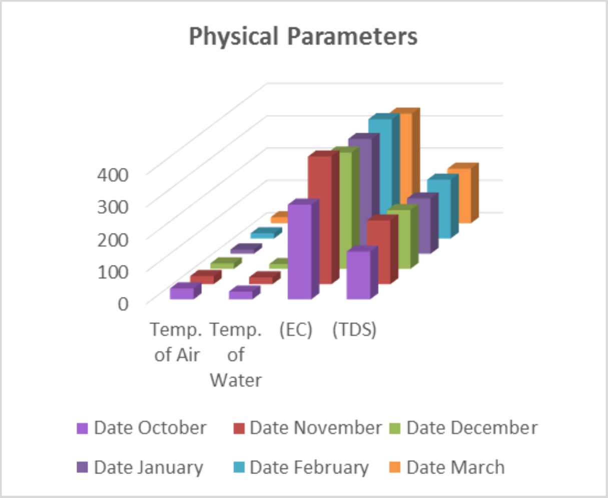

Fig. 2. Monthly changes of the physical parameters studied during the study period

Regarding the chemical characteristics, Fig. (3) demonstrates that the pH of the Tigris River water in the current study ranged from 7.13– 8.42, with the lowest value occurring in January (7.13) and the highest value occurring in October (8.42) (Fig. 1). The presence of bicarbonate ions in the Tigris River water may be the cause of the pH's stability within this narrow range of slightly basicity **(Al-Lahibi, 2021)**. The pH values are in line with the international guidelines **(WHO, 2011)**, which called for pH levels in the range of 6.5 to 8.5. Total alkalinity of the Tigris River water over the study period ranged from 96– 130mg/ L as $CaCO_3$, with November having the lowest value (96mg/ L) and March having the highest value (128mg/ L) (Fig. 3), that gas, CO2, which dissolves in water and produces carbonic acid—which results in total basicity and transient hardness, or calcium and magnesium bicarbonate—is free from alkaline sources in water bodies and is produced by microorganisms breaking down the organic matter in the presence of oxygen **(Ibrahim, 2022)**.

$$CO2+H_2O \rightarrow H_2CO_3$$

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

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

According to **AL-Saffawi and Sardar (2018)**, the consumption of carbon dioxide gas by plants and algae during photosynthesis may be the cause of this relative decrease in the values of total basal concentrations. The results of statistical analysis using the Pearson correlation coefficient confirmed the existence of significant correlations (direct or indirect), as indicated in Table (3). There is an inverse correlation between alkalinity and the majority of the parameters studied, including lead (Pb), with an association value of r=–0.499 at a significant level of $P\leq$ 0.01. The study's results assessed that the Tigris River's water had chloride levels ranging from 19.492 to 24.808mg/ L (Fig. 3). The month of February (19.492mg/ L) had the lowest value, while the month of March (24.808mg/ L) had the highest value.

