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Original Article

Evaluation of organic pollution in Shatt al-Basrah Canal, Southern Iraq

Kadhim Hashim Kanani*[1], Amjad K. Resen[1], Sajid Saad Hassan[2]

[1]Fisheries and Marine Resources, College of Agriculture, University of Basrah, Basrah, Iraq.
[2]College of Health and Medical Technologies, AL-Maaqal University, Basrah, Iraq.

Abstract: Given the environmental importance of the Shatt al-Basra Canal, the current study aimed to examine organic pollution levels in the canal waters using the Organic Pollution Index (OPI) and the Nutritional Status Index (TSI) to identify the variables influencing organic pollution during the period from January 2023 to December 2023. Water samples were collected monthly from two stations. The measured environmental factors were water temperature 16-35℃, salinity 47-20.2 ppt, DO 9-5 mg/L, BOD 0.65-0.10 mg/L, light transmittance 71-18 cm, nitrate 12.24-1.19 mg/, phosphate 0.63-0.13 mg/L, and ammonium 10.48-3.1 mg/L, and chlorophyll-a 61.18-10.4 mg/L. TSI values in the two study stations were 55.96-48.76, and the water quality assessment was within the well-nourished classification in all stations except for the second station, which was within the average nutrition classification. The results showed clear changes in OPI values (95.56-22.35). The water quality of the Shatt al-Basra Canal was classified as sixth (poor) at the first station (60.13), and decreased to fourth (weak) at the second station (41.10).

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Introduction

Pollution of rivers and artificial canals causes severe environmental impacts that threaten human health and aquatic organisms. Uncontrolled sewage discharges into waterways are a major cause of their pollution (Alibi et al., 2020). The main objective of pollution evidence is to monitor the environment, analyze pollution, and convert complex data into information of a single numerical value (Charuvan et al., 2012). In addition to the impact of rivers on various water sources, industrial waste and agricultural activities increase concentrations of nitrogen and phosphorus compounds in aquatic environments, leading to nutrient conditions that promote excessive growth of phytoplankton, benthic algae, and macrophytes. And can lead to highly undesirable changes in ecosystem structure and function, as well as to the emergence of nutrient enrichment that degrades water quality (Krivokapic et al., 2010).

Many international studies have been conducted to assess water quality using the Organic Pollution Index (OPI) and the Trophic State Index (TSI) in water bodies, including Karaouzas et al. (2018), Malik et al. (2020), Ofori et al. (2022), and Segnou et al. (2023), and local studies conducted on the Shatt Al-Basrah Canal, such as Hassan et al. (2011), Gatea et al. (2018), Hassan et al. (2019), and Galo and Resen (2024). Therefore, the current study aimed to investigate the levels of organic pollution in the waters of the Shatt Basrah canal using OPI and TSI to provide a clear and comprehensive picture of organic pollution and to identify the influencing variables by calculating the organic pollution index.

Materials and Methods

Description of the study area: The current study was conducted on the Shatt al-Basrah canal, the second-longest artificial canal in Basrah, after the Shatt al-Arab irrigation canal project. The length of this canal is approximately 37 km, with an average width of 60 m and a depth of 5.5 m. The depth varies from one station to another, increasing towards the Persian Gulf (Wahhab, 1986; AL-Muhanaa, 2020). The study area is affected by tidal currents across Khor Al Zubair.

*Correspondence: Kadhim Hashim Kanani
E-mail: kadhim.hashim@uobasrah.edu.iq

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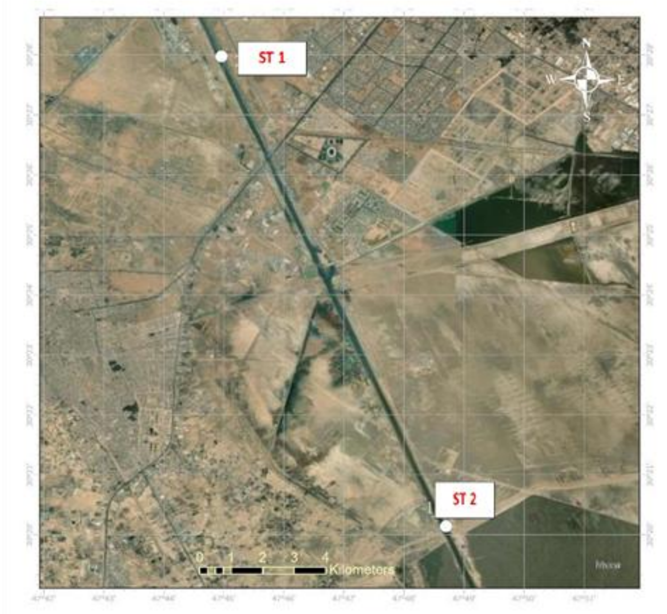

Figure 1. Sampling sites at Shatt Al-Basrah Canal.

