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Research article

Geographical Analysis of the Water Pollution Crisis in the Tigris River in Northern Wasit Governorate during April 2026

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ABSTRACT

During 2026, particularly in April, the Tigris River in the northern parts of Wasit Governorate experienced a significant episode of water pollution that adversely affected water quality from both environmental and public health perspectives. This deterioration raised serious concerns regarding the suitability of river water for drinking, domestic uses, irrigation of agricultural crops, and meeting the water requirements of livestock. The results of river water sample analyses revealed elevated concentrations of several chemical, physical, and biological parameters, as well as heavy metals, with some values exceeding the permissible environmental limits. Therefore, it is essential to investigate this pollution crisis and scientifically identify its underlying causes in order to mitigate its adverse impacts and develop effective measures for its long-term control. Continuous monitoring is also required to prevent the recurrence of similar pollution events in the future, given their potentially serious environmental consequences for human health and various other aspects of life. Accordingly, greater attention should be devoted to scientific studies and research in the field of water pollution, commensurate with its environmental significance and its direct impact on society.

1. Introduction

Water resources are among the most fundamental requirements for sustaining life and achieving sustainable development, as they are directly linked to human health, food security, economic stability, and ecological balance. The importance of conserving water resources has increased considerably in recent decades due to continuous population growth, urban, industrial, and agricultural expansion, as well as climate change, which has significantly affected both the quantity and quality of available water. International reports indicate that the deterioration of water quality has become one of the major environmental challenges facing many countries worldwide, particularly in regions that rely primarily on surface water to meet their various needs. Consequently, sustainable water resource management and the improvement of water quality have become key objectives of sustainable development (World Health Organization [WHO], 2022; UNESCO, 2024).

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The Tigris River is one of the most important rivers in the Middle East, particularly in Iraq, where it represents a major lifeline that has supported ancient Iraqi civilizations for thousands of years. The establishment of major cities and the development of agricultural, commercial, and cultural activities have historically been closely associated with the river, which has provided water for drinking, irrigation, industry, and transportation. The Tigris River supplies extensive agricultural areas and serves as a major source of drinking water for millions of people living in the governorates along its course, including Wasit Governorate. This makes the river a strategic resource of critical importance to national water and food security (Al-Janabi, 2012). Official Iraqi reports also confirm the continued dependence of most governorates located along the Tigris River on its water to meet domestic, agricultural, and industrial demands, making the preservation of its water quality a national priority in water resource management (Iraqi Ministry of Water Resources, 2024; Statistics and Geographic Information Systems Authority, 2025).

However, in recent years, this vital water resource has been subjected to increasing environmental pressures resulting from population growth, urban expansion, and the discharge of untreated domestic, industrial, and agricultural effluents, in addition to declining water releases and the growing impacts of climate change. These factors have contributed to numerous environmental problems associated with the deterioration of water quality and increased concentrations of chemical and organic pollutants, as well as heavy metals, in different sections of the river (Al-Rawi, 2005). Recent environmental reports indicate that these pressures have become increasingly complex as a result of climate change and intensified anthropogenic pressures on water resources, highlighting the need to strengthen environmental monitoring programs and promote integrated water resources management (UNEP, 2024).

The research problem was represented by a number of questions:

1. Do the waters of the Tigris River in the northern areas of Wasit Governorate suffer from pollution?
2. Which water-quality parameters exceeded the permissible environmental limits?
3. What were the main causes of water pollution during the study period?

The research hypotheses represent preliminary answers to the questions raised in the research problem, as follows:

1. The waters of the Tigris River in the northern areas of Wasit Governorate are affected by pollution.
2. The concentrations of some water-quality parameters exceed the permissible limits.
3. The causes of pollution in the Tigris River are multiple; however, the principal sources are drainage water and untreated sewage discharges.

The significance of this study stems from its focus on one of the major environmental and societal problems affecting water and public health security in Wasit Governorate, particularly because a considerable proportion of the population, agricultural activities, and service sectors depend on the waters of the Tigris River.

