Journal of Fisheries
Volume 13 Issue 2 August 2025
Peer Reviewed | Open Access

eISSN 2311-3111
pISSN 2311-729X

DOI: https://doi.org/10.17017/j.fish.1026

Original Article

Fish and macrophyte diversity in a tropical river under threat from municipal waste

Annie Pushpa Isaac • Nirmal Magadalenal Nathaniel

PG and Research Department of Zoology, Voorhees College, Vellore 632 001, Affiliated to Thiruvalluvar University, Serkkadu, Vellore 632 115, Tamil Nadu, India

Correspondence
Nirmal Magadalenal Nathaniel; PG and Research Department of Zoology, Voorhees College, Vellore 632 001, Affiliated to Thiruvalluvar University, Serkkadu, Vellore 632 115, Tamil Nadu, India
nirmalmagdalene@gmail.com

Manuscript history
Received 11 July 2025 | Accepted 31 July 2025 | Published online 6 August 2025

Citation
Isaac AP, Nathaniel NM (2025) Fish and macrophyte diversity in a tropical river under threat from municipal waste. Journal of Fisheries 13(2): 132210. DOI: 10.17017/j.fish.1026

Abstract
Fishes thrive in balanced ecosystems, where threats like invasive fish species and extensive anthropogenic activity can significantly reduce native fish populations. Macrophytes play a crucial role in providing shelter and breeding grounds for small native fish species. This study was conducted to assess the fish and macrophyte diversity, water quality parameters, and potential pollution sources in a tropical river (Virinjipuram (Palar) River, Tamil Nadu) in India between January and March 2025. It also highlights the anthropogenic impacts on fish population. Our results show that 20 species were identified including 18 native and 2 exotic species (*Oreochromis niloticus* and *Oreochromis mossambicus*). Cypriniformes was the most dominant order with 12 fish species, followed by Perciformes (3 species), Cichliformes (3 species) and Siluriformes (2 species). IUCN global status of native species revealed 16 species as Least Concern, *Parambassis lala* as Near Threatened and *Devario fraseri* as Vulnerable. Five macrophytes were observed, indicating potential interactions between fish populations and macrophytes in influencing habitat dynamics. The presence of invasive species and extensive municipal waste dumping along the riverbank is of major concern. Our present finding suggests that measures have to be taken to mitigate the anthropogenic activities to conserve the native fish fauna.

Keywords: fish diversity; macrophytes; Virinjipuram (Palar) River; conservation; anthropogenic impacts

1 | INTRODUCTION

Freshwater ecosystems are the most biodiverse habitats, with a wide variety of fish species that play crucial roles in maintaining ecological balance and providing economic benefits to local communities present nearby (Reid *et al.* 2019). Freshwater ecosystems, though covering less than 1% of the earth's surface, harbour over 50% of all known fish species (~18,000 species) (WWF 2021). Nearly 25% of assessed freshwater fish now threatened with extinction due to pollution, habitat degradation, and over-extraction (Dunham 2025). Tamil Nadu state of India alone hosts 226 freshwater fish species across 13 orders, 34 families, and 93 genera, accounting for ~24 % of India's freshwater fish diversity, and about 43 % of its freshwater fishes are endemic (Mogalekar and Canciyal 2018). The diversity of freshwater fish is influenced by several interlinked factors, including habitat complexity (Guo *et al.* 2022), the presence of macrophytes, and water quality parameters (Choi and Kim 2020). Recent studies in Indian river systems such as the Cauvery and tropical estuarine environments have highlighted that spatial variations in water quality and habitat features significantly affect fish assemblage structure, trophic dynamics, and species richness (Roshith *et al.* 2022; Koushlesh *et al.* 2023; Abinaya *et al.* 2024). Understanding these interactions is essential for the conservation and management of freshwater ecosystems (Gebrekiros 2016). Gebrekiros (2016) also highlighted the need for integrated ecological assessment to conserve freshwater biodiversity.

Among various ecological factors, macrophytes are fundamental ecological drivers that shape the structure, function, and biodiversity of freshwater ecosystems (Thomaz *et al.* 2025). They provide shelter, breeding grounds, and food resources for various freshwater fish species (Thomaz and Cunha 2010). By enhancing habitat heterogeneity, macrophytes support higher fish diversity and contribute to the overall productivity of aquatic ecosystems (Dias *et al.* 2022). Emergent macrophytes such as *Typha angustifolia* and *Cyperus odoratus* play a crucial role in shaping fish assemblages, particularly by offering foraging grounds and refuge for cyprinid species like *Puntius* spp., as observed in littoral habitats across the Indian subcontinent (Yaro *et al.* 1994). Hinz *et al.* (2023) reported that high structural complexity macrophytes significantly attract juvenile fish and these plants provide predator refuge and prey resources, shaping habitat selection and survival during early life stages.

Like macrophytes, physicochemical parameters also affect the distribution and survival of freshwater fishes (Marium *et al.* 2023). For instance, low dissolved oxygen levels can lead to fish mortality, while extreme pH levels can impair metabolic functions (Chapman 2021). Abdel *et al.* (2019) reported that deviations from optimal pH range negatively affect enzymatic activity and growth rates in freshwater fish. The ecological importance of freshwater habitats is increasingly threatened by anthropogenic activities such as urban runoff, agriculture and waste discharge (Vörösmarty *et al.* 2010). Such pressures are evident in the Virinjipuram, where all three impacts–untreated urban effluents, agricultural runoff, and municipal waste accumulation–were observed, posing significant risks to native aquatic biodiversity.

