University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii 25.

Zooplankton as Bioindicators for Assessing the Ecological Status of Kiteiban Canal on Shatt al-Arab, Basra, Iraq

Mhmood A. Chaloob and Naeem S. Hamady

[1]**Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah**
Mhmood.abdulzahra@uobasrah.edu.iq

I. Abstract

This study assessed the ecological status of the Kiteiban Canal, one of the irrigation canals connected to the Shatt Al-Arab River in Basra, southern Iraq, using zooplankton communities as qualitative bioindicators. Zooplankton samples were collected seasonally from three sampling stations representing upstream, midstream, and downstream sections of the canal. Species composition, frequency of occurrence, and dominance patterns were analyzed rather than numerical density, and taxa were classified according to their ecological tolerance into tolerant, moderately tolerant, and sensitive groups.

The results revealed a clear dominance of pollution-tolerant taxa, particularly Rotifera (Brachionus, Bdelloidea, Asplanchna), Protozoa, and Nematoda across all stations, indicating organic pollution and nutrient enrichment. Moderately tolerant taxa such as Cladocera (Daphnia, Moina) and some rotifer genera showed limited to moderate occurrence, while sensitive taxa, including Calanoida, Harpacticoida, and Ostracoda, were weakly present or absent, especially at the midstream station. Spatial variations in community structure reflected differences in environmental stress along the canal, with the highest degradation observed at Station 2.

The findings demonstrate that qualitative analysis of zooplankton community structure is an effective and ecologically meaningful approach for assessing environmental stress in irrigation canals. This study highlights the value of zooplankton as reliable bioindicators and provides a scientific basis for future monitoring and sustainable management of freshwater resources in the Shatt Al-Arab system.

Keywords : *Zooplankton; Bioindicators; Ecological status; Irrigation canal; Organic pollution; Kiteiban Canal; Shatt Al-Arab; Water quality; Freshwater ecosystems*

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II. Introduction

Aquatic ecosystems are highly dynamic systems that respond rapidly to both natural variability and anthropogenic pressures. Rivers, canals, and irrigation channels are particularly vulnerable to environmental degradation due to agricultural runoff, domestic wastewater discharge, and hydrological alterations, which collectively affect water quality and ecological stability (Wetzel, 2001; Allan et al., 2021). These pressures often lead to changes in nutrient dynamics, oxygen availability, and habitat conditions, ultimately influencing the biological communities inhabiting these systems (Bellinger & Sigee, 2010).

Conventional assessments of water quality are primarily based on physicochemical parameters such as temperature, salinity, dissolved oxygen, and nutrient concentrations. Although these measurements provide valuable information about the immediate condition of aquatic environments, they do not adequately reflect the cumulative and long-term impacts of environmental stressors on ecosystem functioning (Ravera, 1980; Reynolds, 2006). As a result, biological indicators have been increasingly adopted as complementary tools, as they integrate environmental effects over time and provide a more realistic assessment of ecological status (Bellinger & Sigee, 2010).

Zooplankton represent a fundamental biological component of aquatic ecosystems and play a central role in trophic energy transfer between primary producers and higher trophic levels, including fish. Their short life cycles, rapid population turnover, and high sensitivity to environmental changes make them particularly suitable as bioindicators of water quality and ecosystem health (Lampert & Sommer, 2007; Dodson et al., 2000). Changes in zooplankton species composition and community structure often reflect variations in nutrient availability, temperature regimes, and pollution levels within aquatic systems (Gyllström et al., 2005).

Several studies have demonstrated that nutrient enrichment, especially nitrogen and phosphorus inputs, strongly influences zooplankton communities through its effect on phytoplankton productivity. Under eutrophic or organically polluted conditions, zooplankton assemblages are frequently dominated by tolerant taxa such as Rotifera and Protozoa, while sensitive groups, including large-bodied Cladocera and Calanoida, tend to decline (Ravera, 1980; Smith et al., 1999; Jeppesen et al., 2005). Therefore, the dominance patterns and presence–absence of specific zooplankton taxa can be effectively used to diagnose ecological stress and trophic status.

