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The Impact of the Al-Madinah Dam on the Environment and Fish Diversity in the Southern Part of the Euphrates River, Iraq

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ABSTRACT
The current study was implemented due to the environmental problems in the region it suffers from, including environmental degradation, poor water quality, the spread of tolerant exotic fish species, and the absence of native species that represent the core of the historical fish population. The importance of this study stems from its attempt to diagnose current problems and overcome them as much as possible. The present study aims to evaluate the environmental situation, analyze fish assemblage composition, which provides some insight on study area conditions, and identify its causes. The data collected in the period from January to December 2024 were used to examine the impact of the Al-Madinah dam on the south of the Euphrates River ecosystem and the influences on spatial-temporal changes on fish assemblage, abundance, diversity, and distribution. The study was designed to study 22 fish species of 19 genera and 10 families. The diversity of species includes 11 natives, 8 exotics, and 3 marines. The study area needs more scientific research to enhance the diagnosis of the conditions that caused its deterioration and to attempt to treat them. The current study concluded that the construction of the dam in the southern part of the Euphrates River, south of Iraq, creates a fragmentation of the environment that led to the deterioration of the ecosystem and a change in the flow regime. This negatively impacted fish populations, resulting in the dominance of exotic fish species, some small native species, and non-economically important local species.

INTRODUCTION

The water is lifeblood for human civilization; it is necessary for drinking, agriculture, biodiversity, industry, and transportation, and is important for cultural and touristic aspects **(Hosseiny *et al.*, 2021)**. The Euphrates River is one of the most important rivers in Southwest Asia. The southern parts of the Euphrates currently suffer from water scarcity, since they receive water from the Tigris River at the confluence of the two rivers near Qurna. This is due to the construction of numerous dams on the river's headwaters in Turkiye and Syria **(Yaseen *et al.*, 2021)**. Most of the world's major rivers are experiencing environment fragmentation, with nearly half affected by dam construction as countries continue to build hydroelectric power infrastructure to meet growing energy demand **(Barbarossa *et al*., 2020)**. Moreover, after climate change and a significant reduction in water discharge of the Tigris and Euphrates Rivers, the building of dams and water control has become a common strategy for managing water resources, including drinking water, agricultural use, flood control, and civil use **(Stakhiv, 1998)**. Water flow regulation in the southern part of the Euphrates River is fundamental to the development of the infrastructure; therefore, the construction of a dam to raise the water level in the Al-Jabaish marsh is necessary to support the abundance, biodiversity, and richness of biota in this wetland **(Prakash, 2021)**. Habitat separation is a major obstacle to fish populations, especially in flowing river environments, because it restricts the migration routes of fish that share several similar behaviors, such as spawning, feeding, and wintering migrations. **(Moniruzzaman *et al*., 2021)**. Dam constructions represented the most important change occurring due to anthropogenic activities in the freshwater ecosystems, creating a fundamental shift in biological, chemical, and physical processes, which poses real problems in the life of organisms and their biodiversity **(Alla & Liu, 2021)**. Major rivers, which have historically supported diverse fish populations, have been particularly affected by the proliferation of dam structures, with dire consequences for the integrity and biodiversity of river ecosystems **(Chen *et al*., 2023)**. These barriers prevent the natural continuity of river systems, altering flow regimes from lotic to lentic systems, sediment transport, and connectivity between habitats, collectively reshaping the composition and function of fish communities **(Thieme *et al*., 2023)**. The dam area is critical, as it supports and organizes the diversity and abundance of aquatic life, including fisheries, which represented a cornerstone in the present study area **(Baird & Hogan, 2023)**. Dam construction prevents fish from moving to reproductive grounds and then reduces the flow of genes among organisms, increasing opportunities to be exposed to environmental stressors **(Zarri *et al*., 2022)**. Simplifying river habitats and adapting to environmental changes, such as the shift toward diverse and uniform habitats and the adaptation of specialized fish species, makes environments more stable **(Stuart-Smith *et al*., 2021)**. However, the consequences are harmful, especially for fish species that need diverse habitats in different life stages; this environmental splitting significantly contributed to the reduction of species migration and prevents species from spawning in their traditional ground areas (**Arthington *et al*., 2016; Tamario *et al*., 2019**). Dams alter the regime of natural flow that fish assemblages have used for a long time, and evolutionary adapted and steady flows downstream of dams alter the breeding environment by removing the natural environmental pulse that encourages fish to spawn **(Chen *et al*., 2023)**. Temperature change has a significant impact on fish reproduction; therefore, releasing water from deep dam reservoirs often results in cooler water than in the natural river environment, leading to a change in the natural thermal pulse for reproduction and growth **(Salaah *et al*., 2018; Salaah, 2021)**. Dams trap sediments and prevent their transport, which leads to changing the course of the river and shifting the nature of the bottom, which is important for the livelihood and reproduction of fish **(Shi**

