

## The Role of Organic and Microbial Contamination in Surface Water Quality Deterioration in Al-Kut City, Wasit Governorate

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### Abstract

This investigation systematically evaluates the influence of organic and microbial pollutants on surface water quality within irrigation channels originating from the Tigris River in Al-Kut City, Wasit Governorate, Iraq. Water specimens were collected from two strategically selected monitoring stations—Shatt Al-Karimiyah (Dujaila River) (Station A) and Al-Khajiyya (Station B)—during October 2025. Comprehensive physicochemical and microbiological analyses were conducted in accordance with standard methods. Turbidity concentrations at both stations (52 and 43 NTU, respectively) significantly above allowable criteria, according to analytical results, while Station B's pH levels were below ideal values of 5.6. Abnormally high (BOD<sub>5</sub>) readings were found, 40 mg/L at Station A and 32 mg/L at Station B, signifying high organic pollution. (COD) values of 44 mg/L and 48 mg/L respectively, give signs of organic and inorganic oxidizable contaminants present. Microbiological analyses showed that there was no residual chlorine at either site, with heterotrophic plate counts exceeding permissible limits (128 and 124 CFU/mL) and total coliform and Escherichia coli concentrations exceeding 8 MPN/100 mL. These empirical findings confirm substantial contamination by organic material and microorganisms, making the water inappropriate for some uses unless it undergoes treatment first.

**Keywords:** COD, BOD<sub>5</sub>, Physical and chemical factors, Al-Khajiyya, Dujaila River, Water quality

دور التلوث العضوي والميكروبي في تدهور جودة المياه السطحية في مدينة الكوت، محافظة واسط  
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### المستخلص

تهدف هذه الدراسة إلى التقييم المنهجي لتأثير الملوثات العضوية والميكروبية في جودة المياه السطحية ضمن قنوات الري المتفرعة من نهر دجلة في مدينة الكوت، محافظة واسط، العراق. جُمعت عينات المياه من محطتين مختارتين للمراقبة هما شط الكريمة (نهر الدجيلية) (المحطة A) والخاجية (المحطة B) خلال شهر تشرين الأول 2025. أُجريت تحليلات فيزيائية وكيميائية وميكروبيولوجية شاملة. أظهرت النتائج ارتفاع قيم العكارة في كلتا المحطتين (52 و 43 NTU على التوالي) بما يتجاوز الحدود المسموح بها، كما سُجل انخفاض في قيم الأس الهيدروجيني في المحطة B لتصل إلى 5.6. كما لوحظت قيم مرتفعة لمتطلب الأوكسجين الحيوي (BOD<sub>5</sub>) بلغت 40 ملغم/لتر في المحطة A و 32 ملغم/لتر في المحطة B، مما يشير إلى وجود تلوث عضوي ملحوظ. كذلك سجل متطلب الأوكسجين الكيميائي (COD) قيماً بلغت 44 و 48 ملغم/لتر على التوالي، وهو ما يدل على وجود ملوثات عضوية وغير عضوية قابلة للأكسدة. وأظهرت التحاليل الميكروبية غياب الكلور المتبقي في كلا الموقعين، مع تجاوز أعداد البكتيريا غيرية التغذية للحدود المسموح بها (128 و 124 CFU/مل)، إضافة إلى ارتفاع أعداد بكتيريا القولون الكلية والإشريكية القولونية إلى أكثر من 8 MPN/100 مل. وتشير هذه النتائج إلى وجود تلوث واضح بالمواد العضوية والكائنات الحية الدقيقة، مما يجعل المياه غير ملائمة لبعض الاستخدامات ما لم تخضع لعمليات معالجة مناسبة.

