The Biobrio ISSN : 2393-9508 e-ISSN: 2582-4902
An International Quarterly Journal of Life Sciences
Website: www.thebiobrio.in SJIF:8.259
12(3&4): 1590-1594, 2025

Zooplankton diversity in relation to land-use patterns in Tilaiya Dam, Jharkhand, India

Soni Kumari[1]* & Ajay Kumar Choudhary[2]
[1]Department of Environmental Studies, DSPM University, Ranchi, Jharkhand, India
[2]Department of Zoology, DSPM University, Ranchi, Jharkhand, India

Received : 20th October, 2025 ; Accepted : 20th November, 2025
DOI:- https://doi.org/10.5281/zenodo.19596648

ABSTRACT

Zooplankton forms a crucial component of freshwater ecosystems, acting as intermediaries between primary producers and higher trophic levels while serving as sensitive indicators of water quality. The present investigation evaluates the diversity, composition, and seasonal dynamics of zooplankton in Tilaiya Dam, Jharkhand, with reference to varying land-use patterns. Four distinct sampling sites representing agricultural influence, cage culture practices, human encroachment, and relatively undisturbed conditions were selected. Monthly sampling was conducted during 2021-2022 and 2022-2023. The zooplankton community was dominated by Rotifera, Cladocera, Copepoda, and Ostracoda. Rotifers, particularly *Brachionus* species, were highly abundant in nutrient-rich and disturbed areas, indicating eutrophic conditions. Cladocerans and copepods contributed significantly to biomass, especially in aquaculture zones. Encroachment areas exhibited reduced diversity and dominance of pollution-tolerant taxa, whereas less disturbed zones showed balanced communities with the presence of sensitive species. Seasonal variation was evident, with peak abundance during late winter and early summer. A comparative analysis indicated a slight increase in zooplankton density during 2022-2023. The study highlights the influence of anthropogenic activities on aquatic biodiversity and supports the use of zooplankton as reliable bioindicators for freshwater ecosystem assessment.

Key Words - Zooplankton diversity, Tilaiya Dam, Rotifera, Land-use impact, Eutrophication, Bioindicators, Freshwater ecology, Seasonal dynamics

***Corresponding author :** sonikumarijan8@gmail.com

INTRODUCTION

Freshwater ecosystems are complex, dynamic, and highly sensitive to both natural and anthropogenic disturbances. These systems support a wide range of biological communities whose structure and function are closely linked to environmental conditions. Among these, zooplankton play a central ecological role by forming an essential link between primary producers (phytoplankton) and higher trophic levels such as fish and other aquatic organisms. Due to their short life cycles, high reproductive rates, and rapid response to environmental changes, zooplankton are widely recognized as reliable indicators of ecological health and water quality (Wetzel, 2001; Mishra *et al.,* 2021).

The composition and abundance of zooplankton communities are largely governed by physico-chemical parameters including temperature, pH, dissolved oxygen, turbidity, and nutrient availability. Variations in these parameters directly influence

species diversity, distribution, and seasonal dynamics. In recent times increasing anthropogenic activities such as agricultural intensification, aquaculture expansion, urbanization, and domestic wastewater discharge have significantly altered the limnological characteristics of freshwater bodies (Kumar & Sharma, 2022; Singh *et al.,* 2023). These changes often lead to eutrophication, which is reflected in the dominance of pollution-tolerant species, particularly rotifers like *Brachionus*.

Reservoir ecosystems, especially those associated with multipurpose river valley projects, are particularly vulnerable to such changes due to their multiple uses and high human dependence. Tilaiya Dam, located in Koderma District of Jharkhand, represents one such ecologically and economically important freshwater system. Over time, the reservoir has developed into a wetland ecosystem supporting diverse flora and fauna, while simultaneously serving as a critical resource for irrigation, fisheries, and domestic water supply.

Wetlands like Tilaiya are known to provide important ecosystem services including nutrient cycling, sediment retention, carbon sequestration, and biodiversity conservation (Das & Gupta, 2024; Verma *et al.,* 2020). However, increasing anthropogenic pressures such as agricultural runoff, encroachment, and aquaculture activities have raised concerns regarding water quality deterioration and ecological imbalance.

