ASSESSMENT OF MICROPLASTICS IN COMMERCIALLY IMPORTANT FISHES COLLECTED FROM THONDI FISH LANDING CENTRE

1. INTRODUCTION

Microplastics are fragments of any type of plastic, less than 5 mm (0.20 in) in length, according to the U.S. National Oceanic and Atmospheric Administration (NOAA) and the European Chemicals Agency. They cause pollution by entering natural ecosystems from a variety of sources, including cosmetics, clothing, food packaging, and industrial processes. The term macroplastics is used to differentiate microplastics from larger plastic waste, such as plastic bottles. Two classifications of microplastics are currently recognized. Primary microplastics include any plastic fragments or particles that are already 5.0 mm in size or less before entering the environment. These include microfibers from clothing, microbeads, and plastic pellets (also known as nurdles). Secondary microplastics arise from the degradation (breakdown) of larger plastic products through natural weathering processes after entering the environment. Such sources of secondary microplastics include water and soda bottles, fishing nets, plastic bags, microwave containers, tea bags and tire wear. Both types are recognized to persist in the environment at high levels, particularly in aquatic and marine ecosystems, where they cause water pollution. 35% of all ocean microplastics come from textiles/clothing, primarily due to the erosion of polyester, acrylic, or nylon-based clothing, often during the washing process. However, microplastics also accumulate in the air and terrestrial ecosystems.

According to NOAA (2013), marine debris is “any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment”. Plastics are the dominant type of marine debris in estuaries (Costa et al. 2011; Smith 2012; Ivar dosul and Costa 2013; Hastuti 2014). Plastic in the marine environment can be fragmented into smaller particles with similar composition when influenced by UV-radiation, abrasion, seawater hydrolysis, and oxidation (Moore 2008).
Reports on the origin of microplastic (MPs) indicate that large plastic debris disintegrate and became smaller (<1mm) MPs via photolytic, mechanical and biological degradation processes in the environment. The proliferation of plastics, particularly of polyethylene bags, polyethylene terephthalate (PET) bottles, and other single use utility materials has resulted to the annual introduction of approximately 300 million tons of plastic products into the environment. The increased incidence of plastics in various compartments of the aquatic environment has been associated with human population increase and plastic pollution. Reports on the origin of microplastic (MPs) indicate that large plastic debris disintegrate and become smaller (<1mm) MPs via photolytic or mechanical degradation, of 1.8 microplastic fragments per fish. These small particles may induce physical and chemical toxicity, including genotoxicity, oxidative, stress, changes in behaviour, reproductive, impairment, mortality, population, growth-rate. The proportion of plastics in the stomach to the intestine showed great variation in different species ranging from 0.5 – 1.9 by items / individual. The ingestion of plastics in fish is closely related to the habitat and gastrointestinal tract structure and it was highly recommended that the entire GIs tract and digestion process be used in future investigation of plastic pollution in fish.

Microplastics in wild fish have potential for causing neurotoxic effects, lipid oxidation damage and human health risks associated with ingestion exposure. Microplastics can cause damage to human cells, at the levels known to be eaten by people via their food. The harm includes cell death and allergic reactions. Plastics are not just heterogeneously distributed on the surface. When plastics enter the marine environment, some sink straight away and others become fouled or entrained in marine snow and subsequently sink. A report was made on microplastics in juvenile European Flounder (*Platichthys flesus*); more specifically, 58% of wild European Flounder had microplastics in their digestive tract, and 75% of caged European Flounder had microplastics in their digestive tract. Microplastics have also been documented in numerous benthic fish species along the Texas Gulf coast. Recently, microplastics were isolated from copepods and Euphausiids (Desforges et al., 2015), which, if ingested by predatory species, could facilitate trophic transfer to organisms higher in the food chain. To understand the implications of microplastics as ubiquitous contaminants in a global context, it must be emphasized to study organisms which are likely to be exposed to microplastics: those whose distributions overlap in time and space with the distribution of microplastic. When such organisms are also of commercial interest, either as direct sources of protein or derivatives e.g.: fish oils (Rochman, Cook, & Koelmans, 2016), they could increase human exposure to microplastics, which is an additional concern. Plastic marine debris poses varied threats to individual organisms as well as entire food webs based on size, chemical composition, and bioavailability (Gall and Thompson 2015). Microplastics, synthetic polymeric particles or fibres 0.0001–5 mm in length are an emerging area of study because they are ingested and respired by hundreds of different marine and aquatic species (Rochman et al. 2016).

Microplastics are ubiquitous in nature and are a concern in aquatic environments, as well as for living resources. In the last decade, studies on microplastic-related environmental problems have started to be the focus of attention (Jabeen et al. 2017; Frias et al. 2018; Hanachi et al. 2019; Herrera et al. 2019; Hossain et al. 2019; Amin et al. 2020; Filgueiras et al. 2020). All of the recent studies conducted around the world aimed at determining
the microplastic pollution in regional or country-based waters and accumulation in living organisms. Kor et al. (2020) reported that the mixing of microplastics from different sources into water environments poses a threat to aquatic organisms, and possibly humans consuming contaminated fish and seafood. Potential effects of MPs on aquatic organisms are due to the physical and chemical effects of these ingested plastics was reported by Barboza et al. (2020). Zakeri et al. (2020) reported that the adverse effects of MPs can be caused by:

1. the particles themselves,
2. added materials during the manufacture of plastic products, and
3. pollutants adsorbed to plastic waste in the environment.

