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Examination of Microplastic Particles in Reef Fish Food in Ternate Island Waters, Indonesia

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Abstract

Microplastics are pollutants, such as debris from human activities that contaminate several marine biotas and the environment. This research examined the occurrence of microplastic particles in the fish digestive tract in Ternate Island waters, Indonesia. The visual method carried out in the laboratory using a stereo microscope with a magnification of up to 40x was used to identify microplastics in the intestines and stomachs of fish. After observation, the pollutants were systematically counted in the range of 0.3-5 mm based on color, size, number, and shape. They were also classified into: 1) fragments, 2) films, 3) lines/fibers, 4) foams, and 5) pellets categories. Furthermore, six types of fishes including Epinephelus Fuscogutattus, Epinephelus coioides, Epinephelus suillus, Siganus canaliculatus, Synanceia, and Scarus Psittacus were collected from four sites, Kasturian, Kampung Makasar, Mangga dua, and Kalumata between August and September 2019. The results showed 183, represented by 83.18%, of the 220 reef fish individuals studied have ingested plastics. Moreover, a total of 594 plastic particles were found in the digestive tract of which 47.81% were fragments, 38.22% films, 2.69% foams, 2.36% fibers, 7.41% line, and 1.52% of 1.8 to 5 mm sized pellets. The color distribution in all locations include 46.80% transparent, 32.15% black, 5.56% pink, 6.06% yellow, 5.22% blue, and 4.21% red. The findings of this study provide the first evidence of microplastic contamination in reef fishes of the Ternate Island waters littoral zone – Indonesia.

Keywords: Microplastic Particles, Reef Fish Food, Ternate Island Waters, Indonesia

1. Introduction

The increase in global plastic production has led to the pollution of oceans with 4.8 to 12.7 million metric tons (MMT) of plastic wastes, and Indonesia was ranked second among the countries with the highest contribution with 0.48-1.29 MMT (Jambeck *et al*., 2015). Microplastics are generally defined as plastics with a diameter less than 5 mm formed through the decomposition of micro-plastics or abrasive materials used in cosmetics and detonation media (Barnes *et al*., 2009). They have the potential to cause damage and contaminate the marine ecosystem due to the continuous increase in the global production of plastic wastes (Barnes *et al*., 2009); (Jundong Wang *et al*., 2016). Microplastics also cause physical and toxicological damage to the marine organism (Law & Thompson, 2014) and threat to marine biota due to their small size which makes them biologically available for organisms in all food networks (Betts, 2008; Wick *et al*., 2013; Bergmann *et al*., 2015).

Marine fauna in the ocean such as marine invertebrates (Murray & Cowie, 2011), fishes (Boerger *et al.*, 2010; Romeo *et al*., 2015; Davison & Asch, 2011), Zooplankton (Cole *et al*., 2013), Crustaceans (Goldstein & Goodwin, 2013) sea birds (Ryan *et al*., 2009), and mammals (Eriksson & Burton, 2003) ingest microplastics in the water, and this has negative effects on their health. The consumption of these particles reduces the eco-physiological function of the organisms thereby causing physical injuries and physiological stress (Rochman *et al*., 2013). In addition, microplastics are prone to contamination by toxic organic pollutants in water (Bakir *et al*., 2014; Rowland *et al*., 2016), which after being ingested enter the food chain to cause bio-magnification (Farrell & Nelson, 2013; Setälä *et al*., 2016).

The contamination of waters areas by microplastics has been reported in Cilacap Gulf with 2.5 mg m^3 concentration (Syakti *et al*., 2017), Jakarta Gulf (Manalu *et al*., 2017), and small islands in Bintan Regency, Kepulauan Riau Province (Syakti *et al*., 2018). The particles currently existing in the Java sea are assumed to have originated from the South China Sea and the Pacific Ocean (Handyman *et al*., 2019). Meanwhile, the microplastics found in the Spermonde Islands of Makassar Gulf were contaminating seagrass beds (Tahir *et al*., 2019) and Muara Jagir of Surabaya City (Firdaus *et al*., 2020). The fishes from *Trichiurus* sp. and *Johnius* sp. were also reported to have ingested microplastics in Pangandaran Gulf (Ismail *et al*., 2019) while other pollutions associated with this material have also been discovered in the Karimunjawa national park waters (Lie *et al*., 2018).

Even though the presence of microplastics in the ocean is a serious threat to marine organism, residents of Ternate

Island of North Maluku Province-Indonesia have a habit of dumping plastic wastes into the sea. Previous research showed the Ternate Island sea is dominated by seven plastic types and these are 1) bottles, 2) bags, 3) glasses, 4) packages, 5) spoons, 6) toys, and 7) straps without any focus on microplastic pollution. This present research was, therefore, conducted to fill this gap by examining the presence of microplastic particles in the reef fish digestive tract in the littoral zone of Ternate Island waters, i.e Katurian, Kampung Makassar, Mangga Dua, and Kalumata.

