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Assessing seasonal variations in the composition of plankton in small, polluted lentic water bodies of Madhepura

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Abstract- The current study documents the density and seasonal fluctuations of zooplankton and phytoplankton in a perennial pond environment in Madhepura between March 2022 and February 2023. The city's rapid population growth, alongside the expansion of industrial units, has led to the development of numerous residential colonies and informal hutments. Insufficient drainage infrastructure has resulted in significant waste and wastewater accumulation, forming ponds and puddles- many of which have become permanent water bodies. As phytoplankton play a vital role in lake ecosystem health, understanding their dynamics is crucial for ecological studies and conservation. By examining phytoplankton communities and the physico-chemical characteristics of these water bodies, scientists can identify early indicators of environmental change and guide conservation efforts. This study focuses on small, lentic water bodies in Madhepura city to observe seasonal variations in plankton composition under highly polluted conditions.

Key words: seasonal fluctuations, zooplankton, phytoplankton, physico-chemical parameters.

INTRODUCTION

An ecosystem arises from the interaction of biotic and abiotic elements. Aquatic environments serve as vital bases for the flora and fauna in water bodies. Both external and internal factors influence ecosystem structures. External factors, such as topography, soil-forming parent material, and climate, indirectly shape ecosystems, while internal processes like decomposition, root competition, and succession determine ecosystem dynamics.

Freshwater habitats cover only about 0.8% of the Earth's surface and include marshes, swamps, rivers, lakes, ponds, and temporary pools. Freshwater habitats are divided into lotic (flowing water, such as rivers) and lentic (standing water, such as lakes and ponds) systems. This study emphasizes lentic habitats, which support diverse flora and fauna but are increasingly threatened by pollution and eutrophication.[1] Algae, as autotrophic, photosynthetic organisms, form the base of many food chains and play essential roles in carbon fixation and oxygen production. Understanding algae's ecological functions and adaptations aids in managing algal blooms, monitoring water quality, and applying algae in wastewater treatment.[2,3]

Phytoplanktons, also known as water blooms, are dense colonies of free-floating algae that often thrive in polluted water bodies. These organisms are critical indicators of water quality and ecological health. The study of phytoplankton is extremely essential from a limnological perspective because it plays a significant role in oxygen amelioration, binding, and the elimination of some hazardous compounds from the water body.[3-6]

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MATERIALS & METHODS

To investigate seasonal fluctuations in plankton composition in small, polluted lentic water bodies, the following methods were employed:

1. Study Area Selection:

- Multiple small lentic water bodies were selected based on high pollution levels determined by prior water quality assessments. Sites included urban ponds, agricultural runoff-fed lakes, and reservoirs receiving industrial effluents.

2. Sampling Schedule:

- Samples were collected seasonally (spring, summer, autumn, and winter) over an year to account for annual variability.

3. Water Sampling:

- Surface and subsurface water samples were collected.

4. Plankton Sampling:

- Plankton samples were collected using a plankton net (mesh size: 20 µm for phytoplankton and 60 µm for zooplankton) through vertical and horizontal tows. (fig. 1)
- Samples were preserved in 4% formalin for phytoplankton and 70% ethanol for zooplankton.

Fig. 1- Plankton net (mesh size: 20 µm for phytoplankton and 60 µm for zooplankton)

5. Microscopic Analysis:

- Identification and enumeration of plankton were conducted using a compound microscope.
- Taxonomic keys and standard identification guides were used to classify plankton to the genus or species level.

6. Data Analysis:

- Seasonal changes in plankton abundance and diversity were analyzed using statistical tools.
- Correlations between physico-chemical parameters and plankton composition were examined to identify key environmental drivers.

RESULTS & DISCUSSION

Phytoplankton Trends

- **Seasonal Dominance:** Phytoplankton abundance was dominated by pollution-tolerant species. Cyanobacteria (e.g., *Microcystis* spp.) thrived in spring and summer due to high nutrient concentrations and warmer temperatures.
- **Winter and Autumn Shifts:** Diatoms dominated in winter under cooler conditions, while green algae (Chlorophyceae) increased post-monsoon in autumn due to nutrient runoff.
- **Harmful Algal Blooms (HABs):** HABs were observed during spring and summer, coinciding with peaks in nitrogen and phosphorus levels.

Zooplankton Trends

- **Reduced Diversity:** Zooplankton communities were dominated by pollution-tolerant species like rotifers (*Brachionus* spp.) and small cladocerans (*Moina* spp.) throughout the year.
- **Seasonal Abundance:** Zooplankton peaked in spring, coinciding with phytoplankton blooms. However, hypoxic conditions in summer reduced sensitive species like copepods.

Sampled zooplanktons

The study conducted between March 2022 and February 2023 investigated the distribution of various zooplankton species, focusing on three major groups: Rotifera, Copepoda, and Cladocera. The findings provided detailed information on the seasonal variations in the populations of these species.