The study provides a scientific assessment of the changes that occurred in the river's water quality during the pollution incident recorded in April 2026. This assessment is based on the results of field monitoring and a set of physical and chemical parameters, indicators of organic pollution load, and heavy metals. The obtained results were also compared with the reference values adopted in environmental monitoring standards and with official water-quality data for Wasit Governorate for the year 2024.

2. Materials and Methods

In order to achieve the objectives of the study, the analytical approach was adopted. This involved collecting and analyzing data obtained from water samples collected from the study area during the study period. The analysis included the principal chemical, physical, and biological characteristics of the water, in addition to heavy-metal concentrations.

The spatial boundaries of the study comprised selected areas in the northern part of Wasit Governorate, specifically Al-Suwaira District, Al-Aziziyah District, and Al-Numaniyah District.

The temporal boundaries of the study covered the period during which the water pollution crisis occurred in April 2026, specifically from 4 April 2026 until the end of the crisis on 22 April 2026.

3. Results and discussion

3.1. Water Characteristics and Environmental Standards

3.1.1. Chemical Characteristics

The chemical characteristics of water reflect the nature of the environmental conditions through which the water has passed, including the types of rocks and soils with which river water has come into contact or in which it has been retained. They also reflect the pollutants introduced into the water from domestic sewage, industrial effluents, agricultural drainage, and other anthropogenic activities. Changes in the chemical composition of water may affect the quality and characteristics of treated water and may also cause serious adverse effects when certain constituents occur at excessively high concentrations. Although many of these elements are beneficial to the human body when present within appropriate levels, they may have harmful and potentially serious effects on human health when their concentrations exceed the permissible limits (Huda Ali, 2013, p. 123).

3.1.2. Physical Characteristics

Physical characteristics of water are relatively easy to measure compared with other water-quality characteristics, even by non-specialists. One of the most important physical parameters is water temperature, as it directly influences several other characteristics, including the rates of chemical reactions, the solubility of gases, and the intensity of taste and odor. Physical characteristics also include

taste, odor, color, turbidity (Turb), electrical conductivity (EC), total dissolved solids (TDS), and total suspended solids (TSS) (Mohammed Ismail, 2010, p. 103).

3.1.3. Biological Characteristics

Biological characteristics include dissolved oxygen (DO), which refers to the concentration of molecular oxygen (O_2) dissolved in water. Dissolved oxygen is essential for the survival of aquatic organisms, and its depletion may impose substantial environmental stress on aquatic ecosystems. It is also considered an important indicator for assessing water quality and the extent of organic pollution, because microorganisms consume dissolved oxygen during the decomposition of organic matter (Ahmed Mays, p. 188).

Biological characteristics also include biochemical oxygen demand (BOD), which is widely used as an indicator of the amount of biodegradable organic waste present in a water sample. It is determined by measuring the amount of oxygen required by aerobic microorganisms to oxidize organic matter into carbon dioxide and water (Hussein Al-Saadi, 2000, p. 401).

Table 1. Types of Water-Quality Characteristics

Chemical Characteristics	Physical Characteristics	Biological Characteristics	Heavy Metals
pH	Water temperature (Temp.)	Dissolved oxygen (DO)	Ni
Total hardness (TH)	Turbidity (Turb.)	Biochemical oxygen demand (BOD)	Cr
Calcium (Ca)	Total dissolved solids (TDS)	—	Cd
Magnesium (Mg)	Electrical conductivity (EC)	—	Pb
Aluminum (Al)	Total suspended solids (TSS)	—	—
Potassium (K)	—	—	—
Alkalinity (ALK)	—	—	—
Phosphate ions (PO_4^{3-})	—	—	—
Sulfate ions (SO_4^{2-})	—	—	—
Nitrate ions (NO_3^-)	—	—	—
Chloride ions (Cl^-)	—	—	—

Karim, 2014, p. 196.

