International Journal of Ecology and Environmental Sciences 52: e0929, 2026
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2026.0929

Microplastics in the Marine Food Chain – Insights from Commercially Consumed Finfish Species in Puducherry, India

TEJASWINI SINGH, ARUNKUMAR PATCHAIYAPPAN AND S.M. SUNDARAPANDIAN*
Department of Ecology & Environmental Sciences, Pondicherry University, Puducherry, India
E-mail: tejaswinisingh002@gmail.com, pu.arunkumar@gmail.com, spsm.ees@pondiuni.ac.in
***Corresponding author**

ABSTRACT

Microplastics (MPs), defined as plastic particles smaller than 5 mm, arise from the degradation of larger plastics or direct introduction, and are increasingly pervasive in global marine environments, posing risks to marine species, ecosystems, and potentially human health across all trophic levels. This research examines the frequency, attributes, and ecological consequences of MP pollution in six commercially important marine finfish species (Malabar Trevally, Small-scaled Terapon, Silver Croaker, Yellowstripe Scad, Bigeye Snapper, and Pugnose Ponyfish) gathered from three coastal landing sites in Puducherry, India. A total of 1,597 MPs were enumerated from 120 specimens. Microplastics were identified in all fish species, with average amounts varying from 10.85 ± 0.89 to 14.65 ± 1.16 particles per specimen. Fibres constituted the majority of microplastic shapes (84.1%), followed by pieces, pellets, and films, with black being the most often seen hue. Fourier transform infrared spectroscopy (FTIR) examination of polymers revealed a dominance of polypropylene (PP), low-density polyethylene (LDPE) and high-density polyethylene (HDPE), and polystyrene (PS), with specific patterns associated with eating behaviours and habitat use. Comparisons with previous regional and global research reveal that feeding ecology, habitat strata, and local anthropogenic stressors influence the spatial and interspecific heterogeneity of MPs ingestion. These data indicate moderate levels of MPs contamination in the Puducherry marine ecosystem, affecting seafood safety and ecosystem health. This study contributes to the growing body of evidence on the prevalence of microplastics in the marine food web. It highlights the need for enhanced management and legislative initiatives to mitigate plastic pollution in coastal areas.

Key words: Microplastic contamination, Marine finfish, Polystyrene, Puducherry coast, Seafood safety

INTRODUCTION

Plastics have become pervasive in contemporary society owing to their durability and affordability; however, insufficient waste management and improper disposal practices have led to their extensive accumulation in natural ecosystems (Wagner and Lambert 2018, Jambeck et al. 2015). Once in the environment, plastics persist for decades, fragmenting into smaller particles that infiltrate terrestrial and aquatic ecosystems, threatening biodiversity and ecosystem functioning (Zeng 2018, Anonymous 2021). Among the various forms of plastic pollution, microplastics are characterized as synthetic polymer particles measuring less than 5 mm in diameter (Arthur et al. 2009), and have garnered global attention as emerging contaminants. Due to their low density, durability, and buoyancy, microplastics are distributed throughout all compartments of the marine environment, from surface waters and sediments to the deep sea, making them accessible to a wide range of organisms (Avio et al. 2020).

Marine organisms ingest MPs either accidentally or indirectly through contaminated prey, mistaking them for planktonic food (Boerger et al. 2010, Wright et al. 2013). Microplastics are consumed by plankton, bivalves, crustaceans, and finfish (Avio et al. 2015, Rochman et al. 2015). Once ingested, MPs can cause physical injuries such as intestinal blockage, reduced feeding activity, and internal abrasions (Lei et al. 2018), while also serving as vectors for toxic chemicals and heavy metals (Hirai et al. 2011, Lithner et al. 2011). These particles can absorb hydrophobic contaminants, including persistent organic pollutants (POPs), polyaromatic hydrocarbons, and trace metals due to their high surface-area-to-volume ratio, increasing their hazardous potential (Guo and Wang 2021, Wang et al. 2018).

The bioaccumulation of MPs and their associated contaminants within aquatic biota has been widely reported (Avio et al. 2015, Gambardella et al. 2017). Although the extent of biomagnification through food webs remains debated (Miller et al. 2020), evidence suggests that smaller MPs (<300 µm) may cross biological membranes, translocating into fish tissues and potentially entering higher trophic levels, including humans (Anonymous 2015). This trophic transfer raises significant concerns for seafood safety, as fish and shellfish are key dietary sources for millions globally (van Cauwenberghe and Janssen 2014). Studies have detected MPs in various human biological samples, including blood, placenta, lung tissue, and stool (Lehner et al. 2019, Wu et al. 2021), indicating widespread human exposure through direct and indirect ways.

Tamil Nadu and Puducherry, located along the southeast coast of India, are particularly vulnerable due to dense fishing activity, tourism, and inadequate solid waste management (Selvam et al. 2020). Previous investigations along the Indian coasts have reported the presence of microplastics in surface waters (Kumar et al. 2018), beach sediments (Veerasingam et al. 2016), and fish intestines (Karuppasamy et al. 2020, James et al. 2022). Although microplastics have been documented in several Indian coastal areas, research concentrating on commercially consumed fish species is limited, especially along the southeastern coast of India. Puducherry, marked by intense fishing operations, urban effluence, and tourism demands, signifies a possible hotspot for MP contamination; nonetheless, systematic data from this area remain limited.

Understanding MP contamination in commonly consumed fish species is essential for evaluating trophic transfer and human exposure risks. Finfish are important vectors of MPs in the marine food web because of their high trophic position and direct human consumption. Moreover, identifying the types and polymer characteristics of MPs in fish gastrointestinal tract (GIT) provides insight into the potential sources. Therefore, the present study investigates the occurrence, abundance, morphology, and polymer composition of MPs in marketed finfish species from the Puducherry coast. This work presents a comprehensive dataset from this region and contributes to the growing body of evidence on