Despite its significance, comprehensive studies focusing on zooplankton diversity in relation to land-use patterns in Tilaiya Dam remain limited. Most existing studies in Jharkhand have been confined to other regions, leaving a gap in understanding site-specific ecological dynamics. Therefore, the present study aims to analyze the spatial and temporal variation of zooplankton communities in Tilaiya Dam with reference to different land-use influences, thereby contributing to the assessment of freshwater ecosystem health.

MATERIALS & METHODS

Study Area

The present study was conducted in Koderma District, located in the northern part of Jharkhand, India. Geographically, the district lies between 24°15' N to 24°30' N latitudes and 85°23' E to 85°50' E longitudes, covering an area of about 1,165.61 km². It forms part of the Chotanagpur Plateau and is situated approximately 165 km north of Ranchi (Government of Jharkhand, 2023).

Tilaiya Dam, one of the prominent water resource structures in the district, is situated at approximately 24°20'38.8'' N latitude and 85°25' 56.201'' E longitude. The reservoir extends over an area of about 60 km² and receives an average annual rainfall of around 127 cm. It has been constructed across the Barakar River, a major tributary of the Damodar River system.

The dam was developed under the Damodar Valley Corporation (DVC) as part of one of India's earliest multipurpose river valley projects. Its primary objectives include flood control, irrigation, and hydroelectric power generation. Over time, the reservoir and its surrounding areas have developed into a wetland ecosystem that supports diverse biological communities including plankton, macrophytes, fish, amphibians, and migratory birds.

The catchment area of Tilaiya Dam is densely populated, and the reservoir serves as a vital resource for local communities. It is extensively used for domestic water supply, agricultural irrigation, fisheries, and livestock maintenance. The wetland contributes to groundwater recharge, nutrient cycling, and local climate regulation.

Increasing anthropogenic pressures such as agricultural runoff, domestic wastewater discharge, population growth, and unregulated fishing activities have led to ecological stress and declining water quality. These factors make Tilaiya Dam an ideal site for studying the impact of land-use patterns on aquatic biodiversity.

Sampling Sites

Four sampling sites were selected based on distinct land-use characteristics:

- **Site I:** Agricultural area influenced by runoff
- **Site II:** Cage culture area subjected to aquaculture activities

- **Site III:** Encroachment area affected by domestic waste and human activities
- **Site IV:** Relatively undisturbed/bridge-side area with lower anthropogenic pressure

Coolection of Samples

Zooplankton samples were collected monthly during 2021–2022 and 2022–2023. Standard plankton collection and preservation methods were followed. Identification was carried out using established taxonomic keys (Battish, 1992). Quantitative estimation was performed to assess abundance and seasonal variation.

RESULTS

Composition and Relative Abundance of Zooplankton

The zooplankton community of Tilaiya Dam during the study period (2021–2023) comprised four major groups: Rotifera, Cladocera, Copepoda, and Ostracoda. Among these, Rotifera emerged as the dominant group throughout the study period, followed by Cladocera and Copepoda, while Ostracoda showed the least contribution.

Table 1. Average annual abundance of major zooplankton groups

Zooplankton Group	2021–2022 (Mean)	2022–2023 (Mean)
Rotifera	~112	~121
Cladocera	~48	~52
Copepoda	~44	~48
Ostracoda	~16	~19

The table clearly indicates that rotifers contributed the highest proportion of total zooplankton in both years. Their dominance reflects nutrient-rich (eutrophic) conditions in the reservoir. A noticeable increase in all groups during 2022–2023 suggests enhanced productivity, possibly due to higher nutrient input or favorable environmental conditions.

Species-wise Abundance Pattern

Species-wise analysis reveals that *Brachionus angularis* was consistently the most dominant species across both years, reaching peak values of 210–220 units. Other rotifers such as *B. calyciflorus* and *Keratella tropica* also showed high abundance, confirming the strong dominance of Rotifera.

Cladocerans like *Moina* and *Ceriodaphnia* showed moderate abundance, while copepods (*Cyclops*, *Mesocyclops*) remained relatively stable. Ostracods (*Cypris*) exhibited the lowest density but consistent presence.