Table 2. Iraqi Environmental Standards

Parameter	Permissible Limit
pH	6.5–8.5
EC ($\mu S/cm$)	2000
Temperature ($^{\circ}C$)	30
Turbidity (NTU)	5

Parameter	Permissible Limit
TSS (mg/L)	40
TDS (mg/L)	600
Cl ⁻ (mg/L)	100
SO ₄ ²⁻ (mg/L)	200
NO ₃ ⁻ (mg/L)	15
PO ₄ ³⁻ (mg/L)	0.2
DO (mg/L)	> 5
BOD ₅ (mg/L)	< 5
COD (mg/L)	< 10
Pb (mg/L)	0.01
O&G (mg/L)	0.05

3.2. Spatial and Temporal Analysis of the Results of Tigris River Water Samples in Northern Wasit

3.2.1. Pollution of the Tigris River in Al-Suwaira District

By comparing the data presented in Tables (2) and (3), the following findings can be identified:

1. Chemical Characteristics

The pH values were fully within the prescribed environmental limits. The highest recorded value was 7.97, while the lowest was 6.95, both falling within the permissible range of 6.5–8.5.

In contrast, phosphate (PO₄³⁻) concentrations exceeded the permissible environmental limit of 0.2 mg/L, reaching 0.66, 0.48, 0.40, 0.29, 0.31, 0.42, 0.38, 0.23, and 0.34 mg/L on 4, 7, 8, 9, 10, 11, 12, 13, and 15 April, respectively.

Similarly, sulfate (SO₄²⁻) concentrations exceeded the environmental limit of 200 mg/L, recording 262, 217, 227, 237, 255, and 210 mg/L on 4, 5, 6, 8, 10, and 16 April, respectively.

Chloride (Cl⁻) concentrations also exceeded the permissible limit of 100 mg/L, particularly during the early days of the pollution crisis. Values of 150.9, 121.5, 111.7, 115.6, and 107.8 mg/L were recorded on 4, 7, 8, 9, and 10 April, respectively.

With regard to nitrate (NO₃⁻), concentrations generally remained within the permissible limit of 15 mg/L in most water samples, except on 4 April, when the concentration reached 20.4 mg/L.

3.2.2. Physical Characteristics

With respect to the physical characteristics of the river water, water temperature (Temp.) remained entirely within the permissible environmental limit. The highest recorded temperature was 11.4°C, while the lowest was 8.2°C, both of which were well below the prescribed maximum limit of 30°C.

However, total dissolved solids (TDS) exceeded the permissible limit of 600 mg/L in most of the analyzed samples. Recorded values were 892, 740, 670, 672, 632, 608, 606, 602, 608, and 640 mg/L on 4, 5, 6, 8, 9, 10, 11, 12, 13, and 22 April, respectively.

Similarly, total suspended solids (TSS) exceeded the permissible environmental limit of 40 mg/L, reaching 191.4 mg/L and 62.41 mg/L on 4 and 7 April, respectively. The concentration then decreased

to 32.42 mg/L on 8 April, falling within the permissible limit. However, it increased again to 58.46 mg/L on 9 April, before declining during the remaining study days and returning to levels within the permissible range.

3.2.3. Biological Characteristics

With regard to the biological characteristics, biochemical oxygen demand (BOD) remained within the permissible limits during most of the study period. However, the results indicated an elevated value of 10.2 mg/L on 4 April, after which BOD values returned to the permissible range during the remaining days of April.

As for dissolved oxygen (DO), the recorded concentrations were within the acceptable environmental limits. According to the adopted standards, DO concentrations below 5 mg/L are considered unsuitable, whereas values equal to or greater than 5 mg/L are considered acceptable. The data presented in Table (3) indicate that the recorded DO values complied with these limits.

3.2.4. Heavy Metals

The concentration of nickel (Ni) exceeded the permissible international limit of 0.02 mg/L in several samples. It reached 0.0351 mg/L on 4 April, 0.0201 mg/L on 8 April, and increased to 0.061 mg/L on 10 April. Thereafter, nickel concentrations declined to levels within the permissible range.

Regarding lead (Pb), a noticeable increase was recorded on 4 April, when its concentration reached 0.0314 mg/L, exceeding the permissible limit of 0.01 mg/L. Lead was not detected in the remaining samples collected during the study period.

3.3. Pollution of the Tigris River in Al-Aziziyah District

By comparing the data presented in Tables (2) and (4), the following findings can be identified:

1. Chemical Characteristics

The pH values were entirely within the prescribed environmental limits. The highest recorded value was 7.94, whereas the lowest was 7.52, both falling within the permissible range of 6.5–8.5.

