© 2026 IJRTI | Volume 11, Issue 4 April 2026 | ISSN: 2456-3315

Assessment of Heavy Metal Contamination and Physico-chemical Quality of Al-Diwaniyah River: Impact on Biological Activity and Water Suitability

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Abstract

Global freshwater scarcity is increasingly exacerbated by deteriorating water quality caused by industrialization and urbanization. This study investigates the impact of urban, medical, and industrial discharges on the water quality of the Al-Diwaniyah River in Iraq. Water samples were collected from three strategic stations: Upstream (Control), Midstream (City Center), and Downstream (Industrial Zone). Physico-chemical parameters, including Dissolved Oxygen (DO), pH, Total Dissolved Solids (TDS), and Electrical Conductivity (EC), were measured alongside heavy metal concentrations (Cu, Ni, Pb, and Cr). Results indicated a severe degradation in water quality as the river flows through the city. DO levels plummeted from 8.2 mg/L at the control site to a hypoxic 1.5 mg/L downstream. TDS and EC significantly increased, with TDS reaching 1450 mg/L, exceeding WHO permissible limits. Heavy metal analysis revealed critical contamination levels at the southern station, particularly for Lead (Pb), which reached 0.650 mg/L—approximately 65 times the WHO limit. The Heavy Metal Pollution Index (HPI) rose from 42.5 (Good) upstream to 185.4 (Highly Polluted) downstream. Biological assays further confirmed high toxicity, as earthworm survival rates dropped to 10% and microbial respiration was inhibited by over 80% in downstream sediments. The findings highlight the urgent need for effective wastewater treatment and industrial regulation to protect the river's ecosystem and public health

Key words: Heavy Metal; Biological Activity; Water Suitability; high toxicity.

Introduction

Global freshwater scarcity is not only caused by insufficient natural resources but also by the gradual deterioration of water quality in many countries, reducing the amount of usable water **(1).** Due to their great toxicity and resistance to degradation, heavy metals (HMs) are one of the main contaminants found in aquatic habitats (**2).** Various natural factors and multiple human activities affect river water quality. Industrialization and urbanization negatively impact fragile water supplies, creating new demands and pollution risks **(3).** Pollution makes water unsuitable for irrigation, and treating it to an acceptable quality is difficult and expensive. On the other hand, as water quality declines, soil and crop problems develop, which in turn reduce yields unless specialized management practices are adopted to maintain or restore maximum production capacity under specific conditions **(4).**

Even though a lot of metals are thought to be necessary, at greater amounts they become hazardous because they can create free radicals, which can interact with membrane systems, proteins, and enzymes leading to oxidative stress. The degree of contamination in the water can be estimated from the concentrations of HMs in the sediments (**5).** A salinity-related water quality issue arises when the concentration of salts in irrigation water becomes excessive, causing accumulation in the root zone of crops to an extent that it negatively influences crop yields. Additionally, toxicity may occur when certain ions from the water are absorbed by the crops and build up within the plant. This is typically linked to the presence of one or more heavy metal ions in the water. In Diwaniyah, environmental pollution from residential and industrial activities poses a significant risk to surface water quality **(6).**

Most factories in the region release their wastewater into local water sources with little to no treatment **(7).** As the demand for irrigation water rises, agricultural lands frequently resort to using subpar irrigation water. Effluents from industries, released into surface waters and inactive treatment facilities, may be utilized for irrigation purposes **(8).** To help design effective measures to alleviate the deleterious impacts of pollution from HMs on both humans and the environment, the HPI may be used It is critical to take action to lessen the impact of HM contamination and stop the ongoing depletion of natural resources **(9).**

Materials and methods:

Selection of Sampling Stations

The study area was strategically selected along the Al-Diwaniyah River to represent a comprehensive pollution gradient, covering the impact of urban, medical, and industrial activities. Three primary sampling stations were identified based on the following criteria:

Station 1: Upstream (Control Point - North Diwaniyah), Near the Al-Daghara head (Sadr Al-Daghara).

This site serves as the Reference or Control Station. It is located at the entry point of the river into the city, where the water is relatively free from local urban and industrial discharges. It provides the baseline data to which other polluted sites are compared.

