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A Qualitative Environmental Study of Some Water Bodies Spread in Makhmour District/Iraq

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ABSTRACT
The Tigris River is one of the most vital water resources in Iraq. This study was conducted on several interconnected water bodies that form part of the Tigris River Basin, specifically within the Makhmur District of Nineveh Governorate. The objective was to assess the environmental status of these water bodies by analyzing both physicochemical parameters and biological components, particularly for algae. Samples were collected and tested for a range of physical and chemical properties, including water temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), nitrates, sulfates, phosphates, alkalinity, and concentrations of sodium, potassium, calcium, and magnesium. The data obtained were compared against Iraqi and international standard specifications to evaluate their suitability for various civil uses. Water temperature showed seasonal variation, reaching up to 29°C in summer and dropping to 12–13°C during winter. The average pH across all study sites was 7.03, indicating near-neutral conditions. However, turbidity values exceeded the internationally acceptable limit of 5 NTU at all sites, suggesting poor water quality based on this indicator. Electrical conductivity increased noticeably during the summer, with the highest reading (4243µS/ cm) recorded at Site 2. In contrast, winter EC values were lower, ranging between 2288 and 2292µS/ cm. Biologically, the study recorded the presence of 17 algal genera, indicating moderate biodiversity and providing further insight into the ecological status of the water bodies.

INTRODUCTION

Water is a vital gift of nature, essential for the survival of humans, animals, and plants. It is not only a symbol of life but also a fundamental requirement for it. Scientific research and studies have long emphasized the importance of water, especially concerning its properties and its role in sustaining life. Water constitutes a significant portion of the cellular content in all living organisms and serves as a medium for numerous biological reactions **(Abdul Jaleel & Shabout, 2024)**.

Moreover, water resources play a critical role in supporting various economic and social sectors **(Amgharou *et al.*, 2022)**. As such, maintaining the quality of freshwater streams is essential for ensuring safe living conditions and the sustainability of productive sectors **(Abdelrazek & Elnaka, 2022)**.

One of the most pressing challenges facing humanity today is environmental pollution, particularly in developing countries. In Iraq, environmental concerns have been exacerbated by prolonged conflict, poor infrastructure, and insufficient environmental awareness. These conditions have led to the accumulation of waste, the spread of diseases, and the contamination of rivers by floodwaters and rainwater runoff. Furthermore, the continuous discharge of untreated industrial, domestic, and agricultural wastewater into the river has significantly deteriorated its quality **(Al-Mandeel *et al.*, 2024)**. As a result, the physical, chemical, and biological properties of the water have been compromised, rendering it unsuitable for many uses **(Mahmood *et al.*, 2021)**.

The current study aimed to evaluate the suitability of some water bodies in Makhmur district in terms of quantity and quality for various uses, in light of the existing shortage and deterioration of the quality of the watercourse due to various human activities, in addition to the cumulative factor of pollutants.

MATERIALS AND METHODS

Study area

The present study was conducted on several water bodies located throughout the Makhmur District, Nineveh Governorate, Iraq. These water bodies are extensions of the Tigris River's flow, situated along its left bank. Some sampling sites were in close proximity to the river, while others were several kilometers away.

Methodology

Sampling and analytical procedures were carried out according to standard methods outlined by **APHA (2017)**. The analysis focused on evaluating the physicochemical parameters of water to assess environmental quality and suitability for civil uses.

Physical parameters

- **Water temperature:** Measured in the field using a mercury thermometer graduated from 0– 100°C.
- **Turbidity:** Determined using a HANNA – LP 2000 turbidity meter. Results were expressed in Nephelometric Turbidity Units (NTU).

