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EFFECT OF SEWAGE DISCHARGES IN THE CITY CENTRE OF DIWANIYAH ON THE QUALITY OF WATER IN SHATT AL-DIWANIYAH

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Research Paper

Abstract: *Untreated sewage discharges represent a major environmental concern over water quality, particularly in urban areas. This paper aims at determining the impact on the quality of Shatt al-Diwaniyah water brought about by how sewage is disposed of in Diwaniyah city. Twelve sampling sites in January and July 2024 were used for field surveys and laboratory analyses. The major contributors to water contamination in this region are ineffective sewage treatment, agricultural runoff, and industrial disposal. In general, a significant amount of pollutants, including electrical conductivity, turbidity, nitrates, and phosphates close to the locations where sewage leaves the treatment site, enters the water, and the industrial areas were noticed in this study. This outcome requires a sense of urgency toward improving waste management systems and control of industrial pollution in curbing environmental degradation in the region. The research gives policymakers and environmental engineers valuable insights into the creation of sustainable water management practices.*

Keywords: *Water Quality, Diwaniyah Wastewater, Sewage Treatment, Water Pollution, Water PH, Electrical Conductivity, Water Turbidity*

1. Introduction

Water pollution is one of the most alarming environmental problems that face ecosystems, public health, and water resources in areas where industrial and sewage discharges are not effectively managed. This particular issue is of great importance in rapidly urbanizing regions because higher population density, industrialization, and a poorly designed wastewater management system result in poor conditions for

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natural water bodies (Al-Asadi & Al-Kafari, 2022). With increases in the scale of industrialization, pressures on water resources become more severe and elevate levels of pollutants affecting human as well as environmental health. Rivers and streams, being basic sources of water for drinking, agricultural purposes, and industry, are more intensively contaminated by untreated sewage, agricultural runoff, and industrial effluents (Tariq & Mushtaq, 2023).

Diwaniyah city, Al-Qadisiyah Governorate, Iraq, is an exemplary case of a region where rapid urbanization and obsolete drainage systems have led to a serious quality condition of water. Shatt al-Diwaniyah is the main watercourse in this region; it is often used for irrigation in favour of agriculture, potable supply for communities next to the lagoon, and industrial purposes (Chabuk et al., 2021). In fact, the recent direct dumping of untreated sewage into the river and fertilizers and pesticides carry-over from farming activities have led to increased nitrates, phosphates, heavy metals, and organic wastes that further enhance water pollution and have extra implications on biodiversity, aquatic ecosystems, and human health (Mushtaq et al., 2020; Tiwari & Pal, 2022).

Arid and semi-arid, like in Iraq, the importance of water resources is irreplaceable. Surface water bodies, which mainly include Shatt al-Diwaniyah, play a significant role in sustaining agricultural production, an integral sector of the local economy; however, a deterioration in the water quality because of pollution is threatening its survival for use in irrigation and safe drinking. Directly, these contaminants may easily penetrate the food chain through contaminated crops and fish, causing cancer and other health problems like neurological and reproductive disorders (Altinbilek & Hatipoglu, 2020; Karri et al., 2021). Despite the critical nature of this issue, the wastewater treatment facilities set up in Diwaniyah and other nearby urban areas are generally grossly under-equipped. Most of these sewage treatment plants either are non-functional or work below their desired capacities, allowing untreated or partly treated sewage to find its way into Shatt al-Diwaniyah (AL-Sulaimen, 2009; Hussein & Azad, 2023).

The findings of this research are to be used in contributing profoundly to understanding the environmental challenges water bodies face within urban-industrial regions, particularly for countries like Iraq. This will also provide critical information for environmental engineers, policymakers, and local governments to construct effective strategies for proper management of waste waters, control of pollution levels, and judicious use of water resources. It shall suggest practical recommendations on the improvements needed in sewage treatment infrastructures, regulation of industrial discharges, and implementing environmentally sustainable agricultural practices. This research work will eventually lead to providing input for the establishment of an integrated water management plan as a means of protecting the quality of Shatt al-Diwaniyah and thus ensuring its continuous suitability as a source for irrigation, drinking water, and industry.

1.1 Aim of the Research

1.1.1 The Natural Characteristics of the Study Area

The study area lies in between latitudes 27.310°N and 18.320°N, and longitudes 42.440°E and 13.450°E as shown in Figure 1. Climatically, the area falls within the arid zone where the average annual temperature is 24.74°C and the yearly rainfall is only 114.8 mm. Meanwhile, annual average rate of evaporation is relatively much greater, namely 258.9 mm. This reduces the efficiency of precipitation and forces attention primarily on importance of surface water resources for drinking purposes and for irrigation and industry. Shatt al-Diwaniyah is the major surface water in this area. It flows northwards from the north area, to flow south-eastward, covering an approximate 121 km within the administrative boundaries of Al-Qadisiyah Governorate. The river has a designed drainage capacity of 60 m^3/s, although the actual measurement revealed a depleted flow, averaging at 43.49 m^3/s. The mean yearly level of the water is recorded at 20.06 m^3 (AL-Shpli & Alasady, 2022; Lazem & Hamzah, 2024).

