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Impact of wastewater on water quality in Shatt Al-Basrah Canal, southern Iraq

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Abstract

Shatt Al-Basrah Canal is an artificial waterway. The primary objective of the canal was to control the water levels of the Shatt Al-Arab River during the flood season. However, their water quality deteriorated after dozens of untreated sewage pipes were poured directly into the canal. The canal currently suffers from extremely high levels of pollution due to the discharge of heavy, untreated sewage from Basrah city, as well as the presence of industrial waste, the power plant, and agricultural land along the canal's banks. Therefore, the current study aimed to assess the water quality of the Shatt Al-Basrah Canal. Water samples were collected, field and laboratory measurements were conducted quarterly from April 2024 to January 2025. The measurements included 19 environmental factors. The results showed that salinity levels reached 47.42 g/L, a sharp decrease in dissolved oxygen (DO) of 2.1 mg/L, and a significant increase in biological oxygen demand (BOD$_5$) of 18.4 mg/L. Nutrients, meanwhile, recorded a significant increase, with nitrate (NO$_3$) concentrations reaching 16.9 mg/L and effective phosphate concentrations (PO$_4$) reaching 7.2 mg/L. Overall, when comparing the results of current study with the Iraqi standard specifications for River water and wastewater, we note that most of the physical and chemical characteristics of the Shatt Al-Basrah Canal water exceed River characteristics and are very close to those of wastewater. Thus, the canal has become a wastewater discharge channel.

Keywords: Water quality, Shatt Al-Basrah, environmental factors, wastewater

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1.Introduction

Water is one of the most precious natural resources on Earth. Therefore, it is one of the most important factors in sustaining life and the rise of civilizations. Water has several essential uses in human life, such as drinking, domestic uses, agricultural processes, industrial processes, and even urban development and transportation. Therefore, they need to conserve water resources, especially freshwater, and to develop programs to monitor and protect water resources from pollution has emerged (Al-Hejuje et al., 2017, Abdul-Ridha, 2021).

Saltwater constitutes approximately 97% of the Earth's water, while the remaining 3% is considered freshwater. This water is naturally taken from Rivers, streams, marshes, and even groundwater that is brought to the surface through well drilling operations for later use. The increasing development of industrial and technological progress and the increased consumption of water for agricultural and domestic activities have led to a deterioration in water quality (Dadolahi-Sohrab and Arjonmand, 2011, Sevda et al., 2018). As a result of the high levels of pollutants that have contaminated water bodies, it has become difficult to carry out self-purification processes (Galo, 2023). With the high population growth, the burden on water resources for drinking and nutrition has increased. Iraq is one of the world's dry countries, so it has begun to suffer from many problems related to water scarcity, which is one of the most difficult environmental problems. The reason for this is the decline in water levels in the Tigris, Euphrates and Shatt Al-Arab Rivers (Lateef et al., 2020).

Water pollution is one of the most dangerous types of pollution to the environment and living organisms. Water constitutes the largest component of living cells, and most vital processes depend on it. Water pollution can be defined as the addition of substances or energy to a body of water that can cause minor or significant harm to human health and other living organisms (Kahami, 2023). Wastewater is a dangerous type of pollution, in general, it can be defined as the water resulting from all human activities, agricultural and industrial, even household waste. It also includes petroleum wastewater discharged from petroleum industry operations, which involve the use of numerous chemical and physical methods to convert crude oil into various forms, such as gasoline, kerosene, diesel, and many other derivatives that have a significant impact on water bodies and all living organisms (Sabbar, 2007).

Various of Iraq's water resources were suffered, particularly in the past two decades, and there has been clear water stress and pressure due to low water levels resulting from various reasons, including the construction of dams in neighboring countries and some climate changes, especially global warming, in addition to the significant decline in annual rainfall rates within Iraq (Sammen, 2013). Therefore, the main water bodies in Basrah (which include the lower part of the Tigris and Euphrates Rivers, the Shatt Al-Arab River, and parts of the Hammar and Hawizeh marshes) are among the most important aquatic environments that have been exposed to severe environmental and hydrological pressure due to significant neglect that coincided with their pollution from various sources. Despite their environmental, social, and economic importance, they have not received the attention required to match their importance as a significant natural resource for biodiversity and their necessity in the areas of environmental, social, and economic development, in addition to their cultural and recreational importance.

Shatt Al-Basrah Canal can be added to the list of water bodies that have begun to gain significant environmental importance due to their connection to the Shatt al-Arab via the Garmat Ali Canal on the one hand, and to the Arabian Gulf via Khor Al-Zubair Canal on the other, in addition to its important economic uses, such as fishing (Taher et al., 2011; Al-Mahmoud et al., 2023). Previously, the primary objective of the canal was to control the water levels of Shatt Al-Arab River during the flood season, which significantly impacted the rise in water levels in Basrah's Rivers and the submergence of their areas. It was also intended to reduce the burden caused by sea tides in areas west of Basrah and mitigate the impact on lands adjacent to the Shatt Al-Basrah Canal. Currently, the canal's primary function is drainage, especially after it was merged with the main drain in the 1980s. Eventually, the canal was transformed into a sewage canal, and its water quality has deteriorated significantly. The canal suffers from extremely high levels of pollution due to the discharge of heavy, untreated sewage from western Basrah, in addition to the presence of industrial wastewater and agricultural land along its banks (Aziz and Sabbar, 2013; Al-Mahmoud et al., 2023).

This shift in the function of the Shatt Al-Basrah Canal and the occurrence of many environmental variables, also increase in pollutant concentrations in the Shatt Al-Basrah Canal due to the increasing and excessive discharge of sewage and drains into it, in addition to the lack of recent studies that are concerned with assessing the environmental status of the canal under these conditions. Therefore, the current study aimed to evaluate the water quality of the Shatt Al-Basrah Canal and determine the degree of pollution that the canal water has reached by studying the physical, chemical and biological factors seasonally and locally.

