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RESEARCH ARTICLE

Preliminary observation on microplastic contamination in the Scombridae species from coastal waters of Pakistan

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ABSTRACT

Microplastics are one of the major pollution problems nowadays, have been found in both marine environments and various fish species worldwide. In this study, the presence of microplastics in the digestive systems and the gills of 6 species from the Scombridae family on the coast of Karachi in Pakistan was investigated. A total of 336 fish were examined for the presence of microplastic in gills and the digestive systems. Microplastics were detected in digestive systems and gills in 11.11%-19.51% and 58.62%-85.71% of total individuals, respectively. The number of microplastics varied from 0.19 to 1.12 items.ind^{-1} in digestive system and 1.5 to 7.04 items.ind^{-1} in gill. Fibre was dominant in both gills (98.67-99.17%) and digestive systems (100%). More extensive and further investigations are needed on microplastic contamination of the biota on the Pakistan coast.

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Introduction

Microplastics are commonly defined as plastic particles less than 5 mm in size (Arthur et al., 2009; Hidalgo-Ruz et al., 2012) that have been found in marine environments (Ivar do Sul et al., 2014; Song et al., 2015; Isobe et al., 2017; Cincinelli et al., 2019) and in marine fish (Neves et al., 2015; Bellas et al., 2016; Karbalaei et al., 2019; Sparks & Immelman, 2020) all over the world. Microplastics' abilities to absorb various contaminants from surrounding environment and they are also a source of

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toxic chemicals added as ingredients during manufacturing (Mato et al., 2001; Teuten et al., 2009; Oehlmann et al., 2009). So, they raised significant concern on their role as a vector for transferring harmful contaminants into the aquatic environment (Brennecke et al., 2016; Jaafar et al., 2021).

Microplastics have been detected in various aquatic organisms, including zooplankton, invertebrates, fish, and marine mammals (Li et al., 2015; Neves et al., 2015; Sun et al., 2017; Güven et al., 2017; Thushari et al., 2017; Aytan et al., 2022a). Laboratory studies have also revealed that microplastics are ingested by several organisms from various trophic levels (Farrel & Nelson, 2013; Messinetti et al., 2017; LeMoine et al., 2018; De Felice et al., 2019).

Fish are generally used as biomonitors to determine the health of aquatic ecosystems (Joy & Death, 2002; Zrnčić et al., 2013). The investigations on the presence of microplastics in fish have gained momentum and results of investigations showed that microplastics have been detected both in the digestive systems and in various tissues and organs in fish, recently (Neves et al., 2015; Mizraji et al., 2017; Abbasi et al., 2018; Koongolla et al., 2020). Several pathways have been suggested for the uptake routes of microplastics in fish and one of the uptake pathways in fish is generally considered as ingestion (Confusing with food, accidental ingestion, transfer with the food chain) (Roch et al., 2020). Filter deposit feeders are non-selective feeders that are prone to unintentionally consuming more inorganic material, on the other hand, predators, choose their prey deliberately and mostly do not have other paths of uptake, so microplastic ingestion is usually due to bioaccumulation (Murray & Cowie, 2011; Wesch et al., 2016). The gill of fish is the most physiologically diverse, anatomically complicated, and multifunctional organ (gas exchange, ion regulation, osmoregulation, hormone synthesis, immunological defense, acid–base balance and ammonia excretion) (Rombough, 2007; Olson, 2011; Secombes & Wang, 2012). The microplastics in gills were retained in this organ during water filtration, causing physical injury to the gills as well as reduced respiratory efficiency, which can lead to hypoxia and be fatal (Barboza et al., 2020).