The regional dynamics of groundwater are very complex and interaction must have occurred with Shatt al-Diwaniyah. There is available evidence of the recharge of groundwater due to the relative higher elevation of the river above groundwater levels. However, reverse recharge has been observed south of Diwaniyah city and north of the Al-Sudair district, where the groundwater level is higher than the river, potentially contributing to localized changes in water quality and flow patterns in the Shatt al-Diwaniyah. Since the region has limited rainfall and relatively high evaporation rates, the interaction between surface and ground water is thus important for maintaining the regional water supply (Al-Asadi & Al-Kafari, 2022; Hao, 2024).

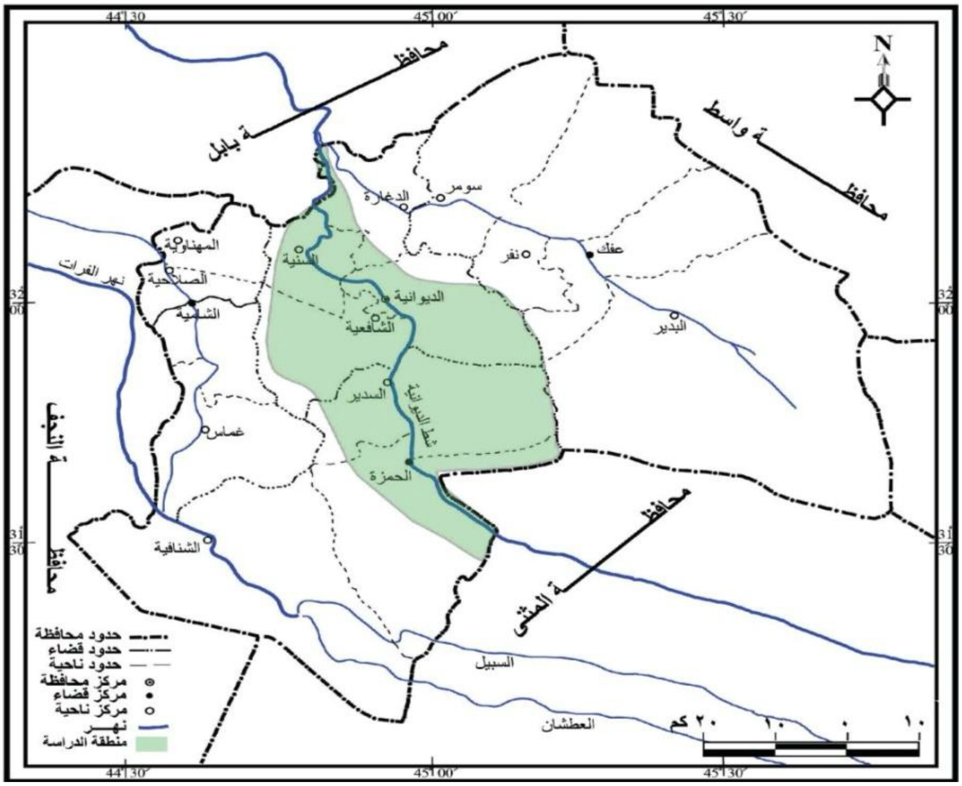

Figure 1: Location of the Study Area in Relation to Al-Qadisiyah Governorate
Source: Al-Qadisiyah Governorate Public Works.

1.1.2 The Main Sources of Pollution in Shatt Al-Diwaniyah Water

Poor sewage systems, agricultural activities, and industrial processes are the major pollution-causing agents in Shatt Al-Diwaniyah. In Sunniyah City, open sewers characterize the undeveloped sewage networks; waste is carried by tankers into the agricultural drains or directly into the Shatt. The Diwaniyah City also does not treat its sewage efficiently and hence emits untreated waste into the waterway, but it manages wastewater through open sewers and rainwater systems. But Al-Sadir City and Al-Hamza City have compromised using proper sewage infrastructure and have adopted the management of wastewater through tankers and open sewers, which contributes more to pollution. Agricultural practices significantly contribute to water pollution: crop farming and livestock raising. The agricultural drains in the north of Sunniyah were unregulated and channel wastewaters from farms into the Shatt, in regions like Al-Bu Nahadh, where there are many field drains the farmers introduced. Again the river is polluted by buffalo wastes and fish breeding at intervals along the river along the Sunniyah and Diwaniyah sides. The textile and rubber factories are located south east of Diwaniyah and thus industrial pollution originates primarily from them. The rubber factory releases its effluent without treatment in the Shatt since it hasn't established any treatment facility. The textile factory, having a treatment unit available, happens to be congested due to excess flow thus leading to further pollution of the Diwaniyah River. The factors put together call for immediate engineering solutions to the problems causing pollution in the Shatt Al- Diwaniyah (Al-Asadi & Al-Kafari, 2022; AL-Shpli & Alasady, 2022; Azhari et al., 2023).

