Abundance, distribution and correlation of microplastics in Tuapejat coastal water Mentawai Islands Indonesia

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Abstract. Tuapejat is the capital city of the Mentawai Islands Regency which is located in North Sipora District, Indonesia. Beside as being the most populous city, Tuapejat is also the center of marine tourism and various activities such as urbanization, restaurants, hotels and trade. Those anthropogenic activities have the potential to provide input of plastics waste into the oceans which eventually degrades into microplastics, which then may pose a major threat to both biota and humans. This study aims to determine and quantify the microplastics content in water and sediment in these coastal waters which was conducted in August 2022. Sampling was carried out at three stations and the results of the study showed that the types of microplastics found were fibers, fragments and films. The highest total microplastics abundance was in commercial port area, whilst the lowest was found around fishing port in both seawater and sediment, respectively. The abundance of microplastics in seawater and sediments between stations in Tuapejat coastal waters was significantly different ($p<0.05$), and there was a positive relationship between the abundance of microplastics in seawater and in sediments. The differences between stations and the relationships that occur are discussed by looking at the influence of water quality parameters and anthropogenic activities around the sampling locations.

1 Introduction

Coastal and oceanic aquatic environments are particularly susceptible to sewage runoff pollution. A wide range of human activities, such as industrial, agricultural, and residential developments, can result in the production of pollutants. Coral reefs, seagrass beds, and mangrove ecosystems are just a few of the marine and coastal habitats that are negatively impacted by pollution from the mainland. One of the contaminants that negatively affects the ecosystem and marine biota is plastic trash

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[1]. According to [2], Indonesia is the second-largest source of marine plastic waste globally. Plastic garbage enters the waterways as a result of both processes in the sea and activities on land, which eventually find their way into rivers and the sea. Small particles known as microplastics will form as marine plastic garbage decomposes.

Microplastics, which are produced when plastic is broken down, are defined as plastic granules or particles having a diameter of less than 5 mm. Microplastics are a problem that is challenging to eliminate from the marine environment since plastic is an extremely tenacious material [3]. The food chain in the water and marine aquatic life are both impacted by microplastic pollution and contamination in general. Microplastics are accumulated by species at low trophic levels, which eventually results in biomagnification at the higher trophic levels. Microplastic-containing water will enter bodies of water and then settle in sediments [4].

The Mentawai Islands in West Sumatra are encircled by water, hence this area has a lot of potential for the fishing sector. The Mentawai Islands are home to around 30,000 people, most of whom work as fishermen. The North Sipora District serves as the administrative center for the Mentawai Islands Regency, often known as Tuapejat. Tuapejat has one of the highest densities of all settlements in the Mentawai Islands Regency. Tuapejat has a variety of companies relating to food service, hotel, retail, and wholesale in addition to the activities connected with the dense population, such as beaches, agricultural endeavors, plantations, and marine fisheries. The waters of Tuapejat serve as the exit for one of the main rivers in the North Sipora District.

Many local activities in Tuapejat have the potential to transfer plastic to the waters, where it eventually decomposes into microplastics. Microplastics found in the waters gravely damage both the biota and humans who consume local fishery products. Therefore, study is required to ascertain the level of microplastic in the surrounding waters of Tuapejat Sipora Utara and the Mentawai Islands.

2 Research Methodology

This research was conducted in August 2022–February 2023 in the waters of Tuapejat Village, Sipora Utara District, Mentawai Islands Regency, West Sumatra Province (Figure 1). Sample analyses were conducted in the Chemical Oceanography Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Science, University of Riau.

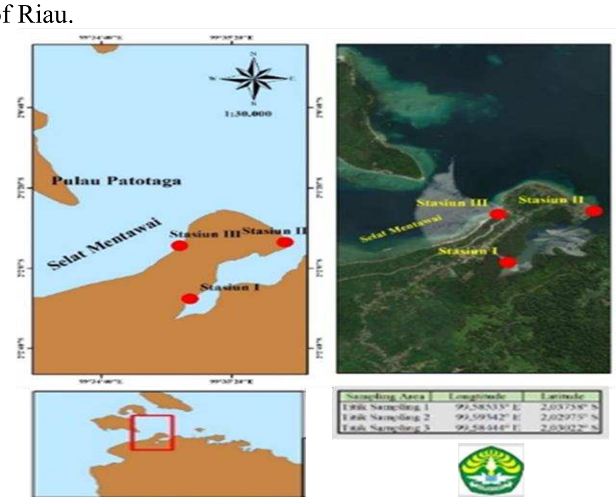

Fig. 1. Map of Research Locations.

