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Spatial Analysis of the Pollution of the Euphrates River Water in the Abu Ghraib District (Physical Characteristics as a Model)

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ABSTRACT

The research investigates the physical characteristics of the Euphrates River water in the Abu Ghraib district, where the river flows southwest, demarcating it from Anbar Governorate. Geographically, the area lies between latitudes 33°8'40" - 33°15'23" N and longitudes 43°50'21" - 44°1'24" E. The study is based on fieldwork and laboratory analyses aimed at detecting pollution by analysing four physical parameters during summer and winter. These physical properties include water temperature, turbidity, dissolved solids, and electrical conductivity. To elucidate pollution levels, the study area was divided into ten sites along the river. By examining pollution indicators through samples taken from these sites and comparing them to permissible pollutant concentration standards for river waters, seasonal variations were observed due to sampling in both summer and winter. The evaluation of the suitability of the Euphrates River water in Abu Ghraib for human drinking, irrigation, and livestock drinking revealed that it is unsuitable for human consumption regarding turbidity and electrical conductivity. However, for agricultural irrigation, the water was found to be low in salinity and suitable for irrigating all crops across all soil types based on the American advisory committee's standards. Regarding total dissolved salts, the water was classified as highly saline, requiring drainage except for sites (5, 6, 7) during winter, which were moderately saline and needed filtration. Nevertheless, the water was deemed suitable for livestock drinking.

Keywords: Spatial Analysis, Euphrates River, Water Pollution, Abu Ghraib, Physical Characteristics.

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Introduction:

Water is the essence of life and the foundation for the creation of living organisms on Earth. It influences the existence and distribution of human, plant, and animal populations. The Euphrates River, along with the Tigris, is one of the main water sources in Iraq, with a total length of 2736 km, of which 1160 km flow through Iraq. It represents a vital economic resource and is crucial for various aspects of life in the study area, such as industry, agriculture, and human consumption. However, due to neglect of water resources and the reduction in Euphrates River flow caused by Turkish and Syrian impacts on water channels, as well as increased population growth driving higher water demand for domestic, agricultural, and industrial uses, pollution concentrations in the river have risen.

This research aims to determine the suitability of the Euphrates River water in the Abu Ghraib district for human drinking, livestock drinking, and irrigation purposes based on its physical characteristics.

The article has a question represents the problemof research What are the polluting characteristics of the river, and have these characteristics exceeded global and Iraqi standards, or are they within acceptable limits?

The research presents a scientific hypothesis, it is about: The physical characteristics of the Euphrates River water in the Abu Ghraib district vary temporally and spatially, its suitability varies according to global and Iraqi standard specifications.

Framework of the Research:

Studying the physical characteristics of the water of the Euphrates River in Abu Ghraib District and comparing the results with local and international standards and specifications to indicate its suitability for various uses (for human drinking, irrigation, and watering animals).

The Euphrates River gains special importance in Abu Ghraib District, as it is the primary water source in Abu Ghraib District and an important natural resource and is relied upon to meet various requirements, especially domestic and agricultural ones, as the district is one of the main areas supplied to the city of Baghdad with animal and agricultural products.

The boundaries of the research are represented by the course of the Euphrates River in Abu Ghraib District, one of the districts belonging to the Baghdad Governorate, which is located in its western part, map (1), as the Euphrates River penetrates it in its southwest, forming a natural and administrative border that separates it from the Anbar Governorate with a length of 38 km. As for astronomically, it is defined between two latitude circles (33°8'40" - 33°15'23") north and two longitudes (43°50'21" - 44°1'24") east.

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The research included taking samples from ten sites distributed along the river in the study area, and a GPS device was used to determine the geographical coordinates of the sample sites. These sites are shown in Table (1) and Map (2).

The time limits for the field study were the year 2023, which included sampling dates for the summer and winter seasons.

