Ecological study of some physical, chemical and bacteriological characteristics of Tigris River water in Wasit province, Iraq

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دراسة بيئية لبعض الصفات الفيزيائية والكيميائية والبكتيريولوجية لمياه نهر دجلة في محافظة واسط - العراق

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المستخلص

أجريت هذه الدراسة على مياه نهر دجلة عند مروره في محافظة واسط ، بواقع خمس محطات تمتد على طول النهر وهي الصويره والنعمانية والكوت قبل سدة الكوت و بعد الخروج من مدينة الكوت وشيخ سعد لتقييم نوعية مياه نهر دجلة بيئيا. تم أخذ العينات شهرياً وبواقع نموذجين لكل شهر ولمدة سنة كاملة أبتداءا من شهر كانون الثاني 2016 ولغاية شهر كانون الأول 2016. شملت الدراسة قياس بعض العوامل الفيزيائية والكيميائية والبكتريولوجية. بينت نتائج الدراسة تغيرات شهرية ملحوظة في قيم كل العوامل المدروسة. اظهرت نتائج الدراسة الحالية ان قيم درجة حرارة الماء تراوحت بين (9 الى 29) م^0, أما قيم العكورة تروحت بين (8 الى 55) وحدة عكورة والايصالية الكهربائية (749 الى 1352) مايكروسيمنز والملوحة (0.479الى0.865) جزء بالألف والمواد الصلبة الذائبة (499 الى 960) ملغم/ لتر والمواد الصلبة العالقة (12 الى 190) ملغم/ لتر. وتبين ان درجة الدالة الحامضية في المياه تتجه باتجاه القاعدية الخفيفة حيث تراوحت بين (7 الى 8.1). و تراوحت التراكيز الشهرية للأوكسجين الذائب (DO) (6.2 الى 12) ملغم/ لتر والمتطلب البايولوجي للاوكسجين (BOD)(0.8 الى 6.4) ملغم/ لتر والقاعدية الكلية (120 الى 230) ملغم/ لتر والعسرة الكلية (284 الى 520) ملغم/ لتر والكالسيوم والمغنيسيوم (71 الى 189) ملغم/ لتر(36 الى 97.4) ملغم/ لتر على التوالي و الكلورايد (90 الى 151) ملغم/ لتر والكبريتات (185 الى 410) ملغم/ لتر. أما المغذيات فقد سجلت النترات قيم (0.6 الى 6.7) ملغم/ لتر وسجلت الفوسفات قيما تراوحت بين (0.08 الى 1) ملغم/ لتر . أما بالنسبة للعوامل البكتيريولوجية فقد تم دراسة العدد الكلي للبكتريا الهوائية وتراوحت اعدادها بين (185 الى 35000) خلية / مل, أما أعداد بكتريا القولون فتراوحت بين (800 الى 110000) خلية/ 100مل, في حين تراوحت أعداد بكتريا القولون البرازية بين (1000 الى 114000) خلية/ 100مل. من خلال النتائج التي تم الحصول عليها ومقارنتها مع دليل منظمة الصحة العالمية لمياه الشرب وموصفات الجهاز المركزي للتقييس والسيطرة النوعية العراقية تعتبر المياه صالحة للاستخدامات المدنية بعد تمريرها في محطات تصفية وتعقيم المياه.

Abstract

This study was performed in the Tigris River water as it passed through Wasit province at the rate of five stations extending along the river, (Al-Sowarah, Al-Nu'maniyah, Al-Kut before Al-Kut Dam, after leaving Al-Kut city and Sheikh Saad), to evaluate the environmental quality of Tigris River water. Samples were collecting monthly, two samples were taken each month, and for a period of one complete year starting from the January 2016 - December 2016.

The study included measuring some of the Physical, Chemical and Bacteriological Factors. The results of this study showed significant monthly changes in the values of all studied factors. The parameters values of current study showed that the water temperature values ranged from 9-29 °C and the values of turbidity ranged between 8-55 NTU, electrical conductivity ranged between 749-1352 µs/cm with Salinity 0.479-0.865 ppt, total dissolved solid 499 – 960 mg/l, total suspended solid values ranging from 12-190 mg/l. It was found that the water of the Tigris River is slightly alkalinity, with pH ranged between 7-8.1. The monthly concentrations of dissolved oxygen (DO) ranged from 6.2 - 12 mg / l, BOD ranged between 0.8 - 6.4 mg / l, total alkalinity ranged between 120-230 mg $CaCO_3$/l, total hardness ranged between 284-520 mg/L, while the concentrations of calcium and magnesium were 71-189, 36-97.4 mg/l respectively, chlorides values varied from 90-151 mg/l, the sulphate values ranged between 185- 410 mg/l. Nitrate values varied from 0.6 -6.7 mg/l and the phosphate values ranged between 0.08-1 mg/l. Tigris River can be considered adequate for civilian uses according to WHO and Iraqi Quality Assurance System after adequate treatment in filtration and sterilization stations.

Introduction

The interest in water resources and the preservation of the quality of their water, and the deserts of living is important and vital to ensure domestic and other services such as irrigation, industry, agriculture, transport and power generation. The world's freshwater resources are sufficient if measured by the average current consumption, but the problem is that the water is not distributed evenly on the surface of the earth on the one hand, and that the rivers come from natural sources, making them can increase and decrease on the other hand. As well as the passage of many rivers away from Human settlements or land not suitable for agriculture as in the Amazon River and the rivers of Cybria (1). As well as, many rivers with variable drainage throughout the year may be flooded in wet seasons as water is less needed and dry in dry seasons as the need for water increases (1). Rivers are one of the most important water sources, on its banks, civilizations, cities and industries are built. Water has the ability to purify itself from impurities by helping environmental factors with this process of self-purification if pollutants are within the water source's ability to tolerate and treat them (2). In other words, a certain volume of running water can carry a limited amount and a certain amount of pollutants (3). Here lies the most serious problem for the Tigris and Euphrates Rivers, on the one hand, the water level in the two rivers decreases year after year due to drought and rain. As well as increased investment waters by neighboring countries on the other hand, increased the amount of pollutants involved in them as a result of industry and agriculture that depend on irrigating land and the use of pesticides, fertilizers, poor sanitation and garbage collection methods. Where he received the major rivers in Iraq, more than 400 million m^3 years of waste materials. In Mosul alone, the amount of liquid jetsam from the cities estimated to reach the Tigris River about (6598) m^3 / h of effluent crude (4). One of the most common environmental pollution is fecal pollution, especially what occurs in river water in rural areas where fecal waste is reached. As clear for it in a more in developing countries, can easily isolate the bacteria of the colon and the possibility of preparation led many researchers recommend the use of these bacteria as evidence of water pollution account (5).