The global freshwater biodiversity crisis is driven by unsustainable land-use practices (Dudgeon *et al.* 2006). Ogidi and Akpan (2022) reported that urban expansion leads to increased pollutant loading in aquatic systems. One major concern is the dumping of waste near riverbanks, which introduces pollutants such as heavy metals, organic matter, and microplastics into aquatic systems. These contaminants degrade water quality, disrupt food webs, and pose direct risks to fish health (Rajak *et al.* 2024). Rivers located near waste disposal areas exhibited significantly poorer water quality and compromised fish health (Igbani *et al.* 2025). Tamil Nadu's freshwater ecosystems, with higher temperatures and lower DO levels during summer and increased turbidity during monsoon months, all of which can directly influence fish diversity and distribution (Aravinth *et al.* 2023).

Virinjipuram (Palar) River, which is a seasonal, rainfed habitat that plays a crucial ecological role in supporting native freshwater biodiversity in Tamil Nadu, India. It holds socioeconomic importance by sustaining local fisheries and agriculture despite increasing anthropogenic pressures and water scarcity concerns. In this study, we examined the relationships between freshwater fish diversity, macrophytes, and physicochemical water parameters, while addressing the impact of municipal waste dumping on this ecosystem. This study aims to inform conservation efforts and promote sustainable practices for freshwater resource management. Despite the ecological and socio-economic importance of freshwater ecosystems, there is a significant lack of research on fish diversity and its ecological drivers in the Vellore District of Tamil Nadu. Based on our literature review, no comprehensive study has been conducted in this region to assess how freshwater fish diversity is influenced by aquatic macrophytes, physicochemical parameters, and pollution stressors. This study aims to provide baseline information essential for freshwater biodiversity in Virinjipuram (Palar) River.

2 | METHODOLOGY

2.1 Study area

The study was conducted in the Virinjipuram region of Vellore District, Tamil Nadu, focusing on a specific stretch of the Palar River (Figure 1). Although the Palar is a major non-perennial river flowing across several districts, this study is limited to the segment passing through Virinjipuram, located about 10 km southwest of Vellore city. The area features semi-urban surroundings with nearby agricultural and residential zones. Seasonal flow variations, local land use, and human activities make this stretch ecologically significant, offering a suitable setting for assessing aquatic biodiversity and environmental parameters on a localized scale.

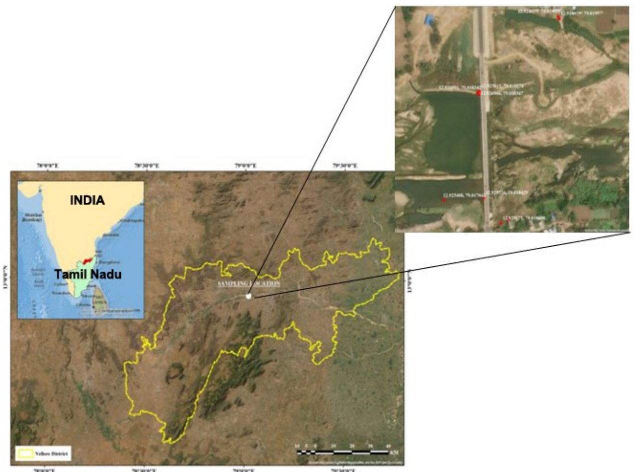

FIGURE 1 Geographical location of the Virinjipuram (Palar) River in Tamil Nadu state of India.

2.2 Fish sampling and identification
Fish sampling was done between January and March 2025. The sampling points were selected based on water availability and accessibility during post-monsoon. Residual water remained due to post-monsoon conditions, as the site tends to dry during other seasons. The geographical coordinates of the sampling locations ranged from latitude of 12.9251° to 12.9549° and longitude of 79.0178° to 79.0195°. These timeframes were chosen based on water availability, which in this region depends heavily on seasonal rainfall and surface runoff. The selected sites retain water during these months; however, the water depth was relatively shallow due to lack of perennial inflow, representing low water volume conditions typical of temporary freshwater systems.

Fish sampling was conducted using three different cast nets (1.2 – 2.4 m radius, 1.3–5.1 cm mesh) to effectively capture a range of small to large-sized fish. All nets were equipped with sinkers weighing between 7 to 14 g, ensuring proper spread and descent in shallow waters. Sampling was done between 07.00 am to 13.00 hours to align with peak activity periods of shallow-water species. A total of nine locations along the river stretch were selected based on habitat features such as vegetation cover, flow variation, human disturbance and accessibility. At each location, seven cast net hauls were performed across diverse microhabitats (open water, near vegetation, and shallow margins), resulting in a total of around 70 fishing hauls during the study period.

Fish specimens were identified using standard taxonomic keys (Hamilton *et al.* 1822; Jayaram 2010), and all scientific names were verified and updated according to the latest version of FishBase (Froese and Pauly 2000). Specimens were preserved in 10% formalin solution for further confirmation and reference in the laboratory. The conservation status of each recorded fish species was verified using the IUCN Red List of Threatened Species database as of IUCN (2025). Scientific names were cross-checked and searched individually on the website Fishbase, and the most recent available global status was recorded for each species. Fish diversity indices (fish diversity indices, Shannon–Wiener, Simpson's, Margalef richness, Equitability, Fisher's alpha, and Berger–Parker dominance) were calculated using the software PAST (version 4.03; Hammer *et al.* 2001).

