Microplastics in digestive tracts of fishes from Jakarta Bay

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Abstract. Microplastics are small plastic particles less than five millimeters in size. Microplastic is dangerous because it becomes a medium for other pollutants such as heavy metals and harmful bacteria to attach on. This study aims to determine the presence of microplastic in the digestive tracts of fishes in Jakarta Bay. The number of fish samples obtained was 25 fishes consisting of several species, namely, Siganus sp., Albulia forsteri, Latjanus sp., Parastromateus sp., Plicofollis argyropleuron, Pampus argenteus, Paraplotosus albilaris, Sardinella fimbria, and Platyecephalus indicus. The samples were grouped into three categories based on the length of their body, namely small fish with a length of 13-24 cm, medium fish 25-36 cm, and large fish 37-90 cm. The method used to identify microplastics in the fishes digestive tract is optical microscopy. Microplastics were found in 19 fish (76%), those identified as fiber is 73%, identified as films is 18%, and identified as fragment 9%. The larger the size of fish the higher the microplastic content of all types. This implies that microplastic bioaccumulation occurs through the food chain.

1. Introduction

Plastics are polymeric materials that are formed at certain temperatures and pressures [1]. Large-sized plastics are formed from resin melt and modified fibers. Since the 20th century, the production of plastic polymers is increasing. When discharged into the environment, plastic gradually degrades and becomes microplastic. Afterward, the industry began to make plastic in micro and nano sizes, which become a bigger threat to the environment [2]. Microplastic was first identified in the 1970s [3] as small plastic particles measuring 5 mm or smaller. Size is an important factor related to the effects of microplastic on the organism. It is very small, which makes it ubiquitous and increases the possibility to be consumed by aquatic organisms [4].

Microplastic can be classified according to its morphological characters, namely size, shape, and color. A large ratio of surface area compared to the volume of a small particle makes microplastic potentially release chemical quickly [1][5]. Microplastics exist in the environment such as water, soil, freshwater, and sea. In the sea, microplastic is found on the beach, shallow waters to deep waters. Microplastic accumulated in high amounts over the seawater and sediment [6].

The primary source of plastic waste found in Jakarta Bay is waste carried by the river flow. There are 13 rivers in Jakarta emptying into the Jakarta Bay. The physical and chemical conditions of river water decreasing the size of plastic waste into microplastic [7]. Microplastic from 7 river estuaries of Jakarta Bay accumulates more at sea surface [6]. The average abundance of microplastic (films,
fibers, fragments, pellets) on the outermost mangrove boundary is approximately 18.405-38.790 particles/kg dry sediment [8]. It contaminates all marine biota for example, in benthic animals and pelagic fish [2][8]. Furthermore, the aquatic organism can survive and accumulate microplastic through the food chain so that the pollutant can endanger human health. The groups of animals most affected by marine waste are mammals and fish. Fish found in Jakarta Bay and Kepulauan Seribu are grouped as demersal fish (fish species whose habitat is at the bottom of the waters) and pelagic fish (groups of fish that inhabit the surface layer to water bodies). Demersal and coral fish in the waters of the Kepulauan Seribu are dominated by Caesionidae, Nemipteridae, Pomacentridae, Labridae, and Lethrinidae [9]. Meanwhile, small pelagic fish commonly found like mackerel (Rastrelliger brachysoma), banyar (Rastrelliger kanagurta), trevally (Selar crumenophthalmus), yellow travelly (Selaroides leptolepis), green travelly (Atule mate), Blackbanded Amberjack (Megalaspis cordyla), goldstripe sardine (Sardinella gibbosa), Threadfin (Ambliggaster sirm), and anchovy (Stolephorus sp.) [10], and among demersal fish like snapper (lutjanus sp.) and grouper (Epinephelus sp.), microplastics are also found in their digestion tracts [11]. This study aimed to determine the presence of microplastics of various sizes of fishes in Jakarta Bay.

2. Methodology.

2.1 Procedure

Nineteen fish samples were obtained from fishermen in Jakarta Bay. Fish samples were put into an icebox and then taken to the laboratory of Research and Development Center of Enviromental Quality and Laboratory. Fishes were grouped by size, namely: small fish with a length of 13-24 cm, medium fish 25-36 cm, and large fish 37-90 cm (figure 1). Whole fishes were individually weighed, measured, and then cleaned. The digestive tract (from oesophagus to the anus) was taken and put into the glass beaker. A solution of HNO₃ + HClO₄ (1:5) was added into each beaker until the sample was submerged and left for 24 hours. Observation of microplastic was conducted visually under a stereo microscope for identifying microplastics [12].