Chemical parameters

- **pH:** Measured using a calibrated pH meter.
- **Electrical conductivity (EC) and total dissolved solids (TDS):** Measured using a TDS-C°-Meter (Model: YL-TDS2-A). EC results were expressed in microsiemens per centimeter (µS/cm), and TDS values in milligrams per liter (mg/L).
- **Dissolved oxygen (DO):** Determined using the Winkler method with azide modification. Water samples were collected in oxygen bottles, to which 2 mL of manganese sulfate and 2 mL of alkaline potassium iodide solutions were added. After gentle mixing and protection from light, 2 mL of concentrated sulfuric acid was added to dissolve the precipitate and release iodine. In the laboratory, 100mL of the treated sample was titrated with sodium thiosulfate

solution ($Na_2S_2O_3$), and DO was calculated using the formula: **DO (mg/L) = (V_thio × N_thio × Eq.wt × 1000) / mL of sample**

- **Biochemical oxygen demand (BOD_5):** Measured using the same procedure as DO. Samples were incubated in dark bottles at 20°C for 5 days. BOD_5 was calculated using: **BOD_5 = DO_initial − DO_day5**
- **Nitrate (NO_3^-):** Measured using the Ultra Violet Screening method. After adding 1mL of 1N HCl to the sample, absorbance was recorded at 220 and 275nm using a spectrophotometer. Final concentration was obtained from a standard curve (mg/L).
- **Orthophosphate (PO_4^{3-}):** Measured using the Stannous Chloride method. A known sample volume was treated with phenolphthalein indicator, 4mL of ammonium molybdate, and 10 drops of stannous chloride. After 10–12 minutes, the absorbance was measured at 690nm using a spectrophotometer. Concentration was determined using a standard curve (mg/L).
- **Sulfate (SO_4^{2-}):** Estimated using the turbidimetric method. To a known volume of the sample, 1– 2mL of 1:1 HCl was added, followed by barium chloride crystals. Absorbance was read at 420nm, and concentrations were derived from a standard curve (mg/L).
- **Total alkalinity:** Determined by titrating a known volume of sample against 0.02N sulfuric acid using phenolphthalein and methyl orange as indicators. Results were expressed in mg/L as $CaCO_3$.
- **Chloride (Cl^-):** Measured using Mohr's method. A known sample volume was titrated against 0.0141N silver nitrate after adding potassium chromate as an indicator. Chloride concentration was calculated using the formula: **Cl^- (mg/L) = (A − B) × N × 35450 / mL of sample**
- **Total hardness (TH):** Measured using EDTA titration. A known volume of sample was treated with buffer and Eriochrome Black T indicator. The solution turned purple, and titration was continued until a blue endpoint appeared. **TH (mg/L as $CaCO_3$) = V × N × Eq.wt × 1000 / mL of sample**
- **Calcium hardness (CaH):** Determined using the same EDTA method but with meroxide indicator. The sample was titrated until a purple endpoint appeared. **CaH (mg/L as $CaCO_3$) = V × N × Eq.wt × 1000 / mL of sample**
- **Magnesium hardness (MgH):** Calculated as: **MgH = TH − CaH**
- **Sodium (Na^+) and potassium (K^+):** Measured using a flame photometer, and results were expressed in mg/L.

RESULTES AND DISCUSSION

Water temperature

Data from Tables (1, 2) indicate seasonal variation in water temperature across all study sites, peaking at 29°C during the summer and dropping to 12– 13°C in winter. This fluctuation is attributed to seasonal changes in solar angle, day length, and water levels, which decrease during the summer **(Al-Kalabi, 2024)**. Importantly, water temperatures across all sites remained within the permissible range set by international standards **(FAO/WHO, 2011)**.

pH

The pH values across all sites averaged 7.03, indicating near-neutral conditions. No significant seasonal variation was observed, with the highest value (7.5) recorded in winter at Site 5 and the lowest (7.0) at sites 1 and 5 during summer. These slight fluctuations may be due to rainfall and the resulting runoff carrying dissolved substances into the water bodies **(Najeeb & Saeed, 2022)**. All pH readings are consistent with historical Iraqi ranges (7.4–8.5) **(Al-Rubaie, 2002; Hussein *et al.*, 2025)** and within the acceptable range of 6–9.5 **(FAO/WHO, 2011; Al-Hamadany *et al.*, 2024)**. .