The literature on MPs toxicity has revealed that these materials can cause physical and chemical toxicity in aquatic organisms, including genotoxicity, oxidative stress, behavioral changes, reproductive impairment, mortality, and a decrease in population growth rate reported by Hanachi et al. (2019). Aquatic organisms can be contaminated with micro- and nano-plastics from water or by feeding contaminated foods or other living organisms was observed by Kolandhasamy et al. (2018); Baalkhuyur et al. (2020) and Li et al. (2020). Hanachi et al. (2019) studied the presence of microplastics in commercially important fish species and the potential risk to human health. Currently, more than 660 marine species are known to be affected by plastics was reported by Claessens et al. (2013) and Carbery et al. (2018). Usually, in marine biota, ingested MPs are either expelled with feces or they sometimes remain in the gastrointestinal tract, causing damage or a false feeling of fullness in the fish stomach. In some cases, it is divided into smaller sizes and enters the circulatory system through the intestinal wall, as reported by Wang et al. (2021). In recent years, many studies have focused on microplastic pollution of water bodies and marine life in the marine environment and coastal areas (Van Cauwenberghe et al., 2013). Numerous researchers have studied microplastic pollution in both river (i.e., freshwater) and marine ecosystems (Neves et al., 2015; Bellas et al., 2016; Devriese et al., 2017; Li et al., 2018).

According to recent reports, the total marine capture fisheries reached a maximum of 82.3 million tonnes in 2015, and the global per capita fish consumptions rises above 20 kg a year (FAO, 2016), nonetheless, all these commercial fish species could be vulnerable to plastic pollution. Despite the presence of microplastics in marine species sold for human consumption such as fish and shellfish, uncertainties remain regarding the potential risk for human health from consuming contaminated seafood was reported by Rochman et al., (2015); Dehaut et al., (2016); Allomar et al., (2017) and Hermabessiere et al., (2017). Field studies have reported microplastic ingestion by marine wild caughtfish species (pelagic and benthic fish) with commercial interest from the English Channel (Lusher et al., 2013), the North Sea (Foekema et al., 2013), the eastern Pacific Ocean (Rochman et al., 2015), the North Eastern Atlantic (Neves et al., 2015) and Mediterranean Sea (Bellas et al., 2016; Nadal et al., 2016). Moreover, similar studies reported the ingestion of microplastics for fish with non-commercial interest (Boerger et al., 2010), confirming the perception that fish are widely exposed to microplastic contamination. While a high number of studies have reported microplastic ingestion by marine fish, less is known about levels of contamination and microplastic ingestion in fish from freshwater and estuarine habitats, as reported by Possatto et al., (2011); Vendel et al., (2017), which are important transport routes of microplastics into the marine environment and a potential sink for these pollutants. Moreover, rivers are known to be land-based source of micro plastics for marine environment, and it has also been estimated that 80% of the plastic found in the ocean comes from land-based sources reported by Browne et al., (2011) and Horton et al., (2017).
Estuaries are among the most valuable aquatic ecosystems, providing variety of goods and services such as food, coastal protection, habitat for a wide diversity of species including seabirds, fish and mammals (Costanza et al., 1997). Among the services provided, estuaries are considered important nursery habitats for fish (Costanza et al., 1997; Martinho et al., 2007). Since drainage systems, such as river systems may be an important vectors for transport of land-based plastics into the marine environment, estuaries are exposed to plastic contamination and have been also considered as microplastics hotspots (Browne et al., 2010; Wright et al., 2013). On reaching an estuary, strong hydrodynamic forces (tides, waves, wind) act on microplastic particles influencing their dispersion, suspension and settling pathways and controlling the trajectory and velocity of these particles entering the marine environment. Though freshwater and transitional environments are often closely connected to microplastics origins and acts as the pathway of microplastics transferring to oceans, limited studies have focused on freshwater bodies when compared with marine studies and data regarding the ingestion of microplastics by organisms in transitional aquatic environments is still lacking.

Given the important ecological role of estuaries and implications of microplastics in ecosystems, this study aims at assessing the occurrence of microplastics in commercial fish species from Thondi coast and to characterize and identify the particles polymers in order to evaluate the potential sources of contamination in these environments. There has been number of studies based on “Microplastic Analysis in Fish Guts”. Menon, Rema Devi & Thobias, (1999) studied the occurrence of microplastics in gut contents of endemic barb Sahyadria chalakkudiens is inhabiting river systems of Western Ghats, South India. Anju et al., (2021) studied concerted on its feeding biology from 730 fishes and has revealed consistent occurrence of microplastics in their guts, pointing to serious plastic pollution affecting riverine ecosystem. James et al. (2020) worked on abundance of microplastic off Kochi, South eastern Arabian Sea India. They observed (4.6%) of microplastics in 16 species of fishes. The major microplastics were fragments in white and blue colours and they found polyethylene (PE) and Polypropylene (PP) were the polymer types of microplastics. The National Centre for Coastal Research (NCCR) found microplastics in seven popular fish varieties. The gut of Indian Mackerel, Greater Lizardfish, Hump head Snapper, Barracuda and Golden Snapper were between 1.93 mm and 2.03 mm in the form of fibres.

As per the data shared by the NCCR scientists, most of the microplastics was red in colour. NCCR scientist Prabakar Mishra said, “They found a high presence of small particles of plastics in the surface seawater during their study in the Bay of Bengal from Pullicat lake to Odisha coast.” According to a study by researchers of Central Marine Research Institute published their reports of the presence of microplastic in commercial fish in Kochi. 16 species (653 individuals) comprising pelagic (eight species) and demersal (eight species) indicate occurrence 4.6% microplastics of size 0.27-3.2 mm in Indian oil sardine, gold stripe sardinella, Indian anchovy, Mackerel, Big eye tongue sole (Kumar et al. 2018). Microplastics found in two fish species bought from fish landing sites in Tuticorin. Out of the total 40 fish, 12 fish showed the presence of microplastic particulates in the intestine. They found microfibers and microplastic fragments in the fish intestine. Microplastics were identified as Polyethylene and Polypropylene by Fourier Transform
Infrared Radiation analysis. Devi et al. (2020) studied the ingestion of microplastics by the alien fish *Pirapitinga, Piaractus brachypomus* in Vembanad lake, the largest brackish water lake in the south-west coast of India, and found microplastics separated the 32-gut content of the 123 fishes. There are 69 microplastic particles represent by fibre, foam and fragments were recovered. They analysed ATRFTIR spectral and revealed the presence of polymers, polyethylene, and Nylon.

