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Study of Benthic Macrofauna and Organic Pollution Indices in Southern Part of Shatt al-Basrah Canal, Basrah, Iraq

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ABSTRACT

The present study aimed to investigate the relationship between benthic macrofauna and levels of organic pollution indicators (OPI) in the banks of Shatt al-Basrah Canal, Basrah, Iraq. The observed ranges of OPI and some water quality parameters were as follows: 1.58-3.9 for OPI, which were above the maximum acceptable pollution limit (1) in all months in Shatt al-Basrah Canal, 13-35.5°C for temperature, 49.9-21.8ppt for salinity, 1.15-5.21mg/ L for ammonium ion, 0.098-0.33mg/ L for phosphate values, 0.53-4.5mg/ L for nitrate values, 0.05-0.27mg/ L for nitrite values, 4.55-10.5 for dissolved oxygen (DO) and 7.2-8.2 for pH. A total of 25 species of benthic macroinvertebrates were collected. The monthly records of benthic macroinvertebrate species in the study area were relatively stable, from October 2023 to September 2024. The monthly changes in the density of benthic macroinvertebrates varied, with a maximum of 243 individuals in May and a minimum of 154 individuals in August. The highest annual total abundance was 599 for the bivalve group and the lowest abundance was 408 for the Cirripedia group. The relationship of OPI with different invertebrate groups varied, with a positive relationship with the bivalve group and Polycheta and a negative relationship with Gastropoda. Therefore, OPI is considered an indicator of pollution in the study area. Cirripedia and crustaceans did not show a clear relationship with organic pollution.

INTRODUCTION

Organic pollutants in sediments come from various sources, including terrestrial and aquatic environments **(Buscail *et al.*, 1995)**. Large amounts of organic pollutants reach rivers from agricultural river banks and are deposited in sediments. In addition, atmospheric transport of terrestrial-derived organic pollutants into river sediments by wind can cause them to be transported by air. Algal biomass, which represents a large proportion of primary productivity in aquatic environments, also contributes to the transport of organic pollutants to sediments **(Danovaro *et al*., 1994; Wurtsbaugh *et al*., 2019)**. In addition, recent studies have examined the contribution and increasing impact of sewage waste, which is released in increasing quantities and causing an increase in organic pollutants in the water and sediments of this canal **(Galo & Resen, 2024)**. Algal biomass, which represents a large proportion of primary productivity in aquatic environments, also contributes to the transport of organic pollutants to sediments **(Grung *et al*., 2021)**. The presence of macroinvertebrates is considered important indicators in global biological monitoring programs and is widely recognized for its importance in assessing water quality **(Mamert *et al*., 2016; Ahmed *et al*., 2024; Al-Baghdadi *et al.*, 2024)**. Benthic invertebrates are important organisms in aquatic ecosystems, serving as food for fish and other aquatic species **(López-López & Sedeño-Díaz, 2015)**. The abundance and distribution of benthic invertebrates are useful for biomonitoring because they respond to organic and inorganic pollution affecting benthic invertebrates **(Sharma & Barkale, 2016; Schratzberger & Ingels, 2018; Al-Baghdadi *et al.*, 2024)**. The presence and abundance of benthic invertebrates are influenced by different environmental characteristics of bottom sediments **(Erin *et al*., 2017)**. The benthic community also plays an important role in the release of nutrients from sediments. On the other hand, river bottom sediments serve as a food source for benthic organisms and other aquatic organisms, and as a result enhance the overall productivity of water bodies **(Karmakar *et al*., 2022)**.

Gatea *et al*. (2018) evaluated the physical and chemical properties of the Shatt al-Basrah water, examining its suitability for domestic or industrial use, such as pH, calcium (Ca), magnesium (Mg), oxygen (PO4), chlorine (Cl), sulfur dioxide (SO4), dissolved oxygen (DO3), nitrogen trioxide (NO3), total dissolved solids (TDS), and electrical conductivity (EC). The analysis results were evaluated according to international drinking water standards. This study confirmed the presence of water pollution in the Shatt al-Basrah canal, which calls for immediate preventive measures to reduce pollution.

Ali *et al*. (2021) also showed an 80% loss in species richness in the Khor al-Zubair area, which indicates a significant decrease in species diversity.

Podura aquatica insect was first recorded by **Okash *et al*. (2022)** in southern Iraq. The study demonstrated the relationship between the insect and some environmental parameters, such as temperature, pH, electrical conductivity (EC), and total organic carbon (TOC). A significant negative correlation was found between insect density and temperature, pH, and TOC. A weak positive correlation was found between density and EC. The study area suffered from high levels of organic matter due to the discharge of Basra Governorate sewage into the Shatt al-Basra canal which increased in summer.

Okash (2023) studied the invertebrate community in two ways: the first through qualitative sampling and the second through quantitative sampling. Of these, 15 species were recorded in the Shatt al-Basrah Canal only. The highest relative abundance of Annelids was recorded at the al-Zubair Bridge station, reaching 62%, and for Mollusca, at the Shatt al-Basrah regulator station, reaching 39%. Diversity indices were used, and the recorded indices ranged from 0-1.25 in the Shatt al-Basrah Canal. The Margalef richness index values for all benthic invertebrates ranged from 0-0.61, the Menhinick wealth index values ranged from 0.12-0.35, and the Pielou equivalence index values ranged from 0-1.

