The effect of household pollutants on the nature of fish assemblages in some internal streams feeding from the Euphrates River, north of Basrah province

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Abstract

The current study was executed due to the lack of a study in the region that evaluated the effect of household pollutants on fish assemblages from January to December 2023 on the internal streams fed by the Euphrates River in Al-Sadiq District, north of Basrah Province. Some ecological parameters were measured: temperature, water salinity, hydrogen ion concentration, dissolved oxygen, biological oxygen demand, total nitrate, and phosphate. A total of 17 fish species Nine species were native, and eight were exotic species belonging to 15 genera, nine families, and five orders, all of them affiliated with the bony fish Osteichthyes class. The number of species varied from six species in December to 14 species in February. The number of individuals in the present study region was 1487, ranging from 50 individuals in December to 169 individuals in May. Four species recorded the highest values of numerical relative abundance in the present study region, which formed 78.01% of the overall number of species in the current work. The species *Orechromis aureus* the most abundant, accounting for 27.98% of the total number of species. *Planiliza abu* was the second most abundant species, accounting for 20.24% of the total catch, whereas *Carassus gibelio* harvested 15.47%. The species *Oreochromis niloticus* formed 14.32% of the overall catch. Diversity index values ranged from 1.43 in December to 2.13 in February. The richness index fluctuated between 1.28 in December and 2.63 in February, while the evenness index varied from 0.72 in June to 0.87 in October. The present study concluded that a moderate effect was noticed on total nitrate and phosphate in the region, and the fish assemblage contributes to recovered habitat for eutrophication by feeding on filamentous algae and aquatic plants.

Keywords: House effluent, fish assemblage, nutrients, north of Basrah

Introduction

Fish assemblages have an important role in aquatic ecosystems, they organize the function, and overall health of water environments (Kim and An, 2021). Fish populations significantly contribute to the total biodiversity of aquatic habitats and ecosystems (Prakash, 2021). Fish in aquatic environments work to cycle nutrients by feeding on dead organisms, detritus, and other organic matter to result in the production of nutrients in aquatic ecosystems through the decomposition of these materials (Petranich et al., 2018; Le Mezo et al., 2022). The fish population has a major role in maintaining the environmental balance. For example, herbivore fish that consume plants prevent the increase in the density of aquatic plants, while predatory fish limit the growth of the prey community (Liu et al., 2019). Fish play an important role in the aquatic food web as both predator and prey, and thus directly affect the dynamics of the ecosystem, and changes in fish populations can have negative repercussions on species via food webs (Reis et al., 2020; Traugott *et al*., 2021). Fish are characterized by being an important economic source of high, easily digestible protein that provides the food needs of human societies. Therefore, the management and maintenance of fish populations play a crucial role in the sustainability of this important resource (Gasco *et al*., 2020).

Small streams in freshwater habitats have been severely affected by human activities, especially after widespread communities and increased populations. Humans widely use water in several spaces for drinking, agriculture, industrial, hydroelectric, home uses, transport, and Aquaculture (Arthington *et al*., 2016; Chowdhary *et al*., 2020). The effect of exchange between terrestrial and aquatic habitats and the influxes of interaction between biotic and abiotic factors make the study of aquatic environments more complex (Gomes x et al., 2017). The modifies of ecological factors feature as a result of a change in land use by that increased turbidity due to the erosion process that takes place by activates of humans (Leitao et al., 2018).

Fish assemblage composition can be variable as are the son of shifting in the condition parameters, for instance, behavior, feeding, reproductive, migrations, and growth, there for fish work as an indicator for ecosystem suitability and measure of environmental stress on fish assemblage (Georgian *et al*., 2019). There is some theoretical and empirical evidence that verifies the role of the environment in the distribution and widespread of fish and other organisms in aquatic habitats e.g. hydrological characteristics, river topographic, type of substrate, plant vegetation, current and the amount of climate change (Radinge and García-Berthou, 2020).

The use of ecological indices to predict in nature of the relationship between fish assemblage composition and ecological condition, and evaluating the river status by analysis of fish assemblage structure, abundance with compared results with other fish communities have a good ecosystem (Akhi *et al*., 2020).

Household pollutants usually include chemicals from cleaners and pesticides, which cause a decline in water quality (Akhtar et al., 2021). The increased concentration of nitrogen and phosphorus in streams has caused the phenomenon of eutrophication, which depletes dissolved oxygen and suffocates and kills aquatic organisms (Diatta et al., 2020). Detergents cause poisoning of water and living organisms, including fish and invertebrates, which affect the food web. When humans eat these organisms, they may affect their health by changing environmental functions (Kenconojati and Azhar, 2020).

There are no studies dealing with the impact of household pollutants on fish assemblage composition in southern Iraq, but there are several studies focused on fish assemblage structure and the conditions factors that affect distribution, abundance, and widespread. Mohamed and Abood (2017) studied compositional change in fish assemblage structure in the Shatt Al-Arab River. Mohamed and Hameed (2019) investigate the impacts of saltwater intrusion on the fish assemblage in the middle part of Shatt Al-Arab River, Shatt Al-Arab River. Abdullah et al. (2023) studied the influence of some ecological factors on fish diversity and abundance in the Al-Huwyzah marsh south of Iraq.

The current study aims to assess fish assemblage composition with a highlight of some environmental parameters and evaluate anthropogenic activity represented by household pollutants on the nature of fish assemblage in some internal streams feeding from the Euphrates River, north of Basrah province.

