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Microplastic Contamination of Edible Fish Tissue: A Case Study of *Caranx tille* (Cuvier, 1833) from Sri Vijaya Puram, Andaman Islands, India

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Abstract: Microplastics (MPs) are now reported from almost every marine habitat, but most fish surveys have examined the digestive tract, a tissue that is usually discarded before cooking. This study measured microplastics in the edible dorsal muscle of the tille trevally (Caranx tille), landed at the Junglighat fish landing centre in Sri Vijaya Puram (formerly Port Blair), South Andaman, India. Fifty-six fish (total length 17.5–20.3 cm; body weight 85.73–100.90 g) were collected on four occasions between April 2023 and October 2024. A 5 g sample of muscle tissue from each fish was digested in 10% potassium hydroxide, filtered and examined under a stereo-microscope, and the recovered particles were classified by colour, shape, size and polymer type. After correction for a single fibre found in eleven procedural blanks, 130 particles were attributed to muscle tissue, equal to 2.32 ± 1.44 items individual^{-1} and 0.46 ± 0.29 items g^{-1} wet weight. Blue particles formed 57.7% of the total, and fibres (43.2%) and filaments (40.6%) were more common than beads (16.2%). All particles were smaller than about 70 µm. Polyester was the principal polymer (52.7%), followed by cellulose (29.0%), with acrylic, polyamide, polyethylene and polypropylene each below 5%. Particle counts were not correlated with fish length, weight or condition. The dominance of small polyester fibres suggests that urban wastewater and fishing gear around Junglighat are the main sources. At the measured abundance, a 100 g serving of C. tille muscle may contain about 46 particles, which supports the inclusion of edible fish tissue in microplastic monitoring in the Andaman Islands.

Keywords: Andaman Islands; Caranx tille; fish muscle; food safety; microplastics; polyester fibres

I. Introduction

Few materials have reshaped daily life as completely as synthetic polymers. Since large-scale commercial production began in the 1950s, plastics have displaced glass, metal, wood and natural fibres in nearly every sector, including food packaging, clothing, construction, transport, medicine and fisheries. A global material-flow analysis estimated that about 8,300 million tonnes of virgin plastic had been manufactured by 2015, and that roughly 79% of all plastic waste generated up to that year had accumulated in landfills or the wider environment rather than being recycled or incinerated [1]. Output has continued to rise, exceeding 400 million tonnes in 2022 [2]. The qualities that make plastics commercially attractive, namely low cost, light weight, chemical inertness and resistance to decay, are the same qualities that allow discarded items to persist for decades once they escape controlled waste streams.

The ocean is the final receiving body for much of this mismanaged waste. Rivers, stormwater drains, sewage outfalls, wind and direct dumping from vessels and coastal settlements all deliver plastic to the sea. Using data on waste generation, waste management and coastal population density, Jambeck et al. [3] calculated that between 4.8 and 12.7 million tonnes of plastic entered the ocean from 192 coastal countries in 2010. They predicted that this input would grow considerably unless waste handling improved. Surveys spanning the five subtropical gyres and several adjoining seas have since indicated that more than five trillion plastic pieces are floating at the sea surface [4]. Floating debris is only part of the total, because a large share of the plastic reaching the sea sinks to the seabed, is stranded on beaches or is taken up by living organisms.

At sea, plastic debris is progressively degraded by solar ultraviolet radiation, heat, oxidation, wave abrasion, and microbial activity, breaking large items into ever-smaller pieces [5]. Thompson et al. [6] drew wide attention to this process when they reported microscopic plastic fragments and fibres in British coastal sediments and in archived plankton samples collected since the 1960s, and introduced the term “microplastics”. An upper size limit of 5 mm was later adopted at an international workshop convened by the United States National Oceanic and Atmospheric Administration [7], and this definition is now followed in most monitoring studies. Microplastics are commonly grouped by origin [8]. Primary microplastics are intentionally produced in small sizes; examples include pre-production resin pellets, industrial abrasives, and microbeads formerly common in cosmetics and toothpaste. Secondary microplastics arise from the breakdown of larger products such as carry bags, bottles, food wrappers, ropes and nets. Because fragmentation continues for as long as debris

remains in the environment, the number of particles is expected to keep increasing even if fresh inputs were to stop.

