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Microplastics Ingestion by Fish in The Pangandaran Bay, Indonesia

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ABSTRACT

This study investigated the occurrence of microplastic particles in the digestive tracts of fishes from Pangandaran bay. The fish were collected by local fisherman. A total of 18 fish representing 2 species (*Trichiurus sp.* and *Johnius sp.*) were examined for microplastics. In total, 193 microplastic particles were found in the gastro-intestinal tracts of all fishes. Microplastic particles were categorized as fragment (49.74%), fiber (22.8%), and film (27.46%), with size ranging from 0.12 to 5 mm. A statistically significant difference existed in the abundance of microplastic ingestion among the two species. The results of this study provide the first evidence of microplastic contamination in fish in Pangandaran bay.

***Keywords*:** Commercial fish, Ingestion, Microplastics, Pangandaran, *Trichiurus*, *Johnius*

1. INTRODUCTION

Global marine litter is dominated by plastic in the ocean (Jambeck *et al*., 2015; UNEP, 2014). Plastic production is between 4.8 to 12.7 million metric tons (MMT) of plastic waste that goes into the sea (Jambeck *et al*., 2015). Indonesia is 2nd in the contribution of plastic marine litter, between 0.48-1.29 MMT (Jambeck *et al*., 2015). Plastic litter is degraded to micro size and commonly called microplastics (MPs) (Andrady, 2011). Other studies have found MPs in intertidal zones, tidal zones, and coastal areas of Indonesia (Dhamar *et al*., 2017; Intan, Budiarsa and Sitongga, 2015; Ismail, Lewaru and Prihadi, 2018). The existence of microplastic in the sea has a negative impact on marine wildlife (Thevenon and Carroll, 2015; Wilcox,

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Mallos, Leonard, Rodriguez, and Hardesty, 2016). The MPs particles are potential toxic to fish, i.e physical and chemical toxicity, because basically microplastic absorbs addictive substances and other monomers that are toxic (Browne, Niven, Galloway, Rowland, and Thompson, 2013; Mato, Isobe, Takada, Kanehiro, Ohtake, and Kaminuma, 2001). Beside that, the presence of MPs in the body of fish can reduce fish fitness and then lead to death (Tosetto, Williamson, and Brown. 2017; Wright, Thompson, and Galloway, 2013). The MPs can be absorbed by the tissues of the body of the fish which can then be transferred to other higher trophic organisms (Farrell and Nelson, 2013). This is very dangerous if the fish is consumed by humans. The level of plastic pollution and feeding habits are important factors that influence consumption of plastic in fish (Romeo, Pietro, Pedà, Consoli, Andaloro, and Cristina, 2015; Ismail *et al*., 2018; Jabeen, Su, Li, Yang, Tong, Mu, and Shi, 2016). The entry of MPs into the body of the fish is caused by accident or wrong prey (Jantz, Morishige, Bruland, and Lepczyk, 2013; Setälä, Fleming-Lehtinen, and Lehtiniemi, 2014). In global studies, the highest percentage of plastic pollution has been reported in marine fish (68% of selected samples), then pelagic fish, demersal fish and freshwater fish (Abbasi, Soltani, Keshavarzi, Moore, and Hassanaghaei, 2018). Microplastics is found in the digestive tract (GIT) (Jabeen *et al*., 2016; Kolandhasamy, Su, Li, Qu, Jabeen, and Shi, 2018).

This paper aims at evaluating the presence of microplastic in Indonesian sea, so it is necessary to investigate microplastics accumalated in commercial fish, sediments and water columns. The purpose is to show that the existence and the microplastic particles are threat to the marine ecosystems in Indonesia. In this study, MPs pollution was investigated on fish from Pangandaran Bay. The abundance, morphotype and size of plastics are recorded throughout GIT and in the intestines of fish. Our goal is to determine the features of plastic pollution in fish and differences in plastic accumulation between GIT.