Turbidity

Turbidity varied seasonally, with values increasing in summer due to reduced water levels and inflow of liquid waste. The highest turbidity (140 NTU) was recorded at Site 5. All sites exceeded the international turbidity limit of 5 NTU, indicating poor water quality **(Wolde *et al.*, 2020)**.

Electrical conductivity (EC)

EC values increased significantly in summer, reaching a maximum of 4243 µS/cm at Site 2, compared to 2288–2292 µS/cm in winter. This rise is attributed to higher evaporation rates, lower water volumes, and increased ion concentration during dry periods **(Shihab & Kannah, 2021; Mohammed, 2022)**. All EC values exceeded the WHO standard of 400 µS/cm, indicating poor water quality **(WHO, 2006)**.

Total dissolved solids (TDS)

TDS values ranged from 1113 to 2248mg/ L, with the highest concentration recorded at Site 4 during winter. These values correlate with EC trends, reflecting a direct relationship between the two variables **(Karthik *et al.*, 2019)**. Since the international limit for TDS is 1000mg/ L **(WHO, 2006)**, all sites are considered to have poor water quality based on this parameter.

Dissolved oxygen (DO)

DO concentrations ranged from 3.2 to 11.6mg/ L during spring. Variations in DO are influenced by temperature, organic matter decomposition, and anthropogenic activities **(Kouti *et al.*, 2025)**. Nevertheless, all DO values remained within WHO acceptable limits **(FAO/WHO, 2011)**.

Biological oxygen demand (BOD_5)

BOD_5 values ranged from 0.1– 1.2mg/ L in spring to 4– 4.5mg/ L in summer. This inverse relationship between DO and BOD_5 indicates organic pollution, likely due to domestic waste discharge **(Mahmoud & Saeed, 2023; Al-Mandeel *et al.*, 2025)**.

Nitrates (NO_3^-)

Nitrate levels ranged from 0.9– 0.97mg/ L in winter to 31– 52.5mg/ L in summer and spring. Elevated concentrations during dry seasons are attributed to agricultural runoff. Despite these variations, all values remained within safe limits for aquatic life **(Houhamdi *et al.*, 2025)**.

Sulfates (SO_4^{2-})

Sulfate concentrations varied seasonally, peaking at 234mg/ L (Site 4) in winter and 135.7mg/ L in spring. All values were below the WHO threshold of 500mg/ L, indicating acceptable water quality concerning this parameter **(Abdul Jaleel & Shabout, 2024)**.

Phosphates (PO_4^{3-})

Phosphate concentrations were at their highest during winter (0.54– 0.6mg/ L), likely due to rainfall and nutrient leaching from adjacent agricultural land **(Al-Saffawi *et al.*, 2006; Khudair, 2013)**. Summer values were lower (0.22– 0.362mg/ L), likely due to uptake by aquatic organisms **(Al-Eryani, 2005)**. All winter values exceeded the WHO permissible limit of 0.4mg/ L **(WHO, 2006)**, indicating poor water quality.

Chloride (Cl^-)

Chloride concentrations exceeded the WHO limit (250mg/ L) in winter, ranging from 490– 494mg/ L. In summer and spring, concentrations were lower (148– 149.9mg/ L). The winter spike is attributed to urban and industrial runoff **(Al-Shaker & Mohammed, 2019)**, rendering water quality poor in terms of chloride during that season.

Total, calcium, and magnesium hardness

Total hardness ranged from 200– 330mg/ L, with calcium hardness between 120 & 185mg/ L and magnesium hardness from 80– 145mg/ L. Seasonal variation was observed across all values. Surface water typically exhibits lower hardness than groundwater due to differences in geological composition **(Shihab & Kannah, 2023)**.

Total alkalinity

Total alkalinity values ranged from 160– 180mg/ L, with higher concentrations in winter at sites 1, 3, and 5. Seasonal changes in waste input and organic decomposition contribute to alkalinity levels, particularly due to the formation of bicarbonates from carbon dioxide **(Saeed & Dawas, 2023)**.

