

# Fish Diversity and Habitat Complexity: The Role of Macrophytes and Physicochemical Parameters in Urban and Rural Tropical Lakes

I. Annie Pushpa<sup>1</sup>, K. Maheshkumar<sup>2</sup>, V. Deepak Samuel<sup>3</sup> and N. Nirmal Magadalenal<sup>1</sup>†

<sup>1</sup>PG and Research Department of Zoology, Voorhees College, Vellore 632 001, Tamil Nadu, India

<sup>2</sup>Department of Zoology, Government Arts College, Nandanam, Chennai 600 035, Tamil Nadu, India

<sup>3</sup>National Centre for Sustainable Coastal Management, Ministry of Environment, Forest and Climate Change, Anna University Campus, Chennai, 600 025, India

Orcid ID: <https://orcid.org/0009-0000-2746-0929>

†Corresponding author: N. Nirmal Magadalenal; [nirmalmagdalene@gmail.com](mailto:nirmalmagdalene@gmail.com)

Key Words	Fish diversity, Macrophytes, Physicochemical parameters, Urban and rural tropical lakes
DOI	<a href="https://doi.org/10.46488/NEPT.2026.v25i04.B4426">https://doi.org/10.46488/NEPT.2026.v25i04.B4426</a> (DOI will be active only after the final publication of the paper)
Citation for the Paper	Pushpa, I. A., Maheshkumar, K., Samuel, V. D., and Magadalenal, N. N., 2026. Fish diversity and habitat complexity: The role of macrophytes and physicochemical parameters in urban and rural tropical lakes. <i>Nature Environment and Pollution Technology</i> , 25(4), B4426. <a href="https://doi.org/10.46488/NEPT.2026.v25i04.B4426">https://doi.org/10.46488/NEPT.2026.v25i04.B4426</a>

## ABSTRACT

Freshwater ecosystems are increasingly impacted by urbanization, agricultural runoff, and invasive species, all of which shape aquatic biodiversity. This study provides a comparative ecological assessment of two contrasting freshwater lakes, Katpadi Lake (urban) and Saina Palayam Lake (rural) located in Vellore District, Tamil Nadu, India. In the present study, a total of 15 fish species were recorded in both the lakes, with *Oreochromis niloticus* being the exotic and invasive. The order Cypriniformes dominated the fish community (60%), reflecting its ecological flexibility. Diversity indices such as Shannon (H') and Simpson (1-D) showed minimal differences between the sites. However, Katpadi Lake exhibited higher total dissolved solids and conductivity, indicating greater anthropogenic impact. A total of 10 macrophytes

were identified from the study sites, representing submerged, floating-leaved, and emergent growth forms. Their distribution varied across urban, and rural areas, reflecting differences in habitat conditions and water quality. Macrophyte diversity was higher in Saina Palayam Lake, suggesting a link between macrophytes complexity and fish diversity. Submerged species like *Najas marina* and *Myriophyllum spicatum* likely contributed to improved habitat conditions for native fauna. Nutrient concentrations, especially elevated nitrate and phosphate levels in Saina Palayam Lake, hint at non-point agricultural runoff, whereas Katpadi Lake exhibited elevated hardness, chloride, and ammonia levels, reflecting a stronger urban pollution influence. This study underscores the need for integrated monitoring of fish, macrophytes, and water quality to manage freshwater biodiversity in varying environmental conditions.

## **INTRODUCTION**

Freshwater ecosystems are among the most biodiverse and ecologically significant habitats and play a fundamental role in ecological stability. They are increasingly threatened by anthropogenic activities across both urban and rural areas (Dudgeon et al. 2006). Studying freshwater fish diversity in urban and rural areas provide valuable insights into how urbanization, industrialization, and agriculture affect aquatic biota (Paul & Meyer 2001; Walsh et al. 2005). Urban areas often experience pressures such as sewage discharge, industrial effluents, and habitat modification, whereas rural areas can be impacted by pesticide and fertilizer runoff from agricultural activities, leading to eutrophication and toxic contamination (Carpenter et al. 1998; Allan 2004). Both contribute differently but significantly to stress in freshwater habitats, which can alter fish diversity and community structure. One of the major biological threats in both environments is the introduction of invasive fish species, which can disrupt native fish populations through competition, predation, and hybridization (Moyle & Light 1996). These species often thrive in disturbed environments and may exacerbate

biodiversity loss, especially when ecosystems are already stressed by poor water quality or habitat degradation (Gido & Brown 1999).

Aquatic macrophytes are essential components of freshwater ecosystems and are closely linked to fish diversity. They contribute to habitat complexity, offer refuge from predators, provide spawning grounds, and support a rich invertebrate fauna that serves as food for many fish species (Diehl & Kornijów 1998; Thomaz et al. 2025). However, macrophyte abundance and diversity can also be negatively affected by pollutants, siltation, and nutrient loading, which are common in both urban drainage and agricultural runoff (Lacoul & Freedman 2006). Physicochemical water parameters such as pH, temperature, conductivity, and nutrient concentrations play a pivotal role in shaping fish communities by determining habitat suitability and influencing biological processes (Allan & Castillo 2007). Low oxygen levels or extreme pH can limit the survival and reproduction of sensitive species, while high nutrient levels may promote algal blooms that destabilize food webs (Gilvear et al. 1999; Wetzel 2001).