Environmental factors such as temperature, salinity, dissolved oxygen, and light availability further regulate zooplankton distribution and community dynamics. Seasonal fluctuations in these variables can induce pronounced shifts in zooplankton assemblages, reflecting changes in metabolic activity, reproduction, and food availability (Sommer et al., 1986; Lampert & Sommer, 2007). Consequently, the analysis of zooplankton community structure provides valuable insight into both temporal and spatial variations in ecosystem condition (Gyllström et al., 2005).

The Shatt Al-Arab River system in southern Iraq has received considerable scientific attention due to its ecological and socioeconomic importance. Previous studies have reported substantial spatial and seasonal variability in zooplankton density and composition, closely linked to changes in environmental factors and water quality (Abbas et al., 2014; Maytham et al., 2019). These investigations highlighted the effectiveness of zooplankton as indicators of environmental change and anthropogenic disturbance within the river system.

Kiteiban Canal, one of the irrigation canals connected to the Shatt Al-Arab River in Basra Governorate, is subject to multiple environmental pressures, including nutrient enrichment from agricultural activities and seasonal fluctuations in hydrological and physicochemical conditions. Recent research conducted in the canal demonstrated clear seasonal variations in water quality parameters and zooplankton density, with a strong positive relationship between nitrate concentrations and zooplankton abundance (Chaloob & Hammadi, 2025). These findings suggest that the canal ecosystem experiences varying degrees of environmental stress that are reflected in its biological communities.

Despite the availability of studies focusing on zooplankton density in Kiteiban Canal, limited attention has been given to the use of **zooplankton species composition and community structure** as direct bioindicators of ecological status. Density-based assessments alone may mask important ecological signals, particularly when tolerant species dominate under stressed conditions (Ravera, 1980; Bellinger & Sigee, 2010). Therefore, evaluating zooplankton communities based on species occurrence, dominance patterns, and taxonomic composition provides a more comprehensive and ecologically meaningful approach to environmental assessment (Dodson et al., 2000; Jeppesen et al., 2005).

Accordingly, the present study aims to assess the ecological status of Kiteiban Canal using zooplankton as bioindicators, with particular emphasis on species composition and community structure. By examining the distribution and dominance of tolerant, moderately tolerant, and sensitive zooplankton taxa across different sampling stations, this study seeks to identify environmental stress signals and spatial variations in ecological condition. The outcomes of this research are expected to contribute to a better understanding of ecosystem functioning in irrigation canals connected to the Shatt Al-Arab system and to support future monitoring and sustainable management of aquatic resources in southern Iraq.

III. Materials and Methods

Study Area

The present study was conducted in the Kiteiban Canal, one of the irrigation canals connected to the Shatt Al-Arab River in Basra Governorate, southern Iraq. The canal plays an important role in supporting agricultural activities in the surrounding areas and is therefore exposed to various anthropogenic pressures, including agricultural runoff and seasonal fluctuations in freshwater input. These factors contribute to variations in physicochemical conditions and biological communities within the canal (Chaloob & Hammadi, 2025).

Three sampling stations were selected along the canal to represent different environmental conditions. Station 1 was located near the connection point with the Shatt Al-Arab River, Station 2 was situated in the midsection of the canal, and Station 3 was located at the downstream end of the canal. This spatial design allowed for the assessment of longitudinal variations in zooplankton community structure in response to changing environmental conditions, as recommended in previous studies on riverine and canal ecosystems (Maytham et al., 2019; Allan et al., 2021).