Sodium (Na^+) and potassium (K^+)

Summer concentrations of sodium and potassium reached 130mg/ L and 17mg/ L, respectively. The increase in potassium is likely due to agricultural runoffs and fertilizers, while sodium levels are influenced by drainage and seasonal water level fluctuations **(Shihab & Kannah, 2021)**. Though sodium levels remained within the WHO limit (200mg/ L), potassium exceeded the permissible value of 12mg/ L at all sites **(Al-Sarraj *et al.*, 2014)**, indicating poor water quality with respect to potassium.

Table 1. Physical and chemical characteristics of the studied sites for winter

Parameter	the site 1	the site 2	the site 3	the site 4	the site 5	Average
Water temperature C°	12	13	12,5	12,4	12	12.3
EC µs/cm	2292	2289	2290	2288	2288	2289
TDS mg/l	1144	1150	1148	2248	1146	1367
Turbidity NTU	12	13	12	12	11	12
ph	7,4	7	7	7	7,5	7
Toata alkalinity mg/l	180	175	180	175	180	178
DO mg/l	6	6,5	7	6,5	7	6. 7
BOD_5 mg/l	2	1,5	1,5	1,5	1,5	2
$SO_4^{=}$ mg/l	233	230	233	234	230	232
PO_4^{-3} mg/l	0,544	0,6	0,6	0,570	0,6	0.582
Cl^- mg/l	494	490	494	490	494	492
NO_3^- mg/l	0,97	0,97	0,90	0,96	0,97	0.954
Total hardness mg/l	200	320	310	310	300	288
Ca^{+2} mg/l	120	120	120	120	120	120
Mg^{+2} mg/l	80	80	80	80	80	80
K mg/l	17	17	17	17	17	17
Na mg/l	130	130	130	130	130	130

Table 2. Physical and chemical characteristics of the studied sites for summer

Parameter	the site 1	the site 2	the site 3	the site 4	the site 5	Average

Water temperature C°	28	29	29	28	28	28.4
EC µs/cm	2301	4243	3420	3043	2226	3046.6
TDS mg/l	1150	2121	1710	1521	1113	1523
Turbidity NTU	110	120	120	130	140	124
Ph	7	6,7	6,8	6,9	7	6.88
Toata alkalinity mg/l	160	170	165	165	160	164
DO mg/l	7	6,1	6,5	6,7	7	6.66
BOD_5 mg/l	4	4,5	4,2	4,4	4	4.22
$SO_4^{=}$ mg/l	90,37	50,87	50,5	50,6	80,7	64.61
PO_4^{-3} mg/l	0,221	0,362	0,350	0,360	0,221	0.303
Cl^- mg/l	99,96	149,95	100	99,9	99.9	109.94
NO_3^- mg/l	42,5	31	49,5	51,7	50,6	45.1
Total hardness mg/l	300	320	310	310	300	308
Ca^{+2} mg/l	160	180	170	175	160	140
Mg^{+2} mg/l	140	140	140	135	140	139
K mg/l	17	17	17	17	17	17
Na mg/l	130	130	130	130	130	130

Table 3. Physical and chemical characteristics of the studied sites for spring

Parameter	the site 1	the site 2	the site 3	the site 4	the site 5	Average
Water temperature C°	17	16	Dry	16	18	16.75
EC µs/cm	3193	3510	Dry	3232	3705	3410
TDS mg/l	1332	1755	Dry	1616	1872	1544
Turbidity NTU	115	140	Dry	110	115	96
ph	7	6,7	Dry	6,9	7	6.9
Toata alkalinity mg/l	165	170	Dry	165	160	165
DO mg/l	3,2	11,6	Dry	7,6	4	6.6
BOD_5 mg/l	0,1	1,2	Dry	2	0,8	1.03
$SO_4^{=}$ mg/l	114,6	41	Dry	170	135,7	115.33
PO_4^{-3} mg/l	0,09	0,099	Dry	0,089	0,14	0.327
Cl^- mg/l	99	148	Dry	98	97	111
NO_3^- mg/l	47,6	45,2	Dry	52,5	38,2	45.9
Total hardness mg/l	310	330	Dry	320	310	318
Ca^{+2} mg/l	165	185	Dry	185	165	175
Mg^{+2} mg/l	145	145	Dry	135	145	143
K mg/l	17	17	Dry	17	17	17
Na mg/l	130	130	Dry	130	130	130

Biological characteristics

Algae

All aquatic systems, whether found above or below the Earth's surface, are subject to changes in quality as a result of anthropogenic activities. Among the organisms inhabiting freshwater systems, algae play a crucial ecological role as primary producers and serve as a main source of energy for other organisms within the ecosystem. Their abundance and distribution are strongly influenced by environmental factors **(Toma & Aziz, 2023)**.

