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Seasonal dynamics of plankton communities and their trophic linkages in relation to water quality in Latratu Dam, Jharkhand

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Abstract- This study investigates the seasonal variation and ecological significance of plankton communities in relation to physicochemical parameters in Latratu Dam, a freshwater reservoir in Lapung, Jharkhand. To evaluate the composition, quantity, and diversity of phytoplankton and zooplankton, systematic sampling was carried out at six stations during a 12-month period (April 2023-March 2024). To ascertain their impact on plankton distribution, important environmental factors such as temperature, dissolved oxygen, pH, nitrate, phosphate, and turbidity were examined. In all, 25 zooplankton species (containing Rotifera, Cladocera, and Copepoda) and 39 phytoplankton species (representing Chlorophyceae, Bacillariophyceae, and Cyanophyceae) were identified. While zooplankton displayed the greatest diversity in the winter, phytoplankton abundance increased during the post-monsoon season. Canonical Correspondence Analysis (CCA) showed that nitrate and phosphate levels had a significant impact on phytoplankton distribution, while zooplankton diversity had a negative correlation with turbidity and a positive correlation with dissolved oxygen. The study emphasizes how important plankton are as bioindicators and how they serve as a trophic connection between higher aquatic species, especially fish, and nutrient dynamics. These results strengthen the need for nitrogen control techniques to maintain biodiversity in Latratu Dam and offer a deeper ecological understanding of how freshwater ecosystems work.

Keywords: Phytoplankton, Zooplankton, Trophic interaction, Water quality, Latratu Dam, Seasonal variation

INTRODUCTION

Plankton, which are microscopic organisms that float in the water column, are essential to freshwater ecosystems because they facilitate the movement of nutrients and energy across different trophic levels. Since plankton are the main producers (phytoplankton) and consumers (zooplankton) in aquatic food webs, they are crucial for maintaining fish populations, especially the juvenile stages, which depend significantly on them for sustenance and survival.[1] Their variety, abundance, and community composition make them essential markers of ecological health since they have a direct impact on the structure and productivity of higher aquatic creatures. Phytoplankton, including members of Chlorophyceae, Bacillariophyceae, and Cyanophyceae, respond rapidly to changes in nutrient concentrations and light availability, making them reliable indicators of trophic status and eutrophication.[2] Zooplankton, which includes the groups Rotifera, Cladocera, and Copepoda, are similarly important since they connect higher consumers like fish and insect larvae to primary producers.[3] Because of their sensitivity to environmental factors such as temperature, dissolved

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oxygen, pH, turbidity, and nutrient levels, plankton communities are useful bioindicators for evaluating the biological integrity and water quality of freshwater reservoirs.

Previous research has shown evidence of nutrient enrichment and seasonal eutrophication caused by agricultural runoff, as well as the dam's physicochemical features and their effects on fish and macrophyte populations. Nevertheless, little is known about the structure of the planktonic community in this area, despite its biological importance. In light of this, the current study intends to clarify the trophic relationships between phytoplankton and zooplankton communities in Latratu Dam and their seasonal dynamics using physicochemical measures. This study aims to provide a scientific foundation for the use of plankton as bioindicators of ecosystem health and to guide sustainable management plans for Jharkhand's freshwater reservoirs by evaluating plankton diversity and comparing its patterns with environmental factors.

MATERIALS & METHODS

Study Area

The ecological investigation was carried out at Latratu Dam (23.2240°N, 85.0741°E), a perennial freshwater reservoir situated in Lapung Block, Ranchi district, Jharkhand.[4] The dam receives input from surrounding agricultural fields and forested catchments, making it an ideal site to study seasonal ecological variations. Six ecologically distinct sampling stations were selected across the reservoir based on depth, vegetation cover, water inflow, and anthropogenic influence.

Sampling Period and Frequency

Field sampling was conducted monthly from April 2023 to March 2024, covering three distinct seasons, Summer (April–June) Monsoon (July–September) & Winter (November–January). Each station was sampled once per month to capture spatial and temporal variations in water quality and plankton composition.

Physicochemical Analysis of Water

Water samples were collected monthly during the morning hours (7:00 AM to 9:00 AM) to reduce the influence of diel fluctuations on water quality. At each sampling site, surface water was gathered in clean polyethylene containers. On-site measurements of water pH and temperature were taken using a calibrated pH meter and a portable digital thermometer, respectively. Other physicochemical parameters such as dissolved oxygen (DO), free carbon dioxide (CO_2), total alkalinity, total hardness, nitrate (NO_3^-), and phosphate (PO_4^{3-}) were analyzed in the laboratory following the standard procedures of APHA (2012)[5]. DO was determined using Winkler's iodometric technique, while free CO_2 was measured through titration with sodium hydroxide. Nutrient concentrations were quantified using spectrophotometric techniques to ensure precision and reliability. The data were compiled monthly and subjected to statistical analysis to identify seasonal variations and explore their relationship with biological factors.