Materials and methods

Description of study area

The present investigation studies the structure and abundance of fish communities in some internal streams feeding from the Euphrates River north of Basrah province. The current study area consists of a large network of internal streams confined between the Euphrates River's west bank groin and the central street in Al-Sadiq District, north of Basrah Governorate. Streams have varying widths and lengths between 3-6 meters and an area of 15 kilometers in length, with depths between one meter to three meters. The area is flooded all year because it is fed by massive electric pumps. The samples were obtained monthly from January to December 2020. For data collection, three stations were chosen: station 1 was at the near the bank of the Euphrates River (N 30°55' 48″, E 47° 17' 42″); station 2 at (N 30°55' 12″, E 47°18' 54″); station 3 at (N 30°54' 18″, E 47° 17' 42″) (Figure 1). Some ecological factors were measured at the same time as the sampling: water temperature (-10 to 100 °C) was measured with a mercury thermometer. Salinity and hydrogen ions were measured using a Lovibond-Sensor Direct 150, made in Germany. Dissolved oxygen (DO) and biological oxygen demand were measured according to Welch (1964). Total nitrate was estimated due to Parsons et al. (1984), and total phosphate was determined according to Murphy and Riley (1962). Fish samples were collected monthly from the three stations using fixed and draft gillnets, cast nets, and electro-fishing with an electric generator (400–500 volts, 10 amps). Fricke et al. (2022) and Froese and Pauly (2022) were used to classify the fish species. The ecological indices used to evaluate the fish assemblage in the present study region were monthly analyses of the relative abundance, according to Walag et al. (2016). Occurrence by Tyler (1971). Fish diversity was measured by Huang et al. (2019), and richness and evenness followed Nyitrai et al. (2012).

Fig. 1. Map of the study area

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Results

Ecological factors

Water temperature rates ranged from 14℃ in January to 34℃ in July, with the mean ± SD 24.25 ± 7.653, while the salinity varied from 1.91 in March to 3.76 PSU in September, with the mean ± SD 2.63±0.707. (Fig. 2). A very weak correlation (r = 0.071) was recorded between temperature and the number of species. A weak negative relationship (r = -0.14) was discovered between salinity and the number of species. The monthly variations in the means of water temperature and salinity showed no significant differences (P>0.05) among the present three stations.

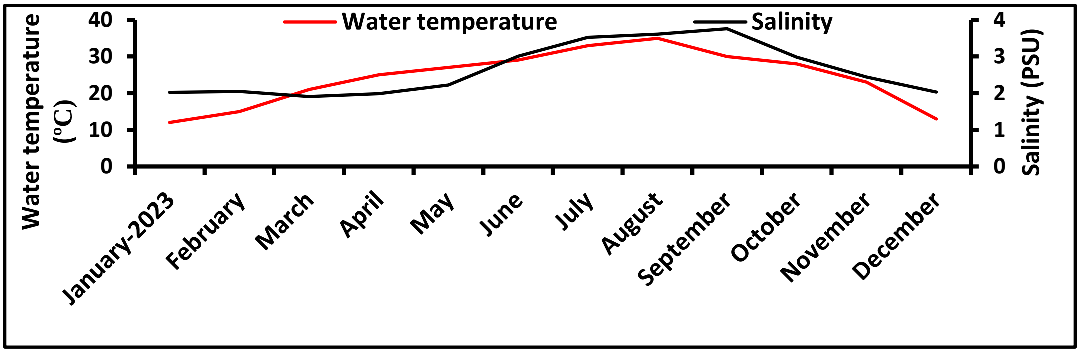

Fig. 2. Monthly variations in the ecological parameter in the study area from January to December 2023.

The hydrogen ion values ranged from 7.32 in July to 8.43 in January, with a mean ± SD of 7.92 ± 0.323. A negative correlation was recorded (r = -0.025) between hydrogen ions and the number of species. The dissolved oxygen values ranged from 5.61 mg/l in August to 9.34 mg/l in January, with a mean ± SD 7.69 ± 1.37. Biological oxygen demand (DOD5) varied from 0.52 mg/l in January to 4.21 mg/l in August, with a mean ± SD of 2.13 ± 1.29 (Fig. 3). In the monthly fluctuations of the means of hydrogen ion, dissolved oxygen, and biological oxygen demand, no significant differences were detected (P>0.05) among the present three stations.

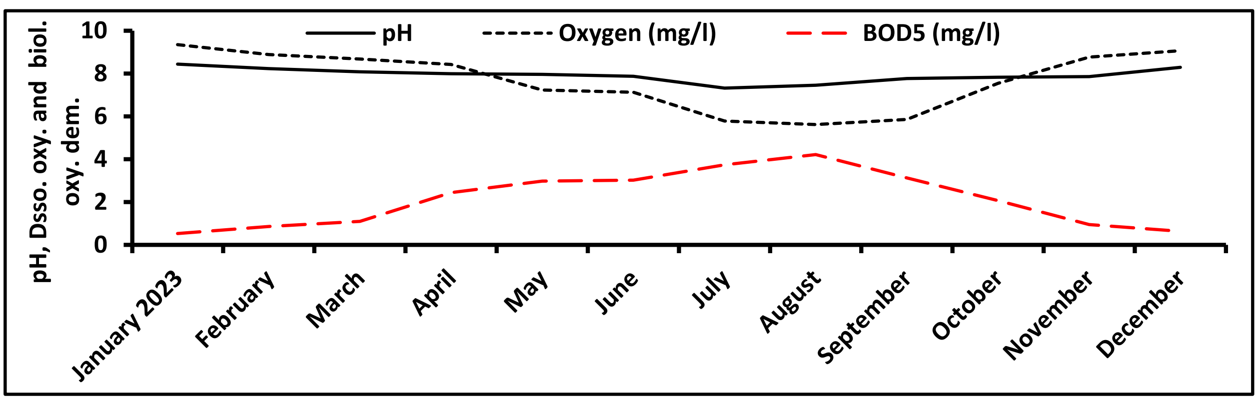

Fig. 3. Monthly variations in hydrogen ion, dissolved oxygen, and biological oxygen demand in the current study area from January to December 2023.