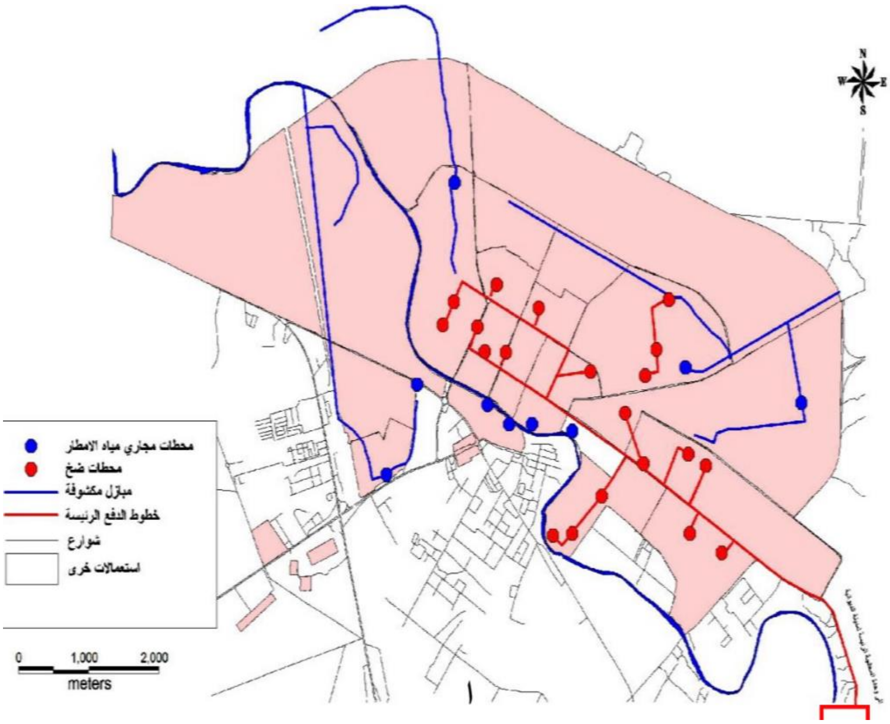

Figure 2: Sewage and Rainwater System in the City of Diwaniyah
Source: Al-Qadisiyah Governorate Public Works.

2. Literature Survey

Discussing critical dangers of agricultural water pollution, to the integrity of the environment, human health and the security of food supplies, they impact the aquatic ecosystem and quality of water. Some of the pollutants emanate from point and non-point sources are a few of the contaminants - fertilizers, pesticides and sediments. The need for effective measures to control pollution is best rated as originating from pressures of population growth in the world and from patterns of consumption of food. According to Zahoor and Mushtaq (2023), it requires integrated water quality management approach, and it must be done through collaboration with stakeholders such as government agencies, NGOs, and farmers. Which involves best management practices, regulatory frameworks, and enhancement of research and monitoring to counteract novel toxins and heavy metals. The future research considerations should be on the source of pollution, economic incentive to reduce pollution, and data collection efforts.

Ranked at five of the country's most vulnerable to climate change, Iraq is also confronted with environmental hazards, which include heavy metals that contaminate its water bodies. Al-Jasimee and Hussein (2023) analyse levels of Cd, Pb, and Ni in the Dalmaj Marsh, a natural heritage described by UNESCO. Its concentrations were high because of the wastewater emitted and agricultural runoff. The average value of Cd, Pb, and Ni were within the range of 1.96, 4.27, and 2.11 µg/l, respectively, thus revealing the requirement of proper freshwater resources control in Iraq.

Moreover, Abd Ulameer and Omran (2024)adopted the weighted arithmetic water quality index (WQI) for assessing the river's water quality of Shatt Al-Hillah River between 2017 to 2021. Their investigation was designed by the study of physiochemical parameters such as pH, EC, TDS and main ions at each station of the river in the generation of a WQI for the same. Results were shown to vary significantly in terms of the quality of water. The best station was station 1, with a WQI of 8.322, while the worst was station 4, with a WQI of 124.99. These results signify the necessity of specific strategies in water management along this river.

In addition to this, Al-Khuzaie et al. (2024) examined the impact of untreated wastewater on Euphrates River in Al-Diwaniyah, Iraq. The research reported several water quality parameters assessed from 40 sampling stations based on heavy metals: Ni, Cr, Pb, Co, Cd, Cu, and Fe. By the Heavy Metal Pollution Index and the Inverse Distance Weighting for spatial prediction, the results obtained show an intense pollution since concentrations of Ni, Fe, and Cd surpass the Iraqi standards. From this finding, therefore, could ascertain that improvement in the management of wastewater within the city will salvage the dire need for mitigating heavy metal contamination in the river.

The water quality monitoring technologies have been reviewed in detail by Thakur and Devi (2024), who recommended that future research be concentrated on portable and user-friendly systems for real-time or on-site monitoring. The authors included several approaches: optical, electrochemical, and biological sensing techniques. The list of approaches was ranked according to their potential for societal use in the ASSURED order. This review also covered how these devices can be combined with IoT solutions that follow the Industry 4.0 trend, looking toward a development trend to make these platforms for water quality accessible, sustainable, and effective in ensuring the sustainability of aquifers and improvement of environmental monitoring.

Furthermore, Naimaee et al (2024) investigated thermal pollution of Karun River, Iran, over the past two decades and its efficiency because of dams and urban runoff on water temperature. In fact, the decrease of downstream water temperature is very remarkable after the damming with as much as 13 degrees in some occasions in the summer season. The work was able to allow the use of remote sensing data in conjunction with ground-based sensors to monitor temperature changes and indicate areas of pollution. Such results underscore the necessity of integrated strategies for thermal pollution abatement and its environmental impacts on river ecosystems.