الكلمات المفتاحية: COD، BOD<sub>5</sub>، العوامل الفيزيائية والكيميائية، الخاجية، نهر الدجيلية، جودة المياه

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### Introduction

A serious worldwide environmental issue that needs quick and ongoing multidisciplinary

attention from stakeholders in academia, government, and civil society is surface water pollution. Surface water systems, which include rivers, streams, lakes, wetlands, reservoirs, and marine habitats, are vital parts of terrestrial hydrological cycles and offer vital ecosystem services that sustain human civilizations and natural biodiversity. Despite their critical importance, comprehensive understanding of their worldwide spatial distribution, temporal discharge variability, and storage capacity dynamics remains inadequately characterized in contemporary hydrological literature [1]. Both point sources, such as concentrated animal feeding operations, municipal wastewater treatment plants, and industrial effluent discharges, as well as diffuse non-point sources, such as agricultural runoff, atmospheric deposition, and urban stormwater drainage, can contribute to the degradation of surface water quality. The complex mixtures of chemical, biological, and physical pollutants introduced by these various contamination pathways pose a threat to environmental sustainability and jeopardize the biogeochemical processes essential to the functioning of aquatic ecosystems and human water security [2]. Deterioration of water quality is a widespread and complex issue that impacts countries at all levels of socioeconomic development. To identify the underlying causes and put successful restoration plans into place, coordinated transdisciplinary methods are required. Rapid urbanization, industrialization, and agricultural intensification are examples of anthropogenic activities that have been conclusively identified as the main causes of the pollution of freshwater ecosystems. These human-mediated activities expose aquatic

environments to a wide range of persistent organic pollutants, heavy metals, nutrients, pathogens, and emerging contaminants, endangering the ecological integrity of nearby landscapes, agricultural productivity, public health infrastructure, and food security systems [3]. Conventional in-situ techniques for characterizing water quality are often resource-intensive, time-consuming, and need a high level of technical proficiency in addition to an exact comprehension of site-specific physicochemical characteristics. The Water Quality Index (WQI), a widely used analytical framework that unifies complicated multi-parameter datasets into unified, standardized categorization metrics indicative of overall pollution status and ecological condition, has evolved as a solution to these methodological limitations. These integrated assessment models are useful for assessing the condition of surface water resources, guiding the development of evidence-based remediation strategies, and determining the main environmental factors causing deterioration in water quality [4].

## **Materials and Methods**

### **Study Area**

Water samples were systematically collected from two strategically chosen monitoring stations in Al-Kut City, Shatt Al-Karimiyah (Dujaila River) (Station A) and Al-Khajiyya (Station B) using internationally recognized and scientifically validated sampling procedures in accordance with ISO 5667 requirements. The geographic coordinates, background information, and map showing the research sites of sample locations are presented in detail in (Table 1 and Figure 1).

