IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

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

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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 do sul 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; Herreraet 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 660marine 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 percapita 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

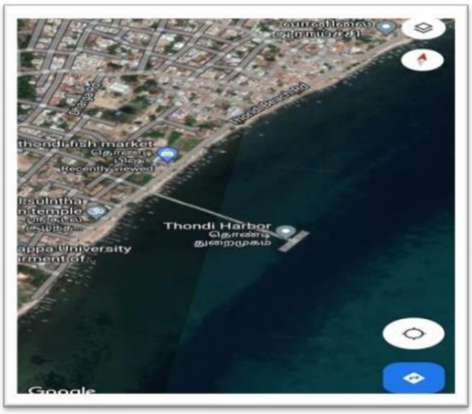
Infrared Radiation analysis. Devi et al. (2020) studied the ingestion of microplastics by the alien fish *Pirapitinga, Piaractus brachypomus* in Vembanad lake, the largest brackish water lake in the south-west coast of India, and found microplastics separated the 32-gut content of the 123 fishes. There 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 Srilanka 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 Srilanka. 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 rainfallvaries 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 Srilanka.

Fig 1. Thondi Centre



Map showing Fish Landing

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 islocated in the southern side of Nagapattinam city.

Furthermore, some tourism sites, such as Velanganni and Nagore are located in this area.

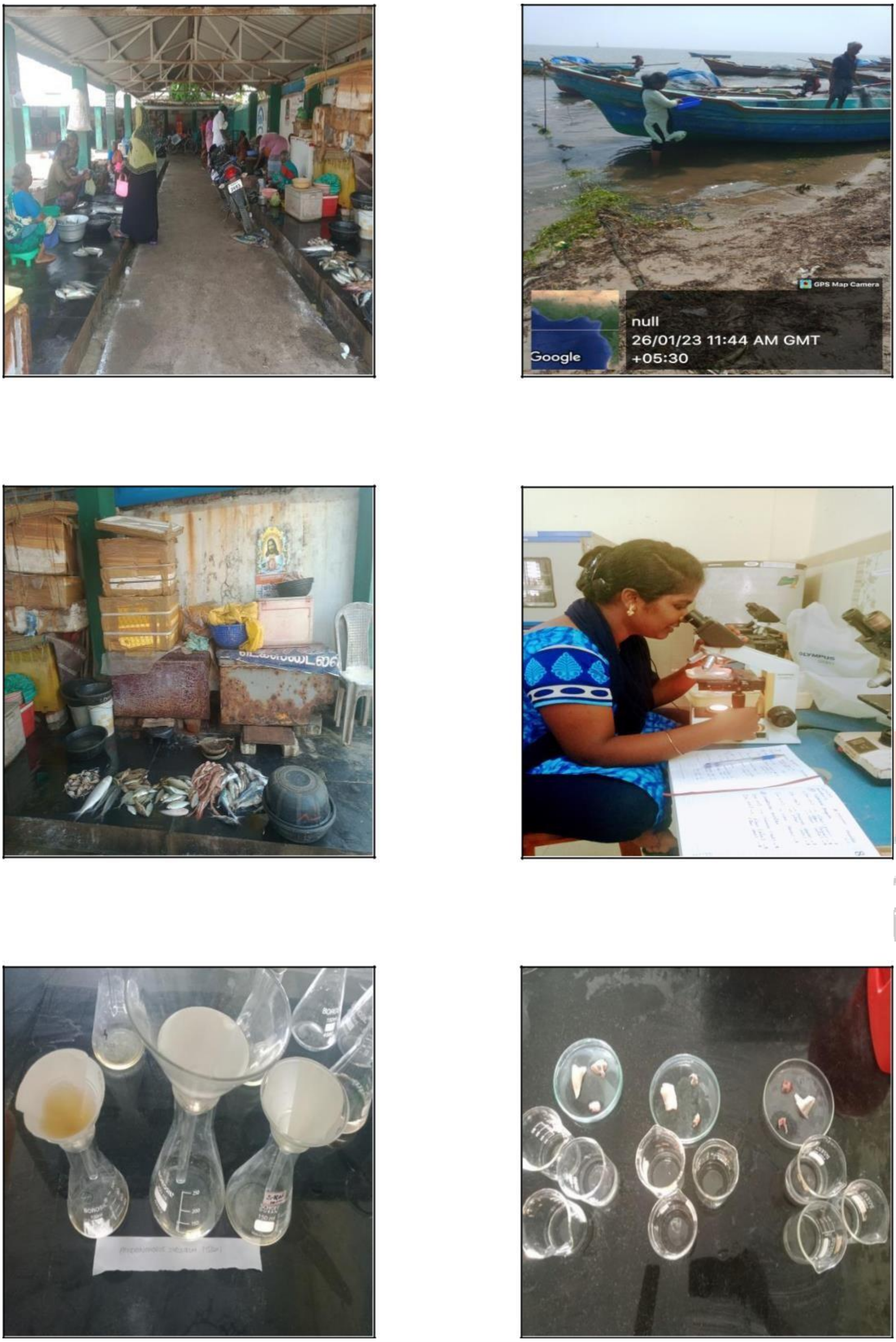
The study area chosen was Thondi coastal area of Ramnathapuram district, Tamil Nadu, south eastern India. Thondi situated on a distance of only 110kms from Madurai city at an elevation of 10 meters at latitude 9.7438°N and longitude 79.0185°E. The Palk Bay area is known for its rich marine biodiversity 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.

Fig. 2. Photos shows the 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 Exocoetid 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, th

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

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 (Forsskal, 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. *ANTHERINOMOROUS ISULARUM (*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 -fin spine more than 1\2 length of first dorsal – fin spine. Anal-fin base about 2 times in soft dorsal-fin base. Feeds on benthic invertebrates (Cornivorous fish). Sold fresh in markets.

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

Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Beloniformes
Family : Hemiramphidae
Genus : *Hemiramphus*
Species : *H. far*

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*)*

Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Siluriformes
Family : Plotosidae
Genus : *Plotosus*
Species : *P.canius*

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)

Kingdom : Animalia
Phylum : Chordata

Class : Actinopterygii
Order : Perciformes
Family : Mullidae

Genus : *Upeneus*
Species : *U. tragula*

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(Cornivorous fish).

10. *TERAPON JARBUA* (Forsskål, 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. Fedding on fishes, insects, algae & sand dwelling invertebrates (Omnivorous fish).

11. *SCOMBEROIDES IYSAN (*Forsskál, 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 (Cornivorous 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 (Cornivorous fish).

14. *PLATYCEPHALUS INDICUS* (Linnaeus, 1758)

Kingdom : Animalia
Phylum : Chordata

Class : Actinopterygii
Order : Scorpaeniformes
Family : Platycephalidae
Genus : *Platycephalus*
Species : *P. indicus*

Description: Maximum length 100.0cm, common length 60.0cm. Dorsal spines (total): 9-10; Dorsal soft rays(total): 13; Anal spines: 0; Anal soft rays:13. Brownish or grays above, whitish below; caudal fin 2-3 horizontal black stripes. Feeds on shrimp, crabs & cuttle fish (Cornivorous fish).

15. *CHIROCENTRUS DORAB (* Forssḱal, 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 11.ocm. 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)

Kingdom	: Animalia
Phylum	: Chordata
Class	: Actinopterygii
Order	: Istiophoriformes
Family	: Sphyraenidae
Genus	: *Sphyraena*
Species	: *S. obtusata*

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)

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

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)

Kingdom	: Animalia
Phylum	: Chordata
Class	: Actinopterygii
Order	: Scombriformes
Family	: Scombridae
Genus	: *Rastrelliger*
Species	: *R. kanagurta*

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 then body depth. A black spot on body near lower margin of pectoral fin. Feeds on phytoplankton & zooplankton (Omnivorous fish).