Galo and Resen (2024) explained the relationship between the nutritional status of the Shatt Al-Basrah Canal and its production levels by calculating the trophic status index (TSI). Statistical analysis showed a relationship between the studied plant species and the levels of the trophic status index.

The present study aimed to investigate and determine the type of relationship between the effect of water quality parameters and OPI ranges on monthly variations in benthic invertebrate density and its relationship to invertebrate diversity along the banks of the Shatt-al-Basrah Canal.

MATERIALS AND METHODS

Study area

The study was conducted in the Shatt al-Basrah Canal located at 30˚19ˈ18.24" N and 47˚49ˈ08.11" E. This is an artificial tidal mudflat canal, facilitating the transfer of floodwaters from the Hammar Marsh to Khor al-Zubair and then to the Arabian Gulf **(UNEP, 2001; Hassan *et al.*, 2018)**. The canal extends southeast to northern Basra, covering approximately 37,157km^2 within the Basrah Alluvial Plain. The area is constantly exposed to pollution, causing serious and continuous degradation of the vegetation cover on the water-covered area. The water in the canal is saline and the vegetation is salt-tolerant, and there is fishing and birding in the area, located between latitudes 30.27° to 30.28° N and longitudes 47.50 to 47.49° E. Sampling was carried out over a 12-month period, from October 2023 to September 2024 (Plate 1).

Water quality parameters

Water quality parameters, such as temperature (°C) and pH, were measured monthly. Water temperature was recorded using a Celsius thermometer, while pH and dissolved oxygen (mg/L) were measured using a digital multimeter (Yasi-multimeter).

Field collection of samples benthic macrofauna

Samples of benthic macrofauna were collected on monthly intervals from the sampling site between 7:00 AM and 10:00 AM over a period of twelve consecutive months at the selected south the Shatt al-Basrah Canal station. A hand trowel was used to collect macrofauna samples, each covering an area of 250cm² and a depth of 5cm.

After collection, the benthic sediments were drained onto a fine mesh screen (0.2mm) and washed with water. The collected benthic invertebrates were preserved in 70% alcohol and were stored in plastic bottles.

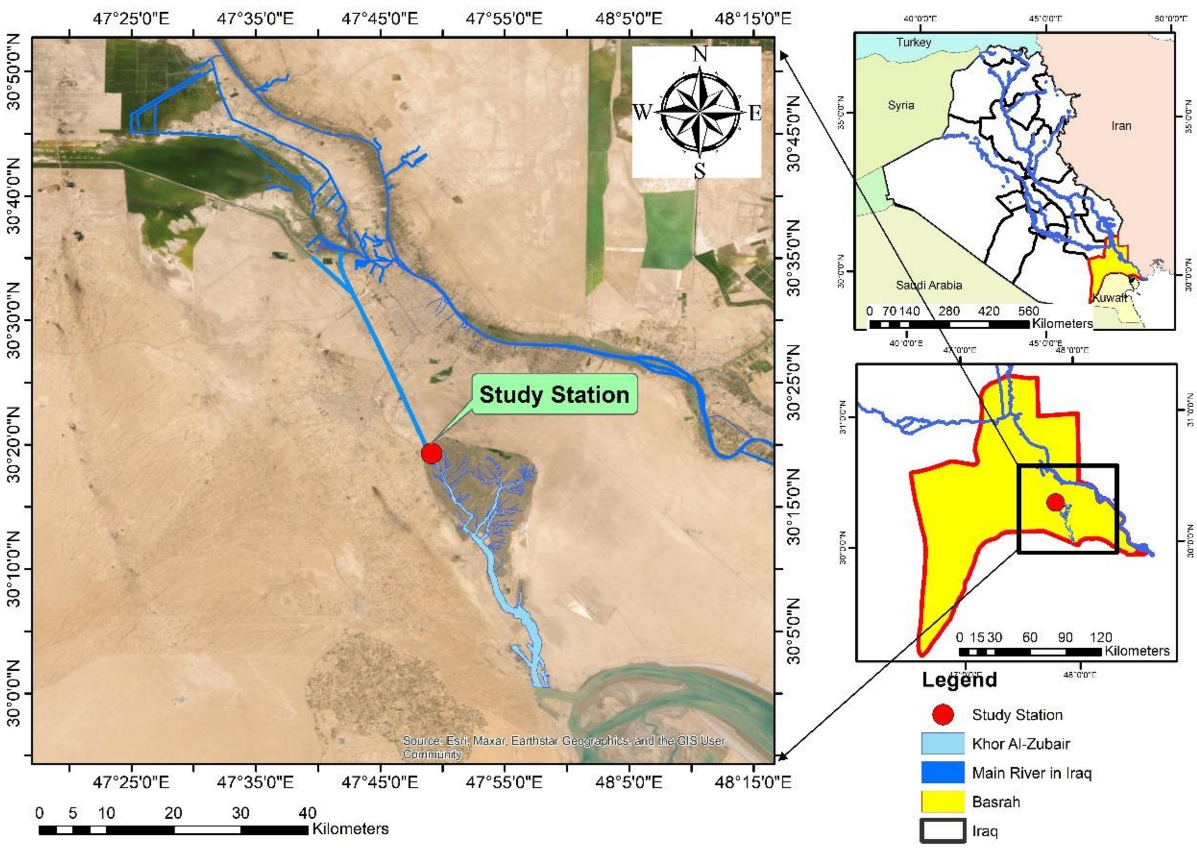

Plate 1. Map of the study area showing the sampling station

Organic pollution index (OPI)

The organic pollution index (OPI) was applied based on **Boluda *et al.* (2002)** and according to the following equation:

$$\mathbf{OPI} = \left(\sum_{i=1}^{n} \frac{Ci}{Cmi}\right)/n$$

Where, Ci is the empirical value for each variable analyzed; Cmi is the maximum allowed, and n: the number of variables used. There are limits to the permissible concentrations of some environmental indicators (Table 1).

