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Assessment of Water Quality of Tigris River and branches in Alkut City using Water Quality Index

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Abstract

Our water quality continues to be negatively impacted by human activities, this is a global problem of critical importance (particularly concerning fresh water and human consumption). Since the 1960s, the critical water quality index (WQI) technique has been used to assess the worldwide water quality state of surface water and groundwater systems. Plans for water resource management must consider extensive data and knowledge about the quality of available water. Water quality indicators are a straightforward technical method for evaluating the state of a river's water quality. In this approach, many water quality characteristics are examined and interpreted in research on river water quality. It can be considered the most important parts of monitoring plans for river quality. In this study, a monitoring plan is achieved for three different stations located on Tigris and branch rivers Al-Dujaili and Al-Gharraf in Wasit/ Al-Kut during the study period for eight weeks from 1/3/2022 to 1/5/2022. Water quality assessment has been conducted using arithmetic quality indices of general water used for drinking and agricultural consumption. It is where the qualitative indices are turned into a single number with no units. Classifying water quality is done by comparing the values of the indices to a scale of ratings that have already been set up. In this study, It has been utilized the Water Quality Index. The following physical and chemical factors are used to determine the water quality index: pH, total dissolved solids (TDS), turbidity, biological oxygen demand (BOD_5), nitrate (NO_3), sulphate (SO_4), chloride (Cl), and phosphate (PO_4). The results showed that each station hal a low rating for the water quality index The average readings for the Tigris River were 187.44, Al-Dujaili 211.49 and Al-Gharraf 255.85, showing that Tigris River and its branches' water is seriously polluted for aquatic life due to the discharge of insufficiently treated wastewater from Al-Kut's residential neighbourhoods.

Keywords: Water Quality Index, River Tigris, Al kut City.

الخلاصة : لا تزال جودة المياه لدينا تتأثر سلبًا بالأنشطة البشرية ، فهذه مشكلة عالمية ذات أهمية حاسمة (خاصة فيما يتعلق بالمياه العذبة والاستهلاك البشري). منذ الستينيات ، تم استخدام تقنية مؤشر جودة المياه الحرج (WQI) لتقييم حالة جودة المياه في جميع أنحاء العالم لأنظمة المياه السطحية والجوفية. يجب أن تأخذ خطط إدارة الموارد المائية في الاعتبار البيانات والمعرفة الواسعة حول جودة المياه المتاحة. مؤشرات جودة المياه هي طريقة فنية مباشرة لتقييم حالة جودة مياه النهر. في هذا النهج ، يتم فحص العديد من خصائص جودة المياه وتفسيرها في البحث حول جودة مياه الأنهار. يمكن اعتباره أهم أجزاء خطط مراقبة جودة النهر. في هذه الدراسة تم إنجاز خطة رصد لثلاث محطات مختلفة تقع على نهر دجلة ونهر الدجيلي والغراف في واسط / الكوت خلال فترة الدراسة لمدة ثمانية أسابيع من 2022/3/1 إلى 2022/5/1. تم إجراء تقييم جودة المياه باستخدام مؤشرات الجودة الحسابية للمياه العامة المستخدمة للشرب والاستهلاك الزراعي. حيث يتم تحويل المؤشرات النوعية إلى رقم واحد بدون وحدات. يتم تصنيف جودة المياه من خلال مقارنة قيم المؤشرات بمقياس التصنيفات الذي تم إعداده بالفعل. في هذه الدراسة ، تم استخدام مؤشر جودة المياه. تُستخدم العوامل الفيزيائية والكيميائية التالية لتحديد مؤشر جودة المياه: الرقم الهيدروجيني ، إجمالي المواد الصلبة الذائبة (TDS) ، التعكر ، الطلب البيولوجي على الأكسجين (BOD_5) ، النترات (NO_3) ، الكبريتات (SO_4) ، الكلوريد (Cl) ، والفوسفات (PO_4). وأظهرت النتائج أن كل محطة لديها تصنيف منخفض لمؤشر جودة المياه ، حيث بلغ متوسط قراءات نهر دجلة 187.44 ، والدجيلي 211.49 والغراف 255.85 ، مما يدل على أن مياه نهر دجلة وفروعه ملوثة بشكل خطير للحياة المائية بسبب لتصريف مياه الصرف الصحي المعالجة بشكل غير كاف من الأحياء السكنية في الكوت.

