Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

Composition of fish assemblages in the southern part of the Main Outfall Drains, Southern Iraq

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ABSTRACT
Fish assemblage was investigated in the southern part of the Main outfall drains, southern Iraq from January to December 2019. Monthly variations were recorded in water quality parameters including water temperature, dissolved oxygen, salinity, electric conductivity, turbidity, hydrogen ion, and total dissolved solids. A total of 10981fish specimens belonging to 27 fish species, 25 genera, 17 families, and eight orders were collected from the southern part of the Main outfall drains. Marine fish species were 19 and eight species from freshwater. Three species were presiding the numerical relative abundance of species formed 80.96% of the total number of species. In this region, *Acetrogobius dayi* represented 32.00%, *Boleophthalmus dussumieri* 28.92% and *Aphanius dispar* 20.04% of the total number of species. The status of ecological indices were poor for diversity index (H), richness index (D) was troubled, and semi-balanced for evenness index (J). The present study showed bad water quality after analyses of physicochemical variables, and also sensory indicators (colour and smell) of the water which play a major role in the blending composition of the fish community structure. The results revealed that salinity has a large contributor to determine the nature spread and distribution of the fish populations. The study exhibited that the river habitat is unstable, affected by three factors: 1) Quantity and quality of freshwater coming from Al-Siphone regulator in Thi-Qar Province; 2) The tidal process spread organic pollution that are dumped in Hamdan region, Southern Basrah City; and 3) The chemical and organic pollutions resulting from reclamation of agricultural lands.

Keywords: Fish assemblage, Indicators, Water Quality, Main outfall drain
Article type: Research Article.

INTRODUCTION
Fish populations have been always utilized as ecological indicators for evaluating and measure of water deterioration in the diverse spatial and temporal variations of water bodies (de Mello *et al.* 2018; Jiang *et al.* 2020). All specialists in fish population studies realize that there is a dialectical correlation between the quality and nature of fish assemblages as well as the water quality (Huang *et al.* 2019). Through the presence of specific species and the nature of the fish community structure, we can predict water quality and vice versa (Zeni & Casatti 2014). Fish assemblages are widely used to know the alterations in the fish community structure, although their ecosystems were modified (Ngor *et al.* 2018). The long-term variations which are correlated with stress from slight incremental alterations in environmental circumstances, lead to alterations in the abundance of fish fauna, and provide an important practical assessment of the impacts of water quality on the fish assemblages of fish (Parker *et al.* 2015). Freshwater ecosystems are among the most changeable systems due to anthropogenic activities and include the hotspot area of biological diversity. These ecosystems encompass a large number of endemic species which are seriously affected by urban pollution, originate from populations growth. Most of their problems are represented by water ecosystem modification, industrial waste, agricultural process, habitat alteration, modifications of hydrology and alien species (Huang *et al.* 2019; Pyron *et al.* 2019). Water contamination and hydrological modification are recognized as the most real threats to freshwater fauna (Pyron

Caspian Journal of Environmental Sciences, Vol. 20 No. 5 pp. 919-928 Received: March 14, 2022 Revised: May 23, 2022 Accepted: July 10, 2022
DOI: 10.22124/CJES.2022.6039