There is obvious variation in concentrations of total nutrients in the study area during the study periods (Fig. 3). The lowest value of total nitrate ranged from 0.54 mg/l in May to 3.58 mg/l in December (mean ± SD 1.43 ± 1.01), while the concentrations of total phosphate fluctuated from 0.34 mg/l in April to 0.99 mg/l in January (mean ± SD 0.73± 0.21). A negative relationship was found between total nitrate and the number of species (r = -0.384) in the study area. A negative correlation (r = 0.157) was detected between total phosphate and the number of species. The monthly fluctuations in the means of nitrate and phosphate concentrations in the present study region showed no significant differences (P > 0.05) among the present three stations (Fig. 4).

Fig. 4. Monthly variations in the concentrations of total nitrate and total phosphate in the present study area from January to December 2023.

Composition of fish assemblage

A total of 17 fish species were caught in the present study region; nine of these species were native, and eight were exotic species. All species belonged to 15 genera, nine families, and five orders, all of them affiliated with the bony fish Osteichthyes class. Cyprinidae, the most abundant family, included four species. The families Leuciscidae and Cichlidae consisted of three species each. Poeciliidae are formed of two species, whereas the families Heteropneustidae, Mastacembelidae, Siluridae, Xenocyprididae, and Mugilidae contain one species each (Table 1).

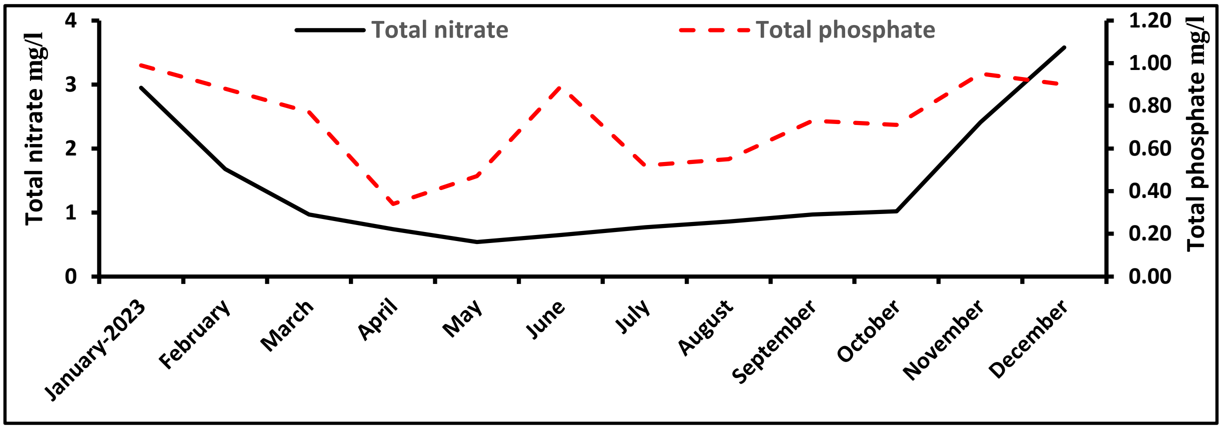

Table.1. Fish species, families, and orders in the present study area with refer to native and exotic fish species

Order	Family	species	Native	Exotic
Cypriniformes	Cyprinidae	*Carassiu gibelio*		+
		Carasobarbus luteus	+	
		Carasobarbus sublimus	+	
		Cyprinus carpio		+
	Leuciscidae	*Acanthobrama marmid*	+	
		Alburnus mossulensis	+	
		Leuciscus vorax	+	
	Xenocyprididae	*Hemiculter leucisculus*		+
Siluriformes	Siluridae	*Silurus triostegus*	+	
	Heteropneustidae	*Heteropneustes fossilis*		+
Synbranchiformes	Mastacembelidae	*Mastacembelus mastacembelus*	+	
Percifomes	Cichlidae	*Coptodon zillii*		+
		Oreochromis aureus		+
		Oreochromis niloticus		+
Mugiliformes	Mugilidae	*Planiliza abu*	+	
Cyprinodontiformes	Poeciliidae	*Gambuzia holbrooki*		+
		Aphanius dispar	+	

Number of species and individuals

The data shows evident changes in the number of species among the study months in the current study area. The number of species varied from six species in December to 14 species appearing in February, with the mean ± SD 10± 2.19. The number of individuals in the present study region 1487 individuals differed from 50 individuals in December to 169 individuals in May, with a mean ± SD of 123.92 ± 34.48 (Fig. 5.). The analysis of the data detected a significant positive correlation (r = 0.702*) between the number of species and individuals. The analysis of the data showed no significant differences (P>0.05) in the number of species and individuals among the three stations.

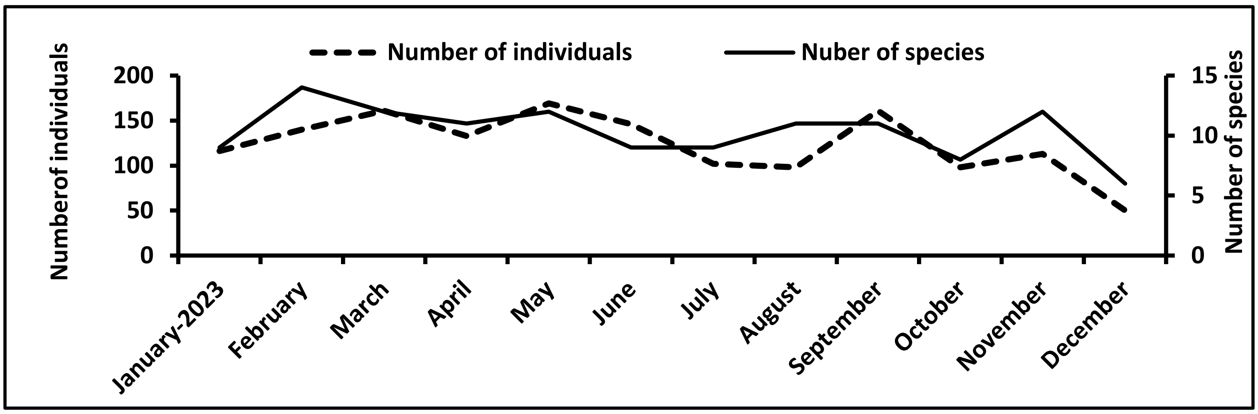

Fig. 5. Monthly changes in the number of species and individuals in the current study area from January to December 2023.