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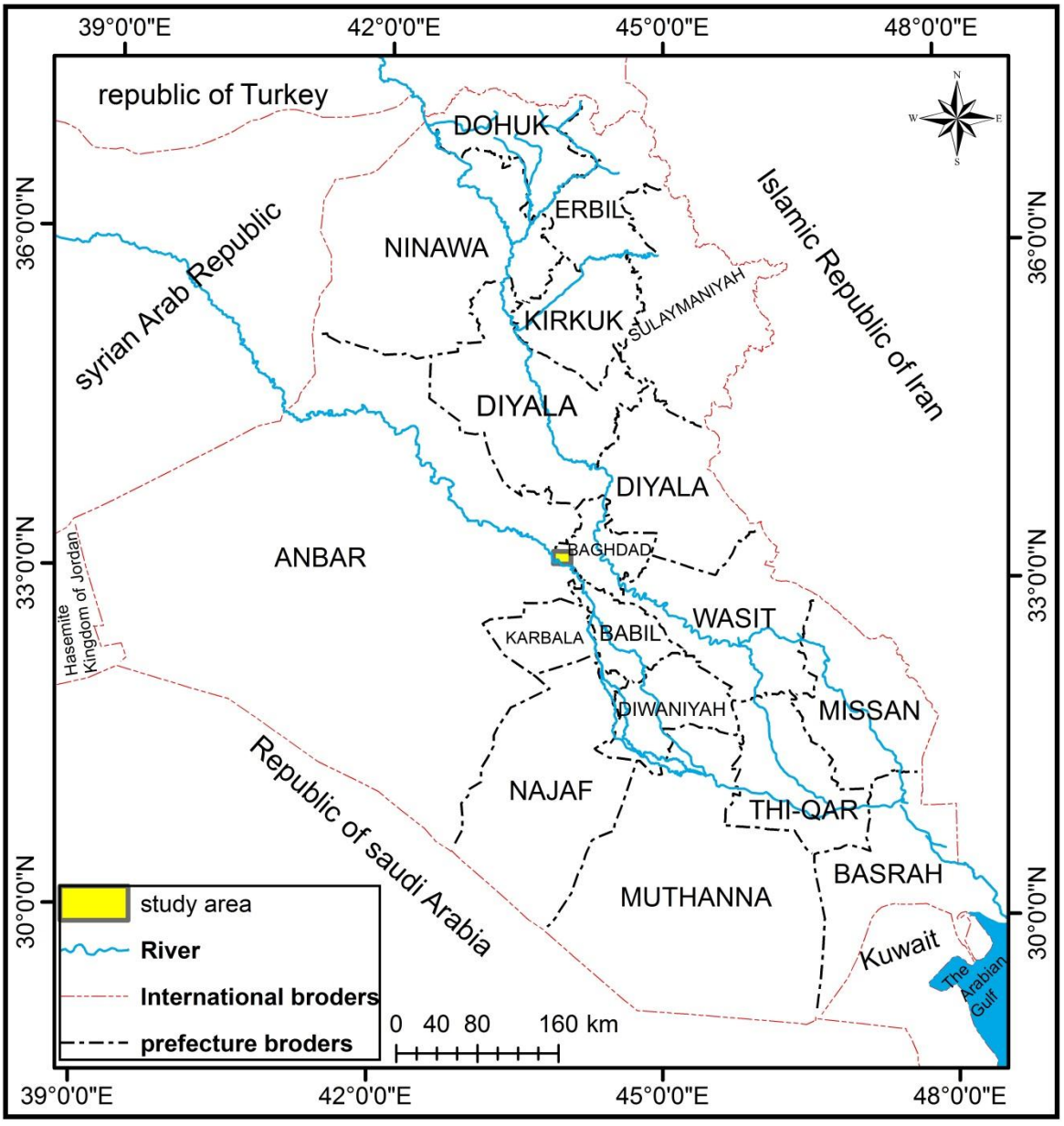
Map (1) of the study site in Iraq and Baghdad Governorate



Source: Based on the Ministry of Water Resources, the General Authority for Survey, the administrative map of Iraq, scale 1/1000000, year 2021, and the outputs of the Arc map 10.8 program.

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First: The physical characteristics of the water of the Euphrates River:

1-Temperature:

Temperature is one of the crucial physical characteristics of water, as its rise can lead to an increase in the growth of green algae, which is an indicator of river pollution. Additionally, higher temperatures can result in a decrease in dissolved oxygen levels and an increase in bacterial activity, leading to the decomposition of solid materials and a rise in the amount of decomposed microscopic bodies, subsequently increasing water turbidity.

As observed from tables (2 and 3), the water temperature of the Euphrates River in the study area ranged between 19.3°C and 25.2°C during the summer, and between 10.9°C and 14.2°C during the winter. These findings indicate seasonal variations in the river's water temperature, as shown in map (3). The reason for this variation is attributed to the sampling being conducted in two different seasons (summer and winter). However, the results were consistent among the sample sites within the same season. The highest temperature in the summer was recorded at site (9) with 25.2°C, while the highest winter temperature was recorded at site (5) with 14.2°C.

Table (1) Sample locations within the Euphrates River

Sample locations	Longitude coordinates(x)	Latitude Coordinates(y)
1	43° 50' 47" E	33° 15' 20" N
2	43° 50' 43" E	33° 13' 12" N
3	43° 51' 24" E	33° 11' 9" N
4	43° 53' 45" E	33° 10' 42" N
5	43° 52' 53" E	33° 12' 0" N
6	43° 54' 26" E	33° 12' 14" N
7	43° 56' 11" E	33° 10' 56" N
8	43° 57' 36" E	33° 9' 10" N
9	43° 59' 6" E	33° 9' 57" N
10	44° 1' 121" E	33° 9' 38" N

Source: Arc map 10.8 output.