Table 2. Maximum and minimum abundance of dominant zooplankton species (2021–2022)

Species	Minimum Value	Maximum Value	Peak Month
Brachionus angularis	160	210	Feb
Brachionus calyciflorus	95	115	Feb
Keratella tropica	85	100	Feb
Moina sp.	65	80	Feb/Jun
Cyclops sp.	40	55	Feb/Jun
Cypris sp.	12	20	Feb/Jun

Table 3. Maximum and minimum abundance of dominant zooplankton species (2022–2023)

Species	Minimum Value	Maximum Value	Peak Month
Brachionus angularis	170	220	Feb
Brachionus calyciflorus	100	120	Feb
Keratella tropica	90	105	Feb/Jun
Moina sp.	70	85	Feb/Jun
Cyclops sp.	45	58	Feb/Jun
Cypris sp.	15	25	Feb/Jun

Seasonal Variation of Zooplankton

A clear seasonal pattern was observed across both years. Zooplankton abundance showed a steady increase during the post-monsoon period (November-February), reaching its peak in the early summer months (March-June). This peak period corresponds to favorable environmental conditions such as moderate temperature and enhanced nutrient availability, which support the growth of rotifers and cladocerans.

During the monsoon season (July-October), zooplankton abundance declined significantly. This reduction can be attributed to dilution effects, high turbidity, and unstable water conditions caused by heavy rainfall. A gradual recovery in abundance begins again with the onset of the post-monsoon season.

Table 4. Seasonal trend of total zooplankton abundance

Season	Abundance Trend	Dominant Group
Post-Monsoon (Nov–Feb)	Increasing	Rotifera
Early Summer (Mar–Jun)	Peak	Rotifera + Cladocera
Monsoon (Jul– Oct)	Declining	Rotifera

Annual Comparison of Zooplankton (2021–2022 & 2022–2023)

A comparison between 2021-2022 and 2022-2023 indicates a consistent increase in zooplankton abundance across all groups. The most pronounced increase was observed in ostracods, followed by rotifers, suggesting improving environmental conditions or nutrient enrichment during the latter study period.

Table 5. Comparative increase (%) in zooplankton abundance

Group	% Increase
Rotifera	7–9%
Cladocera	6–8%
Copepoda	5–7%
Ostracoda	10–12%

DISCUSSION

The present investigation clearly demonstrates that zooplankton community structure in Tilaiya Dam is strongly influenced by surrounding land-use patterns and seasonal environmental variations. The dominance of Rotifera, particularly *Brachionus* species, across most sampling sites reflects nutrient-enriched conditions, which are typically associated with eutrophic water bodies. This observation is consistent with earlier findings, where rotifers, especially *Brachionus angularis* and *Brachionus calyciflorus*, were reported as reliable indicators of eutrophication and organic pollution (Jeppesen *et al.,* 2000; Kumar & Sharma, 2022).

Higher abundance of rotifers in agricultural and encroachment sites suggests that runoff carrying fertilizers and domestic waste significantly enhances nutrient loading. Similar patterns have been documented in Indian reservoirs, where increased nitrogen and phosphorus inputs led to a shift toward rotifer-dominated communities (Mishra *et al.,* 2021). The present study further supports this relationship, as the relatively higher mean abundance of Rotifera (112–121 units) indicates progressive nutrient enrichment over the study period.

Cladocerans and copepods, though secondary in abundance, contributed substantially to the overall biomass, particularly in aquaculture-dominated zones (Site II). Their presence in moderate to high numbers indicates favorable trophic conditions and availability of phytoplankton as a food source. Comparable observations were reported by Singh *et al.* (2023), who noted that aquaculture activities often enhance secondary productivity by increasing organic matter and nutrient recycling. However, excessive nutrient input may eventually lead to reduced diversity due to competitive exclusion, a trend that begins to emerge in highly disturbed zones of the present study.

Encroachment areas (Site III) exhibited comparatively lower species diversity and dominance of pollution-tolerant taxa. This reflects ecological stress caused by domestic waste discharge and human interference. Similar findings were reported by Verma *et al.* (2020), who observed that urban and peri-urban water bodies often show reduced zooplankton diversity with dominance of tolerant species due to deteriorating water quality. The reduced presence of sensitive taxa in such areas in the current study further confirms the adverse impact of anthropogenic disturbances.