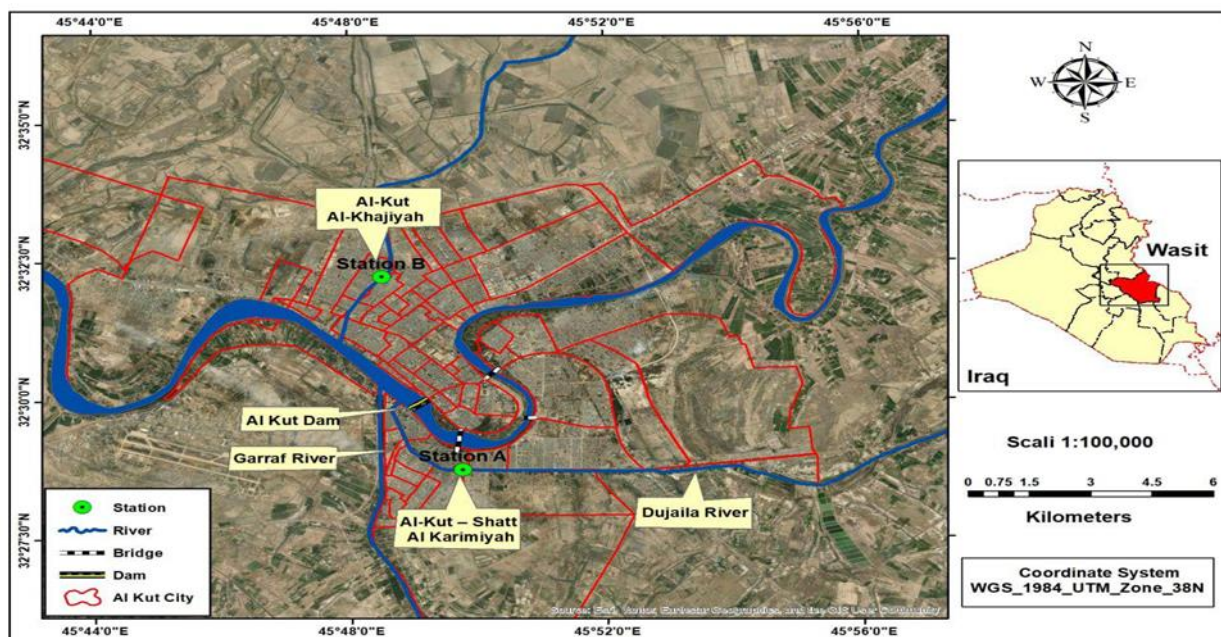


Figure (1): Map showing the research sites

Table (1): Monitoring Station Geographical Coordinates and Features

Station code	Station Name	Latitude	Longitude	Country	Data Source
A	Shatt Al-Karimiyah (Dujaila River)	32°28'42.8" N	45°49'45.6" E	Wasit /Iraq	Google Maps
B	Al-Khajiyyah	32°32'12.6" N	45°48'32.1" E	Wasit /Iraq	Google Maps

**Analytical Methodologies**

Values pH, EC and TDS, water temperature, and turbidity were all measured in situ using calibrated digital by HydroMaster Korean origin. The conventional conversion equation,  $TDS (mg/L) = EC (\mu S/cm) \times 0.64$ , was used to indirectly determine total dissolved solids concentrations from electrical conductivity data. This relationship has been empirically proven for freshwater systems with moderate ionic strength [5]. Under strict aseptic conditions, microbiological evaluations, including residual chlorine quantification, total coliform and Escherichia coli enumeration using the Most Probable Number

(MPN) technique, and heterotrophic plate count determination using the pour-plate methodology, were carried out in accordance with World Health Organization guidelines [6].

As thoroughly detailed in Standard Methods for the Examination of Water and Wastewater [5] standard spectrophotometric and gravimetric techniques were used to determine chemical parameters, such as BOD, COD, TSS,  $Cl^-$ , and  $PO_4^{3-}$ . To evaluate analytical precision, all measurements were made three times. The data were presented as mean values with standard deviations where applicable. Regular equipment calibration, verified reference material analysis,

and the use of method blanks to reduce systematic mistakes were all examples of quality control procedures of certified reference materials, and implementation of method blanks to minimize systematic errors. Mainly descriptive statistical analysis (mean SD) was used to characterize the water quality parameters because of few number of sampling stations. However, variations between stations were supported more from observed method by the comparison of guideline (WHO) and environmental significance.

## Results

### Physical Parameters

Significant geographical differences across measured parameters were found in the water specimens obtained from both monitoring stations after a thorough physicochemical investigation. The results in **Table (2)** showing diverse contamination patterns within the research region. Both (Station A and B ) this was using Hach 2100N Turbidimeter USA origin recorded turbidity values of 52 and 43 NTU, respectively, which were significantly higher than the (WHO) maximum permitted limit (MPL) of 5 NTU. Significant suspended particle matter loading is indicated by these high turbidity levels, which may be caused by soil erosion, organic matter buildup,