The aims of this research:-

Study the physical and chemical properties of Tigris River water and estimating the volume of microbic pollution of the river water through estimating the microbic indications represented by the total number of aerobic bacteria and the total coliform and the total fecal coliform in the district of study.

Materials and Methods

Study area

The current study included Tigris River, one of Iraq's main rivers, and one of the longest rivers in the world. Its total length is 1,900 km, 20% of it in Turkey, 78% of it in Iraq, and only 2% is located along the northeastern corner of Syria and meets the Euphrates River in Qurna to form the Shatt al-Arab (6). Length inside Iraq, 1350 km, and the river is 39 in length (7). The width of the Tigris River between 350-120 meters, while the depth of the water ranges from to 5 - 2 meters during discharge the low. A number of dams have been built on the Tigris River to prevent flooding. These dams are Mosul dam, Samarra dam and Kut dam. There are also power plants as well as agricultural uses (8). The width of the river and its depth depend on the discharge of seasonal water. Many agricultural areas are located on either side of the river (9).

Five stations were chosen along the Tigris River to achieve this study. The first station was at Al-Sowarah, the second station was at Al-Nu'maniyah, the third station was at Al-Kut before the Al-Kut Dam, the forth station was at after leaving Al-Kut city and the five station was at Sheikh Saad), (Fig. 1).

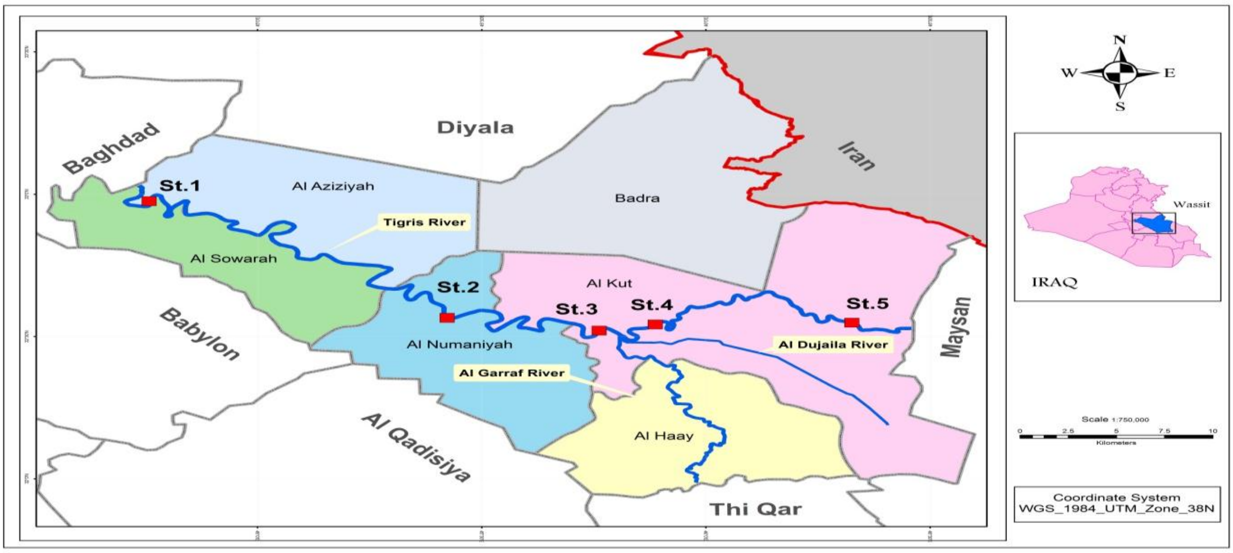

Figure (1): Tigris River in Wasit province with the sampling location.

Map Scale1/100000.

Sample collection

Sampling of physical, chemical and biological variables was performed from the five stations, according to monthly basis from January 2016 till December 2016, to represent all seasons. Sampling usually started at 9 am and completed at 5pm.

Water temperature was measured in the field with a mercury thermometer (0-50 ^{o}C) graduated up to 0.1 intervals, at the depth of 20cm. Electrical conductivity and pH value were measured directly in the field by using portable pH-meter model (WTW pH. 720). Turbidity level by using turbidity-meter. Other parameters like total suspended solids (TSS), total dissolved solids (TDS), total alkalinity, total hardness, calcium (Ca+2), magnesium (Mg+2), chlorides (Cl-), Phosphate (PO4), Nitrate (NO-3), were determined following standard methods (APHA, 2005). Total hardness and calcium were estimated using EDTA titrimetry. Dissolved oxygen and BOD5 were determined using Winkler's method. Nitrate measured by UV- spectrophotometer at a wavelength of 220nm, while sulphate determined by using UV-spectrophotometer at a wavelength of 420nm. Phosphate was determined by spectrophotometer at wavelength of 860nm. Total Bacterial Count (TBC), Total Coliform (TC), Thermo tolerant (Fecal) Coliform Bacteria (FC) and Fecal Streptococci (FS) were determined according to (10).

Results and Discussion

Physio-chemical characteristics

Water temperature values were varied from highest value (30°C) at station 4 in August 2016 and the lowest value (9°C) at station 3 in January 2016 Table (1 and 3a). The statistical analysis showed that there was a significant difference in water temperature among months, while no significant differences appeared between stations in the same season Table (1). We can observe the variation of water temperature through this study. The fluctuations of water temperature between seasons were due to seasonal climate changes (11).