In contrast, phosphate (PO_4^{3-}) concentrations exceeded the permissible environmental limit of 0.2 mg/L, reaching 0.49, 0.38, 0.31, 0.31, 0.30, 0.31, 0.36, and 0.32 mg/L on 4, 7, 8, 9, 10, 11, 12, and 15 April, respectively.

Similarly, sulfate (SO_4^{2-}) concentrations exceeded the permissible environmental limit of 200 mg/L, with values of 294, 298, 224, 245, 225, 206, and 216 mg/L recorded on 4, 7, 8, 10, 12, 15, and 16 April, respectively.

Chloride (Cl^-) concentrations also exceeded the permissible limit of 100 mg/L on most sampling dates, reaching 141.2, 119.6, 118.5, 121.5, 117.7, 104, 107.8, 102.9, and 109.7 mg/L on 4, 7, 8, 9, 10, 11, 12, 14, and 15 April, respectively.

As for nitrate (NO_3^-), concentrations generally remained within the permissible limit of 15 mg/L in most samples, except on 4 April, when the concentration reached 25.2 mg/L.

2. Physical Characteristics

Regarding the physical characteristics of the river water, water temperature (Temp.) remained within the prescribed environmental limit throughout the study period. The highest recorded temperature was 10.8°C, while the lowest was 8.2°C, both well below the maximum permissible limit of 30°C.

However, total dissolved solids (TDS) exceeded the permissible limit of 600 mg/L in most samples, recording 924, 705, 690, 686, 690, 654, 639, and 630 mg/L on 4, 7, 8, 9, 10, 11, 12, and 14 April, respectively.

In contrast, total suspended solids (TSS) generally remained within the permissible environmental limit of 40 mg/L, except on 4 and 11 April, when concentrations reached 81.42 and 84.2 mg/L, respectively.

3. Biological Characteristics

With regard to the biological characteristics, biochemical oxygen demand (BOD) remained within the permissible limits during most of the study period. However, an elevated concentration of 13.8 mg/L was recorded on 4 April, after which BOD values returned to levels within the permissible environmental range during the remaining sampling dates in April.

As for dissolved oxygen (DO), the recorded values were within the acceptable environmental limits. According to the adopted standards, DO concentrations below 5 mg/L are considered unsuitable, whereas values equal to or greater than 5 mg/L are considered acceptable. The recorded values complied with these environmental standards.

4. Heavy Metals

The concentrations of nickel (Ni) remained within the permissible environmental limit of 0.02 mg/L. The highest recorded concentration was 0.0193 mg/L, while the lowest was 0.004 mg/L.

Regarding lead (Pb), it was not detected (N.D.) in the analyzed water samples from the Tigris River in Al-Aziziyah District, as shown in Table (4).

3.4. Pollution of the Tigris River in Al-Numaniyah District

By comparing the data presented in Tables (2) and (5), the following findings can be identified:

1. Chemical Characteristics

The pH values were fully within the prescribed environmental limits. The highest recorded value was 7.96, while the lowest was 7.60, both falling within the permissible range of 6.5–8.5.

In contrast, phosphate (PO_4^{3-}) concentrations exceeded the permissible environmental limit of 0.2 mg/L, reaching 0.46, 0.31, 0.27, 0.33, 0.42, and 0.30 mg/L on 6, 8, 9, 10, 11, and 12 April, respectively.

Similarly, sulfate (SO_4^{2-}) concentrations exceeded the permissible environmental limit of 200 mg/L, recording 260, 272, 254, 218, 208, 260, and 256 mg/L on 6, 8, 10, 11, 12, 13, and 16 April, respectively.

Chloride (Cl^-) concentrations also exceeded the permissible limit of 100 mg/L on most sampling dates, reaching 143.1, 127.1, 125.4, 117.6, 107.8, and 112.6 mg/L on 6, 8, 9, 10, 11, and 12 April, respectively.

As for nitrate (NO_3^-), all recorded concentrations remained within the permissible environmental limit of 15 mg/L. The highest recorded value was 13.2 mg/L, while the lowest was 6.6 mg/L, indicating that nitrate concentrations remained within the acceptable range throughout the reported sampling period.

