



Study some physical, chemical and biological parameters of the waters of the Tigris river after its confluence with the Great Zab River- Nineveh - Iraq

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Abstract

The current study was conducted to evaluate the Tigris River water and to ensure its suitability for drinking and irrigation. The physical, chemical, and biological properties of the waters of the Tigris River after its confluence with the Great Zab River were studied. The studied samples were collected for a period of seven months, monthly from July 2022 to January 2023. for the purpose of study some parameters as Temperature, electrical conductivity EC, total dissolved solids (TDS), turbidity, pH, dissolved oxygen (DO), biological oxygen demand (BOD₅), total alkalinity, total hardness (TH), Calcium, Magnesium, Chloride, Sulfate, Phosphate, Nitrate, Silica, Sodium, Potassium, and Heavy Metal measured, the total number of bacteria (TPC), the total number of coliform bacteria, and the number of plankton. The results of the study showed that many samples conformed to the Iraqi and international specifications for drinking water, except for turbidity, which exceeded the allowable limit in most samples, which is less than 5 Nephelometric Turbidity Unit (NTU), was (9.03-24.84) NTU, as well as the number of bacteria, is high and appeared in all samples throughout the study period (4000-120000) cell/ml. And total Coliform (30-1300) cell/ml, Plankton (101154-650278) cell/l, as for the dissolved oxygen, it was 4.4 mg/L in the month of August. The biological oxygen demand was 0.4 mg/L in October and the highest value was 4.4 mg/L in November. And nitrates were in low concentrations ranging between (8 - 39) mg/L. Heavy metals were in very low concentrations. Al-Kalinity was (108-284) mg/l, Phosphates was (0.124-0.469)mg/l, Sulphates was (20.29-95.71) mg/l, Silica (0.182-.195) mg/l, Na (67-131) mg/l, K (2.3-6.2), and Heavy metals were in very low concentrations.

Keywords: Tigris - greater zab - water quality - wanderers

Introduction

One of the most important problems in the world today is water pollution, especially the water of rivers and lakes within countries (Nashat *et al*, 2017) ^[24]. The world's interest in the quality of drinking water increased, especially after the middle of the twentieth century, When man began to set health standards for the specifications of drinking water that are suitable for consumption that preserves human health and protects it from diseases, many diseases and epidemics have been associated with of contaminated drinking water and spread. many organizations Issue standards through a specialized organization, for example, the World Health Organization (WHO) (Al-Shablawi and Jasim, 2018)^[13]. It has been proven that half of the world's rivers suffer from severe pollution and a low level of water quality, and water pollution is the occurrence of damage or spoilage of water due to the desecration of water courses, which leads to a defect in its environmental systems in one way or another, which reduces its ability to perform its natural role and even become harmful Sometimes when used (Al-Samarrai, 2007)^[11]. What distinguishes environmental systems is the balance between their various elements such as water, air and soil, and they can adapt and adapt to the changes that occur within certain limits.

Humankind has created a major imbalance in this balance, and for this reason the environment and its preservation are considered among the main tasks facing governments in general, and in Iraq this importance acquires a special exception due to the conditions that the country went through from successive wars for decades that resulted in severe deterioration in the elements of the environment such as water, air and soil (Environmental Survey in Iraq for the year 2010) ^[16].

Aim of the study

1. Evaluating the quality of a river water after meeting the Great Zab.
2. Note the monthly changes on the characteristics of the Tigris River.

Materials and Methods

The current study was conducted on the left bank of the Tigris River in the Sultan Abdulla village Which follows Al- Qayyarah district, south of Mosul, at a distance of (54) km from the center of the city of Mosul, after the confluence of the upper Zab tributary with the Tigris River, at a distance of (13) km (Fig. 1).