Synthetic textiles have emerged as a major and often underestimated source of microplastic fibres. In controlled washing trials, Napper and Thompson [9] estimated that a single 6 kg domestic wash of acrylic fabric could release more than 700,000 fibres, and that polyester and polyester–cotton blends also shed large numbers of fibres. Many of these fibres pass through wastewater treatment plants, and where sewage is discharged untreated, they enter coastal waters directly. In a global survey of shorelines, Browne et al. [10] found more microplastics in sediments near densely populated areas. They noted that the proportions of polyester and acrylic fibres in their samples resembled those released from clothing during washing. Fishing activity adds further fibrous debris through the abrasion, breakage, and loss of nets, lines, and ropes made from polyamide, polyethene, and polypropylene.

Their small size and wide distribution make microplastics available to an unusually broad range of marine animals. The particles overlap in size with phytoplankton, zooplankton and suspended detritus. They can be ingested by filter feeders, deposit feeders and predators, either directly from the water and sediment or indirectly through contaminated prey [11]. In fish, plastic has been recovered from the digestive tracts of species living in every major habitat. In the English Channel, for example, Lusher et al. [12] found plastic in more than one-third of the 504 pelagic and demersal fish they examined, with fibres forming most of the particles. Once swallowed, microplastics may block or abrade the gut, create a false sense of fullness, reduce food intake and divert energy away from growth and reproduction [11].

The amount of microplastic that a fish takes up depends on its feeding mode, its position in the water column and its trophic level. Planktivores and filter feeders encounter particles directly, whereas predators are also exposed indirectly through their prey. Evidence for this indirect route has grown. Nelms et al. [13] examined wild-caught Atlantic mackerel and the scats of captive grey seals fed on such fish, and found microplastics in about one-third of the fish and about half of the scat samples, with ethylene propylene as the most frequent polymer in both. They concluded that trophic transfer is an indirect but potentially major route of exposure for any predator that eats whole prey, including humans. For predatory fish, the microplastic burden therefore reflects not only the particles present in the surrounding water but also the load carried by their prey. This makes higher-level predators useful indicators of the extent to which microplastics are moving through coastal food webs.

Microplastics also carry a chemical burden. Plastics are compounded with additives such as plasticisers, flame retardants, antioxidants, ultraviolet stabilisers and pigments, several of which can interfere with endocrine function. In addition, the hydrophobic surfaces of weathered particles accumulate persistent organic pollutants and metals from the surrounding seawater. When Rochman et al. [14] fed Japanese medaka a diet containing polyethene that had been immersed in San Diego Bay, the fish absorbed the sorbed contaminants. They showed signs of liver stress, including glycogen depletion and single-cell necrosis. Microplastics may therefore simultaneously expose organisms to physical and chemical hazards, and the two effects are difficult to separate in field studies.

Most field surveys of microplastics in fish have concentrated on the gastrointestinal tract, because ingested particles are most easily detected there. The gut, however, is normally removed before fish are cooked, so gut data reveal little about the particles that consumers actually swallow [15]. Small fish eaten whole, dried fish and bivalves are exceptions, and plastic debris and textile fibres have been found in such products bought from markets in Indonesia and California [16]. For most commercially important finfish, the fillet is the principal edible portion, and whether microplastics move from the gut into muscle is therefore a central question for exposure assessment. An expert review prepared for the Food and Agriculture Organisation of the United Nations concluded that only the smallest particles are likely to cross the gut wall, and that particles larger than about 150 µm are unlikely to be absorbed [15]. Field studies have nevertheless reported microplastics in fish muscle with increasing frequency. Abbasi et al. [17] detected particles in the muscle, skin, gills and liver of fish from the Musa Estuary in the Persian Gulf. Akhbarizadeh et al. [18] recorded microplastics in the muscle of four commercial species from the same region, observed that the loads rose with body size, and calculated that eating 300 g of these fish per week could deliver between 169 and 555 particles. In the North East Atlantic, Barboza et al. [19] found microplastics in the dorsal muscle of 32% of 150 wild fish from three commercial species, at a mean of 0.054 items g^{-1}, and linked their presence to lipid peroxidation. More recently, Hossain et al. [20] reported a mean of 2.60 items in the muscle of the catfish *Silonia silondia* from a large tropical estuary, together with higher numbers in the gills and digestive tract.