The family of Scombridae is some of the world's most popular food fishes. Their importance as tertiary consumers in the marine food web. Scombrids are pelagic-neritic (open-ocean) fish that live mostly in tropical and subtropical oceans (Froese & Pauly, 2021). Pakistan has a significant Scombrids fish industry (Ahmed et al., 2018). Pakistan's fishing industry is vital to the country's economy. Scombrids fish support fisheries on a large scale and make up almost one-fifth of the total marine fish catch in Pakistan (Ahmed et al., 2016; FAO, 2019). Karachi is situated in the Sindh province and industrial and commercial center of the Pakistan. The marine ecosystem is severely impacted by environmental deterioration throughout Pakistan's coastline, notably in the Karachi city harbor areas (Qaimkhani, 2018). The harbor's location puts it in close proximity to important shipping routes. The harbor handles over 90% of Pakistan's fish and seafood catch and exports. Increased marine pollution in Karachi's coastal area has come from the city's industrialization and economic growth (Ahmed & Bat, 2015). The investigations on microplastic pollution in Pakistan are very limited and the presence of microplastics has been reported from sea water, sediments, and beaches (Balasubramaniam & Phillott, 2016; Irfan et al., 2020a, 2020b; Ahmed et al., 2022) and there is no information about the contamination of microplastics in fish. This study aims to detect the presence of microplastics in digestive systems and gills of the commercial fish from Scombridae family in Karachi-Pakistan.

Material and Methods

Karachi Fish Harbour is located in Karachi, Sindh, Pakistan, in the northeastern border of the Arabian Sea, between 24°50'54.71" N and 66°58'38.68" E (Fig. 1). The harbor's location makes it close to the main shipping routes as well as the main commercial and industrial areas.

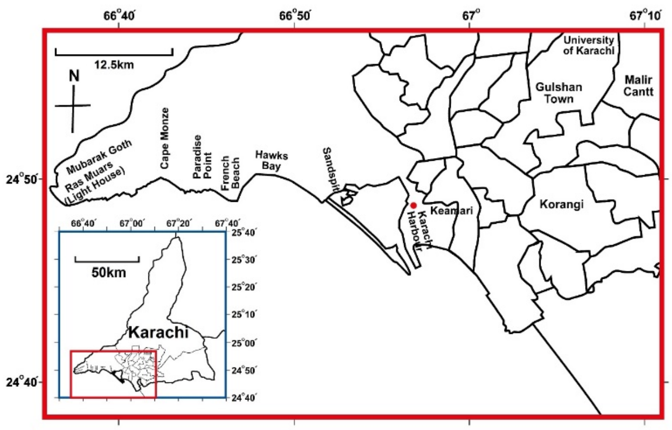

Figure 1. Karachi Fish Harbour

A total of 336 fish from 6 species of the Scombridae family were obtained from fishermen fishing in Karachi Fish Harbour in 2021. Detailed information about the species used in the research is given in the Table 1. The fish samples were transported to the laboratory in ice boxes. Fish samples were washed with distilled water and removed from foreign particles and then frozen -20°C until analysis.

Table 1. Taxonomic and common name, environment, feeding behavior, trophic level and IUCN status of species (Froese & Pauly, 2021; IUCN, 2022).

Species	Common name	Environment	Feeding behaviour	Trophic level	IUCN status*
Rastrelliger kanagurta (Cuvier, 1816)	Indian mackerel	pelagic-neritic	macroplankton such as larval shrimps and fish	3.2	DD
Scomberomorus commerson (Lacepède, 1800)	Narrow-barred Spanish mackerel	pelagic-neritic	small fishes, squids and penaeid shrimps	4.5	NT
Scomberomorus guttatus (Bloch & Schneider, 1801)	Indo-Pacific king mackerel	pelagic-neritic	small fishes, squids and crustaceans	4.3	DD
Euthynnus affinis (Cantor, 1849)	Kawakawa	pelagic-neritic	small fishes, squids, crustaceans, and zooplankton.	4.5	LC
Katsuwonus pelamis (Linnaeus, 1758)	Skipjack tuna	pelagic-oceanic	fishes, crustaceans, cephalopods, and molluscs	4.4	LC
Thunnus tonggol (Bleeker, 1851)	Longtail tuna	pelagic-neritic	fishes, cephalopods, and crustaceans	4.5	DD

Note: *DD: Data Deficiency; NT: Near Threatened; LC: Least Concern

All fish dissect, digestive systems and gills were removed from each fish separately. Digestive systems and gills were placed in glass containers separately and added hydrogen peroxide (H_2O_2, 30%) to eliminate organic matter. After that the solutions were filtered on fine-mesh filters (55 µm pore size) and filters placed in petri dishes for microscopic examination. Zeiss Stemi SV6 stereomicroscope used for examination. To prevent contamination special precautions were taken. All, working surfaces and equipment were cleaned with distilled water, cotton laboratory coats and gloves were worn continually. The filters and solutions were covered with aluminium foils during all procedures to diminish airborne contamination.