and human discharge activities. High turbidity levels can host harmful microbes adsorbed to suspended particles, impair photosynthetic activities by reducing light penetration, and degrade the aesthetic quality of water. And (Station A) recorded a pH of 6.5, whereas (Station B) recorded a pH of 5.6. Station B showed a noticeable acidic deviation, indicating the influence of anthropogenic pollutant loading, industrial effluent discharge, or natural acidification processes resulting from organic matter decomposition, whereas (Station A) only slightly met the lower threshold of the WHO-recommended optimal range (6.5–8.5). The results in (**Table 2**) Stations A and B recorded EC at 1080  $\mu\text{S}/\text{cm}$  and 1040  $\mu\text{S}/\text{cm}$ , respectively, both of which were within the WHO MPL of 2000  $\mu\text{S}/\text{cm}$ . The acceptable criterion of 1000 mg/L was met by the TDS measurements at Stations A and B, which were 691.2 mg/L and 665.6 mg/L, respectively, determined from EC using the usual conversion equation. Although they do not approach critical contamination levels, these intermediate TDS values indicate impacts from both human inputs and natural mineral dissolution. The reported water temperatures at both monitoring sites were 36°C and 35°C, which is in line with the study region's typical dry climate at the time of the sample.

**Table (2): Physical Characteristics of Water Specimens at Monitoring Stations**

Parameter	Station A	Station B	WHO MPL
Turbidity (NTU)	52	43	5
pH	6.5	5.6	6.5–8.5
Electrical Conductivity ( $\mu\text{S}/\text{cm}$ )	1080	1040	2000
Total Dissolved Solids (mg/L)	691.2	665.6	1000

Water Temperature (°C)	36	35	—
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**Chemical Characteristics**

Significant signs of organic pollution This was done using OXi Top Box Is6 aGerman-made device were found at both monitoring sites by chemical analysis, as shown in **Table (3)** (Station A ) concentration of BOD was much higher than the WHO maximum allowable limit of 6 mg/L, whereas (Station B) concentration was measured at( 40 mg/L and 32 mg/L, respectively). Significant biodegradable organic matter loading is indicated by elevated BOD levels, which are most likely the result of decaying organic materials, agricultural runoff including organic fertilizers, and household sewage discharge. Elevated BOD levels suggest possible dissolved oxygen depletion, endangering aerobic aquatic life and ecological processes. In the same table, using the Kjeldahl Digestion Unit – 4 Places (German-made device), (Stations A and B) recorded COD values of (44 and 48 mg/L, respectively), both of which were over allowable limits. The presence of both biodegradable and refractory organic molecules, such as industrial chemicals and xenobiotic

substances resistant to biological degradation, is indicated by the consistently greater COD relative to BOD at both stations. The COD/BOD ratio sheds light on the properties of biodegradability and possible organic contamination sources. At (Stations A and B) the TSS concentrations were measured at (48 mg/L and 42 mg/L, respectively). These levels were also higher than WHO recommendations, supporting the high turbidity observations and showing significant particulate matter loading. The results in **Table (3)**, at (Stations A and B), the concentrations of Cl<sup>-</sup> were measured at (184 mg/L and 176 mg/L, respectively), both of which were under the( 250 mg/L) WHO tolerable range. Concentrations of PO<sub>4</sub><sup>3-</sup> were found to be ( 0.8 mg/L and 0.6 mg/L at both sites), suggesting possible nutrient enrichment from detergent residues, household wastewater outflow, and agricultural fertilizer application. Continued phosphate buildup may encourage algal growth and consequent deterioration of the water quality, even while it is below critical eutrophication limits.

**Table (3): Chemical Characteristics of Water Specimens at Monitoring Stations**

Parameter	Station A	Station B	WHO MPL
BOD <sub>5</sub> (mg/L)	40	32	6
COD (mg/L)	44	48	10
Total Suspended Solids (mg/L)	48	42	—
Chloride (Cl <sup>-</sup> ) (mg/L)	184	176	250
Phosphate (PO <sub>4</sub> <sup>3-</sup> ) (mg/L)	0.8	0.6	—