Sathish et al. (2020) studied the occurrence of microplastics in epipelagic and mesopelagic fishes from Tuticorin, southeast coast of India. They detected higher abundance of MPs in epipelagic fish than in mesopelagic fish and found that the most common PE were blue in colour, fibre shaped and <500 μm in size. James et al. (2021) examined 613 fishes belonging to 12 families. Microplastics were obtained from the gut of 9 out of 25 fishes. Microplastics were more in pelagic than demersal fishes with higher incidences in the family Clupeidae (42%). Among the fishes studied, microplastic ingestion was more in *Selaroides leptolepis* (27.77%), *Sphyraena* sp (14.28%), *Pelates quadrilineatus* (12%), *Caranx* sp. (10.34%), and *Sphyraena barracuda* (10%)

### 2. DESCRIPTION OF STUDY AREA

The Palk Strait is a strait that lies between Tamil Nadu state of India and the Island nation of Sri Lanka. It connects the Bay of Bengal to the northeast with the Gulf of Mannar to the south. The strait is 40 to 85 miles (64 – 137 km) wide. The strait is named after Robert Palk, who was a governor of Madras Presidency (1755 – 1763) during the British Raj period. The Palk Strait is just 35 km of sea water that is found between coast of Sri Lanka and the southeast coast of India. It is studied at its southern end with a chain of low Islands and reef shoals that are collectively called Adam’s Bridge (Rama’s Bridge). The chain extends between Dhanuskodi on Rameshwaram in TamilNadu and Talaimannar in Sri Lanka. The Island of Rameshwaram is linked to the Indian mainland by the Pamban Bridge. Several rivers flow into it, including the Vaigai river of Tami Nadu. The branches of the Grand River Cauvery which drain through the districts of Tanjore, Thiruvarur, Nagapattinam and Ramanathapuram form a large backwater system between Muthupet and Point calimere. The mean annual rainfall varies from 820 to 1650 mm. The monthly average temperature ranges between 24.6°to 29.1°C. Like the English Channel, the Palk strait has been taken up as a challenge by many long distance swimmers. Palk bay is rich in biodiversity having all the important groups of flora and fauna in its environment. Palk bay contains nearly 87 fishing centre within this region. Kachchatheevu is a small island in this area is heavily threatened by Sri Lanka.
Palk Strait has important mangrove forest namely Muthupet located in Thiruvarur district and important pilgrimages like Devipattinam, Thondi and Velanganni. Palk Strait covers five districts like Ramanathapuram, Thiruvarur, Pudukottai, Tanjore and Nagapattinam. In Palk Strait, three rivers and one canal are open to the sea by a narrow mouth. These three rivers are tributaries of river Cauvery such Vettar, Uppanar and Vellar, which run through a large agriculture belt before they enter the sea. The Vettar river flows into the Thiruvarur districts and drains in Nagore located in the northern part of the study area. The river Uppanar and Vedaranyam canals are joined at the Akkaraipatti village before entering the sea and is located in the southern side of Nagapattinam city. Furthermore, some tourism sites, such as Velanganni and Nagore are located in this area.

The study area chosen was Thondi coastal area of Ramanathapuram district, Tamil Nadu, south eastern India. Thondi situated on a distance of only 110kms from Madurai city at an elevation of 10 meters at latitude 9.7438°N and longitude 79.0185°E. The Palk Bay area is known for its rich marine biodiversity and resources such as seagrass, seaweeds, molluscs, echinoderms, crabs, shellfishes etc. The region generally receives rainfall from the north-east and south-west monsoons. The shore water has an average depth of 1-2 m and the seawater is rich in nutrients with moderately high turbidity. The wave action along the Thondi coast is minimal and the sediments are muddy. Since the area serves as a treasure of various economically important marine resources, many socioeconomic and developmental activities such as agriculture, aquaculture, and fishing are performed. Due to these economic activities, the coastal areas receive an abundance of untreated solids and liquid waste and oil spills from the fishing boats were noticed. Fish samples were collected from the Thondi fish market from Jan - March 2023 (Fig. 1 & 2).

3. SCOPE OF THE PRESENT STUDY

This study focuses on the microplastic accumulation in commercial fish species in Thondi fish landing centre. Microplastic pollution is a growing concern in the marine environment. The residence time of plastics and its ability to degrade into smaller particles makes it difficult to eradicate from the environment. Microplastics also pose a threat to human beings by moving up the food chain and ultimately, affecting
mankind. Hence this study will be helpful in assessing the current status of microplastics in commercial fish species in Thondi fish landing centre.
4. MATERIALS AND METHODS  Sample Collection

Fish samples were collected from the Thondi fish market. Fish weight was measured. Twenty-one different commercially important fish from Thondi area were chosen. Length was measured as the tip of longest caudal lobe pinched together, as described by Miller and Lea (1972). Each fish was then dissected and its stomach was carefully extracted and weighed under clean laboratory conditions to investigate a potential effect of fish size on plastic content in the Gastrointestinal tract, Gill and Muscle that could be related to differences in diets or habitat use.
(Fig. 2). The following fish samples were taken for micro plastic analysis:

- **Atule mate** – Those are mainly inshore marine fish. Usually eat crustaceans, bivalves and others small aquatic animal.