Table (1): The range and Mean ± SD for the studied physical and chemical characteristics in water of Tigris River in study area

Stations / Parameters	Station.1	Station.2	Station. 3	Station.4	Station.5
Water Temperature (°C)	10 – 29 20.061 ± 6.169 a	10 – 29 20.117 ± 6.216 a	9 – 29 20.017 ± 6.203 a	10 – 30 20.311 ± 6.149 a	10 – 29 20.072 ± 6.148 A
E.C. (μS/cm)	875 – 1330 1087 ± 106.7 a	870 – 1336 1086.9 ± 107.3 a	749 – 1225 1016.8± 113.7 c	876 – 1342 1091.1 ± 108.5 a	855 – 1290 1064.1 ± 111.6 B
Salinity (ppt)	0.560 – 0.851 0.6953 ± 0.116 a	0.556 – 0.855 0.6953 ± 0.117 a	0.479 – 0.784 0.6508± 0.104 c	0.560 – 0.858 0.6977 ± 0.118 a	0.547 – 0.825 0.6760 ± 0.106 B
TDS (mg/L)	583 – 886 724.5 ± 71.10 a	580 – 890 724.7 ± 71.34 a	499 – 820 678.8 ± 74.94 c	584 – 894 727.6 ± 72.10 a	570 – 860 705.9 ± 74.33 B
Turbidity (NTU)	19 – 51 34.19 ± 8.406 a	20 – 53 34.78 ± 8.482 a	8 – 37 21.69 ± 5.903 b	21 – 55 35.67 ± 8.838 a	9 – 39 22.72 ± 6.236 B
TSS (mg/L)	20 – 182 60.75 ± 46 b	20 – 175 61.44 ± 47.11 ab	12 – 151 39.33 ± 41.66 c	18 – 190 62.78 ± 50.55 a	12 – 150 39.36 ± 40.88 C
pH	7.1 – 7.7 7.455 ± 0.193 b	7.1– 7.7 7.448 ± 0.190 b	7. 3– 8.1 7.675 ± 0.225 a	7 – 7.7 7.435 ± 0.205 b	7.28 – 8 7.660 ± 0.219 A
D.O (mg/L)	7 – 10	6.4 – 10	7.5 – 12	6.2 – 9.9	7.5 – 11.6

	7.998 ± 0.903 b	7.942 ± 0.870 b	9.001± 1.127 a	7.785 ± 0.818 c	8.849 ± 1.067 A
BOD (mg/L)	1.9- 5.5 2.919 ± 1.058 c	2.4 – 6.3 3.496 ± 1.109 b	0.8–2.9 1.691 ± 0.439 d	2.6 – 6.4 3.638 ± 1.059 a	1 – 3 1.753 ± 0.420 D
Alk (mg/L)	130 - 229 178.61 ± 26 .46 b	130 - 229 179.78 ± 27.48 ab	120 - 190 156.83± 20.73 c	131 - 230 180.25 ±27.86 a	121 - 188 157.86 ±20.90 C
T.H. (mg/L)	310 – 510 378.56 ± 62.52 a	310- 515 379.31 ± 62.56 a	284 – 441 327.25 ± 49.29 c	315 – 520 382.25 ± 62.99 a	312 – 488 357.56 ± 55.78 B
Ca^{++} (mg/L)	79 - 184 117.78 ± 34.46 a	80 - 187 117.89 ± 34.49 a	71 - 155 94.08 ± 24.21 c	79 - 188 118.50 ± 34.96 a	75 - 171 107 ± 31.77 B
Mg^{++} (mg/L)	50 – 92 64.61 ± 13.11 b	50 – 95 64.75 ± 13.09 b	36 – 74 50.86 ± 12.57 d	51 – 97.4 66.36 ± 13.69 a	47 – 87 59.22 ± 12.48 C
Cl^- (mg/L)	117 - 147 132.78 ± 6.64 b	120– 147 133.03 ± 7.08 ab	90 – 125 111.75 ± 8.59 C	122– 151 134 ± 6.75 a	92– 126 112.56 ± 8.68 C
SO_4 (mg/L)	240 – 406 317.67 ± 45.56 a	237 – 408 318.06± 46.42 a	185 – 385 286.11 ± 44.07 c	250 – 410 319.89 ± 45.18 a	215 – 399 302.53 ± 49.88 B
NO_3 (mg/L)	1.1 – 6.2 3.349 ± 1.581 b	1. 3 – 6.3 3.408 ± 1.586 b	0.6 – 6 3.225 ± 1.768 d	1.4 – 6.7 3.519 ± 1.579 a	0.9 – 6.3 3.306 ± 1.605 C
PO_4 (mg/L)	0.2 – 0.88 0.4531 ± 0.211 a	0.24 – 0.9 0.4547 ± 0.217 a	0.08 – 0.58 0.2483 ± 0.135 b	0.2 – 1 0.4639 ± 0.226 a	0.1 – 0.55 0.2575 ± 0.133 B

The range of conductivity with salinity in water samples were ranging between 749-1342 μS/cm and 0.479 -0.858 ppt respectively Table (1 and 3a). The EC and salinity had higher values in January 2016 at station 4, while the lower values recorded during March 2016 at station 3, this may be due to the products of decomposition and mineralization of organic materials (12). Also the occurrence of high salinity and EC values in surface water in the winter season due to the rain fall and increasing of water level and river discharge, soil wash and the addition of the salts through the agriculture, urbanization, and industrial activities, which helps to increase the amount of dissolved salts in water this is consistent with (13,14).

The statistical analysis indicated a substantial difference among months for E.C., and salinity at ($P<0.05$) Table (1). The salinity results were within the range of freshwater salinity that ranged from 0 to 3.5‰ (15).

pH values of water samples have ranged from 7.0 – 8.1, the highest value was 8.1 in station 3 during August 2016, while the lowest value was 7 in station 4 during December 2016 Table (1 and 3b). The statistical analysis showed a significant differences among months for pH at ($P<0.05$) and the significant differences between stations at ($P<0.05$) Table (1). pH value for all water samples tended to be higher in summer months and lower in winter months. The pH value tended to side alkaline during the study and for all sites. Since water is the alkaline of nature, it plays a major role in regulating natural pH change (11).

Mean values of TDS were recorded in the Tigris River (499-894 mg/L). In general the highest value of TDS was in January 2016 at stations 4, while the lowest values were during March 2016 at stations 3 Table (1 and 3a). The high value of TDS recorded during winter season months period could be related to increase in the load of soluble salts, mud, increase in the urban and fertilizer runoff, untreated wastewater, septic effluent, decaying plants, animals and erosion of riverbanks. Lower value of TDS recorded in spring season months period might be due to dilution factor and sedimentation of suspended solids and slow decomposition rate during the spring period (16, 17). The statistical analysis showed a significant difference among months at ($P<0.05$) and the significant differences ($P<0.05$) between stations except station 1, 2 with 4 Table (1).