Publisher: University of Guilan,

et al. 2019). Freshwater habitats are more vulnerable to human threats than terrestrial and marine ecosystems, and maintain water resources require knowledge of the effects and historical trends of water, as well as using land to plan suitable solutions for the conservation of the waters (Craig *et al.* 2017; Poff *et al*. 2018). Pyron *et al.* (2019) mentioned that the composition of an assemblage of fish (taxonomic structure) was related to variations in land use. However, assemblages' species composition is correlated with modification of hydrological factors, reduces minimum discharge limits, declines the filling rate, and increased level rates. Generally, the highest diversity values were recorded in the tropical region, whereas in Asia, the level of diversity for families (121 families) was higher than in Africa, and 50 to 55 families were found in inland waters of Latin America. The estimated number of fish species identified is about 34300 fish species over the world, of these species nearly 15,666 species are recorded in freshwater, while other 15,562 in marine water and 3,115 in brackish or are diadromous (Froese & Pauly 2022). Systems of fish assemblage's approximation and divergence (genotype) are based on environmental circumstance variations passed across numerous spatial and temporal scales (Bower & Winemiller 2019). The large harmful impacts on fish populations in the rivers and streams in the desert or semi-desert regions come from the changes in hydrology that alter the ecosystem directly or indirectly and stimulate the changes in propagation and distributions of exotic species (Yang *et al.* 2019). The amount of shifting in riverine fish populations may depends on spatial parameters and the initial resemblance in the fish population structure happened before anthropogenic alterations. It is also related to the extent of habitats which is important to understand the impacts of variations in accumulation on fish assemblages (Taylor *et al.* 2018; Mazareiy *et al.* 2019; Sattari *et al.* 2019; Forouhar Vajargah *et al.* 2020a,b). There is no study discussing the relationship between fish populations and water quality in southern Iraq, but there were several investigations implemented on the Main outfall drains and Shatt Al-Basrah canal, which are taken into account extension to the Main outfall drains include fish diversity (Yousif, 1986; Al-Daham & Yousif 1990; Jasim 2003; Younis & Al-Shamary 2011; Younis & Al-Shamary 2012; Abdullah *et al.* 2018). The aim of the present study is to investigate the effect of water quality represented by physicochemical parameters and demonstration of anthropogenic activities' impacts on the nature of building fish assemblage on the southern part of the main outfall drain in southern Iraq.

MATERIALS AND METHODS

The main outfall drain is called the third river in Iraq, which is stretched to a distance of 565 km from the northwest of Baghdad City to the north of the Persian Gulf (Abdullah *et al.* 2018). The present study area extends about 30 km from the Al-Gttra region N 30º 40´ 12″E 47º 34́ 12″to the south of Al-Khora village N 30º 34́ 12″E 47º 41́ 24′ about five km. The position of study area was determined by Global position system (GPS). The river width is 110 m, but the submerged area can be increased due to the status of the tide and the amount of water provided from the Siphone regulator in Thi-Qar Province to reach one or two km in some places (Al-Munshed 1998; Fig. 1). Some environmental variables were verified simultaneously with the fishing processes. Water temperature (ºC) was measured by a mercurial thermometer (-10 to100 ºC), salinity (g L^{-1}) and hydrogen ion was estimated by Lovibond-Sensor Direct 150 manufactured in Germany; total dissolved solids (TDS) in mg L^{-1} and electrical conductivity (EC) in mS cm^{-1} were estimated directly by Hanna instruments (a waterproof HI-9146). Turbidity was calculated in turbid meter HI- 93703C in Nephelometric turbidity (NTU). Dissolved oxygen (mg L^{-1}) was determined according to Welch (1964). Samples were monthly collected from the region during the study period from January to December 2019 by several fishing methods, drift gillnets, fixed gillnets, seine nets, cast nets as well as observations from fishermen. Fishes were identified according to Fricke *et al.* (2021) and the rest of the scientific names were updated according to Froese & Pauly (2022). Analyses of fish assemblage were performed as follows:

The measurement of relative abundance was performed according to Walag *et al.* (2016). Fish diversity was calculated by Huang *et al.* (2019); evenness and richness based on the methodology of Nyitrai *et al.* (2012). To analyse the relationships among physicochemical factors and species, we used Principal Component Analysis (PCA) program, Canonical Correspondences Analyses (CCA), and Statistical Package for Social Science, Ver. 20 (SPSS).