21. *SCTOPHAGUS 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, Platycephalus 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 in other species, 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), Platycephalus 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%), Platycephalus 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 *Antherinomorous insularum (16), Lethrinus ornatus (11), Rastrelliger kanagurta (11), Leiognathus dussumieri (10), Scatophagus argus (10), Hemiramphus far (10), Pseudotriacanthus strigilifer (9), Terapon* *jarbua (9), Lethrinus lentjan (9), Sardinella gibbosa (9), Scomberoides lysan (8), Sphyraena obtusata (8), Stolephorus indicus (6), Selaroides leptolepis (6), Platycephalus 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 *Pesudotriacanthus strigilifer* (6) and *Gerres oyena* (6) and minimum number of microplastic was observed in gill of *Gerres oyena* (1), *Hemiramphus far* (1), *Platycephalus indicus* (1), *Upeneus tragula* (1), *Scomberoides lysan* (1), *Chiloscyllinum indicum* (1) and *Platycephalus 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 micro plastics (Neves et al., 2015).

In the present study two different structure of micoplastic like fibers and granules, were identified. Among the two types of micro plastic, 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

Upeneus tragula

Sardinella aurita

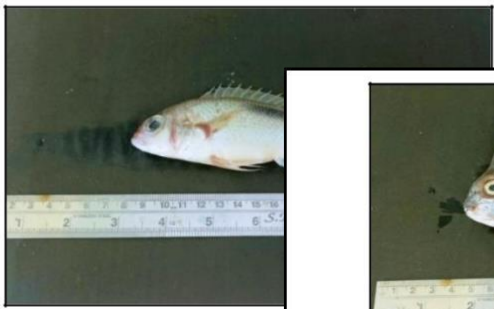
Scomberoides lysan

Lethrinus lentjan

Platycephalus indicus

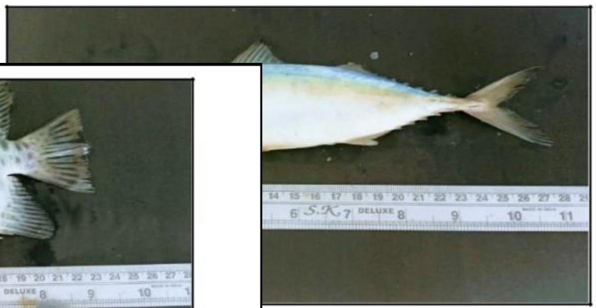
Chiloscyllium indicum

	
Leiognathus dussumieri	*Sphyraena obtusata*



Lethrinus or

Scatophagus argus



iger kanagurta

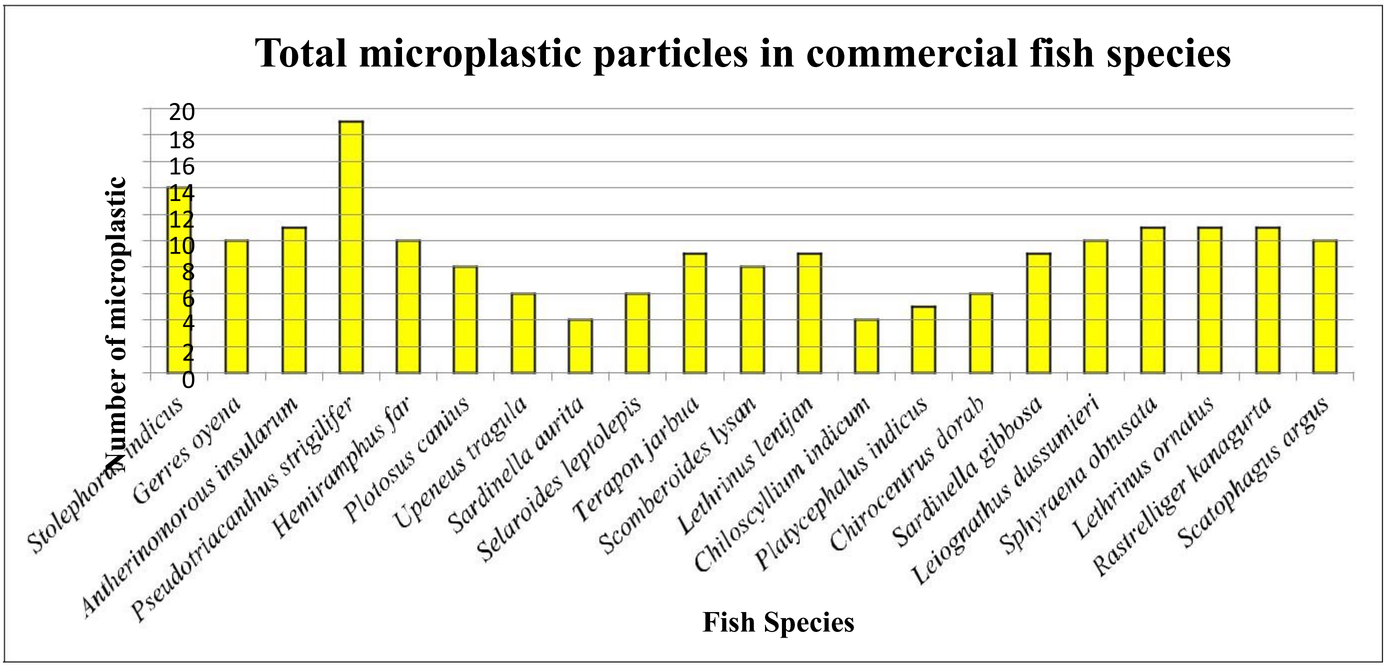
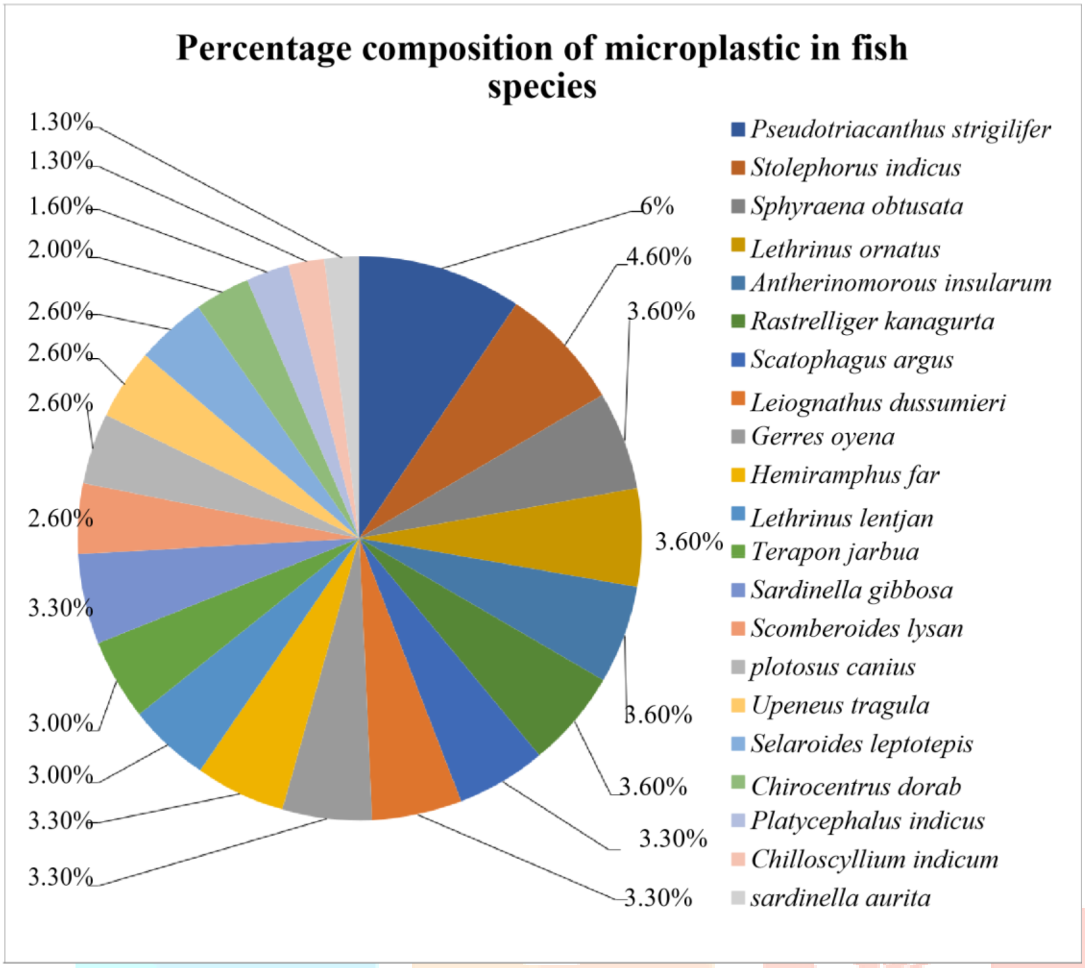


