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Research Article

Zooplankton as Bio-Indicators for Sustainable Urban Water Management in the Vision of Developed India @2047: A Case Study from Jaipur, India

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Abstract

India's goal of becoming a developed nation by 2047 emphasizes the need of long-term socioeconomic growth, which is backed by scientific research and ecologically responsible government. Urban freshwater ecosystems are critical for ecological balance, public health, and economic sustainability; yet, rapid urbanization and increased human activity have caused significant damage. The current study examines the utility of zooplankton communities as biological indicators for assessing urban water quality and ecosystem health, utilizing Amanishah Nala in Jaipur (Rajasthan, India) as a case study. Seasonal sampling was conducted at chosen upstream, contaminated, and downstream sites to investigate geographical and temporal differences. Zooplankton diversity, abundance, and community organization were investigated, together with essential water physicochemical parameters. Species identification was done with standard taxonomic keys, and ecological status was assessed with biodiversity indicators such the Shannon-Wiener Index. Statistical studies were used to investigate the links between zooplankton assemblages and environmental factors. The study is designed to provide baseline data on the biological state of the urban freshwater system and establish the efficacy of zooplankton as water quality indicators. The findings may promote science-based urban water management plans and highlight the necessity of including biological indicators into environmental monitoring programs to align with India's sustainable development goals.

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1. INTRODUCTION

Public health, socioeconomic progress, and ecological stability all depend on freshwater ecosystems. Anthropogenic pressures including solid waste disposal, industrial effluents, and home sewage outflow are increasingly affecting these ecosystems in rapidly urbanizing areas. Water quality and aquatic biodiversity are severely degraded by urban drainage systems, which frequently serve as conduits for untreated wastewater.

As a vital link between primary producers and higher trophic levels, zooplankton are an integral part of aquatic food webs. Zooplankton communities are useful biological markers of ecological health because of their short life cycles and sensitivity to environmental changes, which cause them to react quickly to changes in water quality. Changes in the physico-chemical properties of aquatic habitats are reflected in changes in zooplankton species diversity, abundance, and composition. Protecting aquatic biodiversity and managing urban water supplies sustainably are critical components of India's *Developed India @2047* goal.

Developing evidence-based management methods requires a scientific assessment of contaminated urban freshwater systems utilizing biological indicators. Although Amanishah Nala, a significant urban drainage channel that passes through Jaipur city, has been recognized as a severely contaminated body of water, there are still few thorough biological analyses that concentrate on zooplankton. In Amanishah Nala, Jaipur, the current study is to evaluate zooplankton diversity and its correlation with water quality indices. The purpose of this ongoing project is to produce baseline ecological data that could support sustainable urban water management programs in line with national development goals and long-term environmental monitoring.

2. OBJECTIVES OF THE STUDY

1. To assess the diversity and composition of zooplankton communities in Amanishah Nala, Jaipur.
2. To examine seasonal variations in zooplankton abundance and distribution.
3. To analyze key physico-chemical parameters of water across selected sampling sites.
4. To evaluate relationships between zooplankton assemblages and environmental variables.
5. To assess the applicability of zooplankton as bio-indicators for urban water quality assessment.

STUDY AREA

Amanishah Nala is a significant urban drainage waterway in the semi-arid northwest Indian area of Jaipur, Rajasthan, India. At an average elevation of roughly 431 meters above mean sea level, Jaipur is located between latitudes 26°55′ to 27°05′ N and longitudes 75°45′ to 75°55′ E. The area has a semi-arid environment with warm winters, scorching summers, and modest monsoon rainfall.

Before joining the Dravyavati River system, the nala travels through heavily populated residential and industrial regions from its source in the western portion of Jaipur. It acts as the city's main channel for stormwater and wastewater from homes and businesses. Untreated or partially treated effluents are continuously discharged into the nala due to rapid urban growth and insufficient wastewater treatment infrastructure.

For the purposes of this study, the study region is separated into three zones according to the level of pollution: the downstream zone (post-pollution stretch), the polluted zone (receiving highest residential and industrial discharges), and the upstream zone (comparatively less polluted). This zonation makes it easier to evaluate how biological communities and water quality vary geographically along a pollution gradient. An average of 600–650 mm of rain falls on Jaipur each year, mostly from July to September during the southwest monsoon season. The physico-chemical properties of the nala and its aquatic biota are greatly influenced by seasonal changes in water flow and pollution load. Because of decreased flow and higher pollution concentrations, the nala is especially vulnerable during the non-monsoon season.

3. MATERIALS AND METHODS

The current study uses zooplankton as biological indicators to conduct an ecological evaluation of an urban freshwater drainage system. The selection of Amanishah Nala was based on its exposure to different levels of anthropogenic stress. The study uses seasonal and zonal sampling.

1. **Sampling Design and Frequency:** Seasonal zooplankton sampling is carried out throughout the pre-monsoon, monsoon, and post-monsoon periods. To guarantee spatial coverage, representative sampling locations are chosen within each zone.
2. **Zooplankton Collection and Preservation:** Zooplankton samples are collected by filtering a known volume of water through a standard plankton net with a mesh size of approximately 50–60 µm. Samples are preserved immediately in 4% formalin solution for laboratory analysis.
3. **Identification of Zooplankton:** Zooplankton organisms are identified up to genus or species level, wherever possible, using standard taxonomic keys. Major zooplankton groups such as Rotifera, Cladocera, copepoda, and Ostracoda are recorded.
4. **Physico-Chemical Analysis of Water:** Water samples are collected simultaneously for the analysis of physico-chemical parameters including temperature, pH, dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, and nutrients such as nitrates and phosphates. Analyses are performed following standard methods recommended by APHA.
5. **Data Analysis:** Zooplankton diversity is assessed using biodiversity indices such as species richness and shannon–Wiener diversity index. Statistical analyses including correlation analysis and analysis of variance (ANOVA) are applied to examine relationships between biological and environmental parameters.

4. EXPECTED RESULTS AND DISCUSSION

It is anticipated that the investigation would show clear seasonal and regional differences in zooplankton abundance and diversity throughout the various Amanishah Nala zones. Upstream and downstream areas are expected to have more diversity and abundance, whereas heavily contaminated areas may show lower diversity with a predominance of species that can withstand pollution.

The organization of zooplankton communities is likely to be impacted by seasonal variations in water quality factors as dissolved oxygen, nutrient concentration, and organic load. These anticipated trends can be understood in the context of past research on urban freshwater systems, which found significant correlations between changes in zooplankton assemblages and deterioration of water quality.

The expected results may emphasize the ecological effects of untreated wastewater discharge and the significance of integrating biological indicators into regular water quality monitoring programs from the standpoint of urban water management.

5. CONCLUSION

The current study emphasizes zooplankton's potential as useful bio-indicators for evaluating the ecological health of urban freshwater systems. The study is to produce baseline ecological data that may help sustainable urban water management techniques by concentrating on Amanishah Nala, Jaipur. Early identification of ecological deterioration can be improved and science-based environmental governance can be informed by integrating biological indicators with traditional physico-chemical monitoring techniques. By encouraging environmentally sustainable and scientifically informed urban development, the research's findings are anticipated to support India's long-term ambition of *Developed India @2047*.

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