2. MATERIAL AND METHODS

a. Sample collection

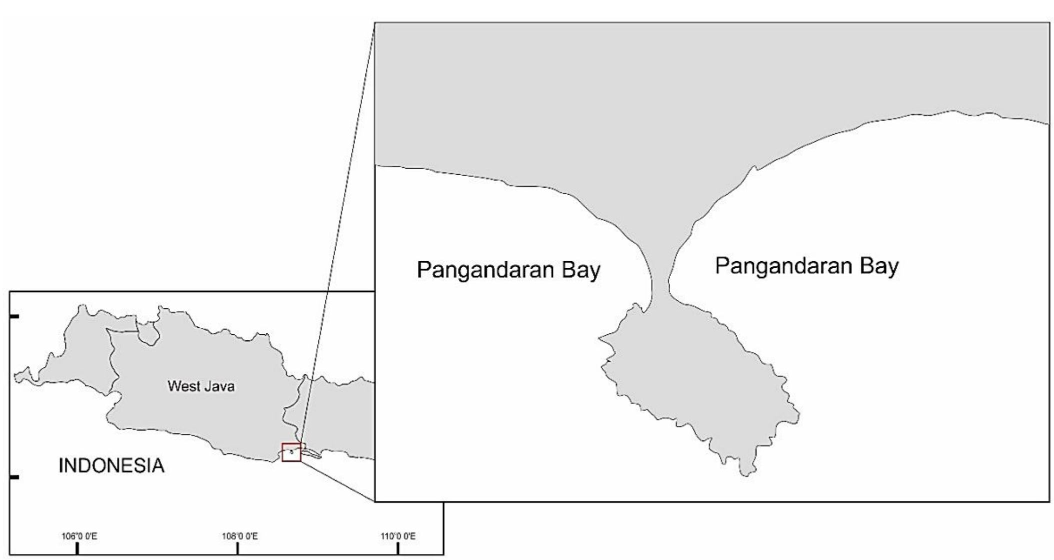


Figure 1. Sample Location

These fishes were collected from the Pangandaran Bay, in Indonesian (Supplementary **Fig. 1**), by local fishermen. A total of 18 fishes collected on April 2018, representing 2 species among other *Trichiurus* sp. and *Johnius* sp. are studied.

The total weight and weight of the fish GIT were calculated, and the total length of each fish was recorded with the accuracy of 0.1 g and 0.1 cm, respectively (Jabeen *et al*., 2016; Romeo *et al*., 2015). Microplastic accumulation was calculated from the intestinal tract and fish stomach or GIT of fish of the location of sample shown in Figure 1.

b. Nitric Acid Solution, Hydogen Peroxide and Fe II (Solution)

The GIT sample was immersed in 20% alcohol, then the fish GIT was crushed with a mixture of nitric acid (65%) with a ratio of 5 : 1. Soaking was carried out for 24 hours in an acidic room. Then the suspension was boiled for 10 minutes and left for 30 minutes (Witte, Devriese, Bekaert, Hoffman, Vandermeersch, Cooreman, and Robbens, 2014). The suspension was then diluted with distilled water, 4 times and filtered with a 0.5 mm filter with a vacuum filtering method. The filtered particles were observed under the stereo microscope (40× magnification). Microplastics were then found of counted types, measurements of length and area of the bridge were done, with the number of particles.

Microplastic methods in these waters can be used to analyze plastic debris as suspended solids in water samples collected by plankton nett, while for processing water samples using a solution of hydrogen peroxide and Fe II. Water samples added 20 mL of a solution of 0.05 M FE (II) to a glass, then added hydrogen peroxide 30%. Then let the mixture stand and close, after being allowed to heat up to 75 ºC on the electric stove for 30 minutes. If organic matter is still visible, add 30% hydrogen peroxide until no natural organic material is seen. Then add 6 g of NaCl per 20 mL of sample to increase water density. Next the last microscope test which is weighing the vial, including the label and stamp; then the samples were identified from the 0.3 mm filter using a monocular microscope to see the number and type of microplastic.

c. Filtration

Saturated salt solution is used as a separation between microplastic and not microplastic by floatation on microplastic. Saturated salt solution, was prepared with a concentration of 1.2 g / mL. Approximately 800 mL of NaCl is inserted into the bottle of the GIT sample, then left for a moment.

The solution is filtered through Wattman paper No. 1 using a vacuum pump. After the filtration process, filter paper is stored in a Petri dish with its lid to observe microplastic particles using a microscope. This procedure has been followed as explained by Van Cauwenberghe and Janssen (2014), and Jabeen *et al.*, (2016).

d. Microplastics Visual Identification

The microplastics particles are assessed visually (Hidalgo-Ruz, Gutow, Thompson, and Thiel, 2012). Microplastics are classified according to Jabeen *et al.*, (2016) and categorized by type into fibers (elongated), fragments (small corner pieces), pellets (round, ovoid), and films (thin, soft, transparent)**.**

e. Statistical analysis

To verify the significant difference between the number of plastic particles and the type of fish, a statistical analysis was performed by using a one-way ANOVA test at a 0.05 level of significance (modified for variant homogenization) using Excel software.

