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Effect of Al-Dalmaj Marsh Discharge Canal on Copepoda Community and Water Quality in the Main Outfall Drain River in Al-Qadisiya Governorate by Using Biodiversity and CCME-WQ Indices

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ABSTRACT

The research evaluated the effect of mixing the Dalmaj Marsh water with the Main Outfall Drain River, which reflected on copepod communities and its water quality. Three sites were selected to test water variables as well as the Copepoda diversity index (Shannon-Wiener index) and density in 2023. The turbidity, DO, BOD_5, and TDS exceeded the acceptable limits for aquatic life. The most effective parameters were TDS, BOD_5, and turbidity, which contributed to creating a low water quality for the river due to it being used for the disposal of agricultural effluents. The CCME-WQ Index values of the sites ranged from marginal in site 2 to poor quality in sites 1 and 3. Site 3 had the lowest quality because it had double the TDS values and the highest turbidity values due to the water coming from the marsh canal to the river. The highest densities and diversities were downstream meeting point of Al-Dalmaj Marsh Discharge Canal with the Main Outfall Drain River (MOD) (at site 3), compared with site 2. The canal water affected copepod density and diversity due to this fauna was positively influenced by high TDS and DO caused by the canal water in the brackish river. The taxa numbers were 22 species. These few species number of the river may be due to the salinity being the most important factor changing the species and abundance of copepods, where it is predicted to be greater when salinity levels are nearer to that of freshwaters or marine waters than in brackish waters. Copepoda taxa of the river were most abundant by nauplii because they fed on a wide range of cell sizes of the phytoplankton as adults. Moreover, *Cyclops* sp. and *Cyclops* (♂) dominated Copepod communities due to their ability to survive seasonally unfavorable conditions.

INTRODUCTION

Studying plankton abundance, distribution, and community composition fundamentally contributes to providing insights into the responses of aquatic systems to environmental changes and an understanding of the structure and functioning of aquatic ecosystems **(Prakash, 2021; Al-Bahathy & Nashaat, 2025)**.

Copepods are important components in all aquatic environments, including freshwater, brackish, and marine water. They make up about 80% of zooplankton populations **(Lee *et al.*, 2018)**. Copepods are also a bioindicator for changing ecosystem conditions because of their short life **(Rahman, 2021)**. Copepods' distribution mainly depends on ecological factors such as salinity, feed availability and water temperature. Salinity is an important parameter affecting copepod productivity and its life cycle **(Chintada *et al.*, 2023)**.

The Main Outfall Drain is a river that originated to discharge effluents from croplands and factories from the middle to the southern part of Iraq. At the south, the river feeds the marsh by the Dalmaj feeding Canal above site 1 and receives water from the marsh via the drainage canal upstream of site 3, about 2 km away, in a site called the waterfall **(Abdullah *et al.*, 2019a).**

The water quality index (WQI) is a mathematical formula used to produce a single number representing the water quality over time and space. Local and international researchers interested in studying water sources may refer to the work of **Maktoof *et al.* (2020)**, who used the Pollution Index and Metals Index to evaluate the ecological condition of a main outfall drain based on six heavy metals: lead, arsenic, cadmium, zinc, copper, and iron. The study revealed a high level of pollution. **Majeed and Nashaat (2022)** studied the effect of Al-thrathar canal north of Baghdad city on Tigris river's chemical and physical properties through analysis of the spatial and temporal variation of 19 water quality parameters. **Al-Bahathy *et al.* (2023)** used CCME water quality index and water pollution index to investigate the changes in the water quality of Tigris River from Al-Aziziyah area to Al-Qurnah for 5 years using 13 water parameters and found that chloride, salts, sulfate, nitrate and heavy metals exceeded the permissible limit most of the time. **Abed *et al.* (2023)** also used CCME water quality to evaluate the water quality of Janabi River in Wast City in three sites, and the index rating ranged from marginal to poor quality. **Salman and Al-Janabi (2024)** chose 10 parameters to apply the Irqai water quality index based on the weight method to follow up the spatial and temporal changes in Al-Dujaila River in Wast City. **Nong *et al.* (2020)** evaluated the water quality of trans-basin water diversion project using WQImin by applying five key parameters (Feacel coliforms, total phosphorus, Hg, water temperature, and Dissolved oxygen), and found it to be an excellent way to manage and assess the water quality. WQI are not limited to surface water, **Nguyen *et al.* (2022)** studied the suitability of groundwater as a drinking source in Vietnam by applying the Integrated Weight Water Quality Index (IWWQI) to thirteen water parameters.

