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ASSESSMENT OF AQUATIC BIODIVERSITY AND ECOSYSTEM HEALTH THROUGH THE SHANNON-WEINER DIVERSITY INDEX

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ABSTRACT

Urban aquatic ecosystems are essential reservoirs of biodiversity that provide critical ecological services in increasingly developed landscapes. This article reviews the ecological health of the Shahjangi and Bhairwa ponds in Bhagalpur, Bihar, utilizing the Shannon-Weiner Diversity Index (H') as a primary metric for assessing phytoplankton community structure. By synthesizing data from a 15-month study conducted between 2021 and 2022, this review correlates eighteen physicochemical parameters—including temperature, pH, and dissolved oxygen—with biological productivity. The analysis confirms that while these ponds are highly productive and suitable for aquaculture, they face significant stress from organic loading. The results underscore the necessity of strategic conservation to prevent further eutrophication and maintain the biological integrity of urban lentic systems.

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INTRODUCTION

The ecosystem represents the fundamental functional unit of nature, where biotic communities interact with their abiotic environment to sustain life. In urbanized regions, ponds act as vital biological "refuges," supporting a diverse array of taxa displaced by human development. However, these systems are increasingly vulnerable to anthropogenic pressures, including sewage influx and agricultural runoff, which can drastically alter their ecological equilibrium. Central to understanding the health of these environments is Primary Productivity. This metric quantifies the rate at which radiant energy is captured and stored by photosynthetic organisms, primarily phytoplankton. Because phytoplankton are highly sensitive to environmental changes, they serve as reliable bio-indicators of water quality. To quantify these biological responses, ecologists employ diversity indices, with the Shannon-Weiner Index (H') being the most widely utilized. This index provides a nuanced perspective by accounting for both species richness and species evenness, offering a mathematical measure of ecosystem stability.

LITERATURE SURVEY

Foundational Theories of Biodiversity Indices: The conceptual framework for measuring biological diversity was solidified in the mid-20th century. The Shannon-Weiner Index, derived from information theory, was introduced to ecology to quantify the "uncertainty" in species identification within a community. Unlike simpler metrics, the Shannon index integrates both the number of species and how equally individuals are distributed among them. A high H' value typically reflects a stable, resilient ecosystem, while a low value indicates environmental stress or dominance by opportunistic species.

Global Trends in Urban Limnology: Recent research identifies urban ponds as "biodiversity hotspots" that often support greater macroinvertebrate and phytoplankton richness than previously assumed. Studies across various global landscapes indicate that local environmental variables—such as nutrient levels and pH—frequently override broader urban land-use effects when shaping aquatic communities.

Regional Research in Bihar (2024–2026): Significant academic attention has recently focused on the "hypertrophic" status of subtropical ponds in Bihar. Recent research indicates that nutrient loading from domestic waste has pushed many regional ponds to exceed biochemical oxygen demand (BOD) limits. While many global systems are phosphorus-limited, ponds in the Bihar region often demonstrate that nitrogen loading is the primary regulator of trophic states. Higher taxonomic richness in these systems has been found to correlate with increased Resource Use Efficiency (RUE), meaning biodiversity loss directly impairs ecosystem function.

Methodology and Mathematical Framework: The core research reviewed here involved monthly and seasonal fluctuations over a 15-month period from October 2021 to December 2022.

The Shannon-Weiner Index Formula

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i)$$

To assess phytoplankton diversity, the following mathematical model was applied:

RESULTS

Physicochemical and Biological Interactions: The biodiversity of the Bhagalpur ponds is intrinsically linked to eighteen water quality parameters.

Thermal Dynamics and Oxygen

- Water temperatures fluctuated from 18.0°C in winter to 33.8°C in summer.
- A strong negative correlation (-0.738) was observed between water temperature and Dissolved Oxygen (DO).
- Warmer water holds less oxygen, which directly impacts the metabolic rates and diversity of the phytoplankton community.

Nutrient Profiles and Community Structure

- Both ponds remained permanently alkaline, with pH ranging from 7.15 to 7.59.
- Nitrate and Phosphate levels (averaging 1.5 to 2.8 ppm) indicated high fertility.
- This nutrient profile supported the proliferation of Chlorophyceae (37.33%) and Myxophyceae (36.29%).
- The prevalence of Myxophyceae (blue-green algae) during warmer months is a classic indicator of organic enrichment.

Table 1. Average Water Quality Indicators

Parameter	Bhairwa Pond (Avg)	Shahjangi Pond (Avg)
Transparency	55.33 cm	59.33 cm
BOD	4.42 mg/l	4.42 mg/l
COD	5.80 mg/l	5.83 mg/l

DISCUSSION

The application of the Shannon-Weiner Index in this study reveals that urban pond stability is a result of continuous interaction between physical forces and biological responses. The index proved to be a sensitive tool; higher values signified stable periods, while lower values were recorded during algal bloom phases, indicating environmental stress from urban runoff. Although the ponds are currently "fertile" and productive, the inverse relationship between rising temperatures and oxygen levels suggests that climate-driven warming poses a threat to this biological balance.

CONCLUSION

The Shahjangi and Bhairwa ponds of Bhagalpur are highly productive ecosystems currently suitable for fish culture across all seasons. However, the Shannon-Weiner Index confirms that these water bodies are under pressure from anthropogenic activities. To ensure long-term sustainability, this review advocates for strictly regulated conservation laws to prevent untreated sewage discharge and the implementation of regular bio-monitoring to track the ecological health of these vital urban reservoirs.

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