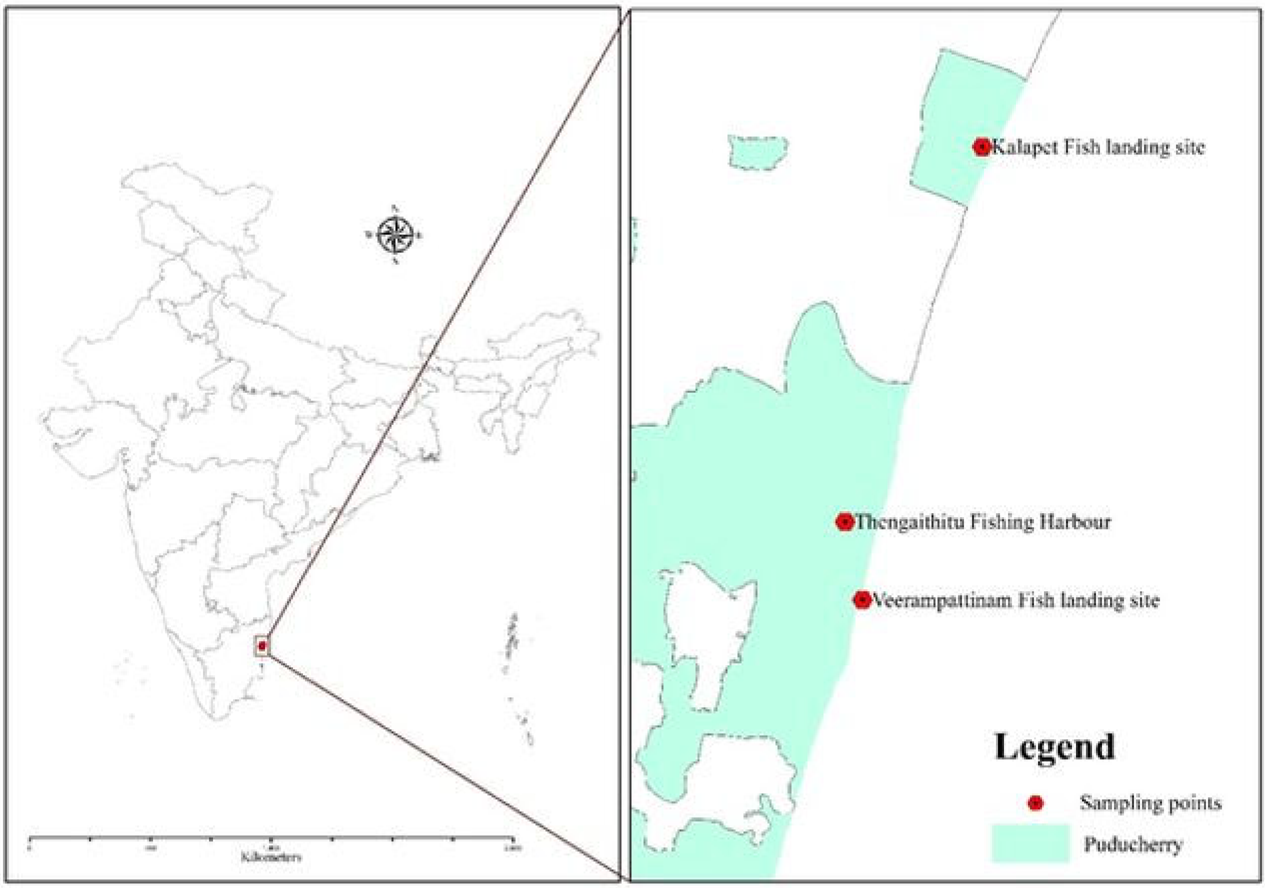

Figure 1. Study area covering three sampling locations of the Puducherry fish landing centres

plastic pollution in tropical coastal fisheries. The findings are expected to support regional policy interventions, such as the implementation of Extended Producer Responsibility (EPR), improved solid waste management, and awareness campaigns among fishers and consumers. Ultimately, this study aims to bridge the scientific and policy gap by linking microplastic contamination in fish with broader implications for food security, marine ecosystem health, and human well-being.

METHODOLOGY

Study area and sampling

The finfish samples were collected from three different fish landing centres and directly from the fishermen's community. The three sampling locations selected were Chinnakalapet (12°012 23.93 N, 79°512 40.23 E), Thegaithithu fishing harbour (11°542 59.63 N, 79°492 19.83 E), and Veerampatinam fish landing site (11°532 39.53 N, 79°492 37.53 E), based on the people's perception of commercially available fish for regular consumption (Fig. 1). A total of six species (Fig. 2) collected (20 individuals/species) *viz*., Malabar Trevally (*Carangoides malabaricus*)**,** Small-scaled Terapon (*Terapon puta*)*,* Silver Croaker (*Pennahia argentata*)*,* Yellowstripe Scad (*Selaroides leptolepis*)*,* Pugnose Ponyfish (*Secutor insidiator*)*,* and Bigeye Snapper (*Lutjanus lutjanus*).

Microplastic extraction

Microplastic extraction from fish specimens was conducted according to the methodology modified from Daniel et al. (2020) to accommodate the current study's requirements. All fish were thawed at ambient temperature before examination. To mitigate the risk of external contamination, dissection instruments and

Carangoides malabaricus (Malabar Trevally) *Terapon puta* (Small-scaled Terapon) *Pennahia argentata* (Silver Croaker)

Selaroides leptolepis (Yellowstripe Trevally) *Secutor insidiator* (Pugnose Ponyfish) *Lutjanus Lutjanus* (Bigeye Snapper)

Figure 2. Finfish species examined for the presence of MPs in their gastrointestinal tracts

work surfaces were meticulously cleaned with distilled water both before and after handling each specimen. Microplastics were extracted from the GITs of the finfish that were identified as target organs owing to their increased probability of microplastic presence with food ingestion.

The GITs were meticulously removed utilising sterilised scalpels, forceps, and scissors on pristine glass plates. Each excised intestine segment was placed into a pre-cleaned petri plate and weighed using an analytical balance before digestion. Chemical digestion was conducted in 250 ml conical flasks containing 150 ml of a 10% potassium hydroxide (KOH) solution. The flasks were sealed with aluminium foil and incubated at 40°C for 72 hrs to promote tissue breakdown. Following incubation, the samples were agitated on an orbital shaker at 150 rpm for an additional 24 hrs at 40°C to ensure complete digestion.

The processed mixtures were then heated in a hot-air oven at 60°C for 2 hrs to remove any remaining moisture. Density separation was subsequently conducted utilising a 5 M sodium chloride (NaCl) solution to extract MP particles. The supernatant was filtered through a 43 µm stainless-steel sieve before undergoing vacuum filtration with Whatman Grade 1 filter paper, which has a pore size of 1 µm. The filter papers were subsequently incubated at 40°C for 1 hr and stored in covered petri dishes for further microscopic and spectroscopic analysis.

Microscopic analysis and quantification

Then, the filter paper was examined under a Magnus Olympus microscope equipped with a 5 MP CMOS camera (Magnus MLXi Plus phase contrast microscope) at 40× magnification. The pictures were captured, and the amount was counted per filter paper. The shape, size, and colour of the MPs were noted.

Characterisation of microplastics

Fourier-transform infrared (FTIR) spectroscopy, utilising a Thermo Scientific Nicolet iS10 spectrometer, captured infrared spectra within the 4000–600 cm^{-1} wavenumber range to analyse the chemical makeup of microplastic particles in fish samples. Out of all the MPs identified, a subset of 40 samples was characterised for polymer identification. The classification of polymer classes was validated by comparing the acquired spectra with reference libraries and previously published spectra (Ranjani et al. 2021)

Quality assurance and quality control

Rigorous quality control was maintained during the extraction and analysis of microplastics from the gastrointestinal tracts of finfish to minimise contamination and ensure data integrity. All solutions, including potassium hydroxide and were pre-filtered to remove background microplastics. Laboratory equipment was meticulously cleaned with filtered water both before and after use. Dissection and sample processing occurred in a clean-air environment, utilising procedural blanks to assess airborne contamination and the efficacy of decontamination protocols. Filter papers, petri plates, and other consumables were handled with gloves and stored in airtight containers lined with silica gel, wrapped in foil, and then underwent microscopic analysis. These measures guaranteed elevated recovery rates and reduced the likelihood of false positives in microplastic identification.

RESULTS

Abundance of microplastics in gastrointestinal tract of finfishes

Microplastics were present in all the fish species studied. A total of 1,597 MPs were extracted from the gastrointestinal tracts of six marine finfish species. The MP concentration varied from 10.85± 0.88 to 14.65±1.15 MPs/individual (Fig. 3). Malabar Trevally and Bigeye Snapper demonstrated the highest concentrations of MPs (14.6±1.43 and 14.65±1.16 particles per individual, respectively), followed by the Silver Croaker (14.4±0.69 particles per individual), and Small-scaled Terapon and Pugnose Ponyfish (12.8±0.98 and 12.55±0.95 particles per individual, respectively). The least number of MPs was recorded in Yellowstripe Scad (10.85±0.89 particles per fish).