A key role for statistical power played in measuring the progress of water quality goals has been further discussed by (McDowell et al., 2024). Analysing monthly monitored streams, the authors determined that while more than 95% of locations had sufficient power to detect changes in nutrients and visual clarity over 20 years, detecting E. coli would require doubling the sampling frequency. This would mean that sampling for specific parameters would have to be increased by fivefold in only 5 years to yield meaningful results, which is expensive. For this reason, the study brings about the need to view enhanced investment in monitoring systems as necessary in a quest to demonstrate policy outcomes for water quality improvement. In addition, the writers argue that the introduction of developing sampling technologies can help reduce costs while the existing frameworks for monitoring might need to be reassessed and rearranged for smoother allocation of resources towards sites that are constantly changing than those that have stable changes (Taubaldiyev et al., 2024).

3. Methodology

The research applied an overall approach that combined field-based work and laboratory analysis in order to thoroughly assess the quality of water in Shatt al-Diwaniyah. To provide a representative overview of the river's condition, samples of water were collected from twelve strategically determined locations along the river during two distinct sampling periods: January and July of 2024. The biannual sampling strategy Pachauri et al. (2024), was used to account for the seasonal fluctuations that may affect the water quality parameters as it would give a more balanced view of pollution patterns throughout the year. Samples were taken with so much care concerning their purity. The sampling sites had been carefully selected depending on their proximity to probable sources of pollution in the area, such as points of sewage discharge and industrial areas where agricultural runoff sites exist. Various physical and chemical properties were scrutinized at each sampling site to determine the overall health status of the river ecosystem. Parameters evaluated included pH, which gives information on the water's acidity or alkalinity level, electrical conductivity in revealing suspended salts and dissolved pollutants; turbidity as it gives information on the level of water clarity and suspended particles; nitrates and phosphates, which are essential indicators of nutrient loading from agricultural runoff; and heavy metals, which pose toxic effects on the aquatic life and risk human health (Hammoumi et al., 2024; Mansour & Kuffi, 2023).

This involved recording the geographic coordinates of sampling points with precise accuracy using GPS technology (Fan, 2024). With such accurate documentation, researchers can link spatial patterns and rates of pollution across the river, enabling them to observe trends and patterns used in mapping targeted interventions. The objective of the research is to identify areas rich with pollutants, besides identifying contributors that degrade water quality, with consideration given to the probable ecological effects on the aquatic ecosystem and the neighbouring communities. The laboratory analysis was perfumed and is based on standard methods to ensure the validity of the results obtained. This approach allowed them to not only draw conclusions about the possible implications of pollutant levels on local water-quality management practices but also to obtain quantitative measurements. Overall, this integrated methodology forms a wholesome framework to assess environmental health that was laid down for potential future studies and engineering interventions to reduce pollution in the river and restore the ecosystem.

4. Results and Testing Analysis

Results from field samples obtained along Shatt Al-Diwaniyah in 2024 reveal severe impacts of sewage dumping on water quality. The general conclusions drawn from the test performed of the physical and chemical properties are detailed in Tables 1 to 5, which include pH values ranging between 7.26, found 500 meters from the wastewater treatment plant discharge, and up to 7.64 at the upstream point (S1). These values have indicated a neutral to slightly alkaline nature of water with relatively lower pH near points of discharge through introduction of acidic pollutants. Electrical conductivity showed a high increase near points of discharge, reaching a maximum value of 1645 µm/cm at the position next to the main rainwater station drainage S3, indicating higher salt concentrations in dissolved forms and concentration of more pollutants and further areas affected by sewage. The variations of the total dissolved solids followed the same pattern, ranging from 674 mg/L at the upstream site, S2 to 988 mg/L near the exit of the rainwater discharge station, S3, which showed the high level of contamination caused by sewage and industrial effluent discharges.

The concentrations of the pollutants also supported the same results, where the maximum concentration of chlorides was found at 231.28 mg/L near the discharge station for the rainwater, S3 indicating the major contribution from the untreated sewer and industrial effluent discharges. Sulphate levels around the industrial zones have also seen a rise to a maximum of 314.96 mg/L at S3, likely due to agricultural runoffs and industrial wastes. Sodium levels were high around the station for the rainwater at 210.65 mg/L (S3), thus further supporting the conclusion that untreated sewages and industrial wastes are deteriorating the quality of water. High biological oxygen demand (BOD) values have been recorded at the effluent discharge points particularly at the end of the sewage treatment, although this also implies that much organic matter is present. It means a very heavy load of pollution from discharges of sewage with crucial implications to aquatic life. Therefore, overall information gleaned from data has vindicated that the major source of pollution in

Shatt Al-Diwaniyah is caused by sewage, although strengthened by the impacts of other industries and influences of agriculture.