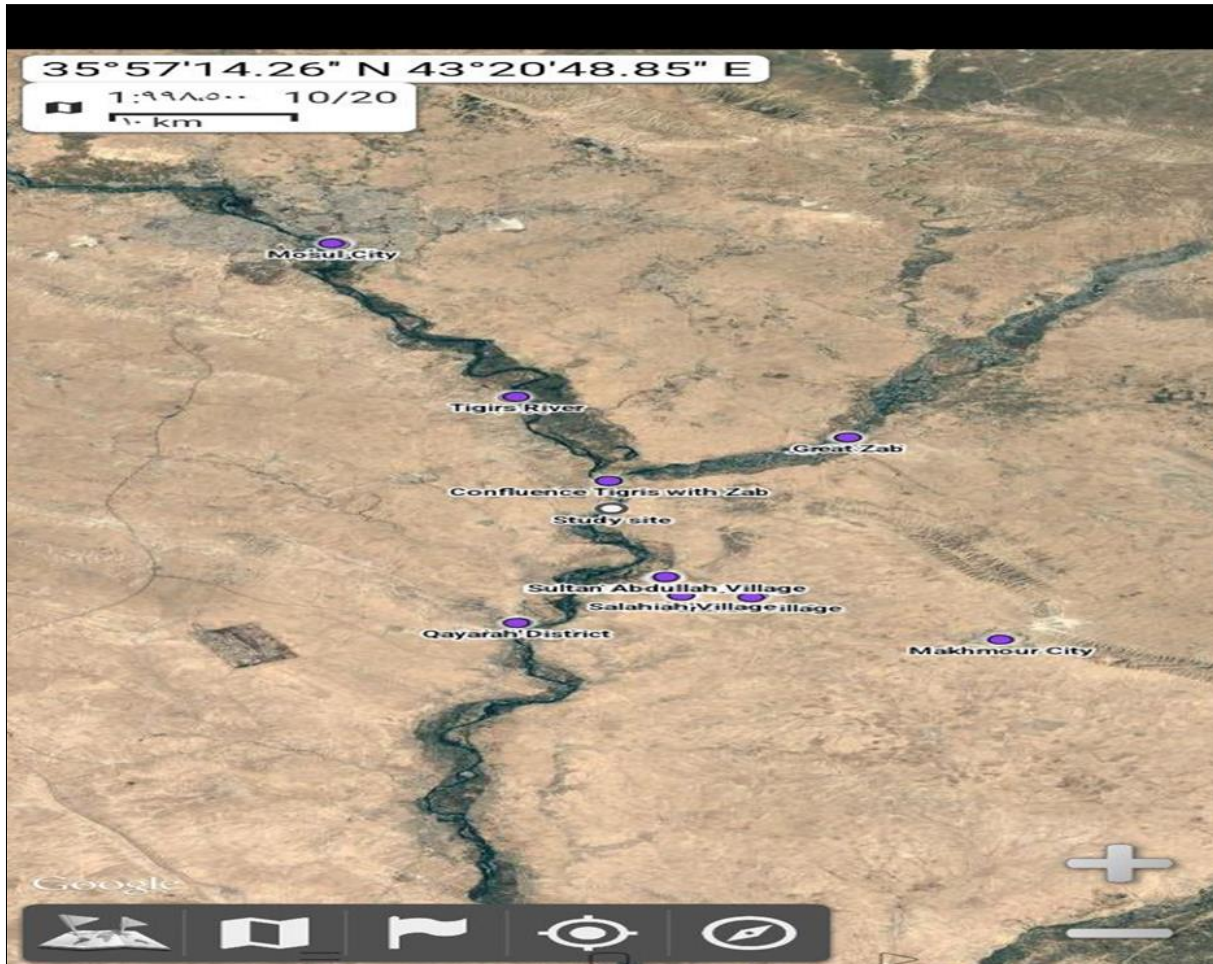


Fig 1: shows the location of the study on a map

Water samples were collected monthly, starting from July until January of the year 2022 AD during the seven month study period. Samples were collected in several different models of bottles, by filling bottles made of polyethylene with a capacity of 2 liters for physical and chemical examinations, after washing them with water from which the sample was taken. And sterile, closed bottles for examining bacteria, and glass bottles of 250 ml for examining dissolved oxygen and BOD₅, and bottles of 1 liter for plankton, and adding Logule's Iodine solution to preserve and stabilize plankton.