Two stations were selected to collect samples: the first is located at 30.4667143N, 47.7487406E, and the second is downstream of the Shatt Al-Basrah canal regulator (30.3352133N, 47.8112176E) (Fig. 1).

Water samples were collected from the stations from December 2022 to November 2023. At the rate of one sample monthly during tide times, and some environmental factors, including water temperature using a simple graduated mercury thermometer, salinity using a Chinese-made water quality meter (AZ-86031) device, dissolved oxygen, and Biological Oxygen Demand (BOD_5) using the modified Winkler method described in APHA (2005), were measured. Furthermore, light penetration using a Secchi disk, active nitrate (NO_3), and active phosphate using the technique described by Parsons et al. (1984) using the spectrophotometer of type 4050, and ammonium (NH_4) by the distillation method described in APHA (2005), and Chlorophyll-a based on Lind (1979) were measured.

Three environmental variables (total phosphorus (TP), Chlorophyll-a, and Light penetration) were selected according to Carlson (1977) (Table 1), to calculate the values of the Trophic state index (TSI) using the equations of TSI (SD) = 60-14.41 Ln [Secchi disc depth (m)], TSI (Chl) = 9.81 Ln [Chlorophyll-a (μg/l)] + 30.6, TSI (TP) = 14.42 Ln [Total phosphorus(μg/l)] + 4.15, and Average TSI = [TSI (TP) + TSI (Chl) + TSI (SD)]/3, where SD = depth of light area using a Secchi disk (meters), Chl.a = concentration of Chlorophyll-a (mg/L), and TP = Total phosphorus (mg/L). The organic pollution index (OPI) value was calculated using four factors of Biological Oxygen Demand (BOD_5), nitrate (NO_3), active phosphate (PO4), and ammonium (NH_4) from the equation below, and this value is classified according to Boluda et al. (2002) (Table 2) using the formula of OPI = (∑ ci / cmi) /n*10, where Ci = Experimental value for each variable analyzed, cmi = the guidelines that stand for the maximal amount of permitted pollution content, and n: is the Number of variables.

Table 1. Water trophic status index scale (Carlson, 1977).

Trophic status	TSI
Oligotrophic	< 30
Mesotrophic	40-50
Eutrophic	50-60
Hypereutrophic	70-80

Table 2. OPI index values based on Boluda et al. (2002) and modified by Saleem (2013).

Limits	Organic pollution level	#
9 ≤	very Good	1
29-10	Good	2
39-30	Medium	3
49-41	Poor	4
59-50	Deteriorated	5
69-60	Bad	6
70 ≥	Very Bad	7

Results

Water temperature: Figure 2 shows monthly changes in water temperature at the two stations. The lowest temperature was recorded in January, at 16℃ at the first station and 14.5℃ at the second station, in December 2022. It rose gradually to 35 and 34℃ in August 2023 for the first and second stations, respectively. There were no significant differences in water temperature between the two study stations ($F = 0.006$, $P>0.05$).

Salinity: Figure 3 shows the monthly salinity changes at the two stations. The lowest salinity was recorded in February (20.2 and 28.5 ppt at the first and second

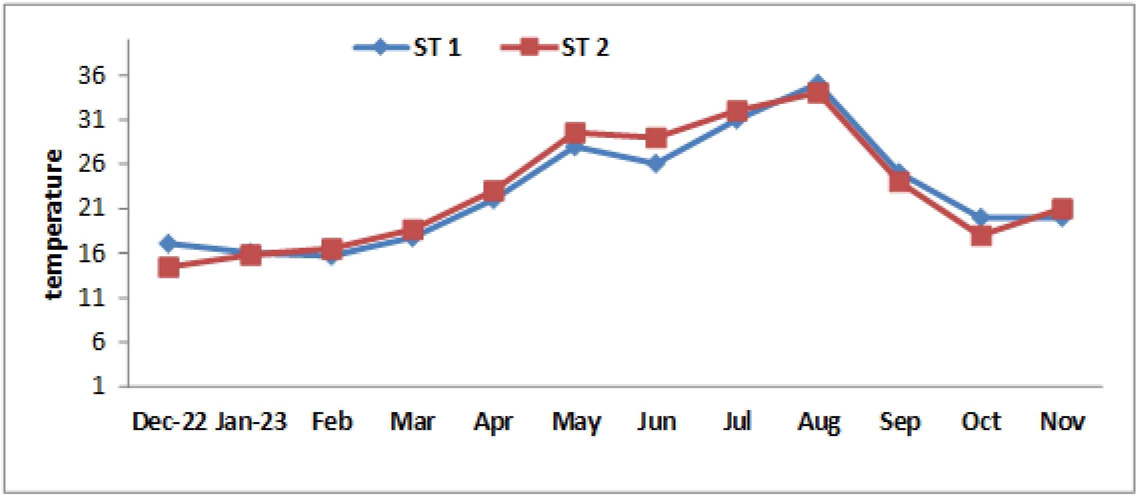

Figure 2. Monthly changes in water temperature for the two studied stations, Shatt al-Basrah Canal.