- **Siganus canaliculatus** – Those are herbivorous fish. Mainly feeding in algae and sea weeds. An accidental case large fish eats benthic crustaceans, bivalves etc.

- **Hemiramphus far** – H. far is an omnivorous fish. Feeding isopods, shells, algae, plant, animal and many different foods item.

- **Lethrinus lentjan** – Those are also carnivorous fish, they eat like crustaceans, mollusks, small snail, small crab, worm etc.

- **Upeneus tragula** – carnivorous fish. Its feeds on bottom dwelling such as worms, shrimps, crabs, snails, clams, and little fish.

- **Chiloscyllium indicum** – Inshore bottom dwelling shark. Found on sandy and muddy bottoms of coastal waters. Feed on small invertebrates. Reproduction is Oviparous.

- **Leiognathus equulus** – Common name Ponyfish, found in estuarine and coastal waters; so, it’s called inshore fish. Feeding habit – Polychaetas, small crustaceans and small aquatic animal.

- **Exocoetidae sp.** – The Exocoeted are a marine fish, known colloquially as flying fish or flying cod. They live all the ocean particularly tropical and subtropical waters. They mainly feed on Plankton, predators like dolphins, tuna, marlin, birds, squid etc.

**Sample Processing**

The Gastrointestinal, Gill and Muscle were dissected and rinsed with distilled water. Then each part was put in beaker and 10% KOH was added. The samples were digested with 10% KOH for at least 72 hours, as recommended by Karami et al. (2017) to ensure complete digestion. After 72 hours, the digested solution was filtered through Whatman no.1 filter paper (110mm). Then it was placed in a closed petri dish and dried in room temperature for one day (24 hours). After drying, the filter paper was analysed under the Compound microscope. Care was taken to avoid airborne contamination (Fig. 2).

**5. CLASSIFICATION AND DESCRIPTION OF FISHES SPECIES**

1. **STOLEPHORUS INDICUS** (Van Hasselt,1823) (Plate 1: Species 1-8)

   Kingdom : Animalia
   Phylum : Chordata
1. **Stolephorus indicus**

Class: Actinopterygii  
Order: Clupeiformes  
Family: Engraulidae  
Genus: *Stolephorus*  
Species: *S.indicus*  

Description: Maximum length 15.5cm, common length 12.0cm, Dorsal spines (total): 0; Dorsal soft rays (total): 15-17; Anal spines: 0; Anal soft rays: 19-21. Body is slender, elongate, rather round in cross-section, belly rounded. Feeds most likely on zooplankton (carnivorous fish).

2. **Gerres oyena** (Forsskål, 1775)

Kingdom: Animalia  
Phylum: Chordata  
Class: Actinopterygii  
Order: Perciformes  
Family: Gerreidae  
Genus: Gerres  
Species: *G.oyena*  

Description: Maximum length 30.0cm, common length 20.0cm, Dorsal spines (total): 9; Dorsal soft rays (total): 10; Anal spines: 3; Anal soft rays: 7. Body silvery with 6-8 irregular, U-shaped premaxila groove mostly without scales. Feeds on small organisms living on sandy bottoms (carnivorous fish).

3. **Antherinomorus insularum** (Jordan & Evermann, 1903)

Kingdom: Animalia  
Phylum: Chordata  
Class: Actinopterygii  
Order: Atheriniformes  
Family: Atherinidae  
Genus: Antherinomorus  
Species: *A.insularum*  

Description: Maximum length 9.8cm, Dorsal spines (total): 6-8; Dorsal soft rays (total): 10-11; Anal spines: 1; Anal soft rays: 15-18. Slender fish with moderately laterally compressed body. Predorsal scales 20-23. Feeds on plankton, mostly crustaceans and forams (Omnivorous fish). Preyed upon by larger species.

4. **Pseudotricanthus strigilifer** (Cantor, 1849)

Kingdom: Animalia  
Phylum: Chordata  
Class: Actinopterygii  
Order: Tetraodontiformes  
Family: Tricanthidae  
Genus: Pseudotricanthus  
Species: *P.strigilifer*
Description: Maximum length 25.0cm, common length 20.0cm. Second dorsal-fish spine more than 1/2 length of first dorsal-fish spine. Anal-fish base about 2 times in soft dorsal-fish base. Feeds on benthic invertebrates (Cornivorous fish). Sold fresh in markets.

5. **HEMIRAMPHUS FARR** (Forsskal, 1775)

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<td>Class</td>
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<td><em>Hemiramphus</em></td>
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<td>Species</td>
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Description: Maximum length 45.0cm, common length 30.0cm. Dorsal spines (total):0; Dorsal soft rays (total):12-15; Anal spines:0; Anal soft rays: 10-12. Greatly prolonged, beak-like lower jaw; upper jaw short, triangular and without scales. Color bluish dorsally, silvery on sides. Adults feed mainly on seagrasses, to a lesser extent on green algae & diatoms (Herbivorous fish).

6. **PLOTOSUS CANIUS** (Hamilton, 1822)

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<td>Class</td>
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<td>Family</td>
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<td>Species</td>
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Description: Maximum length 111cm, common length 80.0cm. A plain dusky-brown species with a black dorsal fin tip. Shows banded pattern at night. Distinguished from adult *Plotosus lineatus* by its long barbels on the nostrils that can reach pass the eyes. Feeds on crustaceans, mollusks & fishes (Carnivorous fish).