The current study followed the standards outlined in the System for Preserving Rivers from Pollution No. 25 of 1967 and the American standards of the Environmental Protection Agency **(EPA, 2001)**.

According to **Boluda *et al.* (2002)**, an index value greater than one indicates the presence of organic pollution, while a value less than one suggests that no such pollution is present.

Table 1. Permissible limits for some environmental factors locally and globally

Indicator	Permissble limit		Indicator Permissible limit Measuring unit Iraqi Standards and Metrology Organization (1967 EPA (2001) (2001) BOD5
	Iraqi Standards and Metrology Organization (1967)	EPA (2001)	Measuring unit
NO_3	15	0.076	$mg.l^{-1}$
NH^+_4	1	-	$mg.l^{-1}$
PO4	0.04	0.13	$mg.l^{-1}$

Benthic fauna count

The density of benthic invertebrates (measured as the number per 250cm²) was determined. The population density of benthic invertebrates (in number per square meter) was calculated using the following formula:

Number of benthic invertebrates per square meter = (number found in the bottom soil of the pond, collected by shovel) × 16 = (number per 250cm²) × 16, where the open mouth area is 250cm².

Data analysis

Based on the results of the normality and variance tests, the data appear to be parametric, as they meet the assumptions of normality and homogeneity of variance. Therefore, One-Way ANOVA was used to compare the means of the different groups. To identify which specific groups differ, Tukey's HSD test was used.

RESULTS

Water quality parameters

Monthly variations in environmental parameters, including temperature, salinity, dissolved oxygen (DO), and pH, were measured at the Shatt al-Basrah Canal study station (Fig. 1). The temperature ranged from 35.5°C in August to 13°C in January. Salinity levels ranged from 49.9ppt in July to 21.8ppt in March. Dissolved oxygen levels ranged from 10.5mg/ L in January to 4.55mg/ L in August. pH values varied from 8.2 in March to 7.2 in June. Ammonium ion concentrations varied from 5.21mg/ L in February to 1.15mg/ L in August. Phosphate values ranged from 0.33mg/ L in January to 0.098mg/ L in May. Nitrate levels fluctuated between 4.5mg/ L in December and 0.53mg/ L in June. Nitrite concentrations varied from 0.72mg/ L in December to 0.05mg/ L in June (Fig. 2).