3. RESULTS AND DISCUSSION

3. 1. Size and Weight of Fish

At the time of fishing, fishermen get a variety of fish products. There are only two types of fish which, according to fishermen, are of economic value, or human consumption. This species can represent consumption fish which can be investigated for MPs presence in its GIT. The measured fish yield is presented in **Table 1**, the intestinal weight of *Trichiurus* sp. is around 3.38% of total weight, while the weight of the *Johnius* sp. intestine is around 0.46% of total weight. Microplastic was found in the digestive tract of all fish with fragments (49.74%), fiber (22.8%), and films (27.46%), with sizes ranging from 0.12 to 5 mm.

Table 1. Number of species caught from fisherman (*n*) together with the average (and minimum and maximum) total lengths (cm), total weights (g), and weight of GIT (g)

n	***Trichius* sp.**	***Johnius* sp.**
	6	12
Total Lenght	$\bar{x}$: 278.8 (200.3 – 440.8)	$\bar{x}$: 175.1 (100.4 – 245.6)
Total Weight	$\bar{x}$: 50.5 (24.3 – 104.5)	$\bar{x}$: 84.4 (25.4 – 160.2)
Weight of GIT	$\bar{x}$: 1.6 (0.61 – 4.73)	$\bar{x}$: 0.4 (0.04 – 1.7)

3. 2. MPs in GIT of Fish

The MPs was found in all sample fish, accumulated in the digestive tract of fish. The total number of microplastic found was 193 particles, of which *Johnius* sp. accumulated more microplastic compared to *Trichiurus* sp. (**Figure 2**). **Table 2** shows that some marine organisms are exposed to microplastic in their digestive tract. In this study, microplastic observations were visualized and differentiated, based on the shape of the microplastic (Abbasi *et al*., 2018; Jabeen *et al*., 2016). Microscopic types of fragments, films and fibers were found in the GIT, but only types of microplastic fragments were found in all digestive tracts of fish.

Figure 3 shows the size of the MPS in the digestive tract of fish not more than 0.5 mm. The type of fiber is the longest of the other types of MPs. The MPs size that accumulates around 0.07 to 0.5 mm (Eerkes-Medrano, Thompson, and Aldridge, 2015). The microplastic color visualized in Figure 3 shows red, black, green and blue.

Table 2. Abundance of microplastics in marine organism from Indonesian

No	Spesies / organism	Feeding Habits	MPs		Location of Fishing	Reference
			Fragmen	Fiber		
1	*Scarus quoyi*	Herbivore	100%	0%	Java Sea	(Ismail *et al.*, 2018)
2	*Chaetodon guttatissimus*	Herbivore	100%	0%	Java Sea	
3	*Priachantus tayanus*	Herbivore	100%	0%	Java Sea	
4	*Valamugil seheli*	Herbivore	95%	5%	Java Sea	
5	*lutjanus lutjanus*	Carnivore	93,29%	6,71%	Java Sea	
6	*Lethrinus atkisoni*	Carnivore	99,39%	0,61%	Java Sea	
7	*Pletorhinchus chrysotaenia*	Omnivore	94,81%	5,19%	Java Sea	
8	Macrofauna	Plankton	100%		Ambon Bay	(Uneputty, 1997)
9	*Epinephelus* sp.	Carnivore	n.a.	n.a. (dominant)	Pelabuanratu bay and ancol bay	(Hapitasari, 2016)
10	*Lutjanus* sp.	Carnivore	n.a.	n.a. (dominant)		
11	Johnius sp.	Omnivore	52,33%	25,78%	Pangandaran Bay	This Study
12	Trichiurus sp.	Carnivore	43,37%	37,66%		