Shapes of microplastics

The shape of MPs (Fig. 4a) found in the GITs of the six finfish species exhibited a pronounced predominance of fiber-type particles, comprising

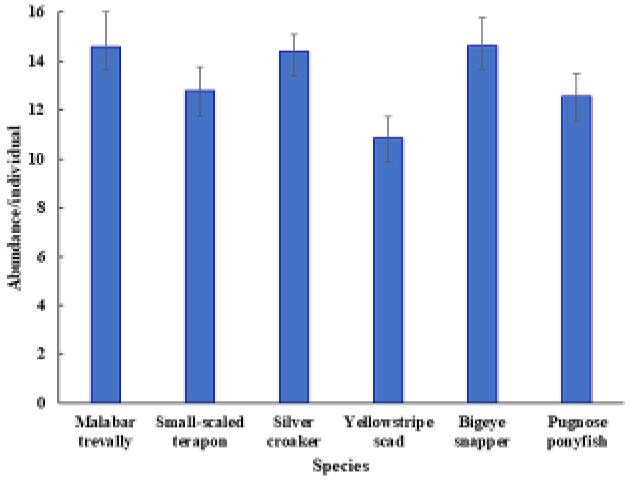

Figure 3. Abundance of microplastics in the gastrointestinal tract of six finfish species in the Puducherry coast, India

84.1% (1344 out of 1597). Fragments represented the second most prevalent shape (Fig. 4b), accounting for 7.6% (122 particles), followed by films at 4.9% (78 particles) and pellets at 3.3% (53 particles). Fiber prevalence was uniform across all fish species. Malabar Trevally exhibited a comparatively greater incidence of MP films than fragments, unlike other species that mostly have fragments rather than films.

Colour of microplastics

The black colour MPs are predominant in the GITs of the six finfish species, constituting 50.46% (Fig. 5) of all retrieved (806 out of 1597 particles). Green (13.58%) and red (12.46%) are the subsequent most prevalent colours, succeeded by brown (9.7%), white (6.76%), blue (6.01%), yellow (0.6%), and purple (0.37%). Although black MPs predominated, modest species-specific differences in secondary colours were noted. There are some species-specific predominances for particular coloured MPs apart from black, such as red by Pugnose Ponyfish and Bigeye Snapper, blue by Silver Croaker, and green by Yellowstripe Scad and Small-scaled Terapon.

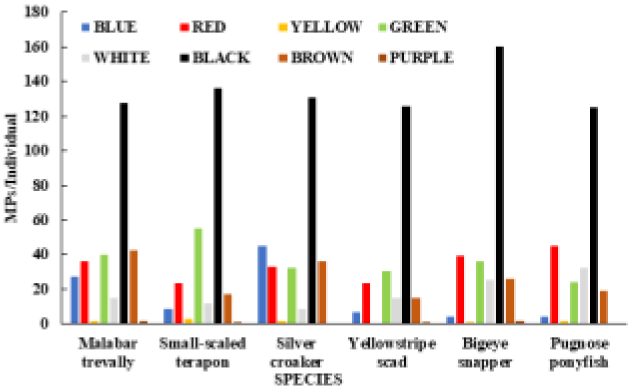

Figure 5. Colour of MPs found in the gastrointestinal tract of six species of finfishes in the Puducherry coast, India

Size of microplastics

MP particle size distribution ranged between 1–5000 µm in the GITs of the six examined fish species (Fig. 6). Significant prevalence was noted for the 1–500 µm category (33% of total particles), followed by 500-1000 µm (29%). The quantity of MPs declined

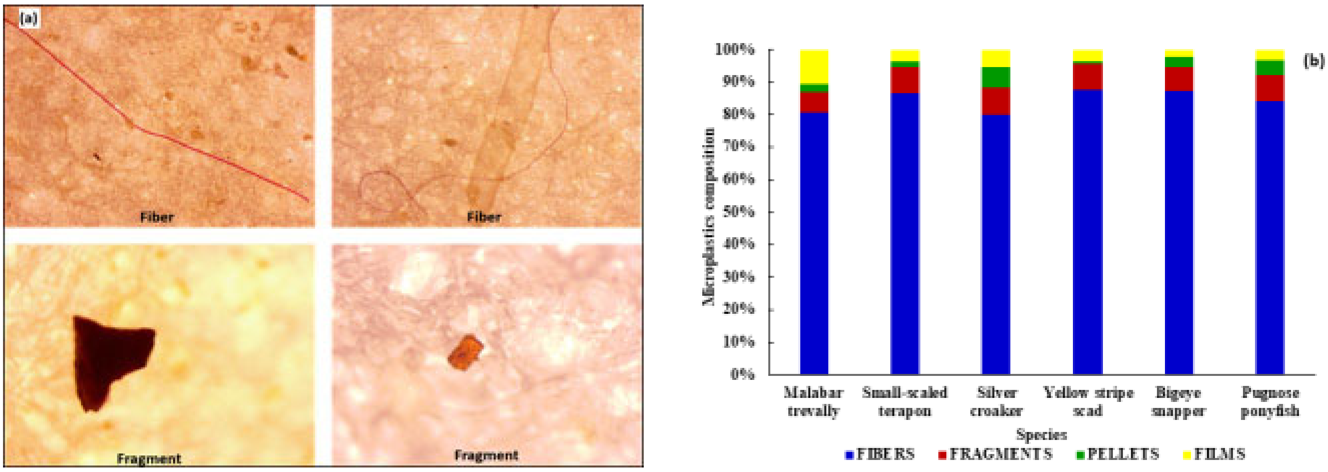

Figure 4. Microscopic images of different shapes (a) and percentage composition of MPs shapes (b) found in finfishes of the Puducherry coast, India

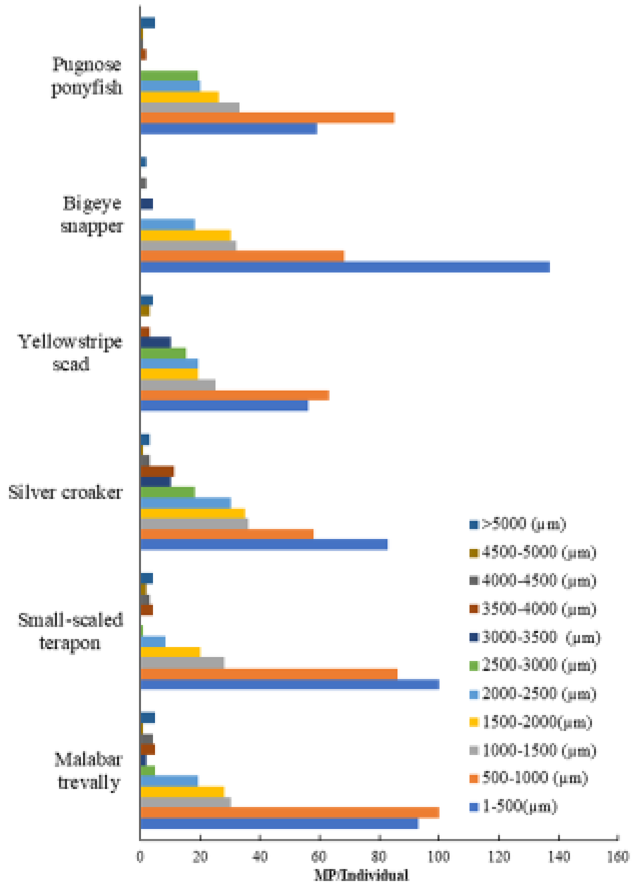

Figure 6. Size-class distribution of microplastics found in finfish GITs in the Puducherry coast, India

significantly with increasing size, with only a minor fraction of particles beyond 3,000 μm. The size distribution pattern was uniform across all six fish species, exhibiting slight interspecific variance. It was observed that there was marginally greater consumption of 500-1000 μm MPs by Malabar Trevally, Yellowstriped Scad, and Pugnose Ponyfish, in contrast to other species.