The entry of sewage, industrial, and wastewater water into rivers may be the cause of the presence of chloride in the river water. Additionally, sedimentary rocks, one of the origins of chloride, play a significant part in the ion's presence. Moreover, chloride ions exhibit extremely high solubility and remain in a permanently dissolved ionic state under natural conditions, participating in precipitation reactions **(Bream *et al.*, 2019)**. The results showed that the Tigris River's dissolved oxygen levels varied from 7.2 to 10.4mg/ L. The greatest level was measured in February at 10.4mg/ L, while the lowest value was recorded in October at 7.2mg/ L, as seen in Fig. (3). The low concentration of organic matter in the water, which microorganisms feed on and use as a source of dissolved oxygen, and the effective aeration processes in the river may be the cause of the high dissolved oxygen values. A number of variables, including temperature, the concentration of dissolved salts, molecular pressure, and the existence of species, influence the amount of dissolved oxygen in the water. The concentration of organic and inorganic particles is influenced by a variety of factors, including waste, flow speed, temperature (lower temperatures increase gas solubility), and microorganisms **(Lateef *et al.*, 2020)**. While the monthly variation in dissolved oxygen values was evident during the current study, its relationship to temperature was not established, despite scientific facts supporting the relationship between dissolved oxygen values and water temperature, which served as the foundation for the interpretation of several researchers' findings, including **Al-Zubaidi (2020)**. For instance, it is evident that during the first three months of the study (in the year 2023), oxygen levels in the river did not surpass 10.2mg/ L, however, in February of 2024, it increased to 10.4mg/ L, but in January of the same year, its value was 8.2mg/ L. In the year 2024, even though the Tigris River's water temperature in February was 13^{o}C, higher than it was in January, there are a number of natural and human-caused factors that could account for the oxygen values' lack of consistency across successive months. These include variations in water levels throughout the year, variations in the quantity and quality of waste that reaches the riverbed, and biological activity, which is directly impacted by all of the aforementioned factors. According to **Al-Safawi and Al-Assaf (2019)**, high temperatures cause bacteria that break down organic matter to become more active, which lowers the amount of dissolved oxygen in the water. There is a strong inverse significant association between dissolved oxygen and water temperature, as indicated by statistical analysis results based on the Pearson correlation coefficient, its value was $r=-0.555$ at a significant level of $P\leq 0.01$ (Table 3). According to the results of the current study, the chemical oxygen demand (COD) of the Tigris River water ranged from 0.96 to 1.53mg/ L, indicating a good water quality, adequate water flow, and the absence of pollutants at levels that would lower the water's dissolved oxygen content. According to **Issakhov *et al.* (2023)**, these outcomes are also ascribed to the decrease in pollution caused by native bacteria and other biological elements that enhance the water. Fig. (3) shows that the Tigris River's nitrite concentrations varied from 0.142 to 0.54µg/ L, December had the greatest value (0.54µg/ L), while October had the lowest (0.142µg/ L). Throughout the study period, all of the Tigris River's nitrite values were rather close to those recorded in December, when there was an increase in nitrite values. Rainfall or over-irrigation following agricultural land fertilization, where nitrogen-rich soil washes into the rivers, could be the cause of the relative increase in nitrite, as evidenced from Table (3), which shows that a (strong) direct correlation relationship between nitrite and phosphate PO_4 was found by statistical analysis using the Pearson correlation coefficient; the association's value was found to be r = 0.710 at a significant level of $P \leq 0.01$, and the direct correlation that exists between phosphate and nitrite in water is frequently the outcome of fertilizers rich in phosphate and nitrogen are frequently used in agriculture to increase crop growth and mitigate pollution caused by human activities like agriculture. Large-scale usage of these fertilizers may cause them to seep into rivers through surface runoff, increasing the water's nitrite and phosphate content **(Al-Hayali *et al.*, 2021)**. The Tigris River water sample had effective phosphate concentrations ranging from 0.0027 to 0.067µg/ L (Fig. 3), 0.067µg/ L was the highest number recorded in January, and 0.0027µg/ L was the lowest. According to **Al-Rawi's (2020)** research, dilution and diffusion effects in the water are the cause of the drop in phosphate values, the amount of rain and fluctuations in water levels brought about by recent climate change are also contributing factors to the decline in effective phosphate values in water, the main source of phosphate is phosphorus, which often increases when using detergents and their derivatives, given the limited use of these detergents and their dissolution with the rest of the excreta in this water, which is reflected in the concentration of phosphate **(Khudair, 2013)**. The other reason for the decrease in phosphate values is the lack of excretion of animal waste from agricultural lands as well as chemical fertilizers that are used to fertilize citrus fruits and agricultural lands. The Tigris River Station had silica concentrations ranging from 1.416- 2.145µg/ L. November had the greatest value (2.145µg/ L), while March had the lowest value (1.416µg/ L), the absence of rain during the research period and the resulting torrents, which dissolve and transport silicon elements in the soil, could be the explanation of this decrease in silica content. Studies on river water show that the growth of aquatic organisms, particularly diatoms, frequently affects low silica levels because they consume it for body building. Dissolved silica is crucial for *bacillus* algae since it is part of the composition of their silica wall **(Mahmoud *et al.*, 2018)**, as shown in Fig. (3).