The objective of this study is to conduct a comprehensive ecological assessment of two contrasting freshwater ecosystems one is Katpadi Lake (KAL) also called Dharapadavedu Lake which is located in the urban area and other one is Saina Palayam Lake (SPL) located in suburban area in Vellore. Despite numerous studies on freshwater fish diversity in Tamil Nadu, integrated comparative assessments of fish assemblages, macrophyte communities, and physicochemical parameters across urban and rural freshwater lakes remain undocumented in the Vellore District. This study presents a comprehensive urban–rural comparison of freshwater lake ecosystems in the region by jointly analysing fish diversity, macrophyte structure, and water quality variables. Study areas allow a comprehensive assessment of ecosystem health and help identify the multifaceted drivers of biodiversity change in freshwater systems. Such holistic studies are especially valuable for informing conservation strategies and guiding the sustainable management of water resources in both urban and rural areas.

## **Materials and Methods**

### **Study Area**

The study was conducted in two freshwater lakes located in Vellore District, Tamil Nadu, India. KAL (catchment area: 17.09 km<sup>2</sup>) is situated in the urban zone of Katpadi, whereas SPL usually called as S.N. Palayam Lake (catchment area: 12.96 km<sup>2</sup>) lies in the rural region of Ponnai (TNWRD, 2020). The geographical locations of KAL (Lat: 12.963766°; Long: 79.128653°) and SPL (Lat: 13.141206°; Long: 79.267942°) of both lakes were mapped and georeferenced using ArcMAP GIS software version 10.8 (Fig. 1). Fish sampling, macrophyte recording, and physicochemical parameter measured. In KAL, sampling was carried out in December 2024, while in SPL, sampling was conducted in April 2025.

### **Fish Sampling and Identification**

Fish samples were collected from both lakes using three sizes of cast nets (radius 1.2–2.4 m; mesh size 1.3–5.1 cm), enabling the capture of both small and large-bodied species. Each net was fitted with sinkers (7–14 g) to ensure efficient spread and descent in shallow waters. Sampling was conducted between 07:00 and 13:00 h, coinciding with peak activity of shallow-water fish. Sampling was conducted separately in each lake using a standardized approach. In each lake, nine representative sampling sites were selected along the lake margins, considering habitat characteristics such as macrophyte cover, water depth, flow variation, anthropogenic disturbance, and accessibility. At each site, six to nine haul operations were performed across different microhabitats, including open water, vegetated zones, and shallow marginal areas. Multiple net types and mesh sizes were employed as described earlier to target a broad range of fish size classes. Captured specimens were photographed on-site for initial documentation and then preserved in 10% formalin for further identification. Species were identified using

standard taxonomic keys (Talwar & Jhingran 1991; Jayaram 2010), and verified with online databases FishBase (Froese & Pauly 2024).

### **Analysis of Fish Diversity**

Relative abundance values for each fish species in Katpadi Lake and Saina Palayam Lake are presented in Table 1. Diversity metrics including Dominance (D), Simpson's index (1-D), Shannon-Wiener index (H), Menhinick's richness index, Margalef's richness index, Fisher's alpha, and the Berger-Parker dominance index were calculated using PAST software version 4.03 (Hammer et al. 2001) to assess species diversity and community structure.

In addition to diversity indices, which primarily describe the diversity, richness and evenness of individual communities, the use of similarity indices such as Jaccard and Sørensen provides valuable insights into beta diversity. While alpha diversity highlights the structure within each site, similarity indices quantify the degree of overlap and turnover of species between sites, thereby complementing diversity measures. This distinction is crucial, as communities may exhibit comparable levels of species richness yet differ markedly in composition. Species similarity between KAL and SPL was assessed using the Sørensen and Jaccard similarity indices. where 'a' represents the number of species shared between the two lakes, 'b' the species unique to KAL, and 'c' the species unique to SPL. The Sørensen similarity coefficient index was calculated as:

$$S_s = \frac{2a}{2a + b + c}$$

and the Jaccard index as:

$$J = \frac{a}{a + b + c}$$

Both indices were used to quantify beta diversity and compare fish community composition between the two sites. To further visualize the similarity patterns, a hierarchical cluster analysis

was performed using the Jaccard similarity coefficient as the distance measure and the unweighted pair-group method with arithmetic mean (UPGMA) algorithm. The dendrogram illustrate the clustering of fish species across sites.

### **Macrophyte Identification**

Macrophyte assessment was conducted using visual, qualitative observations during field surveys. The presence, general abundance, and dominant growth forms of macrophytes were recorded to characterize habitat conditions; however, quantitative measurements such as percent cover, biomass, or spatial extent were not estimated. Accordingly, macrophyte data were used to provide descriptive context for habitat structure. Specimens were identified to the species level using standard macrophyte identification keys (Subramanyam 1962; Cook 1996).

### **Physicochemical Water Analysis**

Physicochemical parameters were analysed from water samples collected at each study site following BIS 10500:2012 and APHA (2017) protocols. pH and electrical conductivity were measured in situ using a portable multiparameter probe (Eutech Instruments, Singapore); turbidity with a Nephelometric Turbidity Meter (APHA 2130B); and total dissolved solids (TDS) with a digital TDS meter. Nutrients (nitrate, nitrite, phosphate, ammonia) were quantified via UV–Visible spectrophotometry (APHA 4500 series), while major and trace metals (iron, manganese, calcium, magnesium) were determined using Atomic Absorption Spectrophotometry (AAS, PerkinElmer). Alkalinity, total hardness, and chloride were measured by titrimetric methods, and short-term oxygen absorbed was assessed using Tidy's Test (4-h BOD; APHA 5210B). Sensory characteristics (colour, odour, appearance) were recorded visually and organoleptically.