### Microbiological Characteristics

Significant public health concerns were raised by the microbiological investigations that showed significant contamination at both monitoring sites, as shown in **Table (4)**. At both stations, residual chlorine was totally absent (0.0 mg/L). In distribution systems, the absence of residual chlorine removes the barrier that prevents pathogen proliferation and microbial regeneration. Concentrations of total coliform bacteria at both sites were much higher than WHO requirements for total absence in drinking water sources, above the MPN method's detection limit (>8 MPN/100 mL). Indicators of overall hygienic quality and possible fecal contamination are total coliforms. *Escherichia coli* enumeration also showed values

over (8 MPN/100 mL at both sites) , conclusively proving recent animal or human fecal contamination. The presence of *E. coli* suggests the existence of potentially harmful microorganisms, such as viruses, parasite protozoa, and enteric bacteria, which pose serious hazards for the spread of waterborne diseases. In the same table, at (Stations A and B), the heterotrophic plate counts were measured at (128 and 124 CFU/mL, respectively), both significantly higher than the (100 CFU/mL) WHO recommended limit. Increased quantities of heterotrophic bacteria suggest the presence of possible opportunistic pathogens, nutrient enrichment that promotes bacterial growth

**Table (4): Microbiological Characteristics of Water Specimens at Monitoring Stations**

Parameter	Station A	Station B	WHO Standard
Residual Chlorine (mg/L)	0.0	0.0	0.2–0.5
Total Coliforms (MPN/100 mL)	>8	>8	0
<i>Escherichia coli</i> (MPN/100 mL)	>8	>8	0
Heterotrophic Plate Count (CFU/mL)	128	124	100

### Discussion

Recent findings consistently indicate a marked deterioration in the water quality of rivers, particularly in regions facing high population and industrial pressures. According to [7] The Water Quality Index (WQI) for surface water in the Tigris River within Wasit Governorate ranged between 352.3 and 1106.5, values that far exceed standard criteria and classify the water as unfit. This trend is supported by [8] who observed a quality gradient in the Tigris River, transitioning

from "good" in the north to "poor" in the far south due to the accumulation of pollutants from human and agricultural activities along the river's path. Similarly, the study by [9] on the Euphrates River confirmed that water quality ranged from "poor" to "very poor," signaling a general crisis in Iraqi surface water quality. These regional findings align with the current study's results, where WQI-related parameters such as BOD and COD were found to be significantly higher than the WHO maximum allowable limits.

Regarding microbiological indicators, research has proven that *E. coli* remains the most accurate and cost-effective indicator for assessing fecal pollution [10] explained that the ease and sensitivity of *E. coli* detection methods make it the preferred standard for monitoring, despite its short survival time in water. From a social perspective, [11] revealed that *E. coli* contamination is often "invisible" to households, which significantly impacts their decisions regarding domestic water treatment. In a similar context, [12] showed that most drinking water samples in Lahore were unfit for human consumption due to contamination with *E. coli* and heavy metals. This correlates directly with the current study's microbiological findings, which showed *E. coli* counts exceeding 8 MPN/100 mL and a total absence of residual chlorine, conclusively proving recent fecal contamination.

In terms of BOD and COD values, they can be explained using the whole analysis framework of Aguilar-Torrejn *et al.* [13], who found that the relationships between COD, BOD and total organic carbon (TOC) were generic as a complementary succession of organic loadings. Kuznietsov and Biedunkova [14] presented correlations between BOD, COD and water temperature in the Styr River, which was also well predicted because high temperatures were recorded (35-36 C) in this study and partially also would enhance the decomposition of organic materials.

In the context of treatment, Shaheen *et al.* [15] provided an excellent illustration of the effectiveness of waste stabilization ponds in attaining pathogen and virus removal efficiencies of in excess of 99%, an affordable solution suited to developing country environments. Another study by Kumari *et al.* [16] also investigated advanced bioremediation procedures using

indigenous bacterial isolates including *Bacillus subtilis* for microplastic contaminants biodegradation, reflecting novel techniques toward sustainable water treatment.

