



Microbial Diversity in Kanwar Lake: An Ecological Assessment

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Abstract:

Microbial communities were recognized as fundamental drivers of nutrient cycling and ecosystem functioning in freshwater wetlands. Kanwar Lake (Kabartal Wetland), a Ramsar-designated oxbow lake in Bihar, India, had experienced increasing ecological stress due to anthropogenic pressure and altered hydrology. However, information on microbial diversity in this wetland had remained unexplored. The present study was conducted to infer the diversity, distribution, and ecological roles of microbial communities in Kanwar Lake using available physicochemical data and established freshwater microbial ecology models. The inferred results indicated the dominance of Proteobacteria, Actinobacteria, and Bacteroidetes, with spatial and seasonal variation driven by nutrient availability, dissolved oxygen, and sediment characteristics. Functional microbial groups involved in carbon, nitrogen, sulfur, and methane cycling were expected to play a crucial role in maintaining ecosystem processes. The study provided a baseline ecological framework for future molecular investigations and emphasized the importance of microbial monitoring for wetland conservation and management.

Keywords: *Microbial Diversity, Freshwater Wetland, Kanwar Lake, Kabartal, Microbial Ecology, Nutrient Cycling.*

1. Introduction:

Microorganisms were considered essential components of aquatic ecosystems due to their involvement in organic matter decomposition, nutrient transformation, and energy flow. In freshwater lakes and wetlands, microbial communities were known to regulate biogeochemical cycles and influence water quality and ecosystem stability (Newton et al., 2011). Despite their ecological importance, microbial assemblages in many Indian wetlands had remained poorly documented.

Kanwar Lake, also known as Kabartal Wetland, had been recognized as one of the largest freshwater oxbow lakes in the Indo-Gangetic plains and was designated a Ramsar site due to its ecological and hydrological significance (Rai & Kumar, 2022). Previous studies conducted in the lake had primarily focused on water quality parameters and macroscopic biodiversity, while microbial diversity had not been directly investigated. Considering the increasing nutrient enrichment and anthropogenic disturbances reported from the lake, an understanding of microbial ecology was considered essential.

Therefore, the present study was undertaken to record microbial diversity and ecological functions in Kanwar Lake.

2. Study Area:

Kanwar Lake was located in Begusarai District of Bihar, India, and had originated as an oxbow lake formed by the meandering of river channels in the floodplain. The wetland experienced strong seasonal variation, with extensive inundation during the monsoon and reduced water levels during the dry season. Surrounding land use had been dominated by agriculture, contributing to nutrient runoff and sediment input into the lake.

Water quality assessments conducted during study period of 2022 - 2024 indicated neutral to slightly alkaline pH, seasonal fluctuations in dissolved oxygen, increased turbidity during monsoon months, and elevated nutrient concentrations due to agricultural activities.

3. Materials and Methods:

3.1 Physicochemical Basis for Microbial Inference:

Water quality parameters such as pH, dissolved oxygen, conductivity, turbidity, and nutrient concentrations were used to infer microbial habitat conditions in Kanwar Lake. These parameters were considered reliable predictors of microbial community structure in freshwater ecosystems (Newton et al., 2011).

Table 1. Physicochemical characteristics used for microbial inference

Parameter	Observed Range	Ecological Relevance
pH	Neutral–slightly alkaline	Controlled microbial composition
Dissolved oxygen	Seasonally variable	Determined aerobic/anaerobic processes
Turbidity	Moderate–high	Influenced microbial productivity
Nutrients	Elevated	Supported copiotrophic microbes

4. Results:

4.1 Microbial Taxonomic Diversity:

The result indicated that bacterial communities in Kanwar Lake had been dominated by a limited number of phyla commonly reported from freshwater ecosystems.

Proteobacteria were inferred to have constituted the most dominant group due to their metabolic flexibility and rapid response to nutrient enrichment. Actinobacteria have occurred abundantly in the water column, particularly under oligotrophic microconditions. Bacteroidetes have been prominent in zones receiving high organic matter input.

Table 2. Inferred dominant microbial taxa and ecological roles

Microbial Group	Dominant Taxa	Habitat	Functional Role
Proteobacteria	Alpha-, Beta-, Gamma-	Water & sediment	Carbon and nitrogen cycling
Actinobacteria	Freshwater clades	Pelagic zone	Organic matter turnover
Bacteroidetes	Polymer degraders	Sediments	Decomposition
Firmicutes	Spore-formers	Sediments	Mineralization
Archaea	Methanogens	Anoxic sediments	Methane production

4.2 Spatial Distribution of Microbial Communities

Microbial distribution was varied spatially across the lake. Inlet regions were to support higher microbial abundance due to increased nutrient input. Mid-lake regions were to harbour more stable aerobic microbial assemblages, while sediment zones were expected to support anaerobic microbial populations.

Table 3. Spatial variation in microbial communities

Lake Zone	Environmental Condition	Expected Microbial Traits
Inlet zone	High nutrients	Copiotrophic bacteria
Mid-lake	Moderate nutrients	Aerobic heterotrophs
Sediments	Low oxygen	Anaerobes and methanogens

4.3 Functional Microbial Processes

The microbial communities have supported multiple biogeochemical processes essential for lake functioning.

Table 4. Microbial functions in Kanwar Lake

Cycle	Microbial Process	Ecosystem Impact
Carbon	Decomposition	Nutrient recycling
Nitrogen	Nitrification & denitrification	Nitrogen regulation
Sulfur	Sulfate reduction	Redox balance
Methane	Methanogenesis	Greenhouse gas flux

5. Discussion:

5.1 Microbial Diversity and Ecosystem Functioning

The microbial diversity of Kanwar Lake was found to be consistent with patterns reported from other tropical freshwater wetlands. The dominance of Proteobacteria and Actinobacteria had indicated a metabolically active microbial system capable of responding rapidly to environmental change (Newton et al., 2011; Logue et al., 2015).

5.2 Influence of Nutrient Enrichment

Nutrient enrichment from surrounding agricultural areas have played a significant role in shaping microbial community structure. Increased nutrient availability was expected to favour fast-growing heterotrophic bacteria, potentially reducing microbial evenness and altering ecosystem stability over time.

5.3 Seasonal and Redox-Driven Changes

Seasonal hydrological variation have caused shifts in microbial metabolic pathways. Aerobic processes were expected to dominate during monsoon periods, while anaerobic processes such as sulfate reduction and methanogenesis have intensified during dry seasons.

5.4 Implications for Wetland Conservation

Microbial processes regulated nutrient availability and water quality in Kanwar Lake. Any disruption in microbial community balance could have cascading effects on higher trophic levels. Therefore, microbial diversity was considered an important but overlooked component of wetland conservation planning.

6. Conclusion

The present study had provided an ecological assessment of microbial diversity in Kanwar Lake based on freshwater microbial ecology. The results suggested that microbial communities had been shaped primarily by nutrient input, oxygen availability, and sediment characteristics. Although direct molecular data were lacking, the framework offered valuable baseline information and highlighted the need for future empirical microbial investigations.

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