Relative abundance

Four species recorded the highest values of relative abundance in the present study region, forming 78.01% of the overall number of species in the current work. The species *O. aureus* is the most abundant, species for 27.98% of the total number of species. Species *P. abu* was the second most abundant species recorded, accounting for 20.24% of the total caught, whereas the fish *C. gibelio* harvested 15.47%. The species *O. niloticus* formed 14.32% of the overall catch (Table 2).

Table 2. Monthly changes in the relative abundance in the present study area from January to December 2023.

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
O. aureus	**20.69**	**22.14**	**19.88**	**15.04**	**37.87**	**36.30**	**12.75**	**19.39**	**38.51**	**33.67**	**37.17**	**46.00**	**27.98**
P. abu	**27.59**	**15.00**	**31.68**	**8.271**	**16.57**	**28.77**	**33.33**	**9.18**	**14.29**	**18.37**	**17.70**	**24.00**	**20.24**
C. gibelio	**27.59**	**20.71**	**4.35**	**36.09**	**7.69**	**17.81**	**18.63**	**31.63**	**4.35**	**12.24**		**12.00**	**15.47**

O. niloticus	12.07	17.14	18.63	12.03	14.79	6.85	7.84	11.22	23.60	15.31	19.47		14.32
C. zillii		3.57	6.83	9.02	8.28	5.48	20.59	17.35	6.83	9.18	8.85		7.94
C. luteus	1.72	3.57	4.35	6.77	3.55			1.02	2.48				2.29
C. carpio		2.14	3.73	3.76	3.55		1.96		1.24	3.06	1.77		1.95
S. triostegus		1.43	2.48	4.51	3.55	1.37	0.98	3.06			0.88		1.68
L. vorax	3.45	5.71	1.86			0.68		2.04			1.77	10.00	1.68
A. mossulensis	2.59	3.57			1.18				3.73	4.08		2.00	1.41
G. holbrooki	2.59		3.73	1.50					2.48		2.65		1.21
P. latipinna		1.43		2.26	0.59				1.86		4.42		0.94
H. leucisculus	1.72		1.24			0.68	2.94	2.04			0.88	6.00	0.94
C. sublimus		1.43	1.24			2.05			0.62		1.77		0.67
A. dispar		0.71			1.18		0.98			4.08			0.54
M. mastacembelus		1.43			1.18			1.02			2.65		0.54
H. fossilis				0.75				2.04					0.20

Ecological indices

The ecological indices fluctuated during the study months in the present study region. The diversity index values ranged from 1.43 in December to 2.13 in February, with a mean ± SD of 1.81± 0.18. The richness index fluctuated between 1.28 in December and 2.63 in February, with a mean ± SD of 1.94 ± 0.38, while the evenness index varied from 0.72 in June to 0.87 in October, with a mean ± SD of 0.78 ± 0.78 ± 0.04 (Fig. 6).

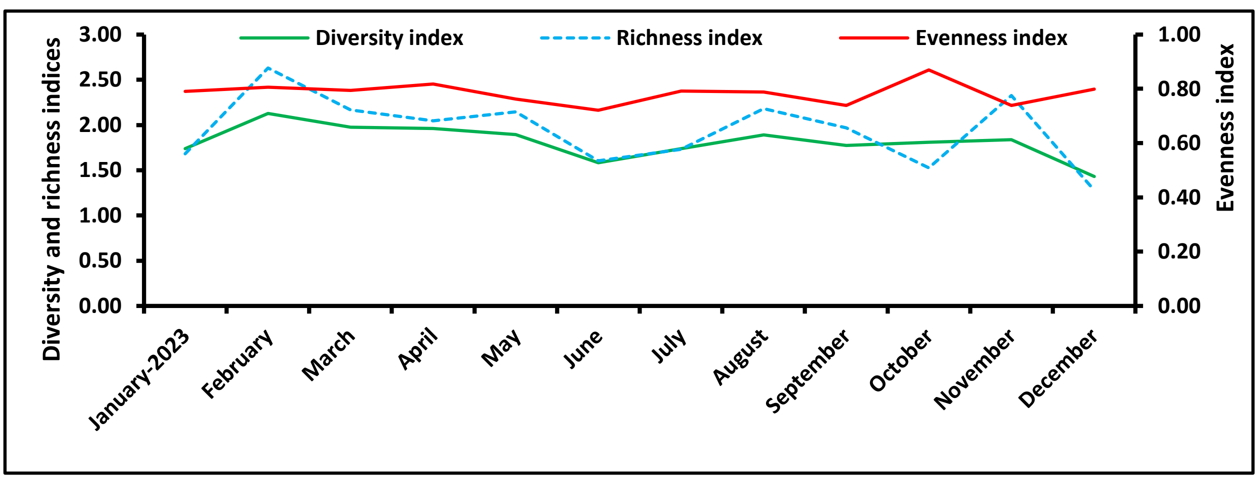

Fig. 6. Monthly variations in the ecological indices among the study months in the present study region.

