

## How increasing pollution in freshwater lakes is posing risk to native plant species causing shift in their diversity

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*This article is about some native flora, which used to inhabit lakes and ponds and lead a joyous life in their pristine natural habitat, but now are struggling for their existence due to various anthropogenic activities as well as nutrient enrichment. It also tells us how condition of native freshwater flora is under stressed condition due to increasing pollution resulting in dominance of invasive plant species.*

### Background

The world is witnessing exceptional increase in sewage generation due to increasing urbanization and water consumption. A major part of generated wastewater finds its way to freshwater lakes and rivers. The freshwater bodies bear double shocks: one from increasing water pollution and another from encroachment activities adversely affecting their native biodiversity. The domestic wastewater is rich in nutrients such as phosphates and nitrates that cause excessive growth of exotic and invasive species in the receiving water bodies. Eutrophication or excessive nutrient enrichment of freshwater ecosystem is one of the greatest challenges the world is facing today. The varied environmental and economic values which our lakes provide are declining at a faster rate. Native species of macrophytes are very important for freshwater ecosystem as they help in maintaining the heterogeneity and ecological functioning of the aquatic ecosystem.

### Freshwater Ecosystem

The freshwater ecosystem which constitutes river and lakes are the treasured natural resources of our society as they support diverse biodiversity. Nutrient enrichment results in eutrophic condition of the lakes thereby causing the ecological shift in the composition of biotic community. The population explosion and its related unplanned urbanization, as well as various ecological stressors like eutrophication, encroachments in the littoral zone of the lakes, siltation, solid waste dumping,

micro-plastics and invasion of exotic macrophytic species considerably affect the ecological balance of the lakes in the central Gangetic plain of Uttar Pradesh, India. The excessive nutrient enrichment within the freshwater lakes result in unbalanced aquatic conditions with the dominance of invasive macrophytes as shown in figure 1. Various lake stressors have viciously affected the fragile and sensitive freshwater ecosystem which leads to deterioration in water quality, aquatic biodiversity and reduction in the lake area.



**Figure 1:** [A] Encroachment by the human settlements around the lakes in urban catchments



*Figure 1: [B] The dominance of aquatic invasive macrophytes due to nutrient enrichment on the littoral area of the lakes*



*Figure 1: [C] The aquaculture activities (cultivation of Trapanatans) in the lakes causing its dominance in the urban lake (Kathauta]heel, Lucknow)*

### Gathering evidences: quantifying the impacts of nutrient enrichment on native plant diversity

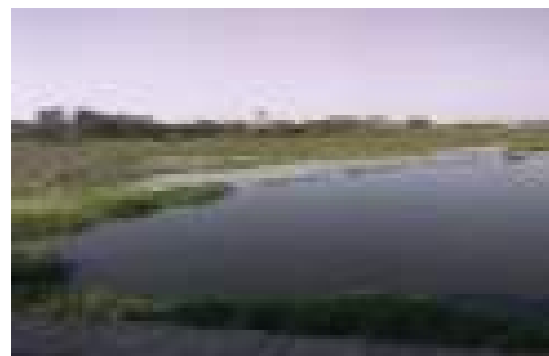
The main purpose of this study is to understand the relationship between macrophytic diversity and trophic state (nutrient levels) of selected lakes in both urban and rural catchments. Three freshwater lakes have been selected in the middle Ganga Basin viz. Kathuata lake and Haibatmau lake situated in the urban catchments of Lucknow and Samaspur wetland situated in the rural catchments of Raebareli district where six interconnected lakes constitute a large wetland-complex. This wetland has recently been included in the Ramsar site – a UN convention that categorizes wetlands on the basis of international significance from the conservation point of view. The main focus of this research work was to understand how nutrient enrichment along with the increasing trophic state of lakes and various anthropogenic activities adversely affected their aquatic macrophytic diversity.

Nutrients loading of the three selected lakes was estimated by analyzing changes in their water quality parameters. It was found that variations in nutrient loading along with various human-induced disturbances resulted in the deviations in the community structure of native plants in these freshwater lakes. Trophic state of the lakes was determined using three major water quality parameters: secchi depth (SD), total phosphorous (TP) and chlorophyll a. In the selected lakes species richness of macrophytes (floating, submerged and emergent) was measured that corresponded to their peak biomass. To quantify the impacts of nutrient enrichment on macrophytic diversity, various diversity indices were evaluated such as species richness, Shannon–Wiener index and importance value index.