1. Materials and Methods

1.2. Description of the Study Area

The Shatt Al-Basrah Canal is located in the southwestern part of Basrah Governorate, within the alluvial plain. It begins at Al-Hammar Marsh in the north and ends at Khor al-Zubair Canal in the south. Its astronomical location lies between latitudes 30.20° - 30.60° N and longitudes 47.00° - 47.60° E. The Shatt Al-Basrah Canal is an artificial waterway connected with the Third River or Main Outfall Drain (MOD), and the Garmat Ali Canal, northwest of Basrah Governorate. It extends east of Al-Zubair District until it flows into Khor Al-Zubair Canal, where the Shatt Al-Basrah Regulator was constructed (Figure 1). The total length of the canal is approximately 42 km between the MOD and Khor Al-Zubair Canal, with an average width of 59 meters, a depth ranging between 3.5 and 5 meters, with a gradient of 5.4 cm/km. The longitudinal column of the main channel of the Shatt Al-Basrah Canal is 29 km long, in addition to the Garmat Ali Canal (currently closed) with a length of 6.3 km, and the Al-Hammar Marsh branch with a length of 24.5 km, which is affected by tidal waves coming from the Arabian Gulf via Khor al-Zubair Canal (Hassan et al., 2018; Al-Mahmoud et al., 2023).

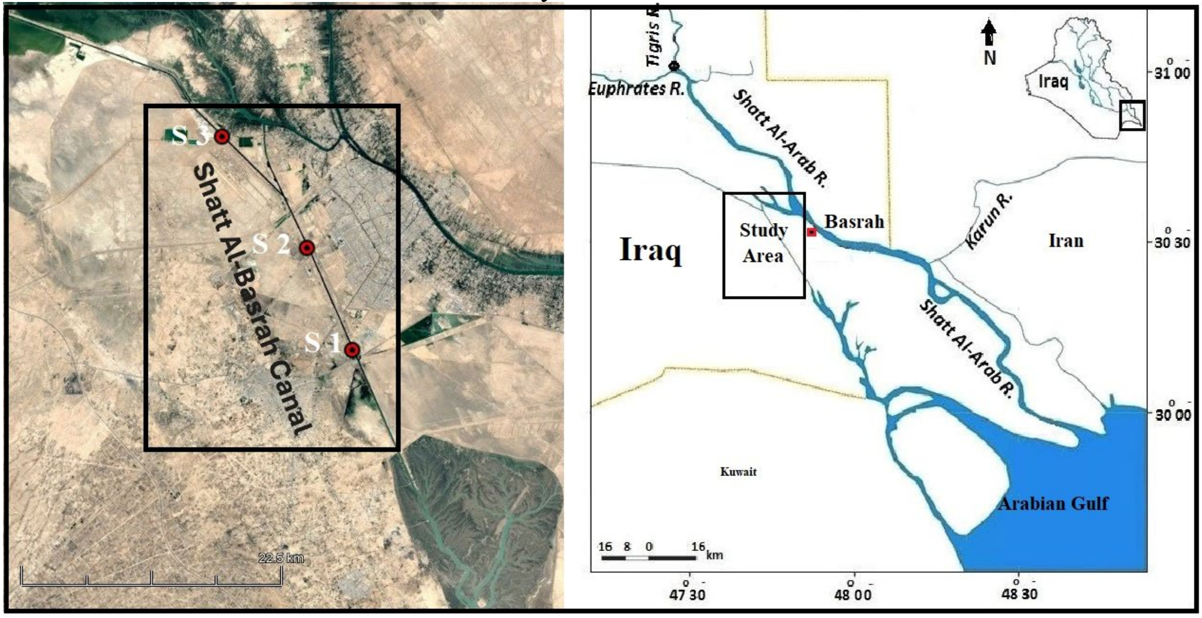

Figure 1: Map of study stations in the Shatt Al-Basrah Canal

Table 1: Coordinates of the study stations in the Shatt Al-Basrah Canal

Station Number	Station Name	Coordinates
1	Shatt Al-Basrah Canal Regulator	N: 30° 24′ 46″ , E: 47° 46′ 27″
2	Mohammed Al-Qasim Bridge	N:30° 29′ 39″, E:47° 44′ 06″
3	Al-Khora Bridge	N:30° 35′ 05″ , E:47° 39′ 33″

2.2. Methods

Three stations were selected in the current study in the Shatt Al-Basrah Canal in Basrah Governorate, their locations were determined using a Global Positioning System (GPS) (Table 1).

Water samples were collected seasonally during the daytime, with two trips per season from April 2024 to January 2025. The water sample were collected in plastic bottles, sealed, and stored in an ice box until they reached the laboratory, all environmental variables were measured with three replicates for each one. Water temperatures was measured in the field using a mercury thermometer. light penetration was measured using a Secchi disc and expressed in centimeters. Hydrogen ion concentration (pH) was measured using a pH meter, electrical conductivity (EC) was measured using an EC meter in millisiemens/cm. Salinity was estimated by multiplying the EC value by 0.64.

For laboratory work, Dissolved Oxygen (DO) concentrations were measured using the Winkler method (azid modification) after oxygen samples were fixed Winkler bottles in the field. This method includes titrating 100 ml of a fixed water sample against sodium thiosulfate solution (0.0125N) with starch solution as indicator, the results were expressed in mg/L. For Biological Oxygen Demand (BOD_5) samples, the dark bottles were left without fixation in the field and transported by ice box to the laboratory for incubation in the dark at 20^{o}C for five days then measured as in DO. Total suspended solids (TSS) were measured gravimetrically according to the method described in APAH (2005).