Fig. 3. Variations of microplastics in fish species

Fig. 4. Percentage composition of microplastic in fish species



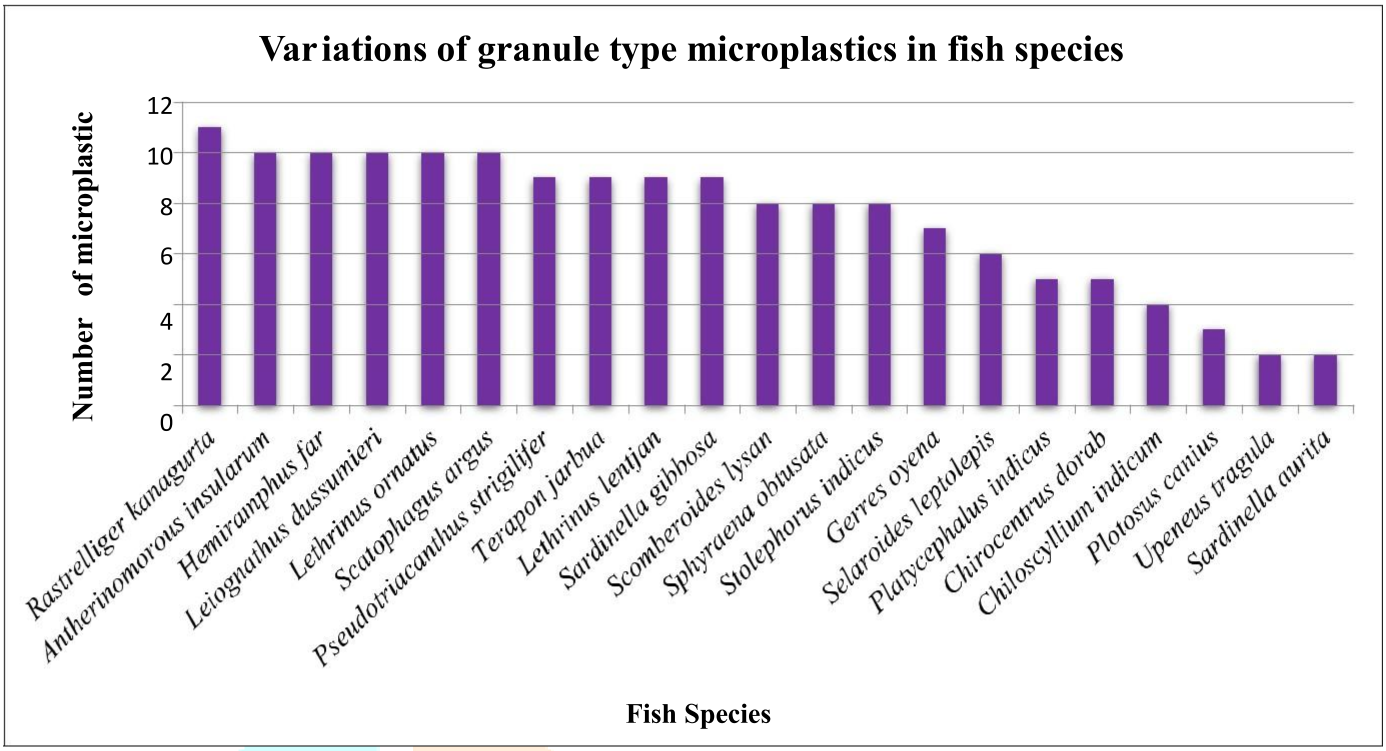


Fig. 5. Variations of granule type microplastics in fish species