& Qin 2023). Habitat fragmentation and change of hydrology are unsuitable for native fish species that need some kind of flow excitement (lotic), but more suitable for exotic fish species (nonnative species) that prefer stable (lentic) conditions **(Rahel & McLaughlin, 2018)**. **Cantonati *et al*. (2020**) point out that the creation of dams and reservoirs naturally shifts the physical composition of the stream environments, altering the diversity of habitats of the river to uniform environments with the same water depth and changing the composition of substrate, and thermal stratification in the reservoirs led to conditions of hypoxia in the deep regions. Construction of dams shifts biodiversity patterns, declines species richness, and causes homogenization of biotic communities via increased similarity and loss of endemic species **(Li *et al*., 2024)**.

No studies have been conducted on the influences of damming on fish assemblages in the riverine ecosystems in Iraq, except one belonging to **Laith *et al.* (2016)** in Himreen Dam Lake, Iraq, but several studies deal with fish assemblage composition. **Abdullah (2017)** studied diversity, abundance, and community structure of fish in the lower part of the Euphrates River in Southern Iraq. **Mohamed and Hameed (2019)** studied the influence of saltwater intrusion on the fish assemblage in the middle part of the Shatt al-Arab River, and **Abdullah *et al*. (2023)** studied the impact of some ecological parameters on fish diversity and abundance in the Al-Huwyzah marsh in southern Iraq.

The current study aims to assess the environmental situation, understand the state of the fish population (which reflects the prevailing environmental conditions), diagnose the reasons, and suggest possible solutions.

MATERIALS AND METHODS

Sampling Area and Locations

Description of the Study Area

The current study was conducted on the Euphrates River, northwest of Basrah Governorate, within the area between Al-Jabaish District and Al-Madinah District, south of Iraq. A dam was constructed on the Euphrates River near the Al-Madinah District, with a width of 350m for the river section, aiming to raise the water levels on the northern side of the river to flow into Al-Jabaish Marsh. Three stations were selected for the study; the first station is located opposite the Al-Jabaish District at N 30° 58′ 12″, E 47° 00′ 36″, and the second station is located to the south of the first station at a distance of 10 kilometers at N 30° 57′ 36″, E 47° 06′ 36″. The third station is located to the south of the dam built on the river at a distance of 4 kilometers at N 30° 56′ 24″, E 47° 15′ 01″ (Fig. 1). Surface water (6 liters) samples were collected monthly from the study stations at a rate of one sample per month from the middle of the river's main stream at a depth of 20cm from the water surface, with three replicates for each site.

Physico-Chemical Parameters

Some environmental factors were measured in the field, such as water temperature, using a simple mercury thermometer. Hydrogen ion (pH) was measured using a

Lovibond–Senso Direct 150 device, made in Germany. and salinity was measured using the YSI 556 MPS equipment with model 2005. Dissolved oxygen (DO) was measured by the **Welch (1964)** method. A Saki disc was used to measure transparency, which was measured using a Hanna HI-93703 device.

Fish Sampling

Fish samples were collected monthly from the study area. Various fishing methods were used: electrofishing, seine nets (40 to 30m length, 3 to 5m height), cast nets, drift, and fixed gillnets (30 to 40m, mesh size 15 to 57mm). Fish samples were stored in a cork container containing crushed ice until returned to the laboratory. Fish were classified according to **Fricke *et al*. (2025)** and **Froese and Pauly (2025)**.

Fish Assemblage Analysis

Fish diversity was calculated according to **Shanon and Weaver (1949)**, as follows: H = -∑ pi ln pi, Where H= diversity index and Pi = the proportion of individuals in the (i) species. Fish species richness was calculated according to **Margalef (1968)** as follows: D= S-1/ lnN, where D= richness index N= number of all individuals in samples. The evenness, as in **Pielou (1977)**, is defined as in the equation J= H/lns where J= evenness index, H= diversity index, and S= number of species. The numerical relative abundance follows **Odum (1970)** % = (ni / N) 100, where ni = number of individuals of the species in the sample and N= Total number of individuals of all collected species. Dominance (D3) according to **Kwak and Peterson (2007)**.