RESULTS AND DISCUSSION

Physicochemical parameters have an essential role in forming and building a diversity of fish assemblage in riverine ecosystems. The monthly variations in the properties of the ecological variables were illustrated in Fig. 2. The minimum value of water temperature was 15 ºC in January and started to increase gradually to reach the maximum of 35 ºC in July with an average of 24.67 ºC ± 6.83, thereafter declined to December. Dissolved oxygen values set out to be slightly high in the cold months then descended in the hot months to record 6.2 mg L^{-1} in July and elevated to 7.9 mg L^{-1} in January, with the mean value of 7.13 ± 0.52 mg L^{-1}. The ranges of salinity were oscillating and average values were observed at 8.09 g L^{-1} in April, while 45.80 g L^{-1} in March (mean = 25.06 ± 10.84 g L^{-1}). Electrical conductivity was strongly related to salinity values recording 13. 96 mS cm^{-1} in April, while 71.70 mS cm^{-1} in March (mean = 39.4596 ± 16.74 mS cm^{-1}). Turbidity started in tempered values to decline at the minimum point of 24.40 NTU in April then the maximum was 88.00 NTU in June and an average of 44.30 NTU ± 19.74. The hydrogen ion recorded relatively high values at the beginning of the study then the values fluctuated to record the lowest at 7.00 in September and the highest at 8.10 in January (mean = 7.42 ± 0.42). A total dissolved solid was observed in the first three months of the study and declined to 8934 mg L^{-1} in April, while 45846 mg L^{-1} in March (mean = 25151.83 ± 10751.19 g L^{-1}) and then the values fluctuated to December (Table 1).

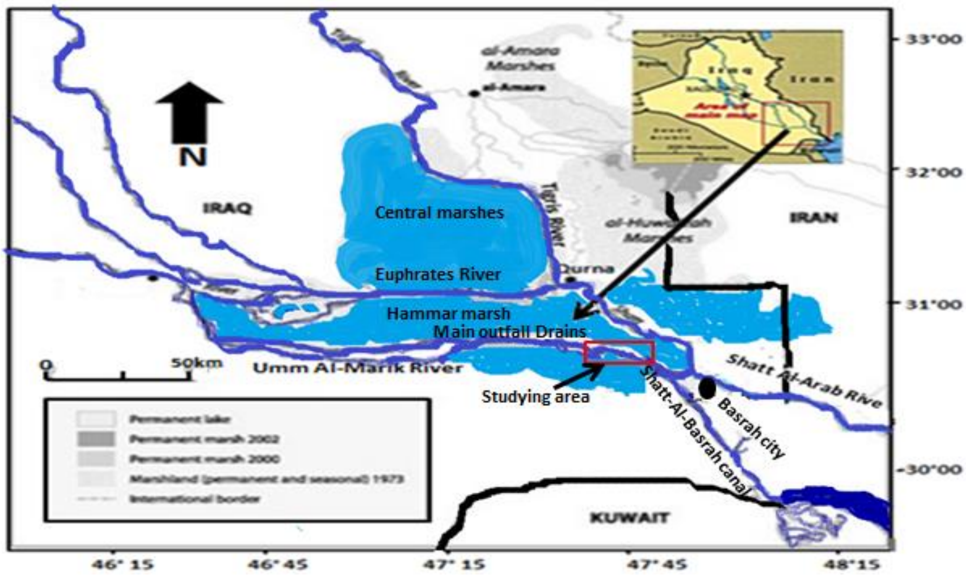

Fig. 1. Map of the southern part of the main outfall drain, southern Iraq.

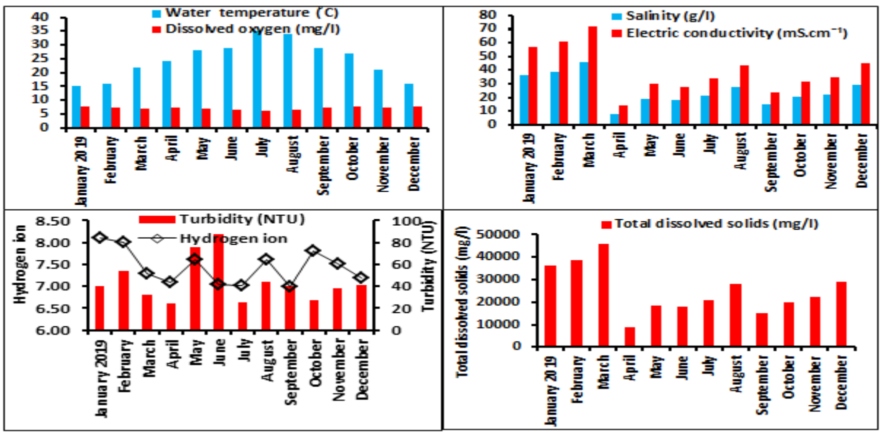

Fig. 2. Monthly variations in the physicochemical variables in the southern part of the Main Outfall Drain, southern Iraq.