## **Results and Discussion**

### **Fish Diversity**

A total of 15 fish species were recorded in both KAL and SPL. The species identified in KAL include *Oreochromis niloticus*, *Anabas testudineus*, *Pethia conchonius*, *Glossogobius giuris*, *Parambassis ranga*, *Puntius sophore*, *Channa striata*, and *Esomus danrica* (Fig. 2 and Table 1). In SPL, the species include *Rasbora daniconius*, *Oreochromis niloticus*, *Amblypharyngodon mola*, *Amblypharyngodon microlepis*, *Salmostoma phulo*, *Puntius sophore*, *Parambassis thomassi*, *Pethia ticto*, and *Rasbora* spp (Fig. 2 and Table 1). Notably, *Oreochromis niloticus*, an exotic and invasive species, was present in both lakes. Its ability to tolerate a wide range of environmental conditions and reproduce rapidly can displace native species and disrupt local food webs (Canonico et al. 2005).

Order Cypriniformes dominated the fish community, representing 60% of the total species diversity, while Mugiliformes and Anabantiformes each contributed 13%, and Cichliformes and Gobiiformes each accounted for 7% (Fig. 3). The species belongs to Cypriniformes are attributed to their ecological adaptability, feeding versatility, and reproductive strategies in varied aquatic habitats (Nelson et al. 2016; Chakraborty 2021).

Small indigenous freshwater fish species (SIFs), including *Amblypharyngodon mola*, *Amblypharyngodon microlepis*, *Pethia ticto*, and *Rasbora* spp., are recorded in the current study area. These SIFs play a vital ecological and socio-economic role in Indian freshwater ecosystems, being highly adapted to the variable environmental conditions typical of tropical lakes and wetlands (Sarkar & Lakra 2010). Sarkar & Lakra (2010) also highlight that despite their resilience, these SIFs are vulnerable to habitat degradation, overexploitation, and competition from introduced species. Hence, targeted conservation and sustainable management practices are essential to protect these SIF populations and maintain ecosystem health in the study region.

### ***IUCN Conservation Status***

All recorded fish species were categorized as *Least Concern* (LC) according to the IUCN Red List (IUCN, 2025) (Table 1). Lewis (2002) emphasizes that tropical lakes are especially vulnerable to eutrophication and deep-water oxygen depletion, making them more sensitive to nutrient loading and hydrological alterations than their temperate counterparts. Tropical systems exhibit heightened and disproportionate changes in water quality and biotic communities when subjected to even moderate nutrient enrichment.

### ***Diversity Analysis***

Diversity indices showed comparable species richness across both sites. The Shannon diversity index ( $H'$ ) was marginally higher in SPL (1.628) compared to KAL (1.615) (Table 2). Magurran (2004) reported a slightly more even distribution of individuals among species in rural sites. The Margalef and Menhinick indices were also higher in SPL, suggesting greater richness relative to sample size. Meanwhile, Berger–Parker and dominance ( $D$ ) indices were elevated in SPL, suggesting the presence of dominant species (*Oreochromis niloticus*) (Table 1). The observed variation in Shannon, Margalef, and Menhinick indices may partly reflect differences in macrophyte heterogeneity and associated habitat complexity. Structurally diverse macrophyte assemblages can enhance habitat availability by providing shelter and feeding opportunities, thereby supporting higher fish richness and evenness, whereas sparse or monospecific vegetation may favor a limited number of tolerant species (Thomaz et al. 2025). Accordingly, the diversity indices represent not only species richness but also habitat structure mediated by macrophyte composition.

Dominance-sensitive indices, particularly Simpson and Berger–Parker, indicated a skewed community structure in both lakes, with a small number of species contributing disproportionately to total abundance. This pattern was largely driven by the overwhelming dominance of the invasive cichlid *Oreochromis niloticus*, which constituted approximately half

of the total fish abundance. The ecological traits of this species, including high reproductive capacity, trophic flexibility, and tolerance to environmental stressors, likely promote numerical dominance and reduce community evenness through competitive exclusion and habitat monopolization (Johnson et al. 2022). Such patterns have been documented elsewhere; for instance, in the hydrologically fragmented Vaigai River–Estuary, *Oreochromis* spp. accounted for over a third of the total catch, markedly reducing community evenness despite moderate to high diversity levels (Mogalekar et al. 2025). Such dominance patterns are commonly associated with disturbed freshwater systems and highlight the need to interpret richness- and dominance-based indices together, as higher species richness may coexist with strong numerical dominance. The similarity in dominance patterns across lakes further suggests that invasive species pressure may partially override spatial differences, influencing overall community structure.

### ***Similarity Analysis***

In the present study, the relatively low similarity values (Jaccard = 0.20; Sørensen = 0.33) emphasize the distinctiveness of fish assemblages between the urban (KAL) and rural (SPL) systems (Table 3). Such dissimilarity reflects the combined influence of surrounding environmental conditions variation, macrophyte composition, and physicochemical conditions, which shape species distributions differently across sites. Including Jaccard and Sørensen indices therefore situates the findings within the broader framework of alpha–beta–gamma diversity, and aligns with established practices in community ecology, where both within-site diversity and between-site similarity are necessary to obtain a comprehensive understanding of biodiversity patterns. The hierarchical cluster analysis based on Jaccard similarity further supported this observation, grouping the two lakes together and highlighting species restricted to individual sites (Fig. 4).

