

## Identification of Microplastics in The Outer Ambon Bay, Mollucas

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### Abstract

Marine plastic debris that enters the sea can be fragmented by physical and chemical factors, then float in the water column or accumulate in sediments, which have the potential to be ingested by marine biota, causing digestive system disorders, fecundity, eating capacity, reproduction, and death. This study aimed to identify the accumulation of microplastics in water and sediments in Outer Ambon Bay using a purposive sampling method and descriptive analysis for data related to microplastics' type, color, and size, as well as follow-up tests of the least significant difference. The results show that the waters of Outer Ambon Bay have been polluted by microplastics. The number of microplastic particles found in water samples at three different depths (0, 50, and 100 cm) was 201 particles L<sup>-1</sup>, and in sediment samples, it was 325 particles g<sup>-1</sup>. It is supported by the fact that the type of fiber has a thin shape and size and can float on the surface of the water and by the existence of beaches where there are fishing activities, boat ports, rivers, and densely populated areas, as well as sandy and muddy sediments that can trap more microplastics during the tidal period. Therefore, it is necessary to prevent the waste problem in the waters of Ambon Bay.

**Keywords:** Identification, Marine Pollution, Microplastics, Outer Ambon Bay.

### INTRODUCTION

Ecologically, Ambon Bay waters have the characteristics of minor island conditions and are usually homogeneous, allowing for multiple uses of resources [1]. Ambon Bay waters are divided into Inner Ambon Bay and Outer Ambon Bay, which are separated by a shallow and narrow threshold known as the Poka-Galala Threshold. Due to the semi-enclosed water type, tidal parameters greatly influence water circulation [2]. On several beaches in the waters of Outer Ambon Bay, surface currents during low tide flow towards the bay due to the water flow leading out of the bay to the northeast, resulting in the accumulation of residential waste being washed out during the low tide period [3].

Noya and Tuahatu [4] reported that the maximum percentage of floating marine waste was plastic waste at 93.44%, metal waste at 1.17%, glass waste at 0.47%, and cloth and paper waste with a minimum percentage of 0.23%. Plastic waste is fragmented into smaller particles by physical and chemical factors such as UV radiation, currents, and waves [5], resulting in microplastic particles. Microplastics are small pieces of plastic that are less than 5 mm (0.2 inches) in length [6], but they still have the same chemical structure as plastic and do not undergo changes in chemical structure or constituent atoms [7]. Microplastics come in various sizes,

including fiber, fragments, films, granules, and foams [8].

Because microplastics often float and have a lower density than saltwater, they gather and become buried in coastal sediments [9]. Additionally, microbial activity, biofouling, and the presence of other adhering particles can cause microplastics to sink and settle on sediment substrates and bottoms [10–12]. Consequently, this makes it possible for microplastics to enter the bodies of aquatic biota [13].

Microplastics harm marine ecosystems, food webs, and organisms [14–17] because many marine biota cannot distinguish between plastic and food [18]. Several studies have reported that polyethylene microparticles were found to have a significant effect on *Tripneustes gratilla* [19], developmental defects in *Lytechinus variegates* [20], and cytogenetic anomalies in *Sphaerechinus granularis* embryogenesis [21]. Therefore, it is necessary to identify the type, color, size, and accumulation of microplastics in water and sediment in the Outer Ambon Bay, Moluccas.

### MATERIAL AND METHOD

#### Study Area

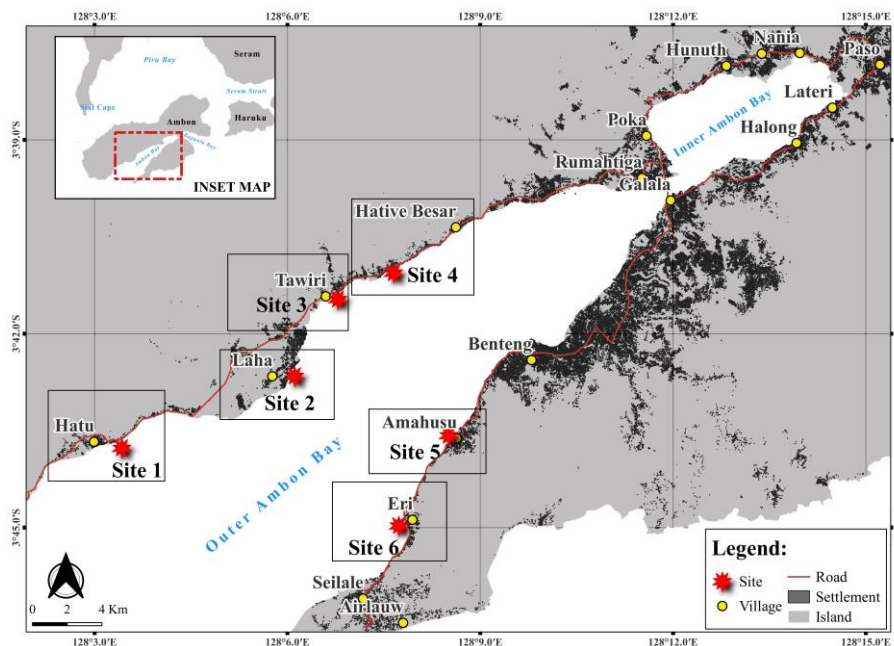
Water and sediment samples were taken from several beaches in Outer Ambon Bay (Fig. 1). Hatu Beach (Site 1) is a local tourist area, and local fishermen engage in fishing activities with traditional boats, but they are far from residential areas. Laha Beach (Site 2) has fishing activities with fishing boats and boat ports in Outer Ambon Bay, directly adjacent to Pattimura-Ambon Airport.