The physicochemical properties of lotic ecosystems play an important role in the building of fish populations. Water temperature is the most important parameter due to directly effect on the level of dissolved oxygen in the ecosystems (Rajwa-Kuligiewicz & Rowiński 2015). The variations in temperature recorded in the present study area were due to different sampling times and monthly variance in temperature that influences the biological, biochemical, trophic, and reproduction of fishes (Camargo *et al.* 2021). The amount of DO is a determinant of water quality which is strongly related to temperature. The pollution of organic matter in the Main outfall drains was high due to the river representing a carrier for heavy water, agricultural residues, and land-washing products.

Therefore the degree of oxygen saturation of water is at its lowest status, as a result of the increased organic matter and other pollutants (Wen & Van De Giesen 2017).

Table 1. The variations in physicochemical parameters with range and mean values with standard deviation (± SD).

Parameter	Unit	Range	Mean ± SD
Water temperature	ºC	15-35	24.67 ± 6.83
Dissolved oxygen	mg L^{-1}	6.2-7.9	7.13 ± 0.52
Salinity	g L^{-1}	8.09-45.80	25.06 ± 10.84
Electric conductivity	mS cm^{-1}	13.96-71.70	39.45 ± 16.74
Turbidity	NTU	25.50-76.11	44.30 ± 19.74
Hydrogen ion	-	7.00-8.10	7.42 ± 0.42
Total dissolved solids	mg L^{-1}	8934-45846	25151 ± 10751

Salinity has played a major role in the distribution of fish fauna in aquatic ecosystems, its effects on primary production, geographical distribution, dispersal, recruitment of larval, and the marine species behaviour (Herbert *et al.* 2015; Santos *et al.* 2017). The Main outfall drains are human-managed, so the river is subject to constant shafting in the quantities of and qualities of freshwater released towards the south, from the Al-Siphon regulator in the Al-Nasiriyah City, as well as affected by marine tidewaters from the Persian Gulf. These changes created a distinct dynamic system, which has a great implication for the fish population's composition (Abdullah *et al.* 2018). The results of electric conductivity were in continuous dynamic changing, when the freshwater discharge from the Al-Siphon regulator decreases, the effect of tidal phenomenon on the salinity ion concentration in the water elevates, leading to the upraised conductivity. Our result is consistent with Corwin & Yemoto (2017). The results showed a high level of turbidity in all months in the present section of the river due to raising the ratio of suspended solid matters as consequently of anthropogenic activities which increased insoluble organic or inorganic materials (Butler & Ford 2018). The present results of pH values rates showed within the ranges of Iraqi inland waters (Ewaid & Abed 2017). The present results of total dissolved solids were high in the studied regions due to high levels of salinity and discharges of effluents from anthropogenic activities especially from January to March, which are in line with Corwin & Yemoto (2017). Fig. (2-A) illustrates the increased influence of salinity, electric conductivity and total dissolved solid respectively compared to the other factors, followed by water temperature and dissolved oxygen, whereas a slight effect appears due to turbidity in the study area. The figure showed an inverse correlation between water temperatures and the other factors (DO, salinity, electric conductivity, hydrogen ion, and total dissolved solids) except the water turbidity which was positively correlated with temperature. The results of environmental variables were subjected to Principal Component Analysis Technique (PCA; Figs. 3A and B), exhibiting that the eigenvalue of the studied factors was 6.39, which is a good value based on the seven factors measured, while the rates of variables were 56.38, 20.79 and 14.20% respectively. However, the impact of accumulation composition of the three components (F_1, F_2 and F_3) was 56.38, 77.17 and 91.37% respectively. Fig. 4. revealed that January, February, March, April, June, July, and September formed 94.66% of the total impacts on the habitat of the study area. November exhibited the lowest variation in the variables (0.007%), while the highest values of impacts were 20.35% in January. Canonical correspondences analysis (CCA; Fig. 5) displayed that the fish species were divided into groups according to species tendencies. Fishes that prefer salinity, turbidity, temperature, electric conductivity, and total dissolved solids were the most influential variables in the study area contributing to the distribution and dispersal of fish species. Turbidity and water temperature also played an important role in the occurrence and distribution of fish species and were inversely correlated with salinity, DO, electric conductivity, and total dissolved solids. Fig. 5. revealed two fish groups according to their preferred first group coexistence associated with salinity represented by species inside the blue circle such as *Ilisha compressa*, *Hyporhamphus limbatus*, *Nuchequula gerreoides*, *Amblyaster sirum*, *Platycephalus indicus*, *Sardine albella*, *Pseudosynanceia melanostigma* and *Eupleurogrammus muticus*. The small group condescension turbidity (species inside a green circle) included *Aphanius dispar* and *Trichiurus lepturus*.