2.3 Macrophyte documentation and identification
Macrophytes were surveyed between January and March 2025 using visual observation along the banks and categorized as floating, emergent, or peripheral based on their growth form; relative abundance was recorded qualitatively. Macrophytes photographs were also taken to record their habitat characteristics. Identification of macrophytes was carried out using standard botanical keys and guides (after Cook 1996).

2.4 Analysis of water quality parameters
Water samples were collected from the study sites for physicochemical analysis in January 2025. Instrumentation and analytical methods followed standard protocols (BIS 10500:2012; APHA 2017) to ensure accuracy in evaluating the water quality parameters. pH and electrical conductivity were measured in situ using a portable multiparameter probe (Eutech Instruments, Singapore), while turbidity was assessed with a Nephelometric Turbidity Meter (APHA 2130B), and total dissolved solids (TDS) were recorded using a digital TDS meter. Nutrient concentrations, including nitrate, nitrite, phosphate, and ammonia, were analyzed using UV-Visible spectrophotometry following APHA's standard colorimetric methods (4500 series). Major and trace metals such as iron, manganese, calcium, and magnesium were quantified using atomic absorption spectrophotometry (AAS, PerkinElmer). Parameters such as alkalinity, total hardness, and chlorides were measured through classical titrimetric methods (APHA 2017). Tidy's Test (4-hour BOD) was conducted to estimate short-term oxygen demand and organic pollution (APHA 5210B).

Sensory characteristics like colour, odour, and appearance were recorded visually and organoleptically. The selection of these 22 parameters was based on their ecological relevance and sensitivity to pollution: nutrients influence macrophyte and algal blooms leading to eutrophication (Smith *et al.* 1999; Carpenter 2005); metals and TDS impact osmoregulation and fish survival (Boyd 1998); pH, conductivity, and dissolved solids are essential for maintaining physiological balance (Randall and Tsui 2002) and physical indicators like turbidity and odour reveal the presence of anthropogenic disturbances such as sewage and agricultural runoff (Kirk 2010).

2.5 Pollution assessment
The extent of pollution sources and pollutants near the riverbank was assessed through visual observation. Presence of municipal waste, including plastics, organic waste, and other pollutants reveal the impact of anthropogenic activities in the study area.

3 | RESULTS AND DISCUSSION
3.1 Fish diversity
The study of the Virinjipuram (Palar) River revealed a total of 20 fish species distributed across four order and five families; of these, *Amblypharyngodon mola*, *Amblypharyngodon melettinus*, *Pethia conchonius*, and *Oreochromis niloticus* were dominant species (Table 1, Figure 2). Among the fish species identified, Cypriniformes was the most dominant order with 12 species, followed by Perciformes (n = 3; 15%) and Cichliformes (n = 3; 15%) (Table 1). Two species were exotic, *Oreochromis mossambicus* and *Oreochromis niloticus*; of which the latter is now invasive in the study area. According to Canonico *et*

al. (2005), presence of invasive species poses ecological concerns as they may outcompete small native fish for resources. Exotic species often lead to trophic alterations and ecosystem destabilization, as observed in similar freshwater systems (Vitule *et al.* 2009).