Chemical oxygen demand (COD) concentrations were measured using a test kit with a range of 0-150 mg/L. Samples were mixed with content of test tube kit and digested for 2 hours at 145°C, then measured spectrophotometrically (DR5000, WTW) with the results expressed in mg/L. Some of nutrient concentrations wear measured, active nitrate was measured using the method described by APHA (2005), which involved adding 1 ml of 1N HCL to the filtered water sample. The optical density was then measured by spectrophotometer at wavelengths of 220 and 275 nm. The results were expressed as (milligrams of nitrogen atoms nitrate/L). To measure active phosphate, the EPA (1978) method was used, A series of dilutions were prepared using the previously prepared solution KH_2PO_4. Then, 50 ml of the filtered sample was taken, and 8 ml of the mixture consisting of ammonium molybdate, antimony potassium tartrate, ascorbic acid, and sulfuric acid were added. The results were read by light absorbance using a spectrophotometer at a wavelength of 885 nm, with the results expressed as (milligrams of phosphorus phosphate/L).

The distillation method according to APHA (2017) was applied for measured the ammonia and ammonium ion at the Al-Wasal Scientific Laboratory for Environmental Analysis. Total nitrogen was measured according to the Kjeldahl method and titrated with sulfuric acid (APHA, 2005). Water samples were measured for total phosphate by digesting the sample with nitric acid and sulfuric acid then placing it in a water bath at 100°C. The process was completed by spectrophotometry at a wavelength of 880 nm.

Finally, the chlorophyll-a concentration was measured by filtering one liter of water samples from each station through the filter unit using GF/C filter paper, then grinding it with a ceramic mortar in a dark place with the addition of 90% acetone. The supernatant was taken after cooling to be measured in a spectrophotometer at the first wavelength of 664 and 750 nm. Then, one drop of hydrochloric acid (1N) was added, left for five minutes, then measured again at a second wavelength at 655 and 750 nm.

The SPSS statistical program version (26) was adopted, and a one-way ANOVA test was applied to determine the spatial and seasonal differences in the values of the variables under the significance level ($p \geq 0.05$), in addition to calculating the correlation coefficient (r) using the Past program between the different variables by applying the Pearson Correlation Coefficient.

2. Results

The results of the current study recorded obvious seasonal changes in water temperature. The highest average of water temperature was recorded at Station 3 (31°C) in the summer, and the lowest average water temperature was recorded in the winter at Station 1 (11°C). The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (where the values of df was 2, F=21.379, while p=0), as well as differences between seasons ($p \leq 0.05$) (where the values of df =3, F=261.769, and p=0)(Figure 2).

Figure (3) shows the seasonal and spatial changes in light transmittance rates for the three study stations, with the highest rate recorded in winter at the third station (76.5 cm) and the lowest rate in spring also at the third station (5.28 cm). The results of the statistical analysis showed significant differences between the stations ($p \leq 0.05$) (as the values of df was 2, F=51.56, while the value of p=0), as well as differences between the seasons ($p \leq 0.05$) (df=3, F=666.422, and p=0).