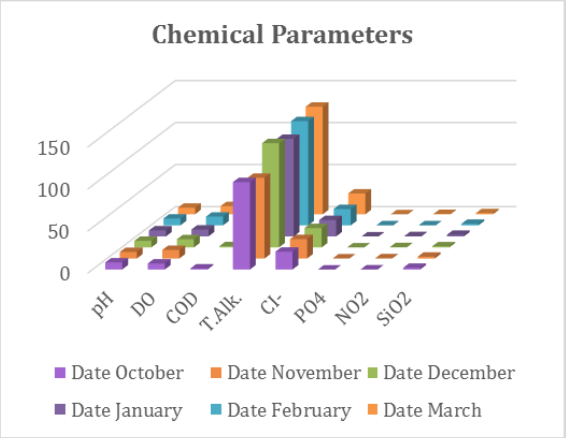

Fig. 3. Monthly changes of chemical parameters studied during the study period

For heavy metals, the results varied, for example, lead concentrations ranged from the lowest in February (0.095mg/ L) to the greatest in October (0.887mg/ L) according to the results of the current study (Fig. 4). These results are lower than the results of **Al-Yazji and Mahmoud (2008)**, which ranged from 4.9 to 14.3mg/ L. The variation in lead levels in the water can be attributed to several factors. Apart from the fluctuations in river levels, during summertime, evaporation tends to concentrate pollutants entering the river from estuaries on both sides. Rainy days also cause a noticeable increase in the amount of pollutants in the water because surface water runoff carries pollutants from roads, soil, and untreated sewage into the river. These concentrations are also influenced by the deposition of air pollutants, industrial, and agricultural processes. The results show that all values surpassed the lead content requirements set by the **Iraqi standards (2009)**, and the World Health Organization **(WHO, 2011)**, rendering the water unsafe to drink due to the elevated lead concentration. Examining Table (3), we see that the statistical analysis's results, as determined by the Pearson correlation coefficient, revealed a straightforward positive significant connection (r = 0.066) between lead and pH, if we looked at the study's results on cadmium, we would discover that the average concentration rate in the Tigris River was 0.0513mg/ L. Additionally, cadmium can be deposited in sediments, but it can also remain in the water for a long time in the form of dissolved ions, which enables it to travel with the water current over large distances without rapidly precipitating. Similarly, cadmium has the ability to connect with both organic and inorganic substances in water, increasing its solubility and decreasing the likelihood that it will precipitate. Additionally, river currents and the constant flow of water facilitate the long-distance transportation of cadmium from the pollution source **(Ali *et al.*, 2023; Sustainability, 2023)**. These findings surpass those of the Tigris River study conducted by **Al-Hamdani (2019)** in the city of Mosul, where the concentration of cadmium varied between 0.03mg/ L and 0.009mg/ L, respectively. The World Health Organization **(WHO, 2011)** found that the amount of cadmium in drinking water is 0.003. When comparing these results with the permissible limits, all concentrations exceed the allowable thresholds, particularly the cadmium levels, making this water unsafe for human consumption. The results show that the average concentration of zinc in Tigris River water was 0.134mg/ L, with the maximum zinc concentration occurring in the month of November at 0.177mg/ L, and the lowest in the month of February at 0.053mg/ L. As per international and Iraqi standards **(WHO, 2011)**, the content of zinc in the Tigris River water was found to be within the allowable limits of less than 3mg/ L for drinking water. The results also revealed that, in comparison to the other months, zinc concentrations were relatively lower in February and March (the rainy season). This could be explained by the fact that precipitation, which is nearly devoid of heavy metals, contributes to the February and March models' lower zinc contents (Fig. 4).

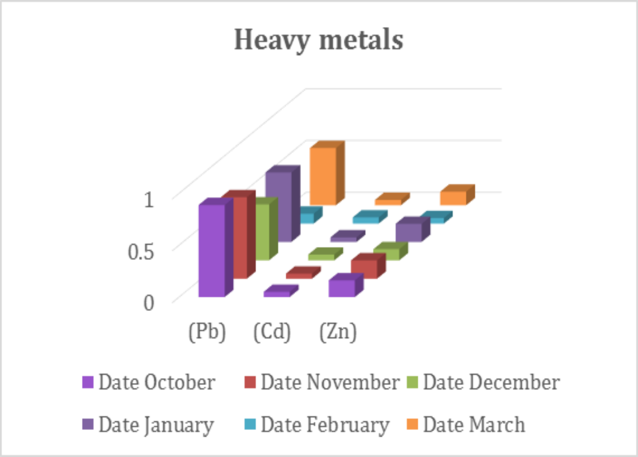

Fig. 4. Monthly changes of heavy metalss studied during the study period

As can be seen from Fig. (5), the total plate count (TPC) in the Tigris River recorded its highest value in February, totaling 14.6×10^2 cell/ ml, while the lowest value recorded during October was 3.6×10^2 cell/ ml.

Bacteria are part of the living components of the ecosystem and are found naturally in natural water. The kind and quantity of bacteria in the water change depending on pollution levels, according to the data reported in the study of **Allen *et al.* (2018)**. They proliferate in response to both temperature increases and the presence of nutrients.