Native species

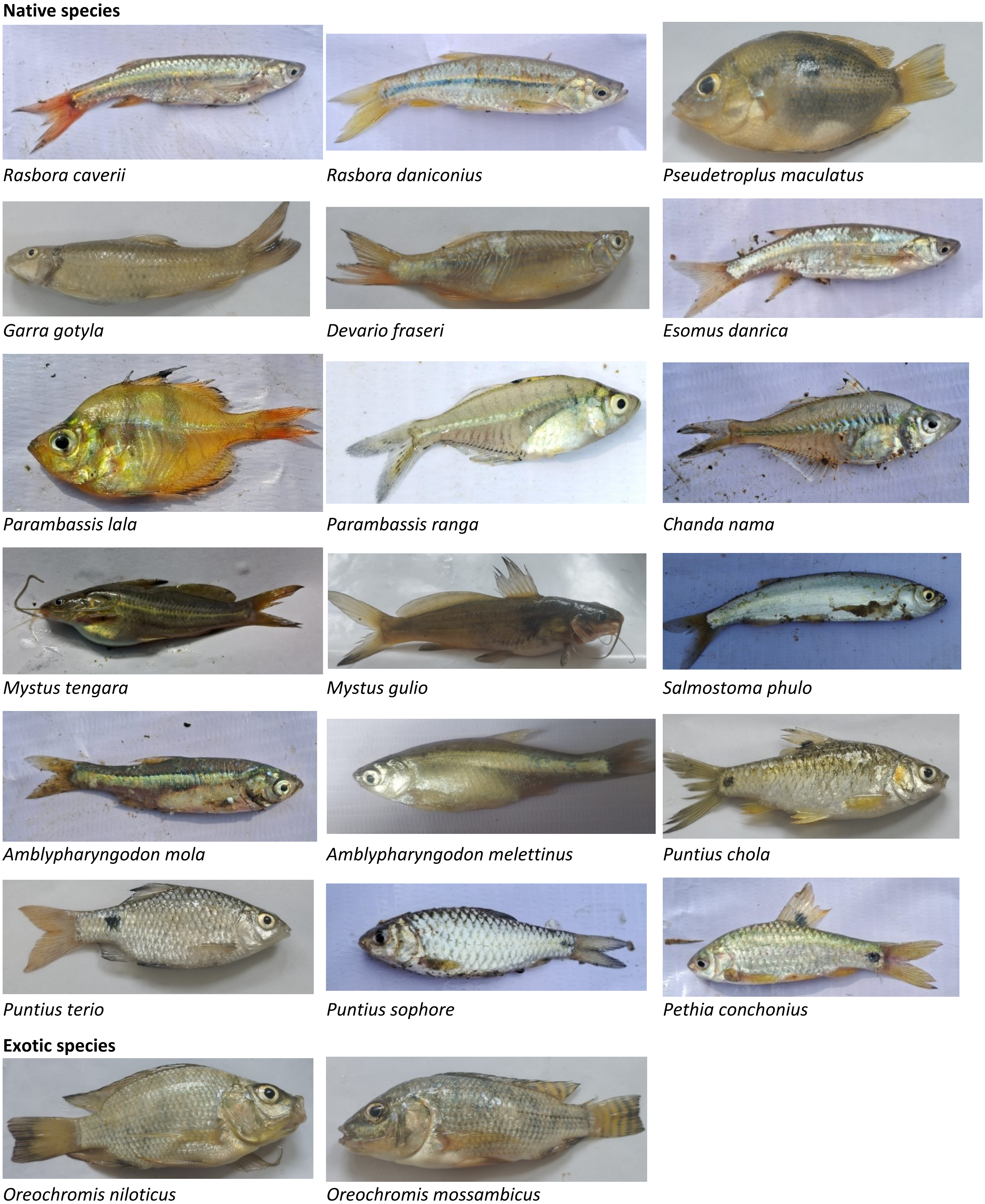

FIGURE 2 Fish species recorded in Virinjipuram (Palar) River of Tamil Nadu, India.

TABLE 1 List of fish species recorded in the Virinjipuram (Palar) River, Tamil Nadu, India.

Order	Family	Scientific Name	Relative abundance (%)	Nativity status	IUCN status
Cypriniformes	Cyprinidae	*Pethia conchonius* (Hamilton 1822)	8.39	Native	LC
		Puntius terio (Hamilton 1822)	4.20	Native	LC
		Puntius sophore (Hamilton 1822)	4.90	Native	LC
		Puntius chola (Hamilton 1822)	0.70	Native	LC
		Garra gotyla (Gray 1830)	4.90%	Native	LC
	Danionidae	*Rasbora caverii* (Jerdon 1849)	0.70	Native	LC
		Rasbora daniconius (Hamilton 1822)	2.10	Native	LC
		Amblypharyngodon mola (Hamilton 1822)	13.99	Native	LC
		Amblypharyngodon melettinus (Valenciennes 1844)	12.59	Native	LC
		Devario fraseri (Hora 1935)	1.40%	Native	VU
		Esomus danrica (Hamilton 1822)	4.90	Native	LC
		Salmostoma phulo (Hamilton 1822)	0.70	Native	LC
Cichliformes	Cichlidae	*Oreochromis niloticus* (Linnaeus 1758)	6.99%	Exotic/ Invasive	LC
		Oreochromis mossambicus (Peters 1852)	3.50%	Exotic	VU
		Pseudetroplus maculatus (Bloch 1795)	0.70%	Native	LC
Perciformes	Ambassidae	*Parambassis ranga* (Hamilton 1822)	13.29%	Native	LC
		Chanda nama (Hamilton 1822)	5.59%	Native	LC
		Parambassis lala (Hamilton 1822)	3.50%	Native	NT
Siluriformes	Bagridae	*Mystus tengara* (Hamilton 1822)	6.29%	Native	LC
		Mystus gulio (Hamilton 1822)	0.70%	Native	LC

IUCN Redlist status: LC - Least Concern: Species is not currently at risk, NT - Near Threatened: Species is close to qualifying for a threatened category in the near future, and VU - Vulnerable: Species is at risk of extinction in the wild.

The introduction of exotic fish species for aquaculture has a relatively recent history compared to terrestrial species introductions. While global fish translocations gained momentum during the mid-20th century, tilapia species—particularly *O. mossambicus*—were widely introduced into India, including Tamil Nadu, during the 1950s for aquaculture enhancement (Sugunan 1995; De Silva *et al.* 2004). These introductions aimed to improve fish yield but soon sparked ecological debates due to the invasive nature of the species. *Oreochromis mossambicus* became established in several reservoirs, though its performance was suboptimal due to issues like stunting, early maturation, and overpopulation. This led to the subsequent introduction of *O. niloticus*, which performed better under aquaculture conditions (Sugunan 1995). However, these introductions have raised ecological concerns in regions with rich indigenous fish diversity.

Diversity indices calculated for the fish population further highlight the ecological richness of the river. Relative abundance of each fish species is given in Table 1. The Dominance Index (0.07791) and Berger-Parker Index (0.1399) indicate low species dominance (Table 2), while the high values for Simpson's Index (0.9221) and Shannon Index (2.725) suggest a diverse and evenly distributed fish population. Additional indices such as Margalef's richness (3.828), Fisher's alpha (6.326), and Equitability Index (0.8874) reinforce the observation of high biodiversity (Table 2). These metrics reflect a healthy aquatic ecosystem. However, the presence of invasive species and pollution near riverbank may potentially undermine the long-term ecological integrity of the system, despite the current diversity levels. According to Sarkar *et al.* (2017), balanced environmental parameters contributed to diverse habitats. Such diversity is critical for maintaining ecosystem stability and ensuring the resilience of fish populations against environmental changes (Mouillot 2013).