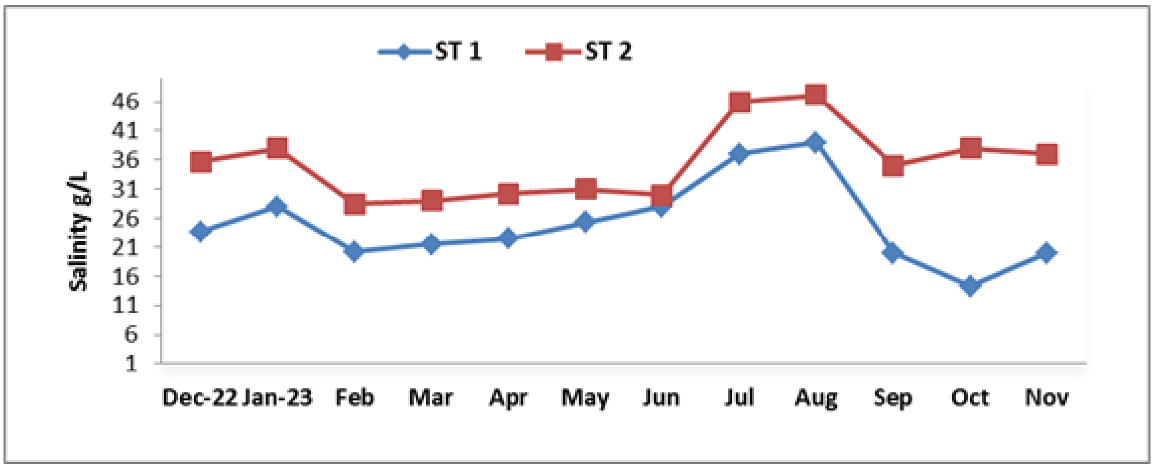

Figure 3. Monthly changes in water salinity for the two studied stations, Shatt al-Basrah Canal.

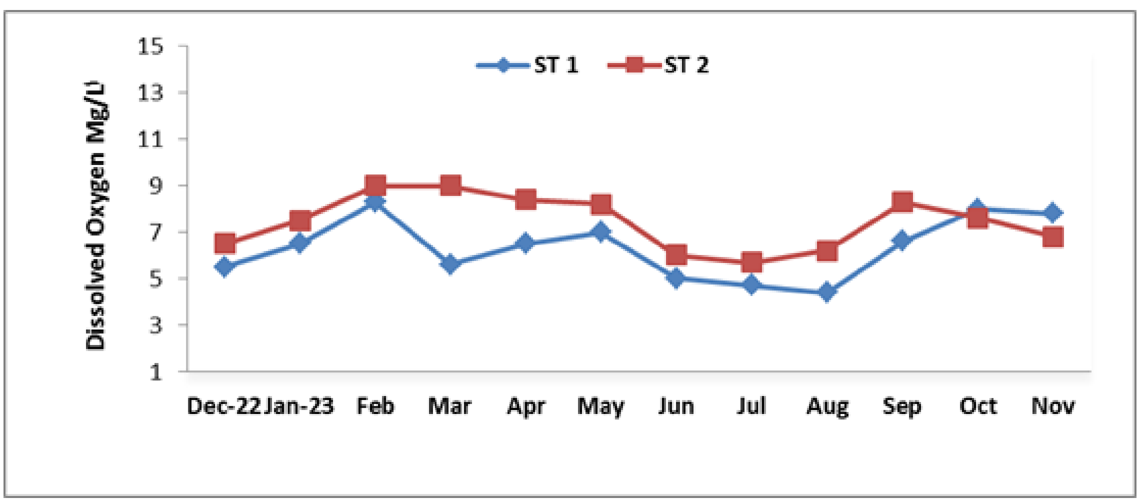

Figure 4. Monthly changes in dissolved oxygen values for the two studied stations, Shatt al-Basrah Canal.

stations, respectively). In contrast, the highest was recorded in August (39 and 47 ppt at the first and second stations, respectively). The results showed a significant difference between the two stations in salinity (F=14.461, *P*=0.001).