2. Method

2.1. Study Area

The research was conducted at Ternate Island, Maluku Utara Province shown in Figure. 1 which was selected due to the fact that 80% of its area is made of the ocean and the residents' activities are predominantly centered on the waters.

2.2. Tools

The tools used include gloves, straps, scissors, ropes, plastic containers, a small shovel, beakers, tweezers, nails, glass objects, Petri dishes, fishing nets, stereo microscopes, and pencils Jabeen *et al.* (2017).

2.3. Microplastics Separation Procedures

The saturated salt solution used to separate microplastics and non-microplastics through the floatation technique was prepared at 1.2-1.5 g/mL concentration. The process involved the addition of approximately 850 mL NaCl into a sample bottle and left for 10-15 minutes after which the solution was filtered using a Wattman filter paper. This was followed by the placement of the filter paper in a covered petri dish to observe microplastic particles using a microscope. The procedure was in line with the method used by Li *et al.* (2016); Jabeen *et al.* (2017).

2.4. Microplastic Visual Identification

A visual method was used to identify microplastics in fish intestines and stomach. This involved the observation of the particles visually at the laboratory using a stereo microscope with magnification up to 40x after which they were calculated systematically in a range of 0.3-5 mm based on color, size, number, and shape and further classified based on five categories which are 1) fragment, 2) film, 3) line/fiber, 4) foam and 5) pellet (Hidalgo-Ruz *et al.*, 2012; Free *et al*., 2014).

2.5. Data Analysis

Microplastic amounts are presented as the mean values. Microsoft Excel software was used to calculate the percentage value of microplastic density data according to type and fish.

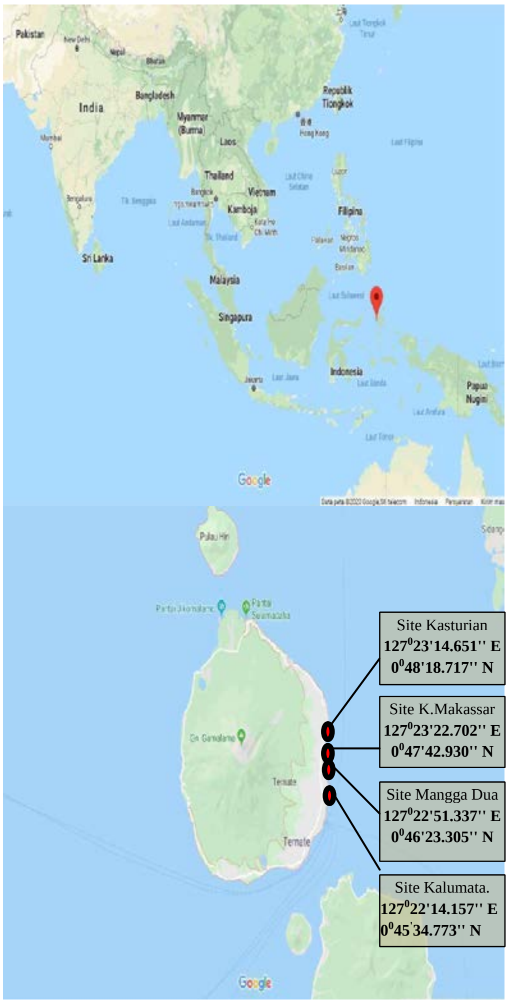

Figure 2. Sample Location (Source: https://www.google.com/maps/; Access March 2020)

3. Results and Discussion

3.1. Microplastic abundance in reef fishes

The results showed 183 individuals, represented by 83.18%, of the 220 reef fishes examined had ingested plastics as shown in Table 1. The six types of fish studied include *Epinephelus Fuscogutattus, E. coioides, E. suillus, Siganus canaliculatus, Synanceia*, and *Scarus Psittacus*. Moreover, a total of 594 plastic particles were found in the digestive tract out of which 47.81% were fragment, 38.22% film, 2. 69% foam, 2.36% fiber, 7.41% was line, and 1.52% pellet ranged between 1.8 and 5 mm as presented in Figure. 3.