These results are consistent with earlier studies that emphasize the ecological drivers of low similarity in fish communities. Koleff et al. (2003) stressed the importance of using multiple similarity measures to capture complementary aspects of community structure, while Johnson & Angeler (2014) and Gebrekiros (2016) reported that environmental heterogeneity and land-use pressures contribute to strong compositional differences across freshwater systems. Similarly, Schlosser (1984) highlighted the role of local habitat features in regulating fish community structure, and Baselga (2007) demonstrated that beta diversity often arises from species turnover along environmental gradients. Supporting this view, Yang et al. (2008) showed that spatial environmental variability is a dominant factor shaping freshwater fish assemblages, commonly reflected in low Jaccard and Sørensen values across contrasting habitats. The low similarity values indicate pronounced species turnover between the two lakes rather than simple differences in species richness. This turnover is likely driven by a combination of environmental and biotic factors measured in the present study. Differences in physicochemical conditions and water depth, together with variation in macrophyte composition and structural complexity, may influence habitat suitability for different fish species, leading to species replacement across lakes.

In addition, the strong numerical dominance of the invasive cichlid *Oreochromis niloticus* in both systems likely modifies community composition by suppressing subordinate native species, resulting in distinct assemblages dominated by different sets of non-dominant species. Macrophyte structure may further mediate these patterns by selectively favouring species adapted to vegetated or open habitats. Together, these factors suggest that beta diversity patterns in the study lakes reflect invasion-driven and habitat-mediated community restructuring rather than random species variation.

### **Macrophyte Diversity**

Macrophyte diversity in KAL comprises *Neltuma juliflora*, *Ceratophyllum demersum*, *Ottelia alismoides*, and *Najas marina* (Fig. 5 and Table 4). Abundance of *Neltuma juliflora*, likely contributes little to aquatic biodiversity and may negatively affect shoreline habitats by increasing water loss and altering habitat structure. In contrast, *Ceratophyllum demersum*, a submerged macrophyte, forms dense underwater meadows that provide cover and spawning sites for small fish and invertebrates (Lacoul & Freedman 2006). *Najas marina*, another submerged species, plays a similar role and helps stabilize sediments, thereby reducing turbidity and supporting clearer waters (Chambers et al. 2008).

SPL displayed higher macrophyte diversity, with species like *Nymphoides aquatica*, *Nymphaea odorata*, *Najas marina*, *Potamogeton distinctus*, *Ottelia alismoides*, *Najas minor*, *Typha angustifolia* and *Myriophyllum spicatum* (Fig. 5 and Table 4). The abundance of submerged and floating-leaved macrophytes in water bodies not only enhances habitat complexity but also contributes to nutrient cycling, oxygenation, and protection of juvenile fish from predation (Wetzel 2001; Lacoul & Freedman 2006). Previous studies have shown that dense *Myriophyllum spicatum* stands can influence trophic interactions by increasing invertebrate abundance, which may subsequently be reduced by fish predation, thereby allowing macrophyte proliferation (Ward & Newman, 2006). In the present study, the qualitative occurrence of dense *Myriophyllum* in SPL coincided with higher dominance index values. While direct causal relationships were not examined, this observed pattern is consistent with established macrophyte–fish interaction frameworks and offers a plausible ecological interpretation of the dominance structure observed in SPL.

Similarly, *Potamogeton* and *Najas* species serve as indicators of moderately nutrient-rich waters, which can favour fish diversity (Chambers et al. 2008). The greater structural heterogeneity in SPL may help explain the slightly better evenness and richness indices observed there, despite the rural area. Overall, the presence and diversity of aquatic

macrophytes appear to significantly influence the spatial distribution, shelter availability, breeding potential, and foraging opportunities of fish communities in both lakes.

### **Physicochemical Parameters**

Physicochemical analysis revealed that both lakes were slightly turbid and yellow in color with odour presence, indicating organic matter or algal content (APHA 2017) (Table 5). KAL had significantly higher total dissolved solids (894 mg/L), conductivity (1277  $\mu\text{mho/cm}$ ), and chloride levels (204 mg/L), pointing to greater anthropogenic pollution (Table 5). As noted by Allan (2004) anthropogenic pollution are likely from urban effluents, sewage discharge, and road runoff. High conductivity values indicate increased ion concentration, often due to domestic wastewater and industrial discharges in urban lakes. Indeed, electrical conductivity serves as a reliable, indirect indicator of pollution in shallow lakes, showing linear correlations with total dissolved solids, sulphates, and other dissolved ions (Das et al. 2006)

SPL had lower overall dissolved ions and turbidity, yet slightly elevated nitrate (3 mg/L) and phosphate (0.13 mg/L) levels were recorded, suggesting non-point source pollution (Table 5). As previously suggested by Carpenter et al. (1998) it is possibly due to agricultural runoff and fertilizer use in surrounding fields. Agricultural runoff is a common contributor to nutrient enrichment in rural freshwater systems, especially where buffer vegetation is lacking. The slightly more alkaline pH (7.62) in SPL also supports the possibility of biogenic activity. Photosynthetic removal of  $\text{CO}_2$  by macrophytes and algae, which shifts the carbonate equilibrium toward higher pH levels. Diurnal and seasonal pH shifts tied to biological metabolism are well-documented in freshwater systems, particularly in wetlands where photosynthesis reduces dissolved  $\text{CO}_2$  and raises pH (Gupta et al. 2021).

Higher free ammonia (1.04 mg/L) was recorded in KAL (Table 5). High ammonia will affect fish health by causing gill damage and inhibiting growth (Randall & Tsui 2002). The

combined assessment of fish species, macrophyte composition, and water quality reflects the influence of surrounding environmental conditions on freshwater biodiversity. While both lakes harbour similar levels of fish diversity, the presence of invasive species, differing macrophyte richness, and variable physicochemical profiles underscore the need for integrated freshwater ecosystem monitoring.