2. Physical Characteristics

Regarding the physical characteristics of the river water, water temperature (Temp.) remained entirely within the permissible environmental limit. The highest recorded temperature was 11.6°C, while the lowest was 8.4°C, both well below the maximum permissible limit of 30°C.

However, total dissolved solids (TDS) exceeded the permissible limit of 600 mg/L in most samples, recording 856, 750, 698, 696, 682, 665, 622, and 892 mg/L on 6, 8, 9, 10, 11, 12, 14, and 16 April, respectively.

In contrast, total suspended solids (TSS) generally remained within the permissible environmental limit of 40 mg/L, except for one sampling date when a concentration of 72.42 mg/L was recorded.

3. Biological Characteristics

With regard to the biological characteristics, biochemical oxygen demand (BOD) remained within the permissible limits throughout the study period. The highest recorded value was 4.7 mg/L on 11 April, while the lowest was 1.1 mg/L on 8 April, with all recorded values remaining within the permissible range.

As for dissolved oxygen (DO), the recorded concentrations were within the acceptable environmental limits. According to the adopted standards, DO concentrations below 5 mg/L are considered unsuitable, whereas values equal to or greater than 5 mg/L are considered acceptable. The data presented in Table (5) indicate that the recorded DO values complied with these standards.

4. Heavy Metals

The concentration of nickel (Ni) occasionally exceeded the permissible environmental limit of 0.02 mg/L. The highest recorded concentration was 0.022 mg/L on 11 April, whereas the remaining samples were within the permissible limits.

Regarding lead (Pb), it was not detected (N.D.) in the analyzed water samples from the Tigris River in Al-Numaniyah District, as shown in Table (5).

Table 3. Results of Tigris River Water Quality Analyses in Al-Suwaira District during April 2026

No.	Parameter	04-4	07-4	08-4	09-4	10-4	11-4	12-4	13-4	14-4	15-4	16-4	22-4
1	pH	7.6	7.0	7.6	7.7	7.7	8.0	7.9	7.5	7.7	7.5	7.8	7.0
2	EC ($\mu\text{S}/\text{cm}$)	1368	1141	1063	1027	966	942	929	905	933	916	908	993
3	Temp ($^{\circ}\text{C}$)	8.4	10.4	8.3	10.2	9.4	10.6	9.8	8.8	10.6	8.2	11.4	8.2
4	TSS (mg/L)	191.4	62.41	32.42	58.46	38.8	62.46	27.12	28.64	9.62	21.18	8.82	12.6
5	TDS (mg/L)	892	740	670	672	632	608	606	602	608	590	593	640
6	TH (mg/L)	382	242	N.D	N.D	N.D	N.D	N.D	N.D	—	—	—	—
7	Ca^{2+} (mg/L)	91.2	62.4	N.D	N.D	N.D	N.D	N.D	N.D	—	—	—	—
8	Mg^{2+} (mg/L)	28.6	20.8	N.D	N.D	N.D	N.D	N.D	N.D	—	—	—	—
9	K^{+} (mg/L)	16.4	10.2	N.D	N.D	N.D	N.D	N.D	N.D	—	—	—	—
10	Na^{+} (mg/L)	125	96.8	N.D	N.D	N.D	N.D	N.D	N.D	—	—	—	—
11	Cl^{-} (mg/L)	150.9	121.5	111.7	115.6	107.8	99.96	101.9	90.16	92.2	98	98	90.16
12	SO_4^{2-} (mg/L)	262	217	227	200	237	196	255	178	180	190	210	170
13	NO_3^{-} (mg/L)	20.4	13.9	12.4	8.64	10.8	7.9	8.1	6.8	5.82	10	7.3	8.8
14	PO_4^{3-} (mg/L)	0.66	0.48	0.40	0.29	0.31	0.42	0.38	0.23	0.16	0.34	0.16	0.25
15	BOD ₅ (mg/L)	10.2	4.6	2.6	—	N.D	2.1	1.8	2.0	—	—	2.8	—
16	DO (mg/L)	6.3	9.8	8.7	9.6	10.2	7.8	8.6	6.85	6.8	6.2	6.4	6.7
17	Ni (mg/L)	0.035	N.D	0.02	0.02	0.061	0.02	0.021	—	—	—	0.007	0.006
18	Cd (mg/L)	N.D	N.D	N.D	—	N.D	N.D	N.D	—	—	—	—	—
19	Cr (mg/L)	0.01	N.D	0.009	0.015	0.006	N.D	N.D	—	—	—	—	—
20	Pb (mg/L)	0.031	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
21	Co (mg/L)	N.D	N.D	N.D	N.D	N.D	N.D	N.D	—	—	—	—	—
22	Fe (mg/L)	0.17	N.D	0.14	0.02	0.26	N.D	N.D	N.D	N.D	—	—	0.10
23	O&G (mg/L)	N.D	N.D	1.6	1.7	0.081	N.D	N.D	—	—	N.D	N.D	N.D
24	Turb (NTU)	—	—	—	—	—	75.4	35.4	—	25.8	38.4	24.1	30.4
25	COD (mg/L)	—	—	—	—	—	1.0	1.4	1.8	1.1	2.6	2.6	3.6
26	TOC (mg/L)	—	—	—	—	—	11.6	8.2	—	—	—	—	—