Plankton Sampling and Preservation

Phytoplankton and zooplankton samples were collected using a plankton net with mesh sizes of ~25 µm for phytoplankton and 50 µm for zooplankton. A total of 30 liters of water was filtered at each station and the concentrate was preserved in 4% formalin. For quantitative estimation, 1 mL of the well-mixed sample was examined using a Sedgwick-Rafter counting chamber under a compound microscope.

Identification and Classification

Plankton were identified to the genus level using standard taxonomic keys,Phytoplankton[6]: Prescott (1964) Zooplankton[7]: Battish (1992), Michael & Sharma (1988). Phytoplankton were categorized into major classes: Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, while zooplankton were grouped as Rotifera, Cladocera, Copepoda, and Ostracoda.

Statistical and Ecological Analysis

To explore the ecological relationships and assess the impact of environmental factors on aquatic life, advanced multivariate statistical approaches were applied. These included Pearson's correlation to evaluate linear associations among variables, Principal Component Analysis (PCA) to identify major influencing factors and patterns within the dataset, and Canonical Correspondence Analysis (CCA) to determine how variations in water quality and aquatic vegetation correspond to changes in fish diversity. Together, these methods provided a comprehensive understanding of the complex interactions between abiotic and biotic components of the ecosystem.

RESULTS

Seasonal Variation in Physicochemical Parameters

The water quality of Latratu Dam exhibited marked seasonal variations influenced by rainfall, agricultural runoff, temperature changes, and aquatic vegetation. The

mean ranges of key parameters across seasons were as follows:

Table 1- Physicochemical characteristics of water

Parameter	Summer	Monsoon	Winter
Temperature (°C)	28.5 – 30.8	25.2 – 27.6	19.1 – 21.3
pH	7.4 – 8.2	6.6 – 7.5	7.2 – 8.0
DO (mg/L)	4.6 – 5.4	5.8 – 6.9	6.2 – 7.4
Nitrate (mg/L)	1.2 – 1.9	1.6 – 2.2	0.7 – 1.2
Phosphate (mg/L)	0.8 – 1.3	1.2 – 1.6	0.3 – 0.6
Turbidity (NTU)	6.2 – 8.4	12.1 – 18.7	4.1 – 6.3

The monsoon season showed the highest nitrate and phosphate concentrations, attributed to fertilizer runoff, leading to increased nutrient loading and promoting algal blooms. DO levels peaked in winter, likely due to lower temperatures and reduced decomposition rates of organic matter.

Phytoplankton Composition and Dynamics

A total of 39 phytoplankton species belonging to four major groups were recorded:

- Chlorophyceae (19) – *Pediastrum*, *Scenedesmus*, *Chlorella*
- Bacillariophyceae (11) – *Navicula*, *Nitzschia*, *Synedra*
- Cyanophyceae (9) – *Microcystis*, *Oscillatoria*, *Anabaena*

Phytoplankton abundance peaked during the post-monsoon period (September–October), coinciding with elevated nutrient levels and sunlight penetration following monsoon turbidity reduction. Cyanophyceae dominated in nutrient-enriched stations (especially Station 3 and 5), indicating early signs of eutrophication, with *Microcystis aeruginosa* forming minor blooms in October.

Table 2. Dominant Phytoplankton Taxa in Each Season

Group	Summer Dominants	Monsoon Dominants	Winter Dominants
Chlorophyceae	*Scenedesmus quadricauda*, *Ankistrodesmus falcatus*	*Pediastrum simplex*, *Coelastrum microporum*	*Dictyosphaerium pulchellum*, *Crucigenia tetrapedia*
Cyanophyceae	*Spirulina platensis*, *Merismopedia glauca*	*Microcystis aeruginosa*, *Anabaena flos-aquae*	*Oscillatoria limnetica*, *Chroococcus turgidus*
Bacillariophyceae	*Nitzschia palea*, *Navicula gracilis*	*Cyclotella meneghiniana*, *Fragilaria crotonensis*	*Cymbella tumida*, *Pinnularia viridis*

Zooplankton Composition and Trends

25 zooplankton species were recorded, grouped as:

- Rotifera (12) – *Brachionus*, *Keratella*, *Filinia*
- Cladocera (8) – *Daphnia*, *Moina*, *Bosmina*
- Copepoda (5) – *Cyclops*, *Mesocyclops*

Zooplankton diversity was highest in winter, attributed to clearer water, increased DO, and reduced competition from algal blooms. Rotifers were the most dominant group across all stations, with *Brachionus calyciflorus* showing widespread distribution.