The values of turbidity were found to range from 8-55 NTU in Tigris River. However, higher values were recorded in January 2016 at stations 4, while the lowest value of turbidity was recorded in April 2016 at station 3 (Table 1). Surface runoffs and domestic wastewater that may lead to the increased turbidity, and increased water levels and high water flow in winter will affect precipitation of suspended solids (18). The statistical analysis showed a significant differences among months at ($P<0.05$), as well as there were significant differences between stations except station 1, 2 with 4 and station 3 with 5 Table (1).

The present study results showed that the TSS concentrations varied between 12-190 mg/L in Tigris River. The mean TSS recorded higher values at station 4 in January 2016 and the lower value at station 3 and station 5 in April 2016 Table (1 and 3a). The TSS values were increased in winter due to increase in water level, soil erosion and rainfall, as well as, other matters such as algae, organic matter and untreated wastewater discharges (19). The statistical analysis showed significant differences among months at ($P<0.05$), and there were significant differences between stations except stations 4 with 2, stations 1 with 2 and stations 3 with 5 Table (1).

Tigris River stations showed variation in dissolved oxygen value Table (1 and 3b). The minimum value was 6.2 mg/L in station 4 during August 2016, and the maximum value of 12 mg/L in station 3 during January 2016. The concentration of dissolved oxygen in Tigris River rise in winter this may be due to the increasing of aeration due of the rainfall, in addition to the decrease of temperature in winter which increase the oxygen solubility (20). Decrease in the dissolved oxygen content during summer season could also be attributed to increase in temperature which will causes a decrease in the concentration of dissolved oxygen, photosynthesis and aquatic organisms respiration also play an important role with fluctuations of dissolved oxygen concentration in water because self-purification occurs when the decomposing organisms use the dissolved oxygen to degrade the organic matter (21, 22).

The BOD_5 concentration values of water samples are shown in Table (1 and 3b). The lowest value was 0.8 mg/L in April 2016 recorded at station 3, whereas the highest value was 6.4 mg/L in December 2016 recorded at station 4. The statistical analysis showed a significant differences among months at ($P<0.05$), and there were significant differences between stations except stations 3 with 5 Table (1). The high BOD_5 value was during autumn and winter and that could probably linked to the level of organic matter load from sewage, industrial or urban discharges (23).

The range of alkalinity values was 120 to 230.6 mg/L Table (1 and 3b). The minimum value of alkalinity (120 mg/L) was recorded at station 3 during December 2016, while the maximum value (230 mg/L) was found in station 4 during August 2016. The study results showed that the river water was a light alkaline and this is indicated by previous studies as the alkalinity recipe is common in Iraqi water to provide bicarbonates salts in water (24). High temperatures can cause high concentrations of total alkalinity and increased rates of decomposition of organic materials and then turning increase calcium carbonate to bicarbonate (25).

The current work has shown that the highest value of total hardness was 520 mg/l in December 2016 at station 4, while the lowest value was 284 mg/l in August 2016 at station 3 (1 and 3b). The statistical analysis showed a significant differences among months at ($P<0.05$), and there were significant differences between stations except station 2 with 4, station 1 with 2 and station 3 with 5 Table (1). The soil erosion towards the nearby waters of which lead to higher concentrations of hardness in the water, and the nature of the soil that adds concentration of calcium and magnesium

ions (26, 27).

The obtained calcium ion data showed that the maximum value was recorded in December 2016 at station 4 which was 188 mg/L while the minimum value was found in August 2016 at station 3 which was 71 mg/L Table (1 and 3b). The results showed that there is an increase in calcium values during the winter. This increasing in winter might be due to the rainfalls that bring salts including calcium, also the decrease of temperature helps in CO^2 increasing in the water and forming carbonic acid that helps in dissolution the salts of calcium and magnesium (28).

The highest value for Mg^{+2} was 97.4 mg/l during December 2016 at station 4, while the lowest value was 36 mg/l in August 2016 at station 3 Table (1 and 3c).

The highest concentration of calcium ion on magnesium values may be due to the fact that the reaction of carbon dioxide with calcium is greater and stronger than its interaction with magnesium. Consequently, larger amounts of calcium are converted into dissolved bicarbonate, or it may be due to a high proportion of soluble sulfate, which may work on the deposition of magnesium sulfate in the form of (29).

The current results found that the highest value for chloride ions was 151mg/l in the December 2016 at station 4, while the lowest value was 90 mg/l in the May 2016 at station 3 Table (1 and 3c). The increase of Cl^- value in station 1, 2 and 3 indicates to pollution by sewage in the water of Tigris River due to the discharged untreated sewage from the city enriched with organic matter in the river (30). Many researchers have reported that rainfall adds chloride directly. In Tigris River the Cl^- ion was within the permissible limit for Iraqi, WHO and American standards for river water.

Concentration of sulphate in the Tigris River water ranging from 185 to 410 mg/L. The sulphate levels increased during December 2016 at station 4 and decreasing during March 2016 at station 3 Table (1 and 3c). The increase in sulphate value in the winter and decrease in spring generally due to the discharge of the domestic sewage and agricultural runoff, these ions can produced from decompositions of organic matters or using chemical fertilizers in agriculture (31). Higher concentrations of sulphate ions in Iraqi water are common in the south part of Iraq because of ground water effect (24).

The nitrate concentrations range between 0.6 – 6.7 mg/L in Tigris River Table (1 and

3c). The minimum value of nitrate (0.6 mg/L) was recorded at station 3 during March 2016, while the maximum value (6.7 mg/L) was found in station 4 November 2016.

The statistical analysis revealed significant differences ($P<0.05$) in NO_3 among months and there were significant differences between stations except station 1 with 2 Table (1). High nitrate level in the Tigris River during autumn and winter is due to the rainfall and fertilizer runoff as well as bacterial activity which convert nitrite to nitrate and the decomposition of organic compounds, but the decreasing of nitrate in spring may be due to the dilution factor and consumption of nitrate by phytoplankton growth and reduction of nitrate to nitrite in the bottom (32). Increase in nitrate content in station 4 could be related to the impact of Al-Kut city on the river by untreated sewage. The banks of Tigris River are certainly with high density of agricultural areas, the nitrogen fertilizers raised with high percentage as a result of increased agricultural activity, in addition to the sewage and industrial discharge in the area that might be the cause of high concentrations of nitrates (33).