Dissolved oxygen (DO): The lowest DO was

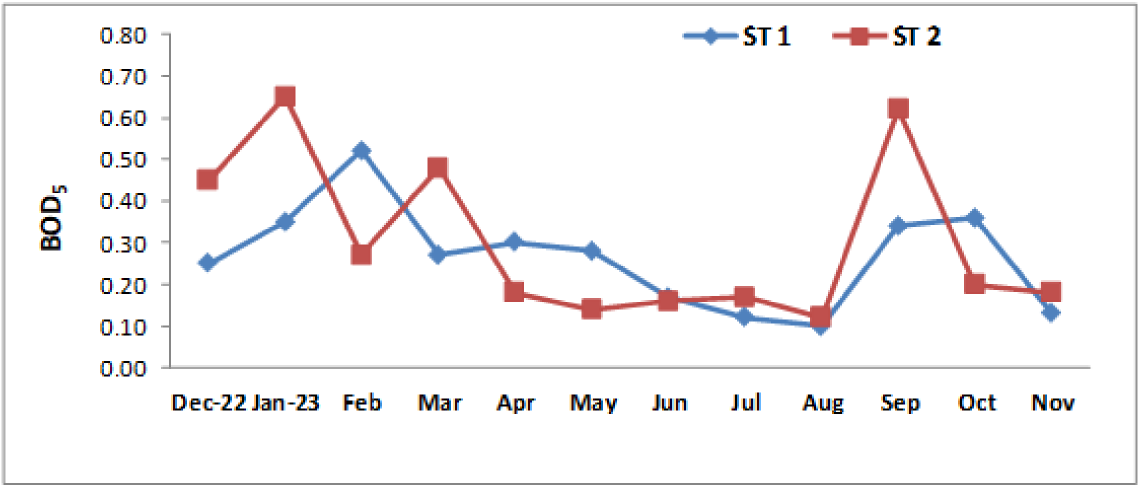

Figure 5. Monthly changes in Biological Oxygen Demand values for the two studied stations, Shatt al-Basrah Canal.

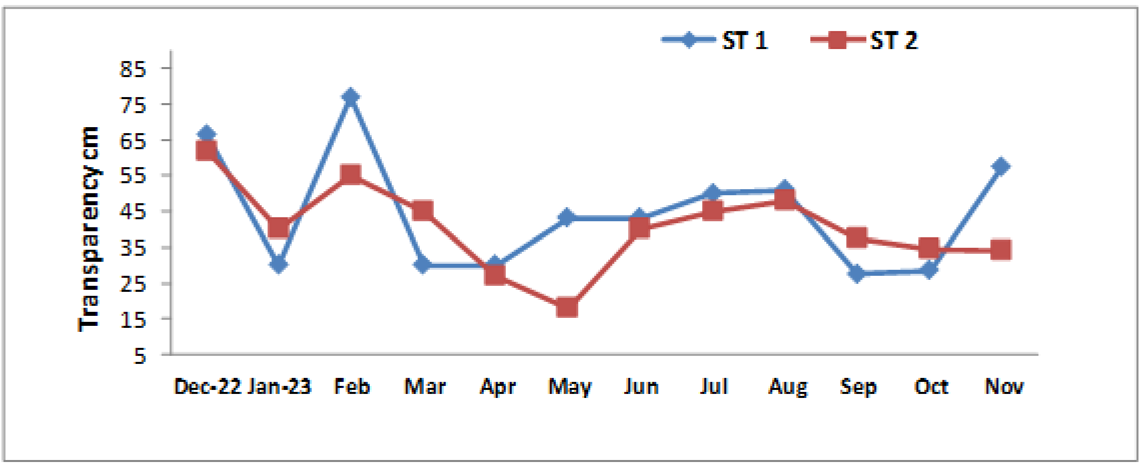

Figure 6. Monthly changes in Transparency values for the two studied stations, Shatt al-Basrah Canal.

recorded at 5 and 6 mg/L in June for the first and second stations, respectively, and the highest values were 8.3 and 9 mg/L in February for the first and second stations, respectively (Fig. 4). A significant difference between the two stations for DO was found (F = 4.790, *P*=0.040).

Biological oxygen demand (BOD_5): The lowest oxygen values were recorded at 0.10 and 0.12 mg/L in August for the first and second stations, respectively, and the highest values were 0.52 mg/L at the first station in February and 0.65 mg/L at the second station in December 2023. No significant differences were found in BOD between the two stations (F =0.006, *P*=0.594) (Fig. 5).

Transparency: The lowest values were recorded at 27.5 cm in September for the first station, 18 cm in May for the second station, and the highest values were 77 cm in February for the first station and 62 cm in December 2022 for the second. No significant differences were found in light transmittance values between the two stations (F =0.469, *P*=0.501) (Fig. 6).

Nitrate (NO_3): The lowest values reached 1.86 and 1.19 mg/L in March for the first and second stations, respectively, while the highest values were recorded 18.18 and 12.24 mg/L in January 2023 for the first and second stations, respectively. No significant differences were found in nitrate between the two stations (F = 3.028, *P*=0.096) (Fig. 7).