7. **UPENEUS TRAGULA** (Richardson, 1846)

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<td>Species</td>
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Description: Maximum length 25.0cm. Dorsal spines (total):8; Dorsal soft rays (total): 9; Anal spines; 1: Anal soft rays: 6. First dorsal fin with a large blotch around tip; one red, brown or black. Yellow barbels but may be pale brown or orange in fresh fish. Feeds on fish, crab & mollusks (Carnivorous fish).
8. *SARDINELLA AURITA* (Valenciennes, 1847)

Kingdom : Animalia  
Phylum : Chordata  
Class : Actinopterygii  
Order : Clupeiformes  
Family : Clupeidae  
Genus : *Sardinella*  
Species : *S. aurita*

Description: Maximum length 41.0cm, common length 25.0cm. Dorsal spines (total): 0; Dorsal soft rays (total): 17-20; Anal spines: 0; Anal soft rays: 16-18; Vertebrae: 47-49. Diagnosis: Body elongated, usually subcylindrical, but sometimes a little compressed. Feeds on plankton (Herbivorous fish).

9. *SELAROIDES LEPTOTEPIS* (Cuvier, 1833) (Plate 2: Species 9-16)

Kingdom : Animalia  
Phylum : Chordata  
Class : Actinopterygii  
Order : Carangiformes  
Family : Caranginae  
Genus : *Selaroides*  
Species : *S. leptolepis*

Description: Maximum length 22.0cm, common length 15.0cm. Dorsal spines (total): 9; Dorsal soft rays (total): 24-26; Anal spines: 3; Anal soft rays: 21-23. They form large demersal schools over soft bottom habitats at depths shallower than 50m. Feeds on copepods (Carnivorous fish).

10. *TERAPON JARBUA* (Forsskal, 1775)

Kingdom : Animalia  
Phylum : Chordata  
Class : Actinopterygii  
Order : Perciformes  
Family : Terapontidae  
Genus : *Terapon*  
Species : *T. jarbua*

Description: Maximum length 36.0cm, common length 25.0cm. Dorsal spines (total): 11-12; Dorsal soft rays (total): 9-11; Anal spines: 3; Anal soft rays: 7-10. Body is oblong moderately and laterally compressed, greatest body depth 2.5-3.2 in SL. Feeding on fishes, insects, algae & sand dwelling invertebrates (Omnivorous fish).
11. *SCOMBEROIDES IYSAN* (Forsskal, 1775)

**Kingdom**: Animalia  
**Phylum**: Chordata  
**Class**: Actinopterygii  
**Order**: Carangiformes  
**Family**: Carangidae  
**Genus**: Scomberoides  
**Species**: *S. lysan*

*Description*: Maximum length 110cm, common length 60.0cm. Dorsal spines (total): 7-8; Dorsal soft rays (total): 19-21; Anal spines: 3; Anal soft rays: 17-19. Mainly solitary but sometimes form small loose groups. Adults feed on small fishes and crustaceans (Carnivorous fish).

12. *LETHIRINUS LENTJAN* (Lacepède, 1802)

**Kingdom**: Animalia  
**Phylum**: Chordata  
**Class**: Actinopterygii  
**Order**: Perciformes  
**Family**: Lethrinidae  
**Genus**: Lethrinus  
**Species**: *L. lentjan*

*Description*: Maximum length 52.0cm, common length 40.0cm. Dorsal spines (total): 3; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 8. This species body is moderately deep, colour of body greenish or grey. Feeds on primarily on crustaceans & mollusks (Carnivorous fish).

13. *CHILOSCYLLINUM INDICUM* (Gemelin, 1789)

**Kingdom**: Animalia  
**Phylum**: Chordata  
**Class**: Chondrichthyes  
**Order**: Orectolobiformes  
**Family**: Hemiscyllidae  
**Genus**: Chiloscyllium  
**Species**: *C. indicum*

*Description*: Maximum length 65.0cm, common length 40.0cm. Dorsal spines (total): 0; Dorsal soft rays (total): 0; Anal spines: 0; Anal soft rays: 0. Nostrils subterminal on snout; pre-oral snout long, mouth closer to eyes than snout tip. Probably mainly feeds on bottom – dwelling in vertebrates, also small fishes (Carnivorous fish).

14. *PLATYCEPHALUS INDICUS* (Linnaeus, 1758)

**Kingdom**: Animalia  
**Phylum**: Chordata
15. **CHIROCENTRUS DORAB** (Forsskål, 1775)

Kingdom : Animalia  
Phylum    : Chordata  
Class     : Actinopterygii  
Order     : Clupeiformes  
Family    : Chirocentridae  
Genus     : Chirocentrus  
Species   : C. dorab  

Description: Maximum length 100.0cm, common length 60.0cm. Dorsal spines (total): 0; Dorsal soft rays (total): 16-19; Anal spines: 0; Anal soft rays: 29-36. The slightly shorter pectoral fin, 11-13% of standard length. It feeds mainly on small fish & crustaceans (Cornivorous fish).

16. **SARDINELLA GIBBOSA** (Bleeker, 1849)

Kingdom : Animalia  
Phylum    : Chordata  
Class     : Actinopterygii  
Order     : Clupeiformes  
Family    : Clupeidae  
Genus     : Sardinella  
Species   : S. gibbosa  

Description: Maximum length 29.6cm, common length 15.0cm. Dorsal spines (total): 0; Dorsal soft rays (total): 13-21; Anal spines: 0; Anal soft rays: 12-23. Total number scutes 32-34. A golden mid lateral line down flank, dark spot at dorsal fin origin. Feeds on phytoplankton and zooplankton (Omnivorous fish).