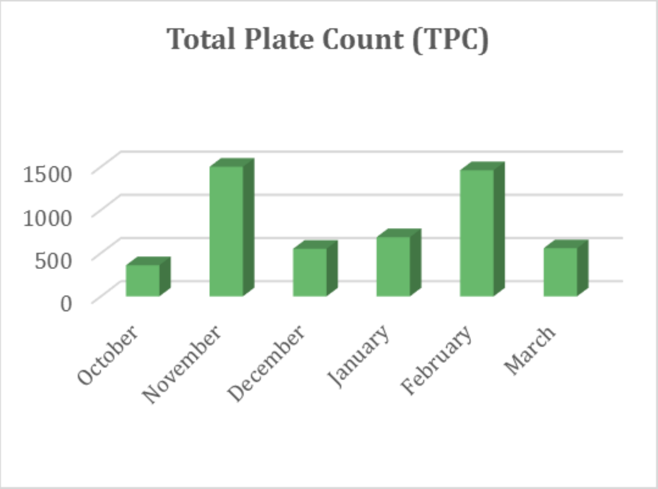

Fig. 5. Monthly changes in the total count of bacteria studied during the study period

The data show that, in comparison to other months, the number of bacteria rose in the months of February and March, when compared to the winter months. There was a discernible rise in the overall number of bacteria throughout the spring and the months of floods and heavy flows. In addition to the impact of high temperatures on the activity and efficacy of bacteria. The water in this body serves as an ideal medium for microbial growth. Winter rainfall increases the water levels, causing a significant erosion of clay materials that elevate turbidity in the river. This turbidity, coupled with the optimal temperatures for microbial development and the increased nutrient influx from salts and other organic and inorganic components, fosters the proliferation of biomass in the water. This situation may be exacerbated by excrement in the Tigris River, dredging activities that wash soil into the river, and the location of the station near the end of Qayyarah City, where pollution levels are higher **(Al-Hamdani, 2021; Mahmood *et al.*, 2021)**. Table (2) shows the results of the statistical analysis.

Table 2. The results of the analyses

Descriptive statistics					
Specified	**Minimum**	**Maximum**	**Mean**		**Std. deviation**
	Statistic	**Statistic**	**Statistic**	**Std. error**	**Statistic**
Air temperature	13.00	34.00	20.6667	3.12694	7.65942
Water temperature	9.00	24.00	16.0000	2.25093	5.51362
pH	7.13	8.42	7.8692	.17630	.43184
Electrical conductivity	293.00	395.00	351.8333	13.97716	34.23692
Total dissolved solids	147.50	197.00	174.7500	6.80655	16.67258
Chloride	19.49	24.81	21.8547	.87610	2.14600
Total alkalinity	96.00	128.00	115.3333	5.20683	12.75408
Dissolved oxygen	7.20	10.40	9.2667	.52068	1.27541
Chemical oxygen Demand	.96	1.53	1.2300	.16523	.28618
Reactive phosphate	.00	.07	.0453	.01030	.02522
Nitrite	.14	.35	.2562	.03815	.09344
Silica ion	1.40	2.15	1.8058	.13039	.31938
Lead	.10	.89	.5878	.11281	.27632
Cadmium	.04	.06	.0513	.00211	.00516
Zinc	.05	.18	.1338	.01963	.04809
TPC	3.60	15.00	8.5200	2.03121	4.97544

Table 3. Correlation coefficient between study site water variables

Pearson's correlations

Variable		Air T.	WT	pH	EC	TDS	Cl	Total alkalinity	Dissolved oxygen	C.O.D.	PO4 2	NO2	SiO2	Pb	Cd	Zn	T.P.C.
1. A. T	Pearson's r	—															
	P-value	—															
2. WT	Pearson's r	0.780***	—														
	p-value	< .001	—														
3. pH	Pearson's r	0.474**	-0.030	—													
	p-value	0.008	0.875	—													
4. EC	Pearson's r	0.292	0.375*	0.007	—												
	p-value	0.117	0.041	0.970	—												
5. TDS	Pearson's r	0.211	0.380*	-0.048	0.932***	—											
	p-value	0.264	0.039	0.802	< .001	—											
6.Cl	Pearson's r	0.170	0.279	-0.083	0.079	0.093	0.173	—									
	p-value	0.3	0.1	0.6	0.6	0.6	0.3	—									