Table 4. Results of Tigris River Water Quality Analysis in Al-Aziziyah District

No.	Parameter	07-4	08-4	09-4	10-4	11-4	12-4	13-4	14-4	15-4	16-4	22-4
1	pH	7.9	7.9	7.7	7.7	7.6	7.9	7.7	7.5	7.7	7.6	7.4
2	EC ($\mu\text{S}/\text{cm}$)	1418	1071	1063	1058	1068	1003	986	954	981	896	9.8
3	Temp ($^{\circ}\text{C}$)	8.2	10.8	9.6	9.8	10.2	10.6	10.2	10.4	8.6	10.8	9
4	TSS (mg/L)	81.42	8.96	28.48	8.66	18.2	84.2	9.16	6.18	8.76	6.42	11
5	TDS (mg/L)	924	705	690	686	690	654	639	630	630	580	594
6	TH (mg/L)	324	305	—	—	—	—	—	—	—	—	—
7	Ca (mg/L)	87	68	—	—	—	—	—	—	—	—	—
8	Mg (mg/L)	26	30	—	—	—	—	—	—	—	—	—
9	K (mg/L)	16	8.4	—	—	—	—	—	—	—	—	—
10	Na (mg/L)	116.8	92.8	—	—	—	—	—	—	—	—	—
11	Cl^- (mg/L)	141	120	119	122	118	104	108	103	110	93.1	96
12	SO_4^{2-} (mg/L)	294	298	224	198	245	200	225	186	206	216	198
13	NO_3^- (mg/L)	25.2	10.9	9.68	8.82	10.3	7.1	7.6	6.46	7.8	7.8	9
14	PO_4^{3-} (mg/L)	0.49	0.38	0.31	0.31	0.3	0.31	0.36	0.18	0.32	0.18	0.3
15	BOD ₅ (mg/L)	13.8	2.8	2.5	—	—	3.8	4.6	—	—	2	—
16	DO (mg/L)	5.4	8.1	8.9	8.4	9.7	8.6	8.3	6.7	5.5	7.62	7
17	Ni (mg/L)	0.014	—	0.019	0.019	0.009	0.02	0.004	—	—	0.019	0.009
18	Cd (mg/L)	N.D	—	N.D	N.D	N.D	—	—	—	—	—	—
19	Cr (mg/L)	0.006	—	N.D	0.018	0.006	—	—	—	—	—	—
20	Pb (mg/L)	N.D	—	N.D	N.D	N.D	N.D	N.D	N.D	N.D	—	N.D
21	CO (mg/L)	N.D	—	N.D	N.D	N.D	—	—	—	—	—	—
22	Fe (mg/L)	0.078	—	0.0444	0.0109	0.077	—	—	—	—	—	0.102
23	O&G (mg/L)	—	—	0.34	0.42	0.064	0.01	N.D	N.D	N.D	—	N.D
24	Turb (NTU)	—	—	—	—	—	97.8	14.9	16.4	14.6	15.4	—
25	COD (mg/L)	—	—	—	—	—	—	2.6	2.4	1.4	2.2	2.8
26	TOC (mg/L)	—	—	—	—	—	—	11	—	—	—	—