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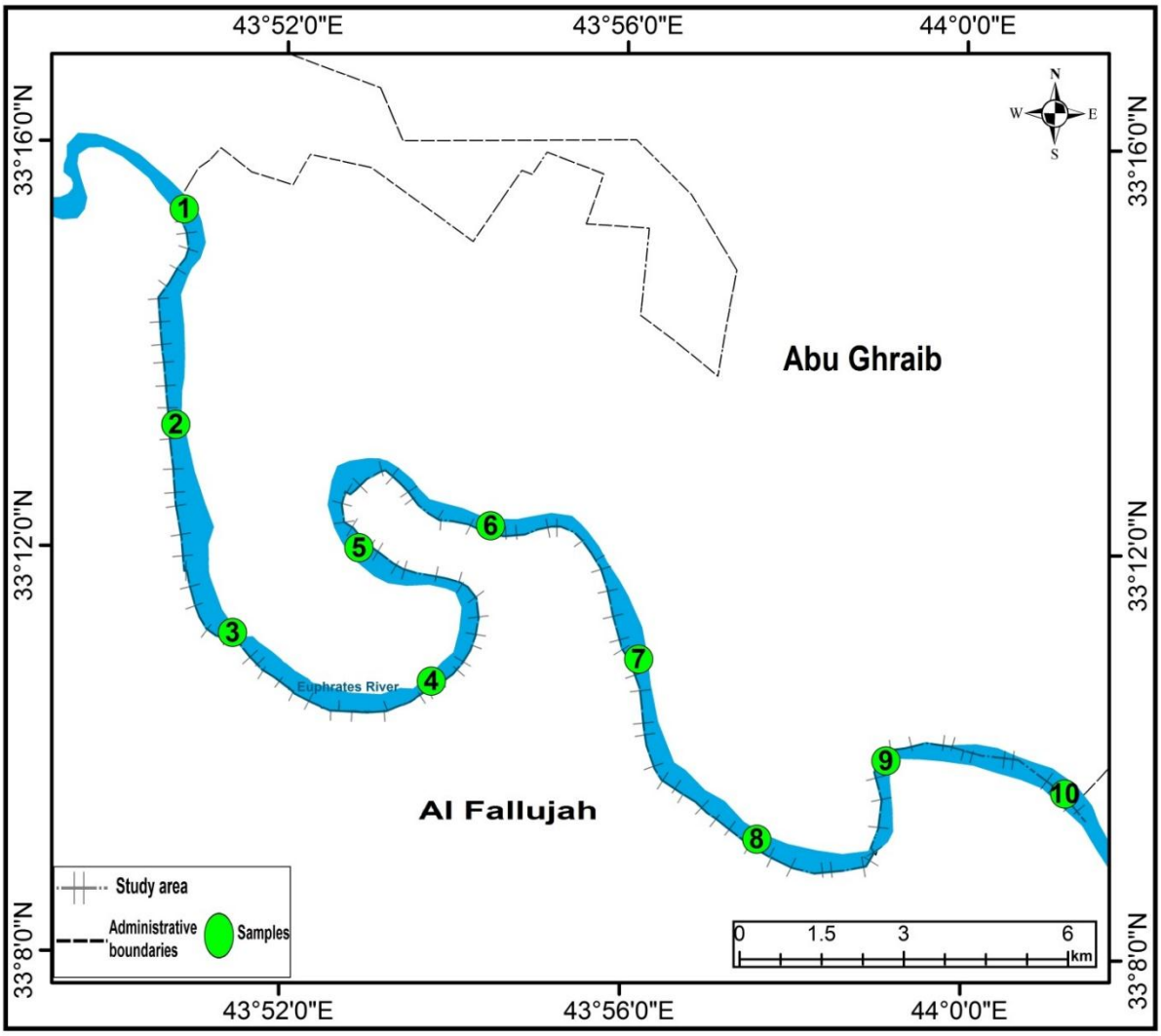
Map (2) locations of Euphrates River water samples



Source: Arc map 10.8 output.

As for the lowest value, it was recorded by site (1) for the summer season and reached (19.3) Celsius, and site (9) was recorded for the winter season and reached (10.9) Celsius. It is clear from the above that the water temperature was low and did not exceed the environmental limits, as they were all within the limits and were less than (35) C, so they did not affect the quality of the water.

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Table (2) Physical characteristics of the study area sites for the summer.

Property Site	TDS mg/L	Electrical conductivity micromoz/cm	Turbidity (NTU)	Temperature C
Location (1)	614	495	9.5	19.3
Location (2)	581	548	8.4	21.2
Location (3)	561	627	10.1	22.1
Location (4)	635	691	8.2	20.5
Location (5)	592	700	11.3	23.4
Location (6)	617	505	12.7	20.3
Location (7)	659	535	11.7	24.2
Location (8)	642	603	13.6	22.8
Location (9)	640	623	10.2	25.2
Location (10)	631	655	14.1	24.1

Source: 1- From the researcher's work based on the results of sample analysis in the laboratories of the Ministry of Science and Technology, Department of Environment and Water, Laboratory Department.

2- Field study dated 7/15/2023.

Table (3) Physical characteristics of the study area sites for the winter.

TDS mg/L	Electrical conductivity micromoz/cm	Turbidity NTU	Temperature C	Property Site
563	448	13.2	11.1	Location (1)
511	509	11.4	13.5	Location (2)
522	547	14.3	13.4	Location (3)
583	607	12.6	12.4	Location (4)
471	636	17.4	14.2	Location (5)