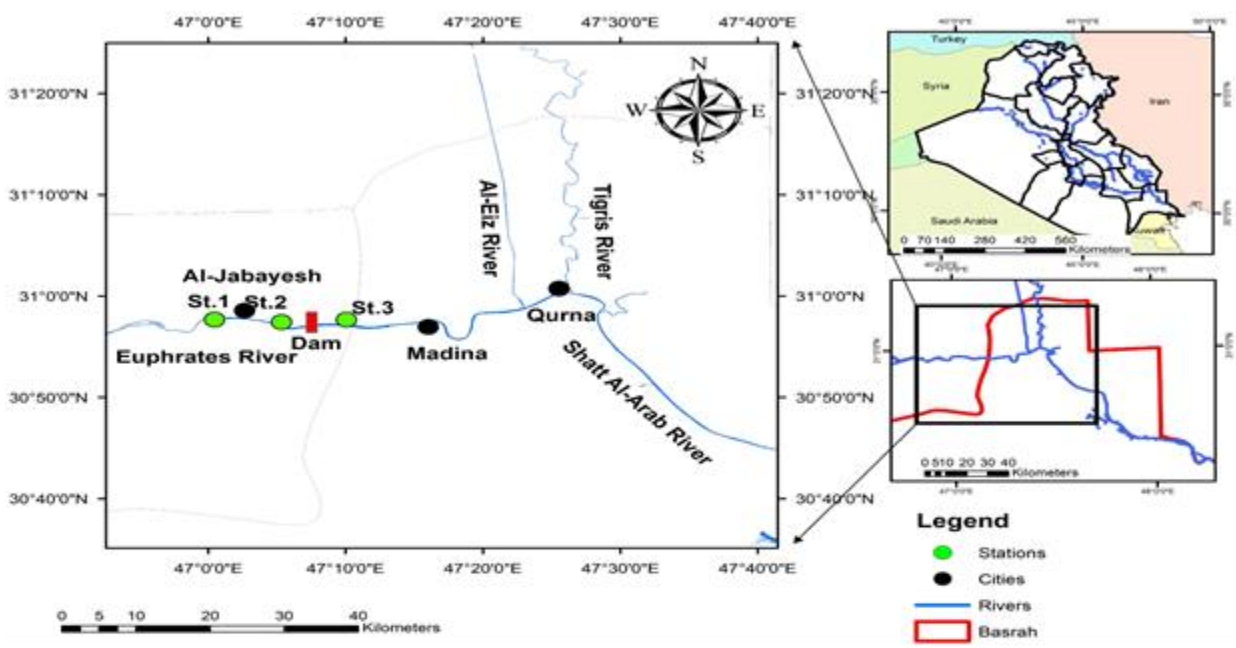

Fig. 1. The Study Area Map Illustrated the Dam Region and the Stations

Statistical Analysis

The Statistical Package for Social Science (SPSS version 20) was utilized to evaluate the variance ANOVA among the three stations' fish populations among the three stations and the number of species and individuals (*P*≤0.05). It was used to find the correlations between environmental factors and the relationships among the number of species and individuals and ecological factors. Microsoft Excel version 2016 was used to draw diagrams. Analysis program canonical correspondence analysis (CCA) in PAST 4.11 Software was utilized to analyze the data.

RESULTS

Physio-Chemical Parameters

Monthly variations in the rate of water temperature, salinity, and hydrogen ion (pH) of the study area in the southern part of the Euphrates River between the districts of Al-Jabaish and Al-Madinah are shown in Fig. (2). Water temperature ranged from 14.06°C in December to 34.54°C in July; The mean and SD values were 25.97 ± 7.17. A weak correlation (r= 0.097) was detected between water temperature and the number of species. Salinity fluctuated from 1.95 to 3.21 psu in October, with a mean of 2.59 ± 0.47. A negative weak relationship (- r = 0.492) was found between salinity and the number of species. The Ph varied from 7.31 in July to 8.18 in February, with a mean of 7.79±0.27. No significant differences in water temperature, salinity, and hydrogen ion in analysis of variance (ANOVA) (*P*> 0.05) were found among the three stations in the study area (Fig. 2).