Reactive phosphate (Po_4): The lowest values were 0.18 mg/L in November at the first station and 0.13 mg/L in April at the second station, whereas the highest values were 0.63 and 0.52 mg/L in June at the two stations, respectively. The results showed no significant differences in phosphate between the two

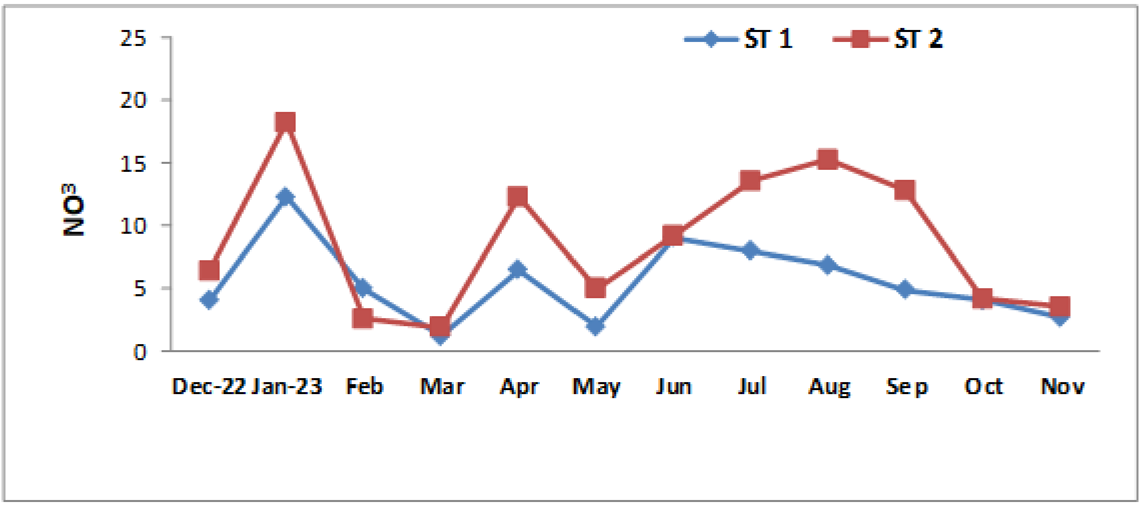

Figure 7. Monthly changes in Nitrate (NO_3) values for the two studied stations, Shatt al-Basrah Canal.

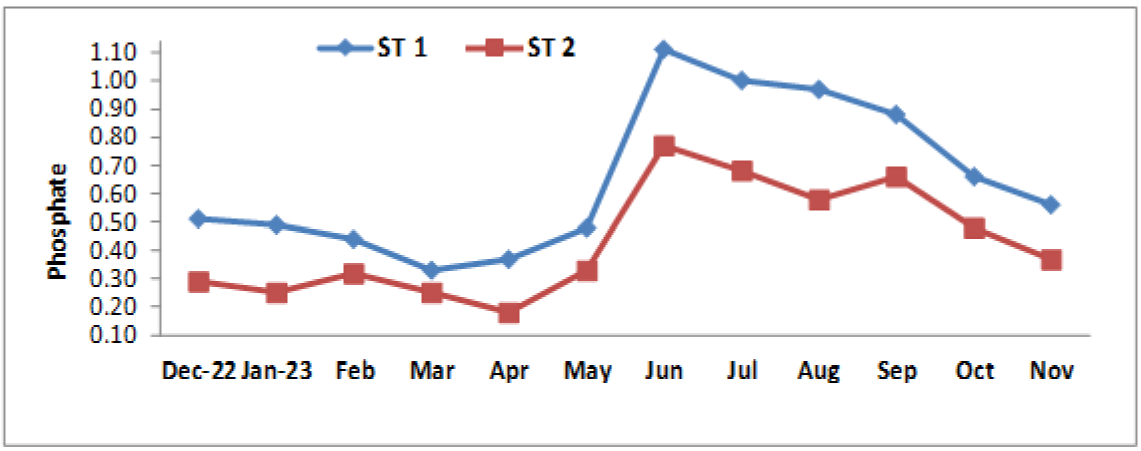

Figure 8. Monthly changes in phosphate (Po4) values for the two studied stations, Shatt al-Basrah Canal.