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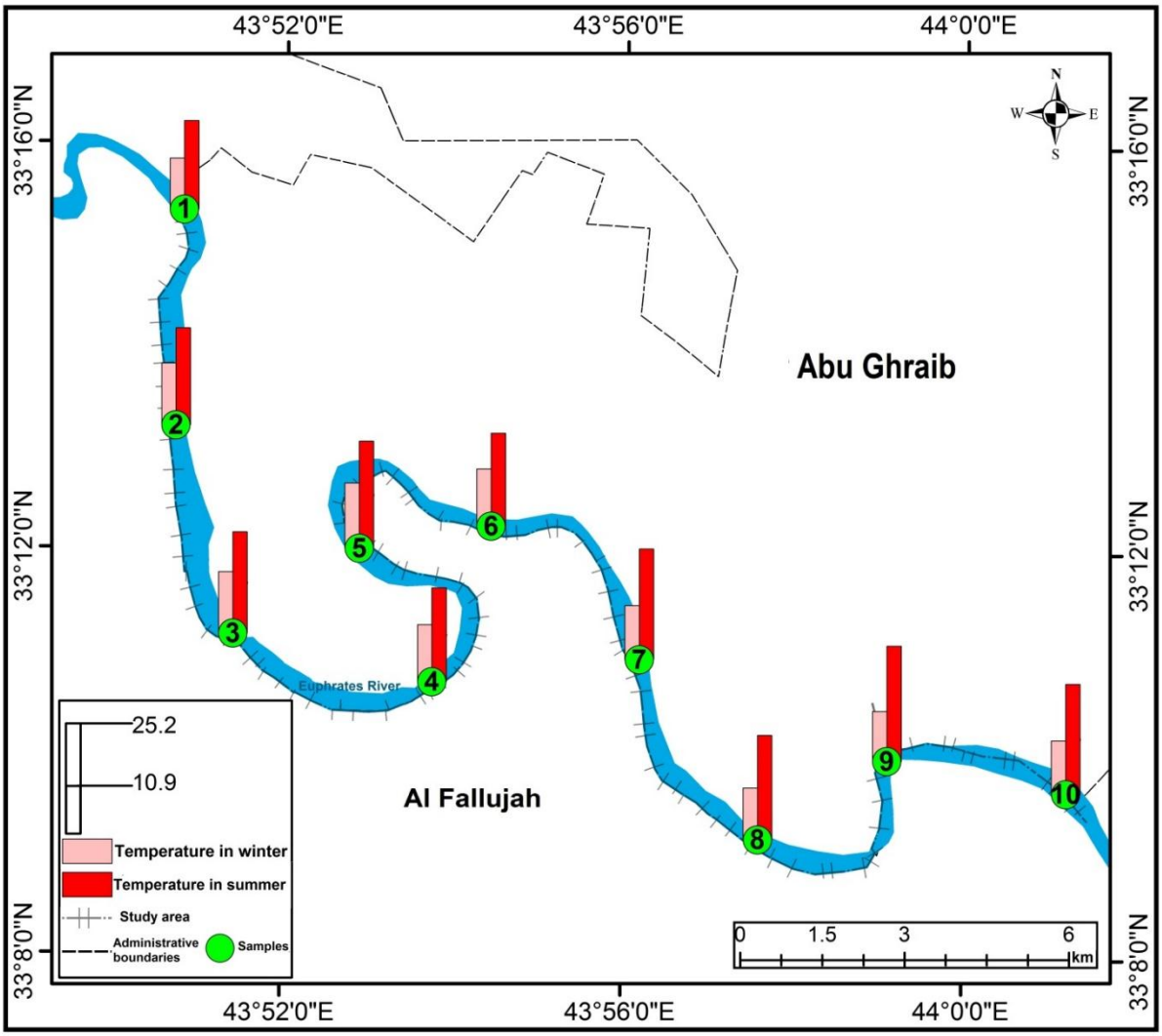
489	460	16.3	12.5	Location (6)
497	476	20.4	11.8	Location (7)
568	536	19.1	11.3	Location (8)
549	642	18.3	10.9	Location (9)
571	678	19.3	11.7	Location (10)

Source: 1- From the researcher's work based on the results of sample analysis in the laboratories of the Ministry of Science and Technology, Department of Environment and Water, Laboratory Department. Field study dated (12/20/2023)

Map (3) temperature values of the waters of the Euphrates River



Source: Arc map 10.8 output.

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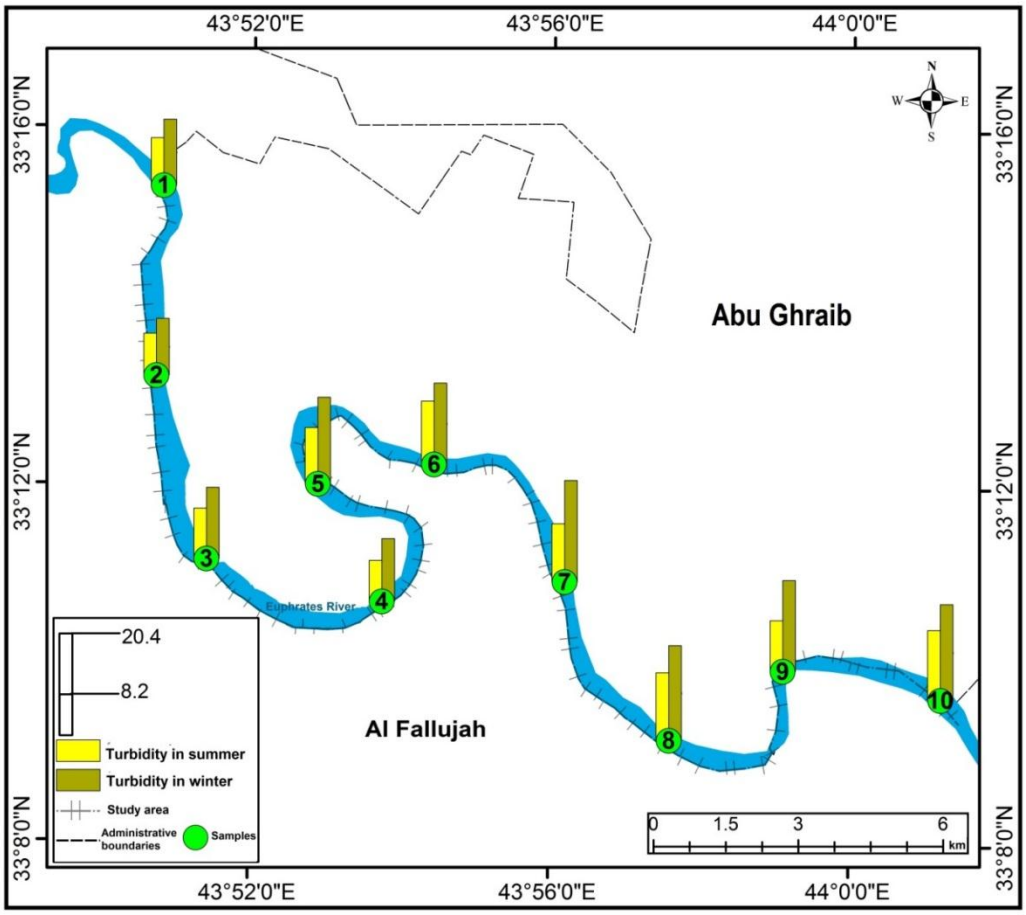
2. Turbidity:

Turbidity results from the presence of suspended or dissolved solids in river water, such as soil particles, sand, clay, and organic and inorganic materials. It also occurs due to the presence of bacteria, microorganisms, or floating plants. River water is characterized by a high turbidity value as a result of the movement of sediments with the water current (Abbawi, 1991).

It is clear from Table (2 and 3) and Map (4) that the values of turbidity concentrations were higher in the winter than in the summer due to the increase in the number of suspended materials such as clay and silt that increase during times of rain, in addition to the speed of water flow at the time of taking samples as the turbidity changes. Water with changing speed of flow, as site (7) recorded the highest values for the winter and reached (20.4), while the highest values for the summer were recorded by site (10) and reached (14.1).

Map (4) Turbidity values for the water of the Euphrates River



Source: Arc map 10.8 output.

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3. Electrical conductivity:

Electrical conductivity is the ability of water to conduct an electric current, and this value depends on the water temperature and the concentration of dissolved solids. The content of dissolved salts in the water is expressed in units of electrical conductivity, which increases by 2% for each 1°C rise in temperature. Elevated values indicate a high concentration of salts, particularly chlorides, sodium, calcium, and magnesium, which can result from either human activities or natural processes (Hussein, 2013).

Tables (2 and 3) and map (5) show spatial and seasonal variations in the sampling sites. Electrical conductivity values are higher in the summer compared to the winter across all sites due to the higher temperatures during summer, which increase conductivity, and the lower water levels, as well as the higher number of pollutants discharged into the river. In the summer, electrical conductivity values ranged between 495 and 700 µS/cm, with site (5) recording the highest value at 700 µS/cm and site (1) the lowest. In the winter, values ranged between 448 and 678 µS/cm, with site (10) recording the highest value and site (1) the lowest. It is evident that the electrical conductivity values have exceeded the permissible environmental limits at all sites.

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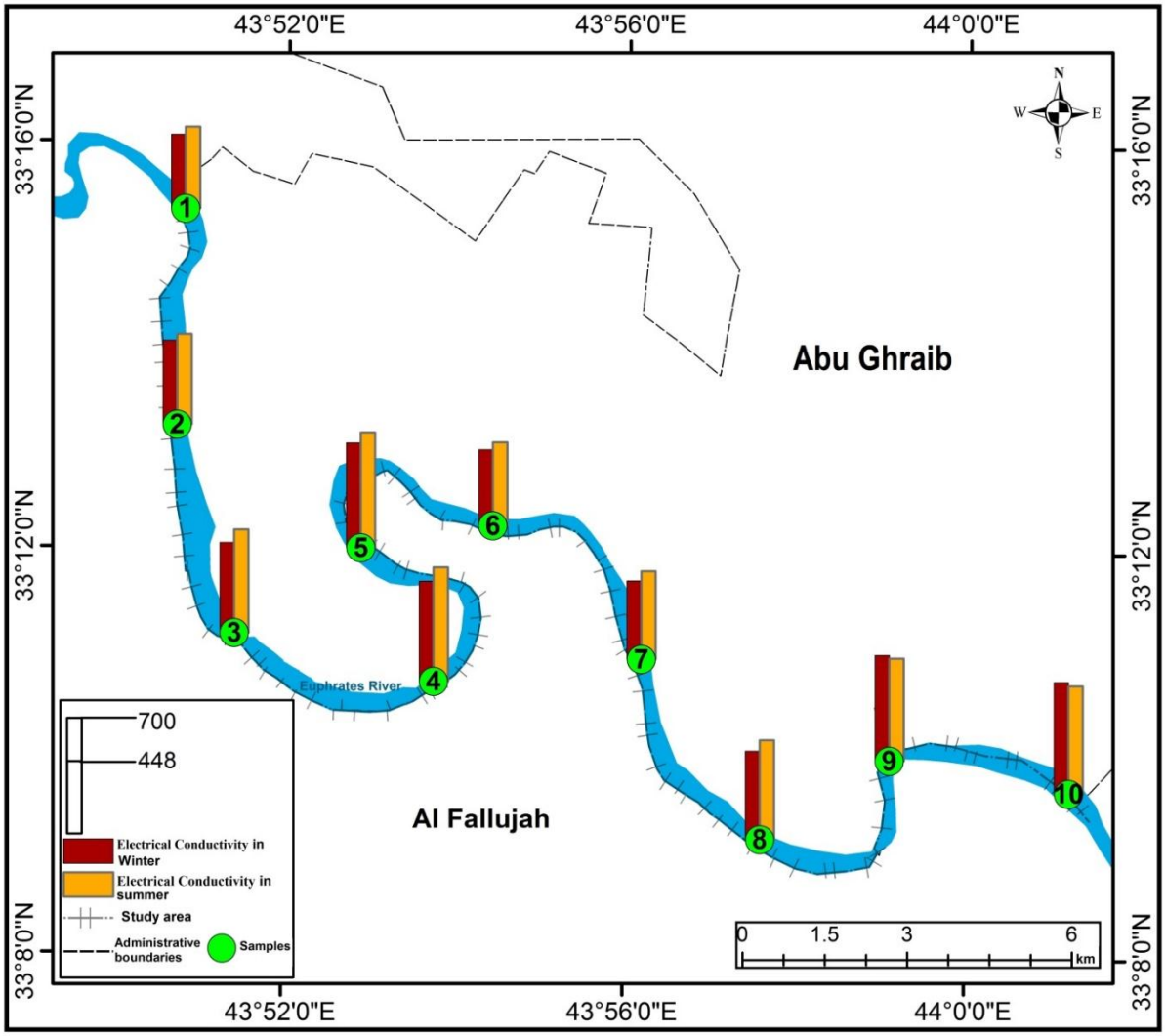
Map (5) electrical conductivity values of the Euphrates River water