Polymer characterisation

Analysis of polymer types of MPs found in the present study indicated wide variation, with low-density polyethylene (LDPE, 28%) and polypropylene (PP, 22%) comprising the predominance (Fig. 7). Other notable polymers identified comprised high-density polyethylene (HDPE, 11%), polystyrene (PS, 17%), polyvinyl chloride (PVC, 11%), polyethylene terephthalate (PET, 8%), and polyamide (PA, 3%).

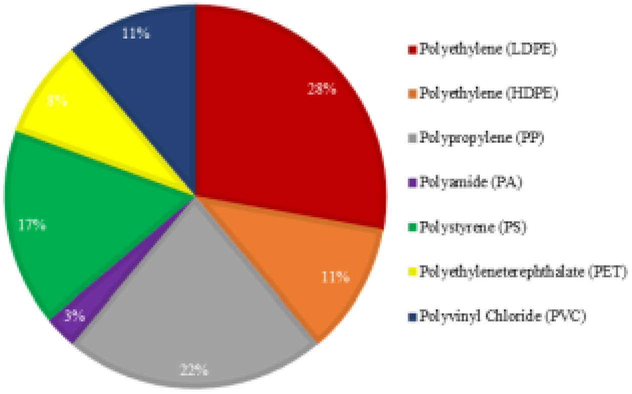

Figure 7. The cumulative percentage of polymer types found in the gastrointestinal tract of finfish in the Puducherry coast, India

DISCUSSION

The presence of MPs in all analysed finfish species signifies extensive plastic pollution throughout the Puducherry coast. The measured MP abundance (10.85–14.65 particles/individual) compares quantities documented for commercially significant fish species from the southeast coast of India and other tropical coastal areas, indicating uniform exposure to microplastics across several trophic guilds. The minor variation in MPs prevalence among the six finfish species examined might be influenced by species-specific ecological characteristics and feeding habits, as well as their respective habitats in the Puducherry coastal waters. The carnivorous Malabar Trevally consumes smaller fish and invertebrates, consequently increasing its exposure to MPs through trophic transfer from contaminated prey (Baalkhuyur et al. 2020, Lin et al. 2023). Similarly, Bigeye Snapper forages near the sediment substrate, potentially enhancing its MP ingestion rates via both direct consumption and indirect exposure through benthic prey and sediment (Akindele et al., 2019; Kumkar et al., 2021). The Silver Croaker is an omnivorous fish that consumes benthic invertebrates and detritus, thereby increasing the probability of ingesting MPs attached to sediments and organic matter (Nodehi et al. 2024). However, Small-scaled Terapon (12.8 ± 0.98 particles) and Pugnose Ponyfish (12.55 ± 0.95 particles) encompass the ingestion of tiny benthic invertebrates and organic materials. These species frequently consume benthic organisms, including polychaetes, molluscs, and detritus, which are likely polluted with sediment-associated MPs. The indiscriminate consumption of benthic debris leads to the inadvertent ingestion of MPs during foraging; nonetheless, their dietary diversity and habitat use attributed to a variation in the MPs intake relative to strict carnivores or benthic filter feeders (El Hag 1984, Nelms et al. 2018, Ory et al. 2018, Lin et al. 2023, Nodehi et al. 2024). The Yellowstripe Scad demonstrated the lowest MP content of all the species studied, primarily due to its pelagic, planktivorous feeding behaviour. As a species primarily consuming zooplankton in the water column, it has little direct interaction with sediment-associated MPs, which are often more prevalent in benthic habitats. Pelagic fish often consume fewer MPs than benthic or demersal species, as MPs are frequently elevated at the seabed where plastics collect (Parvin et al. 2021, Keerthika et al. 2023). Moreover, the selective feeding habits of Yellowstripe Scad on plankton minimise the inadvertent consumption of MPs, in contrast to demersal feeders that ingest silt and detritus containing greater MPs (Roc et al. 2020). Comparative studies have also revealed similar patterns of lower MP load in pelagic species, such as Sardines and Anchovies, relative to benthic or omnivorous fish (Bakir et al. 2020, Keerthika et al. 2023). Demersal fish face elevated exposure risks due to their feeding behaviours, which involve foraging near or inside the sediment, resulting in the consumption of benthic prey, related MPs, and potentially contaminated detrital debris (Janardhanam et al. 2022, Santiago et al. 2023). A study conducted in the lower Meghna River estuary in Bangladesh documented MP concentrations ranging from 10.8 to 22.9 particles/individual in edible fish, with omnivorous and carnivorous fish exhibiting significantly elevated concentrations attributable to trophic transfer and benthic feeding behaviours (Das and Gupta 2025). Studies conducted along the southeast coast of India revealed diverse MP contamination levels among 17 commercial species, with abundances within a comparable range, underscoring their feeding ecology (Harikrishnan et al. 2023).

The prevalence of fibers across all species studied corresponds with prior research, which demonstrates that fibers constitute the most prevalent morphology of MPs in marine ecosystems, especially within the gastrointestinal tracts of fish globally (Kibria 2022). This is ascribed to prevalent sources, including textile shedding and the degradation of fishing gear, which significantly contribute to marine MPs contamination. Fragments and pellets, primarily associated with degraded bigger plastic debris and industrial pellet spillages, are less common yet significant as they constitute secondary MPs from diverse terrestrial and marine origins. Secondary MPs endure in sediments and water columns as irregular, non-uniform particles, increasing their likelihood of unintentional ingestion by both pelagic and demersal species, particularly those feeding near the bottom or on detritus, where these fragments commonly aggregate (Li et al. 2020). Research indicates that fragments generally constitute 7–20% of the total MPs detected in fish GITs, highlighting their pervasive presence in coastal environments and ongoing introduction via runoff, littering, and degradation processes (Lim et al. 2022, Sarma et al. 2022). The Malabar Trevally ingested a greater quantity of MPs films compared to fragments, unlike other species that more commonly consumed fragments than films. This might be because the Malabar Trevally is a carnivorous feeder, also demonstrating active predation through suction feeding, which often entails the quick intake of water and prey. This feeding strategy enhances the possibility of consuming suspended or floating MPs such as films, which are thin, flexible, and can be mistaken for natural prey items such as fish skin or gelatinous plankton (Cáceres-Farias et al. 2023). Films suspended in the water column or near the surface are more accessible to carnivorous fish hunting in mid-water and benthic zones compared to heavier MP particles that tend to sink in sediments (Mallik et al. 2023).