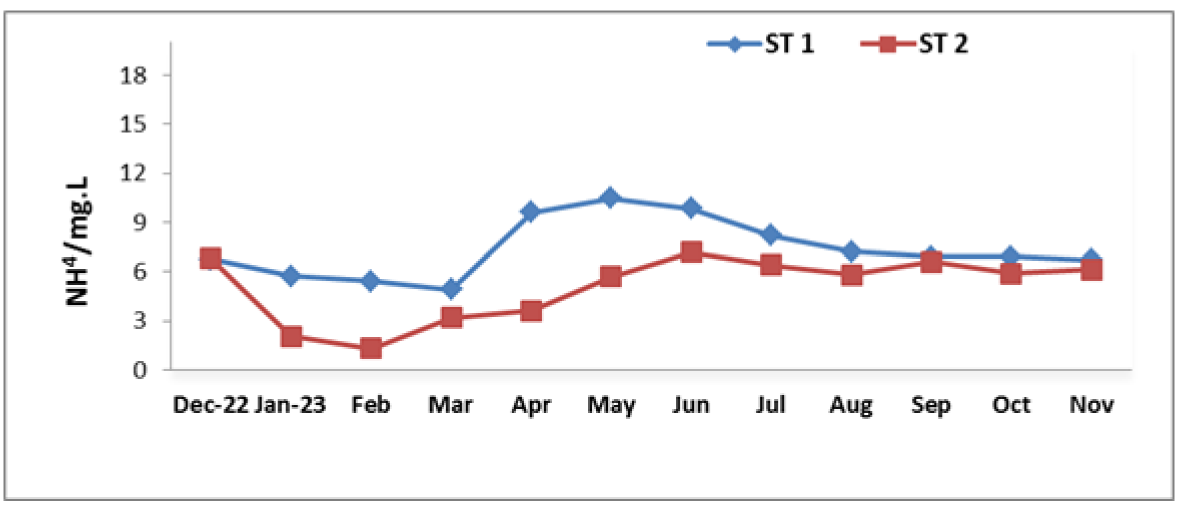

Figure 9. Monthly changes in Ammonium Ion (NH_4) values for the two studied stations, Shatt al-Basrah Canal.

study stations (F=1.530, *P*=0.229) (Fig. 8).

Ammonium Ion (NH_4): The lowest values were 4.9 mg/L in March for the first station and 1.3 mg/L in February for the second station, while the highest values were recorded at 10.48 mg/L in May for the first station and 7.16 mg/L in June for the second

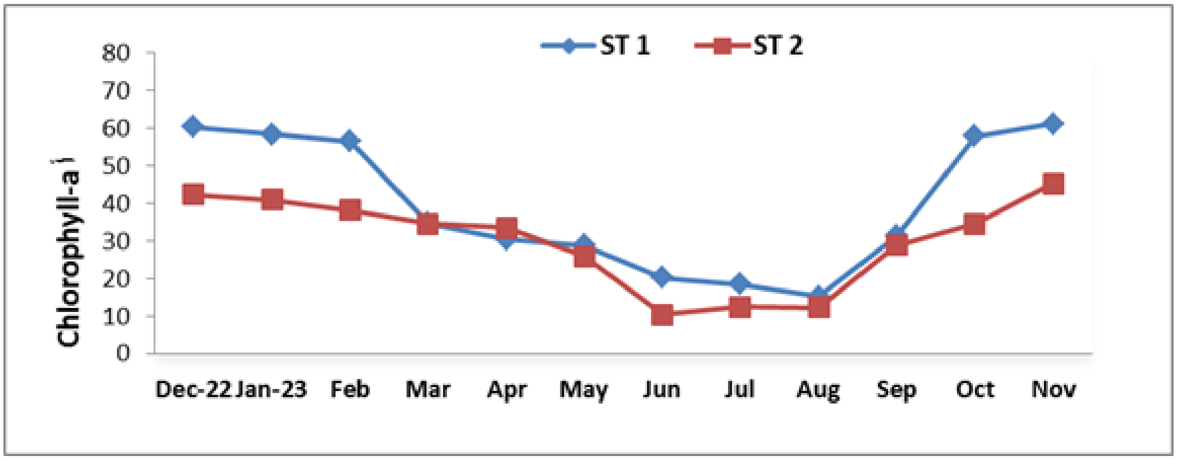

Figure 10. Monthly changes in Chlorophyll a in the two studied stations, Shatt al-Basrah Canal.