The collected water analysis results on April 15, 2024, are presented in Table 1 to show the significant differences between the physical and chemical properties of water at different sampling points. The pH levels differ between 7.26 point 4 and 7.64 point 2, indicating slight differences in the acidity and basicity of the water. This may be an indication of local influences on the quality of the water. Electrical conductivity varied from 1,124 micro Siemens/cm at point 2 to 1,645 micro Siemens/cm at point 3, thus indicating the concentration of dissolved salts; high EC at point 3 may suggest local contamination through industrial and/or agricultural activities. Total hardness ranged from 440 mg/L at point 2 to 512 mg/L at point 3, hence higher values could suggest contamination originating from mineral sources, such as industrial discharges or mineral-rich groundwater. In this regard, chloride concentrations varied from 148.96 mg/L at point 2 to 231.28 mg/L at point 3, respectively, and might represent a probable contamination source from the chlorine compounds that are associated with sewage or industrial effluents. Similarly, sodium levels ranged between 149.15 mg/L at point 5 and reached as high as 210.65 mg/L at point 3, where high sodium concentration may indicate some form of sewage or industrial contamination. Sulphate varied between 226.03 mg/l at point 2 to 314.96 mg/l at point 3 indicating pollution through agricultural and industrial sources of fertilizers and pesticides. Since the fluctuations in water quality with higher electrical conductivity, total hardness, chlorides, sodium, and sulphates results from direct influence of industrial, agricultural, and sewage discharges, thus the data clearly indicate. These variations are dangerous for both aquatic ecosystems and human beings, thus stressing the need for proper monitoring and management strategies in materials and environmental engineering (Bhatt et al., 2024).

Table 1. Testing Sample Performed on 15/April/2024

Parameter	S1 Point of Upstream	S2	S3 Near Discharge of Rainy p.s	S4 500m Far from WWTP Discharge	S5 3 km Far from WWTP (Down Stream)
pH	7.42	7.64	7.35	7.26	7.31
EC µm/cm	1162	1124	1645	1235	1178
TDS Mg/l	698	674	988	741	708
Total AIK mg/l	130	120	160	150	132
TH mg/l	448	440	512	464	452
Ca mg/l	105.6	113.6	120	116.8	110.4
Mg mg/ll	44.89	38.06	51.72	41.96	42.94
Cl mg/l	166.6	148.96	231.28	180.32	156.8
SO4 Mg/l	276.60	226.03	314.96	291.86	228.65
Na mg/l	154.23	149.87	210.65	152.54	149.15
K Mg/l	5.23	4.73	9.94	4.89	4.56

Table 2 highlights water analysis results made on May 7, 2024, for comparison with data made in table 1 and thus, showing the role of seasonal and spatial drivers in determining the quality of water. Ph varied between 7.18 at point 5 to 7.91 at point 1 while reflecting local seasonal impacts because they might vary due to local temperature fluctuations and bacterial activities. Electrical conductivity ranged from 1,144 micro Siemens/cm at point 2 to 1,448 micro Siemens/cm at point 4; increased conductivity levels at point 4 may reflect the discharge of industrial or agricultural runoff with higher salt concentrations. Total hardness ranged between 456 mg/L at point 5 and 533 mg/L at point 4, and increased levels of hardness suggest contamination by industrial effluent or mineral-rich groundwaters. The chloride values ranged from a minimum of 143.08 mg/L at point 2 and rose up to 235.20 mg/L at point 4. A minimum of severe pollution was again probable of the origin from sewage or industrial processes using chlorine compounds for cleaning or sterilization purposes (Amin et al., 2013). Sodium levels were between 93.94 mg/L at point 2 to 115.49 mg/L at point 4 and higher sodium values further indicating the effect of sewage or industrial discharges. Sulphates ranged from 350.71 mg/L at point 1 and 419.15 mg/L at point 3, implying generally that sulphates are increased through pollution with agricultural sources mainly through fertilizers and pesticide application. The variations in such values during different points pose the seasonal effects on water quality where elevated electrical conductivity, total hardness, chlorides, sodium, and sulphate levels at specified locations show the effect of seasonal releases from industrial, agricultural, and sewage activities (Raimi et al., 2022). This analysis calls for the continuous monitoring of the water's quality as a basis for appropriate strategies to mitigate the effects of pollution with a focus on materials and environmental engineering.

Table 2: Testing Sample Performed on 7/May/2024

Parameter	S1 Point of Upstream	S2	S3 Near Discharge of Rainy p.s	S4 500m Far from WWTP discharge	S5 3 km Far from WWTP (Down Stream)
pH	7.91	7.54	7.21	7.25	7.18
EC µm/cm	1205	1144	1295	1448	1179
TDS Mg/l	724	685	775	870	707
Total AIK mg/l	136	130	170	200	160
TH mg/l	460	468	476	533	456
Ca mg/l	118.4	116.8	123.2	128	116.8
Mg mg/ll	40.01	42.94	40.99	51.72	40.01
Cl mg/l	160.72	143.08	168.56	235.2	152.88
SO4 Mg/l	350.71	364.22	419.15	359.86	356.38
Na mg/l	101.21	93.94	108.95	115.49	96.12
K Mg/l	6.07	4.56	7.08	8.07	4.89

Table 3 analysis results for water on made on May 18, 2024, which provide additional information about changes in the quality of water at the same sampling points. The pH values ranged from 7.12 at sampling point 5 to 7.34 at sampling point 3 and reflect the influences locally imposed on the acid-base balance, which is highly influenced by the sewage and industrial discharges. EC was within the range of 1,157 µS/cm at point 5 to 1,464 µS/cm at point 4, with higher EC at point 4 indicating higher concentrations of dissolved salts, likely from point sources of pollution in the vicinity. This contains total hardness that varies from 436 mg/L at point 2 to 484 mg/L at point 3, thus indicating contamination with mineral sources like calcium and magnesium, which might occur due to industrial activities and also with water-ground interactions. For chloride concentration, 146.11 mg/L was noted at point 2 and increased to 234.70 mg/L at point 4, thus indicating significant pollution with sewage and industrial effluents that introduce chlorides into the water. The sodium concentrations ranged between 93.12 mg/L point 5 to 120.49 mg/L point 4 depicting that discharges of sewage and industrial wastewater affect the water quality. Sulphate concentration ranged from 355.41 mg/L at point 1 to 420.18 mg/L point 3. The increase of sulphate levels indicates a steady pollution of agricultural fertilizers and pesticides. These parameters monitored over a certain period of time can give an all-round view of the effects of human activities on the quality of water. High values at some points highlight improvement in water treatment and pollution control systems in the regions plagued by industrial and agricultural discharges, thus bring forwarded the critical role of materials and environmental engineering in acquiring better solutions to these challenges (Musarat et al., 2021).