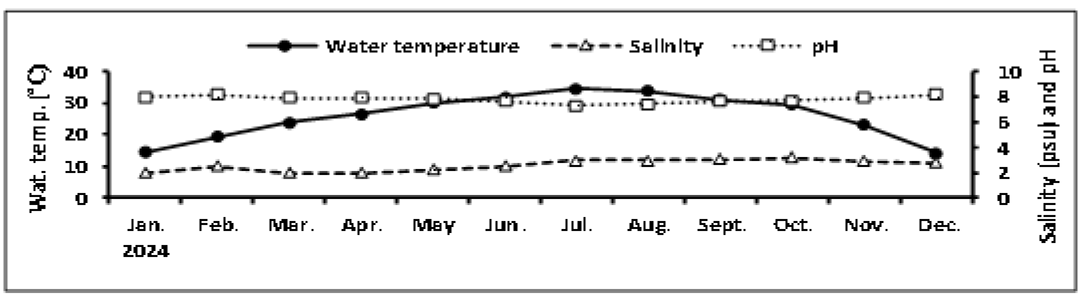

Fig. 2. Monthly Variations in Water Temperature, Salinity, and pH in the Southern Part of the Euphrates River from January to December 2024

Monthly fluctuation in the rates of concentrations of DO ranged from 6.00mg/ L in August to 9.03mg/ L, with a mean of 7.91 ± 1.15. While the rates of transparency differ from 88cm in November to 111cm in May, the mean was 100.17 ± 6.67. There are insignificant differences in ANOVA (*P*>0.05) among the three stations in the dissolved oxygen and transparency (Fig. 3).

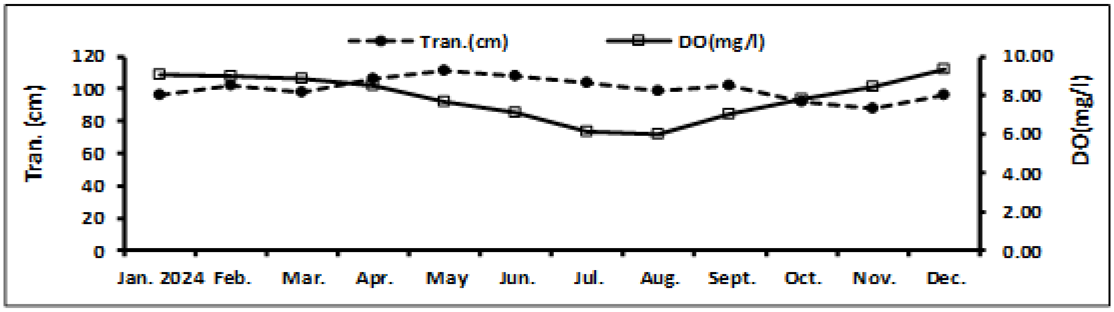

Fig. 3. Monthly Variations in Dissolved Oxygen (DO) mg/L and Transparency in the Southern Part of the Euphrates River from January to December 2024

A total of 22 fish species affiliated with 19 genera and 10 families were captured from the study area after and before the dam in the south part of the Euphrates River, including 11 native, eight exotics, and three marine. The family Cyprinidae was the most abundant family, represented by seven fish species: *Carasobarbus luteus*, *Carasobarbus sublimus*, *Carassius gibelio*, *Cyprinus carpio*, *Garra rufa*, *Cyprinion kais, Mesopotamichthys sharpeyi*. Both families, Cichlidae and Leuciscidae have three species each: *Captodon zilli*, *Orechomis aureus*, and *Orechromis niloticus*; *Alburnus mossulensis*, *Leuciscus vorax*, and *Acanthobrama marmid* respectively. Mugilidae has two species *Planiliza abu*, and *Planiliza subviridis*. The family Poeciliidae is represented by two species *Gambusia holbrooki*, and *Poecillia latipinna*, while the families Xenocyprididae, Siluridae, Mastacembelidae, Engraulidae, and Sparidae have one species each: *Hemiculter leucisculus*, *Sliurus triostegus*, *Mastacembelus mastacembelus*, *Thryssa whiteheadi*, *Acanthopagrus arabicus*, respectively (Table 1).