Table (4) presents the results of algal identification, revealing the presence of 17 algal genera recorded during the winter and summer seasons at sites 1 and 2. These genera belong to several taxonomic groups, as detailed in the Table (4). Notably, certain genera—such as *Oscillatoria*—are recognized as biological indicators of water pollution due to their tolerance for nutrient-rich or degraded environments **(Kannah, 2001)**.

Table 4. Types of algae identified at the study sites

Species	The sites				
	1	2	3	4	5
Division Cyanophyta Order Oscillatoriales Family Oscillatoriaceae *Genus Oscillatoria*	-	+ W S	-	-	-
Order Nostocales Family Scytonemataceae *Genus scytonema*	+ W	-	-	-	-
Order Thalassiosirales Family Stephanodiscaceae *Genus Cyclotella*	-	+ S W	-	-	-
Order Naviculales Family Naviculaceae *Genus Navicula*	-	+ S W	-	-	-
Order Euglenales Family Euglenaceae *Genus Euglena*	+ S	-	-	-	-
Order Chlorococcales Family Selenastraceae *Genus Ankistrodesmus*	-	+ S	-	-	-
Order Sphaeropleales Family Scenedesmaceae *Genus Coelastrum*	-	+ S	-	-	-
Order Chroococcales Family Microcystaceae *Genus* Microcystis	+ S	-	-	-	-
Order Achnanthales Family Cocconeidaceae *Genus Cocconeis*	-	+ S	-	-	-
Order Desmidiales Family Desmidiaceae *Genus Cosmarium*	-	+ S	-	-	-
Order Sphaeropleales	-	+	-	-	-

Species	The sites				
	1	2	3	4	5
Family Cylindrocapsaceae *Genus Cylindrocapsa*		S			
Order Cymbellales Family Cymbellaceae *Genus Cymbella*	-	+ S	-	-	-
Order Sphaeropleales Family Hydrodictyaceae *Genus Pediastrum*	-	+ S	-	-	-
Order Melosirales Family Melosiraceae *Genus Melosira*	-	+ S	-	-	-
Order Fragilariales Family Fragilariaceae *Genus* Synedra	-	+ S	-	-	-
Order Bacillariales Family Bacillariaceae *Genus Nitzschia*	-	+ S	-	-	-
Order Cladophorales Family Cladophoraceae *Genus* Cladophora	+ W	-	-	-	-

CONCLUSION

Electrical conductivity (EC) values showed a significant increase during the summer, with the highest measurements recorded at the second site, in contrast to lower values observed in the winter season. Water quality across all sites was determined to be poor based on turbidity (NTU) and electrical conductivity (EC) indices. However, dissolved oxygen (DO) levels remained within the permissible limits established by the World Health Organization, indicating acceptable oxygenation conditions in the aquatic environment.

RECOMMENDATIONS

It is recommended to carry out detailed monitoring of heavy metal concentrations (such as lead, cadmium, chromium, zinc, copper, and mercury) in both water and sediment samples across different seasons and sites within the Makhmur District. This will help in evaluating potential risks to aquatic life and human health, and in identifying sources of contamination for effective mitigation strategies. Further studies should be undertaken to assess the diversity and abundance of aquatic fungi and bacteria in the study area. These microorganisms are essential bioindicators of water quality and play a crucial role in nutrient cycling. Understanding their composition and response to pollution, especially from organic and chemical sources, will provide valuable insights into the ecological health of these freshwater ecosystems.

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