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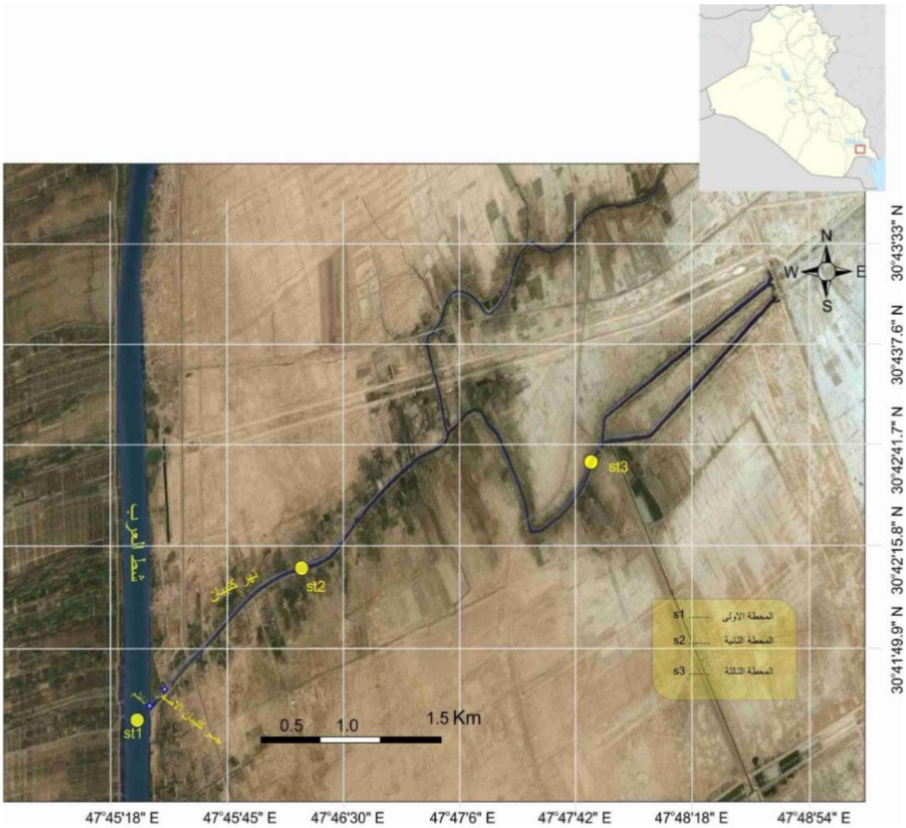

Sampling Design

Zooplankton samples were collected seasonally to capture temporal variations in community composition associated with environmental fluctuations. Seasonal sampling is widely recognized as an effective approach for detecting ecological changes in aquatic systems, particularly in regions characterized by pronounced seasonal variability in temperature, nutrient availability, and hydrological conditions (Sommer et al., 1986; Lampert & Sommer, 2007).

Sampling was conducted at all three stations during each sampling period under comparable hydrological conditions to minimize sampling bias. The sampling strategy focused on obtaining representative zooplankton assemblages rather than absolute population densities, in line with the objectives of using zooplankton as bioindicators of ecological status (Bellinger & Sigee, 2010).

Zooplankton Collection and Preservation

Zooplankton samples were collected using a plankton net with a mesh size of 50 µm, which is suitable for capturing major zooplankton groups, particularly Rotifera, Cladocera, and Copepoda. The net was towed horizontally for a standardized distance at the water surface, following commonly applied methods in similar regional studies (Abbas et al., 2014; Chaloob & Hammadi, 2025).

After collection, samples were concentrated and immediately preserved in labeled polyethylene bottles using 4% formalin solution to ensure proper fixation and prevent post-collection degradation. Preservation procedures followed standard zooplankton sampling protocols to maintain the integrity of morphological characteristics required for accurate taxonomic identification (APHA, 2005; Lampert & Sommer, 2007).

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Taxonomic Identification

Zooplankton organisms were identified under a compound light microscope using standard taxonomic keys and reference literature. Identification was carried out to the lowest possible taxonomic level, preferably species level, particularly for Rotifera, Cladocera, and Copepoda, as species-level identification enhances the reliability of bioindicator-based assessments (Bellinger & Sigee, 2010; Hammadi, 2019).