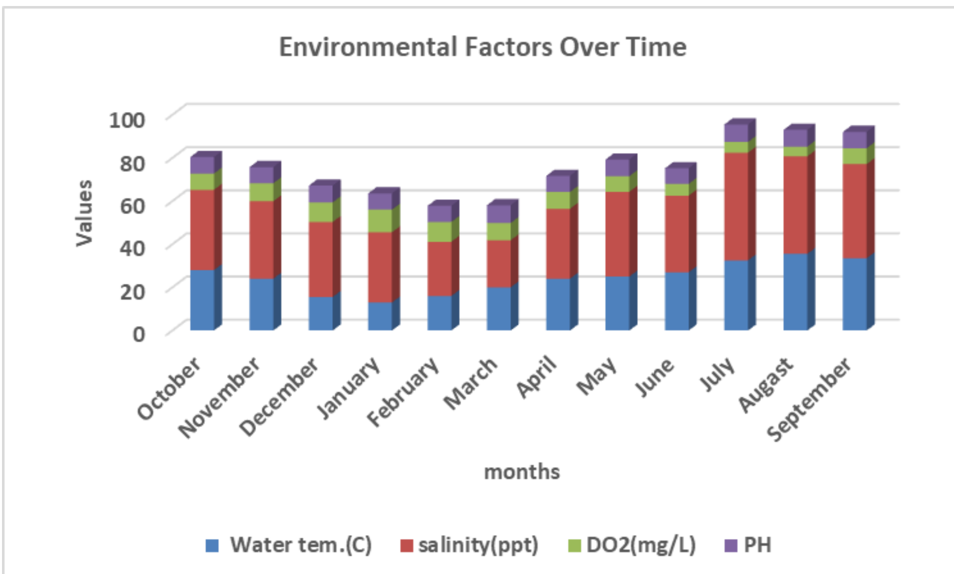

Fig. 1. Monthly changes in environmental factors during the study period

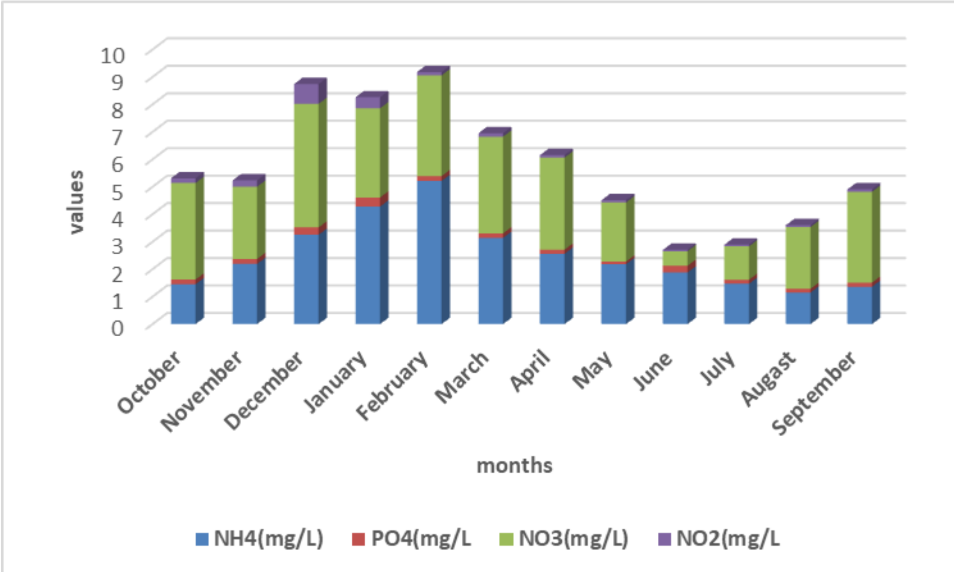

Fig. 2. Monthly variations of water quality factors during the study period

OPI levels of the bottom of Shatt Al-Basrah

Fig. (3) shows the monthly fluctuation of OPI levels of the Shatt al-Basrah Canal. The highest values were recorded in January, recording 3.9, while the lowest values of OPI 1.58 were recorded in August.

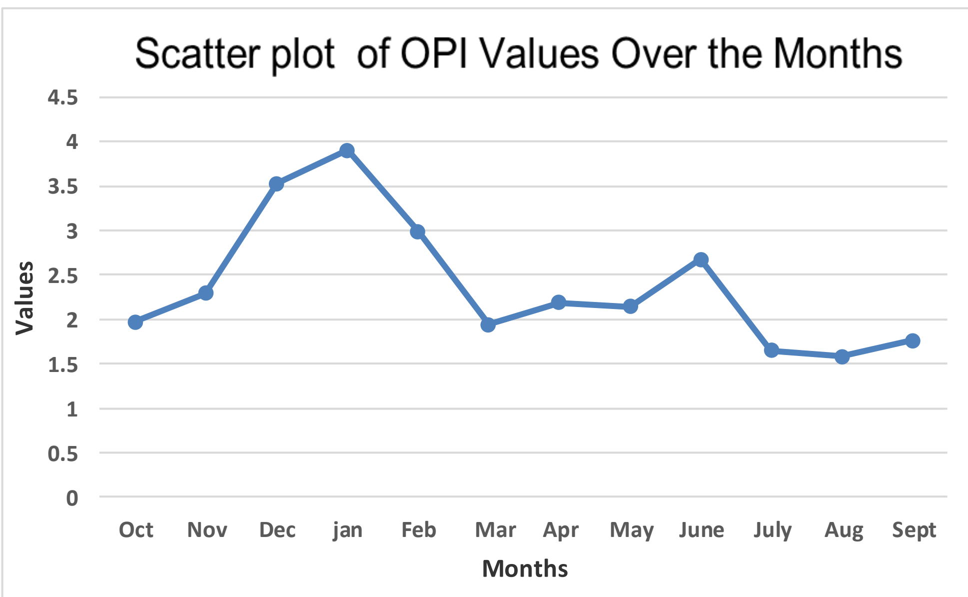

Fig. 3. The OPI values across the months showing the trend, including the peak in December and the stabilization in later months

Group composition and species of benthic macrofauna in the study area

A total of 2,389 individuals representing three phyla—Mollusca, Arthropoda, and Annelida—and five classes—Bivalvia, Gastropoda, Crustacea, Polychaeta, and Cirripedia—were identified in the study. These individuals were classified into 38 species, as shown in Fig. (4) and Table (2).

Table 2. Species composition of benthic macro-fauna in the study area

Polychaeta: *Namalycastis indica, Nephtys hombergii****, *Nereis* sp.***
Bivalvia: *Solen vogina**, *Dosinia laminate****, *Abra cadabra****, *Mactra dissimilis**, *Laevicardium flavum****
Gastropoda: *Assiminea zubairensis, Thais carinifera**, *Diodora funiculate**, *Neripteron violaceum**
Crustacea: Cirripedia: *Amphibalanus amphetrite amphetrite* Isopoda: *Sphaeroma annandalei annandalei* ** Amphipoda: *Parhyale basrensis, Platorchestia* sp. Decapoda: *Macrophalmus depressus**, *Eurycarcinus orientalis**, *Nasima dotilliformis****, *Leptochryseus kuwaitensis*,*** *Ilyoplax stevensi, Uca* sp., *Parasesarma plicatum****

***Ahmed (1975), **ROPME (1986), ***Ali *et al*. (2021)**

Population proportions

- Mollusca constituted 45% of the total benthic macrofauna population, while Arthropoda, Annelida, and Cirripedia accounted for 21%, 17%, and 17%, respectively.
- Among the five classes recorded (Fig. 4):

  Bivalvia had the highest representation, with 599 individuals, comprising 25% of the total population.

  Gastropoda recorded 472 individuals, making up 20% of the total.

  Crustacea contributed 493 individuals, accounting for approximately 21% of the total population.

  Polychaeta group had 417 individuals, making up 17% of the total.

  The Ciriipeda had 408 individuals, comprising 17% of the total population.