Table. 1. Fish Species and Families with Their Diversity Collected from the Study Area from January to December 2024

Species	Abbreviation	Family	Native	Exotic	Marine	Habitat
Planiliza abu	Pab	Mugilidae	*			F
Planiliza subviridis	psu				*	M
Alburnus mossulensis	Amo	Leuciscidae	*			F
Leuciscus vorax	Lvo		*			F
Acanthobrama marmid	Ama		*			F
Hemiculter leucisculus	Hle	Xenocyprididae		*		F
Carasobarbus luteus	Clu	Cyprinidae	*			F
Carasobarbus sublimus	Csu		*			F
Carassius gibelio	Cgi			*		F
Cyprinus carpio	Cca			*		F
Garra rufa	Gru		*			F
Cyprinion kais	Cka		*			F
Mesopotamichthys sharpeyi	Msh		*			F
Sliurus triostegus	Str	Siluridae	*			F
Gambusia holbrooki	Gho	Poeciliidae		*		F
Poecillia latipinna	Pla			*		F
Mastacembelus mastacembelus	Mma	Mastacembelidae	*			F
Thryssa whiteheadi	Twh	Engraulidae			*	M
Captodon zilli	Czi	Cichlidae		*		F
Oreochromis aureus	Oau			*		F
Oreochromis niloticus	Oni			*		F
Acanthopagrus arabicus	Aar	Sparidae			*	M

F: Fresh water species; M: Marine water species.

Relative Abundance (%)

Three species dominated the relative numerical abundance in the current study area, accounting for 60.03% of the total catch, as determined by the dominance index

(D3). The native species, the most abundant species in the current region, formed 24.31% of the overall catch, ranging from 14.75% in November to 38.96% in August. The species accounted for 20.67% of the overall catch in the study area, with a range of 10.16% in February to 25.82% in November. The species in the third degree constituted 15.05% of the total catch, fluctuating from 9.30% in July to 21.72% in November. In the relative abundance term, 11 fish species recorded less than 1% (Table 2).

Table 2. Monthly Variations in the Relative Abundance % of Fish Species Collected from January to December 2024 in the Southern Part of the Euphrates River

Species	Jan.	Feb.	Mar	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
P. abu	14.79	17.65	26.59	22.15	23.97	31.40	29.43	38.96	23.96	21.08	14.75	20.47	24.31
O. niloticus	17.75	10.16	21.43	23.15	18.30	20.54	23.05	19.91	22.36	25.00	25.82	16.54	20.67
C. gibelio	17.16	18.72	9.92	13.42	16.56	9.30	13.48	13.85	13.42	16.67	21.72	21.26	15.05
O. aureus	6.51	8.56	7.54	10.74	11.76	3.49	11.70	14.72	8.31	000	7.79	9.45	8.76
A. mossulensis	10.65	12.30	7.94	5.37	7.84	10.85	4.96	3.90	9.90	9.31	4.51	6.30	7.71
C. zilli	12.43	5.35	5.16	5.37	6.54	5.81	4.26	3.46	5.75	8.33	9.43	4.72	6.25
P. latipinna	4.14	6.42	2.38	3.69	4.36	2.33	2.13		3.83	7.84	3.28	3.94	3.60
S. triostegus	3.55	4.28	4.76	4.70	4.14	3.49	2.48	1.73	3.19	1.96	2.46	3.15	3.41
C. luteus	2.96	4.28	3.57	2.35	0.87	2.33	1.06		0.96	1.96	3.28	5.51	2.12
C. carpio	1.78	3.21	1.59	2.01	1.31	1.94	1.06	1.30	2.24	2.45	2.87	4.72	2.02
L. vorax	5.33	3.21	1.59	1.68	0.65	3.49	0.71		0.32	0.98		0.79	1.39
C. sublimus	0.59		1.98	2.01	0.22	1.55	0.71		2.24		0.41	1.57	0.96
A. marmid	0.59	2.14	1.19	0.67		0.78	1.42	0.43		2.45	1.64	1.57	0.93
H. leucisculus		0.53	0.79	1.01	1.31	0.39	0.71		0.64	1.96	0.82		0.76
G. holbrooki		1.07	1.59		0.65	0.78	0.35	1.73	0.64		1.23		0.69
M. mastacembelus	1.18		0.40	1.01	1.09		1.77		0.32				0.56
T. whiteheadi		1.60	0.40				0.71		0.96				0.30
G. rufa		0.53				0.39			0.96				0.17
C. kais			0.79		0.22	0.39							0.13
M. sharpeyi			0.40	0.67									0.10
P. subviridis					0.22	0.39							0.07
A. arabicus	0.59					0.39							0.07
Spe. number = 22													
Ind. number =3024													

Ecological Indices

The diversity of ecological indices witnessed slight differences in the study area during the study period from January to December 2024. The diversity index ranged from 2.56 in January to 2.91 in May, with the mean 2.73 ± 0.79. The richness index increased from 1.41 in January to 2.89 in June, with a mean of 2.17 ± 0.42. The evenness index varied from 0.54 in September to 0.83 in December, with a mean of 0.74 ± 0.34. The analysis of the data shows no significant differences ($P < 0.05$) between stations 1 and 2, but an important difference ($P > 0.05$) between stations 1 and 3 (Fig. 4).