TABLE 2 Fish diversity analysis of Virinjipuram (Palar) River in Tamil Nadu, India.

Biodiversity indices	Value
Dominance (D)	0.07791
Simpson (1-D)	0.9221
Shannon H	2.725
Margalef	3.828
Equitability J	0.8874
Fisher alpha	6.326
Berger-Parker	0.1399

Out of the recorded fish species, 17 were Least Concern (IUCN 2025). *Parambassis lala* was categorized as Near Threatened, indicating potential vulnerability if local threats persist. Notably, *Devario fraseri* was classified as Vulnerable, signalling a high risk of extinction in the wild. The occurrence of these threatened species alongside invasive species such as *Oreochromis niloticus* underscores the importance of regular ecological monitoring and habitat restoration efforts.

3.2 Macrophyte diversity

Three native and two exotic macrophytes were identified in the study river (Table 3). Although *Chromolaena odorata* is an invasive riparian plant, its potential ecological influence on the aquatic fringe zone is considered in the present study. *Chromolaena odorata* is known to contain bioactive compounds with physiological effects on fish, as demonstrated in *Clarias gariepinus* fed with its leaf extract (Lawal *et al.* 2021). While it was not directly tested in this study, its presence in riparian zones may influence water quality and fish health indirectly. The potential indirect effects of *C. odorata* through leachates or habitat alteration warrant further ecological assessment. As noted by Macêdo *et al.* (2024), *C. odorata* may negatively impact native vegetation and indirectly affect fish relying on such vegetation. Their rapid growth and allelopathic effects may suppress native plant species, altering the structure and function of aquatic ecosystems (Hussner 2012).

Typha angustifolia and *Cyperus odoratus* were observed in the present study. These species play an important role in structuring fish assemblages by offering foraging grounds and refuge for cyprinid fishes like *Puntius* spp. (Yaro *et al.* 1994). Macrophyte enhance habitat complexity, improve water quality by reducing pollutants, and provide shelter for fish species (Thomaz and Cunha 2010). In addition, macrophytes can act as breeding grounds for several fish species, which enhances recruitment rates and population stability (Pelicice *et al.* 2005). However, the overall presence of macrophytes positively influences biodiversity, as their ability to trap sediments and reduce water velocity supports a range of aquatic life.

TABLE 3 List of macrophytes recorded in the Virinjipuram (Palar) River of Tamil Nadu, India.

Scientific Name	Order	Family	Common Name	Nativity status	IUCN status
Chromolaena odorata	Asterales	Asteraceae	Siam Weed	Exotic / Invasive	LC
Typha angustifolia	Poales	Typhaceae	Cattail	Native	LC
Saccharum spontaneum	Poales	Poaceae	Wild Sugarcane	Native	LC
Cyperus odoratus	Poales	Cyperaceae	Fragrant Flatsedge	Exotic	NE
Schoenoplectus sps.	Poales	Cyperaceae	Bulrush	Native	LC

LC-Least Concern: Species is not currently at risk, NE-Not Evaluated: Species has not yet been assessed by the IUCN.

3.3 Physicochemical parameters of water

Physicochemical parameters of the river water provide additional insights into the habitat's suitability for aquatic life. Low turbidity (4 NTU) is recorded in the present study (Table 4). As previously mentioned by Kirk (2010), low turbidity can facilitate light penetration, promoting macrophyte growth and subsequently benefiting fish populations. The near-neutral pH (7.26) and moderate levels of TDS (981 mg L^{-1}) were recorded in Virinjipuram (Palar) River (Table 4). A neutral pH maintains the physiological functions of aquatic species, preventing stress or metabolic disturbances, The elevated TDS may result from urban runoff, sewage inflow, or agricultural leachate (Wondie 2009). Such sources introduce ions like calcium, magnesium, and nitrates into the system. It was also reported that high TDS can affect fish osmoregulation and alter community structure (Boyd 1998). The high TDS observed in the present investigation might be due to the urban runoff, sewage inflow and municipal waste dumping along the river bank.

Nutrient levels like nitrate at 9 mg L^{-1} and phosphate at 0.52 mg L^{-1} are recorded (Table 4). These nutrients can promote macrophyte proliferation but require monitoring to prevent eutrophication mentioned by Smith *et al.* (1999). Elevated nitrate levels, while beneficial in moderate concentrations, can lead to algal blooms, which deplete oxygen and create anoxic conditions detrimental to fish (Dodds 2010). Similarly, phosphate enrichment may favor fast-growing invasive plants, disrupting native species and fish habitats (Carpenter 2005). Effective nutrient management is therefore crucial to maintaining the ecological integrity of the river.

Ammonia levels recorded at 0.83 mg L^{-1} fall within a tolerable range for most freshwater fish but require careful monitoring (Table 4). Chronic exposure to sub-lethal ammonia can impair fish gill function and reduce growth (Xu *et al.* 2023). It increases stress, weakens immunity, and reduces reproductive success. Long-term ammonia exposure also alters fish behaviour and can shift species composition (Jayasree *et al.* 2022). Elevated ammonia can become toxic, impairing fish gill function, disrupting metabolic processes, and reducing reproductive success (Randall and Tsui 2002). Prolonged exposure to sub-lethal ammonia concentrations may stress aquatic organisms and alter community composition. Effective management of organic waste and nutrient runoff is essential to prevent ammonia buildup and protect aquatic health (Camargo and Alonso 2006).