The relatively undisturbed site (Site IV) supported a more balanced zooplankton community, including both tolerant and sensitive species. This indicates better water quality and ecological stability. Such spatial variation in species composition highlights the importance of habitat heterogeneity in maintaining biodiversity. Das and Gupta (2024) also emphasized that less disturbed freshwater ecosystems tend to support higher diversity and ecological resilience.

Seasonal variation observed in the study aligns well with established limnological patterns in tropical regions. Zooplankton abundance peaked during late winter and early summer (November-February), which can be attributed to optimal temperature, stable water conditions, and increased nutrient availability. Similar seasonal peaks have been reported by Michael (1968), who noted that moderate climatic conditions favor rapid zooplankton reproduction. Conversely, the decline during monsoon months is likely due to dilution effects, increased turbidity, and hydrological

instability, which negatively impact zooplankton growth and survival.

The inter-annual comparison revealed a slight increase in zooplankton abundance during 2022–2023 across all groups, with the highest rise observed in ostracods (10–12%). This trend may indicate gradual nutrient accumulation and increasing productivity in the reservoir. Similar year-to-year increases in plankton density have been associated with progressive eutrophication in freshwater bodies (Wetzel, 2001). While moderate productivity supports aquatic food webs, continued nutrient enrichment may pose long-term ecological risks.

The study reinforces the concept that zooplankton communities respond rapidly to environmental changes and can serve as effective bioindicators of water quality. The findings are in strong agreement with previous studies conducted in tropical freshwater ecosystems, confirming that anthropogenic activities such as agriculture, aquaculture, and urbanization significantly alter plankton dynamics.

CONCLUSION

The study confirms that zooplankton communities in Tilaiya Dam respond sensitively to land-use intensity and seasonal forcing. Increasing anthropogenic pressure leads to reduced diversity and dominance of eutrophic indicator taxa, particularly rotifers.

The ecological gradient observed across sampling sites highlights a transition from balanced to disturbed trophic states. Seasonal dynamics further emphasize the role of hydrological stability in regulating plankton populations.

Although the system still retains moderate ecological resilience, continued nutrient loading from agriculture, aquaculture, and human settlements may accelerate eutrophication processes.

Integrated monitoring using zooplankton indices combined with physico-chemical parameters is strongly recommended for long-term ecosystem management.

REFERENCES

APHA. 2017. *Standard methods for the examination of water and wastewater* (23rd ed.). American Public Health Association.

Battish, S. K. 1992. *Freshwater zooplankton of India*. Oxford & IBH Publishing.

Das, S., & Gupta, R. 2024. Wetland biodiversity and ecosystem resilience under anthropogenic pressure in eastern India. *Journal of Aquatic Ecology and Environment*, 38(1): 45–60.

Government of Jharkhand. 2023. *District statistical handbook: Koderma*. Directorate of Economics and Statistics, Government of Jharkhand.

Jeppesen, E., Jensen, J. P., Sondergaard, M., Lauridsen, T., & Landkildehus, F. 2000. Trophic structure, species richness, and biodiversity in Danish lakes along a phosphorus gradient. *Freshwater Biology,* 45(2): 201–218.

Michael, R. G. 1968. Studies on the zooplankton of a tropical fish pond.*Hydrobiologia,* 32:47-68.

Mishra, S., Kumar, A., & Singh, V. 2021. Impact of eutrophication on zooplankton community structure in Indian freshwater ecosystems. *International Journal of Fisheries and Aquatic Studies,* 9(3): 112–118.

Singh, R., Verma, P., & Kumar, N. 2023. Aquaculture-driven nutrient enrichment and its effect on freshwater plankton dynamics. *Aquatic Ecosystem Health & Management,* 26(2): 155–167.

Verma, S., Gupta, A., & Das, P. 2020. Influence of urban runoff on zooplankton diversity in Indian wetlands. *Ecological Indicators,* 115: 106-118.

Wetzel, R. G. (2001). *Limnology: Lake and river ecosystems* (3rd ed.). Academic Press.

Kumar, A., & Sharma, P. (2022). Eutrophication-induced shifts in zooplankton assemblages in reservoir ecosystems of India. *Environmental Monitoring and Assessment,* 194(8), 1–15.

***