Generally, the biodiversity indices of zooplankton groups (Rotifera and Crustacean), as Shannon index, densities, taxa numbers and Jacard index, are used in aquatic environments as bioindicators of water quality **(Goździejewska *et al.*, 2024)**. Therefore, several local and international authors surveyed a zooplankton group to detect environmental stress, such as **Al-Bahathy and Nashaat (2021)**, **Nashaat *et al.* (2021)**,

Nashaat and Al-Bahathy (2022a), **Fefilova *et al.* (2023)**, **Souley *et al.* (2023)**, **Al-Bahathy *et al.* (2024)**, and **Chertoprud *et al.* (2024)**.

Since, there is a large gap in documenting data on the presence and abundance of zooplankton species in the MOD river. The present study aimed to document Copepod's species in the river and to evaluate the effect of the Dalmaj Marsh discharge canal on the ecological indices of Copepod's communities and the water quality of the river. The CCME-WQI is used to evaluate the quality of the river water for aquatic life protection.

MATERIALS AND METHODS

Study area

The MOD River was constructed in 1992 and used to dump effluents from croplands and industrial sources along a 565km length from Iraq’s middle to southern lands. Therefore, the river water is brackish and populated with few organisms. It is rarely used for drinking, irrigation and fishing, and no villages near it depend on its water for any purpose **(Shahadha & Salih, 2021)**.

The study was conducted in the eastern section of the river at Al-Qadisiya Government. Samples were collected seasonally in 2023, from three sites, as shown in Table (1) and Fig. (1). Table (2) represents the rates of water discharges for the MOD River, where there is an interesting increase in Water Discharges in winter.

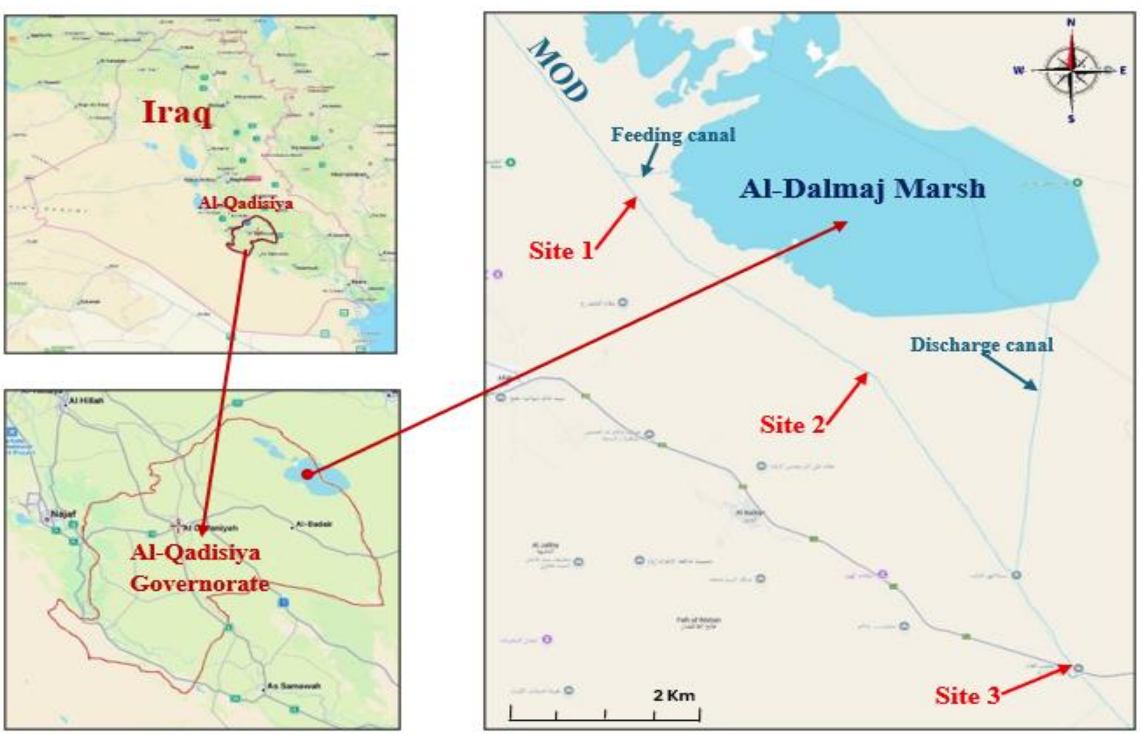

Fig. 1. Map of the study area

Table 1. GPS coordinates of sites of the study area

Sites	GPS coordinates
Site1	(32.449723"N), (45.104582"E)
Site2	(32.061076"N) (45.497721"E)
Site3	(31.86508"N) (45.63843"E)

Table 2. The rates of water discharges for the MOD River (Ministry of Water Resources, 2023; personal communication)

Water Discharges m^3/sec	Winter	Spring	Summer	Autumn
Site1	4	1	0.6	0.58
Site2	3.13	0.9	0.53	0.51
Site3	1	0.3	0.51	0.4

Sampling methods

Copepods sampling was done by filtering 40L of water using a mesh with pores 55µm. Then, it is preserved by a formalin solution of 4%. The Copepods taxa were identified by a compound microscope with magnification X100 **(Tranter *et al.*, 1981)**. Identification was performed using the diagnostic key of **Edmondson (1959)** and **Błędzki and Rybak (2016)**. The water was taken in plastic bottles and then tested, according to **APHA (2017)**.