1. INTRODUCTION

WQI gives essential data about the general water quality status that can be used to choose the best water-treatment method to deal with pollution[1]. High-quality river water is necessary to protect drinking water supplies, promote leisure activities, and establish an ecosystem suitable for fishing and wildlife. In this context, identifying water quality metrics is crucial to evaluating surface water's condition, quality, and degree of pollution. To communicate the findings to experts, related data must be analyzed. Using water quality indices is of the simplest ways to estimate the state of the water source [2]. The main factors affecting surface water quality are human actions and environmental factors. Without these sources, the physical and chemical characteristics of water may be changed by atmospheric processes, rock mineralization, nutrient spills, soil organic matter, hydrological factors, and biological activities inside aquatic creatures[3]. The water quality index was established to serve as a gauge of the chemical and physical quality of water, but it may also be used as a gauge of the environment[1]. River water pollution necessitates considerable effort, and water quality is a critical concern in the domain of creating and managing water resources and requires the collection, analysis, and interpretation of data [4]. The Water Quality Index (WQI) is a simple method for determining the general water quality by using a variety of variables that reduce a vast amount of data to a single, frequently dimensionless number in a repeatable manner [5]. The domestic, agricultural, and industrial uses of water are greatly influenced by its hydrogeochemical properties. The chemistry and quality of the water are significantly impacted by how the water interacts with the lithological units that it runs over [6].Several methods have been developed to evaluate the chemical and quality of the river's water [7]. The type of water needed to maintain thriving ecosystems is significantly influenced by the environment. Small changes in the physical and chemical makeup of a body of water can have a big influence on other aquatic ecosystems, harming their ability to provide ecosystem services and lowering their biological diversity. Some aquatic ecosystems can endure substantial changes in water quality without noting any changes to their composition or functionality. The physical and chemical quality of water deteriorates over time as a result of human activities [6]. The controls on the hydrochemistry and the number of regulating elements at different flow system locations were examined using conventional graphical methods along with multivariate statistical methods and GIS. Additionally, the research area's groundwater suitability for human consumption was assessed using the water quality index (WQI) method [8]. The kind of water needed to maintain thriving ecosystems is greatly influenced by the environment. Because they are sensitive to even the slightest changes in the physical and chemical composition of the body of water, other aquatic ecosystems are also prone to the degradation of ecosystem services and loss of biological diversity. Some aquatic habitats may be able to sustain significant changes in water quality without any noticeable effects on the ecosystem's structure and function. As a result of human activity, the physical and chemical quality of water gradually deteriorates over time[9]. By comparing a sample's physical and chemical characteristics to predetermined standards, water quality is frequently determined. To ensure that clean, safe drinking water is available for human use and to protect human health, guidelines and standards for drinking water quality are developed. These are frequently based on levels of toxicity for people or aquatic life that have been proven to be acceptable by science. [10, 11]. It offers essential details about the current state of the water's general quality, which can be very helpful in choosing the best water-treatment strategy to address the pollution problem [12]. When classifying surface waters using common water characterization metrics, the WQI has been taken into consideration as one criterion. For the majority of domestic usage, it gives a thorough picture of the water quality. WQI is a mathematical instrument that reduces enormous amounts of data on the characterization of water to a single number that represents the degree of water quality. A simple way to assess the condition of the water supply is by using indicators of water quality. A very easy way to evaluate water quality issues is to apply water quality indices, which are viewed as a methodology for delivering a cumulatively formed mathematical term defining a specific degree of water quality [9]. A simple way to assess the condition of the water supply is to use water quality indicators. An easy method to evaluate water quality issues is by applying water quality indices, which are viewed as a method for offering a cumulatively formed mathematical expression reflecting a specific degree of water quality [13]. WQI identifies and analyzes water quality backdrops over time, which may be used in a variety of ways as an ecological indicator to determine the efficacy of water quality management activities[14,9]. The outstanding and regularly established water quality criteria were used in the Weighted Arithmetic Water Quality Index Method to characterize the water quality as shown by the level of virtue [15]. Tigris River is a large river in Iraq that provides Al Kut City in Wasit with a sizable amount of potable water. To reduce biological, chemical, and physical contamination of freshwater, an assessment must be conducted. Tigris, is a big river in Iraq, that provides a major supply of drinking water for Al Kut and Wasit [16]. Particularly in the southern portion of the city, Kut's wastewater treatment facilities are underdeveloped. This causes a significant amount of effluent to be discharged straight into the river or its tributaries. Domestic waste is dumped on both banks of the river within the city, which not only presents difficulties but is harmful to the ecology and general health [17]. This study aims to assess the Tigris River and its tributaries' water quality requirements inside the Al Kut city limits. Additionally, decision-makers might use GIS mapping by adopting the quantum GIS established lengthways to the river according to water quality metrics to present and compare the water value data, related information, and distribution of contaminated river segments in simple projected maps.

2. MATERIALS AND METHODS

There were three sampling stations chosen. During the research period, clean polyethylene bottles were used to collect water samples from the banks of the Tigris River, Al-Dujaili, and Al-Gharraf branches in the city center of AlKut at the beginning of each week for eight weeks from March to May 2022. Several physical and chemical factors were utilized to build the water quality index based on the availability and significance of data. These locations include places affected by the discharge of the domestic waste Water Handling Facility at the original site, as well as other locations where industrial and agricultural activity and human waste were present in the river. pH, total dissolved solids (TDS), turbidity, biological oxygen demand (BOD_5), total nitrates (NO_3), total phosphate (PO_4), sulphate (SO_4), electrical conductivity, and turbidity are among the elements to examine (EC).

The term "biochemical oxygen demand" (BOD) is used to quantify the amount of oxygen consumed by microbes during the decomposition of organic waste.After the samples were transferred into OxiTop bottles, a magnetic stirring rod was applied. In the neck of the bottle, a rubber quiver is placed. The tweezers were used to place three tablets of sodium hydroxide into the rubber quiver. The OxiTop bottle was tightly sealed, and the S and M buttons were simultaneously pressed for two seconds until the display read 00. In the stirring tray, the bottles were incubated for five days at 20 degrees Celsius. After five days, stored values were read by pressing m for one second till the values appeared. (Adapted from the OxiTop Manual).The pH indicates the acidity or alkalinity of water. The pH of all water-related operations in this investigation must be consistent. the pH meter (type WTW, Germany) utilized in this investigation.

TDS levels are measured in water because high levels can harm aquatic river life and crop irrigation and be unfit for drinking. It has the potential to create foaming and corrode some metals. The suspended solid was separated from 50 ml (V) of the sample by filter paper. The beaker was weighed (W1) and filled with the filtered sample, the sample was dried in the oven at 180 C for 1 hour, and then the cup with the dissolved solid was weighed again (W2). TDS can be calculated- :-

$$\text{T.D.S (Mg\textbackslash l)} = \frac{W2-W1}{V} * 1000 * 1000 \quad (1)$$

Where:

V= volume of sample, (L).