The tests were conducted according to what was mentioned in the book (APHA, 1999) [15] and (Abbawi *et al*, 1990) [1]. The tests are temperature measurement with a mercury thermometer, electrical conductivity, total dissolved solids with a YL-TDS2-A Conductivity-TDS-EC-meter, turbidity with a turbidity meter LP2000, (HANNA) Hungarian. pH with a field pH meter Gallenamp Stick P103645, and total alkalinity by wiping the sample against standard sulfuric acid. (0.02N) after adding methyl orange dye until the color turns from yellowish orange to reddish. And total hardness and Calcium by titration against Na₂EDTA solution after adding the hardness regulator solution and Erichrome black T. dye in total hardness and Murexide dye in calcium hardness, and subtracting the second from the first to extract Magnesium. and Chloride by titration against Silver Nitrate after adding Potassium chromate. And dissolved oxygen by the modified Winkler method by adding Winkler solutions A and B, concentrated Sulfuric acid, titration against Sodium thiosulfate, and the BOD₅ by incubating the

samples for five days, and after taking them out from the incubator we follow the same steps of the modified Winkler method.

And Sulphates by a cloudy method by adding HCl and Barium Chloride and reading with a spectrophotometer at a wavelength of 420 nm. Phosphate by stannous chloride method by adding drops of strong acid, ammonium molybdate, and drops of tin Chloride and reading by spectrophotometer at 690 nm wavelength. And Nitrates were measured by ultraviolet light after adding 1 gauge HCl and reading by spectrophotometer at wavelengths 220 and 275 nm. Phosphate concentrations were measured using the stannous chloride method by taking a known volume from the water sample and adding drops of phenolphthalein to it. If the pink color appears, drops of strong acid are added until the pink color disappears then an amount of ammonium molybdate (50 ml of the sample is 4 ml) is added of ammonium molybdate) and 10 drops of tinrose chloride with shaking and stirring, then after 10-12 minutes the absorbance was read at the wavelength of 690 nm using a spectrophotometer. And Silica was measured using the molybdosilicate method and reading by 410 nm. Sodium and potassium were measured using the flame photometric method. Heavy metals were measured by an atomic spectrometer. And the bacterial assays using the method of decimal dilutions and cultivation on Nutrient Agar in the total count of bacteria and on MacConkey Agar in the total count of coliform bacteria and incubation for 24-48 hours at a temperature of 37 C. he Phytoplankton.

The total number of phytoplankton in water samples was counted by filtering (100) ml of the sample by a Millipore filtration unit using millipore filter paper with a pore accuracy of 0.45 micrometer, then the paper is lifted and left at a temperature Room temperature to dry, then placed on a slide microscope slide and a drop or two of lens oil (Immersion Oil) is placed on top of it, then covered with a slide cover, then using an Olympus optical co,LTD compound light microscope model CH3ORF200 and under the objective lens with magnification power (40). ×, the phytoplankton cells present in (30) randomly selected microscopic fields were counted, and then the total number was calculated in units (cells / liter) through the following equation:

Total number of phytoplankton cells/L = (filtration paper area x microscopic field (30) in total cells) / (sample volume in milliliters x microscopic field (30) area) x 1000

Nineteen factors were used to estimate the index, which are as follows: temperature, electrical conductivity, total dissolved salts, turbidity, and other chemical factors such as pH, dissolved oxygen, biological oxygen requirement, total hardness, calcium, magnesium, sulfate, nitrate, phosphate, basic chloride, sodium, potassium, and other biological factors such as total bacteria count and total coliform bacteria. As the data on water quality were collected and arranged according to locations and months, while the values of the water quality index were calculated according to the following:

1. Scope F1

It is the number of variables exceeding the standard criteria (even once during the study period) divided by the total number of variables studied (Lumb *et al*, 2006).

$$F_1 = \frac{\text{Number of Failed Variables}}{\text{Total Number of Variables}} \times 100$$

2. Estimate the value of frequency (F2).

It is the number of examinations that exceeded the standard criteria during the study period divided by the number of total examinations measured (Lumb *et al*, 2006) [21].

$$F_2 = \frac{\text{Number of Failed Tests}}{\text{Total Number of Tests}} \times 100$$

3. Estimate the value of the amplitude (F3).

The number of failed examinations that exceeded the standard criteria, calculated by three steps: (Lumb *et al*, 2006).

Excursion Estimation: It is the number of times the test value is higher than the standard criteria value, and it is calculated from the following equation:

$$\text{Excursion } i = \left\{ \frac{\text{Failed Test Value } i}{\text{Objective}} \right\} - 1$$

Calculating the group of standard deviations (nse) Normal Sum of Excursion: It is the sum of the deviations divided by the sum of the total examinations, and it is calculated from

$$\text{the following equation: } nse = \frac{\sum_{j=1}^n \text{excursion}}{\text{total number of tests}}$$

Then the capacitance F3 is calculated from the following equation: $F_3 = \frac{nse}{0.01 nse + 0.01}$ After finding these factors, the water quality index (CWQI) is calculated from the following equation:

$$CWQI = 100 - \left[\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right]$$

Table 1: The condition of the water sample is expressed by linking the value of the index to a number scale

Degree	Water quality guide	Appreciation	The description
1	Excellent	95-100	The water quality is protected, assuming that there are no sources that pollute the water, and that the water condition is very close to clean levels.
2	Good	80-94	The water quality is protected, but it is weak or slightly threatened, and the water condition rarely deviates from the required or desirable level.
3	Moderate	60-79	Water quality is often protected, but it is weak or threatened from time to time, and the water condition often deviates from the required or desirable level.
4	questionable	45-59	The water quality is often weak or threatened, and the water condition often deviates from the required or desirable level.
5	Bad	0-44	The water quality is always weak or threatened, and the water condition deviates continuously from the required or desirable level.

Results and discussion

The results of the study showed that the air temperature during the study period ranged between 9-30 C, while the water temperature ranged between 11C During the month of January and 24 C during the months of July and September. And the results were in conformity with the Iraqi and world water quality standards, which is less than 35 °C (Iraqi standards for drinking water 2001)[18] The temperature difference is affected by the time and season of the examination. Which is similar to many previous studies, including those (Al-Sarraj *et al*, 2014) [12], where it was 21-23 C in the summer. The electrical conductivity ranged between 384 microsiemens/centimeter (µS/cm) in October and November, which is the lowest value, and the highest

value 470 µS/cm in January. The higher the temperature causes the evaporation process, and the concentration of dissolved salts increases which increases the EC and the results are low due to the distance of the study site from the pollution of cities. These results conform to the quality standards, which are less than 2000 µS/cm (Iraqi standards for drinking water 2001) [18], and the result was close to the study (Saeed, 2009) [26] where it was 331-509 µS/cm from September to May, as well as an approach to the study (Al-Nuaimi, 2017) [8] which is 381-480 µS/cm from January to September. The total dissolved solids ranged between 168 mg/L in November and 203 mg/L in September, and these results conform to the quality standards, which are less than 500 mg/L (Iraqi standards for drinking water 2001)[18]. The