3.4 Pollution

The municipal waste dumped along the riverbank highlights a pressing environmental concern (Figure 3). Improper waste disposal can lead to the release of harmful pollutants, including heavy metals and organic matter, into the water, adversely affecting fish health and diversity (Allan and Castillo 2007; Galib *et al.* 2018). Decomposing waste contributes to nutrient enrichment, potentially exacerbating eutrophication (Carpenter 2005). Additionally, plastic debris can physically harm aquatic organisms and degrade into microplastics, further contaminating the ecosystem (Wright *et al.* 2013). If left unmanaged, pollution could lead to long-term degradation of the river's ecological integrity, emphasizing the need for stringent waste management practices and public awareness.

As reported in other Indian freshwater systems, where studies by Joshi and Chakravarty (2025) emphasized the shift from cultural reverence to responsible river stewardship, and Pelletier *et al.* (2020) highlight the need for resilience-based management to counteract anthropogenic stressors. The current status of the Virinjipuram (Palar) river can be conserved by adaptive and collaborative management of municipal waste along the river bank to sustain aquatic ecological system under growing anthropogenic pressures.

TABLE 4 Physicochemical parameters of water samples collected from Virinjipuram (Palar) River of Tamil Nadu, India.

Parameters	Acceptable limit	Maximum permissible limit in the absence of alternative source	Result
I. Physical parameters			
Appearance	-	-	Slightly turbid
Colour (pt.co.scale)	5	15	Slightly yellowish
Odor	Agreeable	Agreeable	Odorous
Turbidity (NTU)	1	5	4
Total dissolved solids (mg L^{-1})	500	2000	981
Electrical conductivity micro (mho cm^{-1})	-	-	1401
II. Chemical parameters			
pH	6.5-8.5	6.5-8.5	7.26
Alkalinity pH ($CaCO_3$; mg L^{-1})	-	-	0
Alkalinity Total ($CaCO_3$; mg L^{-1})	200	600	300
Total Hardness ($CaCO_3$; mg L^{-1})	200	600	416
Calcium (Ca; mg L^{-1})	75	200	83
Magnesium (Mg; mg L^{-1})	30	100	50
Total iron (Fe; mg L^{-1})	0.3	1	0.00
Manganese (Mn; mg L^{-1})	0.1	0.3	0.00
Free ammonia (NH_3; mg L^{-1})	0.5	0.5	0.83
Nitrite (NO_2; mg L^{-1})	0.2	0.2	0.14
Nitrate (NO_3; mg L^{-1})	45	45	9
Chloride (Cl; mg L^{-1})	250	1000	204
Fluoride (F; mg L^{-1})	1	1.5	0.4
Sulphate (SO_4; mg L^{-1})	200	400	105
Phosphate (PO_4; mg L^{-1})	-	-	0.52
Tidys Test (4Hrs.as O_2; mg L^{-1})	-	-	0.1

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

FIGURE 3 Municipal waste dumped along the riverbank of Virinjipuram (Palar) River of Tamil Nadu, India.

3.5 Limitations

The relatively low number of fish species recorded in this study may be attributed to limitations posed by environmental and methodological factors. Specifically, the limited water depth and low flow conditions during the sampling period. These environmental constraints, combined with the seasonal nature of the water body, likely restricted the availability of diverse microhabitats and reduced fish movement. Other gear types could not be used due to low water depth and seasonal flow, which may be reason for limited species richness observed during the study. Pollution assessment was based on visual observation, which may not fully capture the extent or composition of waste. Future studies would incorporate quantitative measures such as litter density or weight-based surveys for accuracy.

4 | CONCLUSIONS

The Virinjipuram (Palar) River supports a diverse and balanced aquatic ecosystem facilitated by favourable physicochemical conditions and the presence of macrophytes. This study recorded 20 freshwater fish species in this stretch of the river, of which 18 were native to India. The presence of *D. fraseri* (Vulnerable) and *P. lala* (Near Threatened) is ecologically significant, particularly in a semi-perennial river where water availability fluctuates. Although macrophytes were found to support fish diversity by providing shelter, breeding, and feeding grounds, the long-term survival of these sensitive species may be challenged by irregular water flow and increasing anthropogenic stress. In particular, the challenges posed by exotic fish species, invasive macrophytes, potential nutrient enrichment, ammonia levels, and pollution—including municipal waste observed along the riverbank—highlight the need for effective management strategies. These threats can degrade water quality over time and disrupt aquatic life. Therefore, to safeguard the native fish fauna, including conservation-priority species, immediate efforts are needed to prevent waste dumping and to maintain habitat conditions that support ecological balance. These findings emphasize the importance of integrated conservation efforts to sustain freshwater biodiversity.

CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTION

Sampling, species identification and data analysis was performed by Annie Pushpa Isaac. Nirmal Magdalene Nathaniel provided overall guidance and helped in manuscript editing. The final manuscript has been read and approved by both authors.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the corresponding author.

REFERENCES

Abdel-Tawwab M, Monier MN, Hoseinifar SH, Faggio C (2019) Fish response to hypoxia stress: growth, physiological, and immunological biomarkers. Fish Physiology and Biochemistry 45(3): 997–1013.

Abinaya R, Kanishkar A, Sajeevan MK (2024) Temporal variations in fish diversity, guild dynamics, and their association with environmental variables in a tropical estuary. Environmental Monitoring and Assessment 196: 1253.