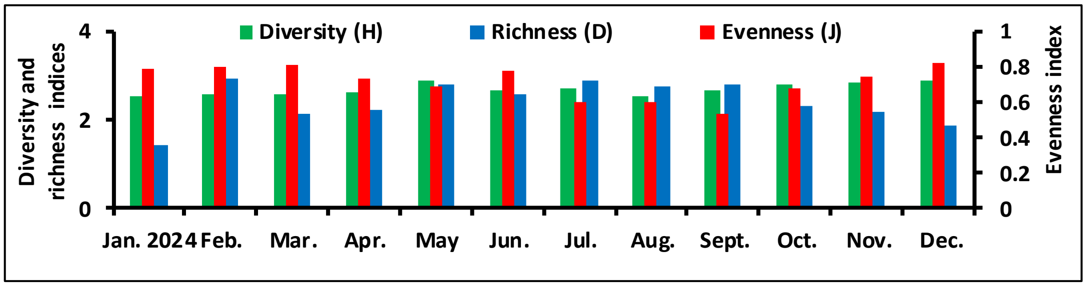

Fig. 4. Monthly Variations in the Ecological Indices in the study area from January to December 2024

The canonical correspondence analysis (CCA) showed that the ordination plot translates the relationships between some of the environmental parameters and fish species. The plots also illustrated the correlation among the conditioning variables and the number of species and individuals. The analysis discovers that DO and pH are the most important factors, which have an impact on the number of species. On the other hand, water temperature, salinity, and transparency influence the number of individuals, with four species preferring these factors (Fig. 5). The plots showed that water temperature is the most influential factor affecting fish species distribution; the plot also illustrated that DO and pH are on opposite sides. The analysis showed that Cichlidae species preferred or were associated with salinity.

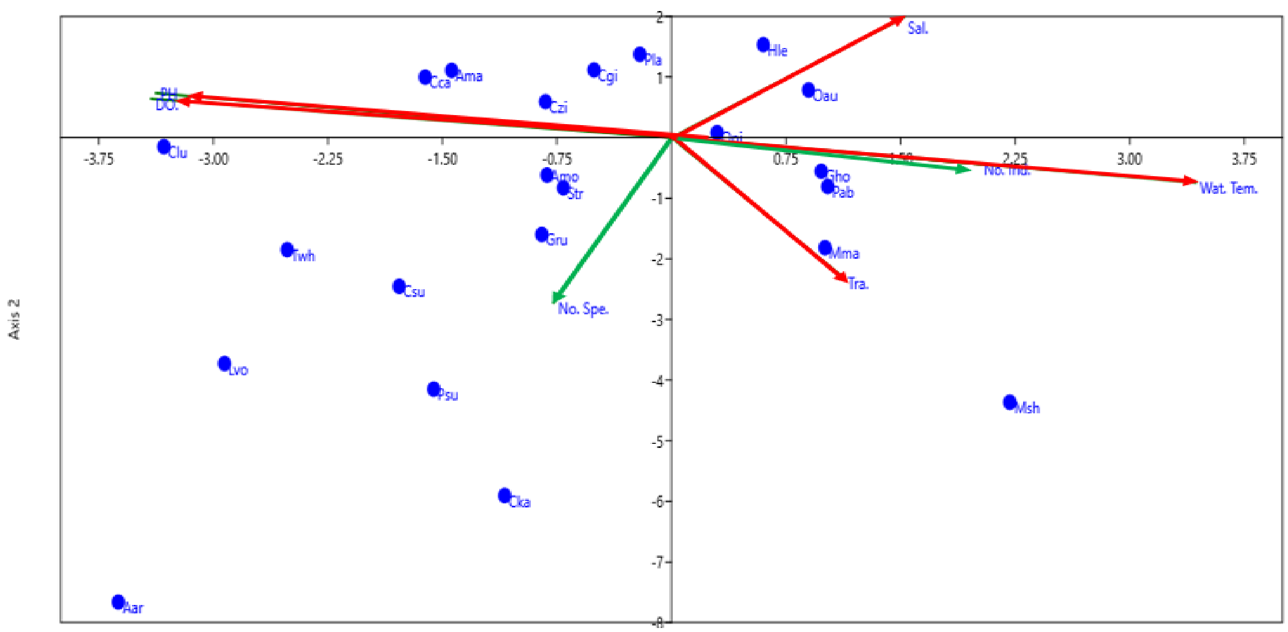

Fig. 5. CCA Ordination Plot Illustrated the Relationships Among Condition Variables, the Number of Species, the Number of Individuals, and Fish Species in the Study Area from January toDecember 2024.

