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MICROPLASTIC CONTAMINATION AROUND CORAL REEFS DIVING SPOT IN TIDUNG ISLAND, KEPULAUAN SERIBU, JAKARTA

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Abstract: Research on microplastic in coral ecosystems in Indonesia is infrequent. This research will observe Microplastic on the coral reef dive tourism in Tidung Island, Kepulauan Seribu, Jakarta Bay. The number of microplastics varied between 60 to 340 particles/kg dry weight. Fiber was the most microplastic type found in all stations; it ranged from 67% to 100%. Size of microplastic found in this study ranged <100 to >1100 μm. We found four types of polymers (polybutylene, polyethylene, polypropylene, and polyester) with the highest percentage of polyethylene at 61.76%. We assume that microplastics observed in coral reef sediment on Tidung island originated mainly from anthropogenic sources. Waste management must be tightened and enhanced in the Kepulauan Seribu and neighboring areas, such as the western area of Java Island and its adjacent areas.

Keywords: anthropogenic, diving spot, microplastics, polyethylene, Tidung island

1. INTRODUCTION

Plastics are affordable, lightweight, and strong materials (Thompson et al., 2009) for use in packaging food, beverages, and other products because of their food safety and long-term shelf (Geijer, 2019). Over half of the estimated 7.8 million tons of plastic debris produced annually in Indonesia is unmanaged (World Bank, 2021) that is potential to accumulate in aquatic habitats both directly and indirectly. Sources of plastic pollution from land (settlements, households, and other activities) and the sea (tourism, port operations, fisheries, etc.) (Thushari & Senevirathna, 2020) significantly contribute to pollution in coastal and marine ecosystems through in-situ and ex-situ pathways (Tekman et al., 2022).

Plastic is degraded through several processes. Plastic polymers absorb ultraviolet (UV) through a photooxidative process, causing the polymer chain to break and the molecular weight to decrease (Yousif & Haddad 2013). In addition, plastic degradation can occur due to microorganisms (Gaur et al., 2022). Plastic waste can be classified according to its size as mega plastic, macroplastic, mesoplastic, microplastic, and nano plastic. Microplastics are plastic particles that size less than 0.5 cm (Cordova, 2018) which have penetrated practically every possible aspect of land and marine ecosystems, such as mangrove ecosystems (Li et al., 2019; Cordova et al., 2021; Duan et al.,2021) seagrass ecosystems (Bonanno & Orlando-Bonaca, 2020; de los Santos et al., 2021; Dahl et al., 2021); and coral ecosystem (Jeyasanta et al., 2020; Patti et al., 2020; Tan et al., 2020).

Indonesia is home to the largest coral reef ecosystem in Southeast Asia. Diverse estimates indicate the total size of these coral reefs at around 51000 km^2. Indonesia's coral reefs are among the most biologically diversified in the world. Over 590 kinds of coral have been discovered in Indonesian waters (Asian Development Bank, 2014). Coral ecosystems must be conserved due to the number of corals in Indonesia. When this plastic enters the marine environment, it negatively impacts the habitat and the creatures that inhabit it. Plastic particles infiltrate the bodies of animals by posing as food (Bhatt et al., 2021). Microplastic buildup disrupts their digestive systems by blocking the intestines of various aquatic animals (Thiel et al., 2018). Microplastics within the coral body may inhibit algal cell multiplication and density and hinder detoxification, nutrient absorption, and photosynthesis. In addition, they may increase oxidative stress, apoptosis, and ion transport in numerous critical endosymbionts (Soares et al., 2020). Kepulauan Seribu national park is close to the densely populated cities of West Java. As Tidung Island is part of the Thousand Islands, a popular diving destination, it is vital to preserving the coral reef ecosystem from contaminants, including Microplastic. Several studies have conducted microplastic research in coral reefs (Cordova et al., 2018; Zhang et al., 2019; Jeyasanta et al., 2020; Sabdono et al., 2022). However, few microplastic studies have been conducted in the diving region, even though it is a commercial sector. This study aims to analyze the occurrence and characteristics of microplastic contamination around the coral reef diving spots on Tidung Island because it is close to the densely populated capital city. This research is supposed to provide information on the status of microplastic pollution in the seas so that the citizens and the government know the importance of preserving the environment by appropriately managing plastic debris.