Food items of some abundant species

The present study dealt with the five most abundant species of food items in the study area. To highlight the role of these species in stream habitats, the results show that five species consume large amounts of pants and algae, represented by *C. zillii*, which feeds 58.90% of macrophytes and 24.55% of algae. The species *O. niloticus* feeds on 49.63% of macrophytes and 25.75% of algae, whereas O. aureus feeds on 43.48% of macrophytes and 33.36% of algae and other species (Table 3).

Table. 3. Food elements of the five most abundant species in the internal streams feeding from the Euphrates River in the present study region.

Species	**Food elements**					
	Macrophytes	**Algae**	**Organic detritus**	**Diatoms**	**Water insects**	**Snails**
O. aureus	**43.48**	**33.36**	**18.13**	**5.03**		
P. abu	**11.46**	**40.12**	**39.45**	**8.97**		
C. gibelio	**37.29**	**28.09**	**14.32**	**6.65**	**7.20**	**6.45**
O. niloticus	**49.63**	**25.75**	**20..38**	**4.24**		
C. zillii	**58.90**	**24. 55**	**10.55**	**5. 61**		

Organic Pollutants

An increase in concentrations of nutrients (NO3, PO4) in the stream water was noticed.. The study detected a high ratio of organic materials (HCO3) which was 180 µg/l as well as sulphate concentration reached to 191 µg/l in the stream waters

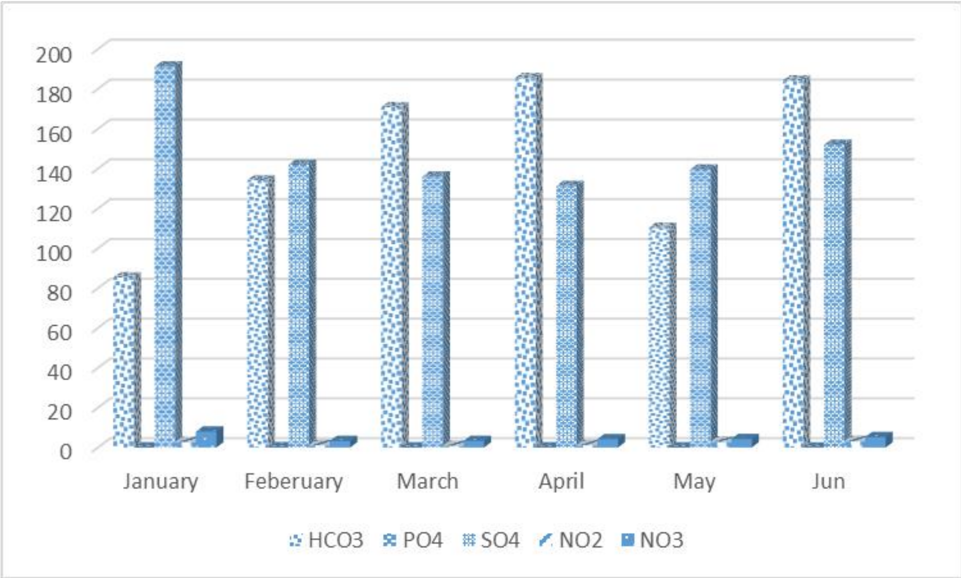

Fig. 7. Organic pollutants measurements (HCO3, PO4, SO4, NO2, and NO3) in internal streams feeding from the Euphrates River in Al-Sadiq District, north of Basrah Governorate.

Discussion

The temperature has a vital role in shaping the composition of the fish assemblages in rivers and streams (Vieira and Tejerina-Garro, 2020). Fish are ectothermic animals, and their body temperature varies with the temperature of the surrounding environment (Nakamura and Sato, 2020). Fish species differ in their preferences and thermal tolerance, and the presence or absence of certain species is strongly related to temperature (Payne et al., 2021). The results revealed that temperatures increased out of their limits in July and August generating some stress, which can weaken fish immunity systems and increase potential susceptibility to diseases Mugwanya et al. (2022). Temperature influences some biological functions; reproduction, spawning, level of oxygen, metabolic rates, patterns of migration, and changes in behavior (Servili et al., 2020; Durtsche et al., 2021).

Salinity is an important factor that can affect fish assemblage in aquatic ecosystems It has a significant impact on the distribution, abundance, and composition of fish assemblage (Asha et al., 2015). Salinity variations force freshwater species to leave upstream and reduction in salinity lead marine species downstream and have a significant impact on the distribution of invertebrate and vegetation that are used as food and refuge for fish, changing salinity may influence the nursery and spawning habitat of fish (Whitfield, 2017; Lauchlan and Nagelkerken, 2020). The salinity concentration in the present study area is within the range tolerance of freshwater.

Hydrogen ion (pH) is a critical parameter to measure water quality that strongly influences aquatic organisms, including fish communities (Rashid et al., 2018). The hydrogen ion in water in southern Iraq tends in the basic direction due to the presence of carbonates and bicarbonates in the soil. Our finding of hydrogen ion values corresponds with (Abdullah et al., 2019).

Detergents are materials used for washing and cause a decrease in the surface tension of water which negatively effects on dissolved oxygen in water, dissolved oxygen (DO) and biological demand (BOD) are important factors in evaluating water quality. There is a negative correlation between dissolved oxygen and biological demand, which is significantly affected by temperature and organic pollutants in the water. Our results refer to moderately polluted water (2–5 mg/l) and agree with (Alewi et al., 2021).

High concentrations of organic carbon pollutants HCO_4 were recorded in the current study (Fig. 7) which affected the livelihood of fish and biodiversity. Under the pressure of organic pollutants, ecosystems have become vulnerable to environmental degradation that has negatively affected river fish health, water quality, and biological integrity (Lee et al., 2023).