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**Figure 1.** Geographical maps show the sampling Site. Site 1: Hatu Beach; Site 2: Laha Beach; Site 3: Tawiri Beach; Site 4: Hative Besar Beach; Site 5: Amahusu Beach; Site 6: Erie Beach.

Tawiri Beach (Site 3) has traditional fishing activities, shipwrecks, rivers directly connected to the beach, and pig farms of local coastal residents. Hative Besar Beach (Site 4) has a river directly connected to the beach, a shipwreck, and a pier for boat docks. Amahusu Beach (Site 5) has local tours and hotels. Erie Beach (Site 6) has traditional fishing activities, fishing boats, a beach reclamation area to construct several tourist facilities, fishing companies, and fishing boat anchoring.

**Water Sampling and Microplastic Analysis**

The water sampling in the water column is divided into three depths, namely 0 cm, 50 cm, and 100 cm. Water samples at a depth of 0 cm were taken using a plankton net (30 cm in diameter and 30 µm mesh size), while water samples at a depth of 50 cm and 100 cm were taken using a sample bottle. The water sample is filtered through a 1 mm sieve, then mixed 100 mL of the water sample with 200 mL of NaCl and stirred for 15 minutes [24]. Then, 20 mL of 30% H<sub>2</sub>O<sub>2</sub> (wet peroxide oxidation) was added to separate the organic materials and stirred for 24 hours at 50°C. Filter the solution again using 1.6 mm GF/A filter paper[25]. Particle classification is categorized based on type, color, size, and the number of microplastic particles [26] using a 10X magnification microscope [27].

**Sediment Sampling and Microplastic Analysis**

The sediment sampling was carried out using a 5 m distance transect parallel to the waterline

at each location. On each transect, three replicates were placed (1 m<sup>2</sup> with a distance of 10 m), then 200 g of wet sediment was taken and dried in an oven at 50°C for 24 hours. The suspension was homogenized by mixing 50 g of sediment with a hypersaline solution on a mechanical shaker to separate organic material and incubated for 24 hours. The sediment particles were allowed to settle for three hours, and then the supernatant was decanted and filtered using a vacuum pump and Whatman GF/A filter paper with a pore size of 1.6 µm. The filter paper was placed in a petri dish and dried in the oven at 50°C for 24 hours [26]. Particle classification is categorized based on type, color, size, and the number of microplastic particles [26] using a 10X magnification microscope [27].

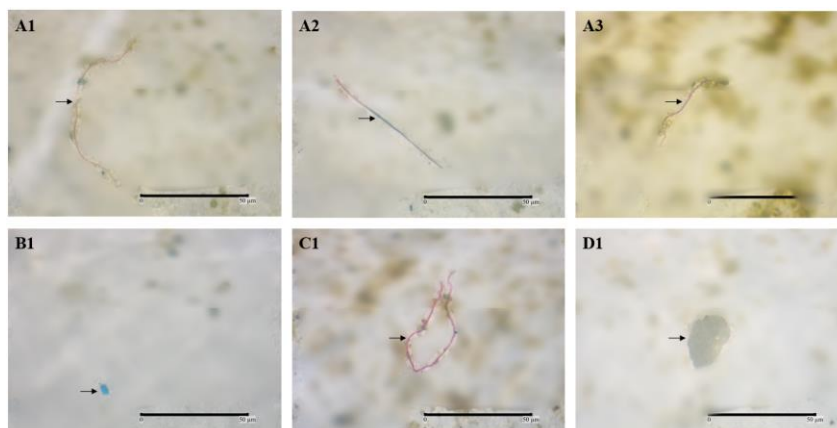
**Data Analysis**

Data analysis was carried out descriptively and presented in tables and graphs. Meanwhile, microplastics' type, color, and size data were analyzed using the Least Significant Difference (LSD) follow-up test.

**RESULT AND DISCUSSION**

**Microplastics in Water**

The results of identifying microplastics found in water samples taken from several beaches in the waters of Outer Ambon Bay indicate that the types of microplastics found are fiber, fragment, film, and pellet types. The color variants were transparent, multicolor, blue, red, yellow, and purple (Fig. 2).