Fig. 6. Variations of Fiber type microplastics in fish species

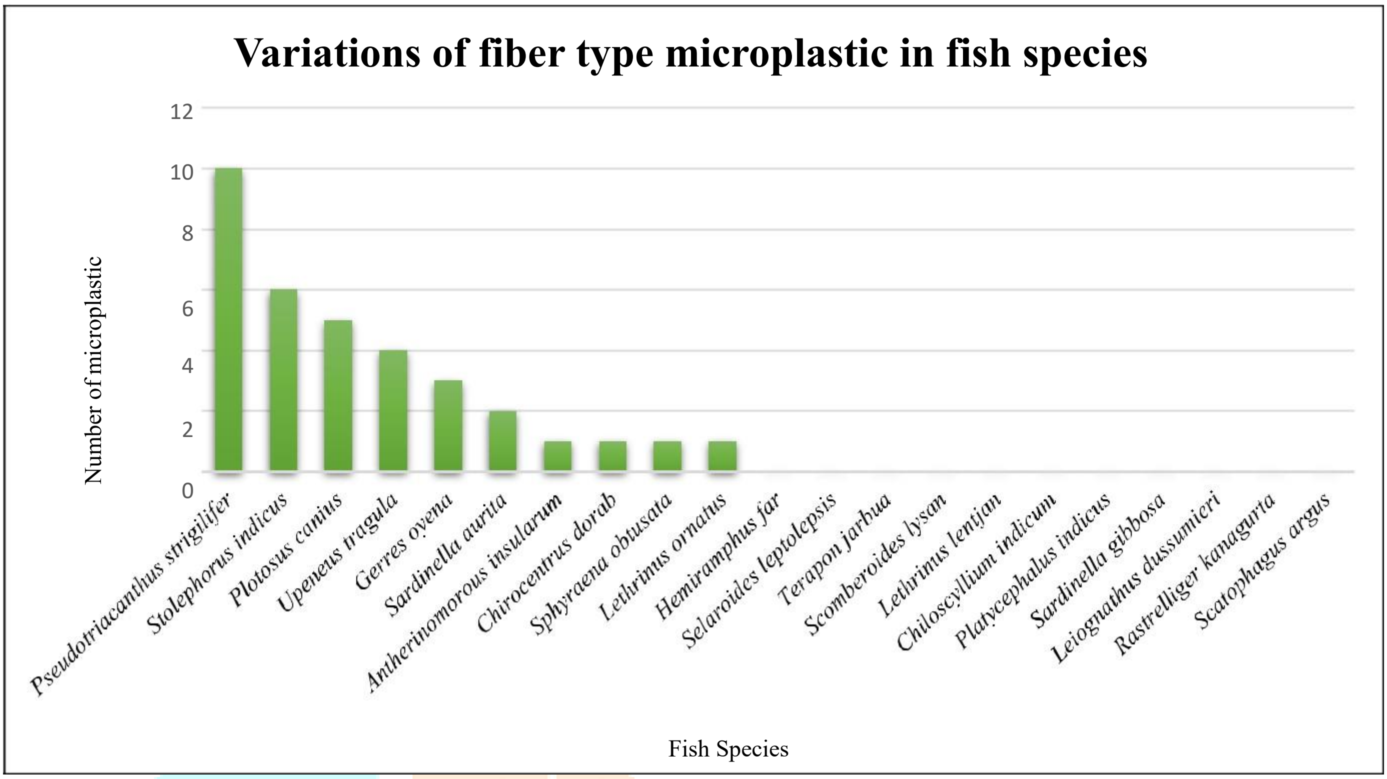


Fig. 7. Variations of total microplastic in different organs of fish species

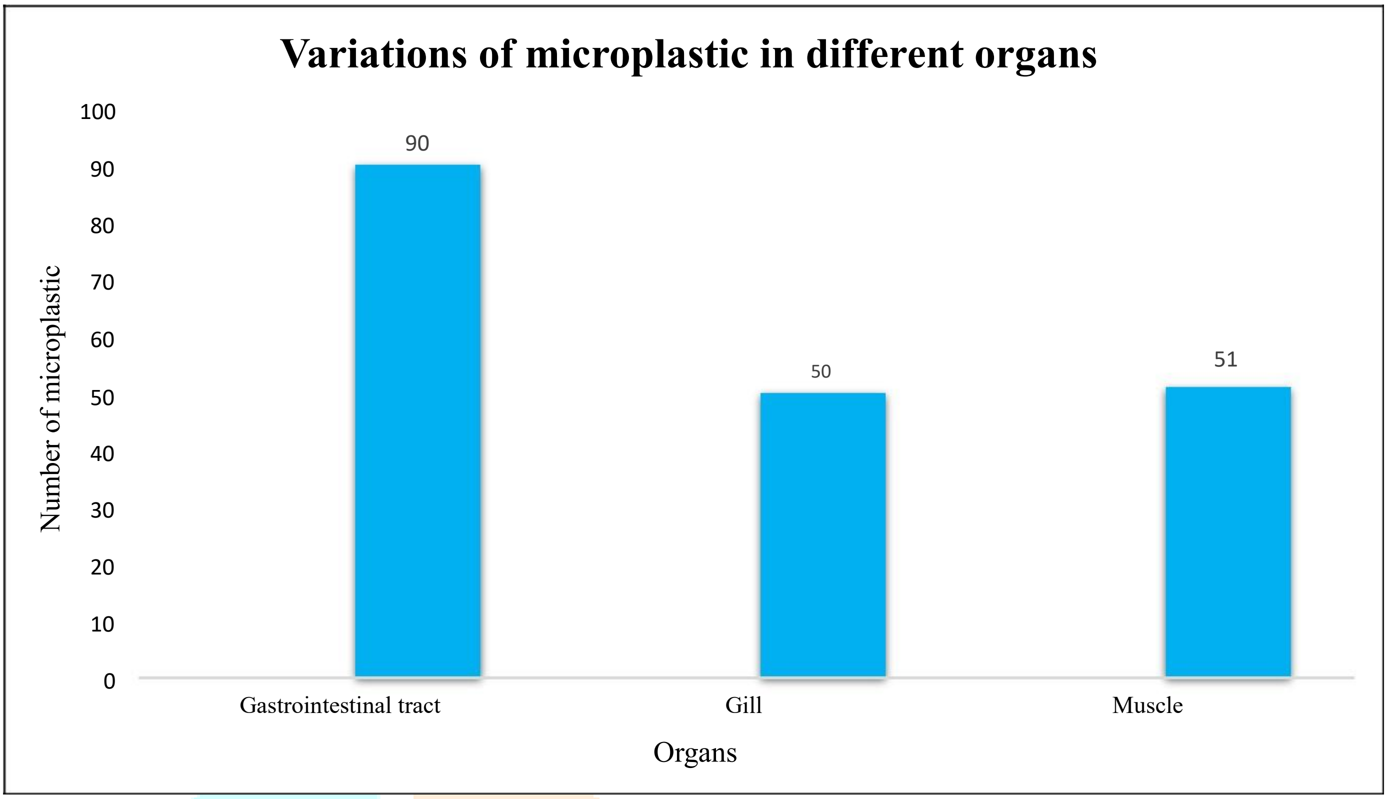
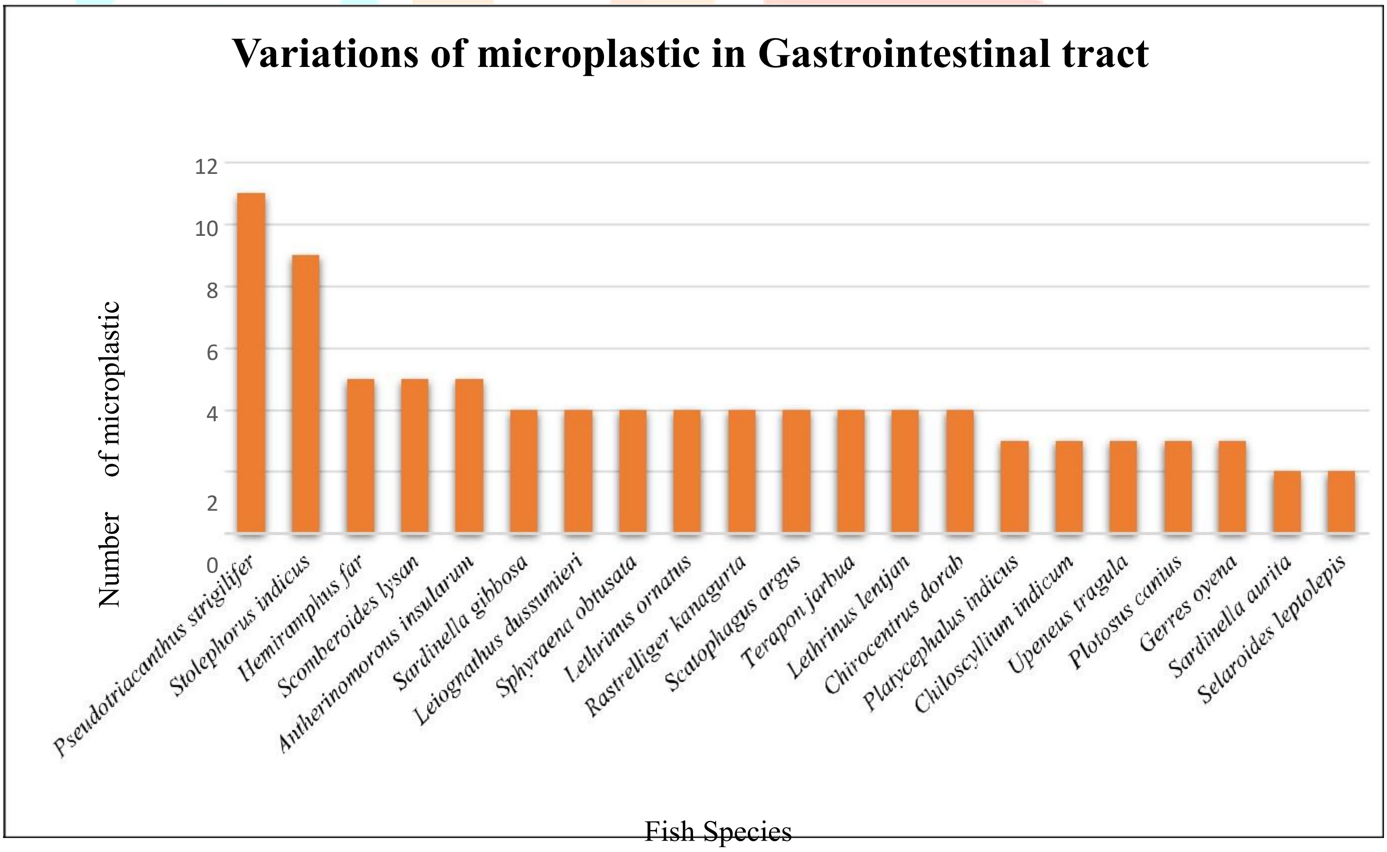