Number of Species and Individuals

There is a clear fluctuation in the number of species and individuals in the study area during the sampling period from January to December 2024. The number of species ranged from 12 in October to 19 in June, with a mean of 15.42 ± 2.75. The number of individuals of fish varied from 127 in December to 459 in May, with a mean of 252 ± 84.84. The ANOVA analysis elucidates that there are no significant differences ($P< 0.05$) in the number of species between sites 1 and 2, while there are noticeable differences ($P> 0.05$) in the species number between stations 1 and 3 (Fig. 6).

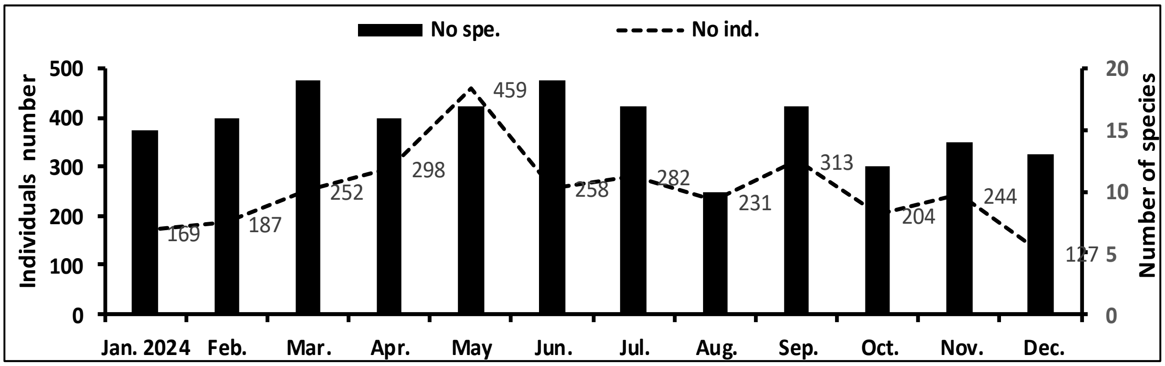

Fig. 6. Monthly Variations in the Number of Species and Individuals in the Study Region from January to December 2024

DISCUSSION

Physicochemical parameters showed a logical correlation with weather and climate variations across different months. The study revealed the absence of marine species at the stations north of the dam, while they were clearly present at the station south of the dam. Both introduced and tolerant native species recorded the highest relative abundance at both the north and south stations, exhibiting a consistent presence throughout most of the study period and recording the largest number of individuals compared to other species.

Fischer and Quist (2019) pointed out that abiotic and biotic factors have implications and contributions to the composition of fish assemblages under the impacts of human activities. However, the present results indicated that ecological features provide some explanations for the structuring, distributions, and abundance of the fish community in riverine ecosystems **(Gebrekiros, 2016)**. The canonical correspondence analysis (CCA) shows that temperature, the largest impact factor, can structure fish assemblage, and the monthly variations in temperature significantly impact fish assemblage composition in the freshwater ecosystems by affecting all biological characteristics of fish: reproductive, feeding, and wintering migrations **(Kindong *et al.*, 2020)**. Salinity has a critical impact on fish assemblage distribution, composition, and spread; the salinity values slightly increased from June to October due to a reduction in the discharge of the Tigris and Euphrates Rivers **(Layla *et al.*, 2018)**. The CCA plot showed that some species are attracted to or resist high salinity, like the tilapia species

(Montazeri *et al*., 2023). Generally, the concentrations of pH values in the current work are near the range of natural alkalinity of the Iraqi limitations for natural waters **(Ismail *et al*., 2019)**. The study showed a significant increase in DO levels, especially in December, January, and February at the the three stations, this may be attributed to lower temperatures, continuous water mixing at the all stations, and the large surface area of the water body **(Salami *et al*., 2020)**. Light penetration is considered an abiotic characteristic that directly affects the presence and spread of fish species. Light penetration is affected by domestic sewage, as well as bottom disturbance, riverbank erosion **(Xu *et al*., 2022)**.