Table 3: Testing Sample Performed on 18/May/2024

Parameter	S1 Point of Upstream	S2	S3 Near Discharge of Rainy p.s	S4 500m Far from WWTP discharge	S5 3 km Far from WWTP (Down Stream)
pH	7.33	7.33	7.34	7.21	7.12
EC µm/cm	1212	1170	1283	1464	1157
TDS Mg/l	727.2	702	769.8	878.4	694.2
Total AIK mg/l	134	126	176	210	155
TH mg/l	444	436	484	452	448
Ca mg/l	108.8	115.2	121.6	120	112
Mg mg/ll	41.96	36.11	43.92	37.08	40.99
Cl mg/l	163.44	146.11	164.35	234.7	157.44
SO4 Mg/l	355.41	361.40	420.18	355.0	603.6
Na mg/l	112.11	97.94	110.95	120.49	93.12
K Mg/l	7.02	5.40	6.07	7.33	5.07

Table 4 shows water analysis results on 29th May, 2024. The physical and chemical properties of water in all the sampling points have only slightly been different. Changes in acidity and basicity in the water along the sampling points are as indicated in the table. The pH values range from 7.30 at point 3 to 7.71 at point 1. EC measured between point 2 at 1,120 micro Siemens/cm and at point 4 at 1,440 micro Siemens/cm represents the dissolved salts in water and might depend on some local sources of pollution. TH varied between 412 mg/L as recorded for point 2 and 488 mg/L for point 3. From this, there are differences that might be influenced by different mineral content concentrations, which impacts the quality of the water. Chloride levels varied from 126.66 mg/L at point 2 to 188.16 mg/L at point 4, and could represent industrial and agricultural pollution mainly from the use of chlorine products as additives in cleaning or manufacturing processes. Sodium levels varied from 97.57 mg/L in point 2 to 121.06 mg/L in point 4, where a high sodium concentration may be contributed to by the contribution of sewage contaminated inputs or industrial discharges. Finally, the quantities of sulphates vary from 248.70 mg/L point 2 to 283.57 mg/L point 4, and thus the largest values are likely to have resulted from agricultural fertilizers and pesticides application. The variations of these values vary from point to point reflecting the stronger impact that is viewed as local in nature through discharges within water qualities particularly in areas with highly concentrated levels of chlorides, sodium, and sulphates. Therefore, monitoring and control strategies in the framework of materials and environmental engineering with special emphasis on water quality control and interconnection techniques (Maqsoom et al., 2021) can draw attention to affecting mitigation impacts caused by intense human activities such as industrial and agricultural discharges.

Table 4: Testing Sample Performed on 29/May/2024

Parameter	S1 Point of Upstream	S2	S3 Near Discharge of Rainy p.s	S4 500m Far from WWTP discharge	S5 3 km Far from WWTP (Down Stream)
pH	7.71	7.55	7.30	7.51	7.41
EC µm/cm	1220	1120	1215	1440	1260
TDS Mg/l	732	672	729	864	756
Total AIK mg/l	140	144	164	178	154
TH mg/l	452	412	488	436	440
Ca mg/l	112	112	124.8	124.8	115.2
Mg mg/ll	41.96	32.20	42.94	30.25	37.68
Cl mg/l	160.72	126.66	154.84	188.16	168.36
SO4 Mg/l	279.22	248.70	275.29	283.57	270.06
Na mg/l	108.47	97.57	111.86	121.06	109.20
K Mg/l	7.9	5.3	6.1	8.3	8.1

Table 5 involves water analysis of various physical and chemical properties measured at different points. The pH varied between 7.87 at point 1 and 7.26 at point 5, showing differences in the acidity and basicity of water points. Electrical conductivity showed that the readings ranged between 1,132 micro Siemens/cm at point 2 to 1,640 micro Siemens/cm at point 3, which pointed to all different concentration of dissolved salts in the water and higher the value of conductivity presents the possibility of pollution sources. Total hardness or TH varied between 438 mg/L at point 2 to 507 mg/L at point 3 and thus indicates mineral differences that can impact on the quality of the water. Chloride concentration ranged from 142.01 mg/L at point 2 to 229.18 mg/L at point 3, indicating industrial and agricultural pollution. Sodium concentration ranged from 148.68 mg/L at point 5 to 208.66 mg/L at point 3, with high concentrations of sodium that indicate contamination by the effluents from sewage or industrial discharges. Lastly, the sulphate levels ranged from 216.23 mg/L at point 2 to 306.78 mg/L at point 3, with high values possibly caused by application of agricultural fertilizers and pesticides. The obtained values in this assessment show that the pollution coming from several sources persists, and this is clearly demonstrated by high values for electrical conductivity, total hardness, chlorides, sodium, and sulphates. This fact underscores the effects of human activity, which include industrial and agricultural effluents, on the quality of water and underlines the necessity for rigorous monitoring and management practices in materials and environmental engineering.