Fig. 8. Variation of microplastics in gastrointestinal tract



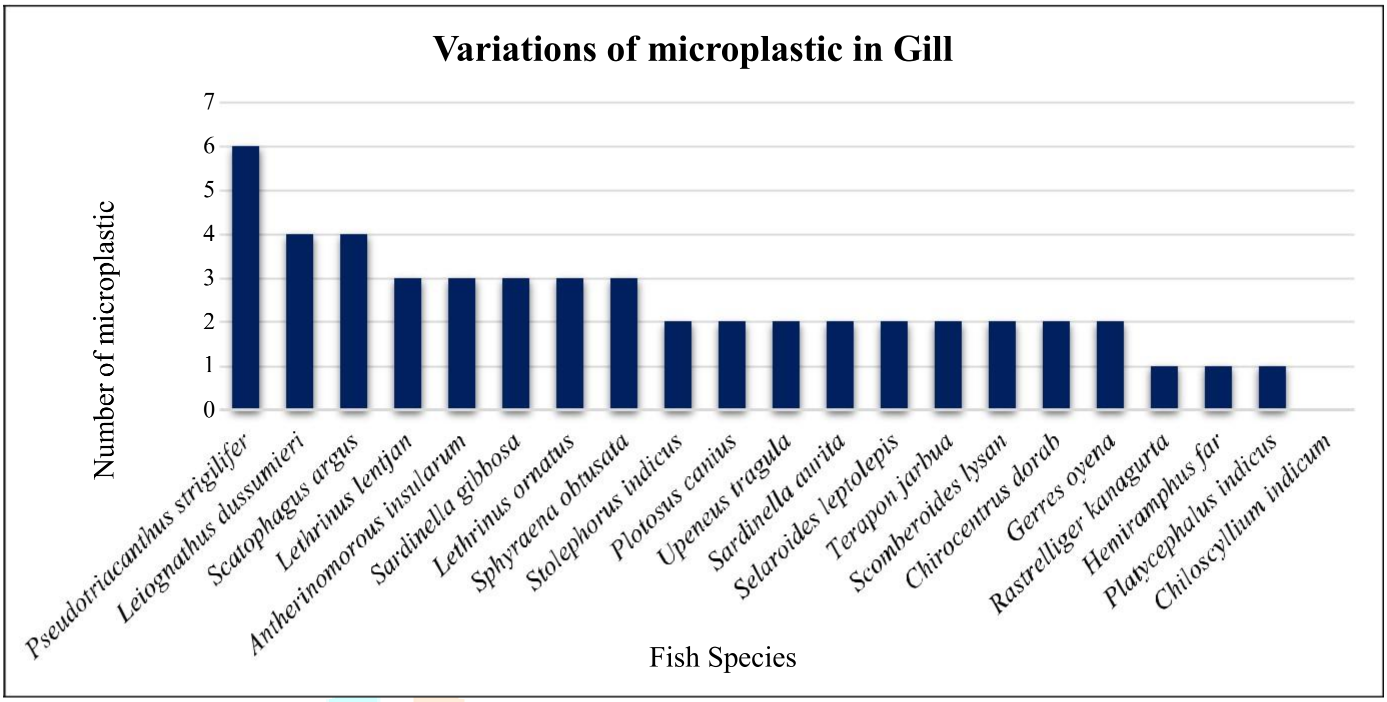


Fig. 9. Variations of microplastics in Gill

Fig. 10. Variations of microplastics in Muscle

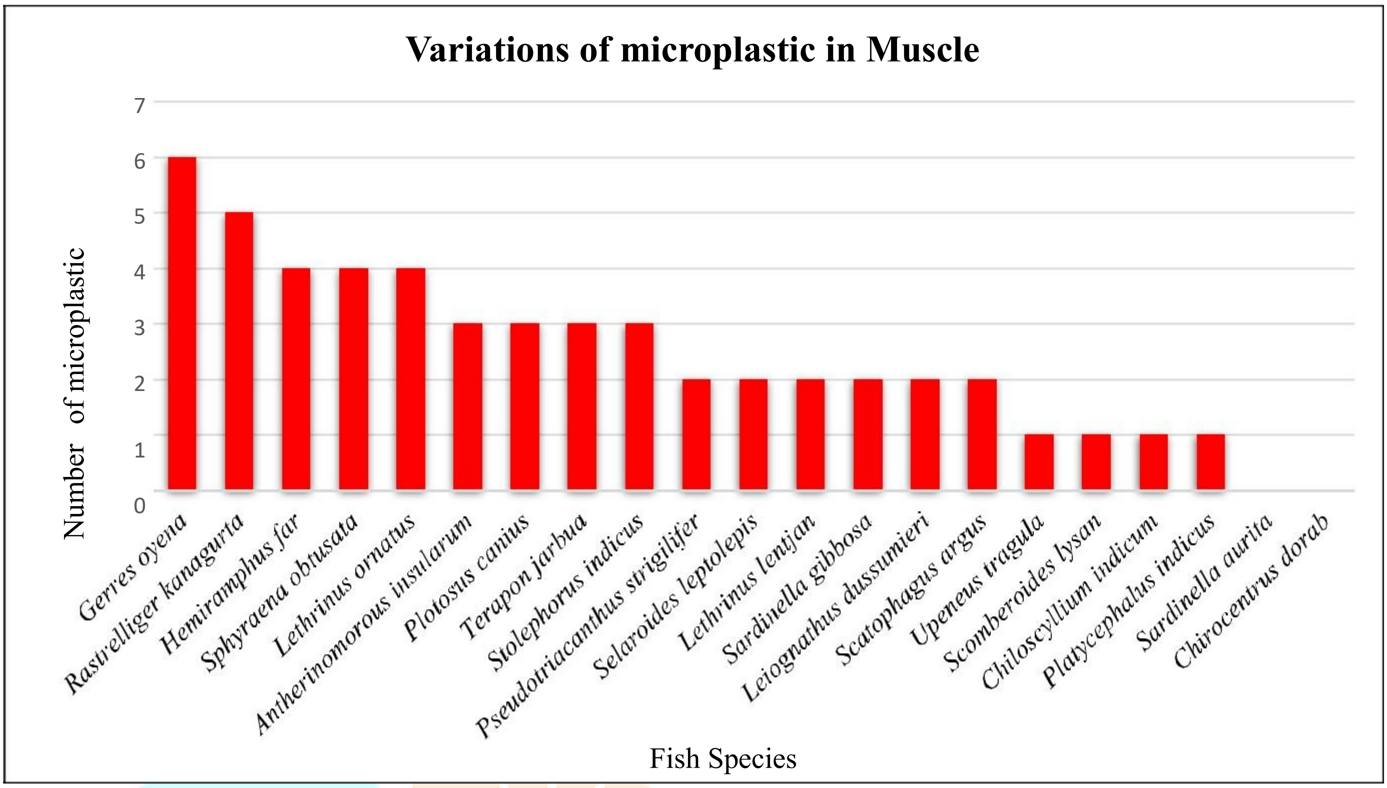
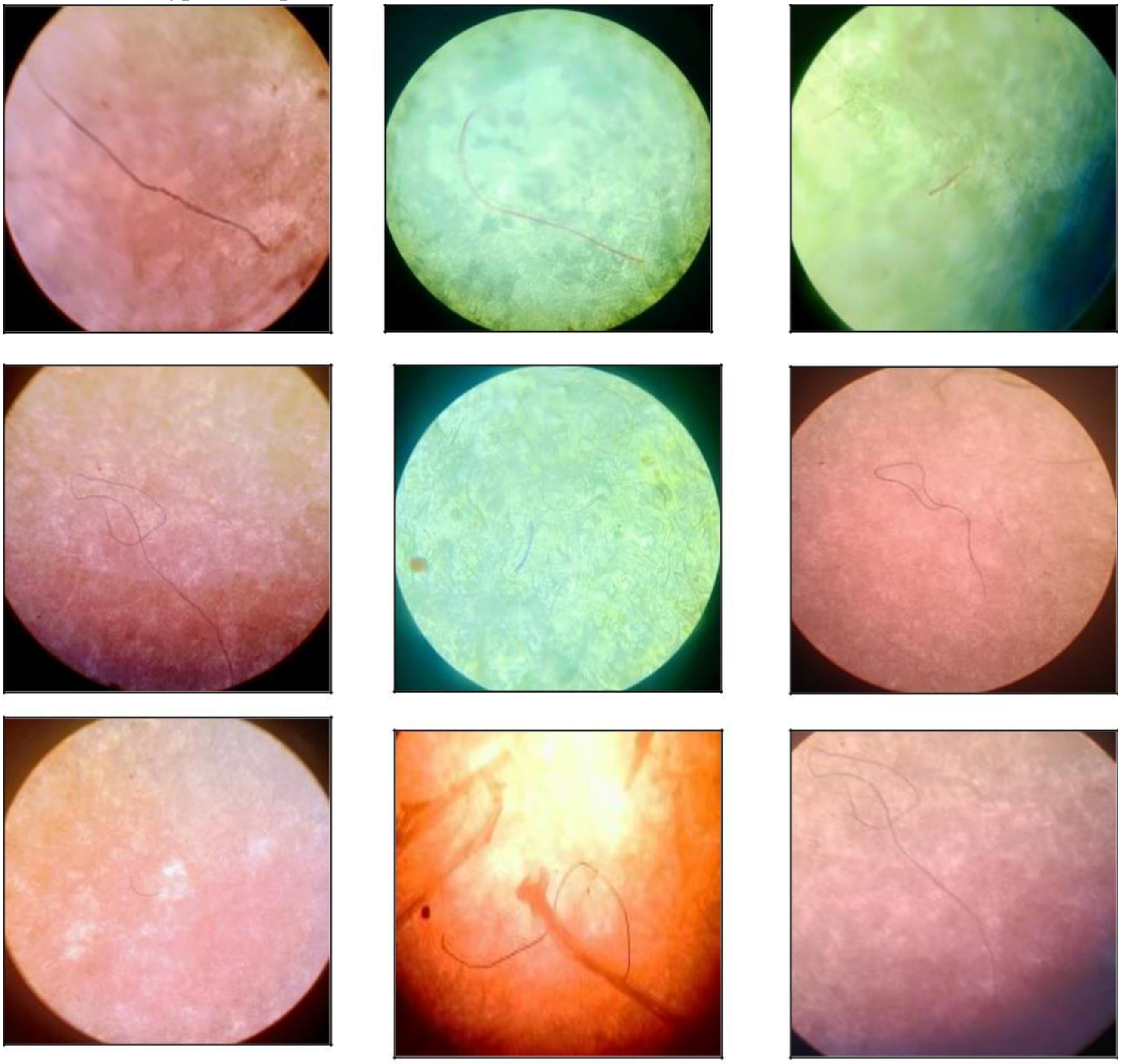