There is now substantial evidence that people are exposed to microplastics. Plastic particles have been quantified in the blood of healthy volunteers [21] and identified in human placental tissue [22]. Experimental work points to possible inflammation, oxidative stress, cytotoxicity and disturbance of the gut microbiota, although the doses used in many laboratory studies exceed realistic dietary exposure [23]. A sound assessment

of the risk posed by seafood requires reliable data on the number, size and composition of microplastics in the parts of fish that people eat, and such data remain scarce for most species and regions [15].

India has one of the largest marine fisheries in the world and a long, densely settled coastline where sewage treatment and solid-waste collection have not kept pace with urban growth. Microplastics have been documented in Indian beach and lake sediments, coastal waters and the gut contents of commercial fishes. On the south-east coast, Sathish et al. [24] recorded mainly blue fibres smaller than 500 µm in the guts of epipelagic and mesopelagic fishes from Tuticorin, with polyethene, polyester and polyamide as the leading polymers, and Karuppasamy et al. [25] recovered polyethene, polyamide and polyester particles from the guts of commercial fishes landed along the Bay of Bengal coast of Tamil Nadu. On the south-west coast, Robin et al. [26] identified polyethene, cellulose, rayon, polyester and polypropylene in the digestive tracts of commercially important fishes from Kerala. Far fewer Indian studies have examined edible tissue. Daniel et al. [27] analysed nine pelagic species sold in Kerala markets. They found microplastics in the muscle and skin of only 7% of fish, whereas 41% of the same fish contained particles in the gills or viscera.

India has begun to respond to the problem through regulation. The Plastic Waste Management Rules of 2016 set out duties for waste generators, local bodies and producers. An amendment notified in August 2021 prohibited the manufacture, import, distribution and sale of a list of single-use plastic items, including plates, cups, cutlery, straws, stirrers and some wrapping films, with effect from 1 July 2022. It raised the minimum thickness of plastic carry bags [28]. These measures target large, visible items, but they do not directly address fibres shed from synthetic textiles or from worn fishing gear, which are among the main sources of microplastics in coastal waters. Monitoring of the particles that actually reach seafood is therefore needed, both to assess whether such regulations are reducing consumer exposure and to identify sources that require further control.

The Andaman and Nicobar Islands, which lie in the south-eastern Bay of Bengal and border the Andaman Sea, are often regarded as comparatively pristine because of their distance from the mainland and their extensive coral reefs, mangroves and protected areas. Recent work shows that they are not free from plastic pollution. Patchaiyappan et al. [29] recorded an average of about 414 microplastic particles per kilogram of beach sediment along the South Andaman coast and identified 13 polymer types. They attributed the contamination to inadequate solid waste management, tourism, and maritime traffic. In Port Blair Bay, Goswami et al. [30] provided the first evidence of microplastic uptake by the islands' marine biota, detecting particles in seawater, sediment, zooplankton, finfish and shellfish. Fibres were the most frequent shape, nylon and acrylic were among the commonest polymers, and the carangid *Carangoides malabaricus* showed the highest ingestion among the fishes studied. More recently, Kumar et al. [31] surveyed sediments at six fish landing centres around Sri Vijaya Puram and found significantly higher microplastic loads at the northern, more urbanised centres, including Junglighat, than at the southern centres, with abundance increasing with built-up area and population density.

Sri Vijaya Puram, the capital of the Union Territory, was known as Port Blair until it was renamed in September 2024. It is the main centre of population, trade and fishing in the islands. Its landing centres support more than 7,000 licensed fishers and nearly 2,900 mechanised and non-mechanised craft, and together they contribute about 43,000 tonnes of fish each year [31]. Junglighat is one of the busiest of these centres. It lies in a heavily built-up part of the city. It is a focus of boat operations, fish handling and processing, so urban runoff, domestic wastewater, worn fishing gear and packaging waste all converge on its shoreline [31]. Fish landed there are supplied fresh to city markets. Information on microplastics in the edible tissues of these fish is therefore directly relevant to the food safety of the local population.