**Figure 2.** Types and colors of microplastics found in water in the Outer Ambon Bay; A1: fiber (yellow), A2: fiber (multicolor), A3: fiber (purple). B1: pellet (blue), C1: fragment (red), D1: film (transparent). Magnification observation 100X and scale bar 50µm.

The average number of fiber-type microplastics in water samples in the Outer Ambon Bay (Table 1) was found to be higher at Laha Beach (Site 2), with 19.33 particles L<sup>-1</sup> but not significantly different from Tawiri Beach (Site 3). Fiber-type microplastic particles showed significant differences from Hative Besar Beach (Site 4) with an average number of 3.33 particles L<sup>-1</sup> but not significantly different from Hatu Beach (Site 1) and Amahusu Beach (Site 5).

The number of fiber types from Erie Beach (Site 6), with 11.67 particles g<sup>-1</sup>, was similar to Amahusu Beach (Site 5) and Tawiri Beach (Site 3). The type of film indicates another significant difference found on Hative Besar Beach, with 2.00 particles g<sup>-1</sup>, which is significantly different from Hatu Beach (Site 1), Laha Beach (Site 2), Tawiri Beach (Site 3), Amahusu Beach (Site 5) and Erie Beach (Site 6).

Most of the microplastic particles in water samples came from Laha Beach (Site 2) and were fiber-type microplastics. This result indicates that the fiber type has a thin shape and size, allowing it to float on the surface of the water). This result is supported by Laha Beach (Site 2), where fishing activities, boat ports, and densely populated areas border the airport. In contrast, the types of

fragments and pellets that are not found on these beaches are fewer or almost non-existent. These types are more degraded and sink into the sediment. Additionally, these results show that the amount of plastic waste in the sea is not only influenced by human activities in the surrounding area but also by current circulation patterns in Ambon Bay [2]. The inner bay of Ambon has a longer flushing time, causing masses of water and other objects entering from the outer bay to last longer.

The average length of microplastic found in water samples in Ambon Luar Bay (Table 2) shows the largest fiber particle found on Erie Beach (Site 6), which is 82.33 µm but not significantly different from fiber particle at Hatu beach (Site 1), Laha beach (Site 2), Tawiri beach (Site 3), and Amahusu beach (Site 5). In contrast, the real difference is shown by the length of the smallest microplastic particles found at Hative Besar Beach (Site 4), which is 39.50 µm. The difference in length is also indicated by film-type microplastic particles from Hative Besar Beach (Site 4), which is 59.90 µm, differing from Hatu Beach (Site 1), Laha Beach (Site 2), Tawiri Beach (Site 3), Amahusu beach (Site 5). ) and Erie Beach (Site 6).

**Table 1.** The average number of microplastic particles found in water in Outer Ambon Bay

Site	Average Number of Microplastics (particles L <sup>-1</sup> )			
	Fiber	Fragments	Film	Pellets
Site 1	7.00 ± 2.00 <sup>ab</sup>	0.00 ± 0.00 <sup>a</sup>	0.67 ± 0.58 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>
Site 2	19.33 ± 3.51 <sup>d</sup>	0.33 ± 0.58 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>
Site 3	16.33 ± 9.07 <sup>cd</sup>	0.00 ± 0.00 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>
Site 4	3.33 ± 0.58 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	2.00 ± 1.00 <sup>b</sup>	0.00 ± 0.00 <sup>a</sup>
Site 5	5.33 ± 1.53 <sup>ab</sup>	0.00 ± 0.00 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	0.33 ± 0.58 <sup>a</sup>
Site 6	11.67 ± 1.53 <sup>bc</sup>	0.33 ± 0.58 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	0.33 ± 0.58 <sup>a</sup>

**Notes:** Site 1: Hatu Beach, Site 2: Laha Beach, Site 3: Tawiri Beach, Site 4: Hative Besar Beach, Site 5: Amahusu Beach, Site 6: Erie Beach. The mean value followed by the same letter was not significantly different according to the LSD Follow-Up Test at the 0.05 significance level.

**Table 2.** The average size of microplastic particles found in water in Outer Ambon Bay

Site	Average Length of Microplastic Particles (µm)			
	Fiber	Fragments	Film	Pellets
Site 1	70.74 ± 28.03 <sup>ab</sup>	0.00 ± 0.00 <sup>a</sup>	19.38 ± 33.57 <sup>a</sup>	2.98 ± 5.16 <sup>a</sup>
Site 2	77.14 ± 1.57 <sup>ab</sup>	2.62 ± 4.53 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>
Site 3	51.97 ± 22.63 <sup>ab</sup>	0.00 ± 0.00 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>
Site 4	39.50 ± 16.11 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	59.90 ± 7.57 <sup>b</sup>	0.00 ± 0.00 <sup>a</sup>
Site 5	60.94 ± 17.32 <sup>ab</sup>	0.00 ± 0.00 <sup>a</sup>	1.79 ± 3.10 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>
Site 6	82.33 ± 27.18 <sup>b</sup>	11.14 ± 19.29 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	5.45 ± 9.43 <sup>a</sup>