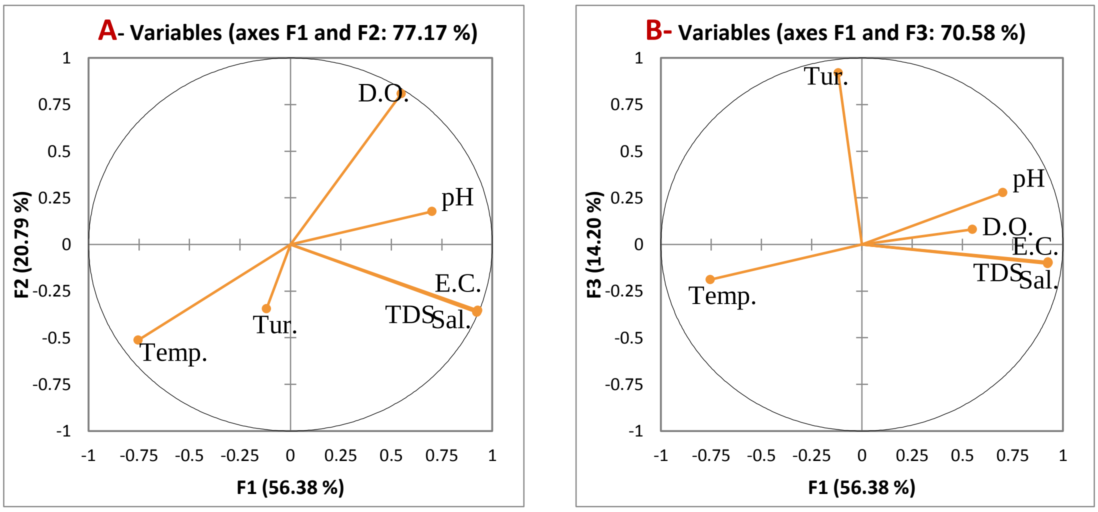

Fig. 3. The correlation among the physicochemical variables in the study area.

Another group including species preferred temperature represented by the species inside orange circle *C. zillii*, *Acanthopagrus bifasciatus T. ilish*, *Thryssa whiteheadi*, *Acanthopagrus arabicus*, *P. latipinna*, *N. nasus*, *Planiliza subviridis*, and *Brachirus orientalis*. These results were in line with Plavan *et al.* (2016) who studied the seasonal composition and abundance of the sub-estuarine fish assemblage on the coast of the Rio de la Plata estuary and with Mohamed & Abood (2017) who reported the compositional alteration in the fish assemblage structure in Shatt Al-Arab River, Southern Iraq.