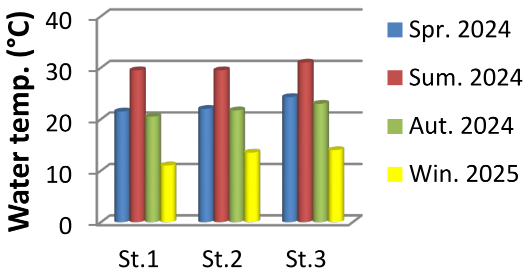

Figure 2: Seasonal and spatial variations in water temperature

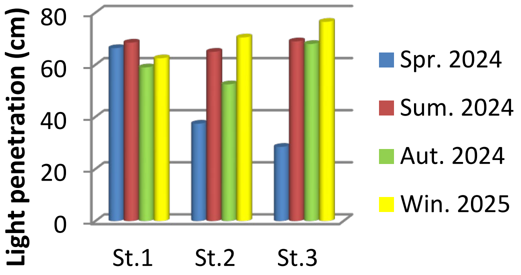

Figure 3: Seasonal and spatial variations in Light penetration…

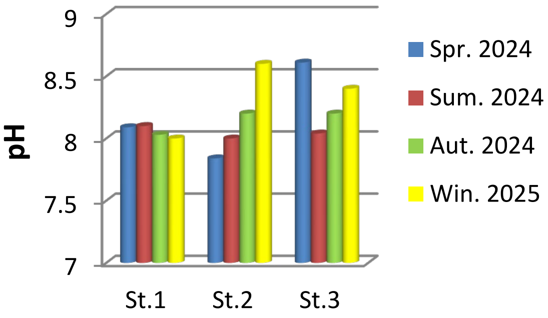

Figure 4: Seasonal and spatial variations of pH

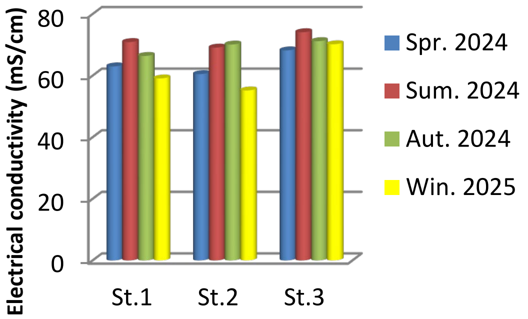

Figure 5: Seasonal and spatial variations of EC

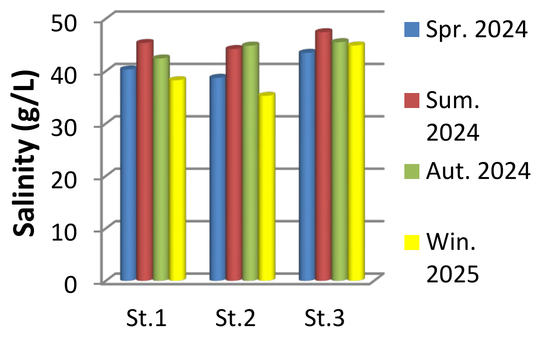

Figure 6: Seasonal and spatial variations of Salinity

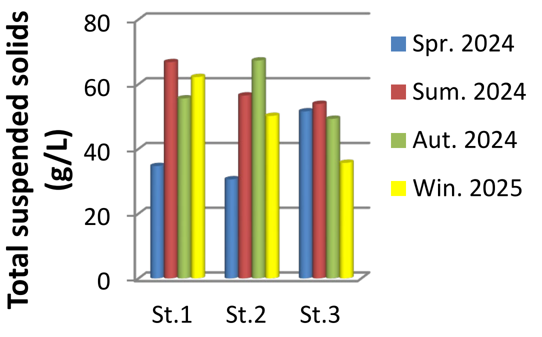

Figure 7: Seasonal and spatial variations of TSS

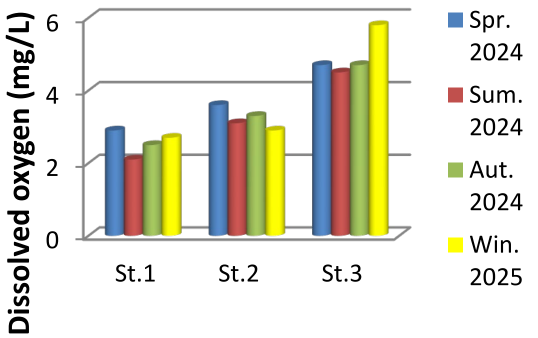

Figure 8: Seasonal and spatial variations of DO

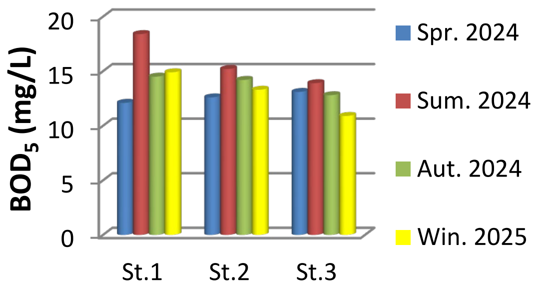

Figure 9: Seasonal and spatial variations of BOD_5

Seasonal and spatial changes in pH values are shown in Figure (4), as the highest rate recorded in the winter at the second station was (8.6), whereas the lowest rate was recorded in the spring at the second station (7.84). The results of the statistical analysis showed no significant differences between the stations ($p \geq 0.05$) (as the value of df=2, and the value of F was 0.236, while the value of p was 0.792), as well as no differences between the seasons ($p \geq 0.05$) (as the value of df=3, and the value of F=0.367, while the value of p=0.778).

The highest rate of electrical conductivity values was obtained in the summer at the third station (74.11 mS/cm), and the lowest rate was obtained in the winter at the second station (55.2 mS/cm)(Fig. 5). The results of the statistical analysis showed significant differences between the stations ($p \leq 0.05$) (as the value of df was 2, F=488.829, and p=0), as well as differences between the seasons ($p \leq 0.05$) (df=3, F=511.169, and p=0). The results of the current study showed significant changes in salinity values, where the highest rate was obtained in the summer at the first station (47.42 g/L) and the lowest rate was recorded in the winter at the second station (35.29 g/L) (Fig. 6). The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (as the value of df was 2, and the value of F was 102.728, while the value of p was 0), as well as differences between seasons ($p \leq 0.05$) (as the value of df was 3, and the value of F was 106.358, while the value of p was 0).

The current study values showed obvious seasonal and spatial changes in the rates of TSS, the highest rate was obtained in the fall at the second station at 67.3 mg/L, while the lowest rate was obtained in the spring at the second station at 30.6 mg/L. (Fig. 7). The results of the statistical analysis showed significant differences between the stations ($p \leq 0.05$) (as the value of df=2, F=3.7, while p=0.04), as well as differences between the seasons ($p \leq 0.05$) (df=3, F=15.061, and p=0).

The changes in DO values are shown in Figure (8), where the highest rate was obtained in the winter at the third station, 5.8 mg/L, and the lowest rate was obtained in the summer at the first station, 2.1 mg/L. The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (where df = 2 and F = 49.924, and p = 0), but there were no significant differences between seasons ($p \geq 0.05$) (where df = 3 and F = 1.648, and p = 0.205). Figure (9) shows the values of the BOD_5 in the three stations, the highest rate obtained in the summer was recorded at the first station (18.4 mg/L), and the lowest rate obtained in the winter was recorded at the third station (10.9 mg/L). The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (as the value of df=2, and the value of F=24.809, while the value of p=0), as well as differences between seasons ($p \leq 0.05$) (as the value of df=3, F=26.455, and p=0). The current study values showed clear seasonal and spatial changes in the COD values, as the highest rate was obtained in the summer at the first station, 83 mg/L, whereas the lowest rate was obtained in the autumn at the third station, 42.7 mg/L (Fig. 10). The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (df=2, F=148.353, and p=0), as well as differences between seasons ($p \leq 0.05$) (df=3, F=47.495, and p=0).

The nitrate concentrations are shown in Figure (11), where the highest rate was obtained in the winter at the third station, 16.9 mg/L, while the lowest rate was obtained in the summer at the first station, 5.44 mg/L. The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (as the values of df = 2, F=112.461, while the value of p=0), as well as differences between seasons ($p \leq 0.05$) (as the values of df=3, F=45.469, and p=0). Figure (12) shows the changes in the effective phosphate values, the highest rate was obtained in the winter at the third station, 7.2 mg/L, and the lowest rate was obtained in the summer at the first station, 2.7 mg/L. The results of the statistical analysis showed significant differences between the stations ($p \leq 0.05$) (where the value of df was 2 and the value of F was 37.185, while the value of p was 0), as well as differences between the seasons ($p \leq 0.05$) (where the value of df was 3 and the value of F was 3.993, while the value of p was 0.019).