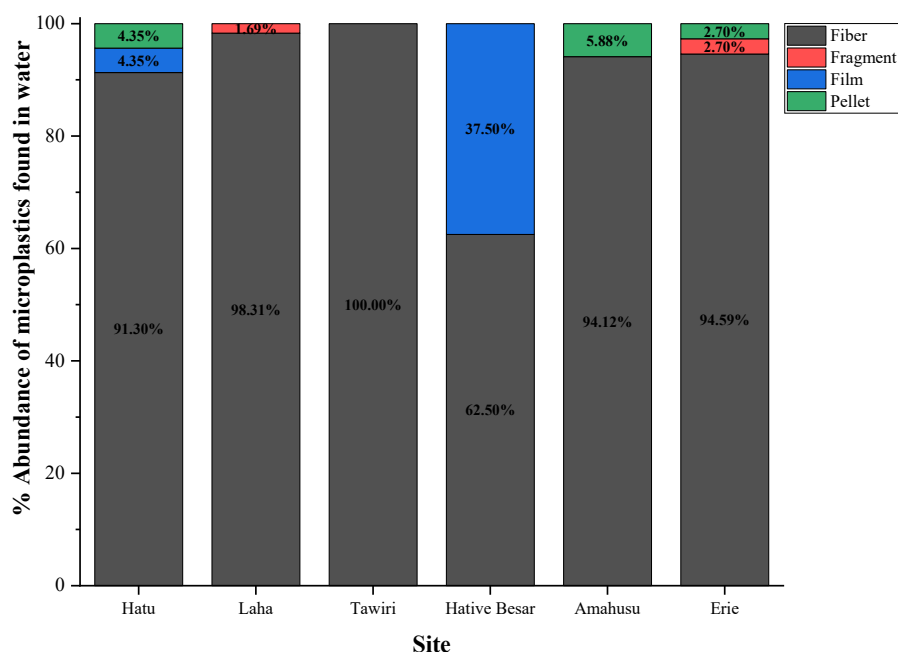
**Notes:** Site 1: Hatu Beach, Site 2: Laha Beach, Site 3: Tawiri Beach, Site 4: Hative Besar Beach, Site 5: Amahusu Beach, Site 6: Erie Beach. The mean value followed by the same letter was not significantly different according to the LSD Follow-Up Test at the 0.05 significance level.

The percentage of microplastic abundance and color found in water samples in Outer Ambon Bay is shown in Figures 3 and 4. Based on the graph, the most abundant type of microplastic found in fiber at Tawiri beach (Site 3) with a percentage of 100%, Laha beach (Site 2) at 98%, Erie beach (Site 6) at 95%, Amahusu beach (Site 5) 94%, Hatu beach (Site 1) 91% and Hative beach (Site 4) Besar at 63%. Film type is only found on Hative Besar Beach (Site 4) with a percentage of 38% and on Hatu Beach (Site 1) at 4%. Pellet types are found on Amahusu Beach (Site 5) with a percentage of 6%, Hatu Beach (Site 1) at 4%, and Erie Beach (Site 6) at 3%. The least found type of microplastic was fragment found on Erie Beach (Site 6), with a percentage of 3%, and on Laha Beach (Site 2), with 2%. The most commonly found microplastic colors were blue at

66.64%, red at 17.02%, multicolor at 8.6%, and the least found colors were transparent, yellow, and purple at 2.58%.

In the water samples, the most common type of microplastic found in the waters of Outer Ambon Bay was fiber because the samples taken were surface water samples. Synthetic fiber consists of three types, namely nylon, polyester, and polyethylene. Polyethylene has a thin shape and can float on the surface of water [28].

In addition, this study's dominant type of fiber is believed to have originated from clothing fibers or water residue from washing. The predominantly blue and red colors found in the water samples are thought to come from anthropogenic artificial colors [30] and synthetic dyes used during plastic manufacturing [31].