Calculation of CCME-WQI

Eight parameters (Water temperature (WT), turbidity, total dissolved solids (TDS), pH, dissolved oxygen (DO), biological oxygen demand (BOD_5), NO_3, and PO_4) were derived seasonally in 2023. Then, the Canadian Index was calculated by comparison of parameter values with guidelines for aquatic life protection. The index values classified as Excellent with range of 95–100, Good with range of 80–94, Fair with range of 65–79, Marginal with range of 45–64, Poor with range of 0–45. The detailed formulation of the WQI mentioned in **Das (2025)**.

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RESULTS

1. Water variables

Table (3) shows the ranges of parameters for the study sites. "No remarkable seasonal variation was observed in the values of pH, water temperature, and NO_3, which ranged between 7.22–7.50, 30–36 °C, and 0.05–0.1 mg/L, respectively. Dissolved oxygen levels ranged from 5.6 to 11.7 mg/L. All measured values remained within the acceptable guidelines for aquatic life.

All samples noted that turbidity values exceeded the acceptable values for aquatic life protection limit, according to **CMME (2018)**. The range of turbidity values was 31.82- 39.47 mg/l.

DO, BOD_5, and TDS were not within the acceptable limits for aquatic life protection. TDS and BOD_5 had higher levels during the summer in the study sites, and high values coincided with low discharges in summer and vice versa in winter, as agreed with a study of the river in the same area by **Al-Zaidy (2021)**.

Table 3. The values of water quality variables for the river (the first line represents mean and standard deviation; the second line represents min and max)

Parameters	**Observed Values**			**Guidelines for aquatic life protection**
	St.1	St.2	St.3	
WT(C°)	30.5±8.5 20-40	32.5±8.34 22-42	34.5±8.81 24-45	15
Turbidity (NTU)	32.5±11.2 23.1-48.8	31.825±15.32 15.5-48.5	39.47±12.3 30.2-57.2	5
TDS (mg/l)	8008.25±2512.03 5141.5-11167.5	9841.12±3845.2 5564-14452.5	20636.87±9233 9457.5-31500	500
pH	7.225±0.18 7.1-7.5	7.25±0.31 7-7.7	7.5±0.4 7.1-7.9	6.5-8.5
DO (mg/l)	5.2±3.67 1.1-9.6	4.91±2.38 2.5-7.65	5.65±1.79 3.9-8.1	7.25
BOD_5 (mg/l)	11.62±8.0 4.2-22	11.05±7.16 3.3-20	9.42±6.7 4.1-19	-
NO_3 (mg/l)	7.089±1.68 2.67-9.29	5.685±0.29 5.28-5.96	11.70±4.56 5.86-15.8	15
PO_4 (mg/l)	0.15±0.09 0.07-0.27	0.07±0.02 0.045-0.09	0.05±0.06 0.009-0.15	0.1

2. CCME-WQI

CCME-WQI of two sites (sites 1 & 3) were poor quality with values < 45. While Site 2 had marginal water quality because it fell within the range of 45–64 (Fig. 2).

TDS, BOD_5, turbidity, and DO were the largest contributors to the poor quality of the river. The failed tests were due to the MOD river being used to discharge the agricultural effluents, as stated in the study of the river by **Khuhawar *et al.* (2023)**. Moreover, a study by **Xu *et al.* (2019)** for the Dan River basin in China stated the negative correlation of low DO levels with high TDS levels.

Fig. (2) shows the spatial variation in CCME-WQI. The higher value of the index was at the first site. While. The lower CCME-WQI value was at the last site (site 3). The double concentrations of TDS in site 3 resulted from water in the marsh discharge canal. The higher concentration of TDS in the marsh can be caused by the higher evaporation rate related to the shallow marsh water **(Casamitjana *et al.*, 2019)** or due to the inflow of groundwater with a high content of dissolved solids into the Dalmaj Marsh, which is transported to the river through the drainage channel **(Guimond & Tamborski, 2021)**.

Finally, our findings proved that the Al-Dalmaj Marsh Discharge Canal affected the river's water quality, especially at site 3 (downstream of the Marsh Canal) of the MOD River, which was of lower quality compared with sites 1 and 2, as explained above.