W1=weight of a cup filled by filtered sample, (g).

W2= weight of cup with the dissolved solid, (g).

The turbid meter requires a nephelometer with a light hotspot to illuminate the sample and at least one image electric locator with an information device to display the right quantity of light dispersed along boundaries related to the direction of incident light. The turbidity meter (type WTW - Germany) utilized in this study. Electrical conductivity (EC) quantifies the capacity of water to conduct electricity. The EC was calculated using portable equipment (a conductivity, TDS, and °C meter), and the instrument indication was converted to conductivity indicators. To calculate the sulfate, 100 ml of the sample was diluted with 100 ml of distilled water in a 400 ml beaker. Add several drops of methyl red reagent. Add two milliliters of hydrochloric acid. The solution is heated for some time. Then, add 10-15 ml of barium chloride while stirring continuously, and it will precipitate. The solution of barium sulfate is placed in the water bath for a second day. On the second day, the solution is filtered using filter paper and hot water is added because cold water dissolves the precipitate. Now the residue is no longer chloride-free. Examining a portion of the filtrate of silver nitrate solution does this. Burn the sample at 800 degrees for one hour, then allow it to cool and weigh it.

$$\text{Sulphates concentration } (SO_4) \text{ mg/lit} = (A-B)/(N * 411.5) \quad (2)$$

Where:

A= Evaporating dish weight with sediment (gm)

B= Evaporating dish weight empty (gm)

N= weight of sample used (gm)   411.5= Atomic weight of sulfate

When performing calculation No_3, place 5 ml of the sample and 5 ml of distilled water for the Blank in a beaker with a volume of 50 ml; add 1 ml of the previously prepared brucine solution to the sample but not to the Blank beaker; then prepare 10 ml of sulfuric acid and begin adding acid to each of the beakers. The sample and the Blank become progressively weaker and a homogenization technique is performed for each beaker. Following this, 10 ml of distilled water is added to the sample and Blank, and the mixture is left to rest for 10 minutes. The sample and the Blank are passed to the waveform test instrument, where the plank is used to whistle the instrument's readout. The sample is placed into the waveform at wavelength 410, and its nitrate concentration is measured. The Nitrate concentration was then determined using the APHA (1999) technique.

When calculating po_4 add 10 ml of reagent (Vanadite-Modibelt) to each sample, completing the volumes of both the sample and Blank with distilled water, leaving the solutions for 15 minutes, transferring the volume of Specific from the plank for zeroing and reading the absorbance of the two models at the wavelength (400) for the low concentration of phosphate and at the wavelength (470) for the high concentration of phosphate with a device that reads the absorbance of the two models After that, the method that was used to calculate the concentration of nitrate was the one that was specified in APHA (1999).

3. ALKUT CITY

Al-Kut is a city in Iraq that can be found to the southeast of Baghdad on the Tigris River's banks. There, in that location, is the administrative center of the Wasit Province. In terms of both land area and population, it is the largest town in the Wasit province. At the beginning of the 19th century, the city of Al-Kut was established along the banks of the Tigris River. The Tigris River flows through the town clockwise from northwest to northwest before turning southeast. Residents are afforded views of the riverbanks thanks to the fact that the Tigris River runs right through the middle of the city. This distinguishing characteristic gives the city its name. The town is located on a river peninsula because the river winds its way around the town, creating a border on three sides of the town.

3.1. Tigris River

It has always been a very important river, and it was of the main sources of water for the ancient civilizations of Mesopotamia. It starts in Turkey's Toros Mountains in Eastern Anatolia and flows southeast to Cizre, where it forms a 32-kilometer border between Turkey and Syria before going into Iraq. The river is about 1,900 km long, with 77 percent of it in Iraq, 22 percent in Turkey, and 7 percent in Syria (22 percent). (1 percent) [18]. Tigris is the main exporter of water life in AlKut. It is the main artery and the nerve of aquatic life in AlKut, where it originates from the northwest to the southeast and divides the city ofAl Kut into two parts. The first section is on the right-hand side. The second section may be seen on the left side. Four bridges connect the two portions of Al Kut city. The Al-Kut barrage is the first, followed by the Kut Bridge-New Ezzah, the Iron Bridge, and Al-Karamah Bridge.

3.2. Dujaili River

[19] Said it has been established that the Dujaili River is a tributary of the Tigris River. This river has a length of 69.45 kilometers, a width of 15 meters, a depth of 2.80 meters, and a discharge rate of 42.15 m3 per second. Its depth is 2.80 meters, while its breadth is 15 meters. In addition to that, the river provides water to 396,000 acres of land. Because the Al-Dujaili River is a branch of the Tigris River, its characteristics are, in turn, inherited from the Tigris River. It runs through Al-Kut city, passing through Wassit District, Wassit City Historical, and Lakash City Historical along the way. All of these cities are located in Al-Kut.

3.3. Al-Gharraf River

Al-Gharraf is the primary tributary of Tigris; it divides from Tigris south of Baghdad at the Al-Kut barrage and flows into the Euphrates basin via the governorates of Wasit and Dhi-Qar until ebbing out north of Nasseria city in southern Iraq. It has an approximate length of 230 kilometers, a maximum flow rate of 622 m3/s, and a drainage area of 435052 106 square meters. It has 52 channels and 968 water system trenches that branch out of it, which together irrigate 700,000 hectares [12]. Al-Gharraf encounters both human and environmental problems, such as a lack of water, the development of plants like the water hyacinth (Eichhornia crassipes), pollution, and the build-up of muck [20].