**Figure 3.** The percentage of the abundance of microplastic types found in water in Outer Ambon Bay

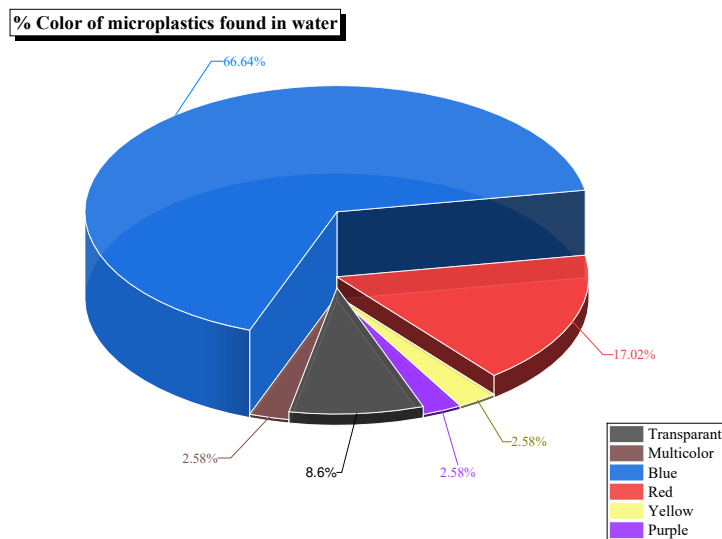


Figure 4. Percentage of microplastic colors found in water in Outer Ambon Bay

### Microplastics in Sediments

The results of identifying microplastics found in sediment samples taken from several beaches in Ambon Luar Bay indicate that the microplastics found include fiber, fragment, film, and pellet types. The color variants were transparent, blue, red, yellow, green, purple, orange, and multicolor (Fig. 5).

The average number of microplastics found in sediment samples in the waters of Outer Ambon Bay (Table 3) showed that the most abundant type of fiber was found on Amahusu beach, with 18.0 particles.g<sup>-1</sup> and the least found on Hatu

beach, with 9.33 particles.g<sup>-1</sup>. The most common type of fragment found on Amahusu Beach is 2.00 particles.g<sup>-1</sup>, and not found on Erie Beach (Site 6). The most common type of film was found at Hative Besar beach (Site 4) with an average of 9.00 particles.g<sup>-1</sup>. It showed significant differences from Hatu Beach (Site 1), Laha Beach (Site 2), Tawiri Beach (Site 3), Amahusu Beach (Site 5), and Erie Beach (Site 6) with the lowest amount of 1.00 particles.g<sup>-1</sup>. The most common type of pellets found on Hative Besar beach (Site 4) is 1.33 particles.g<sup>-1</sup>.

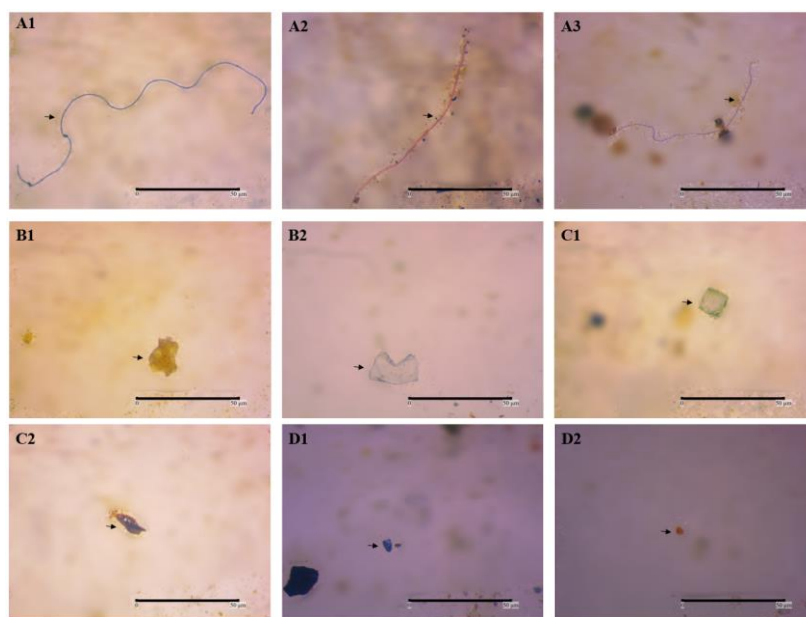


Figure 5. Types and colors of microplastics found in sediment in Outer Ambon Bay; A1: fiber (blue), A2: fiber (red), A3: fiber (purple). B1: film (yellow), B2: film (transparent), C1: fragment (green), C2: fragment (multicolor), D1: pellet (blue), D2: pellet (orange). Magnification observation 100x and scale bar 50µm.

**Table 3.** The average number of microplastic particles found in sediment in Outer Ambon Bay

Site	Average Number of Microplastics (Particles.g <sup>-1</sup> )			
	Fiber	Fragments	Film	Pellets
Site 1	9.33 ± 2.31 <sup>a</sup>	0.33 ± 0.58 <sup>a</sup>	2.67 ± 1.15 <sup>a</sup>	0.33 ± 0.58 <sup>a</sup>
Site 2	10.67 ± 0.58 <sup>a</sup>	0.33 ± 0.58 <sup>a</sup>	2.00 ± 0.00 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>
Site 3	12.67 ± 13.28 <sup>a</sup>	1.67 ± 2.08 <sup>a</sup>	3.67 ± 2.08 <sup>a</sup>	0.67 ± 1.15 <sup>a</sup>
Site 4	11.67 ± 6.81 <sup>a</sup>	1.67 ± 2.08 <sup>a</sup>	9.00 ± 3.61 <sup>b</sup>	1.33 ± 1.15 <sup>a</sup>
Site 5	18.00 ± 21.79 <sup>a</sup>	2.00 ± 1.00 <sup>a</sup>	4.67 ± 2.89 <sup>a</sup>	0.33 ± 0.58 <sup>a</sup>
Site 6	13.67 ± 6.51 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	1.00 ± 1.00 <sup>a</sup>	0.67 ± 0.58 <sup>a</sup>