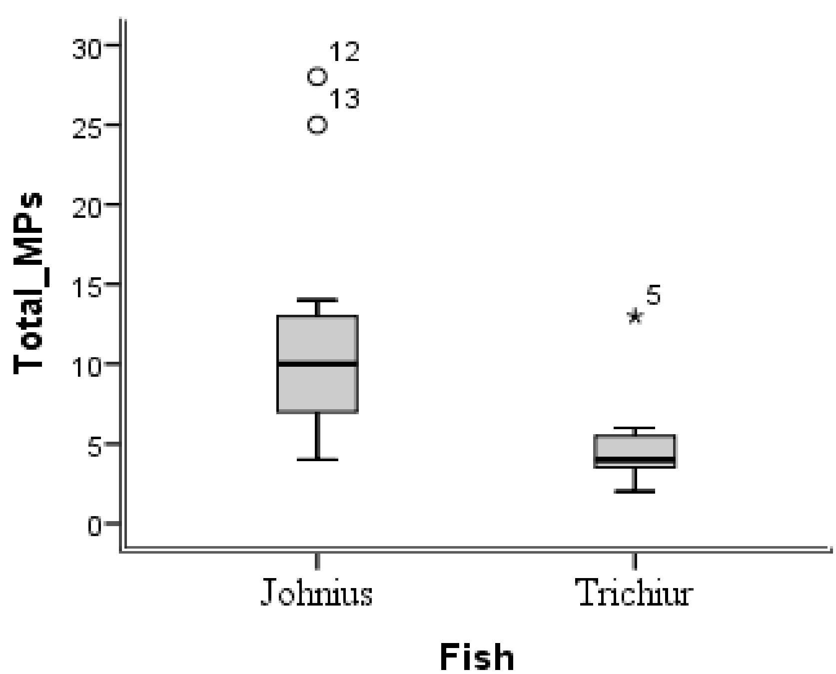
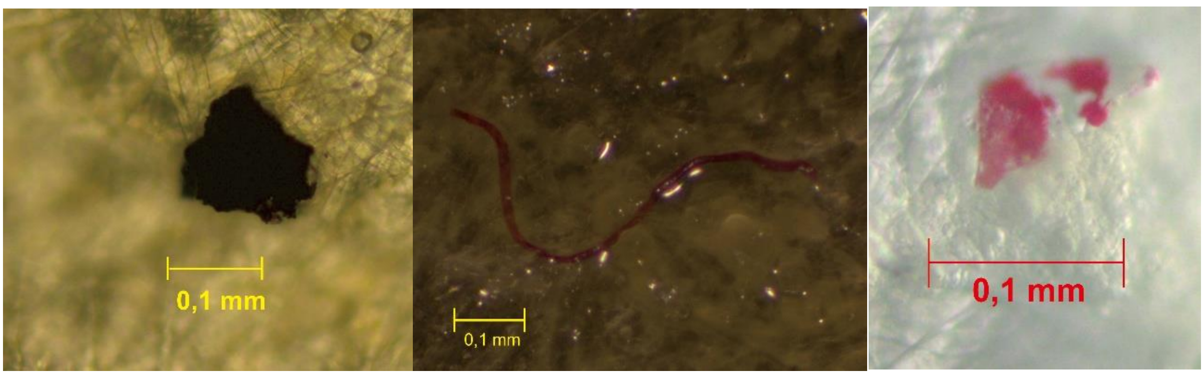


Figure 2. Boxplot Accumulated of *Johnius* sp. compared to *Trichiurus* sp.

The cause of microplastic entry into the digestive tract is due to the wrong prey or accidentally consumed by fish *(Boerger, Lattin, Moore, and Moore, 2010; Kolandhasamy et al*., 2018; Setälä *et al*., 2014). The wrong of preying for these two fish may not be the right reason for microplastic presence in the digestive tract, because these fish are predatory or carnivorous fish. The prey of *Johnius* sp. is a type of crustaceans, while *Trichiurus* sp. is a type of small fish. The most likely there is MPs transfer from the food web (Fanini and Lowry, 2014; Setälä *et al*., 2014).



(a) Film (b) Fiber (c) Fragment

Figure 3. Microplastics types in GIT of Fish

Johnius sp. accumulates more MPs compared to *Trichiurus* sp., even though the two fish are carnivorous fish. This is estimated because it is related to the food habits. Food habits of *Johnius* sp. are crustaceans, while *Trichiurus* sp. is small fish. Crustaceans spend more of their lives in the bottom of the waters, these waters are the site of accumulation of microplastic Graca, Szewc, Zakrzewska, Dolega, and Szczerbowska-Boruchowska, 2017; Munari, Infantini, Scoponi, Rastelli, Corinaldesi, Mistri, and Sea, 2017).

The more microplastic types of fragments are found, this is in harmony with the presence of macro-sized plastic waste around the Pangandaran. The MPs fragments come from macro-sized plastic degradation due to physical or marine chemistry (Wang, Tan, Peng, Qiu, and Li, 2016), whereas the presence of fiber types is thought to originate from fishermen's activities, which come from degraded fishing nets.

There were statistically significant differences in the abundance of *Trichiurus* sp. and *Johnius* sp. fish (0.03 <0.05), so that *Jonius* sp. fish had a higher potential for ingestion MPs.

4. CONCLUSION

Microplastic was found in the digestive tract of all fish, with fragments (49.74%), fiber (22.8%), and films (27.46%), with sizes ranging from 0.12 to 5 mm.

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