The phosphate values in present study ranged between 0.08-1 mg/l in the Tigris River Table (1 and 3c). The minimum value was 0.08 mg/L in station 3 during April 2016, and the maximum value of 1 mg/L in station 4 during December 2016. The statistical analysis showed a significant differences among months at ($P<0.05$) and significant differences among stations except station 1, 2 with 4 and station 3 with 5 Table (1). Increasing levels of PO_4 in Tigris River may be due to high concentration of detergents in sewage, in addition to the high density of agricultural areas, the phosphate fertilizers raised with high percentage as a result of increased agricultural activity that might be the cause of high concentrations of phosphate.

Bacteriological characteristics

The total bacterial in this study ranged between (185 - 35000) CFU/1ml Table (2 and 4). The maximum value was 35000 CFU/1ml in station 4 during January 2016, and the minimum value was 185 CFU/1ml in station 5 during August 2016.

Table (2): The range and Mean ± SD for the studied Bacteriological characteristics in water of Tigris River in study area

Stations / Parameters	Station.1	Station.2	Station. 3	Station.4	Station.5
Total Bacterial Count (CFU/1ml)	700 – 29000 5916 ± 8455 c	1100 – 32000 8400 ± 9839 b	200-18000 3648 ± 5657 d	1150-35000 9129 ± 10746 a	185-16000 3426 ± 5191 D
Total Coliform (CFU /100ml)	2300-65000 25708 ± 19508 c	3200 -108000 46053 ± 32610 b	840-9500 4823 ± 2886.8 d	3400-110000 48758 ± 34598 a	800-9000 4491 ± 2722 D
Faecal Coliform (CFU /100ml)	3000 - 77000 25231 ± 21395 b	8100-109000 44539 ± 31273 a	1160-9900 4621± 3044.9 c	8300-114000 47828 ± 32681 a	1000-9500 4281 ± 2995.2 C

High number of TBC in Tigris River was recorded during autumn and winter ,which might be the consequence of the high level of suspended solid and nutrients in the drainage water which affected the survival of aquatic microflora (34), also it may be because the high numbers of bacterial level of the Tigris River due to receiving the large amounts of sewage especially in Al-Kut city, as well as increase the agricultural activities have led to increase bacteria number in the waters of the river (35). On the other hand, low number of bacteria during spring and summer may be due to flooding period, which dilutes the organic matter which used as food for the bacteria, as well as high temperature which cause the elimination of large number of bacteria (36).

Total Coliform in this study varied between (800 - 110000) CFU/100 ml, current results revealed a high value of T.C recorded in January 2016 at station 4, while the lowest value of T.C was recorded in August 2016 at station 5 Table (2 and 4). The statistical analysis revealed significant differences ($P<0.05$) in T.C between months and significant differences between stations except station 3 with 5 Table (2). The increase in numbers of T.C in station 2 and 4 may be due to the effluent discharged enriched with organic matter from the city which

leads to increase them. Also, this may be due to the increase in concentrations of nutrients as nitrogen and phosphorus from domestic sewage and pollution sources on the riverbanks these result us agree with (37).

Faecal Coliform had ranged between 1000 – 114000 CFU/100 ml in the Tigris River Table (2 and 4). The maximum value of F.C was recorded in January 2016 at station 4, while the minimum value of T.C was founded in April 2016 at station 5. The statistical analysis revealed significant differences ($P<0.05$) in F.C between months and significant differences between stations except station 2 with 4 and station 3 with 5 Table (2). The increase in numbers of FC in station 2 and4 may be due to the continuous subtraction of untreated sewage in the Tigris River from the city. Increase of faecal coliform numbers in water during the winter season to higher survival and growth at suitable temperature (38). Also the reason may be behind might be due to the high rates of turbidity during winter season. High concentrations of calcium and magnesium. Will play the high levels of turbidity role in providing shelter and protection to the bacteria and facilitate their movement through distribution systems (39).

Table (3a): Monthly averages of all water variables examined during study periods

Parameters / Months	Water Temperature (°C)					E.C. (µS/cm)				
	St.1	St.2	St.3	St.4	St.5	St.1	St.2	St.3	St.4	St.5
January	10	10	9.6	10.3	10	1276	1276	1195	1279	1264
February	10.6	10.6	10.3	10.6	10.3	1165	1165	1032	1070	1164
March	16	16	15.3	16.3	15.3	928	927	813	933	913
April	21	21	20	21.3	20. 3	974	974	813	933	913
May	23	23	22	23	22	1033	1034	956	1039	990
June	26	26	25.6	26	25.6	1003	1000	964	1005	987
July	26	26.3	25.6	26.6	25.6	1075	1070	1013	1080	1050
August	28	28	27.6	28.3	27.6	1065	1060	988	1068	1052
September	24.6	24.6	24.6	25	24.6	1069	1075	1020	1078	1070
October	21.3	21.6	3.21	21.6	21	1054	1054	1005	1061	1039
November	20	20	19.3	0.66	19.6	1170	1169	1127	1172	1168
December	11.6	11.6	11.3	12.3	11.3	1230	1230	1190	1230	1233
LSD	0.335					19.97				
Parameters / Months	TDS (mg/L)					Salinity (ppt)				
	St.1	St.2	St.3	St.4	St.5	St.1	St.2	St.3	St.4	St.5
January	850.3	850.7	798	852.7	842	0.816	0.816	0.764	0.818	0.808
February	776.3	776.3	695	780	776.3	0.745	0.745	0.666	0.748	0.744
March	618.3	619	542	622.3	608.3	0.593	0.592	0.520	0.596	0.584
April	649.3	650	600	652.3	639	0.622	0.623	0.575	0.625	0.613
May	688.3	689.3	638	693	660.3	0.661	0.661	0.611	0.664	0.633
June	669	668.3	644	670	658	0.641	0.641	0.616	0.641	0.631