2. MATERIALS AND METHODS

2.1. Study area

Tidung Island is one of the small islands in Kepulauan Seribu, located approximately 50 km from Jakarta bay which is categorized as a flat island whose surface is formed from coral sand. With a width of 200 m and a length of 5 km, Tidung Island is divided into two parts, namely Tidung Besar and Tidung Kecil, connected by a bridge. Tourism and settlement are typical for Tidung Besar Island with around 4000 inhabitants, while nature conservation is priority at Tidung Kecil Island. So, the area of Tidung Island is separated into three zones: residential, nature conservation, and usage.

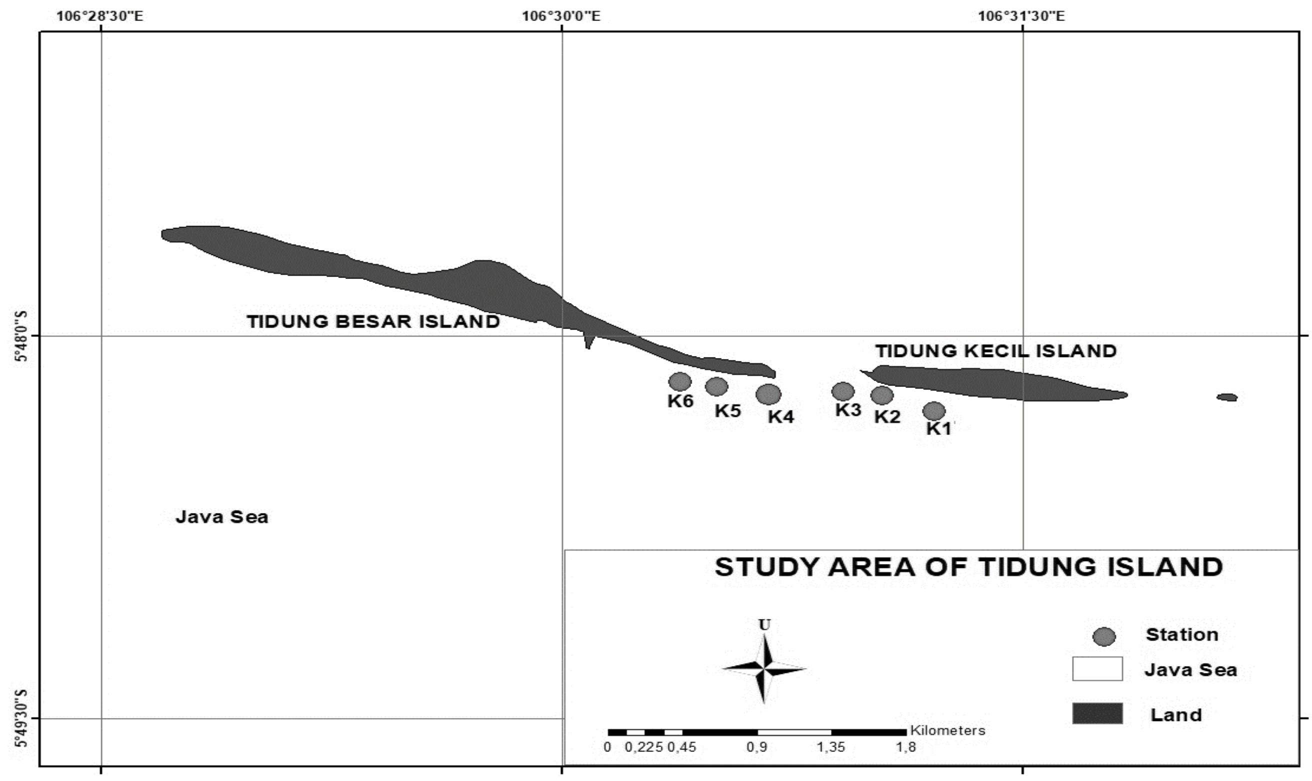

Figure 1. Location of Tidung Island with six sediment sampling sites

2.2. Sampling, sample treatment, and microplastic identification

Six sediment samples from the uppermost five centimeters were taken to analyze microplastics (Patterson et al., 2020; Figure 1). Following the methodology of Cozzolino et al., (2020), microplastics were recovered from dried sediment at a temperature of 40°C. It took 24 hours to extract 50g of dry sediment using 200 mL of $ZnCl_2$ at a concentration of 1.4 g/mL (He et al., 2022). The sample was homogenized for 10 minutes at a speed of two hundred revolutions per minute to ensure it was mixed correctly. Samples were transferred to a beaker glass, then 30% H_2O_2 and Fe(II) SO_4 were each added in a volume of 20 ml. The samples were kept in a water bath at 40°C for a full day (Patterson et al., 2020). After the sample became clear, it was filtered using sterile filter paper with a diameter of 47ml and a pore size of 0.4 mm (Falahudin et al., 2020). Samples were dried at 40°C for three hours. Finally, the samples were examined with a microscope (Nikon Eclipse Ni-U) and a camera (Nikon DS-L4) from Nikon (Cordova et al., 2022). Particles can be distinguished based on their type, size, and color. In the last step of the process, microplastic samples were analyzed using an annular total reflection–Fourier transformation infrared spectrometer (ATR-FTIR, diamond crystal material, Thermo Fisher Scientific Nicolet TM iS5 with Micro Lab FTIR software). The FTIR measured with a resolution of 4 cm, 32 scans, and a spectral range that extends from 650 to 3000cm^{-1} (Cordova et al., 2022).