Carangids (jacks and trevallies) are widely consumed food fishes throughout the Indo-Pacific region. The tille trevally, *Caranx tille* (Cuvier, 1833), is a reef-associated species distributed across the Indo-West Pacific. Adults usually occur alone or in small groups in coastal waters near coral and rocky reefs at depths of roughly 30–120 m, and the species can reach 80 cm in total length [32]. It is a carnivore that feeds mainly on fish and crustaceans, has an estimated trophic level of about 4.1, and is taken by commercial fishers as well as recreational anglers [32]. These traits make *C. tille* a useful indicator of microplastic exposure in coastal food webs. As a mobile, high-level predator, it can acquire particles directly from the water and indirectly from contaminated prey, and the finding that a related carangid carried the highest microplastic load among the fishes of Port Blair Bay [30] suggests that this family may be particularly exposed. Because its flesh is eaten fresh, any particles present in the muscle would pass directly to consumers. To date, however, no study appears to have quantified microplastics in the muscle of *C. tille*, either in the Andaman Islands or elsewhere.

The present study was undertaken to fill this gap. Its specific objectives were to describe the recovered particles in terms of colour, shape, size, and polymer composition, and to use these characteristics to infer their likely sources. The results are intended to provide baseline information for seafood safety assessment and for long-term microplastic monitoring in the Andaman Islands.

II. Materials and Methods

A. Study Area and Sample Collection

Fish specimens have been collected from the fish landing centre at Junglighat, Sri Vijaya Puram (Port Blair), South Andaman, India. Species were selected based on their consumption demand by the local population. Fish were purchased from fishers at the landing centre immediately after landing on four occasions at six-month intervals: April 2023, October 2023, April 2024 and October 2024. April falls before the south-west monsoon, and October falls at its end, so the sampling covered both the drier and the wetter parts of the year. A total of 56 specimens of *C. tille* were collected. Each fish was wrapped in aluminium foil, packed on ice in an insulated box and taken to the laboratory, where it was stored at −20 °C until analysis. Before dissection, each fish was thawed, and its total length (TL) was measured to the nearest 0.1 cm with a measuring board and its body weight (W) to the nearest 0.01 g with an electronic balance.

B. Prevention of Contamination

Several precautions were taken to keep airborne and procedural contamination to a minimum. Analysts wore cotton laboratory coats and nitrile gloves, and plastic equipment was replaced with glass, stainless steel or aluminium wherever possible. Glassware and dissecting instruments were rinsed three times with filtered distilled water before use, bench surfaces were wiped with 70% ethanol, and beakers and Petri dishes were kept covered with aluminium foil except when samples were being added or removed. Dissection and filtration were carried out in a closed cabinet. Eleven procedural blanks, containing digestion solution but no tissue, were taken through every step alongside the samples. A single blue fibre was found in one blank, and the other ten blanks were clean. This particle was subtracted from the total count before abundance was calculated.

C. Tissue Digestion and Filtration

The outer surface of each fish was rinsed with filtered distilled water to remove adhering particles. The skin was then removed, and a 5 g of dorsal muscle was excised from above the lateral line with a stainless-steel scalpel, taking care to avoid bone and viscera. Each portion was transferred to a clean glass beaker containing 10% (w/v) potassium hydroxide (KOH) solution, at about three times the volume of the tissue, and incubated at 60 °C for 24 h [33] to complete digestion. After digestion, the solutions were vacuum-filtered through 0.7 µm cellulose nitrate filter papers. Each beaker was rinsed three times with filtered distilled water, and the rinsings were passed through the same filter. Filters were placed in covered glass Petri dishes and allowed to dry at room temperature.

D. Microscopic Identification and Characterisation

Each filter was examined under a stereo microscope (Olympus SZ61,Tokyo, Japan). Particles were accepted as microplastics if they showed no cellular or organic structure, had a uniform thickness along their length and were evenly coloured [34]. Every particle was assigned to one of six colour classes (blue, red, black, white, brown and yellow) and to one of three shape classes. Fibres were defined as thin, elongated strands; filaments as longer, thicker line-like strands; and beads as spherical or near-spherical particles. Particle dimensions were measured from digital images using Magcam DC Plus 18 digital microscope camera (Magnus Opto Systems, India)and the particles were grouped into five size classes.