The current study values showed noticeable seasonal and spatial changes in ammonia values, where the highest rate was obtained in the winter at the first station, 5.9 mg/L, while the lowest rate was obtained in the summer at the third station, 1.2 mg/L (Fig. 13). The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (where the value of df was 2 and the value of F was 8.882, while the value of p was 0.001), as well as differences between seasons ($p \leq 0.05$) (where the value of df was 3 and the value of F was 19.904, while the value of p was 0). On the other hands changes in ammonium ion values are shown in Figure (14), where the highest rate was obtained in the winter at the first station, 10.8 mg/L, and the lowest rate was obtained in the summer at the third station, 2.4 mg/L. The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (where the values of df=2, F=45.424, and p=0), as well as differences between seasons ($p \leq 0.05$) (where df=3, F= 64.888, and p=0).

Total nitrogen values showed observable seasonally and spatially variations (Figure 15), with the highest rate being 44.7 mg/L in winter at station 1, whereas the lowest rate being 31.3 mg/L in summer at station 2. The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (where the value of df was 2 and the value of F was 11.304, while the value of p was 0), as well as differences between seasons ($p \leq 0.05$) (where the value of df was 3 and the value of F was 75.359, while the value of p was 0). The study results of total phosphate concentrations showed the highest rate being 32.8 mg/L in spring at station 1, and the lowest rate being 21.7 mg/L in autumn at station 2 (Fig. 16). The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (where the value of df=2 F=27.766, while p=0), as well as differences between seasons ($p \leq 0.05$) (where df=3, F=33.016, while p=0).

The results showed obvious changes in chlorophyll-a values (Figure 17), where the highest rate was obtained in winter at the third station, 6.4 µg/L, while the lowest rate was obtained in summer at the second station, 2.1 µg/L. The results of the statistical analysis showed significant differences between stations ($p \leq 0.05$) (where the value of df was 2 and the value of F was 77.571, while the value of p was 0), as well as differences between seasons ($p \leq 0.05$) (where the value of df was 3 and the value of F was 7.497, while the value of p was 0.001).