July	717	715	676	721.3	700	0.687	0.685	0.648	0.690	0.671
August	710	709	660	711	701.7	0.681	0.680	0.632	0.681	0.673
September	712.3	716.3	680	718.7	713	0.684	0.687	0.652	0.690	0.672
October	702.7	703	669	707.3	692	0.674	0.674	0.642	0.679	0.664
November	780	779	751	782.7	778.7	0. 748	0.747	0.721	0.750	0.747
December	820.3	820.3	792	819.7	821.7	0.786	0.787	0.761	0.786	0.788
LSD	12.99					0.012				
Parameters / Months	Turbidity (NTU)					TSS (mg/L)				
	St.1	St.2	St.3	St.4	St.5	St.1	St.2	St.3	St.4	St.5
January	49.6	50	32.33	53	34.3	172	172	146	185	145
February	42	43	27	45	27.6	115.6	120	73	122	70
March	30.6	31.3	16	32	16.6	33	36	14.33	36	17
April	20.6	21	9	22.3	9.67	21.6	20	14	20	14
May	29.6	30.6	21	32.3	21.6	37	34	15	30	15
June	39.3	40	21.6	40.3	22.6	47	48.6	24	48.6	22
July	29	30	20	29	21	38	33	22	32	28
August	26	26	19	27	20	42	41	21	41.3	21
September	40.3	40.6	25.6	42	27	30	28.6	13.6	29.3	13
October	27.3	27.6	22	28	24	38.6	46	16	47	14.3
November	35.3	36	21	36	22	37	36	17	37	18
December	40.3	41	25.6	41	26	117	122	96	125	95
LSD	1.188					1.957				

Table (3b): Monthly averages of all water variables examined during study periods

Parameters / Months	pH					DO (mg/L)				
	St.1	St.2	St.3	St.4	St.5	St.1	St.2	St.3	St.4	St.5
January	7.14	7.13	7.35	7.06	7.37	9.9	9.86	11.50	9.52	11.30
February	7.39	7.37	7.56	7.36	7.53	8.80	8.76	9.96	8.50	9.66
March	7.49	7.48	7.63	7.46	7.6	7.66	7.53	9.10	7.36	8.93
April	7.54	7.52	7.70	7.51	7.69	7.93	7.83	9.30	7.76	9.13
May	7.56	7.56	7.80	7.56	7.79	7.76	7.63	8.60	7.46	8.50
June	7.65	7.64	7.90	7.63	7.87	7.53	7.50	8.96	7.40	8.83
July	7.68	7.67	7.96	7.66	7.98	7.16	7.16	7.70	7.10	7.63

August	7.73	7.71	8.06	7.71	8.00	6.73	6.70	7.66	6.53	7.63
September	7.44	7.45	7.68	7.42	7.68	7.60	7.50	8.09	7.43	8.08
October	7.36	7.36	7.58	7.36	7.57	7.72	7.70	8.32	7.62	8.00
November	7.33	7.36	7.52	7.38	7.51	8.21	8.16	8.69	8.03	8.53
December	7.12	7.11	7.32	7.06	7.31	8.93	8.93	10.10	8.66	9.93
LSD	0.020					0.1660				
Parameters / Months	**BOD (mg/L)**					**Alk. (mg/L)**				
	St.1	**St.2**	**St.3**	**St.4**	**St.5**	**St.1**	**St.2**	**St.3**	**St.4**	**St.5**
January	4.1	4.8	1.9	4.9	2.0	152	151	135	151	135.3
February	3.8	4.33	1.8	4.4	1.83	157.3	160	140	158	140.6
March	2.43	2.9	1.6	3.0	1.6	169	167.3	147	168	147.6
April	2.0	2.4	1.0	2.7	1.1	167.3	168.6	147	170	145
May	2.1	2.5	1.4	2.8	1.53	185	186.6	161	186	163
June	2.5	3.2	1.53	3.3	1.56	197.6	201	170	203	172
July	2.1	2.66	1.6	2.7	1.7	213.6	218.3	185	217	185.6
August	2.0	2.8	1.3	3.0	1.4	225.6	227	185	230	186
September	2.2	2.78	1.58	3.04	1.6	201	200	185	202	186
October	2.6	3.06	1.8	3.11	1.8	179	182	159	183	162
November	4.06	4.86	1.96	5.0	8.53	160	162	145	162	146
December	5.13	5.63	2.8	5.7	2.8	134	132	121	133	123
LSD	0.1199					1.323				
Parameters / Months	**T.H. (mg/L)**					**Ca^{++} (mg/L)**				
	St.1	**St.2**	**St.3**	**St.4**	**St.5**	**St.1**	**St.2**	**St.3**	**St.4**	**St.5**
January	463	465.6	387	466	404	150.3	151	109	154	118
February	381	385	307	382	350	140	142	100	140.6	124
March	332	333	290	338	309	108	108.6	84	109.6	95
April	350	353	300	355	333	97	98	80	99	87
May	333	330	293	335	311	92	92	79	92.3	84
June	319	318	295	322	313	89	88	76	90	86
July	344	343	297	347	332	88	86.6	73	89	82.3
August	310	315	288	320	304	79.3	81.6	71	83.3	76.6
September	361	361.6	313	362	358	89	88	76	90	86

October	379	380	322	378	352	126.6	126	101	127	106
November	463	460	398	469	439	173	172	133	175	169
December	505	506	437	512	485	180.3	180	147	184	170
LSD	4.116					1.476				

Table (3c): Monthly averages of all water variables examined during study periods

Parameters / Months	**Mg^{++} (mg/L)**					**Cl^- (mg/L)**				
	St.1	**St.2**	**St.3**	**St.4**	**St.5**	**St.1**	**St.2**	**St.3**	**St.4**	**St.5**
January	69.6	70	62	72	65	136	137	117	139	119
February	69	70	58	69.3	65	136	134.3	113	135	116
March	53	53.3	42	55.6	47	132	132	104	133	103
April	53	54.6	39	55	46	127	128.3	98	127	100
May	51.6	52	36.6	53.3	49	123	124.3	99	125	101
June	51.6	51.3	38.3	52	50	128	128	108	29	110
July	60.6	59.6	39.6	60.6	52	129	130	113	133	116
August	50	50.3	38	52	48	132	132.6	109	134	111
September	76	75	59	80	68	127	127	113	132	116
October	68	68	55.6	68.3	59.3	139	139	114	139	116
November	82.6	82	68	84.6	77	138	140	118	139	118
December	90	90.6	72	93.2	84.3	144.6	144	123	145	124
LSD	0.966					1.154				
Parameters / Months	**SO_4 (mg/L)**					**NO_3 (mg/L)**				
	St.1	**St.2**	**St.3**	**St.4**	**St.5**	**St.1**	**St.2**	**St.3**	**St.4**	**St.5**
January	381.3	380	320	383	362	4.3	4.3	4.2	4.3	4.26
February	299	297	280	301	290	3	3	2.9	3.2	2.93
March	295	296	272	297	279	1.2	1.3	0.8	1.6	1
April	290	293	274	291	273	2.2	2.2	2	2.2	2
May	245	240	195	252	218	2.1	2.2	2.13	2.36	2.1
June	293	288	284	291.6	283	2.3	2.3	2.2	2.33	2.32
July	280	290	264	293	269	2.26	2.1	2	2.2	2.1
August	305	290	265	300	268	2.3	2.36	2.3	2.4	2.3
September	308.6	307	360	310	307	4.1	4	3.9	4.2	3.9
October	330	330	264	333	312	5.06	5.13	4.66	5.16	5.1