E. Polymer Identification

The chemical composition of the particles was determined by a laser confocal Raman microscope (inVia Reflex, Renishaw Metrological Systems, UK). Spectra were recorded with a 514 nm laser at 0.5% laser power, a 50× objective, an acquisition time of 30 s and one accumulation over 300–2100 cm^{-1}, with a spectral resolution of 1–2 cm^{-1}. Spectra were baseline-corrected and compared with the Open Specy reference library. Each spectrum was compared with a reference polymer library, and a match of 70% or more was accepted as an identification. Particles were classed as polyester (PET), cellulose, acrylic, polyamide (PA), polyethylene (PE), polypropylene (PP) or other materials.

F. Data Analysis

Microplastic abundance was expressed both as items per individual and as items per gram of wet muscle weight (items g^{-1}). The condition of each fish was described by Fulton's condition factor, $K = 100 \times W/TL^3$, where W is in grams and TL in centimetres [35]. The Shapiro–Wilk test indicated that microplastic counts were not normally distributed ($W = 0.848$, $p < 0.001$), so the relationships between microplastic count and TL, W, and K were examined using Spearman's rank correlation. The number of particles that a consumer might ingest was estimated by multiplying the mean abundance per gram by a serving size of 100 g, and annual intake was

estimated by assuming one serving per week. Analyses were carried out in Python 3 with the SciPy library, and results are given as mean ± standard deviation (SD), with significance set at $p < 0.05$.

III. Results

A. Size and Condition of the Fish

The 56 specimens of *C. tille* fell within a narrow size range, with total lengths between 17.5 and 20.3 cm and body weights between 85.73 and 100.90 g (Table I). The mean condition factor was 1.33 ± 0.13, which indicates that the fish were in good condition. All specimens were well below the maximum length of 80 cm reported for the species [32] and were therefore juveniles or young adults.

Table I: Biometric characteristics and microplastic abundance in the dorsal muscle of *C. tille* (n = 56)

Parameter	Mean ± SD	Range
Total length (cm)	19.26 ± 0.77	17.50–20.30
Body weight (g)	94.17 ± 3.37	85.73–100.90
Condition factor, K	1.33 ± 0.13	1.15–1.60
Muscle analysed (g fish^{-1})	5	–
Microplastics, all fish (items individual^{-1})	2.32 ± 1.44	0–4
Microplastics, positive fish only (item individual^{-1})	2.89 ± 0.96	1–4
Microplastics (items g^{-1} wet weight)	0.46 ± 0.29	0–0.80

B. Abundance of Microplastics

Microplastics were present in the muscle of 45 of the 56 fish examined. A total of 131 particles was recovered. After the single blank particle was subtracted, 130 particles were attributed to fish tissue, corresponding to a mean of 2.32 ± 1.44 items individual^{-1} (95% confidence interval 1.94–2.71) and 0.46 ± 0.29 items g^{-1} wet weight. Among the 45 fish that contained microplastics, the mean was 2.89 ± 0.96 items individual^{-1}. The number of particles per fish ranged from 0 to 4. Three particles per fish was the most frequent count (19 fish), followed by four particles (13 fish), while 11 fish contained none (Figure 1).

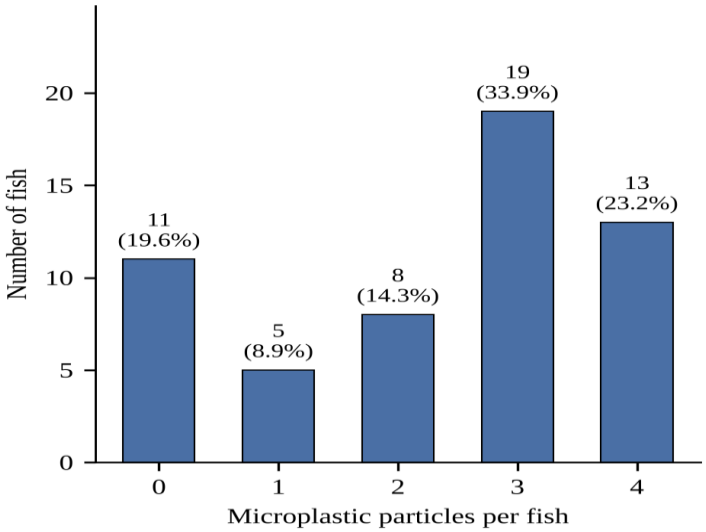

Figure 1: Frequency distribution of microplastic counts in 5 g of dorsal muscle of *C. tille* (n = 56 fish)