The recorded taxa were classified into major zooplankton groups, including Rotifera, Cladocera, Copepoda, Ostracoda, and other miscellaneous groups such as Protozoa and Nematoda. Taxonomic nomenclature followed internationally accepted classifications to ensure consistency with previous studies conducted in the Shatt Al-Arab region (Abbas et al., 2014; Maytham et al., 2019).

Assessment of Zooplankton as Bioindicators

Zooplankton were used as bioindicators of ecological status based on species composition, frequency of occurrence, and dominance patterns rather than numerical density. The relative occurrence of each species at each station was categorized into qualitative abundance classes: absent (–), low occurrence (+), moderate occurrence (++), and high occurrence (+++). This approach is suitable when the objective is to evaluate ecological condition through community structure and species tolerance rather than population size (Ravera, 1980; Bellinger & Sigee, 2010).

Species were further grouped according to their known ecological tolerance into tolerant, moderately tolerant, and sensitive taxa based on published ecological literature. The dominance of tolerant species, particularly Rotifera and Protozoa, was interpreted as an indication of environmental stress or eutrophic conditions, whereas the presence and relative occurrence of sensitive taxa, such as certain Cladocera and Calanoida, were considered indicators of better ecological conditions (Ravera, 1980; Jeppesen et al., 2005).

Data Analysis and Ecological Interpretation

The ecological status of the Kiteiban Canal was evaluated through qualitative analysis of zooplankton community structure across sampling stations. Emphasis was placed on comparing species richness, dominance patterns, and the presence or absence of indicator taxa among stations. This community-based approach provides an integrated assessment of environmental conditions over time and is widely applied in ecological monitoring studies (Dodson et al., 2000; Gyllström et al., 2005).

Spatial variations in zooplankton assemblages were interpreted in relation to the longitudinal position of each station along the canal and potential differences in environmental stress. The results were discussed in the context of previous studies conducted in the Shatt Al-Arab system and similar aquatic environments in southern Iraq (Maytham et al., 2019; Chaloob & Hammadi, 2025).

IV. Results and Discussion

The environmental condition of the Katiban Canal was assessed using a **qualitative community-based bioindicator approach**, which focuses on the composition, presence, and dominance patterns of zooplankton species. Due to the **ordinal nature** of the data (+/++/+++), quantitative diversity indices such as Shannon or Simpson were not applied, as their use on rank-based data can produce misleading results (Wetzel, 2001; Bellinger, 2018). Instead, species were categorized according to **pollution tolerance**, and dominance patterns were analyzed to interpret the ecological status across different sampling sites.

Analysis revealed a **clear dominance of pollution-tolerant taxa**, including rotifers (Brachionus, Asplanchna, Bdelloidea), protozoa, and nematodes, consistently scoring (+++) in several locations. Intermediate-tolerant taxa such as Cladocera (Daphnia, Moina), Keratella, and Polyarthra showed moderate presence (++), while sensitive taxa including Calanoida, Harpacticoida, and Ostracoda were weakly present (+) or absent (–). This pattern indicates **substantial organic pollution and nutrient enrichment**, as dominant resistant species and scarce sensitive species are well-established qualitative indicators of environmental stress (Hamer et al., 2019; Corkum et al., 1998). The predominance of eggs and larval stages compared to adults further reflects **altered reproductive dynamics and stress impacts**, which aligns with previously documented responses of zooplankton to organic loading and eutrophication (Wetzel, 2001; Bellinger, 2018; Hamer et al., 2019).