2.3. Quality Assurance and Quality Control (QA/QC)

Microplastic studies are seriously affected by contamination. The source of contamination in sampling can come from clothing, so it is advisable to use clothing made from cotton or nitrile during research, in addition to using latex gloves (Bagaev et al., 2018; Cutroneo et al., 2020) The use of latex gloves and clothing is recommended to use recognized colors to find out the possibility of contaminating microplastics (Bagaev et al., 2018).

Microplastic contamination also comes from the air, so this research is highly recommended to be carried out under laminar flow (Tamminga et al., 2018). Environmental control of microplastic contamination in the air can also be carried out by providing blank filters placed in open Petri dishes at laboratory research locations. This blank filter was also observed under a stereomicroscope as the sample obtained to confirm it (Barrows et al., 2017). Another negative control can also observe the aqudest (distilled water) used and compare it with the sample (Cutroneo et al., 2020). All glass containers are washed with distilled water, covered with aluminum foil, and heated at 300°C (González-Pleiter et al., 2020).

2.4. Data Analysis

Origin 2018 64 Bit software and PAST4 software (Knibbe, 2008) were used to perform statistical analysis and create plot graphs. The visual representation interprets the microplastic's shape, color, and size using Origin 2018 64 Bit. The statistical tests (Kruskal-test and Dunn's Post Hoc) were declared significant at a P value of 0.05 using PAST4 software.

3. RESULT AND DISCUSSION

Microplastics were detected in all stations (Figure 2). The average abundance of microplastics found was 180 particles/kg. The results of this study were higher than research by Cordova et al., (2018)