Station 2: Midstream (Urban & Medical Impact - City Center), Proximity to the Al-Diwaniyah Teaching Hospital.

This station was chosen to assess the impact of urbanization and healthcare facilities. It represents a zone affected by high population density, domestic sewage leaks, and potential medical liquid waste, which typically increase the levels of certain heavy metals like nickel (Ni) and lead (Pb).

Station 3: Downstream (Industrial & Final Discharge - South Diwaniyah), South of the city, downstream from the industrial zones and main sewage outfalls.

This represents the critical hotspot. It was selected to evaluate the cumulative impact of industrial effluents and untreated municipal wastewater before the river leaves the city. This area is expected to show the highest toxicity levels, significantly affecting bioindicators such as earthworms and microbial activity.

Physical and Chemical Parameters (In-Situ Measurements)

For the parameters (DO, pH, temperature, and EC), measurements were conducted directly in the field using a multi-parameter portable device to ensure accuracy and avoid biological changes in the samples. Temperature (T) and pH: Measured using a calibrated digital pH/temp meter.

The electrode was immersed in the water at a depth of 20-30 cm until the reading stabilized. Electrical Conductivity (EC) and Total Dissolved Solids (TDS): Determined using a handheld conductivity/TDS meter. The device was calibrated using standard KCl solutions. These parameters indicate the concentration of dissolved ions and salts in the river.

Dissolved Oxygen (DO): Measured using a portable Dissolved Oxygen Meter (Polarographic probe). This is crucial for assessing the river's ability to support aquatic life (like earthworms and microbes).2.

Heavy Metals Analysis (Cu, Ni, Pb, Cr) To determine the concentrations of Copper (Cu), Nickel (Ni), Lead (Pb), and Chromium (Cr), the following laboratory steps were followed:

1. Sampling: Water samples were collected in 500 mL polyethylene bottles, previously cleaned with 10% HNO_3.
2. Preservation: Samples were acidified immediately with concentrated Nitric Acid (HNO_3) to pH < 2 to prevent metal adsorption on the container walls and to inhibit microbial activity.
3. Digestion: In the laboratory, samples were digested using a concentrated acid mixture (Nitric acid and Hydrochloric acid) on a hot plate to release bound metals.

4. Detection: The final concentrations were measured using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-OES) or Atomic Absorption Spectroscopy (AAS), as per the standard methods for the examination of water and wastewater.

Result and Discussion

4.1. Physico-chemical Characteristics of Al-Diwaniyah River

Table 1: Show the level of Dissolved oxygen and temperature in Al-Diwaniyah River in three stations

parameters / Area	DO mg/L	T (C)
S_1	8.2	22.5
S_2	5.4	24.2
S_3	1.5	27.8

S_1= Station 1 (Control), **S_2**= Station 2 (Midstream), **S_3**= Station 3 (Downstream), **DO**=Dissolved Oxygen, and **T** = Temperature.

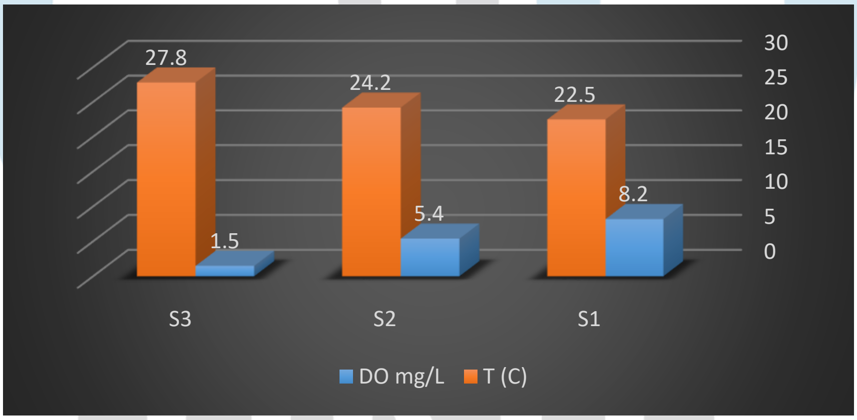

Figure 1: Show the level of Dissolved oxygen and temperature in Al-Diwaniyah River in three stations