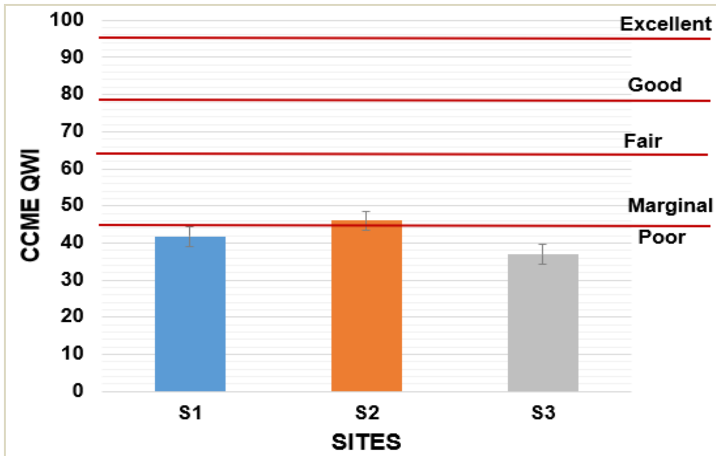

Fig. 2. The spatial variation of CMME-WQI for the protection of aquatic life purpose

3. Ecological indices of copepods community

3.1. The density of Copepoda

The density of Copepoda varied between a lower density 22 Ind.* m^{-3} for *Nauplii* of Copepoda during the winter season at site 3, and a higher value reached 120000 Ind.* m^{-3} for the same taxa during the winter season at the same site, as shown in Fig. (3).

Temporal variations of copepod density showed that two peaks in the winter and autumn may coincide in winter with optimal conditions of high water discharge, as shown in Table (2) which is the same result reported by **Branco *et al.* (2018)**. At the same time, the higher copepods' densities were in the autumn season because of an increment in phytoplankton growth and organic matter and suitable water temperature **(Nashaat *et al.*, 2021)**.

The spatial densities of Copepoda, as shown in Fig. (3), were highest at station 3, located downstream at the confluence of the Al-Dalmaj Canal and the river, compared to stations 1 and 2. This may be attributed to copepod groups being positively influenced by dissolved oxygen (DO) and salinity in brackish water **(Rahman, 2022)**.

This result was supported by some studies that confirmed that the Copepod's densities raised with the higher TDS values in the meeting site, the river with the tributaries had more TDS values, for example, **Abbas *et al.* (2017)** studied the effect of Diyala River on Copepoda in Tigris River. Moreover, **Majeed *et al.* (2022)** examined the effect of the AL-Tharthar River on Copepod's communities in the Tigris River. Similarly, **Nguyen *et al.* (2020)** studied zooplankton in the Mekong Delta in Vietnam, where their results indicated that a slight increase in salinity could drastically break down the zooplankton community as rotifers and cladocera predominated in the water of less than five, while copepods dominated all salinities of more than five.

Finally, our findings proved that the Al-Dalmaj Canal affected Copepod densities in the downstream meeting site of the Canal with the MOD river (site 3), which had higher copepod densities compared with sites 1 and 2 as explained above.

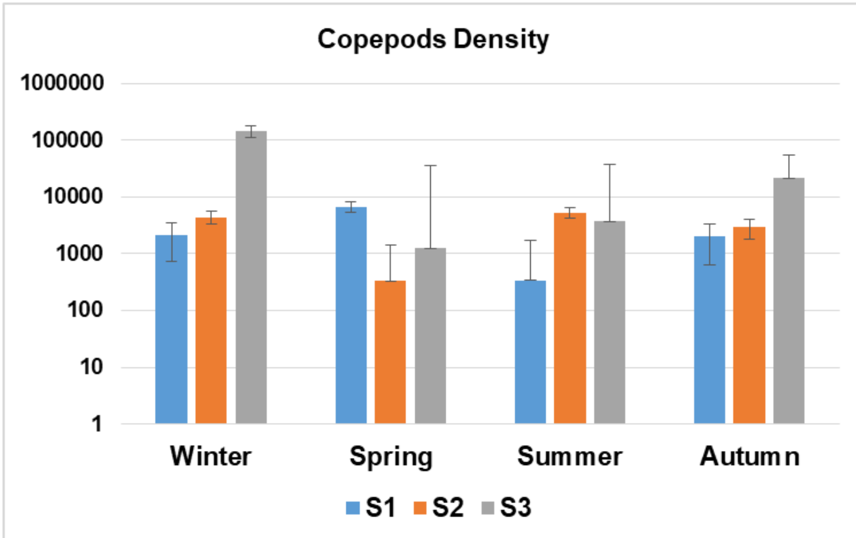

Fig. 3. Total densities of Copepods

3.2. The diversity of Copepoda

The diversity of Copepoda varied between a lower value of 0.271 bit/Ind during the autumn season at site 1. The highest value reached 1.543 during the same season at site 3 (Fig. 4).

Table (5) shows that the river contained 22 Taxa. The few species of the brackish water for the MOD river may be due to the fact that salinity is considered the main factor influencing changes in the assemblage's species and abundance of Copepods where it is predicted to be greater when salinity levels are nearer to that of freshwaters or marine waters than in brackish waters areas **(Paavola *et al.*, 2005; Chertoprud *et al*., 2023)**.