November	380	380	328	382	371	6.1	6.2	6	6.4	6.1
December	401	400	380	405	398	5.8	5.8	5.6	5.86	5.63
LSD	2.457					0.0789				

Parameters / Months	**PO_4 (mg/L)**				
	St.1	**St.2**	**St.3**	**St.4**	**St.5**
January	0.79	0.78	0.41	0.80	0.413
February	0.503	0.49	0.22	0.50	0.23
March	0.31	0.306	0.12	0.32	0.15
April	0.243	0.25	0.09	0.26	0.11
May	0.29	0.28	0.13	0.28	0.14
June	0.29	0.28	0.2	0.283	0.21
July	0.28	0.29	0.21	0.286	0.21
August	0.28	0.28	0.16	0.286	0.17
September	0.4	0.4	0.22	0.4	0.22
October	0.52	0.53	0.26	0.54	0.25
November	0.68	0.7	0.42	0.7	0.42
December	0.85	0.86	0.54	0.9	0.56
LSD	0.0204				

Table (4): Monthly averages of Bacteriological characteristics of all examined stations during the study period

Parameters / Months	**Total Bacterial Count (CFU/1ml)**					**Total Coliform (CFU /100ml)**				
	St.1	**St.2**	**St.3**	**St.4**	**St.5**	**St.1**	**St.2**	**St.3**	**St.4**	**St.5**
January	25000	29800	17700	32667	15700	59000	101000	9200	107000	8700
February	18000	24000	9500	25000	9000	51000	81000	8400	86000	8100
March	890	2500	760	2600	750	37000	69000	7000	71000	6600
April	860	2600	660	2800	680	30000	63000	5600	69000	5100
May	1800	3933	490	4367	520	19000	35000	3900	37000	3600
June	1593	2100	900	2300	900	2600	5600	1250	6100	1150
July	1333	2300	370	2400	280	2700	4300	1000	4400	950
August	727	1133	207	1217	197	2400	3500	890	3600	860
September	750	2867	250	2967	250	3800	12900	1900	13000	1900

October	1233	4267	900	4533	883	24000	49000	5733	51000	5033
November	2200	5100	835	5500	848	35000	54000	6100	58000	5100
December	16600	20200	11200	23200	11100	42000	74333	6900	79000	6800
LSD	452.6					945.5				

Parameters / Months	**Faecal Coliform (CFU /100ml)**				
	St.1	**St.2**	**St.3**	**St.4**	**St.5**
January	69000	104000	9700	112000	9400
February	52000	84000	8500	87667	8300
March	33333	55000	6800	56000	6500
April	3300	23000	1350	31000	1000
May	21000	37000	4100	40000	3750
June	5100	8900	1700	9500	1200
July	5000	11100	1160	12700	1120
August	5800	12500	1180	13800	1100
September	3900	12967	1767	14267	1600
October	25333	51000	5800	54000	5100
November	37000	60000	6200	63000	5300
December	42000	75000	7200	80000	7000
LSD	1039.5				

CONCLUSION

The results of current study indicated that the river water is polluted and unfit for drinking or other human uses without fundamental treatment.

References

1- **Al-Tameemi, A. Sh. (2004).** Ecological and bacteriological study on Tigris River water and Dijala water south Baghdad. M.Sc., Thesis. College of Science, University of Baghdad, Iraq. (In Arabic).

2- **Al-Mashhadani, Y. D., and Al-Sangari, M. N. (2007).** Some specific characteristics of the Tigris River water within the city of Mosul, Proceedings of the first scientific conference of the Center for Environmental Research and Pollution Control, University of Mosul 5-6 June: 56-66. (In Arabic).

3- **Adewoye,S.O. (2010).**Effects of detergent effluent discharges on the aspect of water quality of ASA river Ilorin, Nigeria.Agre.BIO.J.ofnorh America, 1(4):731-736.

4- **Al-Safawi, A. Y. T. (2007).** Study of the quantity and quality of effluents from the city of Mosul and its impact on the quality of water of the Tigris River, Proceedings of the first scientific conference of the Center for Environmental Research and Pollution Control, University of Mosul 5-6 June: 1-10. (In Arabic).

5- **Surbeck, C.Q. Grant S. B., Ahn J. H, and Jiang, S., Soeller, S. A.Holden, P. A. Van Der Werfhorst, L. C. and Brooks, D. J.(2008).** Urban Runoff Impact Study Phase III:Land-Use and Fecal Indicator Bacteria Generation . NWRI Final Project Report. National Water Research Institute .USA.139pp.

6- **Van, D.L. (1975).** The Diversion of Waters Affecting the United States and Mexico. Texas Law Review, 27: 27-61.

7- **Whitton , B. A. (1975).**River Ecology .Blackwell Scientific Publications, Oxford .

8- **Kassim, Th. I., Al-SaadiI, H. A., Al-Lami, A. A., and Al-Jaberi, H. H. (1997).** Heavy metal in water, suspended particles, sediments and aquatic plants of the upper region of Euphrates River, Iraq. J. of Envir. Science and Health. Part A, 32: 2497–2506.

9- **Rzoska, J.(1980).**Euphrates and Tigris, Mesopotamian ecology and destiny. D.W. Junkbv. publication. The Hague, Beston- London.

10- **EPA. (2010).** Pollution of the ocean by sewage, nutrients, and chemicals. Office of water. Non pointed source pollution pointer No's. Document No. EPA 841- F- 96- (Athrogh).