Plate 4. Fiber type microplastics



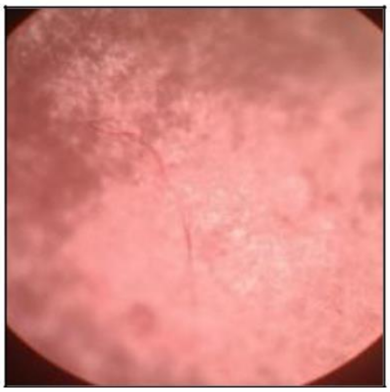


Plate 5. Granule type microplastic

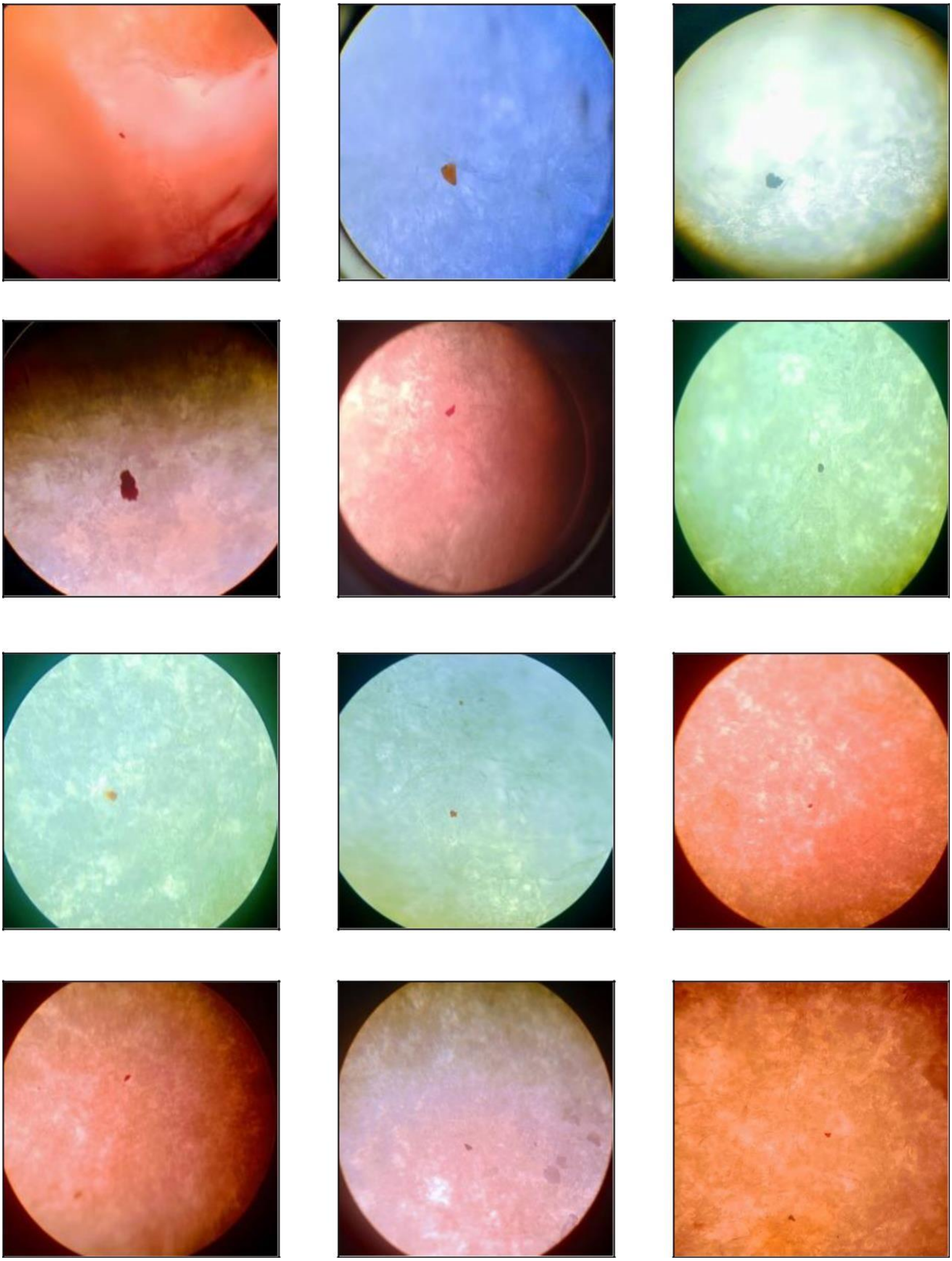


Plate 6. Granule type microplastic

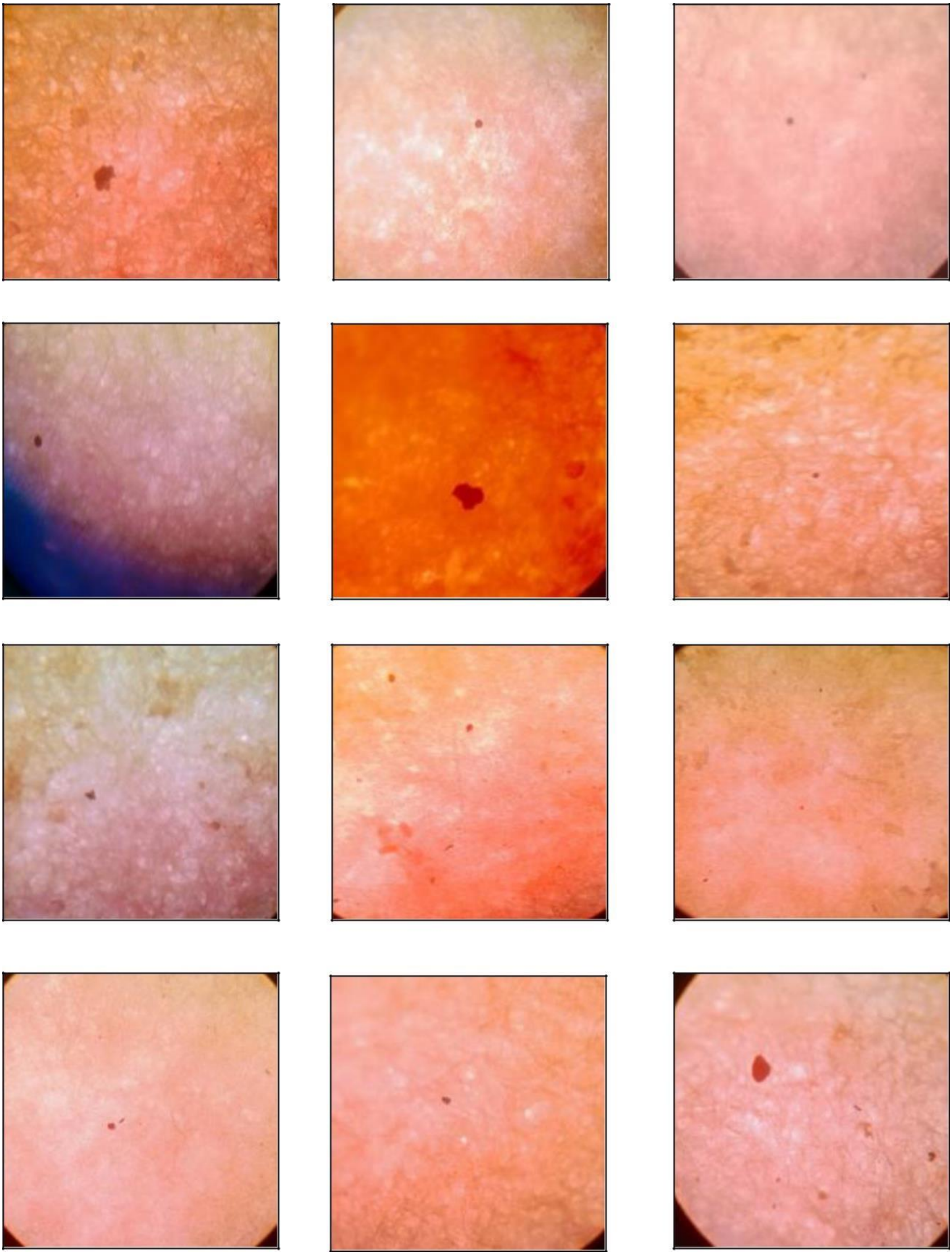
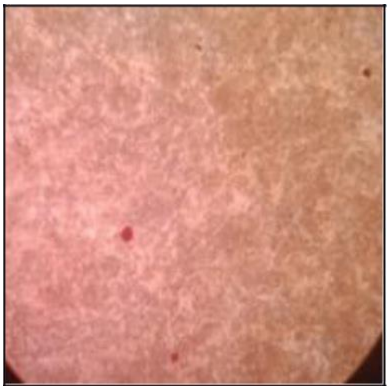
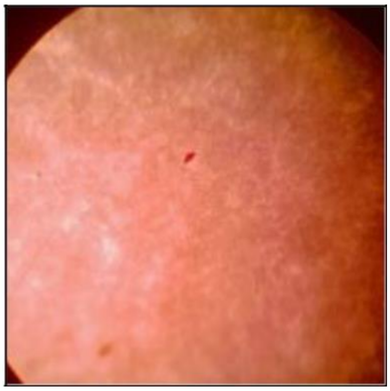


Plate 7. Granule type microplastic





7. REFERENCES

1. Allomar, C., C. Sureda, A., Capó, X., Guijarro, B., Tejada, S., Deudero, S., (2017). Microplastic ingestion by *Mullus surmuletus* Linnaeus, 1758 fish and its potential forcausing oxidative stress. Environ. Res. 159, 135–142. http://dx.doi.org/10.1016/j.envres.2017.07.043

2. Amin RM, Sohaimi ES, Anuar ST, Bachok Z (2020) Microplastic ingestion by zooplankton in Terengganu coastal waters, southern South China Sea. Mar Pollut Bull 150:110616.

3. Avio, C.G., Gorbi, S., Regoli, F., (2015). Experimental development of a new protocol for extraction and characterization of microplastics in fish tissues: first observations in commercial species from Adriatic Sea. Mar. Environ. Res. 111, 18–28.

4. Baalkhuyur FM, Qurban MA, Panickan P, Duarte CM (2020) Microplastics in fishes of commercial and ecological importance fromthe Western Arabian Gulf. Mar Pollut Bull 152:110920. https://doi. org/ 10. 1016/j. marpo lbul. 2020. 110920

5. Barboza LGA, Lopes C, Oliveira P, Bessa F, Otero V, Henriques B, Guilhermino L (2020). Microplastics in wild fish from North East Atlantic Ocean and its potential for causing neurotoxic effects, lipid oxidative damage, and human health risks associated with ingestion exposure. Sci Total Environ 717:134625. https:// doi. org/10. 1016/j. scito tenv. 2019. 134625

6. Bellas J, Martínez-Armental J, Martínez-Cámara A, Besada V, Martínez-Gómez C (2016). Ingestion of microplastics by demersal fishfrom the Spanish Atlantic and Mediterranean coasts. Mar Pollut Bull 109:55–60. https:// doi. org/ 10. 1016/j. marpo lbul. 2016. 06. 026

7. Boerger, C.M., Lattin, G.L., Moore, S.L., Moore, C.J., 2010. Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre. Mar. Pollut. Bull. 60, 2275–2278. http://dx.doi.org/10.1016/j.marpolbul.2010.08.007.

8. Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T.,Claessens, M., De Meester, S., Van Landuyt, L., De Clerck, K., and Janssen, C. R. (2011). Occurrence and distribution of microplastics in marine sediments along the Belgian coast. Marine Pollution Bulletin, 62(10), 2199-2204.

9. Browne, M.A., Galloway, T.S., Thompson, R.C., 2010. Spatial patterns of plastic debris along estuarine shorelines. Environ. Sci. Technol. 44, 3404–3409.