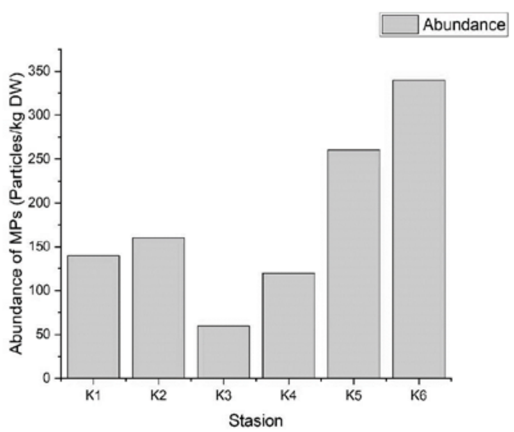

Figure 2. Microplastic Abundance in Coral Sediment

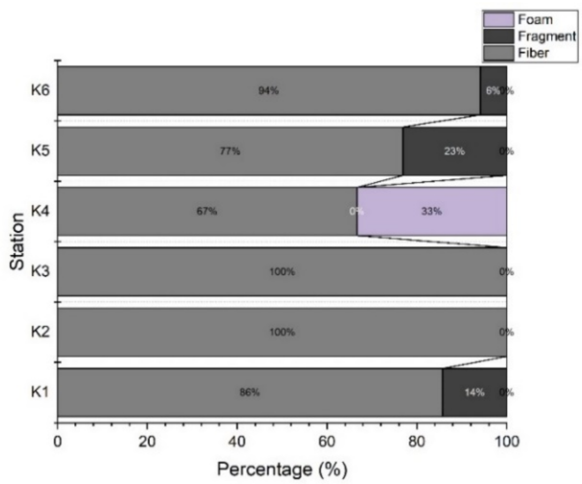

Figure 3. Percentage of Microplastic Type

35-77 particles/kg and Utami et al., (2021) 40-90 particles/kg, however, lower than Yeemin et al., (2018)219-595 particles/kg. Some of microplastic research in coral sediment were state in Table 2. The number of microplastics was 60 to 340 particles/kg dry weight. As shown in Figure 2, station K 6 had the highest concentration of microplastics (340 particles/kg DW), while station K3 had the lowest concentration (60 particles/kg DW).

We classified microplastics into four groups: foam, fragment, fiber, and granule, although we did not find granule-type microplastics in our research. There were significant differences in this study between the type of microplastics especially between fragments and fibers, and between foams and fibers ((Kruskal-test, Wallis's $p < 0.001$; Dunn's Post Hoc, $p < 0.05$). The type of microplastic found was dominated by fiber, with a proportion of 67% to 100% (Figure 3). Two stations, K2 and K3, discovered only fiber. Fragments and foam were only found in small amounts (fragment: 6-23%; foam: 0-33%). The foam was detected at station K4, whereas fiber and fragment types were discovered at stations K1, K5, and K6. Cordova et al., (2018) had the opposite result with our result that found high fiber and less foam. In accordance to Yoswaty et al., (2021), microplastics were found in sediment, water, and digestive system of fish. The type of microplastics were dominated by fiber. Microplastic fiber released during washing and fishing ropes (Tien et al., 2020). This opinion was reinforced by Peng et al., (2017) which found fiber in sediments originating from clothes washing waste. Sources of fiber can also come from fabrics made of cotton and cellulose (rayon) which are widely found in aquatic environments (Cincinelli et al., 2021). Microplastic fiber made from a mixture of natural and synthetic materials are considered microplastics because they have an adverse effect on biota in the aquatic environment (Dris et al. 2016). Microplastic fiber types can also be sourced from the air, which is distributed through the wind (Dris et al., 2016; González-Pleiter et al., 2020).

The size of microplastics was divided into seven size categories; they were <100 μm; 100-300 μm; 300-500 μm; 500-700 μm; 700-900 μm; 900-1100 μm; and >1100 μm (Figure 4). Microplastics >1100 μm were the most often found at each station. The highest percentage of microplastics was 67%, reached by station K3 (300-500 μm) and station K5 (>1100 μm). There was no significant difference in the size of microplastics in each station (Kruskal-Wallis's test, $p < 0.001$; Dunn's Post Hoc, $p < 0.05$). This study found a microplastic size of less than 100 μm, but another study (Table 2) did not find a size of less than 100 μm. The size of microplastic is an important characteristic to determine the possibility of accumulating in biota so that it has the potential to enter the human food chain (Firdaus et al., 2020). Microplastics with a size of 0.2–0.6 mm were found in the liver of Mugil cephalus fish (Avio et al., 2015) and 0.1–0.5 mm in oysters (Jahan et al., 2019). Research by Huang et al., (2020) found microplastics with a size of 0.02–1 mm in several benthic and pelagic biota that live in mangrove ecosystems such as *Amoya chlorostigmatoides*, *Acanthopagrus latus*, *Arriusleioteto cephalus*, *Acentrogobius viridipunctatus*, *Cynoglossus puncticepticeps*, *Osteomugil ophuyseni*, *O. stronylophalus*, *Tylosurus melanotus*, etc. Goldfish are not interested in preying on microplastics that are larger than 2 mm, even when ingested these microplastics will be excreted (Xiong et al. 2019). Microplastics with a size of 1 to 5 mm were found in *Chlamys farreri* scallops in the anal, intestinal and kidney organs more than other tissues (Sui et al., 2020).