Temporal variations of Copepod's diversity values showed that the spring season had higher diversity values in the study period due to suitable water temperature for egg hatching, which coincided with the spring season **(Nashaat & Al-Bahathy, 2022a)**.

Fig. (4) and Table (5) show the spatial variation of diversity values. The highest diversity and taxa number values were at station 3 downstream of the convergence of the discharge canal with the MOD River.

In general, the highest salinity conditions led to the Copepods being higher in both species number and diversity in site 3 compared to sites 1 and 2 **(Nguyen *et al.*, 2020)**.

These findings were consistent with studies in local and different areas of the world. **Rabee (2010)** studied the effect of the Tharthar River on zooplankton groups in the Euphrates River in Iraq. Moreover, **Zhao *et al.* (2023)** studied zooplankton groups in the Genhe River and Genheyuan wetlands of northeast China.

Finally, the findings of the current study and the previous studies proved that Al-Dalmaj Marsh Discharge Canal affected on Copepod diversity, especially at site 3 of the MOD River (downstream the Marsh Canal), which was higher in site 3 compared with sites 1 & 2 as explained above **(Nguyen *et al.*, 2020)**.

Table 4. The mean values of Copepod density and diversity

Indices	Site1	Site2	Site3
Density (Ind.* m^{-3})	2773.82	3238.62	42067.38
Diversity Index (Shanon-weiner Index) bit/Ind	0.90	0.81	1.12

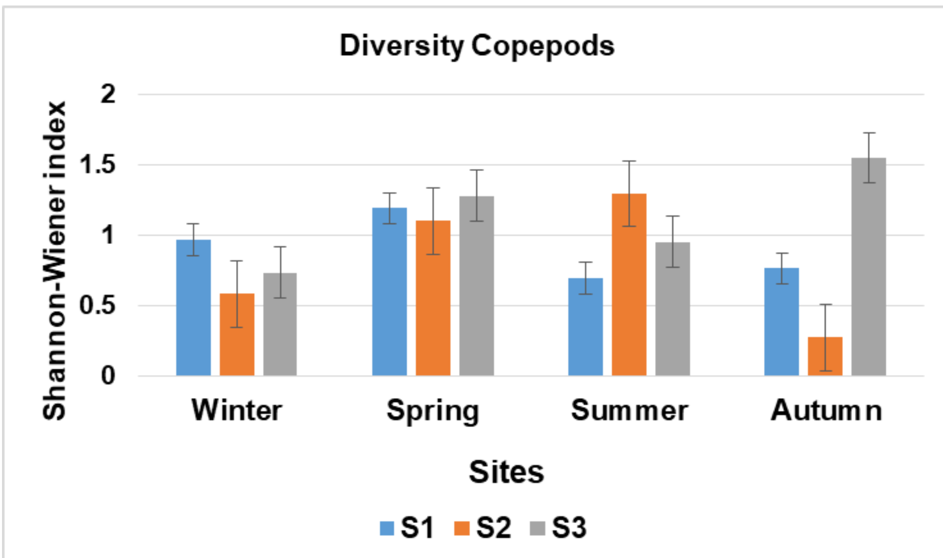

Fig. 4. Shannon-Wiener index (Diversity Index) H of Copepods

Table 5. Taxa numbers of Copepods

Sites	Number of Taxa			
	winter	spring	summer	Autumn
S1	9	6	2	4
S2	9	3	5	2
S3	13	4	3	7

Table (6) shows that the highest occurrence taxa of Copepods in the MOD River were *nauplii*; despite their weaker sensory, swimming capabilities, smaller size, and primitive feeding, nauplii fed on a wide range of cell sizes and consumed many of the same phytoplankton species as adults **(Vogt *et al.*, 2013)**.

Moreover, *Cyclops* sp. and *Cyclops* (♂) had high occurrences at most or all sites of the river due to it having evolved adaptations to survive seasonally abnormal environmental conditions by reducing their metabolic activity either as a late crustacean stage or as an egg, allowing them to colonize extreme habitats such as the brackish river **(Thorp & Rogers, 2015)**.