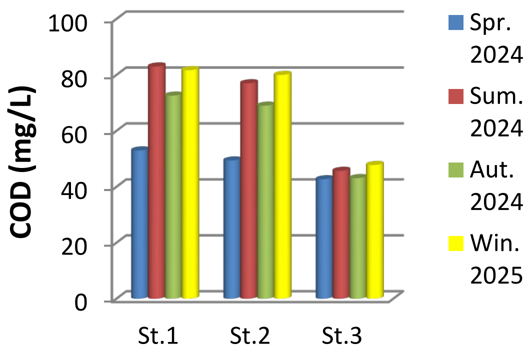

Figure 10: Seasonal and spatial variations of COD

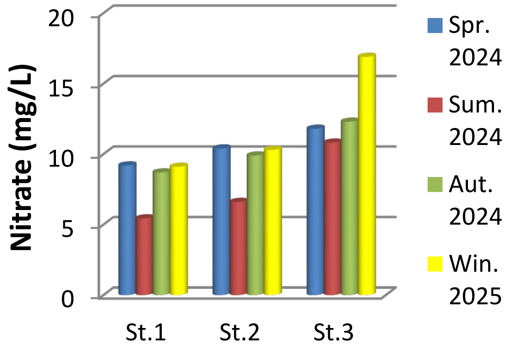

Figure 11: Seasonal and spatial variations of NO_3

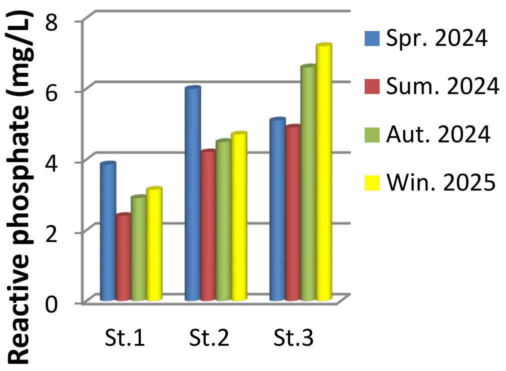

Figure 12: Seasonal and spatial variations of PO_4

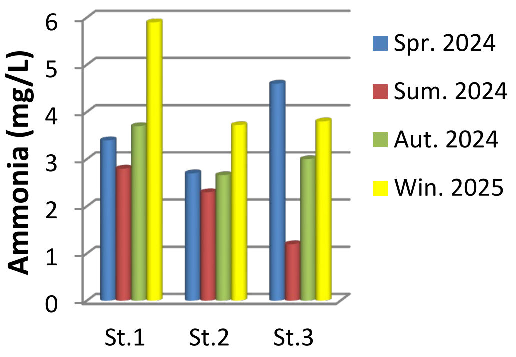

Figure 13: Seasonal and spatial variations of NH_3

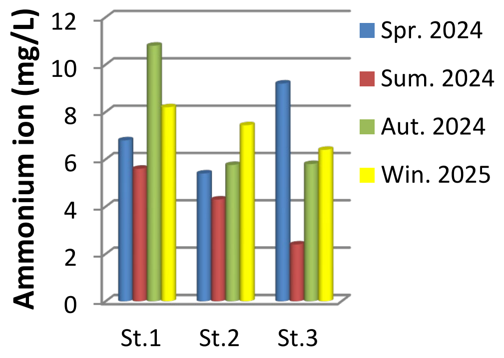

Figure 14: Seasonal and spatial variations of NH_4

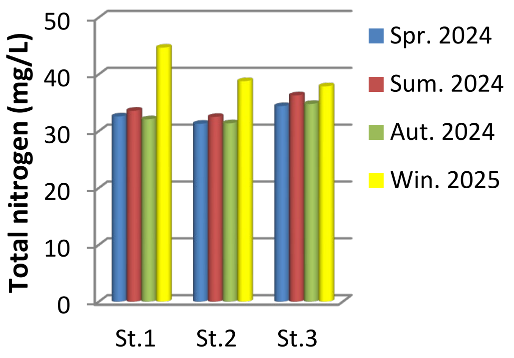

Figure 15: Seasonal and spatial variations of TN

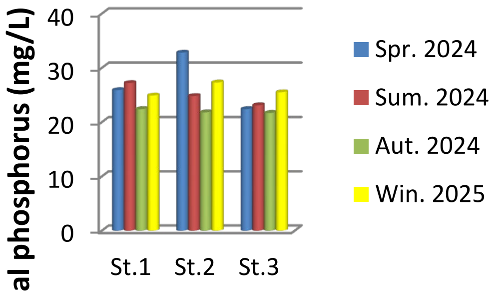

Figure 16: Seasonal and spatial variations of TP

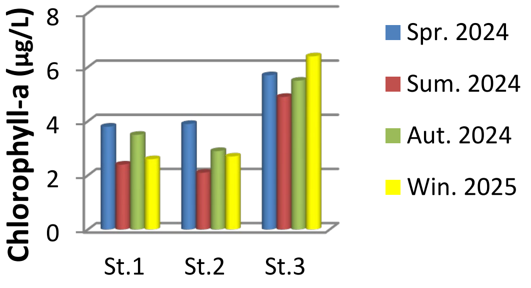

Figure 17: Seasonal and spacial variations of Chl.a

The results of the statistical analysis showed significant differences between the stations as well as between the seasons ($p \leq 0.05$) for all the environmental parameters with exception of pH which had no significant differences between the stations as well as between the seasons ($p \geq 0.05$). As well as, The results of the statistical analysis of DO showed significant differences between the stations, but no significant differences between the seasons.

Table 2: Persons Correlation Coefficient (r) between environmental factors in the Shatt Al-Basrah Canal.

	WT	pH	SD	Salinity	TSS	EC	Chl. a	DO	BOD_5	COD	TN	TP	NO_3	NH_3	NH_4	PO_4
WT		0.331	0.623	0.017	0.495	0.015	0.888	0.906	0.158	0.577	0.028	0.685	0.150	0.170	0.906	0.628
pH	-0.307		0.975	0.764	0.992	0.807	0.231	0.213	0.336	0.659	0.463	0.376	0.124	0.675	0.500	0.338
SD	-0.158	0.009		0.837	0.796	0.859	0.664	0.823	0.811	0.314	0.237	0.785	0.948	0.649	0.446	0.859
Salinity	0.670	-0.096	0.066		0.375	1.06E-	0.217	0.174	0.579	0.255	0.274	0.064	0.749	0.208	0.111	0.636
TSS	0.218	-0.003	0.083	0.281		0.400	0.080	0.143	0.002	0.028	0.670	0.089	0.067	0.792	0.190	0.031
EC	0.678	-0.079	0.057	0.999	0.267		0.203	0.166	0.604	0.238	0.241	0.066	0.734	0.188	0.107	0.613
Chl. a	-0.045	0.373	-0.139	0.384	-0.523	0.395		3.58E-	0.012	9.14E-	0.936	0.452	0.000 3	0.937	0.018	0.004
DO	-0.038	0.387	-0.072	0.419	-0.448	0.426	0.912		0.012	0.001	0.766	0.486	9.98E-05	0.884	0.003	0.000
BOD_5	0.433	-0.303	0.077	0.178	0.794	0.166	-0.691	-0.693		0.009	0.885	0.928	0.000	0.805	0.160	0.002
COD	-0.179	-0.142	0.317	-0.356	0.627	-0.368	-0.893	-0.817	0.708		0.485	0.734	0.013	0.789	0.069	0.005
TN	-0.628	0.234	0.368	-0.343	0.137	-0.366	0.025	0.095	-0.046	0.223		0.899	0.430	0.015	0.881	0.978
TP	-0.130	-0.280	-0.087	-0.549	-0.511	-0.546	-0.239	-0.222	-0.029	0.109	-0.040		0.693	0.970	0.971	0.837
NO_3	-0.441	0.468	0.020	0.103	-0.543	0.109	0.860	0.891	-0.835	-0.688	0.251	-0.127		0.786	0.018	0.000
NH_3	-0.422	0.134	-0.146	-0.391	0.085	-0.407	-0.025	-0.047	-0.079	0.086	0.676	-0.011	0.087		0.110	0.440

NH_4	-0.038	-0.215	-0.243	-0.483	0.405	-0.488	-0.662	-0.775	0.432	0.541	0.048	0.011	-0.662	0.484		0.002
PO_4	-0.155	0.303	-0.057	0.152	-0.620	0.162	0.756	0.886	-0.781	-0.747	-0.008	0.066	0.851	-0.246	-0.783	

3. Discussion

Temperature is one of the most important variables, greatly impacting all chemical, physical, and biological variables within the aquatic environment. They affects the distribution of living organisms, the amount of dissolved gases, and changes in pH, also they are affects electrical conductivity, the amount or percentage of specific gravity, and viscosity, which in turn impacts the biological behavior of these organisms in the aquatic environment (Banana et al., 2016). The results recorded in the current study revealed obvious seasonal changes in water temperature. This is due to Iraq's hot, dry climate, with long daylight hours during the summer and spring, and its moderate climate in terms of temperature and rainfall during the winter, with long night hours (Al-Atbee, 2018).

Light penetration is an important characteristic that reflects the transparency of a water body. This is due to the organic and inorganic materials suspended in the water column, such as clay, silt, phytoplankton, and zooplankton, in addition to external influences such as dust (Al-Abbawy, 2012). The low permeability in the Shatt Al-Basrah Canal is generally due to high water turbidity, which may be due to high temperatures in the summer, leading to increased decomposition of organic matter in the water, or a decrease in the water quantity in the canal, as well as the presence of suspended matter resulting from human and industrial waste and sewage (Mutlaq, 2012). When permeability increases in the winter, the reason may be high water levels resulting from rain, lack of biological activity, and slow decomposition of organic matter due to low temperatures in the winter (Rasheed, 2019).