high temperature and increased evaporation had a role in the results, which are less than in previous studies. The result is low, perhaps due to the influence of the Great Zab River which affects the characteristics of the Tigris River, and the distance of the study site from the pollution of big cities. Where the last study was on the Tigris River, south of the city of Mosul (Al-Hamdani, 2022)^[5] which is 327-436 mg / liter from December to April. As for the turbidity it exceeded 5 NTU, which is the upper limit for the turbidity of drinking water according to Iraqi and international standards, as it recorded its lowest value of 9.03 NTU in January and the highest value is 24.84 NTU during a February month. The factors affecting turbidity are the speed of the water current and the influence of the Great Zab River, which is characterized by the speed of its current, gravel and sand quarries, rain and torrents. This value is close to (Al-Samarrai, 2007)^[11] which is 4.8-38 NTU in September, and (Al-Hamdani and Fadel, 2015)^[4] which is 11.5-57 NTU from September to May. The pH values were identical to the standards (Iraqi standards for drinking water 2001)^[18] as they ranged between 7.7 in November and 8.20 in September, noting that the Iraqi standards specified the pH between 6.5-8.5. The stability of the pH function in the waters of the Tigris River due to the bicarbonate ion, and among the influencing factors are the waste excreted into the water that forms acidic compounds. and the results were similar to many previous studies, and the closest is (Al-Hamdani, 2022)^[5], where it was 7.5-8.01 and (Saeed, 2009)^[26] which is 7.8-8.1. Al-Kalinity results were between 104 mg/L in October and 248 mg/L in July below the minimum standards for Iraqi health, except for July, which is 125-200 mg/L (Iraqi standards for drinking water 2001)^[18] Alkalinity sources in water resulting from the presence of carbon dioxide gas, which is mostly liberated from the dissolution of organic matter by microorganisms in the presence of oxygen. When dissolved in water, carbonic acid is produced, which releases total alkalinity causes. and the result is similar to (Abdallhameed and Hassany, 2019)^[2], where it was 125-254 mg/l, as well as (Mahmoud, 2014)^[23] which is 115-165 mg/l. As for the total hardness in one unit, all its values were identical to the Iraqi specifications, which is less than 500 mg / liter, as it ranged between 105 mg / liter during the month of November and between 160 mg / liter in the month of July. Among the reasons for the high hardness are human, agricultural and industrial wastes, the arrival of the soil on the banks of the river, and the drift of pollutants from the nearby lands to the riverbed, also, the high temperature played a role in increasing the hardness, and these results are close to the results of (Al-Samarrai, 2007)^[11] which is 114-180 mg/L, as well as (Al-Luhaibi, 2021)^[6] which is 140-201 mg/L from November to May. Likewise, calcium hardness was between 72 mg/L in January and 110 mg/L in July, and the values were close to the values of (Abdallhameed and Hassany, 2019)^[2], which is 68-134 mg/L from Autumn to Summer, as well as the hardness of magnesium also, it was between 25 mg/L in November and December and 70 mg/L in September, and it is close to (Al-Luhaibi, 2021)^[6], which is 19-87 mg/L. Chloride values were between 14 mg/L in October and 20 mg/L in January, all of which are below the minimum allowable Iraqi limit of 200-600 mg/L (Iraqi standards for drinking water 2001)^[18] The factors affecting its concentration are the arrival of domestic, industrial and agricultural waste water that contains high levels of