T**able 6.** The occurrence of Copepoda taxa

	Copepoda	Site1				Site2				Site 3			
		Winter	Spring	Summer	Autumn	in Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn
	Cylopoida												
1	*Cyclops exiliss* Coker, 1934		+			+				+	+	+	+
2	*Cyclops vernalis* Fischer, 1853									+			
3	*Diacyclops languidoides* Monchenko, 1980									+			
4	*Cyclops venustoides* Coker, 1934									+			
5	*Ectocyclops phaleratus* (Koch, 1838)					+				+			
6	*Eucyclops agilis* Koch,1838	+						+					
7	*Eucyclops macrurus* (Sars, 1863)					+			+				
8	*Halicyclops* sp.									+		+	+
9	*Macrocyclops albidus* ((Jurine,1820)				+								
10	*Mesocyclops hylalinus* ((Rehberg, 1880)	+			+					+			
11	*Paracompus reggiae* (Wilson M. S., 1958)	+											
12	Paracyclop fimbrituspoprei s (Fischer, 1853)									+			
13	Tropocyclops prosinus (Fischer, 1860)					+							
14	*Cyclops* (♂)	+	+			+				+			+
15	*Cyclops* sp.	+			+	+	+	+		+			
16	Immatur Cyclop	+	+	+						+			+
	Harpacticoida												
17	*Nannopus palustris* Brady, 1880					+	+	+					
18	*Nitocra lacustris* (Schmankevitch, 1875)	+	+							+	+		+
19	*Nitocra* sp.					+							
20	Immature Harpacticoida							+			+		+
21	Nauplii of Copepoda	+	+			+	+	+	+	+	+	+	+
22	*Ergasilus* Nordmann, 1832	+	+	+	+								

3.3. The similarity index

The similarity index measures the similarity correlation of the taxonomic group's occurrence for fauna in the study area **(Nogueira *et al.*, 2017)**.

Table (7) shows low similarity values among the study sites. However, the lowest similarity value for Copepoda communities was between sites 1 and 3 (3%). This may return to site 3 situated under the effect of the marsh discharge canal, which made it less similar compared with site 1, as well as the distance between them (Fig. 5).

Table 7. The similarity index of Copepoda taxa in the MOD river

Step	Clusters	Distance	Similarity	Joined 1
1	2	88.13071	11.86929	2
2	1	93.35213	6.647873	1
Similarity Matrix				
	S 1	S 2	S 3	
S 1	*	6.6479	3.0311	
S 2	*	*	11.8693	
S 3	*	*	*	

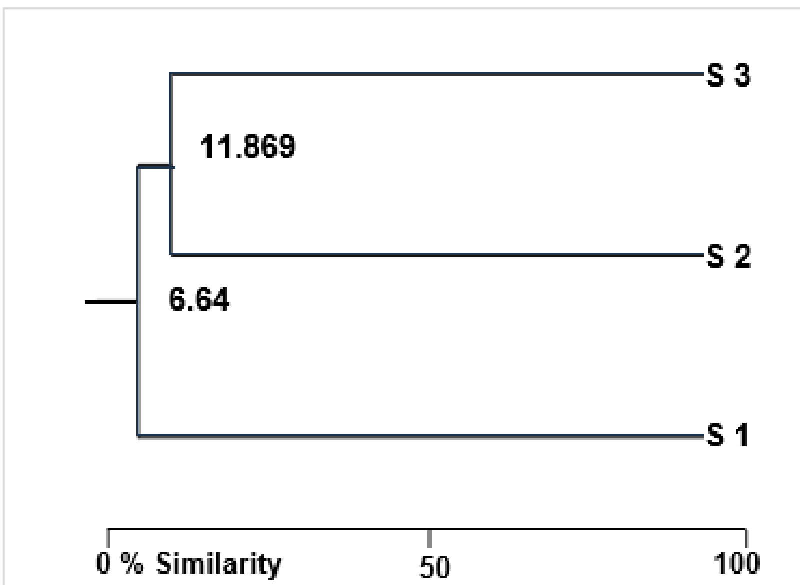

Fig. 5. The similarity index of Copepoda taxa in the MOD river

This finding agreed with **Majeed *et al.* (2022a)**, which found that the lowest value of the similarity index for zooplankton was in a site located under the Tharthar Canal that was characterized by higher TDS in comparison to the Tigris River.

4. Principal component analysis (PCA)

PCA was computed to identify the most important parameters that have a significant effect on water quality in the MOD River by giving the highest degree of factor significance in the test. There are graded classes of PC: strong, moderate, and weak (>0.75, 0.50-0.75, and 0.30-0.50, respectively) **(Teixeira de Souza *et al.*, 2021)**. During analysis, it was chosen to eliminate loading less than 0.5 because it was considered the least affected on the water quality. Two components were extracted from PCA, the first component loaded heavily on TDS and PO_4; These factors are thought to be the most crucial parameters that have the biggest effects. Meanwhile, NO_3, WT, and pH have moderate effects. TDS was the first important factor that had a significant or strong effect on water quality (0.885) and the only parameter that has a uniqueness value (0.133) less than 20%, where the uniqueness of 0.2 indicates that 20 % variable's variance is not shared with other variables in the overall factor analysis, the more 'uniqueness' a variable has, the less significant it is in the factor analysis **(Hofmann, 1978)**, as shown in Table (8) and Fig. (6) (in Fig. 6, the green line represents the positive loading, while the red line shows a negative loading and the line gets thicker whenever PC becomes close to +1 or -1, showing a strong correlation.). The presence of salts causes TDS, and surface water in southern Iraq suffers from pollution by salinity, which is demonstrated by several studies **(Abdullah *et al.*, 2019; Al-Taee *et al.*, 2024; Al-Waeli *et al.*, 2024; Al-Ziyadi *et al.*, 2024)**. In general, the main issue that Iraqi surface water deals with is salinity, but the situation is worse in the south for a lot of reasons, like an increase in temperature and shortage of water discharge, in addition to an increase in agricultural activity that also lead to increase the concentration of the second parameter which is PO_4 (-0.813), where an increase of PO_4 in water can cause eutrophication that leads to excessive growth of algae and aquatic plant, which eventually can destroy the aquatic system **(Akinnawo, 2023)**.