4. WATER SAMPLING

The collection of water samples occurred between 9 and 10 a.m. Using a GPS device to select point source; it consists of three places dispersed along the Tigris River and its branch within the city of Al-Kut (*45°50'0"-45°48'32")*E and (*32°31'33"-32°28'26"*). During the eight-week research period from March to May 2022, water samples from each of the three selected sampling stations were taken using clean polyethylene bottles from central Al-Kut city, two sides of Tigris river, and branches of Dujaili and Gharraf. Surface water samples were taken at a distance of 50-100 from the domestic wastewater of the residential areas of the city of AlKut. Chemical and physical testing was done in the Sanitary Engineering lab of the Civil Engineering Department at Wasit University. The water quality index was calculated using several of physical and chemical variables depending on the data's availability and importance. These locations include areas contaminated by the Domestic Waste Water Handling Facility's discharge at the original site, as well as additional locations where there was industrial and agricultural activity and human waste in the river. ph, total dissolved solids (TDS), turbidity, biological oxygen demand (BOD), total nitrates (NO_3), total phosphate (PO_4), sulphate (SO_4), and electrical conductivity are the variables (EC). Based on standards for the preservation of aquatic life, the water quality index for each place was calculated.

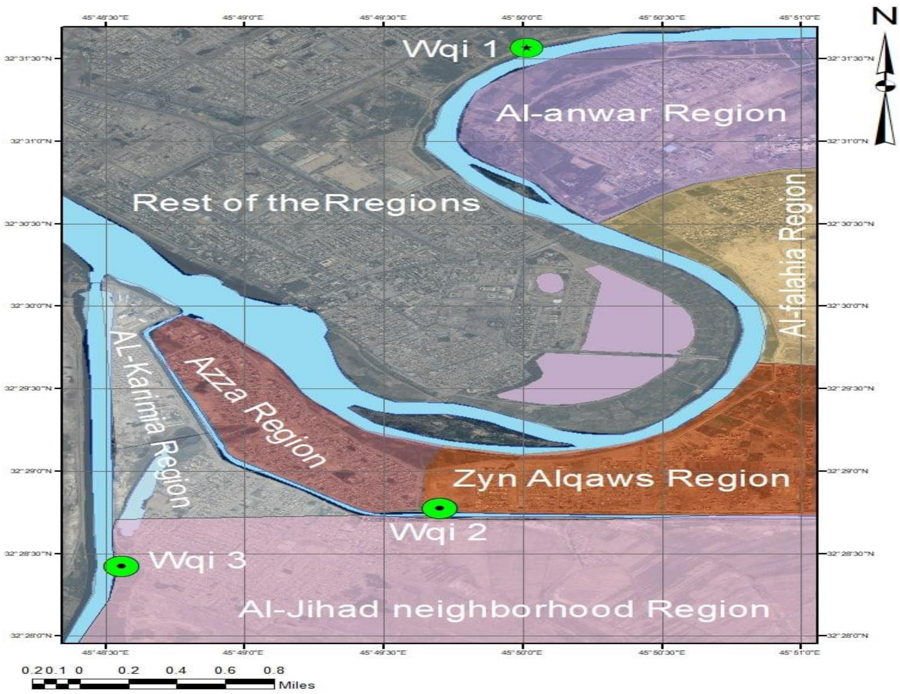

Figure 1 The map and the sampling stations of the study area. Into Tigris river and branch (Arc GIS 10.8).

Table 1. Samples location.

Station (#)	Location	Longitude	Latitude
1	**Tigris**	45°50'0"	32°31'33"
2	**Dujaili**	45°49'41"	32°28'44"
3	**Gharraf**	45°48'32"	32°28'26"

5. WATER QUALITY INDEX (WQI) CALCULATIONS

To complete the evaluation and measurement of the water quality index, each water sample was subjected to eight physical and chemical parameters. The physical and chemical parameters are shown and explained at the beginning of this paper.

The water quality index was measured As shown in equation 1, the quality ranking scale for each variable (q_i) is calculated by the division the actual concentration (C_i) of each parameter by the allowable concentration (S_i) for this parameter and multiplied by 100 [21].

$$q_i = (C_i/S_i)*100 \tag{3}$$

Table 2 shows the WHO and Iraqi standard specifications for the water parameters that were used in this study.

Calculation of the relative weight (W_i) for each parameter, and this relative weight is inversely proportional to the standard concentration (S_i).

$$W_i=1/S_i \tag{4}$$

WQI then can be computed by the division of the cumulative summation of the product quality ranking scale (q_i) and the relative weight (W_i) by the cumulative summation of relative weight (W_i).

$$WQI= (\sum_{i=1}^{i=n} q_i \times w_i)/(\sum_{i=1}^{i=n} w_i) \tag{5}$$

The value of WQI can be compared with the standards of WQI as shown in Table 2.

Table 2 WHO and Iraqi Standard specifications for drinking water parameters.

Parameter	Unit	WHO Standards	Iraqi Standards
BOD_5	mg/l	5	5
TDS	mg/l	1000	1000
pH	Unit less	8.5 – 6.5	8.5 – 6.5
E.C	(μ/cm)	1000	1000
Turbidity	NTU	5	5
Chloride CL	mg/l	250	250
Sulfates SO_4	mg/l	400	250
Nitrates NO_3	mg/l	10	50

6. RESULT AND DISCUSSION

The results are mean standards obtained for two months of the research period for the characterization of water are shown in Tables 2, 3 and 4. Table 2 refers to Tigris, Table 3 refers to Dujaili River, and Table 4 refers to Gharraf River.

Table 3. Characterization of water (WQI) for Stations 1.