Microplastic count showed no significant correlation with total length (Spearman $\rho = 0.06$, $p = 0.68$; Figure 2), body weight ($\rho = -0.08$, $p = 0.56$) or condition factor ($\rho = -0.12$, $p = 0.36$). Within the size range sampled, therefore, larger or heavier fish did not carry more particles than smaller ones.

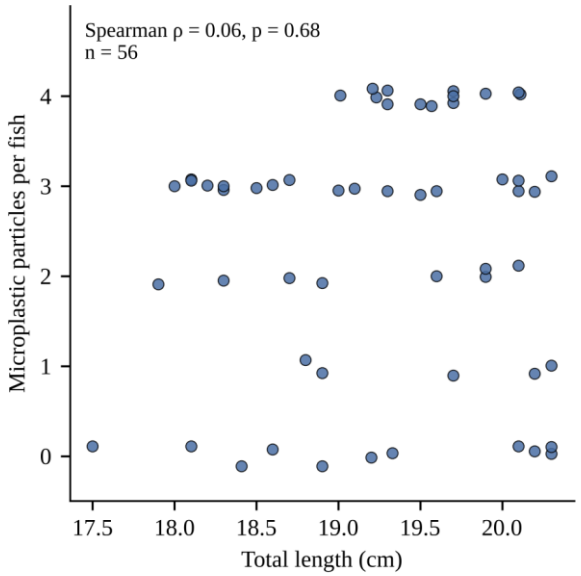

Figure 2: Relationship between total length and microplastic count in *C. tille*; points are jittered vertically to show overlapping values

C. Colour of Microplastics

Six colours were recorded (Figure 3). Blue particles were the most common, accounting for 75 particles (57.7%), and they occurred in 43 of the 56 fish. Red (21.5%) and black (12.3%) particles were next in abundance. White and brown particles each made up 3.8% of the total, and only one yellow particle was found.

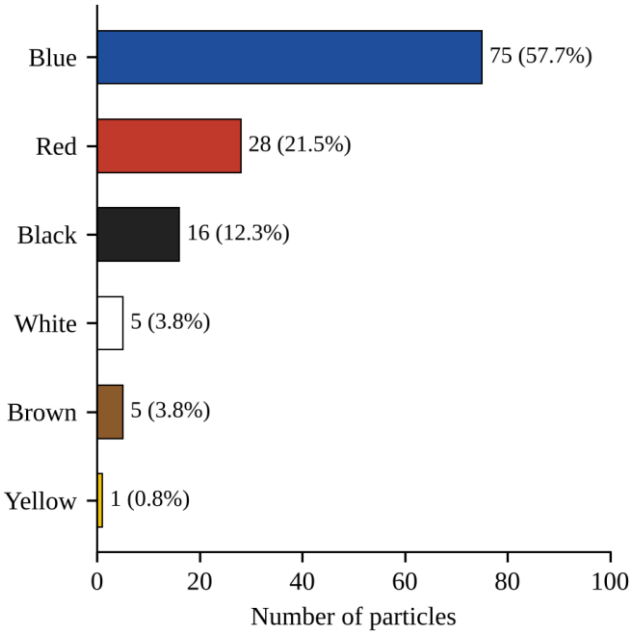

Figure 3: Colour composition of microplastics recovered from the muscle of *C. tille* (n = 130 particles)

D. Shape and Size of Microplastics

Fibres were the most common shape (43.2%), followed closely by filaments (40.6%), while beads made up 16.2% of the particles (Figure 4). Elongated particles (fibres and filaments together) therefore accounted for 83.8% of the total. All particles were very small, with measured dimensions ranging from about 13 to 68 µm (Table II). The largest group was size class II (34.47 × 47.45 µm; 26.7%), followed by class IV (13.02 × 52.82 µm; 23.7%), whereas the largest particles, in class III (66.80 × 67.90 µm), were the least common (11.5%).