PC2 was loaded heavily on BOD_5 and turbidity (-0.879 and 0.874), which can indicate the effect of industrial activity that can discharge their effluent directly to the water bodies, where BOD_5 and turbidity are the main waste for many industries **(Wadeea *et al.*, 2022)**.

Table 8. Component loadings for the water quality parameters under the study

Parameters	PC1	PC2	Uniqueness
TDS	0.885		0.133
PO_4	-0.813		0.343
NO_3	0.717		0.489
W.T.	0.641	-0.479	0.289
pH	0.573		0.588
BOD_5		-0.879	0.197
Turbidity		0.874	0.224
DO		0.623	0.389

Note. Applied rotation method is promax.

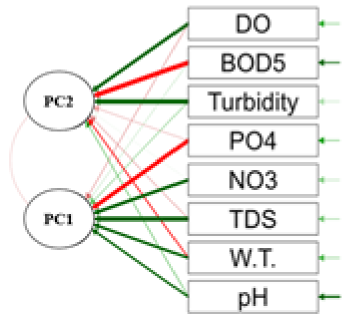

Fig. 6. Component loading diagram of water quality parameters of the study

5. Cluster analyses for water quality parameters

The dendrogram in Fig. (7) indicates two clusters for physicochemical parameters in the river water sites during the study period. The first cluster (Group 1) included two sub-clusters (Fig. 7):

1. Subgroup A: includes pairs of TDS-NO_3. The results showed closely highest concentrations (31500 and 15.8 mg/L) respectively, were recorded at St.3. Also, a single one-sub cluster of pH, which referred to the lowest concentration (7.9 mg/L) at St.3 (Table 3).

2. Subgroup B: pairs of WT-BOD_5. In these parameters, the highest concentration (45 ◦C and 22 mg/L) at St.3 and St.1, respectively, was recorded (Table 3).

The second cluster (Group 2) included two sub-clusters:

1. Subgroup A: pairs Turbidity-DO record the highest concentration of (57.2 NTU) and DO (9.6 mg/L) at St.3 and St.1, respectively (Table 3).

2. Subgroup B: a single sub-cluster of PO_4 parameters, which obtained the highest concentration (0.27 mg/L) at St.1 (Table 3).

A clear variation was observed for physicochemical parameters in river water sites, in which the highest values for pH, WT, Turbidity, NO^-_3 and PO_4 at St.3 were recorded, then the guidelines for aquatic life protection. As for the temperature, its rise in site 3 is because it is collected in the last stage of the sample collection process, after the temperature rises. The daily levels of pH are greatly influenced by water alkalinity, increased photosynthesis by plants and algae use hydrogen, which increases pH levels. This explains the higher pH values in site 3 **(El Nahhal *et al.*, 2021)**. The highest values for turbidity, NO^-_3 and PO_4 may be due to it being affected by water coming from the discharge canal of Al-Dalmag Marsh that met with the Main Outfall Drain in a site called the Waterfall Site about 2 km before Site 3, the fluxes of Al-Dalmag Marsh water contained higher content of Turbidity NO^-_3 and PO_4 **(Casamitjana *et al.*, 2019)**. PO_4 has been separated from the rest of the parameters in a single group, and this may indicate that the source of PO_4 is different from the rest of the other sources, which could be from the detergents that were widely used after the COVID-19 pandemic **(Al-Ani *et al*., 2019; Hashemi *et al.*, 2023)** or the use of a certain type of pesticide that Phosphorous is one of its components **(Liu *et al.*, 2021; Majeed *et al.*, 2022b)**.

Also, at St.1, the highest values were recorded for BOD_5, DO and PO_4, which indicates the industry activities. TDS and the presence of ions like PO_4 represent salinity negatively correlated with DO, reducing oxygen solubility **(Thomas, 2021)**. High levels of BOD_5 in river water indicate a high concentration of organic pollutants, which can come from sources such as sewage discharge, agricultural runoff, and industrial waste, which means an excess of biodegradable organic matter, often from human and animal waste, decaying vegetation, or industrial effluents **(Bouhafa *et al.*, 2020; Jamalianzadeh *et al.*, 2022)**.