Pearson's correlations

Variable		Air T.	WT	pH	EC	TDS	Cl	Total alkalinity	Dissolved oxygen	C.O.D.	PO4 2	NO2	SiO2	Pb	Cd	Zn	T.P.C.	
		69	35	62	80	25	61											
7. T.A	Pearson's r	-0.195	-0.233	0.344	-0.143	-0.141	-0.329	-0.240	—									
	p-value	0.301	0.215	0.063	0.452	0.456	0.076	0.201	—									
8. D. O	Pearson's r	-0.196	-0.555 **	0.483 **	-0.218	-0.195	-0.489 **	-0.326	0.329	—								
	p-value	0.299	0.001	0.007	0.248	0.301	0.006	0.079	0.076	—								
9. C.O.D.	Pearson's r	0.022	0.511 **	-0.592 ***	0.216	0.252	0.405 *	0.338	-0.195	-0.862 ***	—							
	p-value	0.910	0.004	< .001	0.251	0.179	0.026	0.068	0.301	< .001	—							
10. PO4 ^{2}	Pearson's r	-0.464 **	0.074	-0.717 ***	0.038	0.085	0.223	0.088	-0.089	-0.602 ***	0.670 ***	0.628 ***	0.674 ***	0.555 **	0.683 ***	—		
	p-value	0.010	0.699	< .001	0.844	0.654	0.235	0.642	0.639	< .001	< .001	< .001	< .001	0.001	< .001	—		
11. NO_2	Pearson's r	-0.363 *	-0.099	-0.432 *	-0.082	0.005	0.077	0.200	-0.299	-0.400 *	0.407 *	0.331	0.367 *	0.346	0.440 *	0.710 ***	—	
	p-value	0.049	0.604	0.017	0.667	0.979	0.686	0.288	0.108	0.029	0.026	0.074	0.046	0.061	0.015	< .001	—	
12. SiO_2	Pearson	-	0.1	- **	0.1	0.1	0.3	-	-	- **	0.5 **	0.5 **	0.5 **	0.4 *	0.7 **	0.7 **	0.6 **	—

Pearson's correlations

Variable		Air T.	WT	pH	EC	TDS	Cl	Total alkalinity	Dissolved oxygen	C.O.D.	PO_4 2	NO_2	SiO_2	Pb	Cd	Zn	T.P.C.					
	's r	0.175	87	0.520	14	42	49	0.006	0.306	0.601 *	88 *	55	71 *	86 *	85 *	95 *	93 *					
	p-value	0.355	0.322	0.003	0.548	0.454	0.059	0.974	0.100	< .001	< .001	0.001	< .001	0.006	< .001	< .001	< .001	—				
13. Pb	Pearson's r	0.538 **	0.354	0.066	0.058	-0.038	0.260	0.220	-0.499 **	-0.219	-0.043	0.107	0.030	-0.010	-0.045	-0.337	-0.263	-0.226	—			
	p-value	0.002	0.055	0.730	0.762	0.841	0.165	0.242	0.005	0.244	0.822	0.574	0.874	0.957	0.815	0.069	0.160	0.229	—			
14. Cd	Pearson's r	0.151	0.060	0.214	0.153	0.197	0.218	0.130	-0.018	-0.004	-0.118	-0.007	-0.029	0.007	-0.030	-0.150	-0.093	-0.103	0.140	—		
	p-value	0.425	0.751	0.256	0.419	0.296	0.248	0.494	0.924	0.983	0.534	0.973	0.881	0.970	0.874	0.428	0.626	0.587	0.460	—		
15. Zn	Pearson's r	0.187	-0.064	0.095	-0.233	-0.326	-0.101	0.055	-0.300	0.263	-0.443 *	-0.223	-0.356	-0.234	-0.257	-0.367 *	-0.214	-0.210	0.577 ***	-0.325	—	
	p-value	0.321	0.738	0.619	0.215	0.079	0.595	0.773	0.108	0.160	0.014	0.236	0.053	0.214	0.171	0.046	0.256	0.264	< .001	0.080	—	
16. T.P.C.	Pearson's r	-0.282	0.013	-0.273	-0.011	0.057	-0.104	-0.150	0.172	-0.193	0.236	0.220	0.211	0.120	0.541 **	0.599 ***	0.470 **	0.609 ***	-0.570 **	-0.161	-0.240	—
	p-value	0.131	0.945	0.144	0.954	0.766	0.584	0.429	0.365	0.307	0.209	0.242	0.263	0.526	0.002	< .001	0.009	< .001	0.001	0.396	0.202	—

* *P*< .05, ** *P*< .01, *** *P*< .001.

CONCLUSION

When compared to worldwide drinking water standards, the current study's results demonstrated that the Tigris River's water at the study site had different qualities. Additionally, it was discovered that certain characteristics, such heavy metals concentration, exceeded internationally acceptable limits. This indicates that sewage sewers in the Qayyarah area and neighboring villages are affecting the specifications of the river water. Lead, cadmium, and the total plate count of bacteria (TPC) are particularly noteworthy in this regard.

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