Microplastics found were grouped into three types based on their shape and features, namely fragments, fibers, and films, then they were counted manually [13]. The film is a secondary plastic polymer derived from the fragmentation of plastic bags or plastic packaging and has the lowest density. Fiber is a plastic that extends and comes from the fragmentation of monofilament fishing nets, ropes, and synthetic fabrics. Fragments are the result of pieces of plastic products with very strong synthetic polymers [14].

Figure 1. Fish measurement and digestive tract observation.
3. Result and Discussion

Fishes caught in Jakarta Bay in this study, 25 fish samples, namely, Siganus sp., Albula forsteri, Lutjanus sp., Parastromateus sp., Plicofollis argyropleuron, Pampus argenteus, Paraploitosus albilabris, Sardinella fimbriata, and Platyecephalus indicus, 19 of them found to be contaminated by microplastic as shown in their digestive tract. Those contaminated fish, further are classified into small fish and contaminated as high as 24% of the total sample. The rest are medium fish, contaminated at a rate of 33%, meanwhile, the large fish, contaminated at a rate of 43%. It is apparent that the amount of microplastic found correlates proportionally to the size of the fish. Classification of fish size contaminated by microplastic is presented in figure 2.

![Figure 2](image)

**Figure 2.** Fish size grouping as contaminated by microplastics.

There may be a good correlation between the microplastic presence and fish-eating habits. As a matter of fact, microplastics are more commonly found in larger fish as compared to small fish due to the fact that a large fish predates the smaller fish. Smaller fish, in general, can be plankton-eating fish, benthos-eating fish, such as stickleback fish, may consume microplastic found in sediments. Moreover, smaller fish like planktivores such as shiner may consume microplastic suspended in the water column, and possibly also consume the microplastic found in sediments. As a result in the case of larger fish, accumulation of microplastic is probably influenced by a larger volume of feed, since large fish are peak predators in nature, and consume microplastic containing smaller fish [15] [16]. The type of microplastic found in the digestive tract of fish samples, namely fiber, and fragments, is the same type of microplastic found in shells, seawater, sediments, and fish Anodontostoma chacunda (herbivorous), as reported by several studies [2] [7]. Percentage of microplastic type found according to various sizes of fish are variable and the value is presented in figure 3.
Microplastics found were grouped into three types, namely fragments, fibers, and films (figure 3). It was evident that fiber types dominated the microplastic form as many as 73%, followed by 18% film type, and 9% fragments type (table 1). Overall, the larger the size of the fish, the more microplastics of all types are found (refer to figure 3). Various types of microplastics encountered in this research are presented in figure 4.

Table 1. Percentage microplastic types found based on fish size

| Size of fish | Fragments | Fiber | Film |
|--------------|-----------|-------|------|
| Small        | 8         | 48    | 15   |
| Medium       | 12        | 112   | 27   |
| Large        | 16        | 137   | 32   |
| Total        | 36        | 297   | 74   |
| %            | 9         | 73    | 18   |

In general, all microplastic type are found in the digestive tracts appeared to be in the same trend across all fish size. The larger the size of fish the higher the microplastic content of all types (figure 3). This fact indicates that there is bioaccumulation occurring in the food chain. Microplastic
contaminated fish show signs of behavior change or even cause death [17]. Microplastic contamination in the digestive tract of fish will cause digestive problems which will eventually cause stress on fish. While plastic in the digestive tract is likely to decompose into microscopic size, which is easier to translocate and enter into intestinal tissue and then transported into the circulatory system [18]. The risk of microplastic contaminants originating from microplastics in the environment will reach humans through the food chain[19][20].

Bioaccumulation of microplastics occurred when fishes ingest a prey that already contains microplastics. In this study, small fishes were found in the belly of a large fish. This is what causes the potential for high microplastic contamination in large fish and this result is in accordance with [21] which describes bioaccumulation through the food chain model. However, there is no definite value about the amount of bioaccumulation or biomagnification in microplastics ingestion, especially the cause of lower food absorption, reduced energy reserves and effects on other physiological functions. It is also reported that the lowest microplastic concentration has affected marine organisms exposed to water much higher than the levels measured in seawater [22]. Fish that consumed microplastic (polyethylene fragments) show signs of stress until death and this associated with microplastic contamination[17].

4. Conclusion
In general, it can be concluded that all microplastic types are found in the digestive tracts of fish which is indicated to be in the same trend across all fish sizes. The larger the size of fish the higher the microplastic content of all types. The types of microplastic found in the digestive tract were fiber (73%), films (18%) and fragments (9%).

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