The number of microplastic in each fish was counted and categorized to type of microplastics (fibre and fragment). The percentage occurrence of microplastic and the mean microplastic amount in all fish and only fish with contaminated microplastic were determined for each species. The relationships between the number of microplastics and the length of fish were assessed with Spearman correlation analysis in IBM SPSS software.

Results

A total of 336 fish from 6 species were examined for presence of microplastic in the gills and the digestive systems. 250 specimens (74.4%) were contained microplastics in their digestive system or gill (Table 2). More microplastics were found in the gills than in the digestive systems in all analysed fish species.

The minimum and maximum percentages of microplastics in digestive systems of the analysed species were among 11.11% in *E. affinis* and 19.51% in *R. kanagurta*. The highest number of microplastic in digestive system was observed in *T. tonggol* (1.12 $items.ind^{-1}$) and followed by *K. pelamis* (0.93 $items.ind^{-1}$), *E. affinis* (0.80 $items.ind^{-1}$), *S. commerson* (0.76 $items.ind^{-1}$), *S. guttatus* (0.41 $items.ind^{-1}$) and *R. kanagurta* (0.19 $items.ind^{-1}$) respectively. Generally, there was a weak positive correlation between the number of microplastics and fish length except *R. kanagurta, S. commerson* and *S. guttatus* (*E. affinis*: R=0.37 p=0.006; *K. pelamis*: R=0.31, p=0.044; *T. tonggol*: R=0.34, p=0.016).

The minimum and maximum occurrence percentage of microplastics in gills of the analysed species were among 58.62% in *S. commerson* and 85.71% in *R. kanagurta*. The highest number of microplastics in gills was observed in *T. tonggol* (7.04 $items.ind^{-1}$) and followed by *E. affinis* (6.98 $items.ind^{-1}$), *K. pelamis* (6.19 $items.ind^{-1}$), *S. commerson* (3.98 $items.ind^{-1}$), *S. guttatus* (3.49 $items.ind^{-1}$) and *R. kanagurta* (1.5 $items.ind^{-1}$) respectively.

Two different types of microplastics were found during the study. Fibre was dominant in the gills (98.67% in *E. affinis*-99.17% in *R.kanagurta*) and a low percentage of fragment was also found (0.83% in *R.kanagurta*-1.33% in *E. affinis*). In digestive systems only fibre was found (Figure 2).

Table 2. The percentage occurrence and number of microplastics in gills and digestive systems of Scombridae species

Species	No.	Mean size (SD)	Microplastic					
			Gill			Digestive system		
			%	Mean¹	Mean²	%	Mean¹	Mean²
R. kanagurta	82	20.73 (2.60)	59.76	1.5	2.44	19.51	0.19	1
S. commerson	58	43.76 (2.05)	58.62	3.98	6.79	18.96	0.76	4
S. guttatus	51	42.92 (3.49)	78.43	3.49	4.45	11.76	0.41	3.5
E. affinis	54	57.44 (1.06)	85.18	6.98	8.20	11.11	0.80	7.17
K. pelamis	42	51.43 (1.87)	80.95	6.19	7.65	14.29	0.93	6.5
T. tonggol	49	52.43 (3.28)	85.71	7.04	8.21	16.33	1.12	6.87

Note: %: of individual with microplastic, Mean¹: mean microplastic number of all investigated fish, Mean²: mean microplastic number of only contaminated fish