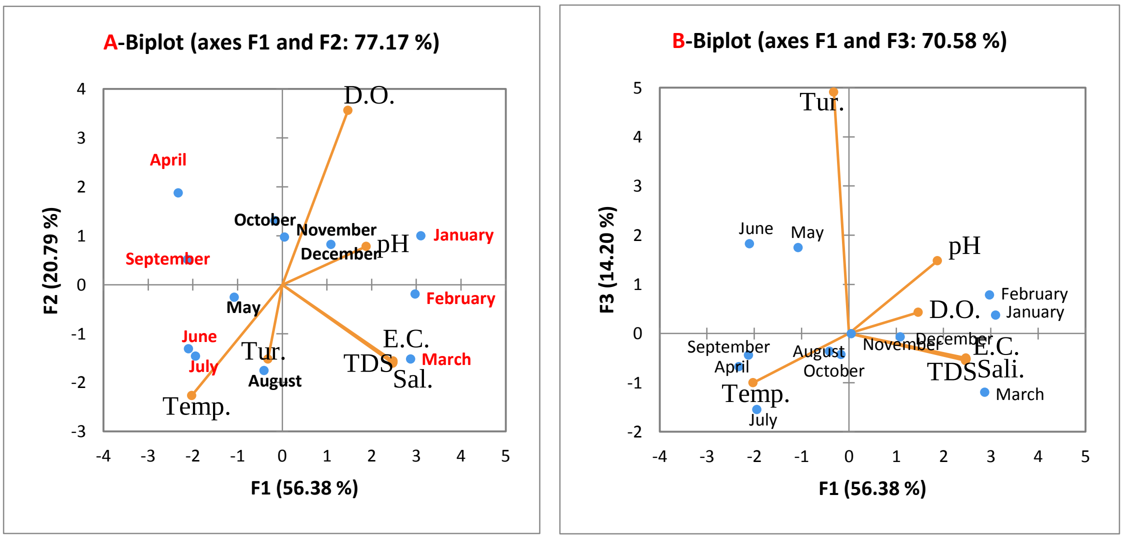

Fig. 4. Principal Component Analysis Technique (PCA). The impacts of present physicochemical variables on study area among the months.

Relative abundance

Three species preside the numerical relative abundance of the study area, forming 80.96% of the total number of species. *Acetrogobius dayi* constituted 32.00%, *Boleophthalmus dussumieri* 28.92%, and *Aphanius dispar* 20.04% of the total caught. Gobiidae, the most abundant family in the investigated area, formed 60.92%, followed by Cyprinodontidae 20.04% and Engraulidae 8.70%, whereas among the eight orders, Perciformes was the most abundant order encompassing 65.26%, Cyprinodontiformes 20.94%, and Clupeiformes 10.47%. The three most abundant species were a non-commercial small size that was not subjected to fishing pressure. The present results were in accordance with Younis & Al-Shamary (2011) and Abdullah *et al.* (2018) from the point view of occurrence and abundance trends (Table 3).

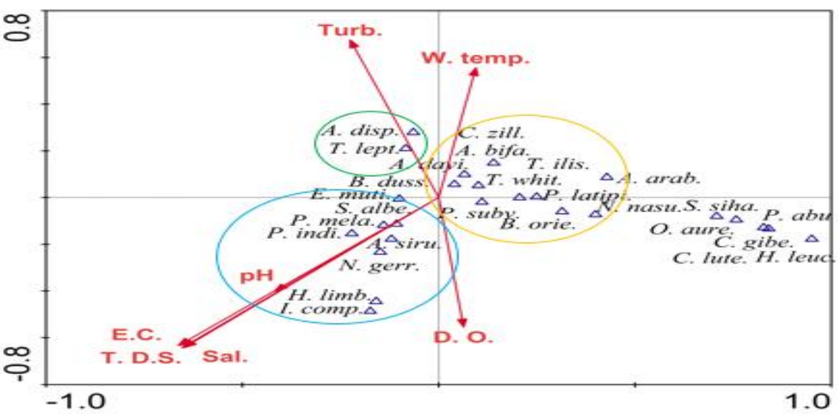

Fig. 5. Canonical Correspondences Analysis (CCA) between the environmental variables and fish species.