Electrical conductivity is affected by a variety of factors, most notably temperature, evaporation, rainfall rates, and the extent of the advance of the salt front from the Arabian Gulf, which is associated with the phenomenon of ebb and flow. Furthermore, the quality of the soil through which the water passes plays an important role, along with the impact of power plants that consume large quantities of water during cooling operations. All of these factors contribute significantly to the increase in salt concentrations (Adlan and Al-Abbawy, 2022). Values increased in the summer due to conductivity, resulting from the frequent discharge of untreated sewage containing large quantities and concentrations of dissolved salts, which in turn leads to increased electrical conductivity in the water. Rates decreased in the winter due to lower temperatures and heavy rainfall (Al-Khal, 2021).

The salinity in the study recorded the highest rate in the summer season, the reason for this may be due to the intrusion of seawater at high tide in the event of the regulator being open, in addition to the drainage water laden with salts from agricultural lands discharged through the general outlet channel and the discharge of huge quantities of untreated domestic wastewater and industrial wastewater such as the Shatt Al-Basrah Gas Power Plant (Al-Aesawi, 2010; Aziz and Sabbar, 2013; Hassan et al., 2018; Al-Mahmoud et al., 2023).

Solids materials are a major contaminant in water. They are present in varying quantities and forms, and generally occur as dissolved solids or suspended solids in the water column. They are closely related to turbidity (APHA, 2005). The reason for the decrease in TSS values in spring is due to several factors, such as rainfall, which in turn reduces water turbidity, and the extent of control over human activities (Li et al., 2024; Luo et al., 2022).

Dissolved oxygen is one of the most important environmental parameters that reflect water quality. A decrease in its value will harm living organisms in the water, while its low level is a good indicator of organic pollution (Rasheed, 2019). High DO values during the winter are due to lower temperatures, which leads to increased solubility of gases in the water. Lower temperatures cause less decomposition of organic matter, thus reducing the consumption of dissolved oxygen (Al-Tamimi, 2022). Low dissolved oxygen levels in the summer are due to higher temperatures, which increase gas evaporation (Al-Taher, 2019; Bonacina et al., 2023; Mahaffey et al., 2020).

There are various factors that influence the determination of BOD_5, including dissolved oxygen concentration, the type of organic matter capable of decomposition, the amount and type of microorganisms, water temperature, pH, and, finally, the amount of toxic and decomposition-inhibiting substances (Al-Zarqa et al., 2019).

As for the chemical oxygen demand (COD) in water, an important indicator of the severity of total organic pollution of biodegradable and non-biodegradable materials, the results of measuring COD vary between different locations and in diverse environments, and also over different time periods depending on the polluting factors (Kumari et al., 2023).

Nitrate is the common form of organic nitrogen found in River and lake waters, due to the dissolved oxygen it contains in surface water, which in turn converts the nitrite form (NO_2) to nitrate (NO_3), which is one of the most important and prominent nutrients for the growth of phytoplankton in water (Rashid, 2019).

Phosphorus exists in several forms, including dissolved and suspended, and is found in two forms: organic and inorganic (Holmer, 2006). Phosphate sources are multiple and varied, coming from agricultural and industrial waste, or from household cleaning materials (Al-Sabah, 2007). The results of the current study showed an increase in phosphate concentrations in the summer, which may be mainly due to the discharge of large quantities of untreated sewage from various residential areas in Basra, in addition to agricultural drainage water transported through the main outlet connected to the Shatt Al-Basra Canal. Matula and Wojtkowska (2025) showed that there are significant changes in all levels of phosphorus forms related to aquatic systems, sediments, and waterways located in areas with high population density and high activity. The decrease in phosphate concentrations during the summer is due to the rise in temperatures, the increase in the amount of solar radiation, and the decrease in the rates of dissolved oxygen in the water, which in turn contributes to the release of phosphorus and then enhances the growth of algae and other aquatic plants, as it causes a decrease in the effective phosphate concentrations in the water (Lv et al., 2024; Zhang et al., 2025; Yin et al., 2023).

As for ammonia ions, their highest concentrations were recorded in the winter due to high levels of dissolved inorganic nitrogen (DIN) resulting from surface runoff and seepage from agricultural lands, which is associated with increased irrigated land and untreated wastewater runoff (Dodds, 2006). Low values occurred during the summer due to plant uptake and decreased ammonia solubility at higher water temperatures (IPCS, 1986). Ammonium is a form of inorganic nitrogen in its reduced state, resulting from the reduction of nitrate to ammonia within the cells of living organisms. Ammonium ions are readily taken up by phytoplankton (Holmer, 2006). Other sources of ammonium ions include wastewater, fertilizers, some industrial products, and detergents (Xie et al., 2012; Bellingham et al., 2012). Ammonium levels increased during the winter season due to the release of large quantities of detergents and organic materials through sewage, industrial waste, and agricultural fertilizers that were released or washed away by rain (Hassan, 2018; Xie et al., 2012; Galo, 2023).

The values total nitrogen were increased during the winter may due to high levels of dissolved inorganic nitrogen (DIN) as a result of surface runoff, which is associated with increased irrigated land and the amount of agricultural fertilizers (Dodds, 2006). Total nitrogen levels decreased in the spring due to high nutrient consumption by algae and aquatic plants. However, when the concentration of dissolved oxygen in the water is relatively high, the conversion rate of nitrite to nitrate increases (Al-Kenzawi, 2007). The reason for the increasing in total phosphate values during the spring may be due to increased nutrient concentrations or the release of pollutants that were not treated, this is consistent with the results of Al-Hajuje (2014).