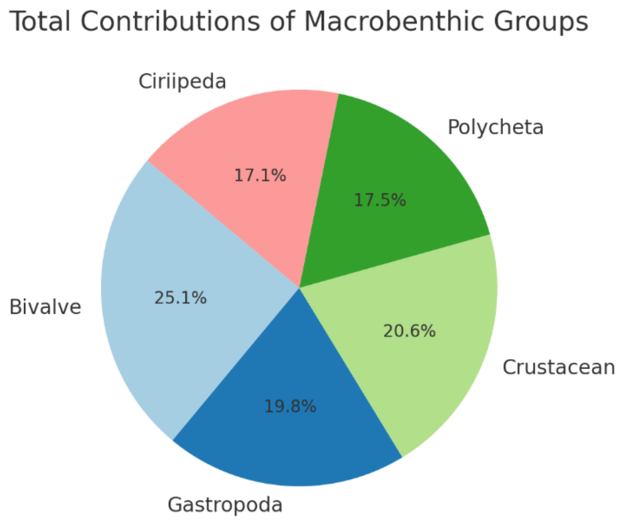

Fig. 4. Relative contributions of different classes of benthic macro- invertebrates in the study site

Temporal variations in abundance and occurrence of benthic macrofauna species

Monthly temporal variations in the occurrence of macrofauna species at the study stations are shown in Fig. (5). The monthly record of benthic macrofauna species observed in the study area was relatively stable, values fluctuated between four species recorded between 2-5 for the months from October 2023 to April 2024 and 5 -12 recorded each for the months May, June, July and September, respectively (Fig. 5).

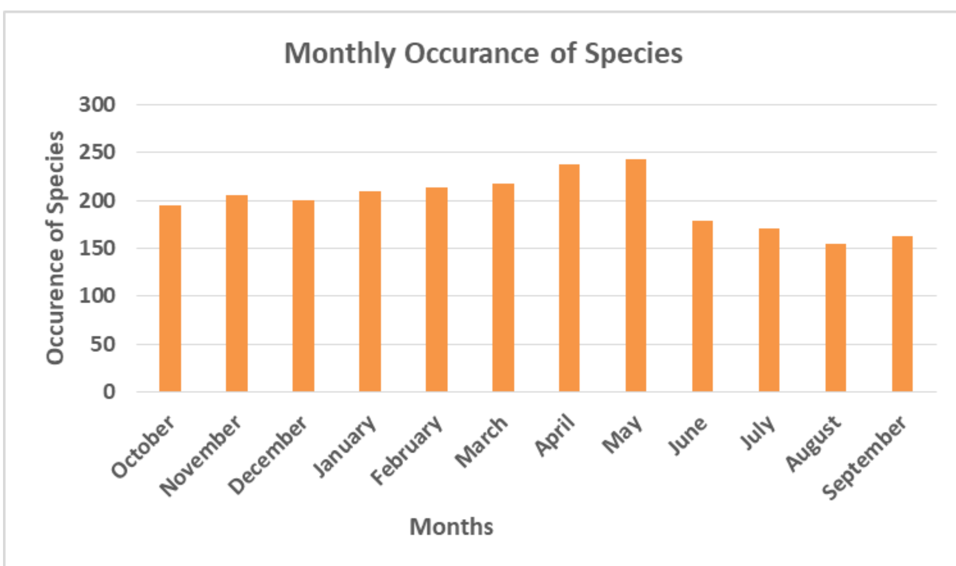

Fig. 5. The monthly occurrence of benthic macrofauna species at the study site

Monthly abundance of benthic macrofauna

The monthly abundance of benthic macrofauna varied from 243 individuals recorded in May to 154 individuals collected in August (Fig. 6). The total abundance for other months was as follows: October: 195 individuals, November: 206 individuals, December: 200 individuals, January: 209 individuals, February: 203 individuals, March: 218 individuals, April: 238 individuals, June: 179 individuals, July: 171 individuals and September: 163 individuals.

The highest abundance of macrobenthic invertebrates was recorded at the the Shatt al-Basrah Canal site (Fig. 6). The highest mean monthly abundance of Bivalvia (66 ind/m²) was recorded in May, while the lowest (22 ind/m²) was recorded in June. Gastropoda was also found to be the least dominant group of benthic fauna. The highest mean monthly abundance of Gastropoda (58 ind/m²) was found in June, with the lowest (28 ind/m²) in January. The highest mean monthly abundance of Crustacea (52 ind/m²) occurred in February, while the lowest (26 ind/m²) was found in August. The highest mean monthly abundance of Polychaeta (54 ind/m²) was recorded in January, with the lowest (21 ind/m²) in March. The highest mean monthly abundance of Cirripedia (45 ind/m²) was recorded in March, and the lowest (22 ind/m²) in July. The results of the one-way ANOVA were: F-statistic: 5.235, *P*-value: 0.0012. Since the *P*-value was less than the typical significance level (e.g., 0.05), we rejected the null hypothesis. This indicates that there is a statistically significant difference in the means of abundance among the five groups (Table 3).