Table 2. Fish species with their families and orders southern part of Main Outfall Drains.

Species	Family	Order	Habitat
Amblyaster sirum	Clupeidae	Clupeiformes	M
Nematalosa nasus			M
Sardine albella			M
Tenelousa ilisha			M
Thryssa whiteheadi	Engraulidae		M
Ilisha compressa	Pristigasteridae		M
Carassius gibelio	Cyprinidae	Cypriniformes	F
Carasobarbus luteus			F
Hemiculter leucisculus			F
Aphanius dispar	Cyprinodontidae	Cyprinodontiformes	F
Pocillia latipinna	Poeciliidae		F
Hyporhamphus limbatus	Hemiramphidae	Beloniformes	M
Planiliza abu	Mugilidae	Mugiliformes	F
Planiliza subviridis			M
Platycephalus indicus	Platycephalidae	Scorpaeniformes	M
Pseudosynanceia melanostigma	Synanceiidae		M
Acetrogobius dayi	Gobiidae	Percifomes	M
Boleophthalmus dussumieri			M
Coptodon zillii	Cichlidae		F
Oreochromis aureus			F
Eupleurogrammus muticus	Trichiuridae		M
Trichiurus lepturus			M
Silago sihama	Sillaginidae		M
Nuchequula gerreoides	Leiognathidae		M
Acnthopagrus arabicus	Sparidae		M
Acanthopagrus bifasciatus			M
Brachirus orientalis	Soleidae	Pleuronectiformes	M

Ecological indices

The study revealed evident fluctuation in the values of ecological indices during the study period. The diversity index values ranged from 0.98 in March to 2.07 in April. The richness index varied from 0.96 in November to 1.94 in April. The evenness index values fluctuated from 0.38 in March to 0.89 in February (Fig. 6).

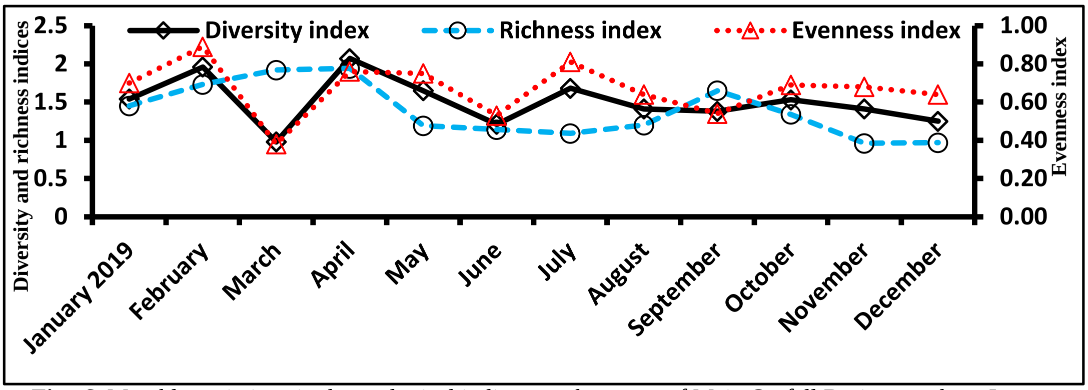

Fig. 6. Monthly variations in the ecological indices southern part of Main Outfall Drains, southern Iraq.

Table 3. The relative abundance of fish species with their families and orders southern part of Main Outfall Drains, southern Iraq.