The concentration of total nitrate in the present study region varies significantly depending on some conditional factors, such as wastewater effluent from houses, agriculture runoff, organic matter decomposition, atmospheric deposition, and nitrogen fixation bacteria. The results indicate elevated nitrate concentrations in November, December, and January due to the above reasons; these consequences are computable and decreased in subsequent months due to the growth and bloom of algae plants (Israa and Neran, 2021; Maaroof et al., 2023). Total phosphate concentrations vary due to a variety of factors, including the influence of household cleaning flows, organic matter decomposition, agricultural runoff, rainfall, and biological activity. The current findings show that phosphate concentrations are elevated from November to February, with a decrease in subsequent months due to the abundance of phytoplankton, algal, and aquatic plants that consume phosphate. These results agree with (Al-Saeedi and Al-Salman, 2022).

Studying fish assemblages coexisting in specific habitats has highlighted important knowledge of aquatic ecosystems' health, ecological balance, biodiversity, and the interactions between fish and the ambient environment (Kim and An, 2021). Several studies have been executed on the Euphrates River north of Basrah province. Al-Noor et al. (2009) caught 21 fish species belonging to 12 families; seven of them were marine, while the present study collected 17 species. These differences between the two studies were due to the absence of marine species in the current study due to the fact that the present region represented an internal region, temporal and spatial variations, and the variation in fishing tools (Ngor et al., 2018). Hussein et al., (2015) found 24 fish species affiliated to nine families from the Euphrates River between Al-Chybiysh and Mudena, these variations may be explained by differences like study region, spatial and temporal changes, fishing tools, and absence of marine species. Abdullah (2017) recorded 23 species affiliated to 23 genera and 11 families from the lower section of the Euphrates River. Disagreement with the current study due to the occurrence of marine species and the differences like the two study areas. The present study's results differed from those of Abdullah et al. (2022) in the number of species caught in the Euphrates River between Mudina and Qurna cities due to the absence of marine species, temporal and spatial differences, varying fishing methods, and differences in the nature study area. The fish assemblage in the present study area comprises half introduced fish and the other half native fish that have adapted to their environment since ancient times. Notably, absence-sensitive local fish like *Luciobarbus xanthopterus*, *Mesopotamichthys sharpeyi*, *Arabibarbus grypus*, and *Luciobarbus kersin*, which are not even found in the Euphrates River from which they get their water feeding (Abdullah, 2017; Abdullah et al., 2022).

The present consequences show the most abundant species similar to other aquatic habitats in the south of Iraq due to the prevailing of *O. aureus*, *P. abu*, and *C. gibelio*. These results are consistent with all recent studies conducted on the southern end of the Euphrates River (Hussein et al., 2015; Abdullah, 2017; Abdullah et al., 2022). Most of these species are characterized as highly tolerant species, possess high fecundity, their individuals are reproductive at a small age or size, and their food is available, which is represented by plants, algae, and organic detritus (Alwan and Mohamed, 2019; Abdullah et al., 2021).

Ecological indices are essential tools for evaluating the aquatic ecosystems of fish by giving digital estimating that can provide information to researchers, ecosystems dynamic, scientific, and understanding of resource management and conservation (Holsman *et al*., 2017). The ecological indices of the current study are within the range of all previous studies conducted on the southern end of the Euphrates River, the values of diversity indices refer to poor status, while rinses indices indicate to half an integrated, and evenness index values pointed as semi-balanced (Jorgensen et al., 2005) (Table 4).

Table 4. Comparisons values of the ecological indices in the present study with the previous studies conducted on the lower parts of the Euphrates River

The study	Diversity index	Richness index	Evenness index
Al-Noor *et al*. (2009)	**1.65**	**--**	**0.53**

Hussein *et al*. (2015)	**1.51-1.69**	**1.26-1.70**	**0.67-0.85**
Abdullah (2017)	**1.11-1.92**	**1.15- 2.33**	**0.53-0.90**
Abdullah *et al*. (2022)	**1.43-3.20**	**1.48-3.57**	**0.37-0.75**
Present study	**1.43-2.13**	**1.48-2.63**	**0.72-0.87**

The present results indicate that these species feed on a high percentage of filamentous algae, macrophytes (aquatic plants), and organic detritus. These results are consistent with (Salih et al., 2019; Mohamed and Al-Wan, 2020). The availability of sunlight in the study area throughout the year supports the growth of aquatic plants and algae, making food available for fish Shihab et al. (2023), there four the study area has been characterized by an intense growth of floating filamentous algae and aquatic plants, especially the species (*Ceratophyllum echinatum*), in the hot months. After the introduction of exotic species such as *O. aureus*, *O niloticus*, *C. zillii*, and *C. gibelio*, it has become highly abundant, the water has become clear, and this phenomenon has disappeared due to the fish feeding on filamentous algae and macrophytes, in addition to preventing oxygen depletion and fish suffocation (Gowri et al., 2021).

Conclusions

The present study concluded that the discharge of household cleaning products and organic materials into rivers results in moderate nutrient concentrations. These concentrations cause eutrophication in the hot and humid months, but there are abundant fish populations feeding on aquatic plants and filamentous algae, such as tilapia fish and some cyprinid species, which protect the environment by restoring ecological balance and preventing oxygen depletion and fish suffocation.

References

Abdullah A. H. J. (2017). Diversity, abundance and community structure of fishes in the lower part of the Euphrates River Southern Iraq, Mesopot. J. Mar. Sci., 2017, 32(2): 64 – 77.

Abdullah, A. H. J., Abdullah, S. A., & Yaseen, A. T. (2021). A Composition and abundance of alien fish species in inland waters, southern Iraq. Iraqi Journal of Science, 373-386.

Abdullah, S. A., Abdullah, A. H. J., & Ankush, M. A. (2019). Assessment of water quality in the Euphertes River, Southern Iraq. The Iraqi Journal of Agricultural Science, 50(1), 312-319.

Abdullah, S. A., Abdullah, A. H. J., & Ouda, Y. W. (2022). Fish diversity of the Euphrates River between Medina and Qurna cities, southern Iraq. International Journal of Aquatic Biology, 10(5), 429-437.