The colour composition of MPs ingested by fish signifies a pronounced preponderance of black MPs, which may be attributed to the degradation of conventional fishing apparatus, tyre abrasion, and textile sources recognised for discharging black plastics into the marine ecosystem (Lim et al. 2022; Napper et al. 2023). Their dark colouration provides concealment in aquatic habitats, enhancing their ability to blend in with natural prey and thereby increasing the likelihood of accidental consumption by fish (Thiele et al. 2021, Lin et al. 2023). The species-specific preference for particular MPs colours, apart from black, such as red by Pugnose Ponyfish and Bigeye Snapper, blue by Silver Croaker, and green by Yellowstripe Scad and Small-scaled Terapon, likely pertains to visual feeding signals and the similarity of these coloured MPs to natural food items. Fish frequently depend on colour vision to identify and choose food, and MPs of specific colours may resemble their favoured prey, rendering them more visually appealing and susceptible to ingestion (Ríos et al. 2022). Red MPs may mimic the appearance of red-hued crustaceans or algae, which in turn may increase the consumption of Pugnose Ponyfish and Bigeye Snapper, as these fish prey on benthic invertebrates and other similarly coloured organisms (Horie et al. 2024). The increased ingestion of blue particles by Silver Croaker may be associated with the blue pigments prevalent in some molluscs or fish larvae that constitute their diet. Likewise, Yellowstripe Scad may confuse green MPs with green algae or planktonic creatures common in their pelagic feeding habitat (Munsterman et al. 2025). Research indicates that fish species have individual preferences for MP colours. Laboratory trials revealed that fish consumed red, green, and yellow plastics at higher rates than grey or white plastics, underscoring species-specific visual attraction to particular hues (Okamoto et al. 2022).

The significant prevalence of small-sized particles relative to the limited quantity of particles over 3000 μm reported in this study indicates that fish mostly ingest secondary microplastics produced by environmental degradation rather than intact source particles. Certain species may exhibit minor differences in relative proportions, potentially linked to their eating behaviours or microhabitat preferences. Research consistently indicates that microscopic MPs (<1 mm) predominate in fish consumption throughout many maritime ecosystems. A meta-analysis indicates that small MPs are ingested more frequently due to their size, which closely mirrors that of natural prey items such as zooplankton, hence enhancing their bioavailability and ease of consumption (Lim et al. 2022). Larger fish typically consume larger MPs due to their wider mouth gap, whereas smaller fish mainly ingest smaller MPs, aligning with size selectivity informed by feeding ecology (Koongolla et al. 2022). A study of various fish species from the South China Sea revealed that predominant MP sizes in fish ranged from 0.02 to 1 mm, corroborating the notion that small MPs predominantly influence contamination patterns in fish intestines (Koongolla et al. 2022). The retention duration of microscopic MPs in fish digestive systems is presumably extended, resulting in greater measured quantities relative to bigger particles that are rapidly expelled or evaded (Lim et al. 2022). The marginally greater consumption of 500–1000 μm MPs by Malabar Trevally, Yellowstriped Scad, and Pugnose Ponyfish, in contrast to other species, can be related to variations in their feeding ecology, environment, and behaviour. Research has shown that species-specific patterns in microplastic size ingestion, influenced by feeding guilds and environmental preferences, result in variations even among fish collected from the same locations (Wu et al. 2020, De Witte et al. 2022, Li et al. 2023)

The polymer profile indicates that the predominant MPs in the local marine environment, and hence most accessible for fish consumption, are buoyant varieties, such as LDPE and PP. These polymers are prevalent in packaging and fishing waste, recognised for their persistence and extensive dispersion in surface and water column environments. The detected ratios of denser polymers (HDPE, PVC, PET, PA) further suggest the existence and bioavailability of MPs in various environmental niches, encompassing both pelagic and benthic zones (Ghosh et al. 2021). The MPs found here primarily originate from a mix of local fishing activities, recreational tourism, domestic waste, and inputs from riverine and estuarine systems. Predominant polymers such as LDPE, which is widely used in plastic bags, packaging films, and components of fishing gear, and PP, commonly found in nets, ropes, and bottle caps, are typically released into the marine environment through the breakdown of fishing equipment, littering, and the improper disposal of single-use plastics (Dowarah and Devipriya 2019). Other notable polymers, including HDPE, PS, PVC, PET, and PA, are traced to sources such as discarded bottles and containers, packaging foam from recreational beach use, broken pipes, household plumbing waste, beverage bottles left by tourists, and the loss and degradation of fishing nets and textiles.

Seasonal fluctuations, unregulated household plastic use, and urban runoff, particularly via nearby estuaries such as Uppanar and Gadilam, further amplify MPs pollution on the coast by flushing land-based debris into the sea, highlighting the interplay between land-based activities and coastal marine contamination (Vaid et al. 2021, Nithin et al. 2023). The Yellowstripe Scad, a pelagic species that mostly feeds in the water column, can more likely ingest MPs, especially fibres and polymers like LDPE, PP, and HDPE, which are prevalent in pelagic environments because of their buoyant nature (Samitra et al. 2025). The Malabar Trevally is predominantly a mid-water and surface feeder, thus likely to consume low-density, floating, or suspended polymers such as LDPE, PP, and HDPE, which prevail in the upper water column and are frequently documented (Filgueiras et al. 2020). Conversely, the demersal and near-bottom foragers, Silver Croaker and Bigeye Snapper, are more inclined to consume neutrally buoyant or higher-density particles, such as PS and PVC, in conjunction with resuspended HDPE fragments (Devi et al. 2024). The nearshore/benthic-associated species, Pugnose Ponyfish and Small-scaled Terapon, forage near the sediment surface, rendering them particularly susceptible to high-density polymers that accumulate in the seabed, specifically PET and PA (nylon), along with sedimented PS and PVC fibres. These assumptions align with documented polymer distributions in numerous field investigations, where PE/PP are prevalent in surface-feeding fish, while PET, PA, and other denser polymers are relatively more abundant in bottom-dwelling species (Erni-Cassola et al. 2019, Bajt 2021, Neelavannan and Sen 2023). The presence of PVC, PA, and PS indicates exposure to diverse pollution sources associated with urban runoff and industrial discharges (Lindfors et al. 2025). Numerous evaluations warn that although the buoyancy model serves as a robust first approximation, local hydrodynamics, particle size, and biofouling/resuspension create significant overlap in actual samples (Bajt 2021, Santonicola et al. 2023).

CONCLUSIONS

This work provides insight into the contamination of MPs in commercially significant finfish species from the Puducherry coast, indicating their pervasive presence in both pelagic and demersal ecosystems. All analysed species exhibited the presence of MPs, indicating moderate levels of pollution. Fibers constituted the predominant form, succeeded by fragments and films, with black and green hues prevailing, attributable to textile fibres, fishing gear, and packaging materials. Polymer analysis indicated the predominance of LDPE, PP, PET, and nylon, signifying diverse origins from fishing and coastal urban activities. These findings align with regional and global research, highlighting the widespread infiltration of plastics into marine food webs. The detection of MPs in fish sold for human consumption suggests a possible exposure route for seafood-consuming people in Puducherry, necessitating further examination of trophic transfer and related health hazards. Enhanced trash management, sustainable fishing techniques, and public awareness are crucial to reducing the influx of plastic and protecting marine food safety.

ACKNOWLEDGEMENTS

The authors acknowledge UGC for the Junior research fellowship given to the first author (ID-200510291087), the Central Instrumentation Facility (CIF) at Pondicherry University for the FTIR analysis. We acknowledge Lakshmi Chandramohan, Ashika Rajeev and Gopika M for their help in sample processing. Mr. Shovashish Karna is acknowledged for his contribution to map-making.

Author’s contributions: Tejaswini Singh – Conceptualization, Original draft writing, data curation and analysis. Arunkumar Patchaiyappan – review, editing and analysis. SM Sundarapandian – Conceptualization, validation, review, editing.