Table 5. Results of Tigris River Water Quality Analysis in Al-Numaniyah District

No.	Parameter	6/4	8/4	9/4	10/4	11/4	12/4	13/4	14/4	15/4	16/4
1	pH	7.9	7.6	7.6	7.8	7.8	7.8	7.9	7.8	8	7.7
2	EC ($\mu\text{S}/\text{cm}$)	1292	1156	1086	1046	1042	1019	930	942	930	919
3	Temp ($^{\circ}\text{C}$)	9.8	8.4	9.6	12	10	11	9.6	11	8.5	10.2
4	TSS (mg/L)	76.4	9.16	12.4	25.2	11.1	10.1	9.16	7.26	7.3	6.88
5	TDS (mg/L)	856	750	698	696	682	665	595	622	596	892
6	TH (mg/L)	300	—	—	—	—	—	—	—	—	—
7	Ca (mg/L)	74	—	—	—	—	—	—	—	—	—
8	Mg (mg/L)	28	—	—	—	—	—	—	—	—	—
9	K (mg/L)	12	—	—	—	—	—	—	—	—	—
10	Na (mg/L)	122	—	—	—	—	—	—	—	—	—
11	Cl^- (mg/L)	143	127	125	118	108	113	96	99.9	108	99.9
12	SO_4^{2-} (mg/L)	260	272	192	254	218	208	260	192	200	256
13	NO_3^- (mg/L)	13.2	9.68	7.85	9.6	8.4	7.5	7.4	6.25	6.6	8.8
14	PO_4^{3-} (mg/L)	0.46	0.31	0.27	0.33	0.42	0.3	0.26	0.15	0.3	0.19
15	BOD_5 (mg/L)	4.2	1.1	—	—	4.7	3.8	3.4	—	—	1.8
16	DO (mg/L)	11	7.3	9.7	10	8.7	8.1	7.3	6.9	9.5	9.3
17	Ni (mg/L)	—	0.008	0.02	0.001	0.02	0.002	—	—	—	0.005
18	Cd (mg/L)	—	—	N.D	N.D	—	—	—	—	—	—
19	Cr (mg/L)	—	0.003 1	0	#### #	—	—	—	—	—	—
20	Pb (mg/L)	—	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
21	CO (mg/L)	—	N.D	N.D	N.D	—	—	—	—	—	—
22	Fe (mg/L)	—	0.127	0.22	0.056	—	—	—	—	—	—
23	O&G (mg/L)	—	0.22	0.1	0.012	N.D	N.D	N.D	N.D	N.D	N.D
24	Turb (NTU)	64.2	—	—	—	22.6	20.5	18.1	19.5	12	14.3
25	COD (mg/L)	—	—	—	—	—	1.7	1.2	1.6	1.8	2.5
26	TOC (mg/L)	—	—	—	—	—	—	8.8	—	—	—

4- Conclusions

1. The results of the study showed that the incident involving the discharge of water from the Diyala River, carrying wastes, suspended solids, and various pollutants into the Tigris River, had a direct

and evident impact on the water quality of the Tigris River in northern Wasit Governorate. Several physical and chemical parameters exceeded the Iraqi environmental standards during the initial days of the incident.