17. **LEIOGNATHUS DUSSUMIERI** (Valenciennes, 1835) (Plate 3: Species 17-21)

Kingdom : Animalia  
Phylum    : Chordata  
Class     : Actinopterygii  
Order     : Perciformes  
Family    : Leiognathidae  
Genus     : Leiognathus  
Species   : L. dussumieri
Description: Maximum length 140cm, common length 110cm. Found in coral sand bottoms of coastal waters, but also enters estuaries. Feeds on small crustaceans, polychaetes, bivalves, & gastropods (Carnivorous fish).

18. *SPHYRAENA OBTUSATA* (Cuvier, 1829)

<table>
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<tr>
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<tbody>
<tr>
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<tr>
<td>Species</td>
<td><em>S. obtusata</em></td>
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</table>

Description: Maximum length 55.0cm, common length 30.0cm. Dorsal spines (total): 6; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 9. Body elongate and subcylindrical with small cycloid scales; head long and pointed, mouth is long and horizontal. Feeds mainly on fishes (carnivorous fish).

19. *LETHRINUS ORNATUS* (Forsskal, 1755)

<table>
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<td>Species</td>
<td><em>L. ornatus</em></td>
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</table>

Description: Maximum length 60.0cm, common length 30.0cm. Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 8. The body is light or olive to brown, becoming lighter below. The centers of the scales are often lighter than the background color. Feeds on mollusks & crustaceans (Carnivorous).

20. *RASTRELLIGER KANAGURTA* (Cuvier, 1816)

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<thead>
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<tbody>
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<td>Genus</td>
<td><em>Rastrelliger</em></td>
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<tr>
<td>Species</td>
<td><em>R. kanagurta</em></td>
</tr>
</tbody>
</table>

Description: Maximum length 36.0cm, common length 25.0cm. Dorsal spines (total): 8-11; Dorsal soft rays (total): 12; Anal spines: 0; Anal soft rays: 13. Head longer than body depth. A black spot on body near lower margin of pectoral fin. Feeds on phytoplankton & zooplankton (Omnivorous fish).

21. *SUCTOPHAGUS ARGUS* (Linnaeus, 1766)
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Perciformes
Family : Scatophagidae
Genus : Scatophagus
Species : S. argus

Maximum length 38.0cm, common length 20.0cm. Dorsal spines (total): 10-11; Dorsal soft rays (total): 16-18; Anal spines: 4; Anal soft rays:13. Ground color is greenish. Juveniles with few large roundish blotches, about size of eye, dark, vertical bars. Feed on worms, crustaceans, insects and plant (Omnivorous fish).

6. RESULT AND DISCUSSION:

In the present observation the microplastic analysis were made in the commercially important fishes namely Stolephorus indicus, Gerres oyena, Atherinomorus insularum, Pesudotriacanthus strigilifer, Hemiramphus far, Plotosus canius, Upeneus tragula, Sardinella aurita, Selaroides leptotepis, Terapon jarbua, Scomberoides lysan, Lethrinus lentjan, Chiloscyllium indicum, Platyccephalus indicus, Chirocentrus dorab, Sardinella gibbosa, Leiognathus dussumieri, Sphyraena obtusata, Lethrinus ornatus, Rastrelliger kanagurta, Scatophagus argus. In all the twenty one species the micro plastics were recorded and observed in the gastrointestinal, gill and muscle. Totally 191 microplastics were observed in 21 species. The maximum number of microplastic were recorded in Pesudotriacanthus strigilifer (19), with the length of 20.5 cm and the weight of 72.5 gm and the minimum number of microplastic were observed in Sardinella aurita (4) with the length of 10.5 cm and the weight of 10gm. Whereas the microplastic were observed and recorded in the following order Pesudotriacanthus strigilifer (19), Stolephorus indicus (14), Sphyraena obtusata (11), Lethrinus ornatus (11), Atherinomorus insularum (11), Rastrelliger kanagurta (11), Scatophagus argus (10), Leiognathus dussumieri (10), Gerres oyena (10), Hemiramphus far (10), Lethrinus lentjan (9), Terapon jarbua (9), Sardinella gibbosa (9), Scomberoides lysan (8), Plotosus canius (8), Upeneus tragula (6), Selaroides leptotepis (6), Chirocentrus dorab (6), Platyccephalus indicus (5), Chiloscyllium indicum (4) and Sardinella aurita (4) (Fig. 3). The percentage contribution of microplastic in the 21 species were estimated as Pesudotriacanthus strigilifer (6%), Stolephorus indicus (4.6%), Sphyraena obtusata (3.6%), Lethrinus ornatus (3.6%), Atherinomorus insularum (3.6%), Rastrelliger kanagurta (3.6%), Scatophagus argus (3.3%), Leiognathus dussumieri (3.3%), Gerres oyena (3.3%), Hemiramphus far (3.3%), Lethrinus lentjan (3.0%), Terapon jarbua (3.0%), Sardinella gibbosa (3.0%), Scomberoides lysan (2.6%), Plotosus canius (2.6%), Upeneus tragula (2.6%), Selaroides leptotepis (2.6%), Chirocentrus dorab (2.0%), Platyccephalus indicus (1.6%), Chiloscyllium indicum (1.3%) and Sardinella aurita (1.3%) (Fig. 4).

In the present study two different structure of micoplastic like granules and fibers were identified (Plate 4-7). The maximum and minimum number of granules type microplastic were identified and observed in Atherinomorus insularum (16), Lethrinus ornatus (11), Rastrelliger kanagurta (11), Leiognathus dussumieri (10), Scatophagus argus (10), Hemiramphus far (10), Pesudotriacanthus strigilifer (9), Terapon
jarbua (9), Lethrinus lentjan (9), Sardinella gibbosa (9), Scomberoides lysan (8), Sphyraena obtusata (8), Stolephorus indicus (6), Selaroides leptolepis (6), Platypcephalus indicus (5), Chirocentrus dorab (5), Chiloscyllium indicum (4), Gerres oyena (3), Plotosus canius (3), Upeneus tragula (1), Sardinella aurita (1) (Fig. 5) and the fibers type of microplastics were observed only in 9 species namely Pseudotriacanthus strigilifer (10), Plotosus canius (5), Upeneus tragula (4), Stolephorus indicus (2), Sardinella aurita (2), Antherinomorous insularum (1), Chirocentrus dorab (1), Sphyraena obtusata (1), Lethrinus ornatus (1) (Fig. 6). Among the two types of micro plastic, the granules type of microplastic were observed to have the maximum number (155) followed by fiber type (36), in stomach, gill and muscles content of the 21 species of fishes.