Conflict of interest: Authors declare no conflict of interest.

REFERENCES

Akindele, E.O., Ehlers, S.M. and Koop, J.H.E. 2019. First empirical study of freshwater microplastics in West Africa using gastropods from Nigeria as bioindicators. Limnologica, 78, 125708. https://doi.org/10.1016/

j.limno.2019.125708

Anonymous. 2015. Sources, fate and effects of microplastics in the marine environment: A global assessment. International Maritime Organisation, London. 96 pages. https://repository.oceanbestpractices.org/handle/11329/1177

Anonymous 2021. Plastics – The facts 2021: An analysis of European plastics production, demand and waste data. Plastics Europe Association of Plastics Manufacturers, Brussels. 34 pages. https://plasticseurope.org/wp-content/uploads/2021/12/Plastics-the-Facts-2021-web-final.pdf

Arthur, C., Baker, J. and Bamford, H. 2009. Proceedings of the International Research Workshop on the Occurrence, Effects, and Fate of Microplastic Marine Debris. NOAA Technical Memorandum NOS-OR&R-30. https://doi.org/10.25607/OBP-1441

Avio, C.G., Gorbi, S., Milan, M., Benedetti, M., Fattorini, D., d'Errico, G., Pauletto, M., Bargelloni, L. and Regoli, F. 2015. Pollutants bioavailability and toxicological risk from microplastics to marine mussels. Environmental Pollution, 198, 211-222. https://doi.org/10.1016/j.envpol.2014.12.021

Avio, C.G., Pittura, L., d'Errico, G., Abel, S., Amorello, S., Marino, G., Gorbi, S. and Regoli, F. 2020. Distribution and characterization of microplastic particles and textile microfibers in Adriatic food webs: General insights for biomonitoring strategies. Environmental Pollution, 258, 113766. https://doi.org/10.1016/j.envpol.2019.113766

Baalkhuyur, F.M., Qurban, M.A., Panickan, P. and Duarte, C.M. 2020. Microplastics in fishes of commercial and ecological importance from the Western Arabian Gulf. Marine Pollution Bulletin, 152, 110920. https://doi.org/10.1016/j.marpolbul.2020.110920

Bajt, O. 2021. From plastics to microplastics and organisms. FEBS OpenBio, 11(4), 954-966. https://doi.org/10.1002/2211-5463.13120

Bakir, A., Desender, M., Wilkinson, T., van Hoytema, N., Amos, R., Airahui, S., Graham, J. and Maes, T. 2020. Occurrence and abundance of meso- and micro-plastics in sediment, surface waters, and marine biota from the South Pacific region. Marine Pollution Bulletin, 160, 111572. https://doi.org/10.1016/j.marpolbul.2020.111572

Boerger, C.M., Lattin, G.L., Moore, S.L. and Moore, C.J. 2010. Plastic ingestion by planktivorous fishes in the North Pacific Gyre. Marine Pollution Bulletin, 60(12), 2275-2278. https://doi.org/10.1016/j.marpolbul.2010.08.007

Cáceres-Farias, L., Espinoza-Vera, M.M., Orós, J., Garcia-Bereguiain, M.A. and Alfaro-Núñez, A. 2023. Macro and microplastic intake in seafood variates by the marine organism's feeding behaviour/ : Is it a concern to human health/ ? Heliyon, 9, e16452. https://doi.org/10.1016/j.heliyon.2023.e16452

Daniel, D.B., Ashraf, P.M. and Thomas, S.N. 2020. Microplastics in the edible and inedible tissues of pelagic fishes sold for human consumption in Kerala, India. Environmental Pollution, 266, 115365. https://doi.org/10.1016/j.envpol.2020.115365

Das, L.R.S. and Gupta, S. 2025. Comment on Unveiling Microplastics in Commercial Brackish Water Fishes from the Lower Meghna River Estuary of Bangladesh. Bulletin of Environmental Contamination and Toxicology, 115(3), 1-9. https://doi.org/10.1007/s00128-025-04105-x

De Witte, B., Catarino, A.I., Vandecasteele, L., Dekimpe, M., Meyers, N., Deloof, D., Pint, S., Hostens, K., Everaert, G. and Torreele, E. 2022. Feasibility study on biomonitoring of microplastics in fish gastrointestinal tracts. Frontiers in Marine Science, 8, 794636. https://doi.org/10.3389/fmars.2021.794636

Devi, S.S., Saifudeen, N., Kumar, K.S. and Kumar, A.B. 2024. Does the microplastics ingestion patterns and polymer composition vary across the oceanic zones? A case study from the Indian coast. Marine Pollution Bulletin, 204, 116532. https://doi.org/10.1016/j.marpolbul.2024.116532

Dowarah, K. and Devipriya, S.P. 2019. Microplastic prevalence in the beaches of Puducherry, India and its correlation with fishing and tourism/recreational activities. Marine Pollution Bulletin, 148, 123-133. https://doi.org/10.1016/j.marpolbul.2019.07.066

El Hag, E.A. 1984. Food and food selection of the Penaeid prawn *Penaeus monodon* (Fabricius). Hydrobiologia, 110(1), 213-217. https://doi.org/10.1007/BF00025792

Erni-Cassola, G., Zadjelovic, V., Gibson, M.I. and Christie-Oleza, J.A. 2019. Distribution of plastic polymer types in the marine environment: A meta-analysis. Journal of Hazardous Materials, 369, 691-698. https://doi.org/10.1016/j.jhazmat.2019.02.067

Filgueiras, A.V., Preciado, I., Cartón, A. and Gago, J. 2020. Microplastic ingestion by pelagic and benthic fish and diet composition: A case study in the NW Iberian shelf. Marine Pollution Bulletin, 160, 111623. https://doi.org/10.1016/j.marpolbul.2020.111623

Gambardella, C., Morgana, S., Ferrando, S., Bramini, M., Piazza, V., Costa, E., Garaventa, F. and Faimali, M. 2017. Effects of polystyrene microbeads in marine planktonic crustaceans. Ecotoxicology and Environmental Safety, 145, 250-257. https://doi.org/10.1016/j.ecoenv.2017.07.036

Ghosh, G.C., Akter, S.M., Islam, R.M., Habib, A., Chakraborty, T.K., Zaman, S., Kabir, A.H.M.E., Shipin, O.V. and Wahid, M.A. 2021. Microplastics contamination in commercial marine fish from the Bay of Bengal. Regional Studies in Marine Science, 44, 101728. https://doi.org/10.1016/j.rsma.2021.101728

Guo, X. and Wang, J. 2021. Projecting the sorption capacity of heavy metal ions onto microplastics in global aquatic environments using artificial neural networks. Journal of Hazardous Materials, 402, 123709. https://doi.org/10.1016/j.jhazmat.2020.123709

Harikrishnan, T., Janardhanam, M., Sivakumar, P., Sivakumar, R., Rajamanickam, K., Raman, T., Thangavelu, M., Muthusamy, G. and Singaram, G. 2023. Microplastic contamination in commercial fish species in southern coastal region of India. Chemosphere, 313, 137486. https:/ /doi.org/10.1016/j.chemosphere.2022.137486

Hirai, H., Takada, H., Ogata, Y., Yamashita, R., Mizukawa, K., Saha, M., Kwan, C., Moore, C., Gray, H., Laursen, D., Zettler, E.R., Farrington, J.W., Reddy, C.M., Peacock, E.E.