Species	No.	%	Family	No	%	Order	No	%
Amblyaster sirum	12	0.10	Clupeidae	192	1.75	Clupeiformes	1150	10.47
Nematalosa nasus	18	0.164						
Sardine albella	16	0.146						
Tenelousa ilisha	146	1.33						
Thryssa whiteheadi	955	8.69	Engraulidae	955	8.70			
Ilisha compressa	3	0.02	Pristigasteridae	3	0.03			
Carassius gibelio	42	0.38	Cyprinidae	57	0.52	Cypriniformes	57	0.52
Carasobarbus luteus	11	0.1						
Hemiculter leucisculus	4	0.03						
Aphanius dispar	2200	20.04	Cyprinodontidae	2200	20.04	Cyprinodontiformes	2299	20.94
Pocillia latipinna	99	0.90	Poeciliidae	99	0.90			
Hyporhamphus limbatus	9	0.08	Hemiramphidae	9	0.082	Beloniformes	9	0.08
Planiliza abu	65	0.59	Mugilidae	232	2.11	Mugiliformes	232	2.11
Planiliza subviridis	167	1.52						
Platycephalus indicus	6	0.055	Platycephalidae	6	0.055	Scorpaeniformes	9	0.08
Pseudosynanceia melanostigma	3	0.027	Synanceiidae	3	0.027			
Acetrogobius dayi	3514	32.00	Gobiidae	6690	60.92	Percifomes	7166	65.26
Boleophthalmus dussumieri	3176	28.92						
Coptodon zillii	6	0.05	Cichlidae	32	0.29			
Oreochromis aureus	26	0.23						
Eupleurogrammus muticus	238	2.16	Trichiuridae	262	2.39			
Trichiurus lepturus	24	0.21						
Silago sihama	37	0.337	Sillaginidae	37	0.34			
Nuchequula gerreoides	9	0.08	Leiognathidae	9	0.08			
Acnthopagrus arabicus	134	1.22	Sparidae	136	1.24			
Acanthopagrus bifasciatus	2	0.01						
Brachirus orientalis	59	0.53	Soleidae	59	0.54	Pleuronectiformes	59	0.54

The present results revealed that the diversity index is shown as poor according to Jorgensen *et al.* (2005). The richness index tends to be troubled and the evenness index seems semi-balanced. The values of ecological indices were within the general trend of the previous studies (Yousif 1986; Jasim 2003; Younis & Al-Shamary 2011; Abdullah *et al.* 2018), with a slight increase in the range of some indices due to that studies implemented to the south adjacent to the northwest area of the Persian Gulf which allows entering a large number of marine species leading to the elevated values of the diversity index (Table 4).

Table 4. Comparison of ecological indices with the previous studies southern part of Main outfall drains, southern Iraq.

The study	The study region		Diversity index	Evenness index	Richness index
Yousif (1986)	Shatt Al-Basrah canal		0.49-2.84	0.07-0.50	1.33-5.32
Jasim (2003)	Shatt Al-Basrah Canal and Shatt Al-Arab River		0.17-2.13	0.24-0.98	0.28-2.87
Younis and Al-Shamary (2011)	Shatt Al-Basrah Canal	Station 1	1.01-2.32	0.37-0.86	0.95-3.05
		Station 2	0.88 -2.24	0. 37-0.79	1.45-3.06
Abdullah *et al.* 2018	Main outfall drains (Al-Kii bridge area)		1.23-2.17	0.52-0.88	1.14-2.02
The present study	The southern part of Main Outfall Drains, Southern Iraq		0.98-2.07	0.38-0.89	0.96-1.94

CONCLUSION

The present study concluded that water quality represented by physicochemical variables plays an important role in the composition of the fish community structure that mostly constitutes the tolerant marine and freshwater fish species. Moreover, salinity contributes to a large degree in determining the nature of fish assemblages. In addition, the present section of the river represented an unstable habitat with poor water quality due to organic and chemical pollutions resulting from the process of reclamation of agricultural lands, and as a result of human management of freshwater quantities coming from Al-Siphone regulate in the Thi-Qar Province. The tidal processes contribute to the spread of organic pollutants which are thrown into the river from the Hamdan region in Southern Basrah City.

ACKNOWLEDGMENT

The author's grateful Department of Marine Vertebrate, Marine Science Centre to provide the facilities and opening the laboratories to perform the present work.

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Bibliographic information of this paper for citing:

Jaafer Abdullah, A,H, Gani Abdullah, S,A, Yaseen, A,T 2022, Composition of fish assemblages in the southern part of the Main Outfall Drains, Southern Iraq. Caspian Journal of Environmental Sciences, 20: 919-928.