Microplastic Observation has been made in the gastrointestinal, gill and muscle of 21 samples of commercial fishes. Totally 191 microplastic were observed in 21 species and the gastrointestinal content showed the 90 number of microplastic, gill and muscle showed the 50 and 51 number of micro plastic (Fig. 7). In gastrointestinal the maximum number of microplastic were observed in Pesudotriacanthus strigilifer (11) and minimum number was observed in Sardinella aurita (2) and Selaroides leptolepis (2) (Fig. 8) whereas in gill and muscle, the maximum number of microplastic were observed in Pseudotriacanthus strigilifer (6) and Gerres oyena (6) and minimum number of microplastic was observed in gill of Gerres oyena (1), Hemiramphus far (1), Platypcephalus indicus (1), Upeneus tragula (1), Scomberoides lysan (1), Chiloscyllium indicum (1) and Platypcephalus indicus (1) (Fig. 9 & 10). In the present study, two different structure of micoplastic like fibers and granules were identified.

Microplastic particles, are too small, can be misidentified by fish or accidentally ingested as prey, and also fish can ingest other contaminated organisms (Zakeri et al. 2020). Amin et al. (2020) reported that the human activities play an important role in the microplastic distribution in marine environments. As plastic debris can be carried to the marine environment via rivers, transitional systems such as estuaries play a key role in the transportation of these particles from the land to the sea; and due to the dynamic nature of these ecosystems, microplastics can potentially remain in these habitats for extended periods of time and be ingested by several species was reported by Ivar do Sul and Costa, (2014) and Vermeiren et al., (2016). Ingestion of microplastics by marine fish species is now considered a widespread phenomenon with some authors supporting the hypotheses that plastic particles could be mistaken for prey and incidentally ingested (as they might have similar shapes and forms as preys) or even directly ingested from prey items already containing micro plastics (Lusher et al., 2013; Lusher et al., 2015; Ory et al., 2017). Barboza et al. (2020) stated that the MPs can be divided into smaller particles by internalizing microplastics in the fish digestive system. Li et al. (2020) stated that the presence of microplastic in fish may differ according to the nutritional status of the fish. The abundance of MPs in waters allows fish to easily take these particles and store them in their tissues. Recent researches had been showed that most of fish species are susceptible to MPs ingestion. After ingestion by fish, these pollutants can accumulate in the fish gastrointestinal tracts and transport to other fish organs (Wang et al. 2020). The MPs abundance in fish gastrointestinal tract is closely related to the habitat of the fish (Zhang et al. 2020a,b). Wang et al. (2020) reported that the fish MPs ingestion mostly comes from the gastrointestinal analysis. In the present study the percentage
contribution of microplastic in the 21 species showed this similar and related study has been made in the commercially targeted marine fish species in the English Channel (36.5%), reported by Lusher et al. (2013), for pelagic and demersal species from the Mediterranean coast of Turkey (34%), Güven et al., (2017) or from the Adriatic Sea (28%), Avio et al., (2015). In Portuguese waters it was reported 19.8% of individuals ingesting microplastics (Neves et al., 2015).

In the present study two different structure of microplastic like fibers and granules, were identified. Among the two types of microplastic, the granules type of microplastic were observed in maximum number (155) followed by fiber type (36), in stomach, gill and muscles content of the 21 species of fishes. The high fiber percentage in our study suggests that the high abundance of microplastic here is due to the surrounding wastewater (Li et al. 2020). Fibers were the dominant category of microplastics ingested by fish from the Mondego estuary, with 96% of the total occurrence. Growing evidence confirms that microfibers from synthetic origin comprise an overwhelming fraction (> 80%) of microplastics found in the marine environment and ingested by biota (UNEP, 2016). Most of the fish studies from marine, estuarine and freshwater environments reported high variability in the frequency of ingested fibers by these species. In addition, Dris et al. (2017) reported that the atmospheric fiber shedding is also an important mode for the spreading of microfiber pollution to the environment and should be taken into account when considering fibers contamination in aquatic habitats. In terms of MPs shapes; the results found in the present study are similar to previous investigations (Amin et al. 2020). In the tissues, the fibers are dominant than other shapes (fragments, pellets), because they are one-dimensional materials and break into smaller pieces easily (Wang et al. 2021).