Akhi, M. M., Jewel, M. A. S., Haque, M. A., Sarker, B. K., Khatun, M. S., Paul, A. K., ... & Das, S. K. (2020). Multivariate approaches to determine the relationship between fish assemblage structure and environmental variables in Karatoya River, Bangladesh. Community Ecology, 21, 171-181.

Akhtar, N., Syakir Ishak, M. I., Bhawani, S. A., & Umar, K. (2021). Various natural and anthropogenic factors responsible for water quality degradation: A review. Water, 13(19), 2660.

Alewi, H., Obeed, W., Abdulridha, M., & Ali, G. (2021). An inquiry into the relationship between water quality parameters: Biochemical oxygen demand (BOD5) and chemical oxygen demand (COD) in Iraqi Southern region. In AIP Conference Proceedings (Vol. 2404, No. 1). AIP Publishing.

Al-Noor, S.S., Mohamed, A.R.M. and Faris, R.A.K. 2009. Structure of the fishery of the lower Euphrates River, Qurna, Iraq. Iraqi J. Agric., 14(8): 157-169 (Special Issue) (In Arabic).

Al-Saeedi, H. M. S., & Al-Salman, I. M. (2022). Seasonal variations in the phytoplankton community in a lentic ecosystem and its relationship to environmental variables (An applied study in the artificial lake of the island of Baghdad, Iraq). Texas Journal of Agriculture and Biological Sciences, 8, 13-35.

Alwan, S. M., & Mohamed, A. R. M. (2019). Analysis of the biological features of the blue tilapia, Oreochromis aureus in the Garmat Ali River, Basrah, Iraq. Asian Journal of Applied Sciences, 7(6).

Arthington, A. H., Dulvy, N. K., Gladstone, W., & Winfield, I. J. (2016). Fish conservation in freshwater and marine realms: status, threats and management. Aquatic Conservation: Marine

Asha, C. V., Cleetus, R. I., Suson, P. S., & Nandan, S. B. (2015). Environmental factors structuring the fish assemblage distribution and production potential in Vembanad estuarine system, India. International Journal of Marine Science, 5. and Freshwater Ecosystems, 26(5), 838-857.

Chowdhary, P., Bharagava, R. N., Mishra, S., & Khan, N. (2020). Role of industries in water scarcity and its adverse effects on environment and human health. Environmental Concerns and Sustainable Development: Volume 1: Air, Water and Energy Resources, 235-256.

Diatta, J., Waraczewska, Z., Grzebisz, W., Niewiadomska, A., & Tatuśko-Krygier, N. (2020). Eutrophication induction via N/P and P/N ratios under controlled conditions effects of temperature and water sources. Water, Air, & Soil Pollution, 231, 1-18.

Durtsche, R. D., Jonsson, B., & Greenberg, L. A. (2021). Thermal conditions during embryogenesis influence metabolic rates of juvenile brown trout Salmo trutta. Ecosphere, 12(2), e03374.

Gasco, L., Acuti, G., Bani, P., Dalle Zotte, A., Danieli, P. P., De Angelis, A., ... & Roncarati, A. (2020). Insect and fish by-products as sustainable alternatives to conventional animal proteins in animal nutrition. Italian Journal of Animal Science, 19(1), 360-372.

Georgian, S. E., Anderson, O. F., & Rowden, A. A. (2019). Ensemble habitat suitability modeling of vulnerable marine ecosystem indicator taxa to inform deep-sea fisheries management in the South Pacific Ocean. Fisheries research, 211, 256-274.

Gomes, M. P., Garcia, Q. S., Barreto, L. C., Pimenta, L. P. S., Matheus, M. T., & Figueredo, C. C. (2017). Allelopathy: An overview from micro-to macroscopic organisms, from cells to environments, and the perspectives in a climate-changing world. Biologia, 72(2), 113-129.

Gowri, G., Chalapathi, K., & Shiva Prasad, G. (2021). Summer Kills In Fish Ponds and Its Prevention Measures. Science for Agriculture and Allied Sector A Monthly e News Letter, 3(6), 31-37.

Holsman, K., Samhouri, J., Cook, G., Hazen, E., Olsen, E., Dillard, M., ... and Andrews, K. (2017). An ecosystem-based approach to marine risk assessment. Ecosystem Health and Sustainability, 3(1), e01256.

Hussein S.A., Abdulla A.A.M., Abdullah S.A., (2015). Ecology and fish Structure in the Southern sector ofthe Euphrates River, Iraq. Basrah Journal of Agricultural Sciences, 28(1): 82-94.

Israa Ibrahim, L. A. Z. I. M., & Neran Adnan, A. L. (2021). Measuring pollution based on total petroleum hydrocarbons and total organic carbon in Tigris River, Maysan Province, Southern Iraq. Caspian Journal of Environmental Sciences, 19(3), 535-545.

Jorgensen, S.E, Xu, E.F.L., Salas, F. and Marques, J.C. 2005. Application of indicators for the assessment of ecosystem health, pp: 5-65. In Jorgensen, S. E. Costanza, R. and F. L. Xu (Eds.). Handbook of ecological indicators for assessment of ecosystem health. CRC Press, 2000 N.W. Corporate Blvd., Boca Raton, Florida, 577 pp.

Kenconojati, H., & Azhar, M. H. (2020). The harmful effect of commercial powder detergent on water flea (Daphnia sp.). In IOP Conference Series: Earth and Environmental Science (Vol. 441, No. 1, p. 012081). IOP Publishing.

Kim, J. Y., Atique, U., & An, K. G. (2021). Relative abundance and invasion dynamics of alien fish species linked to chemical conditions, ecosystem health, native fish assemblage, and stream order. Water, 13(2), 158.