There is extensive literature on the combined influence of natural mechanisms and anthropogenic sources on groundwater quality deterioration. On the Tigris River, the interaction between natural effects of geological dissolution of minerals such as gypsum and rock salt and human contributions like discharges of untreated waste water led to increased degradation of the water quality according to Olewi and Al-Dabbas [17]. With regard to microbiological deficiencies noted in the present study, these were further supported by Al-Jawahery *et al* [18] for example: who detected ongoing microbial contamination of treated drinking water sources in Babylon Governorate, where 64% of reverse osmosis treated samples were coliform positive despite an almost complete removal of chemical contaminants (96.6%). This demonstrated the need for additional disinfection processes, such as UV irradiation.

Regional and global comparisons are used to provide background against which the current findings are placed. Enyew *et al.* [19] recorded turbidity as high as 497.3 NTU in the similarly applicable Giha River, Ethiopia, significantly higher than the present study, but highlighting the burden of high suspended solids on urban and agricultural catchments. pH acidity observed at Station B (5.6) reflects upstream values in the upper Giha River (5.51) where organic acids and low buffering capacity were present in the freshwater systems. Contrasting alkaline pH by RIVER [20] at the Pandu River reflects detergents and industrial waste inputs.

The concentration of electrical conductivity (EC: 1080 and 1040  $\mu\text{S}/\text{cm}$ ) and total dissolved solids (TDS: 691.2 and 665.6 mg/L) in the current investigation are approaching their maximum permissible limits, thus undoubtedly indicative of extremely high levels of land utilization and agricultures practice. Afkri *et al.* [21] established a positive and high significant correlation ( $r = 0.87$ ) between electrical conductivity (EC) and total dissolved solids (TDS) affording them the suggestive indices of accumulation of dissoluble ions resident within fertilizers and domestic sewages. Bramhankar *et al.* [22] found similar increased concentrations of TDS correlated with domestic sewages derived from human denizens in heavily populated mega-cities.

Elevated water temperatures measured in the current investigation (35-36)  $^{\circ}\text{C}$  is in agreement with earlier studies whereby Afkri *et al.* [21] obtained it as an influential factor in modulating seasonal variations in water quality and its available nutrients.

Total absence of residual chlorine, and BOD, total coliform and *E. coli* counts above 8 MPN/100 mL, respectively, are indicative of, and are in tandem with, a contamination concern and threats of outbreaks of waterborne pathogens in situations of no effective disinfection system in place, as warned by Tashakori and Jalili [23]. After having carried out the WQI classification system used by Bramhankar *et al.* [22], the water quality indicators found at both these sampling stations would be ranked in the “unfit for human consumption” category, as classified for the highly polluted Nag River, Maharashtra. Further, besides also venturing into the effects in terms of taste, navigation, water treatment, gastrointestinal health, ordinary taste, taste newness and potable water, Verma *et al.* [24] lighted on the fact that TDS

readings of this magnitude in the first place would be perceived as indicator of deteriorating water purity.

### Conclusions

The current records of the quality of surface waters at the two stations in the City of Al-Kut show marked deterioration with many of the physicochemical and microbiological indicators surpassing maximum permissible limits set by WHO. The high BOD and COD levels pointed to high organic contamination resulting from the discharge of untreated wastewaters and diffuse runoff from farmlands. The presence of *E. coli* at the two stations confirmed fecal pollution while the complete lack of residual chlorine made the waters vulnerable to microbial recontamination .

The increase in turbidity, acidity (low pH at B), and high number of heterotrophic bacteria at the surface illuminated the extent of anthropogenic influences on surface water quality of the study area. These findings are in agreement with the regional studies reporting widespread surface water deterioration at the Tigris-Euphrates basin and provide a compelling reason for adopting non-disruptive water resources management initiatives. Further research needs to be directed toward: spatial expansion of the monitoring network, implementation of seasonal sampling efforts, and the use of sophisticated risk assessment techniques—such as QMRA—to fully characterize the public health risks from water usage in the region

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