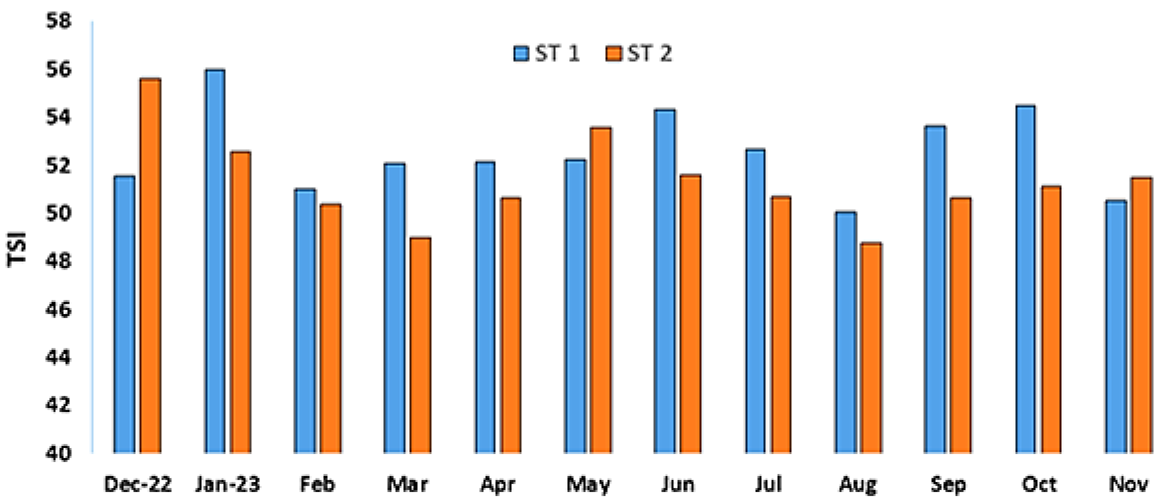

Figure 11. Monthly changes in TSI for the two studied stations, Shatt al-Basrah Canal.

station (Fig. 9). A significant difference of NH_4 between the two stations (F = 9.140, *P*=0.006).

Chlorophyll-a: The lowest values recorded were 15.3 mg/L in August for the first station and 10.4 in June for the second station, while the highest values were recorded as 61.18 and 45.26 mg/L in November for the two stations, respectively. No significant differences were found in Chlorophyll-a concentrations between the two stations (F = 2.295, *P*=0.144) (Fig. 10).

Trophic state index (TSI): TSI results showed fluctuations across the two study stations. The first station recorded the highest values in January 2023, at 55.96. The lowest value was 50.04 in August, while the highest was 55.61 in December 2022. The lowest value was 48.76 in August. The water quality assessment was classified as good nutrition at all stations except in August, when the second station was classified as Mesotrophic (Fig. 11).

Organic pollution index (OPI): Monthly changes in OPI showed apparent variation between the two stations during the study period, with the highest values of 95.56 and 67.63 recorded in June for the first and second stations, respectively. The lowest values were 33.21 at the first station in March and 22.38 at the second station in April (Fig. 12).

Discussions

Water temperature is one of the most important factors influencing the environment of aquatic ecosystems, as it affects the distribution and abundance of living organisms (Banana et al., 2016). The results of the current study showed an apparent monthly variation in water temperature at the study stations, attributable to

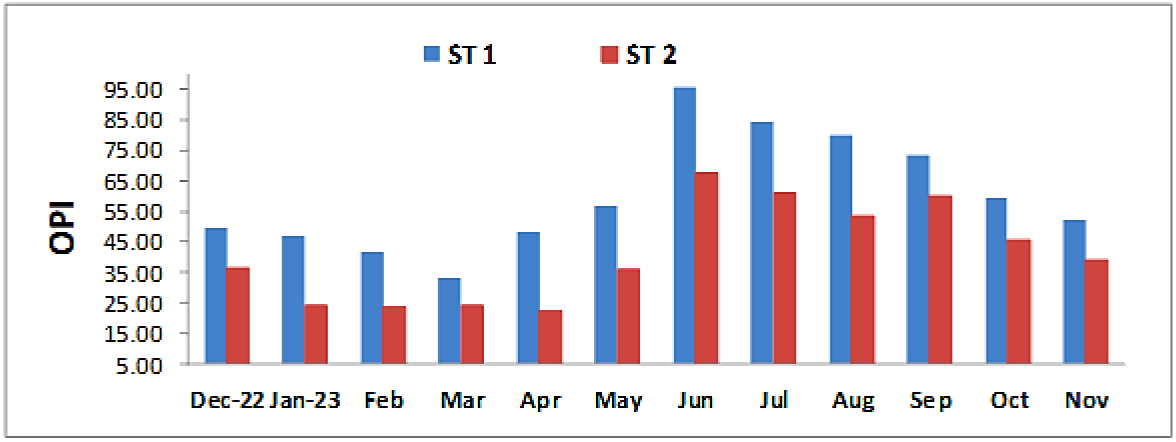

Figure 12. Monthly changes in OPI values for the two studied stations, Shatt al-Basrah Canal.

differences in water depth, water levels, and the prevailing environmental conditions in each area (Lampert and Sommer, 1997; Galo, 2023).

The current study recorded high salinity compared to previous studies, and this is due to high concentrations of salinity during the summer because of increased evaporation, as well as the lack of freshwater discharge from the Euphrates River and the construction of an earthen dam on the upper part of the canal from the side of the Karma Ali River. The lower part of the Canal is affected daily by tides from the Persian Gulf (AL-Aesawi, 2010), the continuous increase in salinity from human activities and untreated wastewater (Hassan et al., 2018), and the irregular opening of regulator gates (personal communication).