Lauchlan, S. S., & Nagelkerken, I. (2020). Species range shifts along multistressor mosaics in estuarine environments under future climate. Fish and Fisheries, 21(1), 32-46.

Lee, S.-J.; Mamun, M.; Atique, U.; An, K.-G. Fish Tissue Contamination with Organic Pollutants and Heavy Metals: Link between Land Use and Ecological Health. *Water* **2023**, *15*, 1845. https://doi.org/10.3390/w15101845

Le Mezo, P., Guiet, J., Scherrer, K., Bianchi, D., & Galbraith, E. (2022). Global nutrient cycling by commercially targeted marine fish. Biogeosciences, 19(10), 2537-2555.

Leitão, R. P., Zuanon, J., Mouillot, D., Leal, C. G., Hughes, R. M., Kaufmann, P. R., ... & Gardner, T. A. (2018). Disentangling the pathways of land use impacts on the functional structure of fish assemblages in Amazon streams. Ecography, 41(1), 219-232.

Liu, X., Qin, J., Xu, Y., Zhou, M., Wu, X., & Ouyang, S. (2019). Biodiversity pattern of fish assemblages in Poyang Lake Basin: Threat and conservation. Ecology and Evolution, 9(20), 11672-11683.

Maaroof, B. F., Omran, M. H., Al-Qaim, F. F., Salman, J. M., Hussain, B. N., Abdellatif, M., ... & Hussein, W. A. (2023). Environmental assessment of Al-Hillah River pollution at Babil Governorate (Iraq). Journal of the Geographical Institute" Jovan Cvijic", SASA, 73(1), 1-16.

Mohamed, A. M., & Al-wan, S. M. (2020). Biological aspects of an invasive species of Oreochromis niloticus in the Garmat Ali River, Basrah, Iraq 13, 15–26. IOSR Journal of Agriculture and Veterinary Science, https://doi. org/10.9790/2380-1302011526.

Mugwanya, M., Dawood, M. A., Kimera, F., & Sewilam, H. (2022). Anthropogenic temperature fluctuations and their effect on aquaculture: A comprehensive review. Aquaculture and Fisheries, 7(3), 223-243.

Murphy, J. and Riely, J. P. (1962). A modified single solution method for the determination of phosphate in natural water. Anal. Chem. Acta., 27:31-36.

Nakamura, I., Matsumoto, R., & Sato, K. (2020). Body temperature stability in the whale shark, the world's largest fish. Journal of Experimental Biology, 223(11), jeb210286.

Ngor, P. B., Grenouillet, G., Phem, S., So, N., & Lek, S. (2018). Spatial and temporal variation in fish community structure and diversity in the largest tropical flood-pulse system of South-East Asia. Ecology of Freshwater Fish, 27(4), 1087-1100.

Parsons, T. R.; Maita, Y. and Lalli, C. M. (1984). A manual of chemical and biological methods for seawater analysis Pergamum press Oxford, 60 p.

Payne, N. L., Morley, S. A., Halsey, L. G., Smith, J. A., Stuart-Smith, R., Waldock, C., & Bates, A. E. (2021). Fish heating tolerance scales similarly across individual physiology and populations. Communications Biology, 4(1), 264.

Petranich, E., Covelli, S., Acquavita, A., De Vittor, C., Faganeli, J., & Contin, M. (2018). Benthic nutrient cycling at the sediment-water interface in a lagoon fish farming system (northern Adriatic Sea, Italy). Science of the total environment, 644, 137-149.

Prakash, S. (2021). Impact of Climate change on Aquatic Ecosystem and its Biodiversity: An overview. International Journal of Biological Innovations, 3(2): 312-317.

Radinger, J., & García-Berthou, E. (2020). The role of connectivity in the interplay between climate change and the spread of alien fish in a large Mediterranean river. Global Change Biology, 26(11), 6383-6398.

Rashid, Z. A., Amal, M. N. A., & Shohaimi, S. (2018). Water quality influences on fish occurrences in Sungai Pahang, Maran District, Pahang, Malaysia. Sains Malaysiana, 47(9), 1941-1951.

Reis, A. D. S., Albrecht, M. P., & Bunn, S. E. (2020). Food web pathways for fish communities in small tropical streams. Freshwater Biology, 65(5), 893-907. river. Global Change Biology, 26(11), 6383-6398.

Salih, O. A., Al-Dubakel, A. Y., & Abed, J. M. (2019). A Comparative Study of Feeding of Three Fish Species in the Southern Part of Al-Chibayish Marsh, Iraq. Basrah Journal of Agricultural Sciences, 32, 140-152.

Servili, A., Canario, A. V., Mouchel, O., & Muñoz-Cueto, J. A. (2020). Climate change impacts on fish reproduction are mediated at multiple levels of the brain-pituitary-gonad axis. General and Comparative Endocrinology, 291, 113439.

Shihab, H. F., Mohammed, A. A. H., & Kannah, A. M. (2023). Environmental Factor and their Impact on the Abundance of Aquatic Plants in Iraq. Journal for Research in Applied Sciences and Biotechnology, 2(4), 58-65.

Traugott, M., Thalinger, B., Wallinger, C., & Sint, D. (2021). Fish as predators and prey: DNA-based assessment of their role in food webs. Journal of Fish Biology, 98(2), 367-382.

Vieira, T. B., & Tejerina-Garro, F. L. (2020). Relationships between environmental conditions and fish assemblages in tropical savanna headwater streams. Scientific Reports, 10(1), 2174.

Wel ch, P. S. (1964). Limnology. 2nd . ed Mc Graw. Hill Book Co., New York. pp:538.

Whitfield, A. K. (2017). The role of seagrass meadows, mangrove forests, salt marshes and reed beds as nursery areas and food sources for fishes in estuaries. Reviews in Fish Biology and Fisheries, 27(1), 75-110.