Allan JD, Castillo MM (2007) Stream ecology: structure and function of running waters. Springer, Dordrecht, Netherlands.

APHA (2017) Standard methods for the examination of water and wastewater, 23rd edition, American Public Health Association, Washington D.C., USA.

Aravinth A, Kannan R, Chinnadurai G, Manickam N, Raju P, ... Santhanam P (2023) Temporal changes in plankton diversity in relation to hydrographical characteristics at Perumal Lake, Cuddalore District, Tamil Nadu, India. The Journal of Basic and Applied Zoology 84: 13.

BIS (2012) Indian standard – drinking water specification. IS 10500:2012. Bureau of Indian Standards, New Delhi, India.

Boyd CE (1998) Water quality for pond aquaculture. Auburn University, Alabama, USA.

Camargo JA, Alonso Á (2006) Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: a global assessment. Environment International 32: 831–849.

Canonico G, Arthington A, McCrary J, Thieme M (2005) The effects of introduced tilapias on native biodiversity. Aquatic Conservation: Marine and Freshwater Ecosystems 15: 463–483.

Carpenter SR (2005) Eutrophication of aquatic ecosystems: bistability and soil phosphorus. Proceedings of the National Academy of Sciences USA 102: 10002–10005.

Chapman DV (2021) Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring, 2nd edition. CRC Press, London, UK.

Choi JY, Kim SK (2020) Effects of aquatic macrophytes on spatial distribution and feeding habits of exotic fish species *Lepomis macrochirus* and *Micropterus salmoides* in shallow reservoirs in South Korea. Sustainability 12(4): 1447.

Cook CDK (1996) Aquatic and wetland plants of India. Oxford University Press, New York, USA.

De Silva SS, Subasinghe RP, Bartley DM, Lowther A (2004) Tilapias as alien aquatics in Asia and the Pacific: a

review. FAO Fisheries Technical Paper 453: 1–65.
Dias RM, Tófoli RM, da Silva JCB, Gomes LC, Agostinho AA (2022) Effects of habitat complexity on trophic interactions of three congeneric fish species. Aquatic Ecology 56(3): 877–889.
Dodds WK (2010) Freshwater ecology: concepts and environmental applications of limnology. Academic Press, Amsterdam, Netherlands.
Dudgeon D, Arthington AH, Gessner MO, Kawabata ZI, Knowler DJ, ... Sullivan CA (2006) Freshwater biodiversity: importance, threats, status and conservation challenges. Biological Reviews 81(2): 163–182.
Dunham W (2025) Study documents extinction threats to world's freshwater species. Reuters, Washington, D.C.
Froese R, Pauly D (2000) FishBase 2000: concepts, design and data sources. ICLARM, Los Baños, Laguna, Philippines. 344 pp.
Galib SM, Mohsin ABM, Parvez MT, Lucas MC, Chaki N, ... Islam MN (2018) Municipal wastewater can result in a dramatic decline in freshwater fishes: a lesson from a developing country. Knowledge and Management of Aquatic Ecosystems 419: 37.
Gebrekiros TS (2016) Factors affecting stream fish community composition and habitat suitability. Journal of Aquaculture and Marine Biology 4: 00076.
Guo C, Li S, Li W, Liao C, Zhang T, ... Hansen AG (2022) Spatial variation in the composition and diversity of fishes inhabiting an artificial water supply lake, Eastern China. Frontiers in Ecology and Evolution 10: 921082.
Hamilton F, Baird SF, Swaine J (1822) An account of the fishes found in the river Ganges and its branches. Archibald Constable and Company, Edinburgh and Hurst, Robinson and Co., London, UK.
Hammer Ø, Harper DAT, Ryan PD (2001) PAST: Paleontological Statistics software package for education and data analysis. Palaeontologia Electronica 4(1): 1–9.
Hinz H, Anglada P, Gayá Vilar A, Cheminée A, Pérez-Ruzafa Á, García-Charton JA (2023) Macrophyte complexity influences habitat choices of juvenile fish. Marine Biology 170: 125.
Hussner A (2012) Alien aquatic plants in European countries. Weed Research 52: 397–406.
Igbani F, Okere AE, Obadiah N (2025) Effects of river dumping on fish biodiversity and water quality: a critical review. GSAR Journal of Agriculture and Veterinary Sciences 2(6): 145–159.
IUCN (2025) The IUCN Red List of threatened species. version 2024–3. https://www.iucnredlist.org
Jayaram KC (2010) The freshwater fishes of the Indian region. 2nd edition. Narendra Publishing House, Delhi, India.
Jayasree PA, Das BC, Jifiriya MJ, Varghese T, Pillai D, Rejish Kumar VJ (2022) Ammonia induced toxico-physiological responses in fish and management interventions. Reviews in Aquaculture 15(1): 1–16.
Joshi S, Chakravarty P (2025) An assessment of human impact on tropical rivers: a critical review on worship to responsibility, case of India (pp. 607–635). In: Remotely sensed rivers in the age of anthropocene. Environmental Science and Engineering, Springer.
Kirk J (2010) Light and photosynthesis in aquatic ecosystems, 3rd edition. Cambridge University Press, Cambridge, UK.
Koushlesh SK, Johnson C, Sarkar UK, Das AK, Das BK, ... Naskar BK (2023) Exploring fish assemblage structure, feeding guild, and water quality in a typical river-reservoir interface of tropical large reservoir environment, Central India. Environmental Science and Pollution Research 30: 2179–2204.
Lawal MO, Aderolu AZ, Gafari WA (2021) Effects of *Terminalia catappa*, *Chromolaena odorata* and *Psidium guajava* leaf extracts on growth, biochemical and haematology of *Clarias gariepinus*. Department of Marine Sciences, University of Lagos, Nigeria.
Macêdo RL, Haubrock PJ, Klippel G, Fernandez RD, Leroy B, ... Cuthbert RN (2024) The economic costs of invasive aquatic plants: a global perspective on ecology and management gaps. Science of the Total Environment 908: 168217.
Marium A, Chatha AMM, Naz S, Khan MF, Safdar W, Ashraf I (2023) Effect of temperature, pH, salinity and dissolved oxygen on fishes. Journal of Zoology and Systematics 1(2): 1–12.
Mogalekar HS, Canciyal J (2018) Freshwater fish fauna of Tamil Nadu, India. Proceedings of the International Academy of Ecology and Environmental Sciences 8(4): 213–230.
Mouillot D, Graham NA, Villéger S, Mason NW, Bellwood DR (2013) A functional approach reveals community responses to disturbances. Trends in Ecology and Evolution 28(3): 167–177.
Ogidi OI, Akpan UM (2022) Aquatic biodiversity loss: impacts of pollution and anthropogenic activities and strategies for conservation (pp. 421–448). In: Ngang IEE, Akpan UM, Afiesimama BMO (Eds) Biodiversity in Africa: potentials, threats and conservation. Springer.
Pelicice FM, Agostinho AA, Thomaz SM (2005) Fish assemblages associated with *Egeria* in a tropical reservoir: Investigating the effects of plant biomass and diel period. Acta Oecologica 27: 9–16.
Pelletier MC, Ebersole J, Mulvaney K, Rashleigh B, Gutierrez MN, ... Lane C (2020) Resilience of aquatic systems: review and management implications. Aquatic Sciences 82: 44.
Rajak P, Ganguly A, Nanda S, Mandi M, Ghanty S, ... Sarkar S (2024) Toxic contaminants and their impacts on aquatic ecology and habitats (pp. 255–273).