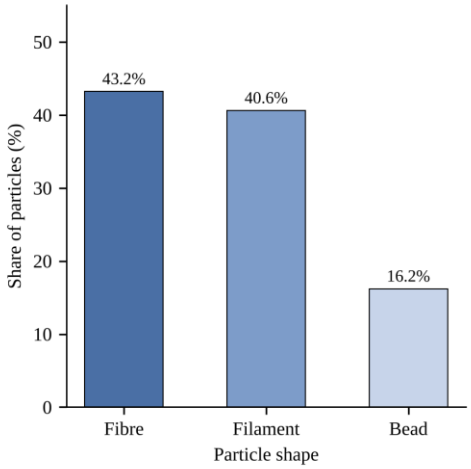

Figure 4: Shape composition of microplastics recovered from the muscle of *C. tille*

Table II: Size classes of microplastics recovered from the muscle of *C. tille*

Size class	Dimensions (µm)	Particles (n)	Share (%)
I	42.36 × 34.23	23	17.6
II	34.47 × 47.45	35	26.7
III	66.80 × 67.90	15	11.5
IV	13.02 × 52.82	31	23.7
V	49.74 × 54.95	27	20.6

E. Polymer Composition

Six polymer types were identified, together with a small group of other materials (Figure 5). Polyester (PET) was dominant, with 52.7%, and cellulose was second (29.0%). Acrylic (4.6%), polyamide (3.8%), polyethylene (2.3%), and polypropylene (1.5%) were minor components, and other materials accounted for 6.1%. Synthetic polymers together accounted for 64.9% of the particles.

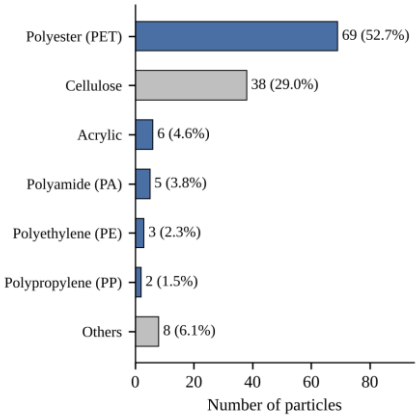

Figure 5: Polymer composition of microplastics recovered from the muscle of *C. tille* (n = 131 particles); grey bars denote non-synthetic or other materials

F. Estimated Dietary Intake

Based on the mean abundance of 0.46 items g^{-1}, a 100 g serving of *C. tille* muscle would contain about 46 microplastic particles (95% confidence interval 39–54 particles). A person eating one such serving each week would ingest roughly 2,400 particles per year from this species alone.

IV. Discussion

A. Transfer of Microplastics to Muscle

The presence of microplastics in muscle indicates that some particles crossed the gut wall and were carried to other tissues. The FAO review cited earlier considered that particles larger than about 150 µm are

unlikely to be absorbed and that only the finest fraction is likely to reach internal organs [15]. All particles recovered here were well below that size, consistent with absorption throughout the gut. However, the mechanism by which particles of this size reach skeletal muscle is still poorly understood. The possibility that particles were introduced during handling was considered. Only one fibre was found in eleven procedural blanks; the skin was removed and the body surface rinsed before muscle was excised, and these steps indicate that laboratory contamination contributed very little to the counts.

No relationship was found between microplastic count and fish length, weight or condition. This differs from the finding of Akhbarizadeh et al. [18], who reported that microplastic loads in muscle increased with body size. In the present study, however, total length varied by only 2.8 cm, which leaves little scope to detect a size effect. Sampling a wider size range of *C. tille*, including larger adults, would be needed to test whether microplastics accumulate in muscle as the fish grow.