No.	Parameters	Unit	C_i	S_i	q_i	W_i	$W_i * q_i$
1	BOD_5	(mg/L)	4.75	40	11.88	0.03	0.30
2	T.D.S	(mg/L)	736.25	1000	73.63	0.00	0.07
3	E.C	(μ/cm)	1292.75	1000	129.28	0.00	0.13
4	pH		7.575	7.5	101.00	0.13	13.47
5	CL	(mg/L)	132	250	52.80	0.00	0.21
6	SO_4	(mg/L)	251.75	250	100.70	0.00	0.40
7	NO_3	(mg/L)	5.2125	50	10.43	0.02	0.21
8	TURB.	(NTU)	14.5	5	290.00	0.20	58.00
		Summation		**0.39**		**72.79**	
WQI						**187.44**	

Table 4. Characterization of water (WQI) for Stations 2.

No.	Parameters	Unit	C_i	S_i	q_i	W_i	$W_i * q_i$
1	BOD_5	(mg/L)	16.375	40	40.94	0.03	1.02
2	T.D.S	(mg/L)	826.875	1000	82.69	0.00	0.08
3	E.C	(µ/cm)	1293.75	1000	129.38	0.00	0.13
4	pH		7.6375	7.5	101.83	0.13	13.58
5	CL	(mg/L)	133.875	250	53.55	0.00	0.21
6	SO_4	(mg/L)	243.375	250	97.35	0.00	0.39
7	NO_3	(mg/L)	5.3	50	10.60	0.02	0.21
8	TURB	(NTU)	16.625	5	332.50	0.20	66.50
Summation						**0.39**	**82.13**
WQI						**211.49**	

Table 5. Characterization of water (WQI) for Stations 3.

No.	Parameters	Unit	C_i	S_i	q_i	W_i	$W_i * q_i$
1	BOD5	(mg/L)	78.75	40	196.88	0.03	4.92
2	T.D.S	(mg/L)	898.75	1000	89.88	0.00	0.09
3	E.C	(µ/cm)	1445.625	1000	144.56	0.00	0.14
4	pH		7.75	7.5	103.33	0.13	13.78
5	CL	(mg/L)	144.125	250	57.65	0.00	0.23
6	SO_4	(mg/L)	279.125	250	111.65	0.00	0.45
7	NO_3	(mg/L)	6.125	50	12.25	0.02	0.25
8	TURB.	(NTU)	19.875	5	397.50	0.20	79.50
Summation						**0.39**	**99.36**
WQI						**255.85**	

6.1 Data analysis

To give a complete picture of the results, WHO Standards were used in the WQI calculations and the comparison of the collected data with standard water quality based on the Tables 3, 4, and 5 as shown in Tables 6, and 7.

Table 6 WHO specifications for river water parameters.

Parameters	Unit	WHO Standards
BOD_5	(mg/L)	40
T.D.S	(mg/L)	1000
E.C	(µ/cm)	1000
PH	-	7.5
CL	(mg/L)	250
SO_4	(mg/L)	250
NO_3	(mg/L)	50
TURB.	(NTU)	5

Table 7 Water quality classification depends on the value of WQ I [22]

WQI	Water Quality
Less than 50	Excellent
50-100	Good
100-200	Poor
200-300	Very Poor
More than 300	Unsuitable for drinking

6.2 Tigris river results

The effect of the analysis of physical and chemical parameters for WQI calculation showed that the level of TDS varied from 675 mg/L in the station (wqi1) to 800, and there were differences. Among the readings due to changes in temperature and humidity during the sampling period, all readings were less than 1000 mg/L TDS at Station (Wqi1) which was not suitable for drinking water [1] The pH of the water was between 7.50– 7.8 range, 7.6 at the station (Wqi1) within Iraqi standards of drinking water (6.5 -8.5) water has alkaline value, as shown by multiple previous investigations of Iraqi surface water [23]. In this study, BOD_5 values ranged from 4.5 mg\L less than 5 mg\L to 5 mg/L at the station (WQI1) which was equal to 5 mg/L Within the limits of the standard specifications set by the Iraqi standards, On the other hand, it was found that the turbidity values were of 12 to 16 NTU and It exceeded the 5 NTU specified by Iraqi drinking water guidelines, which has a significant impact on the WQI rating. Nitrate level in the river varied from 4.7 mg/L to 5.7 in the station (WQI1), which was within the standard level of mg/l, there were differences due to temperature changes in the river, the specification was within the limits of 50 mg/l and which were not drinkable. While the values of chlorides ranged from 125 to 140 mg/l in station No. 1, these values were lower than the Iraqi standard (250 mg/l). The level of sulphate in the river ranged from 231 mg / l to 271 in station (Wqi1), which was higher than the standard level of mg/l, and there were differences due to changes in temperature and household materials that are excreted in the river, and the specifications were within 250 mg/L. Finally, electrical conductivity values ranged from 1245 µs/cm at the station (1) which was below the standards to 1365 µs/cm, and was more than the standard of 1000 µs/cm. This is due to the lack of ionic transport within pure water, and any salts or impurities dissolved in water enable water to conduct electricity when salts are dissolved in water, they split into ions, which are electrically charged atoms. The results of the study of theTigris River differed from the surface water, some within the specifications and others outside the specifications. The results showed that the waters of Tigris are polluted, and the figure below shows the cases of change in polluted water.