10. Carbery M, O'Connor W, Palanisami T (2018) Trophic transfer of microplastics and mixed contaminants in the marine food web and implications for human health. Environ Int 115:400– 409.

11. Claessens M, Van Cauwenberghe L, Vandegehuchte MB, Janssen CR. (2013). New techniques for the detection of microplastics in sedimentsand field collected organisms.

Marine Pollut Bull 70(1–2): 227–233.

12. Costa MF, Silva-Cavalcanti JS, Barbosa CC, Portugal JL, Barletta M. 2011. Plastics buried in the inter-tidal plain of a tropical estuarine ecosystem. J Coast Res Speci Issue 64: 339-343.

13. Costanza, R., d'Arge, R., de Groot, R., Farberk, S., Grazzo, M., Hannon, B., Limburg, K.,Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

14. Dehaut A, Cassone AL, Frère L, Hermabessiere L, Himber C, Rinnert E. (2016). Microplastics in seafood: benchmark protocol fortheir extraction and characterization. Environ Pollut 215:223–233.https:// doi. org/ 10. 1016/j. envpol. 2016. 05. 018

15. Devriese, L.I., De Witte, B., Vethaak, A.D., Hostens, K., Leslie, H.A., 2017. Bioaccumulation of PCBs from microplastics in Norway lobster (*Nephrops norvegicus*):an experimental study. Chemosphere 186, 10e16.

16. Dris, R., Gasperi, J., Mirande, C., Mandin, C., Guerrouache, M., Langlois, V., Tassin, B. 2017. A first overview of textile fibers, including microplastics, in indoor and outdoor environments. Environ. Pollut. 221, 453–458. http://dx.doi.org/10.1016/j.envpol. 2016.12.013.

17. Filgueiras AV, Preciado I, Cartón A, Gago J (2020) Microplastic ingestion by pelagic and benthic fish and diet composition: a case studyin the NW Iberian shelf. Mar Pollut Bull 160:111623. https:// doi.org/ 10. 1016/j. marpo lbul. 2020. 111623

18. Foekema, E.M., De Gruijter, C., Mergia, M.T., van Franeker, J.A., Murk, A.J., Koelmans, A. A. (2013). Plastic in north sea fish. Environ. Sci. Technol. 47, 8818–8824. http://dx.doi.org/10.1021/es400931b.

19. Frias J, Pagter E, Nash R, O'Connor I, Carretero O, Filgueiras A. (2018). Standardised protocol for monitoring microplastics in sediments. Deliverable 4.2. JPI-Oceans BASEMAN Project. https://doi. org/ 10. 25607/ OBP- 723

20. Gall, S.C., and Thompson, R.C., 2015. The impact of debris on marine life. Mar. Pollut. Bull. 92 (1-2), 170-179.

21. Güven, O., Gökdağ, K., Jovanović, B., Kıdeyş, A.E., 2017. Microplastic litter composition of the Turkish territorial waters of the Mediterranean Sea, and its occurrence in the gastrointestinal tract of fish. Environ. Pollut. 223, 286–294. http://dx.doi.org/10.1016/j.envpol.2017.01.025.