2. Turbidity reached its highest levels during the period from 11 April 2026 to 16 April 2026, indicating the transport of large quantities of sediments and suspended solids with the incoming water flow into the river.
3. Most water samples collected from the study sites showed noticeable increases in total dissolved solids (TDS) and electrical conductivity (EC), indicating an increase in the dissolved salt load and the influence of polluted discharges on river water quality.
4. Chloride and sulfate concentrations exceeded the Iraqi environmental limits at several sampling sites during the pollution period, reflecting an increase in the dissolved salt content of the river water.
5. Phosphate (PO_4^{3-}) concentrations continuously exceeded the permissible limits in most samples and were among the parameters most affected by the pollution event. This indicates an increased nutrient load potentially associated with domestic and agricultural wastes.
6. Some sites, particularly in Al-Suwaira and Al-Aziziyah districts, recorded elevated nitrate (NO_3^-) concentrations on 4 April. However, most recorded values remained within the permissible environmental limits, indicating that the impact of nitrate pollution was relatively limited compared with that of phosphate.
7. Dissolved oxygen (DO) concentrations remained within levels suitable for aquatic life at most study sites, indicating that the Tigris River maintained a degree of self-purification and environmental recovery despite exposure to the pollution event.
8. Heavy metals, particularly lead (Pb), cadmium (Cd), and chromium (Cr), did not reach concerning levels in most samples, although limited increases in nickel (Ni) were recorded during the early days of the incident.
9. Some sampling sites in Al-Suwaira District recorded elevated concentrations of oil and grease (O&G), particularly on 8 and 9 April, suggesting a contribution from petroleum-related or organic pollution sources associated with the incoming water flow.
10. Comparison with the official environmental statistical data for Wasit Governorate for 2024, as reported in the publication *Environmental Statistics of Iraq: Water Quantity and Quality for 2024* issued by the Statistics and Geographic Information Systems Authority, showed that the pollution event resulted in a clear deviation from the usual characteristics of Tigris River water, particularly in electrical conductivity (EC), total dissolved solids (TDS), chlorides, and sulfates. This supports the conclusion that the event had a measurable environmental impact beyond the normal variability in river water quality.
11. The study indicated that the environmental effects of the incident were not limited to the immediate period of occurrence but extended for several weeks thereafter, emphasizing the importance of rapid response to emergency pollution events.
12. The findings confirm that pollution resulting from the discharge of untreated water poses a direct threat to water security, public health, and the aquatic environment in Wasit Governorate. Such pollution falls within the concept of “environmental pollution” as defined in the Iraqi Environmental

Protection and Improvement Law No. 27 of 2009, because abnormal increases in several physical and chemical parameters adversely affected water quality. This highlights the importance of enforcing the legal measures stipulated under the law to protect water resources.

5- Recommendations

1. Prevent the discharge of polluted drainage water and contaminated tributary waters into the Tigris River unless appropriate environmental treatment has been carried out and compliance with Iraqi environmental standards has been verified.
2. Establish an early-warning system for detecting sudden pollution events in the Tigris River and link environmental monitoring stations to joint emergency operation centers involving the Ministry of Water Resources, the Ministry of Environment, and local governments.
3. Increase the number of water-quality monitoring stations along the Tigris River within Wasit Governorate to ensure continuous monitoring of environmental changes.
4. Adopt a national periodic monitoring program covering physical, chemical, and biological parameters, heavy metals, and oil and grease concentrations in river water.
5. Use official environmental statistical data issued by the Statistics and Geographic Information Systems Authority as a baseline for evaluating future pollution events, thereby enabling scientifically standardized assessment of the magnitude of environmental changes.
6. Require all governmental and private entities to refrain from discharging liquid or solid wastes into waterways without prior treatment in accordance with applicable environmental legislation.
7. Upgrade and expand wastewater treatment plants in cities and towns located within the Tigris River basin to reduce organic loads and nutrient inputs entering the river.
8. Reduce the indiscriminate use of chemical fertilizers and promote integrated nutrient management in agriculture to limit the movement of nitrates and phosphates into surface waters.
9. Implement periodic programs for the removal of accumulated sediments and solid materials from secondary rivers and drainage channels that discharge into the Tigris River.
10. Conduct long-term seasonal studies to assess changes in water quality and evaluate the influence of climatic and hydrological conditions on the transport and distribution of pollutants.
11. Enhance environmental awareness among citizens, educational institutions, and civil society organizations regarding the risks associated with dumping waste into rivers and the importance of protecting water resources.
12. Recognize the Tigris River as a strategic national resource and develop an integrated plan for managing environmental risks associated with emergency pollution events to ensure the sustainability of water resources and protect public health.
13. Enforce the provisions of Iraqi Environmental Protection and Improvement Law No. 27 of 2009 in cases of river pollution, particularly provisions concerning accountability of responsible parties, obligations to remediate environmental damage, compensation to the state for treatment and remediation costs, and the application of prescribed penalties against violators. Effective and deterrent penalties should also be imposed on entities or individuals responsible for polluting waterways in accordance with Iraqi environmental legislation.

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