Table 8 The highest and lowest value of Tigris River during the research period**.**

Parameters	Unit	highest value	lowest value	WHO Standards
BOD_5	(mg/L)	5	4.5	5
T.D.S	(mg/L)	800	675	1000
E.C	(µ/cm)	1365	1245	1000
pH		7.8	7.5	8.5-6.5
CL	(mg/L)	140	125	250
SO_4	(mg/L)	271	231	250
NO_3	(mg/L)	5.7	4.7	50
TURB.	(NTU)	16	12	5

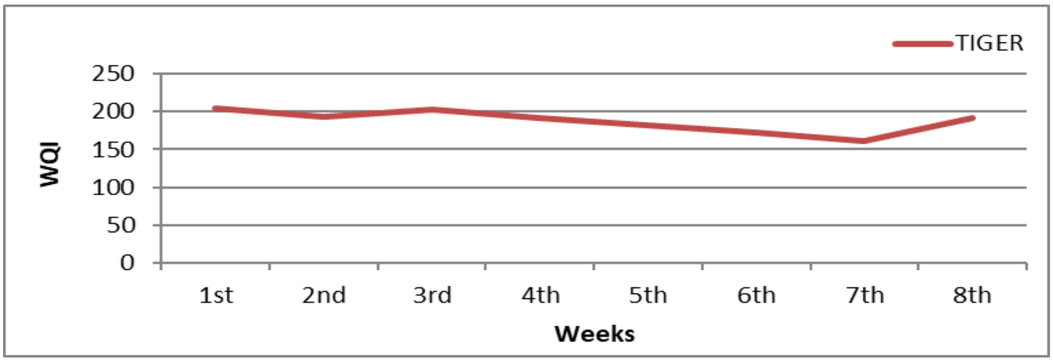

Figure 2. Values of water quality index for three stations.

6.3 Dujaili river results

The Dujaili River is a branch of Tigris branches inside the city of Al Kut and is adjacent to the residential areas. The river changes were studied for eight weeks, and the results showed the analysis of physical and chemical parameters to calculate the WQI that the level of from TDS of 750 mg/L at the station (wqi2) to 800 mg/L, there were different. Among the readings of the result of organic matter subtraction from sewage stations, soil friction and moisture during the sampling period, all readings were less than 1000 mg/L of total solids in station (wqi2) that were unsuitable for drinking water. The water pH was between 7.40-7.8 range, 7.612 in the station (wqi2) within the Iraqi standards for drinking water (6.5-8.5) all readings were within the limits the water had an alkaline value as in many previous research studies on Iraqi surface water. The BOD5 values ranged from 2 mg/l less than 5 mg/l to 75 mg/l in the station (1), which was more than 5 mg/l. The readings were rising during the examination period due to climate change, where the last two readings were outside the limits of Standard specifications defined by the Iraqi specifications. However, it was discovered that turbidity values ranged from 13 to 18 NTU, greater than the 5 NTU recommended by Iraqi regulations for drinking water. This has a significant impact on the WQI value and reduces the rate of oxygen delivery in the water, which leads to aquatic lifelessness. While the values of chlorides ranged from 125 to 148 mg/l in station no. (WQI 2), these values were lower than the Iraqi standard (250 mg/l) a high chloride concentration may be an indication of sewage or industrial waste contamination, as well as the entry of salt water or seawater into an aquifer or freshwater body of water. High chloride concentrations corrode metal pipelines and buildings and are toxic to most trees and plants. It would be easier to choose the best experimental water treatment techniques if the amount of chlorides in river water is kept to a minimum[24] Surface water nitrate contamination has received attention on a worldwide scale and is a problem that is getting more important. To determine the origins, levels, and any non-carcinogenic health concerns associated with nitrate pollution indicate a variety of sources, including as manure, wastewater, soil nitrogen, and inorganic fertilisers. Septic waste, inorganic fertiliser, and soil organic matter nitrification are the main sources of nitrate in river water. Nitrate level in the river varied from 5.1 mg/L to 6.2 in the station (WQI2), which was within the standard level of 50 mg/l, there were differences due to temperature changes in the river, the specification was within the limits of 50 mg/l and which were not drinkable [25]. The level of sulphate in the river ranged from 210 to 289 mg/L in Station (WQI2)which is higher than the standard mg/L level, and there were differences due to changes in temperature, acid rain and household substances excreted in the river It can also be formed from the leakage of sulphates to water, which is present in some types of soil and rocks Shows the impact of sulphur water on the environment significantly, The sulphates present in marine life affect fish One of the effects of excess sulphur water on the human immune system is that it causes cancer and the specifications were within 250 mg/[26]. Finally, electrical conductivity values ranged from 1200 µs/cm at the station (wqi2) which was below the standard to 1490 µs/cm, and it was more than the standard of 1000 µs/cm. The results showed that the water branch of the Dujaili River is more polluted than Tigris, according to the study of surface water.

Table 9 The highest and lowest value of Dujaili River during the research period.

Parameters	Unit	highest value	lowest value	WHO Standards
BOD_5	(mg/L)	75	2	5
T.D.S	(mg/L)	800	750	1000
E.C	(µ/cm)	1490	1200	1000
pH		7.8	7.4	8.5-6.5
CL	(mg/L)	148	125	250
SO_4	(mg/L)	289	210	250
NO_3	(mg/L)	6.2	5.1	50
TURB.	(NTU)	18	13	5

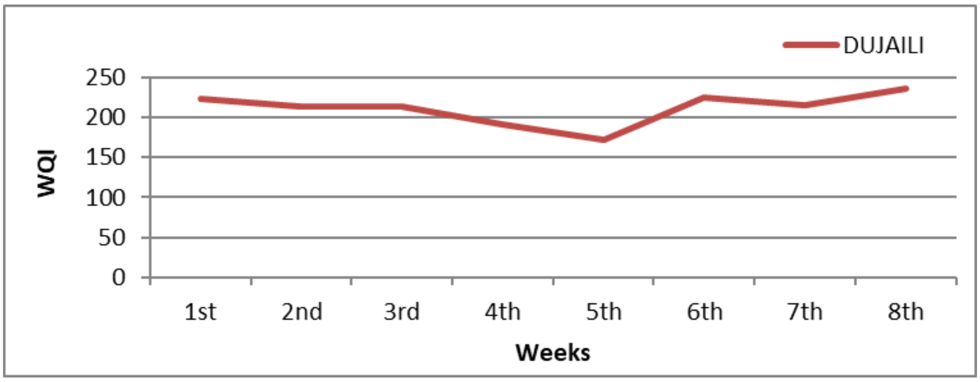

Figure 3 Values of water quality index for three stations.