11- **Weiner, E.R. (2000).** Application of environmental chemistry. Boca Raton, London, U.K.

12- **UNEP (United Nations Environment Programme) (2006).** Navarro River, Total Maximum Daily Loads for Temperature and sediment. Region IX.

13- **Wahab, H. R. (2010).** Investigation of lead and chromium in phytoplankton and zooplankton in section of Tigris River at Baghdad city. M.Sc. Thesis. College of Science, University of Baghdad, Iraq.

14- **Dar, I. A.; Sankar, K. and Dar, M. A. (2010).** Spatial assessment of groundwater quality in Mamundiyar basin, Tamil Nadu, India. Environ. Monit. Assess.

15- **Pitt, R.E. (2000**). Water Quality Conditions in the Cahaba River and Likely Pollution Sources. Department of Civil and Environmental Engineering. University of Alabama.

16- **Imnatoshi and Sharif, U. A.(2012).** Geomorphology and seasonal variations of physicochemical parameters of Doyang River Nagaland. Int. J. Environ. Sci. Vol.6(1&2): 05-09.

17- **AL-Zamili,H.F. (2007**). Monthly variations of some environmental factors of AL-Gharraf River, J. of DhiQar, 3 (3):17-2.

18- **Gangwara, R.K.; Khareb,P.; Singha, J. and Singha, A. P. (2012).** Assessment of physico-chemical properties of water: River Ramganga at Bareilly, U.P. J. Chem. Pharm. Res., Vol. 4(9):4231-4234.

19- **Bamakanta, G.;Sunakar, P.; Satyabhama,T. and Prasad, T. U. (2013).** Seasonal variation of Nagavali River water quality at the vicinity of paper mill near Jaykaypur, Odisha, India.Int. Res. J. Environment Sci.Vol. 2(5): 46-52.

20- **Adeyemo, O. K.; Adedokun, O. A.; Yusuf, R. K. and Adeleye, E. A. (2008).** Seasonal changes in physioco-chemical parameters and nutrient load of river sediments in Ibadan city, Nigeria. Global NEST J. 10(3): 326-336.

21- **Dallas, H.F. and Day, J.A (2004).** The effect of water quality variables on aquatic ecosystems : a review WRC Report No TT224/04. Water Research Commission. 222 pp.

22- **Toma, J. J. (2013).** Limnological study of Dokan, Derbendikhan and Duhok lakes, Kurdistan region of Iraq.Open J. Eco.Vol.3 (1): 23-29.

23- **Chapman, D.(1992).** Water Quality Assessments, 1st Ed. Chapman and Hall, London and New York.

24- **Talling, J. F. (1980).** Water characteristics in Euphrates and Tigris in Mesopotamia in: Rzoska J. (Ed.) Ecology and Destiny. Monogr. Biol. 38: 63-81.

25- **Hassan, F. M.; Salih, M.J. and Hamid, H. A. (2005).** Estimation of some heavy metals in the wastewater to AFPC public-Iraq and its effects. Journal of Environmental Research and Sustainable Development. 8 (1): 51-75.

26- **Boyd and Claude E. (2000).** Water quality an Introduction Kluwer Acadamic Publishers, USA, 330P.

27- **Al-Saadi, H.A. (1994).** Aquatic ecology in Iraq and its Polluted Source. Proceeding of the Arabic conference Scientific research and its role in environmental protection from pollution page 59- 88 Edited by H.A. Al-Saadi, sept. 21- 28, 1993. Damascus, Syria.

28- **Maulood, B. K.; Al- Saadi,H. A. and Al-A'adamy, A. S. (1990).** The environmental and pollution practical. Dar AL-Hekma for publishing, Baghdad University.

29- **Kassem, T. I. (1986).** "Environmental study on benthic algae of some marshes in southern Iraq", M.Sc. Thesis. College of Science University of Basra, Iraq. (in Arabic).

30- **Chapman, D. (1996).** Water Quality Assessments: A Guide to the Use of Biota, Sediments and Water. Environmental monitoring, 2 ed. UNESCO, WHO and UNEP. E & FN Spon, London UK.

31- **Grasby, S.E., Hutcheon, I. and Krouse, H.R. (1997).** Application of the stable isotope composition of SO42- to tracing anomalous TDS in Nose Creek, southern Alberta, Canada, Applied Geochemistry. 12(5): 567-575.

32- **Allen, C. M. (2011).** Seasonal transport of suspended solids and nutrients between Bear River and Bear Lake. M. Sc. Thesis. College of science, University of Utah State.

33- **Attee, R. S. (2004).** Water characteristics in the Shatt Al-Arab river and the main drainage with some contamination levels of heavy metals. Ph.D thesis, Basrah University. pp-128. (In Arabic).

34- **Hader, D.P.; Kumar, H.D.; Smith, R.C. and Dobler, W.I. (1998).** Effects on aquatic ecosystems. J. Photochem and Photobiol. 46: 53-68.

35- Adams, S.B. and Kolo, R.J. (2006). Public health implications of Gurara River around Izam Environs, Niger State, Nigeria. Fisheries Society of Nigeria (FISON). Conference Proceedings.

36- **Abdo, M. H.; Sabae, S. Z.; Haroon, B. M.; Refaat, B.M. and Mohammed, A. S. (2010).** Physico-chemical characteristics, microbial assessment and antibiotic susceptibility of pathogenic bacteria of Ismailia Canal Water, River Nile, Egypt. J. American Science. 6(5):243-250.

37- **Al-Abadi, H. J.S. (2011).**Investigation of microbial and metal contamination of waters and sediments in Abu-Zariq Marsh southern of Iraq. M. Sc. Thesis. College of Science, University of Thi-Qar, Iraq.

38- **Byamukama, D.; Mach, R. L.; Kansiime, F.; Manafi, M. and Farnleitner, A. H. (2005).** Discrimination efficacy of Fecal Pollution detection in different aquatic habitats of a high-altitude tropical country, using presumptive Coliforms, Escherichia coli, and Clostridium perfringens Spores. Appl. Environ. Microbiol. 71(1): 65-71.

39- **Allen, M. J.; Brecher, R. W.; Copes, R.; Chair, S. E. and Payment. (2008).** Turbidity and microbial risk in drinking water. The minister of health, province of British Columbia: 47 pp.