22. Hanachi P, Karbalaei S, Walker TR, Cole M, Hosseini SV. (2019). Abundance and properties of microplastics found in commercial fish meal and cultured common carp (*Cyprinus carpio*). Environ Sci Pollut Res 26(23): 23777–23787. https:// doi. org/ 10. 1007/s11356- 019- 05637-6.

23. Hastuti AR. 2014. Distribusi spasial sampah laut di ekosistem mengrove Pantai Indah Kapuk Jakarta. [Undergraduate thesis]. Institut Pertanian Bogor, Bogor. [Indonesian].

24. Hermabessiere, L., Dehaut, A., Paul-Pont, I., Lacroix, C., Jezequel, R., Soudant, P., Duflos,G. (2017). Occurrence and effects of plastic additives on marine environments andorganisms: a review. Chemosphere 182, 781–793. http://dx.doi.org/10.1016/j.chemosphere.2017.05.096.

25. Horton, A.A., Walton, A., Spurgeon, D.J., Lahive, E., Svendsen, C., 2017. Microplastics in freshwater and terrestrial environments: evaluating the current understanding to identify the knowledge gaps and future research priorities. Sci. Total Environ. 586,127–141. http://dx.doi.org/10.1016/j.scitotenv.2017.01.190.

26. Ivar do Sul, J.A., Costa, M.F., 2014. The present and future of microplastic pollution in themarine environment. Environ. Pollut. 185, 352–364. http://dx.doi.org/10.1016/j.envpol.2013.10.036

27. Ivar do Sul JA, Costa MF. 2013. Plastic pollution risks in an estuarine conservation unit. J Coast Res 65: 48-53

28. Jabeen K, Su L, Li J, Yang D, Tong C, Mu J, Shi H (2017) Microplastics and mesoplastics in fish from coastal and fresh waters of China. Environ Pollut 221:141–149. https:// doi. org/ 10.1016/j. envpol. 2016. 11. 055

29. Karami A, Golieskardi A, Ho YB, Larat V, Salamatinia B. (2017). Microplastics in eviscerated flesh and excised organs of dried fish Sci Rep 7(1):1–9. https:// doi. org/ 10. 1038/ s41598-017- 05828-6

30. Kolandhasamy P, Su L, Li J, Qu X, Jabeen K, Shi H (2018) Adherence of microplastics to soft tissue of mussels: a novel way to uptake microplastics beyond ingestion. Sci Total Environ 610:635–640.https:// doi. org/ 10. 1016/j. scito tenv. 2017. 08. 053

31. Kor K, Ghazilou A, Ershadifar H (2020) Microplastic pollution in the littoral sediments of the northern part of the Oman Sea. Mar PollutBull 155:111166. https:// doi. org/ 10. 1016/j. marpolbul. 2020.111166

32. Kühn, S., van Werven, B., van Oyen, A., Meijboom, A., Bravo Rebolledo, E.L., vanFraneker, J.A., 2017. The use of potassium hydroxide (KOH) solution as a suitable approach to isolate plastics ingested by marine organisms. Mar. Pollut. Bull. 115: 86–90.

33. Li B, Su L, Zhang H, Deng H, Chen Q, Shi H (2020) Microplastics in fishes and their living environments surrounding a plastic productionarea. Sci Total Environ 727:138662. https:// doi.org/ 10. 1016/j.scito tenv. 2020. 138662

34. Li, J., Liu, H., Paul, C.J., 2018. Microplastics in freshwater systems: a review on occurrence, environmental effects, and methods for microplastics detection. Water Res. 137, 362e374.

35. Lusher, A.L., McHugh, M., Thompson, R.C., 2013. Occurrence of microplastics in thegastrointestinal tract of pelagic and demersal fish from the English Channel. Mar. Pollut. Bull. 67, 94–99. http://dx.doi.org/10.1016/j.marpolbul.2012.11.028.

36. Lusher, A.L., Tirelli, V., O'Connor, I., Officer, R., 2015. Microplastics in Arctic polar waters:the first reported values of particles in surface and sub-surface samples. Sci.Rep. 1–9. http://dx.doi.org/10.1038/srep14947.

37. Martinho, F., Leitão, R., Viegas, I., Dolbeth, M., Neto, J.M., Cabral, H.N., Pardal, M.A.,2007. The influence of an extreme drought event in the fish community of a southern Europe temperate estuary. Estuar. Coast. Shelf Sci. 75, 537–546.

38. Moore CJ. 2008. Synthetic polymers in the marine environment: A rapidly increasing, long-term threat. Environ Res 108 (2): 131-139.

39. Nadal, M.A., Alomar, C., Deudero, S., 2016. High levels of microplastic ingestion by the semipelagic fish bogue *Boops boops* (L.) around the Balearic Islands. Environ. Pollut., 214: 517–523. http://dx.doi.org/10.1016/j.envpol.2016.04.054.

40. Neves, D., Sobral, P., Ferreira, J.L., Pereira, T., 2015. Ingestion of microplastics by commercial fish off the Portuguese coast. Mar. Pollut. Bull. 101: 119–126. http://dx.doi.org/10.1016/j.marpolbul.2015.11.008

41. Ory, N.C., Sobral, P., Ferreira, J.L., Thiel, M., 2017. Amberstripe scad *Decapterus muroadsi* (Carangidae) fish ingest blue microplastics resembling their copepod prey along the coast of Rapa Nui (Easter Island) in the South Pacific subtropical gyre. Sci. Total Environ. 586: 430– 437. http://dx.doi.org/10.1016/j.scitotenv.2017.01.175.

42. Possatto, F.E., Barletta, M., Costa, M.F., do Sul, J.A.I., Dantas, D.V., 2011. Plastic debris ingestion by marine catfish: an unexpected fisheries impact. Mar. Pollut. Bull. 62,1098– 1102. http://dx.doi.org/10.1016/j.marpolbul.2011.01.036.

43. Rochman, C.M., Tahir, A., Williams, S.L., Baxa, D.V., Lam, R., Miller, J.T., Teh, F.-C., Werorilangi, S., Teh, S.J., 2015. Anthropogenic debris in seafood: plastic debris and fibers from textiles in fish and bivalves sold for human consumption. Sci. Rep. 1–10. http://dx.doi.org/10.1038/srep14340.

44. Rummel, C.D., Löder, M.G.J., Fricke, N.F., Lang, T., Griebeler, E.M., Janke, M., Gerdts, G. (2016). Plastic ingestion by pelagic and demersal fish from the North Sea and Baltic Sea. Mar. Pollut. Bull. 102, 134–141. http://dx.doi.org/10.1016/j.marpolbul.2015.11.043.

45. Van Cauwenberghe, L., Vanreusel, A., Mees, J., Janssen, C.R., 2013. Microplastic pollution in deep-sea sediments. Environ. Pollut. 182, 495–499. http://dx.doi.org/10.1016/j.envpol.2013.08.013.

46. Vendel, A.L., Bessa, F., Alves, V.E.N., Amorim, A.L.A., Patrício, J., Palma, A.R.T. (2017). Widespread microplastic ingestion by fish assemblages in tropical estuaries subjected to anthropogenic pressures. Mar. Pollut. Bull. 117, 448–455. http://dx.doi.org/10.1016/j.marpolbul.2017.01.081.

47. Vermeiren, P., Muñoz, C.C., Ikejima, K., 2016. Sources and sinks of plastic debris in estuaries: a conceptual model integrating biological, physical and chemical distribution mechanisms. Mar. Pollut. Bull. 113, 7–16. http://dx.doi.org/10.1016/j.marpolbul.2016.10.002.

48. Wright, S.L., Thompson, R.C., Galloway, T.S., 2013. The physical impacts of microplastics on marine organisms: a review. Environ. Pollut. 178, 483–492. http://dx.doi.org/10.1016/j.envpol.2013.02.031.

49. Zhang, J., Chen, H., He, H., Cheng, X., Ma, T., Hu, J., Yang, S., Li, S., Zhang, L. (2020). Adsorption behavior and mechanism of 9-Nitroanthracene on typical microplastics in aqueous solutions. Chemosphere 245, 125628.