Table 3. Tukey's HSD test result to identify which specific groups differ

Group 1	**Group 2**	**Mean Difference**	**p-Value**	**Lower Bound**	**Upper Bound**	**Significant (Reject Null)**
Bivalve	Ciriipeda	-17.0833	0.001	-25.618	-8.549	Yes
Bivalve	Crustacean	-10.9167	0.029	-19.451	-2.382	Yes
Bivalve	Gastropoda	-8.25	0.098	-16.784	0.284	No
Bivalve	Polycheta	-9.25	0.056	-17.784	0.716	No
Ciriipeda	Crustacean	6.167	0.437	-2.368	14.702	No
Ciriipeda	Gastropoda	8.833	0.095	-0.702	18.368	No
Ciriipeda	Polycheta	7.833	0.152	-1.702	17.368	No
Crustacean	Gastropoda	2.667	0.869	-6.868	12.202	No
Crustacean	Polycheta	1.667	0.958	-7.868	11.202	No
Gastropoda	Polycheta	-1.0	0.9	-10.535	8.535	No

□

Significant differences were found between:

- **Bivalve and Ciriipeda** ($P < 0.05$)
- **Bivalve and Crustacean** ($P < 0.05$)

□ There were no significant differences between other group pairs.

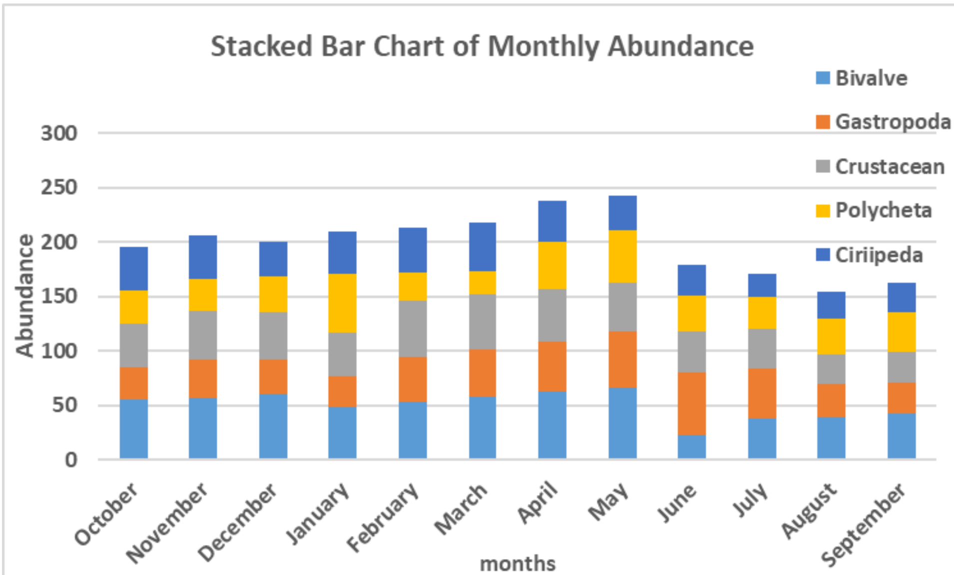

Fig. 6. Stacked bar chart displays the contribution of each group to the total abundance per month.

Correlation between benthic macrofauna and organic pollution index (OPI) and water quality factors

The relationships between the number of individuals of benthic acrofauna and measured water quality parameters, along with OPI, are shown in Table (4) and Fig. (7). The correlation analysis revealed significant relationships between benthic macrofauna groups and various factors, including OPI: ($r = 0.950$; $P < 0.01$), Temperature: ($r = 0.824$; $P < 0.01$), Salinity: ($r = 0.874$; $P < 0.01$), dissolved oxygen (DO): ($r = 0.616$; $P < 0.01$), pH: ($r = 0.512$; $P < 0.01$). Although the number of individuals of benthic macrofauna showed a negative relationship with temperature and salinity, the relationship with OPI and DO was positive. A negative but non-significant relationship was observed between the number of individuals of benthic macrofauna and pH ($r = 0.345$; $P > 0.01$).

Table 4. The correlations between measured water quality parameters, OPI, and the number of individuals of benthic macrofauna in the study area

Water quality parameter/ OPI	**Benthic macrofauna variable (No. of individuals/m²)**
OPI	Positive correlation (*)
Temperature (°C)	Negative correlation (*)
Salinity	Negative correlation (*)
Dissolved Oxygen (DO, mg/l)	Positive correlation (*)
pH	No significant correlation (ns)

+= positive correlation; -= negative correlation; ns= no significant correlation; *P*>0.01; *: significant correlation; *P*<0.01.

