

# Challenges and Strategies for Sustainable Urban Aquaculture: A Limnological Review of Anthropogenic Stressors in the Middle Gangetic Plain

## Abstract

Urban aquaculture is a vital component of food security and livelihood for the burgeoning populations of South Asian cities. However, the hydrobiological integrity of these urban water bodies is under severe threat from rapid urbanization and unregulated waste disposal. This review evaluates the limnological transition of traditional ponds in Bhagalpur, Bihar, from pristine ecosystems to stressed urban sinks. By synthesizing data on nutrient loading, organic pollution indicators, and biodiversity indices, the article identifies the core stressors hindering productivity. Furthermore, it proposes integrated management strategies, including nature-based solutions, to ensure the long-term sustainability of urban fisheries.

**Keywords: Urban, Ponds, Limnological.**

## 1. Introduction: The Urban Blue-Space Crisis

As cities expand, the pressure on peri-urban and intra-urban freshwater bodies intensifies. In Bhagalpur—the historical "Silk City" of Bihar—perennial ponds like Sahjangi and Bhairwa have historically served as the backbone of local fisheries. In the contemporary era, these ponds are no longer influenced solely by the monsoonal rhythm but by "Anthropogenic Seasonality" (Siddique et al., 2023). This review analyzes the systemic degradation of these ecosystems, exploring how urban stressors alter the metabolic rate of the water and the diversity of the life it supports.

## 2. The Mechanics of Cultural Eutrophication

The most significant impact of urbanization on pond hydrobiology is nutrient enrichment, or cultural eutrophication. Domestic effluents, rich in nitrogen and phosphorus from detergents and organic waste, accelerate primary productivity to unstable levels.

- **Nutrient Influx:** Recent studies highlight that urban ponds in the Gangetic plain act as "nutrient traps" (Prasad et al., 2024). While high nutrient levels initially boost fish food (phytoplankton) production, they eventually lead to the dominance of Cyanophyceae (blue-green algae).
- **The Hypoxic Cycle:** Excessive algal growth leads to high daytime Dissolved Oxygen (DO) through photosynthesis, followed by catastrophic night-time depletion as algae and organic matter respire and decompose. This cycle is a leading cause of mass fish mortality in urban aquaculture (Saha et al., 2021).

## 3. Organic Loading and Chemical Stressors

37 Unlike rural ponds, urban water bodies receive a cocktail of organic and  
38 inorganic pollutants.

- 39 • **BOD and COD Dynamics:** The research in Bhagalpur revealed elevated  
40 Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)  
41 levels, averaging above 4.4 mg/l and 5.8 mg/l, respectively. This indicates a  
42 high organic load that competes with fish for available oxygen.
- 43 • **Chloride as a Marker:** Increased chloride concentrations in urban ponds serve  
44 as a direct marker for human interference and sewage contamination (Kumari,  
45 2023). High chloride levels can alter the osmotic balance of aquatic organisms,  
46 leading to reduced growth rates in commercially important carps.

#### 47 **4. Biodiversity Loss and Biotic Integrity**

48 Urbanization typically leads to a "biotic homogenization," where sensitive  
49 native species are replaced by a few pollution-tolerant taxa.

- 50 • **Shannon-Weiner Index (H')**: Biodiversity indices are critical for quantifying  
51 this shift. While the ponds in Bhagalpur currently maintain a moderate  
52 diversity ( $H' \sim 2.8\text{--}3.2$ ), the trend indicates a gradual decline in species  
53 evenness.
- 54 • **Bio-indicators:** The presence of specific genera like *Microcystis*  
55 (Cyanophyceae) and Rotifers (Zooplankton) often correlates with high organic  
56 pollution. Recent research emphasizes that maintaining high taxonomic  
57 diversity is essential for the ecological resilience of aquaculture ponds against  
58 disease outbreaks (Thakur et al., 2022).

#### 59 **5. Strategies for Sustainable Restoration**

60 To safeguard urban aquaculture, the review proposes a shift from reactive to  
61 proactive management:

- 62 1. **Integrated Peripheral Drainage:** Constructing peripheral drains to divert raw  
63 sewage away from pond basins is the first step toward restoration.
- 64 2. **Nature-Based Solutions (NbS):** Implementing "Floating Treatment Wetlands"  
65 (FTWs) using native macrophytes like *Canna* or *Vetiver* can biologically  
66 sequester excess nutrients before they trigger algal blooms.
- 67 3. **Community-Led Conservation:** Engaging local fishing communities in the  
68 monitoring of water quality ensures the socio-ecological sustainability of the  
69 resource.

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## 73 **6. Conclusion**

74 The urban ponds of the Middle Gangetic Plain are at a crossroads. While they  
75 possess high natural productivity, the footprint of urbanization is narrowing their  
76 ecological margins. Sustainable urban aquaculture requires a multidisciplinary  
77 approach that integrates limnological monitoring with urban engineering. By  
78 preserving the hydrobiological integrity of these ancient ponds, cities like Bhagalpur  
79 can maintain a resilient source of protein and a vital cooling hub for the urban  
80 microclimate.

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