Source: Arc map 10.8 output.

4- Dissolved solids:

Total Dissolved Solids (TDS) refers to the sum of all organic and inorganic substances dissolved in water. These solids originate primarily from the weathering of rocks in the Earth's crust, with secondary sources including household and industrial wastewater. Non-organic substances contributing to TDS typically consist of dissolved salts such as sulfates, nitrates, and the salts of sodium, calcium, and potassium (Rimawi, 2004).

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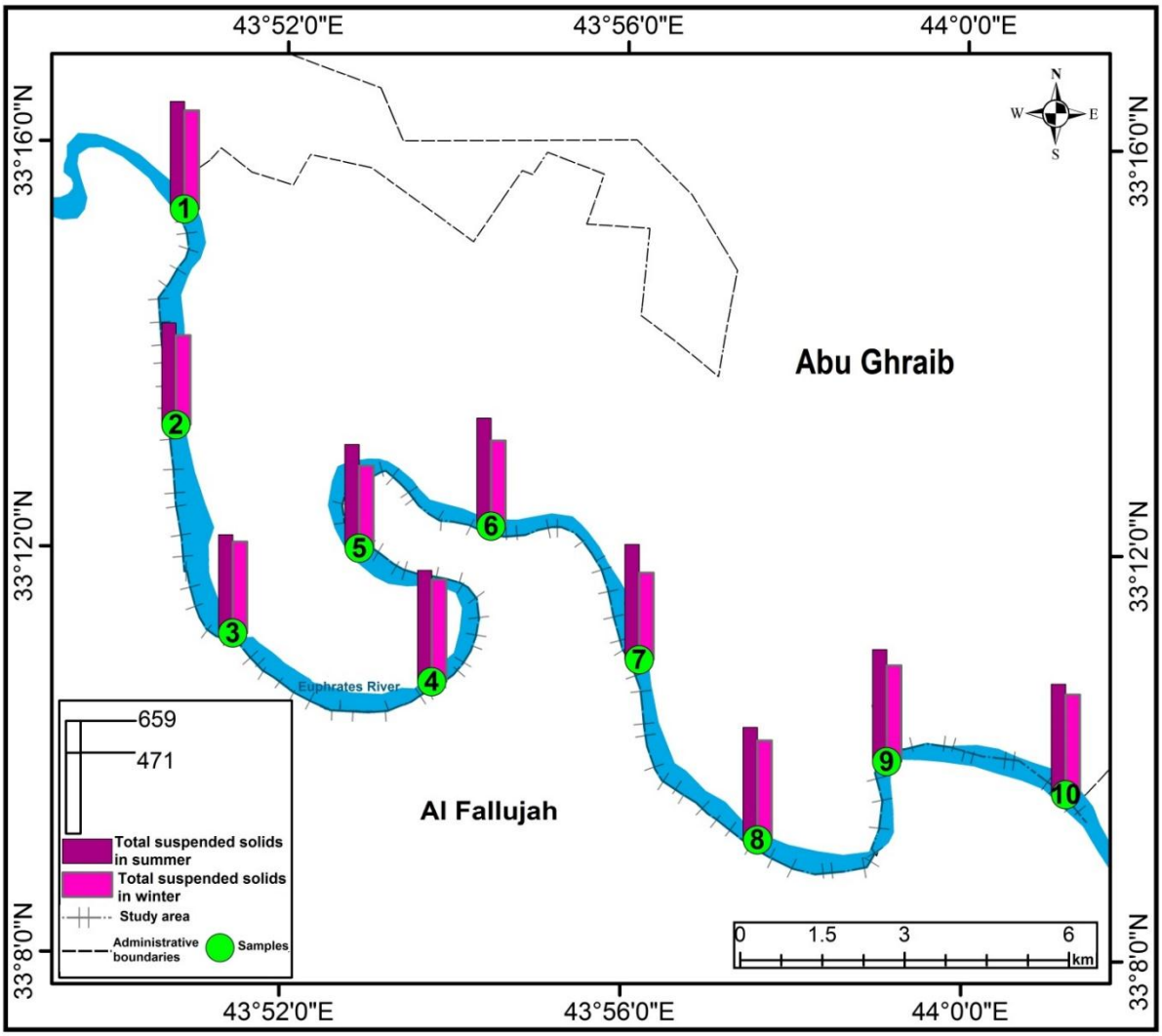
From Tables (2 and 3) and map (6), it is evident that there are seasonal variations in TDS values. These values are higher in the summer than in the winter, ranging between 561 and 659 mg/L in the summer, with the highest values recorded at site (7) and the lowest at site (3). In the winter, TDS values ranged between 471 and 583 mg/L, with site (4) showing the highest values due to the increased presence of agricultural (plant and animal) waste and sewage discharge into the river.