Site-Specific Patterns

Table 1. Dominance of zooplankton taxa across Katiban Canal sampling sites

Taxa/Group	Site 1	Site 2	Site 3	Tolerance	Environmental Interpretation
Brachionus (Rotifera)	+++	+++	++	Resistant	Indicates high organic pollution and nutrient enrichment
Asplanchna (Rotifera)	++	+++	++	Resistant	Dominance reflects eutrophication
Bdelloidea (Rotifera)	+++	+++	+++	Resistant	Highly tolerant to environmental stress
Protozoa	+++	+++	+	Resistant	Presence indicates elevated organic load
Nematoda	++	+++	++	Resistant	Confirms anthropogenic impacts
Daphnia (Cladocera)	++	+	+	Intermediate	Moderate tolerance; decline reflects environmental stress
Moina (Cladocera)	+	++	+	Intermediate	Reduced presence indicates nutrient-driven imbalance
Keratella	++	+	++	Intermediate	Transitional taxa, responsive to moderate stress
Polyarthra	+	++	+	Intermediate	Indicates fluctuating environmental conditions
Calanoida (Copepoda)	+	–	+	Sensitive	Weak presence indicates ecological degradation
Harpacticoida	+	+	–	Sensitive	Sensitive to organic pollution; decline confirms stress
Ostracoda	–	+	–	Sensitive	Absence indicates low ecological quality

Note: + = limited tolerance; ++ = moderate presence; +++ = dominant.

Site 1 displayed a relatively balanced community dominated by tolerant species (+++), including rotifers and protozoa, with moderate presence of intermediate taxa (++), and weak occurrence of sensitive species, indicating **moderate environmental impact** from nutrient enrichment and organic load.

Site 2 exhibited the highest dominance of tolerant taxa (+++), with minimal presence of intermediate taxa (+) and almost complete absence of sensitive species (–), reflecting **severe anthropogenic stress**, likely from domestic and agricultural wastewater inputs (Corkum et al., 1998; Hamer et al., 2019).

Site 3 presented a slightly more balanced pattern: tolerant species remained dominant, some intermediate taxa were moderately present (++), and one sensitive species appeared (+), suggesting **less severe, but still significant environmental stress**.

The general pattern across all sites—**dominance of resistant species, moderate presence of intermediate taxa, and scarcity of sensitive species**—is consistent with previously reported ecological responses to eutrophication and organic pollution in freshwater systems (Wetzel, 2001; Bellinger, 2018; Hamer et al., 2019; Corkum et al., 1998; Reynolds, 2006; Dodson et al., 2005).

Implications for Bioassessment

The **qualitative community-based approach** proves highly effective for detecting ecological stress in the Katiban Canal, especially in cases where numerical abundance data may be unreliable. Focusing on **species presence, dominance, and absence** allows for early detection of environmental degradation, assessment of nutrient enrichment impacts, and guidance for monitoring and remediation efforts. By avoiding inappropriate use of quantitative diversity indices on ordinal data, this method provides **robust and ecologically meaningful interpretations** (Thorp & Covich, 2010; Wetzel, 2001; Bellinger, 2018).

In conclusion, the zooplankton community patterns in the Katiban Canal indicate a **freshwater system impacted by organic pollution and nutrient enrichment**, with transitional zones and varying levels of environmental stress across sites, confirming the **effectiveness of qualitative bioindicators** as reliable tools for ecological assessment in freshwater canals.

V. Conclusions

The results of this study indicate that the structure of the zooplankton community is an effective qualitative bioindicator for assessing the ecological status of the Kiteiban Canal. The dominance of pollution-tolerant taxa, particularly rotifers, protozoa, and nematodes, reflects the presence of organic pollution and nutrient enrichment, whereas the weak occurrence or absence of sensitive taxa such as Calanoida, Harpacticoida, and Ostracoda indicates a deterioration in water quality, especially in the midsection of the canal. Spatial variations in zooplankton assemblages further demonstrate differing levels of environmental stress along the canal as a result of variable anthropogenic pressures. Overall, the findings confirm that qualitative, community-based zooplankton assessment provides a reliable and ecologically meaningful approach for environmental monitoring and supports sustainable management of irrigation canals connected to the Shatt Al-Arab River system.

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