In: Shit PK, Datta DK, Bera B, Islam A, Adhikary PP (Eds) Spatial modeling of environmental pollution and ecological risk. Woodhead Publishing, UK.

Randall DJ, Tsui TKN (2002) Ammonia toxicity in fish. Marine Pollution Bulletin 45: 17–23.

Reid AJ, Carlson AK, Creed IF, Eliason EJ, Gell PA, ... Cooke SJ (2019) Emerging threats and persistent conservation challenges for freshwater biodiversity. Biological Reviews 94: 849–873.

Roshith CM, Manna RK, Samanta S, Suresh VR, Kumar L, ... Das BK (2022) Fish diversity and assemblage structure along the river-estuary continuum in the River Cauvery, India. Aquatic Ecosystem Health and Management 25(2): 53–61.

Sarkar UK, Pathak AK, Lakra WS (2017) Freshwater fish diversity in India: environmental threats and conservation perspectives. Reviews in Fish Biology and Fisheries 17: 295–314.

Smith VH, Tilman GD, Nekola JC (1999) Eutrophication: impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. Environmental Pollution 100: 179–196.

Sugunan VV (1995) Reservoir fisheries of India. FAO Fisheries Technical Paper 345: 1–423.

Thomaz S, Cunha E (2010) The role of macrophytes in habitat structuring in aquatic ecosystems: Methods of measurement, causes and consequences on animal assemblages' composition and biodiversity. Acta Limnologica Brasiliensia 22: 218–236.

Thomaz SM, Cardozo ALP, Quirino BA, Yofukuji KY, Aleixo MHF, Fugi R (2025) A review of the ecological role of aquatic macrophytes on freshwater fish. Hydrobiologia 852: 3257–3290.

Vitule JRS, Freire CA, Simberloff D (2009) Introduction of non-native freshwater fish can certainly be bad. Fish and Fisheries 10: 98–108.

Vörösmarty CJ, McIntyre PB, Gessner MO, Dudgeon D, Prusevich A, ... Davies PM (2010) Global threats to human water security and river biodiversity. Nature 467(7315): 555–561.

Wondie TA (2009) The impact of urban storm water runoff and domestic waste effluent on water quality of Lake Tana and local groundwater near the city of Bahir Dar, Ethiopia. MPS Thesis, Cornell University, Ithaca, NY, USA. 120 pp.

Wright SL, Thompson RC, Galloway TS (2013) The physical impacts of microplastics on marine organisms: a review. Environmental Pollution 178: 483–492.

WWF (2021) The world's forgotten fishes: why freshwater biodiversity is essential and needs urgent global attention. World Wide Fund for Nature, Gland, Switzerland. 68 pp.

Xu Z, Cao J, Qin X, Qiu W, Mei J, Xie J (2023) Toxic effects on bioaccumulation, hematological parameters, oxidative stress, immune responses and tissue structure in fish exposed to ammonia nitrogen: a review. Aquatic Toxicology 259: 106486.

Yaro I, Maughan OE, Arya HP (1994) The role of aquatic vegetation in the habitat use of cyprinid fishes in Indian inland waters. FAO Fisheries Technical Paper 287: 1–32.

AP Isaac https://orcid.org/0009-0007-1707-0901
NM Nathaniel https://orcid.org/0009-0000-2746-0929