Despite the overall efforts to assess the levels of microplastic contamination in fish from aquatic environments, the major challenge in comparing field studies is the variety of approaches used to isolate and characterize the recovered plastic particles. The inspection of the anthropogenic debris is also variable regarding the target organ and some authors only analysed the stomach content (e.g. Boerger et al., 2010), while others analysed the stomach and intestines of fish separately (Güven et al., 2017) or the whole gastrointestinal tract of fish (Jabeen et al., 2017), which may underestimate the real number of particles ingested by individuals and preclude the clear assessment of the levels of contamination. Jabeen et al. (2017) reported that the analysis of the complete GIT should be undertaken, when possible, since the exclusion of the intestines is likely to result in conservative estimates of plastic ingestion. In the present study, the whole GIT of fish was analysed following similar recent studies (Nadal et al., 2016; Rummel et al., 2016; Jabeen et al., 2017). Since the visual inspection of the gut content could be also insufficient to extract all plastic particles, some studies have recently improved the analytical methods to increase the efficiency of extraction by using chemicals (e.g., KOH, H2O2, HClO4) and enzymes (protease, lipase) to dissolve the biomass and sort the plastics (Foekema et al., 2013; Avio et al., 2015; Bellas et al., 2016; Rochman et al., 2015), but some of these chemicals can be destructive also for some plastic polymers. According to recent reports comparing extraction efficiencies solutions (Dehaut et al., 2016; Kühn et al., 2017) the digestion solution with KOH (10%) seems to produce the least plastic damage and these authors recommended the use of this solution to
general quantitative studies of plastic ingestion by fish and other macro invertebrates. Overall, our findings confirm the presence of plastic particles in all 21 commercially important fish species investigated from the Thondi fish market. Our results highlight differences in the frequency and abundance of plastic items present in the stomach, gill and muscle contents of carnivorous and herbivorous species with open-ocean pelagic species having ingested significantly more plastics.
Stolephorus indicus

Atherinomorus insularum

Gerres oyena

Pseudotriacanthus strigilifer
Hemiramphus far\nPlotosus canius\nUpeneus tragula\nSardinella aurita
<table>
<thead>
<tr>
<th>Image 1</th>
<th>Image 2</th>
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<td><img src="image1.png" alt="Fish 1" /></td>
<td><img src="image2.png" alt="Fish 2" /></td>
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<tr>
<td><strong>Scomberoides lysan</strong></td>
<td><strong>Lethrinus lentjan</strong></td>
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<tr>
<td>Image 3</td>
<td>Image 4</td>
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<tr>
<td><img src="image3.png" alt="Fish 3" /></td>
<td><img src="image4.png" alt="Fish 4" /></td>
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<tr>
<td><strong>Platycephalus indicus</strong></td>
<td><strong>Chiloscyllium indicum</strong></td>
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</table>
Chirocentrus dorab
Sardinella gibbosa
Leiognathus dussumieri
Sphyraena obtusata
Lethrinus ornatus
Rastrelliger kanagurta
Scatophagus argus
Total microplastic particles in commercial fish species

Fig. 3. Variations of microplastics in fish species
Fig. 4. Percentage composition of microplastic in fish species

Percentage composition of microplastic in fish species

- Pseudotriacanthus strigilifer
- Stolephorus indicus
- Sphyraena obtusata
- Lethrinus ornatus
- Antherinomorus insularum
- Rastrelliger kanagurta
- Scatophagus argus
- Leiognathus dussumieri
- Gerres oyena
- Hemiramphus far
- Lethrinus lentjan
- Terapon jarbua
- Sardinella gibbosa
- Scomberoides lysan
- Plioseus canius
- Upeneus tragula
- Selaroides leptotepis
- Chirocentrus dorab
- Platyccephalus indicus
- Chiloscyllium indicum
- Sardinella aurita
Fig. 5. Variations of granule type microplastics in fish species
Fig. 6. Variations of Fiber type microplastics in fish species

Variations of fiber type microplastic in fish species

![Graph showing the variations of fiber type microplastics in different fish species.](image)

- **Fish Species**:
  - Pseudoeucanthus striigular
  - Scolopsis indicus
  - Plotosus canis
  - Uropsetta frigida
  - Gobius ovata
  - Sardineus aurita
  - Atherinomorus lacunosus
  - Chirocentrus dorab
  - Sphyraena ohiata
  - Leiognathus longipinnis
  - Scorpaenidae (generic)
  - Torquigenera
  - Seriola spp.
  - Leiognathus typhle
  - Lutjanus kasmira
  - Lutjanus gibbus
  - Sartodon dussumieri
  - Rhinopomatus excelsus
  - Scaridae (generic)

Fig. 7. Variations of total microplastic in different organs of fish species
Fig. 8. Variation of microplastics in gastrointestinal tract

Variations of microplastic in different organs

<table>
<thead>
<tr>
<th>Organs</th>
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<tbody>
<tr>
<td>Gastrointestinal tract</td>
<td>90</td>
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<tr>
<td>Gill</td>
<td>50</td>
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<td>Muscle</td>
<td>51</td>
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Variations of microplastic in Gastrointestinal tract

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<td>Gastrointestinal tract</td>
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<tr>
<td>Gill</td>
<td></td>
</tr>
<tr>
<td>Muscle</td>
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</table>
Fig. 9. Variations of microplastics in Gill

Variations of microplastic in Gill

Fish Species

Number of microplastic

0 1 2 3 4 5 6 7

Pseudosciaena crocea
Lepomis cyanellus
Scatophagus argus
Atherinomorus lacunosus
Lethrinus chalcalbus
Sphyraena dengue
Stegastes fasciatus
Pinnosus caeruleus
Sardina pilchardus
Solea solea
Lepidopus japonicus
Chirocentrus dorab
Garricka olivacea
Scomberoides hybida
Beryx splendens
Chilomycterus bleeki
Chilomycterus indicus
Beryx splendens

Fig. 9. Variations of microplastics in Gill
Fig. 10. Variations of microplastics in Muscle

Variations of microplastic in Muscle

<table>
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<td>Rastrelliger kanagurta</td>
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<td>Plectorhombus meleagris</td>
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<td>Tropec jurea</td>
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<td>Tetraocheilus nigricinctus</td>
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<td>Lethrinus cephalus</td>
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<td>Clupeonella harengus</td>
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Plate 4. Fiber type microplastics

Plate 5. Granule type microplastic
Plate 6. Granule type microplastic
Plate 7. Granule type microplastic
7. REFERENCES