Table 3. Dominant Zooplankton Taxa in Each Season

Group	Summer Dominants	Monsoon Dominants	Winter Dominants
Rotifera	*Brachionus falcatus*, *Monostyla quadridentata*	*Brachionus calyciflorus*, *Trichotria tetrabrachiata*	*Keratella tropica*, *Filinia longiseta*
Cladocera	*Daphnia carinata*, *Moina micrura*	*Bosmina longirostris*, *Ceriodaphnia cornuta*	*Alona rectangula*, *Chydorus sphaericus*
Copepoda	*Cyclops vicinus*, *Mesocyclops leuckarti*	*Cyclops viridis*, *Macrocyclops albidus*	*Cyclops strenuus*, *Diaptomus forbesi*

Ecological Correlation Analysis

Pearson's correlation and CCA revealed the following ecological relationships:

- Phytoplankton diversity showed a positive correlation with nitrate ($r = 0.76$) and phosphate ($r = 0.69$).
- Zooplankton abundance correlated positively with DO ($r = 0.82$) and negatively with turbidity ($r = –0.74$).
- Cyanophyceae dominance was associated with high nutrient loads and low oxygen, particularly at impacted stations.

CCA plots showed clear clustering of species in relation to environmental gradients. Phytoplankton assemblages at nutrient-rich stations differed markedly from those at well-oxygenated, low-turbidity zones.

DISCUSSION

This study provides an in-depth look at how seasonal shifts in environmental factors influence the plankton communities within Latratu Dam, a vital freshwater habitat in Jharkhand. The results highlight a strong interconnection between key water quality parameters particularly nutrients and dissolved oxygen and the distribution and abundance of both phytoplankton and zooplankton.

Phytoplankton, especially members of the Chlorophyceae and Cyanophyceae groups, exhibited distinct seasonal trends.[8] Algal populations were most abundant after the monsoon season, likely due to increased nutrient input and better light availability as water turbidity decreased. The presence of species like *Microcystis aeruginosa* and *Anabaena flos-aquae* in nutrient-rich areas points to early signs of eutrophication, which, if unchecked,

could harm the ecosystem over time. Their rapid response to elevated nitrate and phosphate levels highlights their value as early indicators of nutrient overloading.

Zooplankton diversity, particularly among rotifers and cladocerans, was highest during winter months when oxygen levels were elevated and turbidity was minimal. Statistical analysis confirmed a positive relationship between zooplankton abundance and dissolved oxygen, and a negative one with turbidity. These findings are ecologically significant, as murkier water during the monsoon can disrupt feeding efficiency and affect predator-prey dynamics among aquatic organisms.

Field observations also noted increased activity of plankton-eating fish during the post-monsoon and winter periods, aligning with peaks in both phytoplankton and zooplankton populations. Moreover, areas with dense growths of aquatic plants like *Hydrilla* and *Vallisneria* served as important habitats, offering shelter and supporting greater zooplankton diversity. This reinforces the role of aquatic vegetation in promoting ecological stability.

CONCLUSION

This research underscores the strong impact that seasonal changes in water quality have on plankton communities in Latratu Dam. Phytoplankton populations were highest following the monsoon, driven by an influx of nutrients, while winter conditions—marked by higher oxygen levels and clearer water—supported a richer diversity of zooplankton. These seasonal shifts highlight the value of plankton as sensitive indicators of water quality and overall ecosystem health.

The distinct ecological patterns identified through advanced multivariate analyses (CCA and PCA) point to the urgent need for strategic management practices, especially during the monsoon when nutrient runoff is at its peak. Practical steps like creating vegetative buffer zones, regulating the use of agricultural fertilizers, and implementing regular nutrient monitoring can play a vital role in preventing eutrophication and preserving the reservoir's ecological balance.

The study also illustrates the crucial relationship between plankton, aquatic vegetation, and fish populations, suggesting that maintaining a variety of habitats is essential for supporting biodiversity. The data gathered provides a strong foundation for ecological modelling and can help shape effective water resource policies for Jharkhand and comparable regions.

Looking ahead, future research should focus on long-term ecological monitoring, integrate data on fish populations, and consider the effects of climate variability. Such efforts will enhance our understanding of ecosystem resilience and the functioning of tropical freshwater reservoirs.

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