B. Characteristics and Probable Sources

The predominance of blue particles agrees with earlier reports from Indian coastal fishes, in which blue fibres were the most common type of ingested microplastic [24]. Blue and other strong colours are widely used in synthetic clothing, ropes and fishing nets. It has also been suggested that visual predators may mistake coloured particles for prey, which could increase the uptake of certain colours. However, this has not yet been tested in this species.

Fibres and filaments together accounted for 83.8% of the particles, with polyester as the leading polymer. This combination points to synthetic textiles as the main source. Washing polyester garments releases large numbers of fibres [9], and these fibres dominate shoreline microplastics near sewage discharges [10]. In Sri Vijaya Puram, domestic wastewater from the densely built-up areas around Junglighat drains into the adjacent coastal waters, which provides a likely pathway. The smaller amounts of polyamide, polyethylene, and polypropylene are typical in fishing nets, ropes, and packaging. They are consistent with the intensive boat and fish-handling activity at the landing centre [31]. Similar polymers have been reported in fishes from the south-east coast of India [24, 25]. Beads (16.2%) may come from personal-care products or industrial abrasives, both of which are primary sources of microplastics [8].

The polymer profile found here differs from that reported earlier for Port Blair Bay, where nylon, acrylic and ionomer Surlyn were among the most abundant polymers [30], and from that of sediments at the city's landing centres, where aramid fibre and synthetic rubbers were prominent [31]. These differences may reflect differences among environmental compartments, sampling periods, and analytical methods. They also suggest that the particles retained in fish muscle are a selective subset of those present in the environment, favouring small fibres.

Cellulose made up 29.0% of the particles. Cellulose-based fibres such as rayon and dyed cotton are semi-synthetic or natural materials rather than plastics. Still, they are shed in large numbers from textiles and are frequently reported together with microplastics in fish [16, 26]. Even if cellulose and other materials are excluded, synthetic polymers alone account for 64.9% of the particles, equivalent to about 0.30 items g^{-1} of muscle. This conservative estimate is still several times higher than most reported values for fish muscle [19, 27].

C. Implications for Consumers

At the abundance measured here, a 100 g serving of *C. tille* muscle would contain about 46 particles, or about 2,400 particles per year for a person eating one serving each week. This is of the same order as estimates for fish consumers in the North East Atlantic and the Persian Gulf [18, 19]. Because the particles were found in the muscle, they cannot be removed by gutting or cleaning the fish before cooking. In island communities, where fish is an everyday food, the actual intake could be considerably higher. The health effects of ingesting microplastics at these levels are still uncertain. Laboratory studies suggest possible inflammation, oxidative stress and transfer of associated chemicals, but data for realistic human exposure are lacking [14, 23].

D. Limitations and Future Work

This study has some limitations. Only muscle tissue was analysed, so microplastic loads in the gut and gills and their relationship to muscle loads are unknown. The fish covered a narrow size range, and the number of fish from each sampling occasion was too small to allow seasonal comparison. Particles smaller than the filter pore size, and any particles altered by alkaline digestion, may have been missed [33]. Future work should compare several tissues, include a wider size range and a larger number of fish per season, analyse water and sediment at the fishing grounds simultaneously, and use micro-FTIR or Raman spectroscopy to detect smaller particles.

V. Conclusion

This study provides, to the best of our knowledge, the first record of microplastics in the edible muscle of the tille trevally, *Caranx tille*, and the first such record for a commercially landed fish at Junglighat, Sri Vijaya Puram. Microplastics were present in 80.4% of the fish examined, at a mean of 2.32 items individual^{-1} and 0.46 items g^{-1} wet weight. The particles were mainly small blue polyester fibres and filaments, all less than about 70 µm in size, which points to urban wastewater carrying textile fibres, together with fishing gear, as the main sources. Microplastic load was not related to fish size or condition within the narrow size range studied.

Because these particles occur in the part of the fish that people eat, they represent a direct route of human exposure, with an estimated 46 particles per 100 g serving. The findings highlight the need to include edible fish tissue in routine microplastic monitoring in the Andaman Islands, to improve the collection and treatment of domestic wastewater in Sri Vijaya Puram, and to promote the proper disposal and recovery of worn fishing gear at landing centres such as Junglighat. Further research should compare tissues, seasons and size classes, and should assess the toxicological significance of dietary microplastics for island seafood consumers.

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