We found varied microplastic colors. They were blue, black, red, transparent, white, gray, green, gold, and brown, with blue, black, and red being dominant (Figure 5). The highest percentage of microplastic color was black (57%, station K1). We found 3-7 colors per station, with the highest number at stations K5 and K6. There was no significant difference in the size of microplastics in each station (Kruskal-Wallis's test, $p < 0.001$; Dunn's Post Hoc, $p < 0.05$). Syakti et al,. (2018) stated that the color of microplastics found in waters can attract biota to eat them because the color of microplastics can visually stimulate biota which might be considered to resemble food. The opinion of Syakti et al., (2018) was reinforced by Nelms et al., (2018) which states that black, red, and blue microplastics were prey for *Scomber scombrus* and *Halichoerus grypus*. Green and black microplastics are eaten more by goldfish (*Carassius auratus*) than blue, red, and white (Xiong et al. 2019). Black, transparent, and blue colors were consumed by scallops (*Chlamys farreri*) (Sui et al. 2020).

FTIR spectroscopy determined the chemical composition of 34 of the detected microplastic particles. We randomly select particles with a uniform shape and size distribution across all samples. All 34 particles were identified as being made of a synthetic polymer. We identified four different polymers (Table 1). They were polybutylene (5.88%), polyethylene (61.76 %), polypropylene (20.58%), and polyester (11.76%). Polyethylene was the highest percentage of all the samples. Polyethylene is the most prevalent synthetic material used to replace cotton/hemp in the production of industrial fishing equipment such as ropes, net cages, gill nets, and purse seines (Yu et al., 2019). There are two types of polyethylene, High-density polyethyle(HDPE) is utilized for milk bottles, and low-density polyethylene (LDPE) is utilized for

Table 2. Comparison of Properties of Microplastics Found in Coral Sediments according to Different Sources

Location	Range of Abundance (particles/kg)	Type	Color	Size Range (μm)	Polymer	Reference
Tidung Island, Indonesia	60-340	foam, fragment, and fiber	blue, black, red, transparent, white, gray, gold, green, and brown	<100 - >1100	polybutylene, polyethylene, polypropylene, and polyester	This study
Sekotong, Lombok, Indonesia	35-77	foam, fragment, granule	-	<200- >5000	polystyrene, polypropylene, and polyethylene	Cordova et al., 2018
Rameswaram Island, India	259 ± 88	fiber, fragment, foam, film	transparent, blue, white, yellow, black, red, brown, and green	<1000-5000	polyethylene, polypropylene, polyethylene terephthalate, polyamide, cellophane, polyurethane, polyester, polystyrene, polyvinyl acetate and polyvinyl chloride	Jeyasanta et al., 2020
Mu Ko Similan National Park, Thailand	219-595	-	-	500-1000	polypropylene, polyethylene	(Yeemin et al,. 2018)
Java Sea	40-90	fiber, fragment, film	blue, black, red, white, and transparent	125 µm - 5 mm	polypropylene	(Utami et al., 2021)
Marine Protected National Parks of Gulf of California, Mexico	-	fiber, fragment, spheres	white, others, transparent, blue, black, pink and red	-	polypropylene, polyethylene terephthalate, high-density polyethylene (HDPE), low-density polyethylene (LDPE), polystyrene, polycarbonate, polyurethane and rayon	(Arreola-Alarcón et al., 2022)
Reef sediments, Vembar Group of Islands, Gulf of Mannar	154 particles	fibet, pellet, fragment, and film	White, Green, Blue, Red, Black, and White	<1 mm	polypropylene, polyethylene, polystyrene, and nylon	(Pradhap et al., 2023)