Map (6) values of dissolved solids in the water of the Euphrates River



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Second: The suitability of the Euphrates River water for human drinking purposes:

The use of river water for human drinking must be within the limits of the physical characteristics permitted according to the standard specifications that have been adopted locally and internationally. When comparing the analysis results for the water of the Euphrates River shown in Tables (2 and 3) with the Iraqi and international standard specifications in Table (4), it becomes clear what Come:

1. Temperature:

The results of the temperature comparison showed that it did not exceed the permissible limits according to the Iraqi and World Health Organization specifications, which amounted to (35) C for both seasons. The temperature values ranged between (10.9 - 25.2) C. These changes in temperature are a result of the high temperature in the summer and its low temperature. in Winter.

Table (4) Standard specifications for water suitability for human use (drinking) according to Iraqi and international standards

Water specifications in the study area	WHO Specifications	Iraqi Specifications	Property
25.2 - 10.9	35	Less than 35	temperature
20.4 - 8.2	5	5	Turbidity
700 – 448	400	400	Electrical conductivity
659 – 471	1500	1000	Dissolved solids

Source: The researcher, based on 1- The Central Organization for Standardization and Quality Control, Standard Specifications for Drinking Water No. 417, Second Update, 2009.

2- Who, International Standard for dripping water, 3rd, Geneva Switzerland, 1971, p.36.

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3- Laboratory analyses

1. Water turbidity:

Through the results of the comparison of water turbidity, it becomes clear that all study sites exceeded the permissible limits of water quality specifications for human drinking according to the Iraqi and World Health Organization specifications, amounting to (5), for both seasons. Therefore, the river water is classified as unfit for human drinking in terms of turbidity (Murad et al. 2024).

2. Dissolved solids:

The results of the comparison of electrical conductivity showed that all sites exceeded the permissible limits, which is (400) micromos/cm for water quality specifications for human drinking, for both seasons. Therefore, the water of the Euphrates River in the study area is classified as not suitable for drinking in terms of electrical conductivity due to the influence of human waste, especially sewage waste and agricultural waste.

3. Dissolved solids:

It was found, by comparing the results of the tests with the permissible standards for the quality of human drinking water, that all sites did not exceed the permissible limits, and thus they are classified as acceptable in terms of the concentration of dissolved solids according to the Iraqi and international specifications, which are (1000) and (1500) mg/L, respectively...

Third: The suitability of the Euphrates River water for agricultural irrigation purposes:

There are many standards adopted for the purpose of classifying the suitability of water for agricultural irrigation, and to determine the suitability of the water of the Euphrates River in the study area for irrigation, the following standards were relied upon:

1. American Advisory Committee Standard:

To determine the suitability of the Euphrates River water in the study area for irrigation of agricultural crops according to the American Advisory Committee standard, which depends on the value of electrical conductivity, and by comparing the value of the electrical conductivity of the river water in the study area with Table (5), it is classified as having low salinity as it was less than 750 and suitable for irrigation of all Agricultural crops in all types of soils.

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Table (5) Classification of water according to its suitability for irrigation operations according to the American National Advisory Committee standard

Suitability for irrigation	Concentrations of electrical conductivity micromoz / cm	Water classification
Suitable for irrigation of all agricultural crops in all types of soils	Less than 750	Saline
Suitable for irrigation of some salt-tolerant crops in soils with good drainage	1500-750	Medium salinity
Suitable for irrigation of salt-tolerant crops, provided that the soil is well drained	3000 – 1500	High salinity
Can be used to irrigate some crops while taking care of soil drainage	75000 – 3000	Extremely high for salinity
It cannot be used to irrigate crops even when well-drained soil is available	More than 75,000	Excessively high salinity

Source: Report of the committee of water quality criteria, National Technical Advisory Committee of Interior, Washington, 1968, P170.

2. Total dissolved salts group:

It is evident by applying Table (6) to the value of dissolved solids in Tables (2 and 3), as they were all more than (500) mg/L and are classified as high salinity and can be used if drainage is available for both seasons, with the exception of location (5, 6, 7) for the separation In winter, it was less than (500) and is classified as medium salinity and requires filtration.