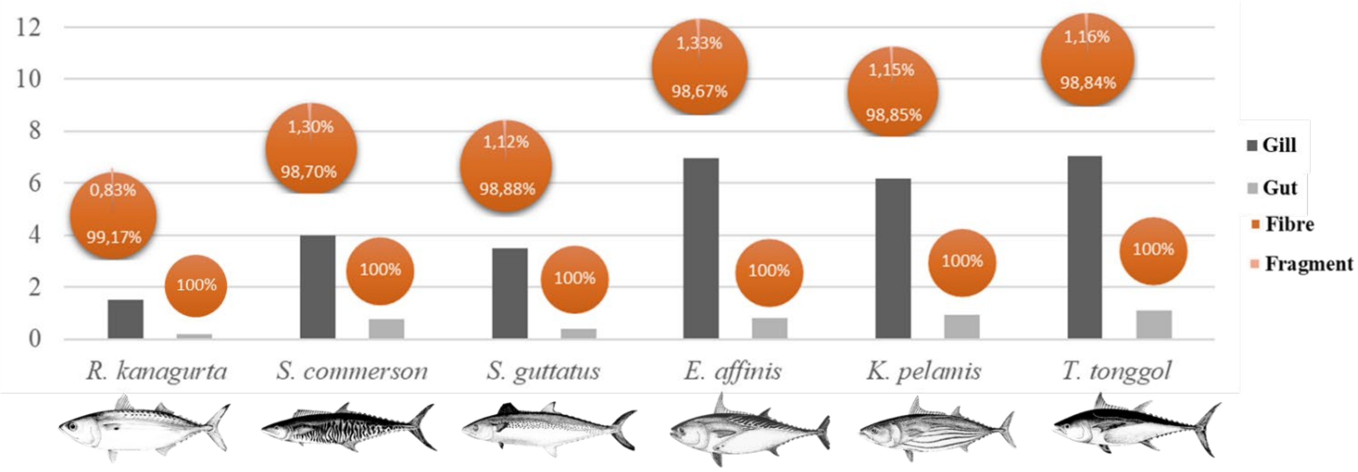

Figure 2. Types and abundance of microplastics in gill and digestive system from the species of the Scombridae family

Discussion

The amount of research on microplastic pollution in the aquatic environment of the Pakistan is quite a few (Balasubramaniam & Phillott, 2016; Irfan et al., 2020a, 2020b; Ahmed et al., 2022). The presence of plastic spherules in fish was one of the first articles on this issue (Carpenter et al., 1972). Investigations showed that microplastics were found in the digestive systems and in various tissues and organs in fish (Mizraji et al., 2017; Abbasi et al., 2018; Su et al., 2019; Koongolla et al., 2020). In the current study, microplastics were detected in both digestive system and gills of 6 different commercial fish species in Karachi, where there is a lack of data on a regional basis. As a result of the study, the number of microplastic in the gills was found to be higher than the digestive systems for all specimens.

Microplastics were detected in digestive systems 11.11%-19.51% of total individuals and the number of microplastics in digestive systems varied from 0.19 to 1.12 items.ind^{-1}. The results of the present study are similar to the investigation carried out on Scombrids by various researchers in different environments, the percentage occurrence of plastic in gastrointestinal tract was found between 0-71% and the number of plastic particles were 0-6.71 items.ind^{-1} (Table 3).

Various factors may have caused the presence of plastic in the digestive systems of fish. Plastic particles may be consumed intentionally mistaking for food, or unintentionally, or they can be passed via trophic transfer (from prey to predator) and

Table 3. Microplastic presence in digestive systems of Scombridae species from different environments

Species	Location	Abundance items.ind^{-1} (% of individual with microplastic)	Type	References
S. japonicus	Portuguese	0.57±1.04 (31%)	Fibre, Fragment	Neves et al. (2015)
S. scombrus		0.46±0.78 (31%)		
S. japonicus	Mediterranean, Turkey	6.71 (71%)		Güven et al. (2017)
S. japonicus	Peru	0.03 (3.3%)	Fragment	Ory et al. (2018)
S. japoicus	Hangzhou Bay and Yangtze Estuary, China	0.8±0.8 (56%)	Fibre, Fragment	Su et al. (2019)
R. kanagurta	Kochi, Arabian Sea, India	(0-55%)		James et al. (2020)
Scomber spp.	Moroccan Atlantic shelf	(27%)		Maaghloud et al. (2020)
Rastrelliger sp.	Southeast coast of India	(0%)		James et al. (2021)
R. kanagurta				
S. sarda	Black Sea, Turkey	4 (70%)	Fibre, Fragment	Aytan et al. (2022b)
R. kanagurta, *S. commerson*, *S. guttatus*, *E. affinis*, *K. pelamis*, *T. tonggol*	Karachi-Pakistan	0.19-1.12 (11.11%-19.51%)	Fibre	This study

drinking has also been identified as a potential source of microplastic consumption, particularly for big marine fish (Ory et al., 2017; Athey et al., 2020; Roch et al., 2020). Ingestion of plastic can cause various adverse effects such as deterioration of feeding capacity, digestive system blockage, starvation and death, poor quality of life and reproductive capacity and plastics can adsorb and concentrate potentially harmful toxic compounds from the aquatic environment (Gregory, 2009; Wright et al., 2013).