and Ward, M.W. 2011. Organic micropollutants in marine plastic debris from the open ocean and remote and urban beaches. Marine Pollution Bulletin, 62(8), 1683–1692. https://doi.org/10.1016/j.marpolbul.2011.06.004

Horie, Y., Mitsunaga, K., Yamaji, K., Hirokawa, S. and Uaciquete, D. 2024. Variability in microplastic color preference and intake among selected marine and freshwater fish and crustaceans. Discover Oceans, 1, 5. https://doi.org/10.1007/s44289-024-00005-w

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R. and Law, K.L. 2015. Plastic waste inputs from land into the ocean. Science, 347(6223), 768-771. https://doi.org/10.1126/science.1260352

James, K., Kripa, V., Vineetha, G., Padua, S., Prema, D., Babu, A., John, S., John, S., Lavanya, R. and Joseph, R.V. 2022. Microplastics in the environment and in commercially significant fishes of mud banks, an ephemeral ecosystem formed along the southwest coast of India. Environmental Research, 204, 112351. https://doi.org/10.1016/j.envres.2021.112351

Janardhanam, M., Sivakumar, P., Srinivasan, G., Sivakumar, R., Raman, T., Singaram, G. and Harikrishnan, T. 2022. Microplastics in Demersal Sharks from the Southeast Indian Coastal Region. Frontiers in Marine Science, 9, 914391. https://doi.org/10.3389/fmars.2022.914391

Karuppasamy, P.K., Ravi, A., Vasudevan, L., Elangovan, M.P., Mary, P.D., Vincent, S.G. and Palanisami, T. 2020. Baseline survey of micro and mesoplastics in the gastro-intestinal tract of commercial fish from Southeast coast of the Bay of Bengal. Marine Pollution Bulletin, 153, 110974. https://doi.org/10.1016/j.marpolbul.2020.110974

Keerthika, K., Padmavathy, P., Rani, V., Jeyashakila, R., Aanand, S., Kutty, R., Tamilselvan, R. and Subash, P. 2023. Microplastics accumulation in pelagic and benthic species along the Thoothukudi coast, South Tamil Nadu, India. Marine Pollution Bulletin, 189, 114735. https://doi.org/10.1016/j.marpolbul.2023.114735

Kibria, G. 2022. Global review and analysis of the presence of microplastics in fish. Asian Fisheries Science, 35(3), 191-256. https://doi.org/10.33997/j.afs.2022.35.3.003

Koongolla, J.B., Lin, L., Yang, C.P., Pan, Y.F., Li, H.X., Liu, S. and Xu, X.R. 2022. Microplastic prevalence in marine fish from onshore Beibu Gulf, South China Sea. Frontiers in Marine Science, 9, 964461. https://doi.org/10.3389/fmars.2022.964461

Kumar, V.E., Ravikumar, G. and Jeyasanta, K.I. 2018. Occurrence of microplastics in fishes from two landing sites in Tuticorin, South east coast of India. Marine Pollution Bulletin, 135, 889-894. https://doi.org/10.1016/j.marpolbul.2018.08.023

Kumkar, P., Gosavi, S.M., Verma, C.R., Pise, M. and Kalous, L. 2021. Big eyes can't see microplastics: Feeding selectivity and eco-morphological adaptations in oral cavity affect microplastic uptake in mud-dwelling amphibious mudskipper fish. Science of the Total Environment, 786, 147445. https://doi.org/10.1016/j.scitotenv.2021.147445

Lehner, R., Weder, C., Petri-Fink, A. and Rothen-Rutishauser, B. 2019. Emergence of nanoplastic in the environment and possible impact on human health. Environmental Science & Technology, 53(4), 1748-1765. https://doi.org/10.1021/acs.est.8b05512

Lei, L., Wu, S., Lu, S., Liu, M., Song, Y., Fu, Z., Shi, H., Raley-Susman, K.M. and He, D. 2018. Microplastic particles cause intestinal damage and other adverse effects in zebrafish *Danio rerio* and nematode *Caenorhabditis elegans*. Science of the Total Environment, 619-620, 103. https://doi.org/10.1016/j.scitotenv.2017.11.103

Li, B., Su, L., Zhang, H., Deng, H., Chen, Q. and Shi, H. 2020. Microplastics in fishes and their living environments surrounding a plastic production area. Science of the Total Environment, 727, 138662. https://doi.org/10.1016/j.scitotenv.2020.138662

Li, Y., Tao, L., Wang, Q., Wang, F., Li, G. and Song, M. 2023. Potential health impact of microplastics: A review of environmental distribution, human exposure, and toxic effects. Environment and Health, 1(4), 249-257. https://doi.org/10.1021/envhealth.3c00052

Lim, K.P., Lim, P.E., Yusoff, S., Sun, C., Ding, J. and Loh, K.H. 2022. A meta-analysis of the characterisations of plastic ingested by fish globally. Toxics, 10(4), 186. https://doi.org/10.3390/toxics10040186

Lin, X., Gowen, A.A., Pu, H. and Xu, J.L. 2023. Microplastic contamination in fish: Critical review and assessment of data quality. Food Control, 153, 109939. https://doi.org/10.1016/j.foodcont.2023.109939

Lindfors, S., Österlund, H., Lorenz, C., Vianello, A., Nordqvist, K., Gopinath, K., Lykkemark, J., Lundy, L., Vollertsen, J. and Viklander, M. 2025. Microplastics and tyre wear particles in urban runoff from different urban surfaces. Science of the Total Environment, 980, 179527. https://doi.org/10.1016/j.scitotenv.2025.179527

Lithner, D., Larsson, A. and Dave, G. 2011. Environmental and health hazard ranking of plastic polymers based on chemical composition. Science of the Total Environment, 409(18), 3309-3324. https://doi.org/10.1016/j.scitotenv.2011.04.038

Mallik, A., Bhushan, S., Chakraborty, P., Ramteke, K. K., Pal, P., Jaiswar, A. K., Sreekanth, G.B. and Nayak, B.B. 2023. Study of feeding biology and diet-associated microplastic contamination in selected creek fishes of northeastern Arabian Sea: A multi-species approach. Marine Pollution Bulletin, 190, 114875. https://doi.org/10.1016/j.marpolbul.2023.114875

Miller, M.E., Hamann, M. and Kroon, F.J. 2020. Bioaccumulation and biomagnification of microplastics in marine organisms: A review and meta-analysis of current data. PloS one, 15(10), e0240792. https://doi.org/10.1371/journal.pone.0240792

Munsterman, F., Allan, B.J.M. and Johnson, S.L. 2025. The availability and ingestion of microplastics by an intertidal fish is dependent on urban proximity. New Zealand Journal of Marine and Freshwater Research, 59(4), 685-698. https://doi.org/10.1080/00288330.2024.2365272

Napper, I.E., Baroth, A., Barrett, A.C., Bhola, S., Chowdhury, G.W., Davies, B.F.R., Duncan, E.M., Kumar, S., Nelms, S.E., Niloy, M.N.H., Nishat, B., Maddalene, T., Smith, N., Thompson, R.C. and Koldewey, H. 2023. The distribution and characterisation of microplastics in air, surface water and sediment within a major river system. Science of the Total Environment, 901, 166640. https://doi.org/10.1016/j.scitotenv.2023.166640

Neelavannan, K. and Sen, I.S. 2023. Microplastics in Freshwater Ecosystems of India: Current Trends and Future Perspectives. ACS Omega, 8(38), 34235-34248. https://doi.org/10.1021/acsomega.3c01214