6.4 Al-Gharraf river results

Al-Gharraf River is a branch of Tigris branches, and it branches off from Tigris at the barrage of the city ofAl Kut in Waist Governorate and passes through the cities of Al-Muwaffia and the district, then enters the territory of Dhi Qar Governorate and passes through the cities towards Al-Fajr, the city of Qalaat Sukkar, Al-Rifai, Al-Nasr district, Al-Shatra and Al-Gharraf sub-district It is adjacent to many residential and agricultural areas within the city [18] The number of TDS ranged from 850 mg/L at the station (WQI3) to 975 mg/L, and there were discrepancies, according to the study of physical and chemical parameters for WQI calculation. All values at Station (WQI3) were less than 1000 mg/L TDS, which meant that the water was unfit for drinking owing to variations in temperature and humidity throughout the sample period. The pH of the water was in the range of 7.6 to 7.9, 7.6 at the station (WQI3), and within the range of Iraqi regulations for drinking water (6.5 to 8.5), meaning that it had an alkaline value[27]. PH is an important factor that tells whether water is good for different uses. The range of pH values found in this study was mostly the same as the pH values of fresh water[28]. In this study, the BOD values ranged from (60-125) mg/L to more than 5 mg/L (WQI3) outside the limits of the standard specifications set by the Iraqi standards. The reason for the high amount of bod in the Garraf River is due to the direct disposal of household waste in large quantities, as well as industrial waste This will affect the fish in the river and affect the farmers who use the water for irrigation This agrees with[29]**.** On the other hand, it was found that the turbidity values were 19 to 21 NTU and which was higher than the 5 NTU suggested by the Iraqi standards for drinking water, the soil erosion in the nearby catchment and a large number of suspended solids from untreated sewage was thought to be to blame for the increased turbidity during rainy seasons. Most of the increased turbidity comes from surface runoff and household waste [30]. While the values of chlorides ranged from 130 to 148 mg/l in station no. (WQI3), these values were lower than the Iraqi standard (250 mg/l) a high chloride concentration may be Effluents from small-scale industry and the disposal of waste from markets and residential usage polluting the water. To meet the water quality criteria, water quality management is thus vitally needed.[31]**.** Nitrate level in the river is varied from 5.8mg/L to 6.5 in the station (WQI3), which was within the standard level of 50 mg/l, there were differences due to temperature changes in the river, the specification was within the limits of 50 mg/l and which were not drinkable. The main sources of nitrate in the river water of manure and septic waste were inorganic fertiliser, residential sewage, and nitrification of soil organic matter. That means that nitrate contamination is made worse by human activity. In most provinces, there is a moderate danger to human health from nitrate in surface water. Children have a greater no carcinogenic health risk than adults [25]. Sulphate concentrations in the river at Station (WQI3) varied from 250 mg/L to 295 mg/L, above the standard amount of 250 mg/L. There were variations brought on by temperature shifts, acid rain, and domestic products dumped into the river. Additionally, it may result from sulphates, which are prevalent in particular kinds of soil and rocks, leaking into the water. Demonstrates the major effects of Sulphur water on the ecosystem. Fish are impacted by the sulphates found in marine life. The criteria were within 250 mg/L, and one of the impacts of high Sulphur water on the human immune system is that it promotes cancer. Finally, electrical conductivity values ranged from 1400 µs/cm at the station (WQI3) which is below the standards to 1540 µs/cm and it was more than the standard of 1000 µs/cm. The results showed that the water branch of Tigris River, the AL Gharraf, is more polluted inside the city due to fertilizers and household waste.

Table 10 The highest and lowest value of the Dujaili River during the research period.

Parameters	Unit	highest value	lowest value	WHO Standards
BOD_5	(mg/L)	125	60	5
T.D.S	(mg/L)	975	850	1000
E.C	(µ/cm)	1540	1400	1000
pH		7.9	7.6	8.5-6.5
CL	(mg/L)	250	130	250
SO_4	(mg/L)	295	250	250
NO_3	(mg/L)	6.5	5.8	50
TURB.	(NTU)	21	9	5

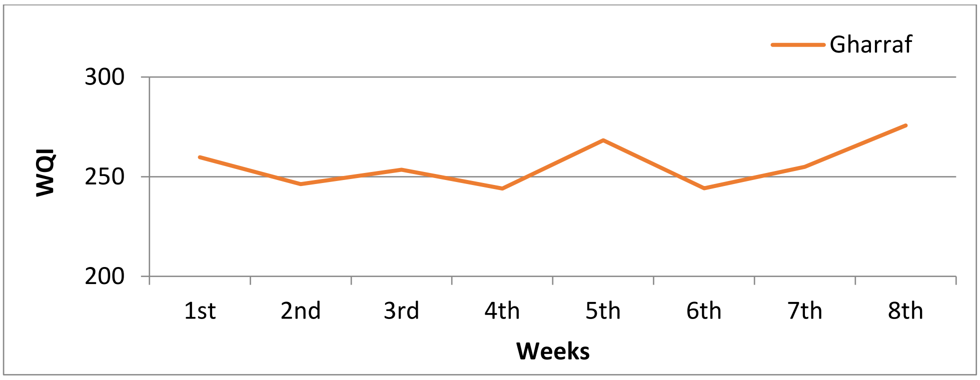

Figure 4. Values of water quality index for three stations.