**Note:** Site 1: Hatu Beach, Site 2: Laha Beach, Site 3: Tawiri Beach, Site 4: Hative Besar Beach, Site 5: Amahusu Beach, Site 6: Erie Beach. The mean value followed by the same letter was not significantly different according to the LSD Follow-Up Test at the 0.05 significance level.

The most commonly found microplastic particles in sediment samples came from Erie Beach (Site 6), characterized by muddy sand substrates for fishing activities, reclamation areas for local tourism facilities, and anchoring fishing boats. Microplastic with a density greater than seawater will sink and accumulate in sediments.

Sediment grain size can affect the deposition of microplastics in sediments. Sandy and muddy sediments can trap microplastics in water during tides. Fine and muddy sediments trap more microplastics in the sediment [31].

The average length size of microplastics found in sediment samples in the waters of Ambon Luar Bay (table 4) shows that the largest fiber particle size was found at Laha Beach (Site 2), which was 91.35 µm and significantly different from the fiber particle size at Hatu beach (Site 1), Tawiri Beach (Site 3), Amahusu beach (Site 5) and Erie beach (Site 6). The difference in length size is also shown by film-type microplastic particles from Erie Beach (Site 6), which is 8.42 µm different from Hatu Beach (Site 1), Laha Beach (Site 2), Tawiri Beach (Site 3), Hative Besar Beach ( Site 4) and Amahusu beach (Site 5).

The percentage of microplastic abundance (Fig. 6) found in sediment samples in the waters of Outer Ambon Bay shows that the highest abundance of fiber types of microplastic was found on Erie Beach (Site 6) with a percentage of

89.13%, Laha Beach (Site 2) 80.00%, Hatu Beach (Site 1) 73.68%, Amahusu Beach (Site 5) 72%, Tawiri Beach (Site 3) 67.86% and Hative Besar Beach (Site 4) 50%. Most types of fragments were found at Tawiri beach (Site 3) with a percentage of 8.93%, Amahusu beach (Site 5) at 8.00%, Hative Besar beach (Site 4) at 6.94%, Hatu beach (Site 1) at 2.63%, and Laha beach ( Site 2) 2.50%. No fragment-type microplastics were found in sediments recovered from Erie Beach (Site 6). The most common types of film are found on Hative Besar Beach (Site 4) with a percentage of 37.50%, Hatu Beach (Site 1) at 21.05%, Tawiri Beach (Site 3) at 19.64%, Amahusu Beach (Site 5) at 18.67%, Laha Beach (Site 2) ) 17.50% and the least found on the coast of Erie Beach (Site 6) with a percentage of 6.52%.

The most common types of pellets were found at Hative Besar Beach (Site 4) with a percentage of 5.56%, Erie Beach (Site 6) at 4.35%, Tawiri Beach (Site 3) at 3.57%, and Hatu Beach (Site 1) at 2.63%. Pellet-type microplastics were not found in sediments taken from Laha Beach (Site 2).

The most commonly found microplastic color (Figure 7) is blue with a percentage of 46.27%, transparent at 28.07%, yellow at 7.77%, red at 7.71%, multicolor at 3.7%, orange at 2.78%, and the fewest colors found are purple and green, with a percentage of 1.85%.

**Table 4.** The average size of microplastic particles found in sediment samples in Outer Ambon Bay waters

Site	Average Length of Microplastic Particles (µm)			
	Fiber	Fragments	Film	Pellets
Site 1	43.61 ± 9.37 <sup>a</sup>	16.00 ± 27.72 <sup>a</sup>	50.97 ± 15.63 <sup>b</sup>	6.71 ± 11.62 <sup>a</sup>
Site 2	91.35 ± 5.81 <sup>b</sup>	14.08 ± 24.38 <sup>a</sup>	34.33 ± 11.28 <sup>b</sup>	0.00 ± 0.00 <sup>a</sup>
Site 3	61.26 ± 14.14 <sup>a</sup>	13.98 ± 12.75 <sup>a</sup>	32.72 ± 6.84 <sup>b</sup>	10.80 ± 18.71 <sup>a</sup>
Site 4	51.88 ± 11.77 <sup>a</sup>	15.08 ± 13.17 <sup>a</sup>	51.45 ± 10.74 <sup>b</sup>	24.76 ± 21.85 <sup>a</sup>
Site 5	52.63 ± 13.79 <sup>a</sup>	30.49 ± 18.58 <sup>a</sup>	42.56 ± 3.81 <sup>b</sup>	8.76 ± 15.17 <sup>a</sup>
Site 6	45.48 ± 18.51 <sup>a</sup>	31.50 ± 28.23 <sup>a</sup>	8.42 ± 14.59 <sup>a</sup>	13.86 ± 12.02 <sup>a</sup>