The current study captured 22 fish species belonging to 19 genera and 10 families, including 11 native freshwaters, eight exotics, and three marine species, these results corresponding with **Hussein *et al*. (2015)**, who collected 24 fish species belonging to nine families, and with **Abdullah *et al*. (2022)**, who reported collecting 22 fish species affiliated with 21 genera and 12 families in the Euphrates River between Medina and Qurna cities, southern Iraq. Interestingly, the buildings of dams need comprehensive studies for all ecological and biological trends in the region for the present time and in planning for the future **(Wu *et al*., 2019)**. Dams built on rivers continue to have numerous impacts on freshwater fish assemblages and the ecosystem **(Liu *et al*., 2022)**. Barriers have a critical impact on fish migrations and movements; they can delay or block the accessibility of the fish to their intended destination and prevent fish assemblage sustainability **(Jubb *et al*., 2023)**, this is very clear in the current study, via the prevention of migratory marine fish species from reaching the first station north of the dam **(Zhang *et al*., 2020)**. All studies that were conducted in this region or in the adjacent areas ensure the absence of historical fish populations in the area due to the deterioration of habitats and the decline in water quality **(Keijzer *et al*., 2024)**. **Coade (2010)** pointed that 53 freshwater species were detected in inland waters; 44 of them were native and 9 were exotic, indicating distributions in different habitats inside Iraq due to feature variations. Environmental segregation and change regime flow support the occurrence and distribution of uncommercial small exotic fish species in the region **(Boddy *et al*., 2020)**. Barriers to construction on the river's ecosystems have led to hydrological disconnection and habitat partition, resulting in biological homogenization **(Zheng *et al*., 2025)**, with the increasing abundance of tolerant and exotic species; four tolerant exotic species topped the relative abundance: *P. abu*, *O. niloticus*, *C. gibelio*, and *O. aureus* (24.31, 20.67, 15.05, and 8.76%), respectively **(Abdullah *et al*., 2022)**. The current study aligns with **Hussein *et al*. (2015)**, who worked in the same area, in the dominance of *P. abu* at 34.19%, but differs in the dominance of other species: *C. zilli* at 22.72% and *A. mossulensis* at 14.22%. The differences in the species topping the area are attributed to the entry of new exotic species that adopted suitable reproductive strategies, making them occupy first ranks in abundance, and due to spatial and temporal variations, this illustrates the dam's impact because stopping the flow of water and establishing a stable environment promotes the development of tolerant species, both native and invasive

(Chen *et al*., 2022). High abundance indicates a high number of species individuals, and habitat fragmentation creates stable, slow-flowing environments, which are preferred by tolerant native and exotic fish species **(Gebrekiros, 2016)**. The values of ecological indices are decreasing compared to previous research conducted in the current region and nearby areas, primarily due to habitat partitioning and changes in flow regimes **(Tonkin *et al*., 2018)**. Habitat fragmentation leads to habitat degradation with a decline in ecological indices values that support exotic and small uncommercial fish; these conditions are unsuitable for native and sensitive species **(Khan *et al*., 2022)**. All studies that were conducted inside Basrah province **(Hussein *et al*., 2015; Abdullah, 2017; Mohamed & Abood, 2017; Hameed *et al*., 2022; Abdullah *et al*., 2022)**, confirmed an increase in the number of individuals of tolerant native small fish species like *P. abu* and exotic species that are prevalent in the study regions and a retrogradation in the number of species and individuals of sensitive fish species, which represented the core of the fish assemblage in the past, due to environmental deterioration and the reduction in freshwater discharge from the Tigris and Euphrates Rivers due to habitat segregation by the construction many of dams that altered the environment's nature.

CONCLUSION

Given the accumulation of habitats' problems, the current study was conducted to show the fragmentation of habitats caused by dams and the alteration of the flow regime that have created degraded, unhealthy environments devoid of stimulation and flow. This situatin has led to a change in the composition of fish populations toward small, non-commercial, tolerant, or dominant invasive fish species in addition to causing the departure of native local species that represent the core of the historical composition of the fish population in inland waters. The current research contributes to uncovering environmental imbalances and to addressing them. Furthermore, future scientific studies should focus on continuous environmental monitoring and on addressing environmental problems before they become more complicated.

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