Dissolved Oxygen (DO) and Temperature (T): At the upstream station (S_1), DO recorded its highest concentration at 8.2 mg/L, indicating a healthy aquatic environment. However, a drastic decline was observed at the downstream station (S_3), reaching a critical level of 1.5 mg/L. This hypoxia is attributed to the thermal discharge and high organic load from industrial outlets, where temperature rose from 22.5°C at S_1 to 27.8°C at S_3, as shown in **table 1**

The obtained results that River water contained dissolved oxygen concentrations ranging (6.3-10.1) mg/L, the current finding **(10).**

Table 2: Show the level of Total Dissolved Solids, pH and Electrical Conductivity in Al-Diwaniyah River in three stations

parameters / Area	TDS mg/L	pH	EC
S_1	420	7.4	850
S_2	780	7.8	1560
S_3	1450	8.4	2900

S_1= Station 1 (Control), **S_2**= Station 2 (Midstream), **S_3**= Station 3 (Downstream), **TDS**= Total Dissolved Solids, and **EC** = Electrical Conductivity.

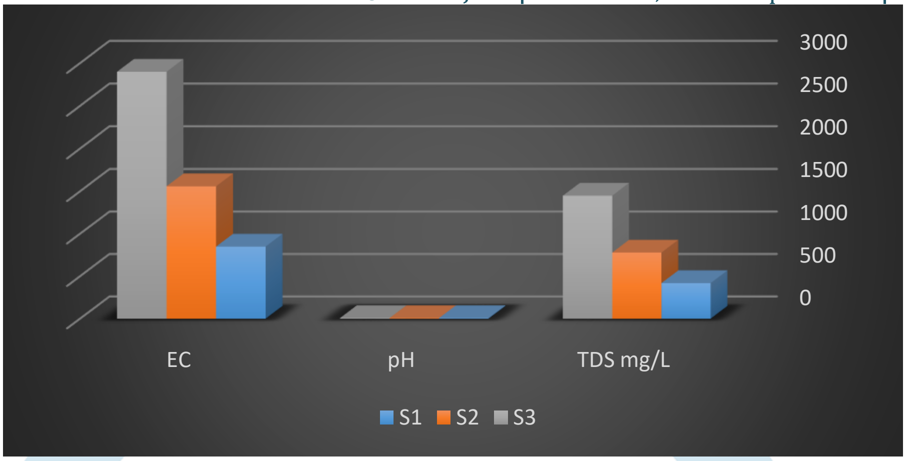

Figure 2: Show the level of Total Dissolved Solids, pH and Electrical Conductivity in Al-Diwaniyah River in three stations

In table 2 show the level of TDS, EC, and pH: Electrical Conductivity (EC) and Total Dissolved Solids (TDS) exhibited a significant increase as the river passed through the city. TDS jumped from 420 mg/L at S_1 to 1450 mg/L at S_3, exceeding the WHO permissible limits. The pH values shifted from a neutral state (7.4) at the entrance of the city to a more alkaline state (8.4) at the southern station, likely due to the influence of alkaline industrial detergents and waste.

The results that Electrical conductivity was between (998- 1380) µs/cm. Total dissolved solids and total suspended solids were their values varied between (620-932) mg/L and (2-28) mg/L respectively. **(10).** The TDS was ranged from 654 mg/l to 1109mg/l, the doesn't current finding **(11).** The results of physics properties were from 7.05 to 8.3 for total dissolved solids (T.D.S.) values were from 2100 to 756.6 mg/L, electrical conductivity values were between 1140 and 3500 µs/cm, the current finding **(12).**

4.2. Heavy Metals Concentration (Cu, Ni, Pb, and Cr)

Table 3: Show the level of Total Copper, Nickel, Lead, and Chromium in Al-Diwaniyah River in three stations

parameters / Area	Cu mg/L	Ni mg/L	Pb mg/L	Cr mg/L
S_1	0.008	0.02	0.004	0.10
S_2	0.075	0.065	0.048	0.45
S_3	0.420	0.210	0.650	0.180

S_1= Station 1 (Control), **S_2**= Station 2 (Midstream), **S_3**= Station 3 (Downstream), **Cu**= Copper, Ni = Nickel, Pb = Lead, and **Cr** = Chromium.