**Note:** Site 1: Hatu Beach, Site 2: Laha Beach, Site 3: Tawiri Beach, Site 4: Hative Besar Beach, Site 5: Amahusu Beach, Site 6: Erie Beach. The mean value followed by the same letter was not significantly different according to the LSD Follow-Up Test at the 0.05 significance level.

The most common types of microplastic found in sediment samples were fiber, fragments, and films. The types of plastic that are often found are polyvinyl chloride, polyamide (nylon), and polyethylene terephthalate (PET) [28]. However, other types of plastic, such as polyethylene (used as plastic food packaging), polypropylene (used as plastic packaging or wrap), and expanded polystyrene, such as plastic cups, can also sink if both organic and non-organic components cover the surface of the microplastic.

Microplastics can float on the water's surface with a lower density than seawater. Meanwhile, microplastic, which has a higher density than seawater, will sink with the sediment. There is another possibility that microplastics that have a lower density will mix with sediments at the bottom of the waters. It is influenced by suspended sediment, which will carry low-density microplastics to the bottom of the waters. In addition, hydrological factors such as turbulence, upwelling currents, and tides also significantly affect the accumulation of microplastics in waters and sediments [32].

Microplastics found in water and sediment in the waters of Outer Ambon Bay include types of fiber, fragments, films, and pellets with various transparent, multicolor, blue, red, yellow, purple,

green, and orange colors. Fiber-type microplastics were the most common type found at the six Sites in this study.

Fiber-type microplastics resemble fibers or fishing nets and can emit bright blue light when exposed to ultraviolet light. It suggests that blue is predominantly found in this study's microplastic particles from water and sediment. Fiber can originate from nylon fibers in clothing, fishing lines, ropes, and fishing nets [24]. Several beaches in the waters of Outer Ambon Bay serve as locations for fishing boats (Site 1 and Site 2), boat docks and farms (Site 3 and Site 4), tourist beaches and hotels (Site 5), as well as beach reclamation areas and fish companies (Site 6) which may impact the surrounding waters [31] and contribute to fiber-type marine debris in the seawater [32]. Fibers can also enter the waters through domestic waste from laundry activities [33].

In addition to fibers, other types of microplastics found include fragments, films, and pellets. Fragments are derived from more oversized plastic products like containers, while films originate from raw materials used in plastic production [33]. Film-type microplastics result from the breakdown of commonly used plastic containers and food packaging [24].

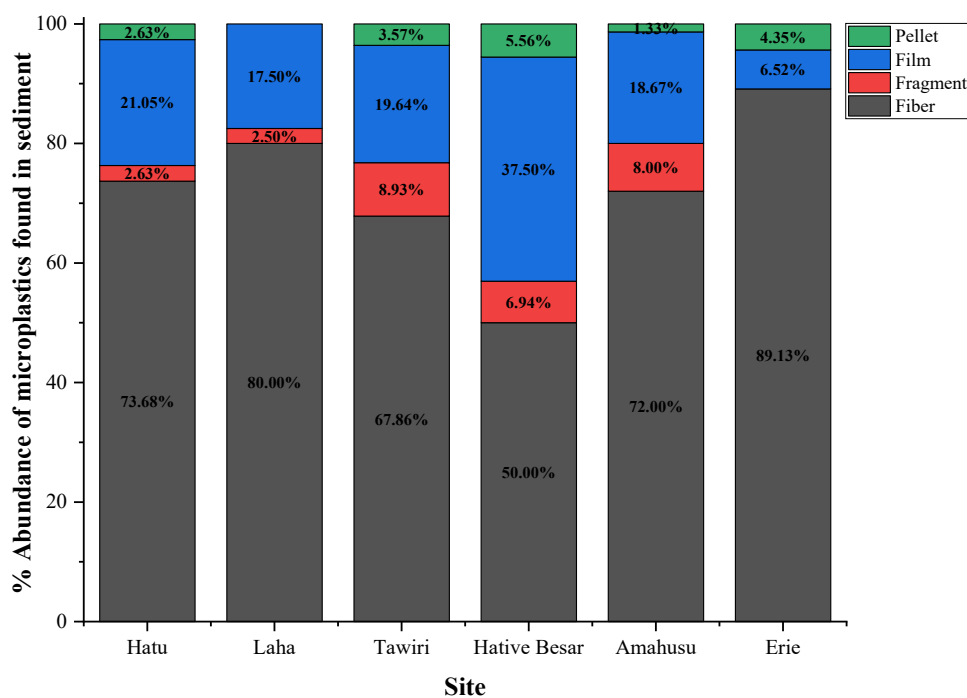


Figure 6. The percentage of microplastic colors found in sediment in Outer Ambon Bay