A noteworthy increase in the species richness of floating macrophytes, while decrease in species richness of submerged macrophytes was observed due to increase in total phosphorous concentration. Lakes situated in urban catchments of Lucknow viz. Kathauta and Haibatmau were found to be in mesotrophic state, while Samaspur wetland which is the Ramsar site situated in Raebareli district was found to be in oligotrophic condition. Finding of

this research suggested that increase in the lake's trophic state and human-induced impacts such as encroachment badly affected the composition, dominance and diversity of macrophytes in the freshwater lakes.

Anthropogenic interference in the freshwater ecosystem like aquaculture activities had adversely affected the macrophytic diversity as seen in Kathauta lake. This lake was fragmented into two segments for one for *Trapa* cultivation (locally known as *Sinhgara*) and other one for fish rearing (as seen in figure 2) which had adversely affected the composition of native macrophytic species. This research reported that oligotrophic Samaspur wetland had highest species richness and diversity due to lower trophic state and fewer anthropogenic disturbances which caused increase in species richness and habitat heterogeneity in comparison to mesotrophic Kathauta and Haibatmau lakes. Among the three lakes, urban lake *i.e.* Kathauta lake was under the highest level of anthropogenic alterations and had higher total phosphorous values, showing lowest species diversity and species richness. Species evenness was maximum in both the urban situated Kathauta and Haibatmau lakes, due to the excessive growth of invasive free-floating macrophytes which resulted in biotic homogenization.



*Figure 2: Fragmentation in the urban (Kathauta) lake for the purpose of Trapa cultivation in the first half segment and fish rearing in the other segment of the lake*





Figure 3: How the lakes will describe themselves...



IM: Invasive macrophytes; NM: Native macrophytes

Figure 4: Conversation between invasive macrophytes (IM) and native macrophytes (NM) of different lakes characterized by different nutrient status (trophic state)

**Actions that are required: Bridging the gap between research and practice**

The unique ecohydrological conditions along with nutrient-rich runoff and widespread catchment land use changes favour flourishing growth of exotic invasive macrophytes such as *Eichhorniacrassipes*, *Ceratophyllumdemersum*, *Potamogetoncrispus*, *Azollafliculoides*, *Myriophyllumaquaticum*, *Trapanatans*, and *Typhaangustifolia*. They are among the dominant and widespread species of macrophytes in the urban lakes. Excessive growth of exotic invasive macrophytic species adversely affects the native macrophytes species. Cultural eutrophication in lakes have caused loss in species richness of

native macrophytes thereby leading to the dominance of invasive aquatic macrophytes (as seen in the figure 5), thereby creating a problematic condition for the freshwater lake. This process hinders the ecological functioning of lakes. This research showed that, with increasing nutrients in the lakes, spread of invasive macrophytes occurs, whose leaves often cover the surface of the water, thereby posing danger to submerged aquatic flora and fauna. Therefore, it is important to understand the relationship between trophic state and macrophytic diversity of nutrient-rich lakes. It is also important to understand the impact of pollution on aquatic biodiversity.



**Figure 5:** [A] Dominance of invasive aquatic macrophytes in the Haibatmau Lake. [B] Image showing the Samaspur wetland (Ramsar Site).

From this evidence-based research work, it is suggested that strict monitoring and management of both point and non-point sources of pollution need to be done. The evaluation of water quality and its relation to macrophytes diversity helps in understanding how pollution along with anthropogenic disturbances change the composition of aquatic flora which in turn could affect the freshwater ecosystem biodiversity and various supporting ecological processes. The findings also indicate that various human-induced changes in the lake's catchments such as land use changes, unplanned urbanization, aquaculture activities and discharge of partially treated and untreated wastewater must be addressed in the master plan. A timely intervention could restore the ecological health of these freshwater lakes.

Above all, the integration of holistic management and conservation strategies in the restoration plan of freshwater lakes should be taken up by researchers and local bodies for so that their environmental and economic values can be optimized.

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