### Limitation

Although the primary objective of the study was to examine spatial variation between the lakes, differences in sampling periods may have contributed to some of the observed variations. KAL was sampled during the post-monsoon season, whereas SPL was sampled during peak summer, and seasonal changes in hydrological conditions may influence water quality, macrophyte abundance, and fish assemblages. The findings therefore be interpreted with the understanding that both spatial factors and seasonal variability may have played a role, and future synchronized multi-season sampling would help further refine spatial comparisons.

### Conclusion

The present study highlights the intricate linkages between fish diversity, macrophyte composition, and physicochemical conditions in the two investigated freshwater lakes. Diversity indices revealed that SPL supported a slightly higher fish diversity than KAL, likely due to greater macrophyte richness and structural complexity, which provide a range of niches for feeding, breeding, and shelter. Such habitat heterogeneity, combined with favorable water quality conditions, appears to sustain more balanced species assemblages despite the dominance of *Oreochromis niloticus*. The observed macrophyte diversity ranging from submerged to emergent forms play a pivotal role in biodiversity maintenance, while physicochemical analyses revealed site-specific differences in parameters such as pH, conductivity, nutrient concentrations, and ionic composition, reflecting both natural processes

and anthropogenic influences. Together, these factors underline the need for integrated lake management approaches that address habitat complexity, control of invasive species, and pollution mitigation to sustain the ecological integrity.

**Funding:** This work was supported by the Tamil Nadu Chief Minister Research Fellowship.

**Conflict of Interest Declaration:** The authors declare no conflict of interest

**Ethical approval:** Not Applicable

**Informed consent:** Not Applicable

**Author contribution:** Manuscript writing, Sampling, species identification and data analysis was performed by Annie Pushpa Isaac. Fish species identification was helped by K. Maheshkumar and V. Deepak Samuel. Nirmal Magdalene Nathaniel provided overall guidance and helped in manuscript editing. The final manuscript has been read and approved by all the authors.

**Data Availability Statement:** The datasets generated during the current study are available from the corresponding author upon reasonable request.

## Reference

Allan, J.D., 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems.

*Annual Review of Ecology, Evolution, and Systematics*, 35, pp.257–284.

Allan, J.D. and Castillo, M.M., 2007. *Stream ecology: structure and function of running waters*.

New York: Springer.

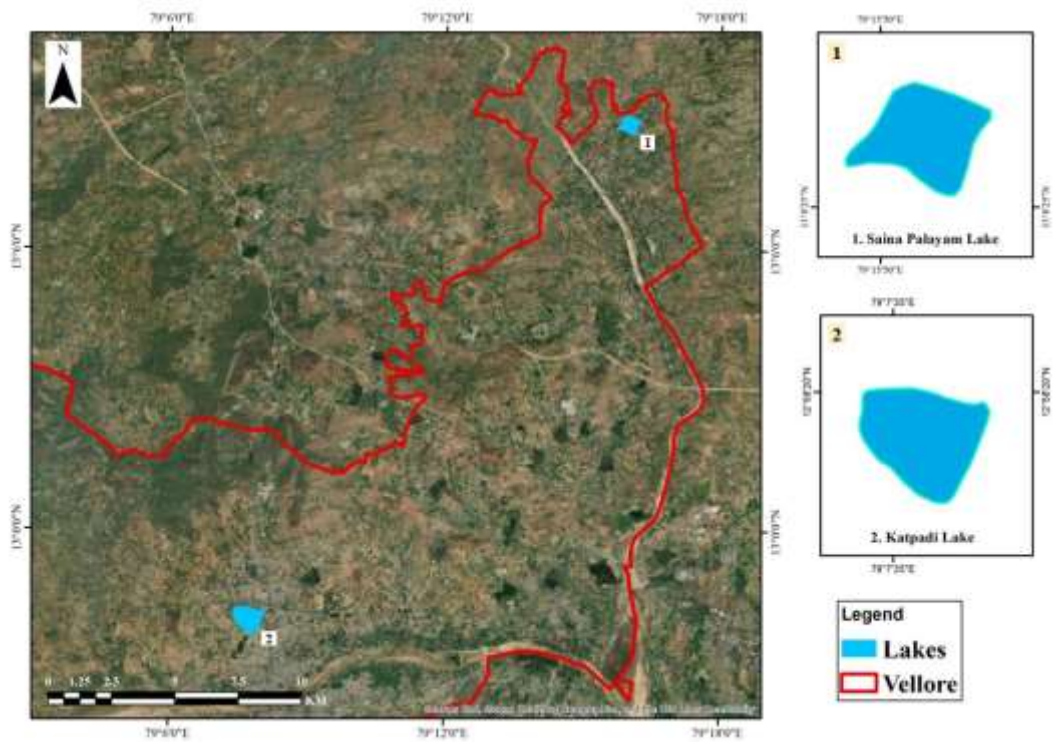
APHA, 2017. *Standard Methods for the Examination of Water and Wastewater*. Twenty-Third Edition. American Public Health Association, Washington, DC, USA.