Nelms, S.E., Galloway, T.S., Godley, B.J., Jarvis, D.S. and Lindeque, P.K. 2018. Investigating microplastic trophic transfer in marine top predators. Environmental Pollution, 238, 999-1007. https://doi.org/https://doi.org/10.1016/j.envpol.2018.02.016

Nithin, A., Sundaramanickam, A., Saha, M., Hassanshahian, M., Thangaraj, M. and Rathore, C. 2023. Risk assessments of microplastics accumulated in estuarine sediments at Cuddalore, Tamil Nadu, southeast coast of India. Environmental Monitoring and Assessment, 195(7), 890. https://doi.org/10.1007/s10661-023-11434-z

Nodehi, R.N., Hadi, M., Hosseinzadeh, A. and Azizi, N. 2024. Correction to: Comprehensive systematic review and meta-analysis of microplastic prevalence and abundance in freshwater fish species: the effect of fish species habitat, feeding behaviour, and Fulton's condition factor Journal of Environmental Health Science and Engineering, 22(2), 609. https://doi.org/10.1007/s40201-024-00923-z

Okamoto, K., Nomura, M., Horie, Y. and Okamura, H. 2022. Color preferences and gastrointestinal-tract retention times of microplastics by freshwater and marine fishes. Environmental Pollution, 304, 119253. https://doi.org/10.1016/j.envpol.2022.119253

Ory, N.C., Gallardo, C., Lenz, M. and Thiel, M. 2018. Capture, swallowing, and egestion of microplastics by a planktivorous juvenile fish. Environmental Pollution, 240, 566-573. https://doi.org/10.1016/j.envpol.2018.04.093

Parvin, F., Jannat, S. and Tareq, S.M. 2021. Abundance, characteristics and variation of microplastics in different freshwater fish species from Bangladesh. The Science of the Total Environment, 784, 147137. https://doi.org/10.1016/j.scitotenv.2021.147137

Ranjani, M., Veerasingam, S., Venkatachalapathy, R., Mugilarasan, M., Bagaev, A., Mukhanov, V. and Vethamony, P.J.M.P.B. 2021. Assessment of potential ecological risk of microplastics in the coastal sediments of India: A meta-analysis. Marine Pollution Bulletin, 163, 111969. https://doi.org/10.1016/j.marpolbul.2021.111969

Ríos, J.M., Tesitore, G. and de Mello, F.T. 2022. Does color play a predominant role in the intake of microplastics fragments by freshwater fish: an experimental approach with Psalidodon eigenmanniorum. Environmental Science and Pollution Research International, 29(32), 49457-49464. https://doi.org/10.1007/s11356-022-20913-8

Roc, S., Frie, C. and Brinker, A. 2020. Uptake routes of microplastics in fishes/ : practical and theoretical approaches to test existing theories. Scientific Reports, 10, 3896. https://doi.org/10.1038/s41598-020-60630-1

Rochman, C.M., Tahir, A., Williams, S.L., Baxa, D.V., Lam, R., Miller, J.T., Werorilangi, S. and Teh, S.J. 2015. Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. Scientific Reports, 5(1), 14340. https://doi.org/10.1038/srep14340

Samitra, I., Werorilangi, S. and Burhanuddin, A.I. 2025. Microplastic contamination in commercially important fish from Labuan Bajo fish landing site, Donggala, Central Sulawesi, Indonesia. Egyptian Journal of Aquatic Biology and Fisheries, 29(5), 1323-1345. https://doi.org/10.21608/ejabf.2025.366970.5730

Santiago, D., Robert, C., Nobre, D., Silva, N. and Barroncas, E. 2023. Microplastic in mangroves: A worldwide review of contamination in biotic and abiotic matrices. Marine Pollution Bulletin, 195, 115552. https://doi.org/10.1016/j.marpolbul.2023.115552

Santonicola, S., Volgare, M., Pace, E.Di., Mercogliano, R., Cocca, M., Raimo, G. and Colavita, G. 2023. Research and characterization of fibrous microplastics and natural microfibers in pelagic and benthic fish species of commercial interest. Italian Journal of Food Safety, 12(1), 11032. https://doi.org/10.4081/ijfs.2023.11032

Sarma, H., Hazarika, R.P., Kumar, V., Roy, A., Pandit, S. and Prasad, R. 2022. Microplastics in marine and aquatic habitats: sources, impact, and sustainable remediation approaches. Environmental Sustainability, 5(1), 39-49. https://doi.org/10.1007/s42398-022-00219-8

Selvam, S., Jesuraja, K., Venkatramanan, S., Roy, P.D., Singaraja, C., Elango, L. and Chung, S.Y. 2020. Microplastics in the sediments of Chennai coast, India - Implications for pollution management. Marine Pollution Bulletin, 151, 110804. https://doi.org/10.1016/j.marpolbul.2019.110804

Thiele, C.J., Hudson, M.D., Russell, A.E., Saluveer, M. and Haddad, G.S. 2021. Microplastics in fish and fishmeal: An emerging environmental challenge/ ? Scientific Reports, 11, 2045. https://doi.org/10.1038/s41598-021-81499-8

Vaid, M., Mehra, K. and Gupta, A. 2021. Microplastics as contaminants in Indian environment: A review. Environmental Science and Pollution Research, 68025-68052. https://doi.org/10.1007/s11356-021-16827-6

van Cauwenberghe, L. and Janssen, C.R. 2014. Microplastics in bivalves cultured for human consumption. Environmental Pollution, 193, 65-70. https://doi.org/10.1016/j.envpol.2014.06.010

Veerasingam, S., Venkatachalapathy, R., Sudhakar, S., Velu, G., Raja, P. and Jain, R. 2016. Microplastics in sediment cores from the coastal environment of India. Marine Pollution Bulletin, 109(1), 524-530. https://doi.org/10.1016/j.marpolbul.2016.05.082

Wagner, M. and Lambert, S. (Eds.). 2018. Freshwater Microplastics: Emerging Environmental Contaminants. Springer, Cham. https://doi.org/10.1007/978-3-319-61615-5

Wang, J., Tan, Z., Peng, J., Qiu, Q. and Li, M. 2018. Microplastics as contaminants in the marine environment: A review of their occurrence, fate and effects. Marine Pollution Bulletin, 136, 276-281. https://doi.org/10.1016/

j.marpolbul.2018.09.050

Wright, S.L., Thompson, R.C. and Galloway, T.S. 2013. The physical impacts of microplastics on marine organisms: A review. Environmental Pollution, 178, 483-492. https://doi.org/10.1016/j.envpol.2013.02.031

Wu, F., Pennings, S.C., Tong, C. and Xu, Y. 2020. Variation in microplastics composition at small spatial and temporal scales in a tidal flat of the Yangtze Estuary, China. Science of the Total Environment, 699, 134252. https://doi.org/10.1016/j.scitotenv.2019.134252

Wu, M., Yang, C., Du, C., Liu, M., Xu, S. and Song, Y. 2021. Microplastics in humans: Emerging health implications. Environmental Science & Technology, 55(14), 9541-9553. https://doi.org/10.1021/acs.est.1c01537

Zeng, E.Y. (Ed.). 2018. Microplastic Contamination in Aquatic Environments: An Emerging Matter of Environmental Urgency. Elsevier, New York. https://doi.org/10.1016/C2016-0-04784-8

Received:4th November 2025
Accepted: 9th January 2026