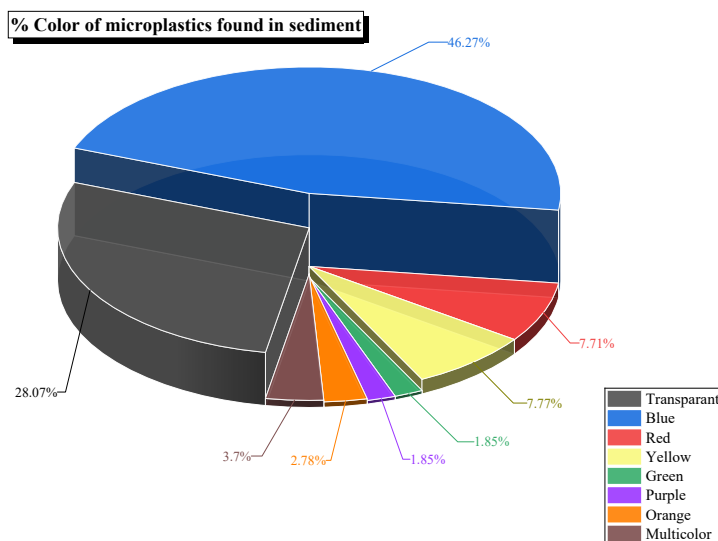


Figure 7. The percentage of microplastic colors found in sediment in Outer Ambon Bay

Based on the research results, the types of microplastics found in small quantities were fragments, films, and pellets. In the water sample, these pellets were only found on Amahusu Beach (Site 5) and Erie Beach (Site), which are beaches with tourism activities, hotels, and reclamation areas where the material is being stockpiled for the construction of tourism facilities for local and international communities. The waste from the results of this activity is indicated to be the cause of the pellet-type microplastic particles. Even though this type is a primary material that the factory directly produces as a raw material for making plastic products, there are no plastic manufacturing factories on the coast around Outer Ambon Bay [34]. This type of film comes from plastic waste, with a weak layer fragmented from plastic packaging and low density. In contrast, the type of fragments is suspected to come from pieces of plastic products that are more significant in size, such as plastic cutlery and disposable products.

Several previous studies in Ambon Bay waters have also shown microplastic accumulation in water, sediments, and marine biota. In their research, Tuhumury and Ritonga [35] found 360 fiber types and 61 particle fragments of microplastics from the blood clam *Anadara granosa* in Tanjung Tiram, Ambon Bay waters. Manullang [36] also reported that the highest abundance of marine plastic waste was found in the interior of Ambon Bay. The results show a substantial contribution from the circulation of water masses in Ambon Bay with the distribution of plastic waste overflow throughout the bay.

However, the type of microplastic polymer particles found in this study was unknown.

Microplastics threaten marine life and can also enter the human food chain, impacting health. In the human body, after consuming food containing microplastics, they interact with the mucus layer of the digestive tract. The microplastic particles then combine and penetrate the mucosal layer, coming into contact with epithelial cells. Subsequently, microplastics are transferred to the lymphatic and circulatory system, reaching and accumulating in organs such as the liver, kidney, spleen, heart, and brain, ultimately impacting human health [39]. Consumption of microplastics can lead to chromosomal changes, resulting in infertility, obesity, and cancer [40]. Ingesting microplastics can also trigger local inflammation and cancer through immune cell response, particularly in individuals with metabolic disorders and impaired cleansing mechanisms [41]. Polyvinyl chloride microplastic that enters the digestive organs and bloodstream can bind to serum albumin, disrupt protein molecular structure and function, spread to various organs via the bloodstream, and cause more severe in vivo damage [42]. Furthermore, polymer tests must be carried out to determine the type of polymer from the microplastic particles found in Outer Ambon Bay.

#### CONCLUSION

The water of Outer Ambon Bayare was polluted by microplastics, with 201 particles L<sup>-1</sup> found in water samples and 325 particles g<sup>-1</sup> in sediment samples. The fiber-type microplastic

particles at Laha Beach and Hative Besar Beach differed significantly. Fishing activities, boat ports, rivers, densely populated areas, and sandy and muddy sediments contribute to the microplastic problem. Therefore, preventing waste in Ambon Bay waters is crucial.

#### Acknowledgement

The authors would like to thank Indonesia Endowment Fund for Education (*Lembaga Pengelola Dana Penelitian – LPDP*) for funding this research, as well as all laboratory staff in the Microbiology Laboratory, Faculty of Mathematics and Natural Sciences, and Department of Biology, University of Pattimura, who provided assistance and support during the research.

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