- Baselga, A., 2007. Disentangling distance decay of similarity from richness gradients: response to Soininen et al. *Ecography*, 30, pp.838–841.
- Canonico, G.C., Arthington, A., McCrary, J.K. and Thieme, M.L., 2005. The effects of introduced tilapias on native biodiversity. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 15(5), pp.463–483.
- Carpenter, S.R., Caraco, N.F., Correll, D.L., Howarth, R.W., Sharpley, A.N. and Smith, V.H., 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecological Applications*, 8(3), pp.559–568.
- Chakraborty, S.K., 2021. Ecology of fishes of rivers: functional roles. In: Babu, C. and Sivaperuman, C. (eds.) *Riverine ecology, Vol. 2*. Cham: Springer, pp.187–286.
- Chambers, P., Lacoul, P., Murphy, K. and Thomaz, S., 2008. Global diversity of aquatic macrophytes in freshwater. In: *Abstracts of the 5th International Weed Science Congress*. Vancouver, Canada, p.323.
- Cook, C.D.K., 1996. *Aquatic and wetland plants of India*. New York: Oxford University Press.
- Das, S., Mandal, R. and Bandyopadhyay, S., 2006. Role of electrical conductivity as an indicator of pollution in shallow lakes. *Asian Journal of Water, Environment and Pollution*, 3(1), pp.153–156.
- Diehl, S. and Kornijów, R., 1998. Influence of submerged macrophytes on trophic interactions among fish and macroinvertebrates. In: *The structuring role of submerged macrophytes in lakes*. Springer, pp.24–46.
- Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z.I., Knowler, D.J., Lévêque, C. and Sullivan, C.A., 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews*, 81(2), pp.163–182.

- Froese, R. and Pauly, D., 2024. *FishBase*. Available at: <https://www.fishbase.org>.
- Gebrekiros, S.T., 2016. Factors affecting stream fish community composition and habitat suitability. *Journal of Aquaculture & Marine Biology*, 4(2), 00076.
- Gido, K.B. and Brown, J.H., 1999. Invasion of North American drainages by alien fish species. *Freshwater Biology*, 42(2), pp.387–399.
- Gilvear, D.J., Karr, J.R. and Chu, E.W., 1999. Restoring life in running waters: better biological monitoring. *Water, Air, and Soil Pollution*, 116, pp.666–667.
- Gupta, D., Ranjan, R.K., Parthasarathy, P. and Ansari, A.M.S., 2021. Spatial and seasonal variability in the water chemistry of Kabar Tal wetland (Ramsar site), Bihar, India: multivariate statistical techniques and GIS approach. *Water Science and Technology*, 83(9), pp.2100–2117.
- Hammer, O., Harper, D.A.T. and Ryan, P.D., 2001. PAST: paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, 4(1), pp.1–9.
- IUCN, 2025. *The IUCN Red List of Threatened Species*, Version 2025-1. Available at: <https://www.iucnredlist.org>.
- Jayaram, K.C., 2010. *The freshwater fishes of the Indian region*. Delhi: Narendra Publishing House.
- Johnson, C., Sarkar, U. K., Koushlesh, S. K., Das, A. K., Das, B. K. and Naskar, B. K., 2022. Fish assemblage, ecosystem status and potential impact of Nile Tilapia in Halali Reservoir of Central India. *Environment, Development and Sustainability*, 24(6), 7753-7775.

- Johnson, R.K. and Angeler, D.G., 2014. Effects of agricultural land use on stream assemblages: taxon-specific responses of alpha and beta diversity. *Ecological Indicators*, 45, pp.386–393.
- Koleff, P., Gaston, K.J. and Lennon, J.J., 2003. Measuring beta diversity for presence–absence data. *Journal of Animal Ecology*, 72(3), pp.367–382.
- Lacoul, P. and Freedman, B., 2006. Environmental influences on aquatic plants in freshwater ecosystems. *Environmental Reviews*, 14(2), pp.89–136.
- Lewis, W.M. Jr., 2002. Basis for the protection and management of tropical lakes. *Freshwater Biology*, 47(5), pp.957–970.
- Magurran, A.E., 2004. *Measuring biological diversity*. Oxford: Blackwell Publishing.
- Mogalekar, H.S., Sudhan, C., Katare, M.B. and Swami, A.M., 2025. Fish assemblage dynamics, Tilapia invasion, trophic guilds, and conservation priorities in the hydrologically fragmented Vaigai River–Estuary continuum, India. *Thalassas: An International Journal of Marine Sciences*, 41, p.153.
- Moyle, P.B. and Light, T., 1996. Biological invasions of fresh water: empirical rules and assembly theory. *Biological Conservation*, 78(1–2), pp.149–161.
- Nelson, J.S., Grande, T.C. and Wilson, M.V.H., 2016. *Fishes of the world*. 5th edn. New York: John Wiley & Sons.
- Paul, M.J. and Meyer, J.L., 2001. Streams in the urban landscape. *Annual Review of Ecology and Systematics*, 32, pp.333–365.
- Randall, D.J. and Tsui, T.K., 2002. Ammonia toxicity in fish. *Marine Pollution Bulletin*, 45(1–12), pp.17–23.

- Sarkar, U.K. and Lakra, W.S., 2010. Small indigenous freshwater fish species of India: significance, conservation and utilisation. *Aquaculture Asia Magazine*, 15(3), pp.34–35.
- Schlösser, I.J., 1984. Fish community structure and function along two habitat gradients in a headwater stream. *Ecological Monographs*, 52(4), pp.395–414.
- Subramanyam, K., 1962. *Aquatic angiosperms*. New Delhi: CSIR.
- Talwar, P.K. and Jhingran, A.G., 1991. *Inland fishes of India and adjacent countries*. Vols. 1–2. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.
- Thomaz, S.M., Cardozo, A.L.P., Quirino, B.A., Yofukuji, K.Y., Aleixo, M.H.F. and Fugi, R., 2025. A review of the ecological role of aquatic macrophytes on freshwater fish. *Hydrobiologia*, 852, pp.3257–3290.
- TNWRD, 2020. *Catchment area statistics*. Chennai: Government of Tamil Nadu.
- Walsh, C.J., Roy, A.H., Feminella, J.W., Cottingham, P.D., Groffman, P.M. and Morgan, R.P. II, 2005. The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society*, 24(3), pp.706–723.
- Ward, D.M. and Newman, R.M., 2006. Fish predation on Eurasian watermilfoil (*Myriophyllum spicatum*) herbivores and indirect effects on macrophytes. *Canadian Journal of Fisheries and Aquatic Sciences*, 63(5), pp.1049–1057.
- Wetzel, R.G., 2001. *Limnology: lake and river ecosystems*. New York: Academic Press.
- Yang, Y.C., Cai, X. and Herricks, E.E., 2008. Identification of hydrologic indicators related to fish diversity and abundance: a data mining approach for fish community analysis. *Water Resources Research*, 44(4), W04401.