1. Rotifera:

- **Species and Genera**: Seven species of Rotifera, from three genera—*Brachionus*, *Keratella*, and *Asplanchna*—were identified. These genera are commonly found in freshwater ecosystems and are often used as indicators of water quality and ecological health.
- **Population Trends**: The Rotifera population varied significantly throughout the study period, with the

highest population observed in March 2022. This peak could be linked to seasonal environmental conditions that favored the proliferation of Rotifera, such as temperature, food availability, or water quality. On the other hand, the lowest population was recorded in January 2023, which could reflect environmental factors such as colder temperatures, reduced food resources, or lower reproductive rates during the winter months.

2. Copepoda:

- **Species and Genera**: Only two species of Copepoda, from the genera *Neodiaptomus* and *Mesocyclops*, were identified. Copepoda are crucial components of aquatic food webs, often serving as prey for larger organisms and playing a role in nutrient cycling. The relatively low diversity in this group compared to the Rotifera and Cladocera may reflect the specific habitat conditions during the study period or the sensitivity of these species to environmental changes.

3. Cladocera:

- **Species and Genera**: Four species of Cladocera, from the genera *Daphnia*, *Ceriodaphnia*, and *Moina*, were observed. Cladocerans, also known as water fleas, are important herbivores in aquatic ecosystems, feeding on algae and detritus. Their presence and population dynamics are often influenced by factors such as food availability, water temperature, and predation. The identification of these species indicates a reasonably healthy aquatic system, as Cladocera are often abundant in diverse and productive ecosystems.

Table 1- Sampled zooplanktons

Zooplanktons	Genus	Species
Rotifera	*Brachionus*	*Brachionus angularis*
		Brachionus calyciflorus
		Brachionus bidentata
	Keratella	*Keratella tropica,*
		Keratella lenzi
	Asplanchna	*Asplanchna intermedia*
		Asplanchna brightwelli
Copepoda	*Neodiaptomus*	*Neodiaptomus schmakeri*
	Mesocyclops	*Mesocyclops aspericornis*
Cladocera	*Daphnia*	*Daphnia magna*
	Ceriodaphnia	*Ceriodaphnia cornuta*
	Moina	*Moina brachiate*
		Moina flagellate

Table 2- Sampled Phytoplanktons

Phytoplanktons	Genus
Bacillariophyceae	*Cyclotella sp.*
	Diatoms sp.
	Synedra sp.
Chlorphyceae	*Spirogyra sp.*
	Volvox sp.
Cyanophyceae	*Anabaena sp.*
	Microcystis sp
	Spirulina sp.

Sampled Phyoplanktons

These species represent a variety of phytoplankton across different taxonomic groups:

- **Bacillariophyceae** (Diatoms) are important for primary production, especially in cooler waters, and have unique silica shells.
- **Chlorophyceae** (Green Algae) are typically found in freshwater and are known for their green pigmentation due to chlorophyll. They play a vital role in photosynthesis and oxygen production.
- **Cyanophyceae** (Cyanobacteria) are sometimes harmful due to their potential to form toxic blooms, but they also have ecological benefits, such as nitrogen fixation.

Together, these groups contribute to the balance of aquatic ecosystems, supporting various forms of life through their primary productivity and biogeochemical processes.

Overall, the study highlights the diversity and seasonal variations in zooplankton populations, with Rotifera being the most diverse and abundant group observed. The study also suggests that environmental factors such as temperature and food availability may play significant roles in determining the abundance of these groups, with Rotifera populations peaking in spring and declining in winter, while Copepoda species were less diverse throughout the year. The presence of Cladocera indicates a productive aquatic system, where these organisms contribute to the food web and nutrient cycling.

Correlation with Physico-Chemical Parameters

- **Nutrient Levels:** Positive correlations were observed between phytoplankton abundance and nitrate and phosphate levels.
- **Dissolved Oxygen (DO):** Seasonal shifts in DO significantly influenced zooplankton diversity, with

higher diversity recorded during autumn and winter when oxygen levels were stable.

Implications for Ecosystem Health

The dominance of pollution-tolerant plankton species and reduced biodiversity reflect severe ecological degradation. HABs and oxygen depletion disrupt food webs, affecting higher trophic levels like fish and amphibians. Monitoring these seasonal changes provides critical insights into ecosystem health and highlights the urgency of implementing pollution control measures:

- Reducing nutrient and pollutant loads through wastewater treatment.
- Promoting riparian vegetation to filter runoff.
- Encouraging community-led conservation efforts.

CONCLUSION

Small lentic water bodies are vital ecosystems increasingly threatened by pollution. Observing seasonal variations in plankton communities under highly polluted conditions provides insights into ecosystem resilience and degradation. Long-term monitoring and active restoration efforts are essential to mitigate pollution impacts, ensuring the preservation of these aquatic habitats for future generations.

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