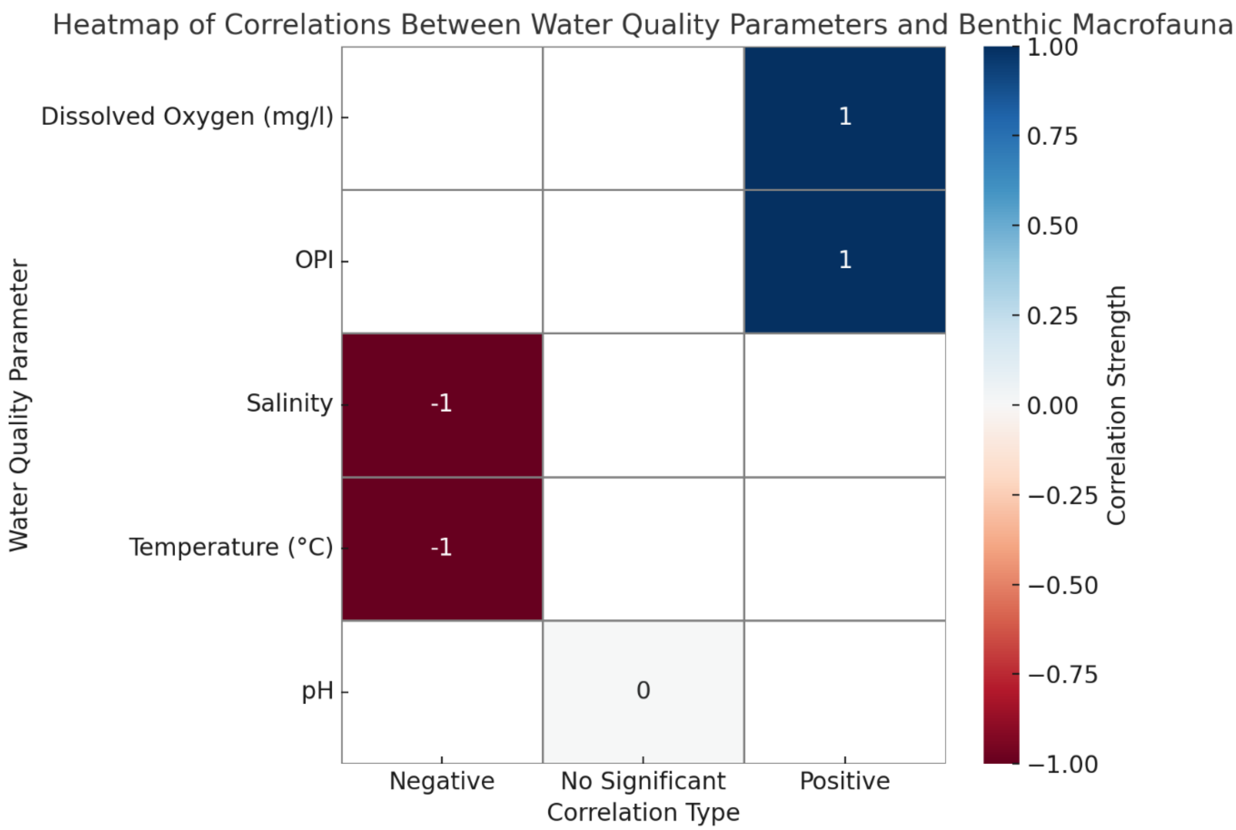

Fig. 7. Heatmap visualizing the correlations between water quality parameters, the OPI, and benthic macrofauna abundance. The correlation types are represented with color gradients: red for positive correlations, blue for negative correlations, and gray for no significant correlation

DISCUSSION

Impact of change to environmental parameters on benthic fauna

Water temperature is one of the most important factors affecting the environment of water bodies through its effect on several chemical and physical factors, viz. gases dissolved in water, pH, conductivity, specific density, and viscosity. The highest and lowest values were recorded during August and January, respectively. The decrease in water temperature in winter and its increase in summer in the ecosystem follows the temperature of the surrounding air **(Fouzia & Amir, 2013)**. During summer, the study area is affected by the long hours of daylight and the resulting brightness of sunlight affecting the surface of the water. The river's shallowness, due to reduced flow during summer, increases its vulnerability to air temperatures **(Galo, 2023)**. This differs from the winter season, which is characterized by short daylight hours, weak sunlight, and varying levels of water depth. The reason for the difference may also be attributed to changes in climate, being hot and dry during summer and cold and rainy during winter **(Al-Hejuje, 2014; Ahmed *et al.*, 2022a)**.

Mean annual temperatures in Iraq have increased by approximately 0.7°C since 1950 **(Hassan *et al.*, 2018)**. These rising temperatures are likely to impact benthic fauna significantly. Temperature is one of the primary limiting factors influencing the occurrence and distribution of species in the intertidal zone. Most of the time, high temperatures are associated with high salinity, which leads to increased stress on benthic communities **(Ali *et al.*, 2000)**. **Parmesan (2006)** showed that variations in environmental conditions surrounding organisms play a major role in naturally regulating the distribution and abundance of organisms. Therefore, understanding how species adapt and respond to extreme climate changes has become a major area of interest in both terrestrial and marine ecosystems **(Helmuth *et al.*, 2006)**.

The decrease in salt concentrations during the cold months may be due to rainfall and the increase in Shatt al-Basra Canal discharges during those months of the year.

Dissolved oxygen in water plays an effective role in regulating the vital processes of several aquatic organisms. It cannot be measured or studied even if its value is lower than the level necessary for the continuation of the life of these organisms **(Abowei, 2010; Ahmed *et al.*, 2022a)**. Current research showed a decrease in oxygen values during the summer and an increase during the winter and spring at the study stations, as there is an increase in the rate of decomposition of organic matter and an increase in oxygen consumption by aquatic organisms resulting from the rise in water temperature during the summer, especially in June **(Moyel, 2014)**. Most of the time, the reason for the increase in dissolved oxygen values during the winter, especially in January, is the inverse relationship between the dissolution of gases and temperature **(Durmishi *et al.*, 2008)**.

The current study showed that dissolved oxygen values are low most of the time at the study station due to household waste and untreated sewage **(Charles *et al.*, 2019)** in the Shatt al-Basrah Canal. The results of the study showed that the pH values were almost moderate and were in the acidic direction in most months and basic during the end of winter and the beginning of spring.

The decrease in the pH value may be due to the release of untreated household and agricultural wastes directly into the river, the decomposition of which leads to an increase in the acidity of the water and thus a decrease in the pH value **(Sanchez *et al*., 2007)**. This was confirmed by the study of **Okash (2024)**.

The ecological condition ranged from moderately disturbed (scale 1.58) to very disturbed (scale 3.9) due to water pollution, garbage, fishing activities, and boats along the shores, as well as untreated sewage collection from several points.