Table 1. The Number of Reef Fishes that have Ingested the Microplastic Waste in Ternate Island Waters

Fish Species	Number of Samples	Number of Fish that Ingested Microplastics	Number of Microplastics based on Shape						Total
			Fragment	Film	Foam	Fiber	Line	Pellet	
Epinephelus fuscogutattus	29	23	37	32	3	5	12	0	89
Epinephelus coioides	36	31	64	24	0	5	2	0	95
Epinephelus suillus	65	56	60	14	3	2	17	2	98
Siganus canaliculatus	47	35	43	67	2	2	1	1	116
Synanceia	27	27	62	78	4	0	12	4	160
Scarus Psittacus	16	11	18	12	4	0	0	2	36
	220	**183**	**284**	**227**	**16**	**14**	**44**	**9**	**594**

Based on the types of fish, *Synanceia* was found to have ingested 26.94% and *S.canaliculatus* 19.53%. Moreover, 89 plastic particles were discovered in the digestive tract of *E. fuscogutattus*, 95 in *E. coioides*, 98 in *E. suillus*, 116 in *S. canaliculatus*, 160 in *Synanceia*, and 36 in *S.Psittacus* as shown in Table 1 and Figure. 2.

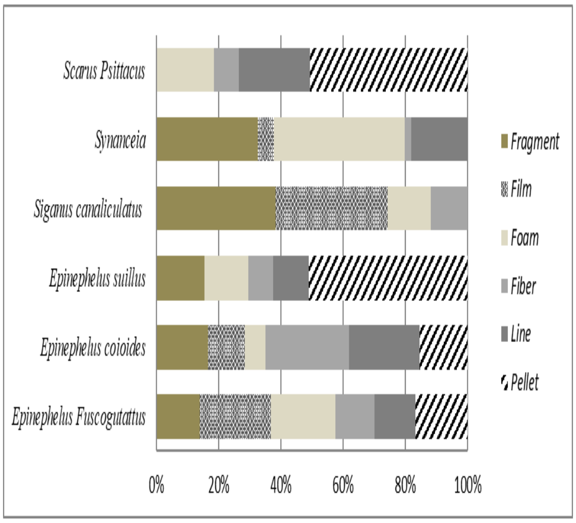

Figure. 2. Percentage of microplastic particles ingested by fish

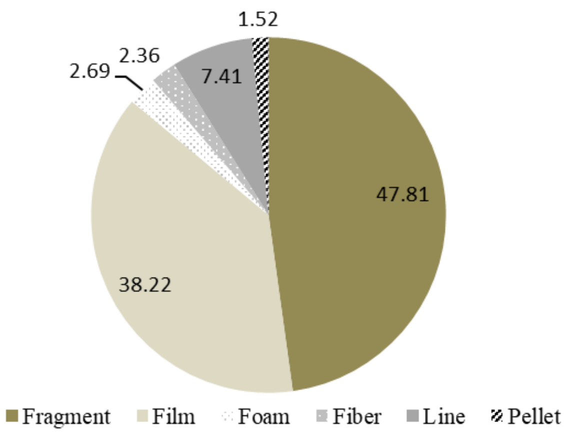

Figure 3. Total Percentage of Microplastic Type ingested by fish

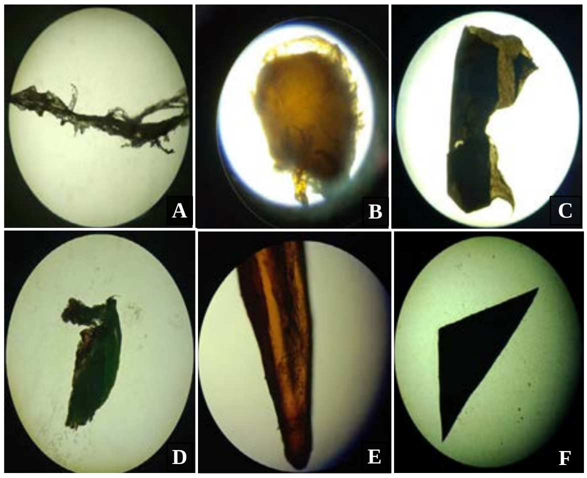

Figure. 4. The Stereo shape of microplastic; (A) Pellet (B) foam, C) film, (D) Fiber, (E) line, (F) fragment

The colors of microplastic particles ingested by *E. fuscogutattus* fish were found to be transparent with 53.93% followed by black with 26.97%, pink with 13.48%, yellow with 3.37%, and blue and red with 1.12%. Meanwhile, *E. coioides* ingested 33.68% transparent, 28.42% black, 13.68% blue, 15.79% red, 6.32% yellow, and 2.11% pink. *E. suillus* had 57.14% transparent, 34.69% black, 2.04% pink, 1.02% blue, 3.06% yellow, and 2.04% red. Moreover, *S. canaliculatus* ingested 58.62% transparent, 36.21% black, 1.72% pink, 2.59% blue, 0.86% yellow, and no red color was recorded. In *Synanceia,* 41.88% transparent, 25.63% black, 8.13% pink, 7.50% blue, 14.38% yellow, and 2.50% red were recorded. Finally, *S. Psittacus* was recorded to have 19.44% transparent, 63.89% black, 5.56% pink, 2.78% blue, and 8.33% red without any yellow particle as shown in Figure. 3. The total color distribution of microplastics ingested by the reef fishes in all sites includes 46.80% transparent, 32.15% black, 5.56% pink, 6.06% yellow, 5.22% blue, and 4.21% red as shown in Figure. 4.