The current study showed that DO in the Shatt al-Basrah canal increased in winter and autumn and decreased in summer at both study stations. The reduction in DO during the summer is attributable to increased rates of organic matter decomposition and oxygen consumption by aquatic organisms (Moyel, 2014). High DO during winter and autumn due to the inverse correlation between gases and temperatures (Durmishi et al., 2008).

The current study showed that BOD_5 varied between the two study stations, despite all stations being exposed to the same pollutants, which result from receiving large quantities of untreated wastewater and industrial waste (Charles et al., 2019). The high BOD_5 at the two stations is attributable to increased sewage and waste discharges and to elevated temperatures, which increase microbial activity that consumes dissolved oxygen. The low values at the second station result from exposure to tidal processes that dilute pollutants continuously discharged into the canal. This is consistent with Galo's (2023) findings in the same area.

Transparency is a major factor influencing the presence and distribution of fish species, indirectly through its impact on water-body productivity (Swatland, 2020). The transparency range recorded in this study is 18-66 cm; Wahhab (1986) reported 8-69 cm in the same area, Resen et al. (2011) reported 37-61 cm, and Galo (2023) reported 23-55 cm. The low values of light penetration are due to a significant increase in suspended matter, which peaks in early summer. In addition to the low speed of the water current, the regulator controls the rate of water flow at this station, which may be open for only a few hours per day or month. The absence of side branches, which leads to the deposition of suspended matter, and the difference in phytoplankton density are consistent with studies by Resen et al. (2011) and Galo (2023).

The current study indicated an increase in effective nitrates during the winter months because the decrease in water temperature increased DO, thereby facilitating the conversion of nitrites to nitrates via oxidation (Hussein and Fahad, 2008). Its decrease in the warm months is due to low oxygen concentrations that limit the oxidation of nitrite to nitrates, and phytoplankton consumption during these months, which further reduces its concentration (Al-Imarah et al., 2017).

Phosphate concentrations were highest during summer and winter at the two study stations, likely due to low consumption by phytoplankton and other organisms. Rain may play an important role in delivering phosphorus from the Earth's crust, agricultural land, and untreated sewage and industrial wastewater (Wetzel, 2001). It decreases in autumn and spring because phytoplankton, algae, and aquatic plants may consume it, consistent with studies by Hassan et al. (2011), Gatea et al. (2018), and Galo (2023). The high ammonium ion concentrations at the first station throughout the study period, relative to the second station, are attributable to the large quantities of detergents and organic matter in sewage and untreated household and industrial waste (Charles et al., 2019), while their decrease during the warm months may be due to their consumption by phytoplankton (Ahmed, 2017).

The increase in chlorophyll a was two-model; the first increase occurred during winter and continued into spring, attributable to the rise in diatom abundance during these seasons. It is considered the season of flowering algae, during which household waste and sewage are released untreated and are affected by organic waste (AL-Saadi et al., 1990). The decline during summer and autumn may be due to nutrient consumption by algae during winter and spring, resulting in low algal populations and an inability to bloom again, thereby reducing chlorophyll a value (Antoniades and Douglas, 2002). The results of the current study were consistent with those of Jabir (2014) in the same area.

Trophic state index (TSI): Based on the results, the stations' TSI values were almost similar. The first station recorded slightly higher values, and both stations were classified as well-fed. The higher value at the first station may be due to the station receiving untreated local and industrial sewage, as well as wastewater containing phosphate compounds from household and agricultural detergents. In addition, high chlorophyll levels at this station, low light penetration, high nutrient concentrations, and increased phytoplankton and suspended matter concentrations led to elevated turbidity, resulting in a high index value (Al Asadi and Al Hejuje, 2019). The results of the current study were consistent with those reported by Shawi (2010) in Khor Al-Zubair and by Galo and Resen (2024) in the same area.

Organic pollution index (OPI): The results of the current study showed pronounced monthly variation in OPI values at both study stations. They differed in the pattern of monthly changes. The water of the Shatt Al-Basrah canal was classified within the sixth category (poor) in the first station, where the value of the index (60.13) is higher than in the second station. This may be attributed to the large quantities of untreated sewage and industrial wastewater entering via pollutant-release pipes, which are rich in organic matter and originate from the nearby population (Hassan et al., 2018). In addition to the lack of water inflow from the Euphrates, the presence of the Basrah refinery, which discharges waste into the Shatt Al-Basrah canal, reduced OPI at the second station, with its average index reaching 10.41, classified as the fourth category (weak), as well as because of marine water entrance from Khor Al-Zubair, resulting in high salinity, the station's effected by tidal event.

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