High values of the index were recorded in the studied area during all months, and this was confirmed by the study by **Galo and Resen (2024)** for the same Canal.

The highest values of the OPI index were recorded during the cold months, while the lowest values were recorded during the hot months and the values were median during the remaining months. The reason for the increase in index values during low water temperatures may be related to the increase in nitrogen due to rainfall and the decrease in nutrient consumption by plankton and aquatic plants. This is consistent with the study of **Galo (2023)**, who studied the water and sediments of the Shatt al-Basrah Canal.

The results show that the monthly abundance for total species varied throughout the months of the year, as the highest total abundance of organisms was recorded during the spring months, especially the end of spring, while the lowest was recorded during the hot months, which proves that the presence of species of organisms is linked to changes in two environmental factors that are most influential, namely temperature and water salinity, as was the case for the decreased values of dissolved oxygen in water which has a significant effect on decreasing the abundance of species. This phenomenon was confirmed by **Al-Baghdadi *et al*. (2024)** in their study.

The presence of plants is linked to suitable environmental conditions, especially the temperature, water salinity, and DO, which play a role in the presence and abundance of invertebrates. They feed mainly on plants, lichens, and fungi, and they adapt to the plants that colonize the ecosystem. According to **Chevalier *et al*. (2001)**, the presence of plants associated with suitable environmental conditions, especially the two environmental factors mentioned above, have a role in the presence and abundance of invertebrates, which feed mainly on plants, lichens, and fungi and adapt to the plants that colonize the ecosystem **(Chevalier *et al.*, 2001; Guiller *et al.*, 2012)**.

The study showed a negative relationship between temperature and the abundance of all living organisms, which is consistent with the studies of **Al-Baghdadi *et al.* (2021, 2024)**. A negative relationship was also found between water salinity and the crustacean group, as the highest abundance was during the spring months coinciding with the lowest salinity value, and the results showed less abundance coinciding with the highest salinity value during the hot months. These results were confirmed by the study of **Al-Baghdadi *et al*. (2024)**, as they studied the OPI index and two types of snails to monitor the environmental changes occurring in the Shatt al-Arab waters, and recorded a positive relationship between dissolved oxygen and the abundance of worms, as the highest abundance of worms was with increasing DO values, and the least abundance of worms was with the lowest DO concentrations in the hot months.

A positive relationship was recorded between the OPI index and the abundance of Polycheta, as the highest values were recorded during January, while the values were low with the abundance during the hot months. This finding is consistent with the study of **Al-Kanani *et al*. (2023)**, when they studied the effect of organic pollution on a type of Polycheta in the Shatt al-Arab. On the other hand, a negative relationship was recorded between the abundance of Gastropoda and OPI, as the lowest abundance was recorded with the highest values of OPI. This was congruent with the study of **Al-Baghdadi *et al*. (2024)** regarding the importance of using snails as an indicator of organic pollution.

Bivalve abundance was associated with moderate temperatures and a high abundance of vegetation cover, while no clear relationship was observed with the Organic Pollution Index (OPI). Unlike other groups, Cirripedia showed a distinct association with salinity and pH levels, displaying a positive relationship with pH and a negative relationship with salinity.

Species composition in the current study

In the present study, approximately 25 species of benthic invertebrates were identified, belonging to Bivalvia (9 species), Crustacea (7 species), Gastropoda (6 species), polychaetes (2 species), and Cirripedia (1 species). This is similar to the findings of **Ali *et al.* (2017)**, who recorded 33 species in a previous study at the Shatt al-Basrah Canal.

Mudflate is an important biodiversity system, despite environmental changes, especially changes in temperature and salinity. The benthic fauna of the intertidal zone of the Khor Al-Zubair area seems to have been exposed to very harsh environmental conditions, where many species, especially molluscs, and polychaetes, could not survive and disappeared.

Although only a few species of microbes (low biodiversity) are found in intertidal mud swamps, they are well adapted to this habitat, having high density and wide distribution.

CONCLUSION

The values of OPI were higher than the maximum acceptable pollution limit of 1 during all months in the Shatt al-Basrah Canal, and the highest values were recorded during January, while the lowest values were during August.

The Bivalve group had the highest annual abundance rate, followed by the Crustacean, and the lowest annual abundance rate was for Cirripedia, The highest rate for all groups was found during May, and the lowest rate for all groups was recorded during August, which shows the important role of moderate temperatures in providing adequate food and their role in the abundance of invertebrate groups in the bank area.

There was a difference in the effect of environmental factors on invertebrate groups, and the effect of temperature, salinity, and dissolved oxygen on the distribution of invertebrate groups in the polluted environment.

The relationship of OPI differed with various invertebrate groups, and the relationship was positive with the bivalve group and Polycheta and negative with the Gastropoda. Therefore, it considered OPI as an indicator in the studied area since Cirripedia and crustaceans were shown. These aquatic organisms are tolerant of organic pollution.

Recommendations

The study aimed to identify key invertebrate groups that can indicate pollution in areas that severely threaten living organisms.

Local and governmental initiatives are urgently needed to clean up the area and prevent further pollution and environmental damage caused by the discharge of untreated sewage into the canal.

Author's contribution

All authors reviewed and checked the manuscript, and both authors approved the final version. Writing and general supervision by Dr. Nada, collection and analysis by Dr. Khaled, review and proofreading by Dr. Mayada

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