Table 5: Testing Sample Performed on 12/June/2024

Parameter	S1 Point of Upstream	S2	S3 Near Discharge of Rainy p.s	S4 500m Far from WWTP discharge	S5 3 km Far from WWTP (Down Stream)
pH	7.87	7.47	7.33	7.40	7.26
EC µm/cm	1178	1132	1640	1242	1180
TDS Mg/l	693	669	982	732	710
Total AIK mg/l	129	120	158	149	132
TH mg/l	444	438	507	460	448
Ca mg/l	103.4	110.6	118	115.8	112.2
Mg mg/ll	43.77	37.02	50.66	39.69	40.39
Cl mg/l	163.6	142.01	229.18	177.22	150.18
SO4 Mg/l	266.60	216.23	306.78	283.54	224.55

Parameter	S1 Point of Upstream	S2	S3 Near Discharge of Rainy p.s	S4 500m Far from WWTP discharge	S5 3 km Far from WWTP (Down Stream)
Na mg/l	152.23	149.87	208.66	149.43	148.68
K Mg/l	5.37	4.33	9.87	4.76	4.44

5. Discussion

The key environmental impact of untreated sewage, agricultural runoff, and industrial effluent on the quality of Shatt al-Diwaniyah's waters are highlighted by this study. This is a problem for the global environment; however, its effects are much more pronounced in dry and semi-dry climates like Iraq, where available water resources are both scant and crucial for agriculture, drinking, and industrial use. Such water bodies undergo the extreme effects of pollution to the health of humans and the environment (Shaawiat et al., 2019). In general, water pollution in an urban area is an impact of the build-up of a multitude of pollutants brought about by poor waste management and growing industrialization. The study has been in consensus with many previous studies that observed the fact that in most countries undergoing rapid urbanization, the natural water body systems are highly degraded because of the absence of proper infrastructure for waste treatment.

This study found specific indicators of the following pollutants, elevated electrical conductivity, pH, nitrates, and phosphates proximate to points of untreated sewage discharge. These pose a potential threat of causing a decline in the quality of water with possible serious effects on the ecosystem and people dependent on it (Al-Zaiadi & Jarallah, 2023). Electrical conductivity values from 1,120 to 1,645 µS/cm near the discharge points indicate higher salt and pollutant contents in dissolved form. High electrical conductivity is characteristic near the urban wastewater discharge points and shows a significant accumulation of dissolved ions, primarily industrial effluent and sewage waste. In addition, the studies in line with high chloride and sulphate concentrations exist near discharge points because of the toxic accumulations that are a result of sewage and industrial effluents necessitate the application of materials engineering in monitoring and control of such pollutants (Maxe, 2001).

Materials and environmental engineering would argue that these results are of urgent need for better processes of sewage treatment. This would reduce the concentration of contaminants in the water bodies such as Shatt al-Diwaniyah, hence reducing the environmental burden. This can be achieved by providing efficient treatment facilities through the implementation of decentralised treatment plants and segregation of industrial wastewater streams. There is also a great variation in spatial and seasonal variability, which calls for constant monitoring. Seasonal analysis revealed that some of these pollutants, like sodium at a peak value of 210.65 mg/L near the points of discharge of rainwater, emanate from agricultural runoff that happens during peak farming periods. Such results indicate an urgent need for integrated approaches to pollution control that must be both industrial and agricultural.

The closer regions to the sewage discharging points show a prevalence of high BOD and turbidity, implying organic matter load. High BOD implies heavy organic load that could potentially deplete dissolved oxygen in water, harming the aquatic life and ecosystem as a whole. This study provides insight into fluctuating levels of pollution at specific discharge points. This supports more comprehensive frameworks of environmental engineering calling for stricter pollution control and regular testing of point and non-point sources of pollution. In addition, the results of this study concur with regional studies on water pollution, as pollutant levels in Shatt al-Diwaniyah frequently surpass the internationally acceptable quality standards of water, calling for rigorous enforcement of environmental regulations.

The effects on the aquatic environment extend beyond being adverse to the environment; instead, nitrates and phosphates, most predominantly from agriculture, promote the nutrient loading in waters to cause eutrophication. Eutrophication leads to algal bloom, thereby reducing water's clarity and harming water-sustaining organisms with scarcity of oxygen (Nieder et al., 2018). In relation to the above, Shatt al-Diwaniyah's nutrient loading has led to unsustainable agricultural systems there. Moreover, this study reaffirms the significant role of materials and environmental engineering in countering water pollution through developing advanced monitoring, waste treatment, and pollution mitigation strategies. With the level of contamination being as high as it is, coupled with the effects on human and environmental health, future efforts will have to be directed at sustainable waste management practices integrated with technological innovations to make Shatt al-Diwaniyah a long-term usable safe and viable resource.