chloride, as well as evaporation and the low water level, These results are close to the study of (Goran, 2009)^[17] which was 14.1-20.9 ppm from May to January. And dissolved oxygen, its values fluctuated between 4.4 -11.6 mg/L in August and January due to the inverse relationship between temperature and the solubility of oxygen, noting that the minimum allowable is 5 mg/L (Iraqi standards for drinking water 2001)^[18], as most of the results were identical to the specifications except for the mentioned value, which is 4.4 mg/L. One of the factors affecting dissolved oxygen is the speed of water flow, which increases the mixing and the solubility of oxygen, the activity of microorganisms as the oxygen decreases and the temperature is inversely proportional to the solubility of gases., and these values are close to the study (Al-Hamdani, 2022)^[5], which is 3.9-7.4 mg/L. And the Biological Oxygen Demand (BOD₅), each value conformed to the specifications and was less than 40 mg/L (Iraqi standards for drinking water 2001)^[18], as it ranged between 0.8 mg/L in November and 4.4 mg/L in October. High temperatures increase the activity and effectiveness of microorganisms that decompose organic matter in the water and consume larger amounts of dissolved oxygen in the water. Which is also close to (Al-Hamdani, 2022)^[5] which is 0.1-4.1 mg. /Liter. The Sulfates were between 20.29 mg/L in July and 95.17 mg/L in October, These results matched the Iraqi standards, which are less than 400 mg/L (Iraqi standards for drinking water 2001)^[18] factors affecting sulphate waste from industrial and sewage water and most of it is reduced when the pH is 7 by the action of anaerobic bacteria and the presence of organic matter is reduced to hydrogen sulfide gas, which gives an unacceptable smell to water. The result was close to the study (Al-Yazji and Mahmoud, 2008)^[14], which was 72-80.2 mg/L, also for (Al-Mashhadani and Jassim, 2012)^[7], which was 74-114 mg/l from November to June, and for (Al-Luhaibi, 2021)^[6], which was 24-59 mg/l. And Nitrates were between 8.43 mg/liter in July and 39 mg/liter in December, noting that the Iraqi determinants ranged between 25-250 mg/liter (Iraqi standards for drinking water 2001)^[18] Nitrates increase with the rise in temperature, which microorganisms analyzes the of organic matter and converts them into nitrites and then nitrates, and the results are similar to those (Jumaa and Al-Shawani, 2018)^[19] which is 0.25-13.85 mg/liter from July to February and (Salman, 2019)^[27], reaching 9 mg/L from January to October. And phosphate results were between 0.123 mg/liter in December and 0.469 mg/liter in January, noting that the determinants are 0.4 mg/liter (Iraqi standards for drinking water 2001)^[18], for river water and are imperceptible for drinking water Phosphate decreases due to high temperatures that increase the metabolism of microorganisms that feed on phosphate, which is close to (Al-Obaidi, 2013)^[10] where it was 0.07-0.482 mg/liter, as well as the result of (Al-Mashhadani and Jassim 2012)^[7], which was 0.21-1.25 mg/l. Silica ranged between 0.182 mg/L in October and 0.195 mg/L in December Silica is affected by water currents that raise silica materials from the bottom to the surface and be consumed by microorganisms, especially diatoms. Sodium was between 41.9-67.2 mg/l Sodium is affected by groundwater, as well as agricultural and industrial waste, and its concentration is higher than potassium, and it is also affected by the adsorption process, and this result may be due to the presence of groundwater springs close to it (Khuwaidem, 2012)^[20], which reached 81

mg/l from February to July. And potassium ranged between 2.3- 6.2 mg / liter and the same reason is the presence of groundwater springs. The results of the examination showed that lead had a value between the lowest value, which was 0.0304-0.221 mg / liter, which is lower than the study (Al-Yazji and Mahmoud, 2008)^[14], which was between 4.9-14.3 ppb during.

Summer, and close to the study (Al-Obaidi *et al.*, 2014)^[9], which was between 0.01-0.36 ppm from February to December. The site is far from the sewage outfalls. The results of the examination showed the presence of iron between zero - 0.378 mg /L, and the results were close to the study (Abed *et al.*, 2013)^[3], as it was between 0.23-0.29 mg /L from November to December. It was also close to the study of (Al-Obaidi *et al.*, 2014)^[9], where it was between 0.03-0.78 mg /L. The results of the examination showed copper values between 0.098-0.264 mg /L, and the results were similar to the study (Razzouqi, 2021)^[25], as it was

between 0-0.11 mg /L from January to July. The total number of bacteria(TPC) was between 4000 cells/ml in January and 120,000 cells/ml in September and these numbers are close to the results (Al-Hamdani, 2022)^[5], which were between 400-600000 cells/ml for total bacteria and 280-3600 cells/100ml for total E.coli. The total number of coli bacteria was between 30 cells/ml in December and 1300 cells/ml in November Factors affecting bacteria include sewage water, organic materials that feed bacteria, animal waste containing fecal coliform bacteria, and temperatures as the higher the temperature the greater the activity of the bacteria. As for the number of plankton it was between 101154 cells / liter in January and 650,274 cells / liter in September, and the effect of temperature can be seen on the activity of plankton. cells/liter as well as (Al-Nuaimi, 2017)^[8] which was 504524-332713 cells/liter. Table (2) shows the results of the analysis.