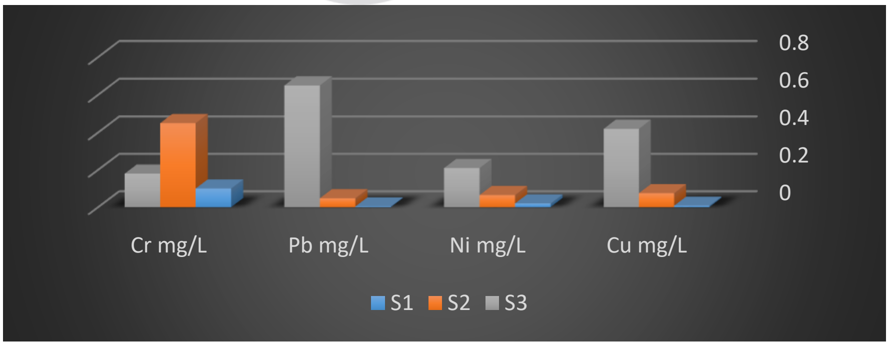

Figure 3: Show the level of Total Copper, Nickel, Lead, and Chromium in Al-Diwaniyah River in three stations

The analysis of heavy metals revealed a state of high contamination at the southern sites of Al-Diwaniyah city, as shown in **table 3**.

Lead (Pb) and Chromium (Cr): Lead (Pb) concentrations at S_3 were recorded at 0.650 mg/L, which is approximately 65 times higher than the WHO limit (0.01 mg/L). Similarly, Chromium (Cr) increased from 0.010

mg/L (S_1) to 0.180 mg/L (S_3). These high levels are directly linked to the untreated industrial effluents and scrap metal activities in the southern industrial zone.

Copper (Cu) and Nickel (Ni): Nickel (Ni) showed a notable increase at S2 (0.065 mg/L) near the hospital, reaching its peak at S_3 (0.210 mg/L). Copper (Cu) followed a similar trend, peaking at 0.420 mg/L at the downstream station.

The results showed that the highest concentrations of heavy metals in water and sediment samples were related to pb and Zn, the current finding **(13).** The highest concentration of Lead(pb) in the summer was 3.11 micrograms. Kg−1 in, while the lowest concentration in the winter was 0.22 micrograms. Kg−1 **(14).** The highest results of Pb and Ni have been 0.1247and 0.157 ppm, respectively, the doesn't current finding **(12).**

4.3. Heavy Metal Pollution Index (HPI)

To evaluate the overall toxicity, the HPI was calculated for the three stations.

1. Station 1 (Control): Recorded an HPI of 42.5, indicating "Good Water Quality."
2. Station 2 (Midstream): The index rose to 95.8, approaching the critical threshold of 100.
3. Station 3 (Downstream): Recorded a massive HPI of 185.4, classifying the water as "Highly Polluted." This indicates that the water at the southern exit of Al-Diwaniyah is toxic and unsuitable for most biological uses.

4.4. Biological Response (Earthworms and Microbial Activity)

The chemical toxicity was reflected in the biological tests. The survival rate of earthworms dropped from 100% in S_1 soil to only 10% when exposed to S_3 sediments. Furthermore, microbial respiration (CO_2 evolution) was inhibited by over 80% at Station 3 compared to the control station, confirming that the heavy metal accumulation has reached levels that paralyze the natural self-purification capacity of the river.

Conclusion

The study concludes that the Al-Diwaniyah River is subject to significant environmental stress due to the discharge of untreated municipal, medical, and industrial wastewater. A clear pollution gradient was observed, with the downstream station (South Diwaniyah) acting as a critical hotspot for heavy metal toxicity. The excessive concentrations of Lead, Nickel, and Chromium, coupled with a massive increase in the Heavy Metal Pollution Index (HPI), render the water at the city's exit "Highly Polluted" and unsuitable for most biological and agricultural uses.The drastic reduction in earthworm survival and microbial activity underscores the long-term ecological damage being inflicted on the river's natural self-purification capacity. To mitigate these deleterious impacts, it is essential to implement specialized management practices, reactivate treatment facilities, and establish continuous monitoring systems. Without immediate intervention, the ongoing contamination will continue to deplete natural resources and pose a severe risk to both the environment and human health in the region.