**Fig. 1** Geographical location of the study areas

**Native Species**



*Amblypharyngodon mola*



*Rasbora daniconius*



*Esomus danrica*



*Salmostoma bacalia*



*Amblypharyngodon microcep*



*Rasbora sps.*



*Chanda nama*



*Puntius sophore*



*Anabas testudineus*



*Pethia conchonius*



*Channa striata*



*Pethia ticto*

**Exotic/Invasive Species**



*Gossogobius giuris*

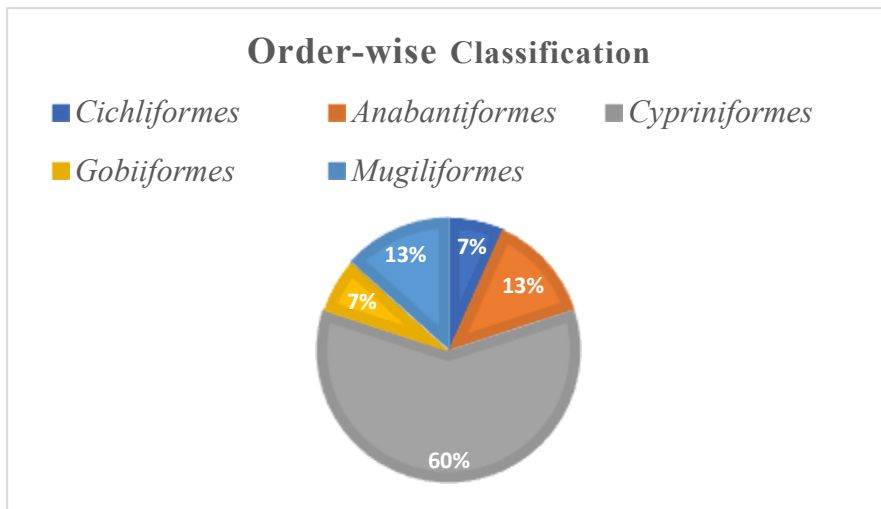


*Parambassis ranga*

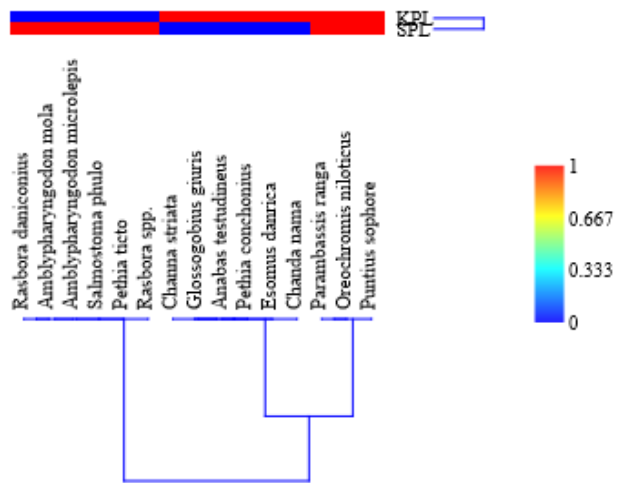


*Oreochromis niloticus*

**Fig. 2** Fishes recorded in Katpadi Lake (KAL) and Saina Palayam Lake (SPL)



**Fig. 3** Percentage composition of fish species across different taxonomic orders in the KAL and SPL



**Fig. 4** Cluster dendrogram illustrating the similarity in fish species composition between KAL and SPL sites based on hierarchical clustering analysis.