7. CALCULATION AND CLASSIFICATION OF WATER QUALITY INDEX (WQI)

WQI is referred to as a rating that accounts for the combined impact of several water quality criteria[32]. The river water quality index was calculated from eight factors: BOD_5, TDS, pH, Ec, turbidity, PO_4, NO_3, and chlorides for three sampling stations for evaluation Drinking water of Tigris River And its branches are Dujaili and Al-Gharraf inside the city. The WQI was calculated using computational water quality. The results of the WQI calculation including the turbidity parameter classified the river as water-poor as for drinking in the main river, Tigris, over a period of eight weeks, the length of the research period was poor, and not for drinking purposes the WQI was calculated for the Dujaili branch of Tigris River (WQI_2). The water with turbidity is rated very poor and is not used for drinking objective. In addition, WQI was calculated in the branch of Tigris al-Gharraf (WQI_3), where it was found that it is the most polluted river, and the water was very poor and unsuitable for drinking due to direct household waste, as well as chemical fertilizers for agriculture. The change of WQI at the stations between Tigris River and its branches depends on the population density of the area and the change in pollutant discharges from one area to another, and the WQI value decreases as the river moves away from the residential areas The downstream direction was indicative of different pollutants entering the waterway Due to various human and natural factors such as release [33]. Mainly, the pollutants emitted from the residential area's plant that Contain chemicals, human activities, and wastewater are probably one of the most substantial reasons for the decline in water quality downstream Agricultural runoff and careless trash dumping are two potential sources of contamination with these contaminants. The water quality index for each location over the course of the study varied from 161.4 to 275.5, indicating that the water quality ranged from "extremely bad" to "unfit for drinking." According to this judgment, AL Kut's Tigris cannot be used as a source of drinkable water without first being treated. As a result, this study has provided sufficient data to assist government organizations in developing and implementing policies for river protection and public health.

8. COOMPARISON BETWEEN TIGRIS, DUGAILI AND AL-GHARRAF

The values of the rivers differed within the city, where the rate of pollution of Tigris River, which is the main artery inside Al Kut, was polluted during the first weeks. The pollution began to decline and came back up again, and the water, according to the classification WQI, was poor according to the analysis of the physical and chemical parameters. Tigris, a prominent river in the essential region of Iraq, provides water for the big command area in Wasit Governorate. The purpose of this investigation was to consider water quality and, as a consequence, to calculate pollutant loads on the river near its source. According to the research, the water quality is poor As for the water of the Dujaili River, it was parallel to Tigris in terms of pollution, as it was higher than Tigris River in the first, second, and third week and was equal to Tigris in the fourth week, and it started declining in the fifth week and re-increased in the sixth week, due to the high temperature and the quantities of household pollutants thrown into the river and the water according to the classification WQI were very poor according to the analysis of physical and chemical parameters Finally, the Gharraf River inside the city, which surrounds the population areas, was very polluted, as the pollution rates were high during the study period, as they exceeded Tigris, as well as the branch of Dujaili and Gharraf as a result of household pollutants and agricultural, industrial and oil factories inside the city. The river and the water according to the classification WQI were very poor according to the analysis of physical and chemical parameters.

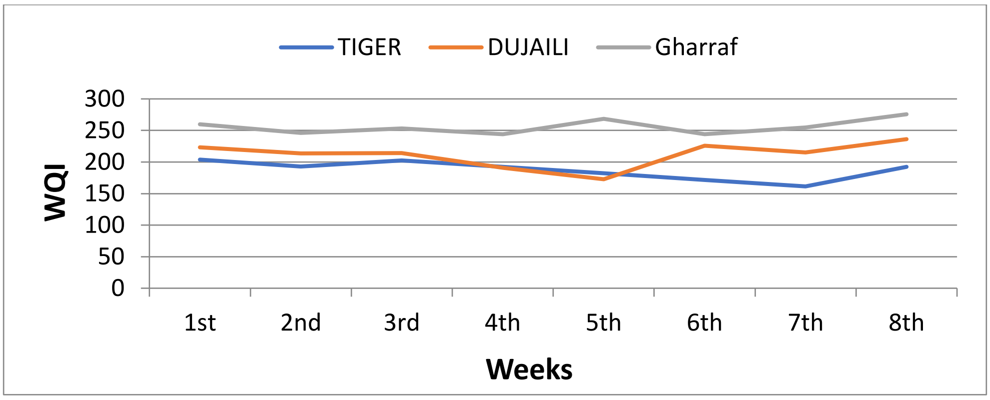

Figure 5 Comparison between the rivers.

9. CONCLUSION

This study evaluated the water quality and its suitability for use. The results indicate the physical and chemical analysis of the Tigris River inside the residential areas AlKut City. It is poor water due to the direct dumping of sewage into the river without any treatment, which is the main artery of the city, and the same is true for the Dujaili River (a Branch of the Tigris River inside the city). The results indicate that the water is very poor due to the large quantities of domestic water presented to the river without any treatment, water scarcity and high evaporation rates. Finally, the Al-Gharraf River, the Tigris branch inside the city, was studied, and it was found that it is not suitable for human use. It had the highest pollution rate compared to the Tigris and Al-Gharraf during the study period due to the domestic wastewater and the quantities of garbage inside the river, agricultural fertilizers and animal waste in the river.

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