In present study, microplastics were detected in gills 58.62%-85.71% of total individuals and number of microplastics in gills varied from 1.50 to 7.04 items.ind^{-1}. Research on the presence of microplastic in gills of fish is relatively limited (Abbasi et al., 2018; Su et al., 2019; Huang et al., 2020; Koongla et al., 2020; Lin et al., 2020; Jaafar et al., 2021). In Scombridae species, the frequency rate and number of microplastics in gills were found similar in Yangtze Estuary-China [*S.japonius*: 2.4±2.0 items.ind^{-1} (%78 of total fish) (Su et al., 2019)] with present study and Barboza et al. (2020) was found lower (*S.colias*: 0.7±1.0 items.ind^{-1}) than present study in Northwest (NW) Portuguese coastal waters. In this study microplastic abundance in gills higher than the digestive systems. Similarly, the microplastic abundance reported as higher than in gills than digestive systems in Persian Gulf by Abbasi et al. (2018) in Malaysia by Jaafar et al. (2021). but contrary more microplastic was found in digestive systems than gills in China (Su et al., 2019; Koongla et al., 2020; Lin et al., 2020) and the Northeast Atlantic Ocean (Barboza et al., 2020). The results can be showed variations due to the species, habitats, surrounding environments and gill's structures. Therefore, the uptake of microplastics via gills depend on microplastic size, and morphology of the gills (Collard et al., 2017; Barboza et al., 2020). Microplastics found in the gills are due to their keeping in the gills during filtration of water (Barboza et al., 2020), so microplastic content in water affects plastic uptake of gills. Microplastics can cause physical harm to the gills as well as reduced respiratory efficiency, which can be fatal (Barboza et al., 2020).

Fibre dominant shape of microplastic in the present study like many other study (Su et al., 2019; Lin et al., 2020; Aytan et al., 2022b). Recently published article on microplastic contamination of Pakistan coast (including Karachi), the high amount of microplastics has been detected in surface water and sediments, and these are mostly fibres (>%99) (Ahmed et al., 2022). Several factors were affected the plastic uptake, and one of them microplastic concentration in the water. Therefore, the fibre density found in fish caught in the region supported by the Ahmed et al. (2022). Washing machine effluent is discharged into the local sewer system, which plays a crucial role in the fate and transportation of fibres into the marine environment due to the huge number of fibres released when clothing is washed (Napper & Thompson, 2016). Karachi Fish Harbour is near the major commercial sectors and various industrial districts of Karachi, Sindh, Pakistan. Furthermore, because of the region's intensive agricultural, household, and urbanization activity, the harbour may receive enormous amounts of untreated agricultural and domestic sewage (Ahmed et al., 2015). Therefore, it was stated that every day, 450 million gallons of untreated water is poured into the sea in Karachi and other coastal cities during the apex court hearing in December 2017, because no sewage treatment plants are operational (Qaimkhani, 2018).

Conclusion

Microplastics are in fact a global issue. Aside from the increasingly well-known challenges that ocean litter poses to the environment, coastal communities, and marine industries, there is now hard evidence that it poses a large-scale and substantial threat to the well-being of wild marine species.

In this study, a total of 336 fish from Scombridae family were examined for the presence of microplastic in gills and digestive systems. 74.4% of fish were contaminated with microplastics in their digestive system or gill and fibre was dominant. The risk of bioaccumulation is significant in long-lived species and for those who use fish as food. Many studies have shown that microplastics are more present in the digestive tract than in fish meat. Therefore, the fish should be cleaned thoroughly by washing with plenty of water before consumption.

There is a very limited number of investigations on microplastic contamination both marine environment and biota in Pakistan coast, so more extensive and further research are needed.

Compliance With Ethical Standards

Authors' Contributions

Author QA Conception and designed the study, FY data acquisition, LB and AÖ wrote the first draft and critical revision of the manuscript, QMA technical or material support, IS data analysis and interpretation. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, ethics committee approval is not required.

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