Table 2: Shows the results of the analyzes

Months Adjective	July	August	September	October	November	December	January
Air Temperature C°	30.0	27.0	28.0	26.0	17.00	15.0	9.00
Water Temperature C°	24	22	24	20.5	17	13	11
Electrical Conductivity µs/cm	392	402	411	384	384	418	470
Total Dissolved Solids Mg/L	193	191	203	176	168	164	174
Turbidity NTU	24.84	15.00	12.18	20.85	14.30	18.34	9.03
pH function	8.20	8.10	8.00	8.03	7.70	7.85	8.14
Al-Kalinity mg/L as CaCO ₃	248	108	124	104	128	132	132
Total Hardness mg/L as CaCO ₃	160	145	145	140	105	125	130
Ca Hardness mg/L as CaCO ₃	110	100	75	80	80	100	72
Mg Hardness mg/L as CaCO ₃	50	45	70	60	25	25	58
Chloride mg/L	17	17	15	14	17	20	20
Dissolved Oxygen mg/L	6.4	4.4	5.6	7.6	7.9	8.8	11.6
Biological Oxygen Demands mg/L	2.8	1.6	2.4	4.4	0.8	1.2	1.2
Sulphates mg/L	20.29	22.57	22.37	95.71	27.37	36.77	77.77
Nitrates mg/L	8.43	9.65	13.03	11.49	13.73	39.00	11.56
Phosphates mg/L	0.163	0.222	0.152	0.124	0.143	0.123	0.469
Silica mg/L	0.183	0.188	0.191	0.182	0.187	0.195	0.183
Sodium mg/L	67.2	67	131	67	92.6	41.9	67.2
Potassium mg/L	4.3	4.1	5.1	3.7	6.2	6.2	2.3
Iron mg/L	0.364	0.378	0.0389	zero	Zero	0.0349	Zero
Lead mg/L	0.221	0.211	0.0304	0.126	0.131	0.124	0.125
Copper mg/L	0.232	0.231	0.098	0.281	0.264	0.213	0.211
Total Plate Count cell/ml	60000	50000	120000	8000	80000	19000	4000
Total Coliform cell/ml	200	200	100	100	1300	30	60
Plankton cell/L	137280	578022	650274	447968	560274	578022	101154

Water indices are one of the simplest methods of dividing the state of water quality. There are several types of water quality indices that depend on the physical, chemical, and biological properties of water, Each has its own calculation method (Shihab & Kanna, 2021)^[28]. The results of the water quality index for the purpose of drinking (CWQI) showed that the water of the Tigris River in the study site is classified as good as its value was (80.53).

Table(3) shows the relationship of the correlation with the Pearson coefficient between the physical, chemical, and biological parameters, and that there are direct and inverse relationships and others that are not linked to any relationship. We note that the air temperature is directly proportional to each of the water temperature, total hardness, dissolved solids, sodium ion, and phytoplankton, with its effect on raising the water temperature and

increasing the evaporation process, and then increasing the concentration of hardness ions, solids and their salts, and increasing plankton metabolism, and it is inversely proportional to each of Dissolved oxygen, chloride, sulfate, phosphate, electrical conductivity, and total alkalinity, by reducing the solubility of oxygen and the absorption of nutrients by microorganisms. The water temperature is directly proportional to the total number of bacteria by increasing the rates of food metabolism. The pH function is directly proportional to dissolved oxygen, the biological requirement for oxygen and electrical conductivity through the process of photosynthesis, and inversely proportional to the total number of bacteria due to the bacteria being affected by acidity. In the results of the current study, electrical conductivity was not directly proportional to temperature and TDS. (Mahmoud, 2021)^[22] noticed that