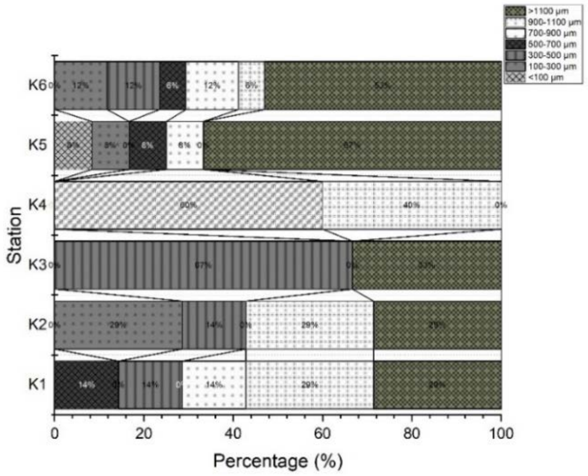

Figure 4. Percentage of Microplastic Size

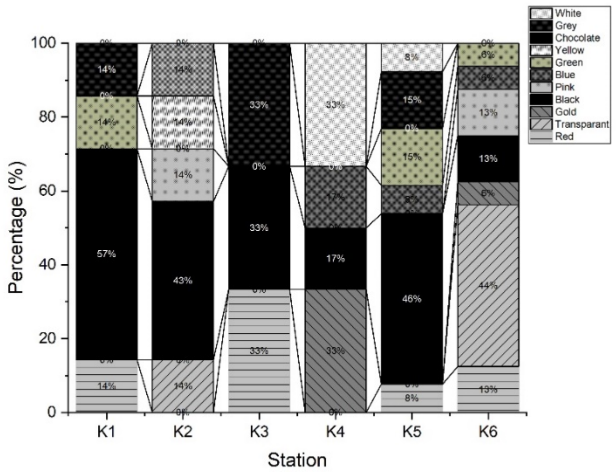

Figure 5. Percentage of Microplastic Color

storage bottles and packaging material (Chappell et al., 2022). Other polymers of microplastics found were polybutylene, polypropylene, and polyester. Polybutylene is widely used in the transportation and electronics industries (Barhoumi et al., 2008). Polypropylene is frequently used in home applications such as lids for plastic bottles, yogurt containers, and lunch boxes. It is one of the fastest growing polymers because it is a robust and rigid plastic whose molecular weight may be adjusted and which can be made at different crystallinities (Chappell et al., 2022). Polyester is the most widely used synthetic fiber worldwide. Fabrics created from it are strong, resilient, resistant to shrinking, stretching, and creasing, and have a wide variety of uses due to their inexpensive cost. Polyester fibers are mainly used for clothing but also in home furnishings and several industrial uses (Manshoven et al., 2021).

Table 1. Polymer Types of Microplastic in the Samples of Coral Sand

Polymer types	Sediment	
	Total samples	**%**
Polybutylene	2	5.88
Polyethylene	21	61.76
Polypropylene	7	20.58
Polyester	4	11.76

Based on our study, the source of microplastics around coral reef diving spots mostly comes from fishing and washing clothes due to the discovery of lots of fiber, long microplastic sizes and lots of polyester and polyethylene polymers. These findings may pose a threat of microplastic contamination to organisms inhabiting this area. To determine microplastic pollution in coral reef regions, conducting additional, in-depth research on microplastics in water, sediment, and organisms is essential. In this case, we strongly advise that plastic waste management must be tightened and improved in the Kepulauan Seribu and other regions, such as the western region of Java Island and its bordering regions, especially on polybutylene, polyethylene, polypropylene, and polyester plastic waste.

4. CONCLUSION

This study observed the occurrence and characteristic microplastic that contaminated Tidung Island around the diving spot. The following findings that have been obtained were all sampling areas had contaminated microplastics, the average abundance of microplastics was 180 particles/kg, the types of microplastic found were foam, fragment, and fiber, there were ten colors of microplastic that were to be found (blue, black, red, transparent, white, gray, green, gold, and brown), size of microplastic found in this study ranged <100 to >1100 μm, and there were four polymers that were to be found (polybutylene, polyethylene, polypropylene, and polyester).

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