*Nymphaea odorata*



*Nymphoides aquatica*



*Typha augustifolia*



*Potamogeton distinctus*



*Myriophyllum spicatum*



*Najas minor*



*Najas marina*



*Ottelia alismoides*



*Ceratophyllum demersum*



*Prosopis juliflora*

**Fig. 5** Macrophytes recorded in KAL and SPL

**Table 1** Fishes recorded in Katpadi Lake and S.N. Palayam Lake

S. No	Scientific Name	Order	Family	Relative Abundance KAL (%)	Relative Abundance SPL (%)	KA	SP	Common Name	Exotic/ Invasive	IUCN
1	<i>Oreochromis niloticus</i>	Cichliiformes	Cichlidae	50.34	52.86	✓	✓	Nile tilapia	Exotic/ Invasive	LC
2	<i>Anabas testudineus</i>	Anabantiformes	Anabantidae	5.03	0	✓	–	Climbing perch	Native	LC
3	<i>Pethia conchonius</i>	Cypriniformes	Cyprinidae	16.78	0	✓	–	Rosy barb	Native	LC
4	<i>Glossogobius giuris</i>	Gobiiformes	Gobiidae	3.36	0	✓	–	Tank goby	Native	LC
5	<i>Parambassis ranga</i>	Mugiliformes	Ambassidae	2.68	5.29	✓	–	Indian glassy fish	Native	LC
6	<i>Puntius sophore</i>	Cypriniformes	Cyprinidae	6.71	8.81	✓	✓	Pool barb	Native	LC
7	<i>Channa striata</i>	Anabantiformes	Channidae	3.36	0	✓	–	Striped snakehead	Native	LC
8	<i>Esomus danrica</i>	Cypriniformes	Danionidae	10.07	0	✓	–	Indian flying barb	Native	LC
9	<i>chanda nama</i>	Mugiliformes	Ambassidae	1.68	0	✓	–	Elongated glassy perchlet	Native	LC
10	<i>Rasbora daniconius</i>	Cypriniformes	Danionidae	0	6.61	–	✓	Scissortail rasbora	Native	LC
11	<i>Amblypharyngodon mola</i>	Cypriniformes	Danionidae	0	10.57	–	✓	Mola carplet	Native	LC
12	<i>Amblypharyngodon microlepis</i>	Cypriniformes	Danionidae	0	7.93	–	✓	Indian carplet	Native	LC
13	<i>Salmostoma phulo</i>	Cypriniformes	Danionidae	0	2.2	–	✓	Finescale razorbelly minnow	Native	LC
14	<i>Pethia ticto</i>	Cypriniformes	Cyprinidae	0	3.52	–	✓	Ticto barb	Native	LC
15	<i>Rasbora</i> spp.	Cypriniformes	Danionidae	0	2.2	–	✓	Rasbora species	Native	LC

**Note:** ✓ = Present; – = Absent; **LC (Least Concern):** Species is not currently at risk.

**Table 2** Diversity Analysis in KAL and SPL

	KAL	SPL
Dominance_D	0.2996	0.311
Simpson_1-D	0.7004	0.689
Shannon_H	1.615	1.628
Menhinick	0.5214	0.5974
Margalef	1.404	1.475
Fisher_alpha	1.75	1.873
Berger-Parker	0.5034	0.5286

**Table 3** Species Distribution and Similarity Indices between KAL and SPL

<b>Species Distribution</b>	<b>Count</b>
Shared species (a)	3
Unique to Katpadi (b)	6
Unique to Palayam (c)	6
<b>Similarity Indices</b>	
Jaccard	0.2
Sørensen	0.333

**Table 4** Macrophytes recorded in KAL and SPL

S. No.	Species	Order	Family	KAL	SPL	Common Name	Exotic/ Invasive	IUCN
1	<i>Neltuma juliflora</i>	Fabales	Fabaceae	✓	–	Mesquite	Invasive	LC
2	<i>Ceratophyllum demersum</i>	Ceratophyllales	Ceratophyllaceae	✓	–	Hornwort	Native	LC
3	<i>Ottelia alismoides</i>	Alismatales	Hydrocharitaceae	✓	✓	Duck lettuce	Native	LC
4	<i>Najas marina</i>	Alismatales	Hydrocharitaceae	✓	✓	Spiny water nymph	Native	LC
5	<i>Nymphoides aquatica</i>	Asterales	Menyanthaceae	–	✓	Banana lily	Native	NE
6	<i>Nymphaea odorata</i>	Nymphaeales	Nymphaeaceae	–	✓	white-water lily	Native	LC
7	<i>Potamogeton distinctus</i>	Alismatales	Potamogetonaceae	–	✓	Pondweed	Native	LC
8	<i>Najas minor</i>	Alismatales	Hydrocharitaceae	–	✓	Lesser naiad	Native	LC
9	<i>Myriophyllum spicatum</i>	Saxifragales	Haloragaceae	–	✓	Eurasian watermilfoil	Native	LC
10	<i>Typha angustifolia</i>	Poales	Typhaceae	–	✓	Narrowleaf cattail	Invasive	LC

Note: ✓ = Present; – = Absent; LC-Least concern and NE-Not evaluated

**Table 5** Physico-chemical parameters of water samples collected in KAL and SPL

	<b>Acceptable Limit</b>	<b>Maximum permissible limit in the absence of alternative source</b>	<b>KAL</b>	<b>SPL</b>
<b>I. PHYSICAL EXAMINATIONS</b>				
1. Appearance			slightly turbid	slightly turbid
2. Colour	-	-	slightly yellow	slightly yellow
3. Odour	Agreeable	Agreeable	odoursome	odoursome
4. Turbidity NTU	1	5	4	0
5. Total dissolved solids mg/L	500	2000	894	337
6. Electrical conductivity micro mho/cm	-	-	1277	481
<b>II. CHEMICAL EXAMINATIONS</b>				
7. pH	6.5-8.5	6.5-8.5	7.32	7.62
8. Alkalinity pH as CaCO <sub>3</sub> mg/L	-	-	0	0
9. Alkalinity Total as CaCO <sub>3</sub> mg/L	200	600	244	112
10. Total Hardness as CaCO <sub>3</sub> mg/L	200	600	296	206
11. Calcium as Ca mg/L	75	200	61	41
12. Magnesium as mg/L	30	100	35	25
13. Free Ammonia as NH <sub>3</sub> mg/L	0.5	0.5	1.04	0.53
14. Nitrite as NO <sub>2</sub> mg/L	0.5	0.5	0.14	0.05
15. Nitrate as NO <sub>3</sub> mg/L	45	45	10	3
16. Chloride as Cl mg/L	250	1000	204	69
17. Fluoride as F mg/L	1	1.5	0.4	0.4
18. Sulphate as SO <sub>4</sub> mg/L	200	400	111	23
19. Phosphate as PO <sub>4</sub> mg/L	-	-	0.14	0.13
20. Tidys Test 4Hrs.as O <sub>2</sub> mg/L	-	-	0.1	0.1

**Note:** The accepted limits and maximum permissible limits are as per BIS (2012).