Many recommendations are proposed (Esmaeilian et al., 2018; Gavrilescu et al., 2015), to overcome these challenges. To begin with, the wastewater discharged from cities to Shatt Al-Diwaniyah should be treated and house sewer connections to rainwater drainage should be prevented. Industrial water should be treated in a separate unit of every factory and discharge to Diwaniyah River should be strictly regulated as well as it meets environmental standards. The authorities have to enforce taxes and warnings on violators. Other very essential aspects include the organisation of the drainage networks, with connections to a main stream and not directly into the Shatt. This prevents agricultural pollutants from leaking into the water body. A lot of public awareness programs should be conducted to educate residents not to use the beach water for drinking or even bathing unless treated. Finally, integrating environmental education into the curriculum from kindergarten levels up to the university level will finally help present future generations with an environment of responsibility and awareness.

6. Conclusion

This study draws attention to the violent nature of sewage disposal on the quality of Shatt Al-Diwaniyah's waters beside very important insight into the sources of contamination, which include domestic, agricultural, and industrial contributions. The results include the alarming water-quality degradation with elevated concentrations of pollutants such as electrical conductivity, total dissolved solids, chlorides, sulphates, and biological oxygen demand. These findings speak for the pressing need to upgrade wastewater management, to strengthen the regulations of industrial discharges into it, and to raise public awareness of matters affecting the quality of water.

7. Limitations

Among the limitations of this research is that the findings depend on a number of limitations from which they have been obtained. For example, the basis on which the study obtains its results is through samples taken at twelve points only within the Shatt Al-Diwaniyah. In addition, one needs to note that the sampling sites selected were in strategic points, as they are those that are closer to known sources of probable pollution. The above may not adequately represent the overall health of the river. It can differ significantly along different sections of the river, depending on such factors as local land use practices, industrial point sources, and wastewater management systems. The results, therefore likely do not reflect all the spatial variability of pollution levels and the cumulative impacts of pollution throughout the entire river system.

The study was conducted at two particular times of the year, January and July. Such a study cannot account for seasonal variations in the water quality of the river. The temporal variations of rivers can be expected to be high, particularly concerning the parameters of water quality, due to various factors such as rainfall, temperature, and seasonal agricultural activities. For instance, heavy rainfall will create greater runoff and loading of pollutants in certain seasons of the year. Conversely, drought may concentrate pollutants in lower water volumes. In failing to take into account such seasonal fluctuations, the study might overlook some crucial insights about the changing patterns of pollution levels and their implications for aquatic life as well as how best to manage water quality.

8. Future Directions

In fact, future studies would go even further to include longitudinal studies of the temporal changes in water quality over extended periods. It would then be indicative as to whether measures designed to treat wastewater have been effective and assess their real impacts on the health of a river with time. More fundamentally, research into the ecological impacts of pollution on local communities and aquatic life can shed light on understanding environmental health in terms of human well-being. Further, an assessment of the socioeconomic implications of bad water quality would have been very useful to understand the effects of pollution on livelihoods, public health and the local economy.

Other ways through which increased exploration and study of new and innovative treatment technologies and strategies to combat pollution are necessary. These efforts include scientific study of community-based approaches that let the local population take part in monitoring and managing their water quality. Public-private partnerships to promote resource sharing and exchange of expertise in dealing with challenges related to water pollution have to be fostered. Enhanced effectiveness in mitigating pollution is likely to arise from such collaborative efforts and contribute positively to practices that leave positive impacts upon the environment while assisting in the livelihoods of local communities.

Future research should incorporate advanced monitoring techniques, such as remote sensing and high temporal resolution with real-time data analytics, into future water quality monitoring. Advanced monitoring techniques may be crucial in capturing rapid changes in pollutant levels and emerging pollution hotspots. This is a highly interdisciplinary study that would integrate elements of environmental science, economics, and public health in order to derive comprehensive insights into the many varied consequences of water pollution. Lastly, studies focusing on community resilience and adaptive management strategies would form essential knowledge toward effective policymaking that safeguards the waters and enhances sustainable development in the region. Future research in the direction of areas highlighted by this study will contribute towards better-informed policy decisions and formulating a holistic plan to effectively act against water quality in Shatt Al-Diwaniyah and similar ecosystems.

9. Implications

This research project requires a critical necessity of cooperation and coordination between governmental bodies, industries, and local communities to carry out a practical approach toward effective issues in water quality. Thus, collaborative partnerships should be established to provide a comprehensive strategy that uses all their strengths. Among the measures to be taken for it to possibly ensure that the water quality in Shatt Al-Diwaniyah returns to health, there are proper implementation of wastewater treatment processes, appropriate regulatory frameworks, and awareness among people regarding the need to maintain water quality. In addition, involving local people within the decision-making process, encouraging them to participate in water management project development, strongly underpins the campaigns. Therefore, this research paper is a stepping stone for solving the intricate issues concerning the river, while stimulating the requirement for the long-term authentic endeavour toward the restitution of a healthy aquatic habitat and community health.

Promoting innovations in new water treatments with traditional practices will eventually lead to more sustainable, adapted local solutions. Monitoring and evaluating water quality will remain a benchmark on maintaining effectiveness of strategies and responsiveness to changes in environmental circumstances. Ecology health integrated in the community development plans will encourage the balanced ecosystem with growth of economic prosperity. At the bottom line, developing stewardship and environmental responsibility among all stakeholders is essential for realistic progress toward restoration of Shatt Al-Diwaniyah to ensure its sustainability for future generations.

Data Availability:

Will be available upon request from the corresponding author.

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