Regarding chlorophyll, the results of the current study showed that chlorophyll concentrations increased during the winter and decreased during the summer. High temperatures and increased light intensity stimulate the growth of green and blue-green algae with high levels of chlorophyll a (Al-Taher, 2019). The reason for the decrease in chlorophyll levels during the summer is due to the lack of nutrient availability, as well as they are affected by environmental changes (Al-Asadi, 2019). It is worth noting that the results of our current study recorded very low concentrations, which are lower than previously recorded. This is probably due to the low growth of algae and phytoplankton in the waters of the Shatt Al-Basrah Canal, due to the significant increase in pollutant concentrations compared to previous years, which led to the existence of a lethal environment for most living organisms, especially primary producers.

The results of the current study on the Shatt Al-Basrah Canal revealed significant variations in most of the physical, chemical, and biological characteristics across the study stations and during different seasons. It is noteworthy that this variation and fluctuation in values did not follow a specific or clear pattern of increase and decrease across the study seasons. Some stations recorded high values during the cold winter, while other values increased during the hot summer, or vice versa. This situation can be explained by the multiplicity and diversity of pollutant sources and the quantities of pollutants that introduce various substances through wastewater into the canal at different times, which may be reflected in the concentrations of the measured factors. In general, the cause for the fluctuations in the values of the measured environmental factors across the study seasons may be due to the uncontrolled discharge of domestic wastewater and industrial waste containing large quantities of various compounds, such as organic matter and other chemical compounds. This is in addition to the infiltration of agricultural drainage water containing nitrogenous fertilizers, which contributes to the increased values (Moyel, 2023).

Generally, when comparing the results of current study with the Iraqi standard specifications for River water and sewage according to River Maintenance Regulation No. 25 of 1967 (Table 3), we note that most of the physical and chemical properties of the Shatt Al-Basrah water have exceeded the river specifications and are close to the specifications of sewage water. This confirms our conclusion about the deviation the water quality of Shatt Al-Basrah canal towards a channel for draining wastewater.

Table 3: Comparison the results of the current study with the Iraqi standard specifications for river water and sewage according to the River Maintenance System No. (25) of 1967.

Quality	Rivers and their tributaries	streams and canals	Wastewater	Current study

Color	normal	normal	unnatural	Dark and almost black
Water temperature (°C)	-	-	<45	11-31
TSS (mg/l)	-	-	750	30.6-67.3
pH	6.5-8.5	6.5-8.5	6-9.5	7.84-8.6
DO (mg/l)	> 5	> 5	-	2.1-5.8
BOD_5 (mg/l)	<3	<5	1000	10.9-18.4
COD (mg/l)	-	-	-	42.7-83
NO_3 (mg/l)	15	15	-	5.44-16.9
PO_4 (mg/l)	0.4	0.4	-	2.4-7.2
NH_3 (mg/l)	-	-	10	1.2-5.9
NH_4 (mg/l)	1	1	-	2.4-10.8

4. Conclusion

The current study aimed to evaluate the water quality of the Shatt Al-Basrah Canal after the opening of dozens of untreated sewage pipes that discharged directly into it. Water samples were collected quarterly from April 2024 to January 2025. Measurements included 19 environmental parameters. The pH was alkaline, while the results showed a significant increase in salinity levels, resulting in very saline water. However, the dissolved oxygen (DO) concentration decreased sharply and became almost nonexistent. Conversely, a significant increase in the biological oxygen demand (BOD_5) was recorded, reflecting the large quantities of organic matter accumulated in the canal. Furthermore, nutrient levels showed significant increases, particularly for nitrates (NO_3) and active phosphates (PO4). Overall, when comparing the results of this study with Iraqi standards for river and wastewater, it was observed that most of the physical and chemical properties of the Shatt Al-Basrah Canal water exceed those of rivers and closely resemble those of wastewater. Consequently, the canal has effectively become a sewage discharge channel.

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تأثير مياه الصرف الصحي على جودة المياه في قناة شط البصرة، جنوب العراق

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الملخص

قناة شط البصرة مجرى مائي اصطناعي. كان الهدف الرئيسي من القناة هو التحكم في منسوب مياه نهر شط العرب خلال موسم الفيضان. إلا أن جودة مياهها تدهورت بعد فتح عشرات من أنابيب الصرف الصحي غير المعالجة لتصب بشكل مباشرة فيها. تعاني القناة حاليًا من مستويات تلوث عالية جدًا بسبب تصريف مياه الصرف الصحي الثقيلة غير المعالجة من مدينة البصرة، فضلا عن وجود نفايات صناعية ومحطة توليد الكهرباء والأراضي الزراعية على ضفاف القناة. لذلك، هدفت الدراسة الحالية إلى تقييم جودة مياه قناة شط البصرة. جُمعت عينات من المياه، وأُجريت قياسات ميدانية ومختبرية بشكل فصلي للفترة من نيسان 2024 إلى كانون الثاني 2025. وشملت القياسات 19 عاملاً بيئياً. أظهرت النتائج أن مستويات عالية للملوحة بلغت 47.42 غ/لتر، وانخفاضاً حاداً في الأكسجين المذاب (DO) بمقدار 2.1 ملغم/لتر، وزيادة معنوية في الطلب البيولوجي للأكسجين (BOD_5) بمقدار 18.4 ملغم/لتر. في الوقت نفسه، سجلت العناصر الغذائية زيادة معنوية، حيث وصل تركيز النترات (NO_3) إلى 16.9 ملغم/لتر، وتركيز الفوسفات الفعال (PO_4) إلى 7.2 ملغم/لتر. وبشكل عام، عند مقارنة نتائج الدراسة الحالية بالمواصفات القياسية العراقية لمياه الأنهار ومياه الصرف الصحي،

نلاحظ أن معظم الخصائص الفيزيائية والكيميائية لمياه قناة شط البصرة تتجاوز خصائص الأنهار، وهي قريبة جداً من خصائص مياه الصرف الصحي. وبالتالي، أصبحت القناة قناة تصريف لمياه الصرف الصحي.

الكلمات المفتاحية: جودة المياه، شط البصرة، العوامل البيئية، مياه الصرف الصحي