there is no clear linear relationship between the EC and the TDS. Likewise (Saeed, 2009)^[26] and the latter explained the result because of the organic materials, floats and muds that water carries, which do not contribute to an increase in the electrical conductivity values, while increasing the total solids. The EC is based only on dissolved solids and not on total solids. The turbidity is directly proportional to the biological requirement for oxygen due to the increase of microorganisms with the presence of an increase in turbidity, which sticks to their particles, and is inversely proportional to the electrical conductivity, and the reason may be due to the increase in organic materials that have weak electrical conductivity. Dissolved oxygen is directly

proportional to the vital requirement for oxygen, sulfate, phosphate, and electrical conductivity. Perhaps the reason is due to the abundance of microorganisms that oxidize organic matter and consume quantities of dissolved oxygen. DO is inversely proportional to silica and the total number of bacteria and phytoplankton. The reason may be due to the high temperature and its effect on the solubility of oxygen and the increase in aquatic activity. The vital requirement for oxygen is inversely proportional to the total number of bacteria, because the higher the number of bacteria, the higher the oxygen consumption. The total hardness is directly proportional to the total dissolved solids, sodium and plankton because it is a form of salt.

Table 3: shows the correlation coefficient between water parameters in the studied site.

	Temp Air	Temp Water	pH	Turb	DO	BOD	TH	Cl	SO ₄	NO ₃	PO ₄	TDS	T Alk	TPC	T coli	Plankton
Temp Air	1	0.879	0.748	0.196	0.174	0.416	0.979	-0.681	-0.348	-0.228	0.144	0.788	-0.883	0.106	-0.800	0.715
Temp Water		1	0.780	-0.294	-0.030	0.009	0.827	-0.571	-0.636	-0.178	0.032	0.982	-0.587	-0.086	-0.772	0.628
PH			1	-0.042	0.586	0.436	0.598	-0.941	-0.052	0.437	-0.536	0.683	-0.404	-0.628	0.992-	0.107
Turb				1	0.501	0.863	0.241	-0.264	0.671	0.011	0.122	-0.449	0.093	-0.636	-0.074	0.067
DO					1	0.829	0.096	-0.803	0.778	0.825	-0.770	0.189-	-0.077	-0.968	-0.616	-0.511
BOD ₅						1	0.361	-0.704	0.700	0.375	-0.295	-0.179	-0.672	-0.931	-0.526	-0.066
TH							1	-0.532	-0.413	-0.411	-0.339	0.748	-0.940	-0.245	-0.662	0.833
Cl								1	-0.264	-0.552	0.598	0.427-	0.440	0.853	0.961	0.024
SO ₄									1	0.663	-0.527	-0.759	0.193	-0.713	0.011	-0.692
NO ₃										1	-0.985	-0.252	0.461	-0.659	-0.391	-0.843
PO ₃											1	0.093	0.450-	0.612	0.478	0.718
TDS												1	-0.481	0.093	-0.659	0.635
T Alk													1	0.322	-0.501	-0.807
TPC														1	0.680	0.289
T coli															1	-0.164
Plankton																1

Conclusions

1. Tigris River water at the study site is classified as good according to the Canadian index for the purpose of drinking.
2. There is an effect of the sewage outfalls of the nearby villages on the river water.
3. Some variables exceeded the permissible limits of the Iraqi and international specifications, such as turbidity and the number of bacteria.

Recommendations

1. Conduct periodic studies on rivers, especially those used for drinking.
2. Treating wastewater before entering the river to reduce water pollution.
3. Developing the work of water filtration plants to deliver potable water to citiz.

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