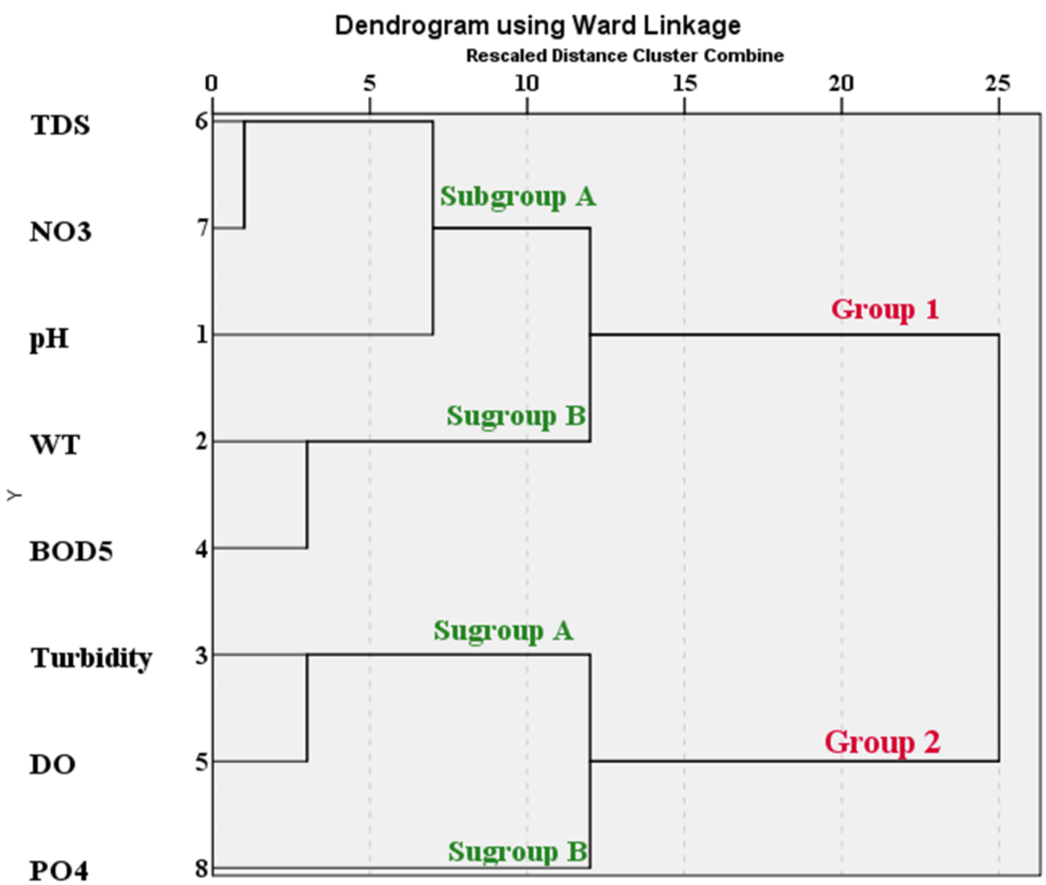

Fig. 7. Dendrogram using Ward linkage

CONCLUSION

It is concluded that the MOD River contains brackish water of poor to marginal quality. In general, TDS, BOD_5, and turbidity were the most influential parameters contributing to the degraded water quality, largely due to the river being used for the disposal of agricultural effluents. Spatial variation indicated that the CMME-WQI recorded its lowest values at Site 3 compared to other sites. This may be attributed to the approximately double concentrations of TDS and turbidity at Site 3, likely influenced by the water from a discharge canal that enters the river about 2 km upstream of this location.

The Copepoda community exhibited the highest densities and diversity at Site 3 relative to Sites 1 and 2. This suggests that the discharge canal has a significant impact on Copepoda populations, particularly at Site 3, where brackish water with elevated salinity and dissolved oxygen (DO) levels appears to favor their abundance. The limited number of species in the MOD River may be due to the influence of salinity, which is considered a key factor affecting both species richness and copepod abundance. Species numbers and abundance tend to increase when salinity levels approach those of either freshwater or marine environments, rather than in intermediate brackish conditions.

Furthermore, the lowest similarity index was observed between Sites 1 and 3, reflecting the pronounced effect of the marsh discharge canal on the river's copepod community. Among Copepoda, Nauplii, *Cyclops* sp., and male *Cyclops* were the most abundant. Nauplii thrive due to their ability to feed on a broad range of phytoplankton cell sizes, similar to adults, while *Cyclops* sp. and *Cyclops* (♂) are capable of surviving under seasonal and environmentally stressful conditions.

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