Table (6) Quality of water suitable for irrigation based on (TDS)

Specifications	Total dissolved salts mg/l
Brackish water suitable for irrigation	Less than two hundred
Medium salinity and need filtering	500-200
High salinity and can be used if puncture is available	1500 – 500
Remarkably high salinity, unsuitable for irrigation and needs concentrated puncture	3000 – 1500
Unfit for irrigation	More than five thousand

Source: Worked by the researcher based on the specifications of the Food and Agriculture Organization (FAO) 1997

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Fourth: The suitability of the Euphrates River water for drinking purposes:

Concentrations of dissolved salts in water used for drinking animals must not exceed permissible limits. There are many standards to determine the suitability of water for drinking animals, including:

(Grist and Lowry)1- Classification

To determine the suitability of water for drinking animals according to this classification, as it depends on one variable, which is the total concentration of dissolved salts, and by comparing the values of the limits in Table (7) with the values of dissolved salts in the sites of the study area (Tables 2 and 3), we note that all sites are suitable for drinking all animal species.

Table (7) Suitability of water for drinking animals according to specifications (Crist and Lowry).

Salinity mg/l	Animal species
2860	Poultry
6435	Horses
7150	Milk cattle
10000	Meat livestock
12900	Sheep

Source: Crist and Lowry, on Ahmed Hussein Hussein, Spatial analysis of groundwater in the Tal Afar region using contemporary technologies, doctoral thesis (unpublished), University of Mosul, College of Education, 2013, p. 154.

3. Food and Agriculture Organization (FAO)

When comparing the values of total dissolved salts for samples of the study area with the standard specifications of the Food and Agriculture Organization of the World (FAO), Table (8), we find that all river water is classified as very good water for drinking animals according to the standard specifications of the Food and Agriculture Organization of the World (FAO). The salt values where the total dissolved water content of the Euphrates River is less than (3000) mg/L, and thus it is suitable for drinking by animals, according to the World Food and Agriculture Organization (FAO).

Table (8) Food and Agriculture Organization International Standard Specifications for Water Suitability for Animal Consumption for Dissolved Solids Values

Usable water	Permitted water	Good water	Incredibly good water	Ion concentration
10000	7000	5000	3000	TDS

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Source: Worked by the researcher based on the guidelines of the Food and Agriculture Organization (FAO)

Conclusions:

1. There are seasonal changes in temperatures for the Euphrates River sites due to sampling being taken in two seasons (summer and winter), but the results were close between the sites and did not exceed environmental limits.
2. All sites recorded exceeding the permissible limits for electrical conductivity concentration, especially in the summer, as the value of electrical conductivity increases with rising temperatures.
3. The values of water turbidity concentrations were higher in the winter than in the summer due to the increase in the number of suspended materials such as clay and silt that increase during times of rain, in addition to the speed of water flow at the time of sampling, as the turbidity of the water changes with the change in flow speed.
4. Evaluation of the water of the Euphrates River showed that it is not suitable for human drinking in terms of turbidity and electrical conductivity.
5. The results showed that it is suitable for agricultural irrigation as having low salinity and suitable for irrigating all agricultural crops in all types of soil according to the American Advisory Committee standard. It was classified in terms of total dissolved salts as high salinity and can be used if drainage is available for both seasons, with the exception of site (5, 6, 7) for the winter season. It was classified as having medium salinity and required filtration, while it was found to be suitable for drinking by animals.

Recommendations:

1. Working to spread environmental awareness among citizens by activating the role of the media in how to preserve and deal with the environment and establishing research centres for the maintenance and development of water resources in all Iraqi universities.
2. Issuing laws and legislation related to river water management to reduce water pollution and preserve health and the environment.
3. Controlling sources of pollution through the treatment of waste and working to establish heavy water treatment plants so that this water is purified and recycled for other uses such as agricultural use and benefiting from it in the manufacture of fertilizers.

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Reverences

1. Hebert. F. lund, Indusial Polution control, MCGraw Hill book, Newyork, 1971, p. 11.
2. Souad Abd Abbawi and Muhammad Suleiman Hassan, Practical Environmental Engineering (Water Tests), Dar Al-Hekma, Mosul, 1990, p. 50.
3. Dete, M, Water Wells, implementation, maintenance, and restoration jotln wileg and sons, London, 1997. P 379.
4. Ahmed Hussein Hussein, Spatial analysis of groundwater in the Tal Afar region using contemporary technologies, doctoral thesis (unpublished), University of Mosul, College of Education, 2013, p. 110.
5. Omar Al-Rimawi, Basics of Environmental Science, Dar Wael for Printing and Publishing, Amman, 2004, p. 206.
6. Israa Abdul wahid Ali Murad, Ayat Saeed Hussein, Hayam Numan Falih Mohammed, 2024, Simulation of Extraordinary Flood Risks for the Diyala River Section Within the Abu Sayda and Al-salam Districts Using Hec-ras (Hydrological Study), Kurdish Studies, Volume 11, No: 2, pp. 3660-3670.
7. https://kurdishstudies.net/menu-script/index.php/ks/article/view/969/597

DOI: https://doi.org/10.33193/eJHAS.14.2024.315