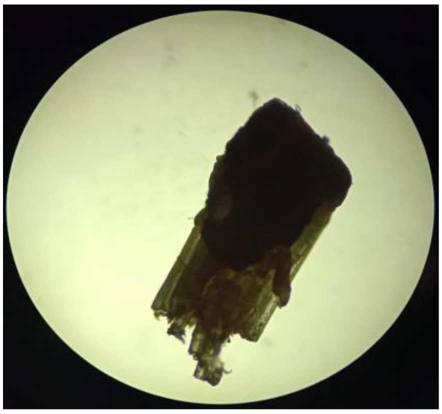

Figure. 5. Color distribution of microplastics ingested by five types of fish

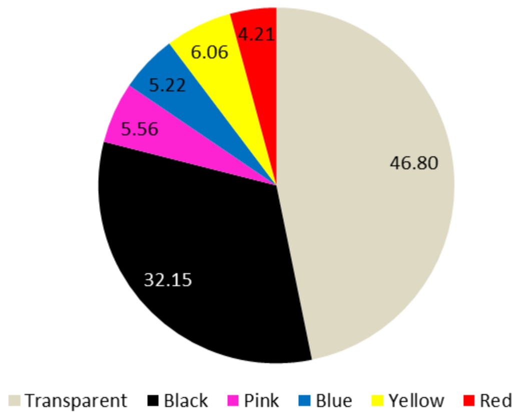

Figure. 6. Color distribution of microplastics ingested by fish in all locations

4. Discussions

The result showed the microplastic particles found in the digestive organelle and stomach of reef fishes in the Ternate Island waters littoral zone were likely from several plastics dumped into the ocean by humans and later consumed by the fishes, which later caused a disturbance in their food network. This is in line with the report that the presence of microplastics in sediments and seawater is caused by human activities such as waste disposal (Ng & Obbard, 2006). It has also been discovered that microplastics are not only in the coastal areas but also in the deepest reach of the ocean, East Atlantic Sea, Asia Sea, and the North Pole (Van Cauwenberghe *et al*., 2013; Lusher *et al*., 2014; Ivleva *et al*., 2017; Wagner & Lambert, 2018; Jun Wang *et al*., 2019; Jamieson *et al*., 2019;)

Microplastics are found by fishes at 200-478 m depth and ingested by zooplankton in shallow waters (Zhu *et al*., 2019; Botterell *et al*., 2019). It has also been reported that they sink and accumulate in sediments causing a risk in the ecological system for benthic communities (Vianello *et al*., 2013; Jun Wang *et al*., 2019). Moreover, chronic exposure to microplastics is seldom deadly but has a bad impact on animals (Galloway *et al*., 2017) due to their ability to cause oxidative and pathological stresses, decrease in body immunity function, cancer, and a change in the chromosome which further leads to infertility and obesity (Sharma & Chatterjee, 2017; Guzzetti *et al*., 2018).

The microplastic colors found in the fish digestive organs were transparent, black, pink, yellow, and red. The most dominant colors were transparent and black while *Epinephelus fuscogutattus* and *Synanceia* fishes mostly had pink and yellow and *Epinephelus coioides* were observed to have ingested mainly blue and red. The data also showed the particles were carried by water and presumed to be embedded in muddy, sandy, and rocky substrates. However, fishes were unable to differentiate between food and microplastic particles in the littoral zone. Moreover, the predominant microplastic shape was the filament type due to its elongated structure and movement in the water. Previous studies showed the proportion of fish with microplastics in their digestive tract has increased over the last 60 years (Nadal *et al*., 2016; Pace, 2018). Moreover, transparent and colored particles have been reported to be dominant in fish intestines (Stolte *et al*., 2015; Hastuti *et al*., 2019) while blue fibers were found in the fish larva (Steer *et al*., 2017).

5. Conclusion

The results showed microplastic particles were found in the digestive tracts of *E. fuscogutattus, E. coioides, E. suillus, S. canaliculatus, Synanceia*, and *S. Psittacus* collected in four locations in Ternate Island waters – Indonesia littoral zone. The particles ingested were discovered to be fragment, film, foam, fiber, line, and pellet while the colors were transparent, black, pink, yellow, blue, and red. Therefore, further research is recommended to examine and evaluate the microplastic pollution level in deeper sea biota. The sample size should also be increased by including other fish types in future studies. For practical application, the local government needs to manage its coastal environment through a community-based approach to reduce the plastic-type pollution in the Ternate Island waters, Indonesia.

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