References

1- Mateo-Sagasta, J., Zadeh, S. M., Turral, H., & Burke, J. (2017). Water pollution from agriculture: a global review. Executive summary.

2- Appiah-Opong, R., Ofori, A., Ofosuhene, M., Ofori-Attah, E., Nunoo, F. K., Tuffour, I., ... & Fosu-Mensah, B. Y. (2021). Heavy metals concentration and pollution index (HPI) in drinking water along the southwest coast of Ghana. Applied Water Science, 11(3), 57.

3- Inyinbor Adejumoke, A., Adebesin Babatunde, O., Oluyori Abimbola, P., Adelani Akande Tabitha, A., Dada Adewumi, O., & Oreofe Toyin, A. (2018). Water pollution: effects, prevention, and climatic impact. Water challenges of an urbanizing world, 33, 33-47.

4- Mukheef, R. A. A. H., Obayes, A. A., & Omran, Z. A. (2022). Study The Suitability of Water Quality For Agricultural Uses In Al-Diwaniyah Governorate in Iraq. Asian Journal of Water, Environment and Pollution, 19(1), 87-92.

5- Mitra, S., Chakraborty, A. J., Tareq, A. M., Emran, T. B., Nainu, F., Khusro, A., ... & Simal-Gandara, J. (2022). Impact of heavy metals on the environment and human health: Novel therapeutic insights to counter the toxicity. Journal of King Saud University-Science, 34(3), 101865.

6- Gebre, A. E., Demissie, H. F., Mengesha, S. T., & Segni, M. T. (2016). The pollution profile of Modjo River due to industrial wastewater discharge. Modjo town, Oromia, Ethiopia. Journal of Environmental and Analytical Toxicology, 6(3), 1-5.

7- Ali, M. A., Alawsy, W. S. A., & Alabadi, L. A. S. (2025). Study of Heavy Metals Pollution in Diwaniyah River Water. Jornal of Al-Muthanna for Agricultural Sciences, 12(1).

8- Ali, M., Abdel-Hameed, A., Farid, I., Abbas, M., & Abbas, H. (2016). To What Extent Can Complimentary Irrigation of Wheat with Wastewater, on Soils Along Belbais Drain, Affect the Plants?. Journal of Soil Sciences and Agricultural Engineering, 7(6), 409-416.

9- Mahmood, B. A. (2021). ENVIRONMENTAL PROPERTIES AND ANALYSIS OF THE EUPHRATES RIVER WITHIN ANBAR GOVERNORATE IN IRAQ: A REVIEW. Iraqi Journal of Desert Studies, 11(2).

10- Hussein, K. M., Al-Bayati, S. A., & Al-Bakri, S. A. (2019). Assessing water quality for Al-Diwaniyah River, Iraq using GIS technique. Engineering and Technology Journal, 37(7), 256-264.

11- Abbas, A. A. A., & Hassan, F. M. (2018). Water quality assessment of Euphrates river in Qadisiyah province (Diwaniyah river), Iraq. The Iraqi Journal of Agricultural Science, 49(2), 251-261.

12- Ibrahiem, S. K., & Walli, H. A. (2025). Assessment of K and Heavy Metal Levels in Euphrates River of Al-Qadisiyah Governorate. Nature Environment and Pollution Technology, 24(1), 1-10.

13- Alkam, F. M., Al-Haidarey, M. J., & Alasedi, K. K. (2014). A study of some physicochemical parameters and heavy metals in the Diwaniyah River/Euphrates Iraq. Int J Sci Res, 3(6), 110-113.

14- Jarallah, R. S., & Al Husseini, H. M. H. (2021, April). Study of the Contamination of Soils Irrigated from Diwaniyah River with Lead/Iraq. In IOP Conference Series: Earth and Environmental Science (Vol. 735, No. 1, p. 012002). IOP Publishing.