The research method employed in this study was a survey method, in which water quality data (current velocity, degree of acidity (pH), temperature, water brightness, and salinity) as well as water and sediment samples were collected on-site for further examination in a laboratory.

3 Microplastic Analysis in Water

Water samples that have been filtered with plankton net are poured into a 200 mL glass bottle to be mixed with a saturated NaCl solution in a ratio of 1:3 and left for 24 hours to separate the plastic from the remaining impurities. The solution was then taken from the surface in amounts as large as 10 mL and transferred to an Erlenmeyer flask to be homogenized. Then, 1 mL of the solution was taken and dripped into the Sedgewick Rafter Counter Cell to be observed under a microscope.

3.1 Analysis of microplastics in sediments

Separation of microplastic particles from sediments was carried out in several stages, as follows: Sediment samples from each observation station were weighed at as much as 100 grams [5]. Drying is done in an oven at 105°C for 24 hours to reduce the water content [6]. After finishing the oven, the sediment samples were put into the dessicator. Sediment samples that have been dried are then taken, weighing as much as 50 grams. The sediment sample was suspended in saturated NaCl (36.5 g of NaCl dissolved in 100 ml of distilled water) and then filtered using vacuum filtration. Microplastic observation using the Sedgewick Rafter Counting Cell under the Olympus CX23 microscope by taking 1% of the total solution.

3.2 Sediment fraction analysis

Sediment fraction analysis used two methods, namely the multilevel sieving method and the pipette method. The stages of analyzing the type of sediment fraction refer to [7].

4 Results and discussion

4.1 Microplastics in water and sediments

The results of the analysis of water and sediment samples found three types of microplastics in the form of fibers, films, and fragments (Figures 2 a, b, and c).

(a) (b) (c)

Fig. 2. Microplastic Types.

The most common microplastics found in the waters of Tuapejat Village are fiber- and fragment-type microplastics. The highest abundance of microplastic types of fiber and fragments is at ports, and the lowest is at TPI. Tuapejat Village Harbor, which is a place for fishermen and settlements, causes a lot of plastic waste to enter the waters, such as fishing nets or fishing lines that break. This statement is supported by [8], which states that microplastic types of fiber originate from fishing activities and that fiber is a type of microplastic derived from textile materials, fishing thread, or rope. The sources of fiber-type microplastics are thought to come from synthetic fabrics, fishing boat waste, and fishing gear such as fishing nets and fishing lines [3]. The large number of stalls and restaurants around the port is one of the factors that causes many types of microplastic fragments to be found in the area. Fragment-type microplastics are characterized by irregular pieces of a certain thickness. According to [9], the fragments come from broken plastic, waste bottles, jars, mica folders, small pieces of gallon pipe, ready-to-eat food packages, and waste disposal. According to [10], fragment-type microplastics originate from the fragmentation of secondary plastic products.

The least common type of microplastic is film. The highest abundance of microplastic film types in sediments was at the port and at Jati Beach in the water. The lowest abundance of microplastics is at TPI. Film-type microplastics are in the form of thin and transparent sheets compared to fragment-type microplastics. Films are irregular in shape, but compared to fragments, this type of film is thinner, more flexible, and usually transparent. The types of fragments are stiff, thick, and irregular and have a variety of different colors [11]. [12], [13,14,15] states that the most common waste found on beaches and ports is plastic packaging waste and other packaging bags, which are practical containers for beach visitors or users of sea transportation. Film is a secondary plastic polymer derived from the fragmentation of plastic bags or plastic packaging [16].

4.2 Abundance of microplastics in water and sediments

Table 1 displays the mean abundance of microplastics by station and type in the seawater of Tuapejat Village, Mentawai Islands.

Table 1. Abundance (mean ± Std. deviation) of microplastics in water.

Station	Abundance (Particle/Liter)			Total
	Fiber	Fragment	Film	
1	63,33±47,26	140±108,17	83,33±25,17	286,67 ±55,08
2	340±121,24	156,67±37,86	106,67±41,63	623,33±135,76
3	183,33±101,17	146.67±23.09	166,67±41,63	496,667±141,54
Mean	195,57±145,69	147,78±58,90	118,89±49,10	468,89±179,06

Based on the data presented in Table 1, it can be seen that the average abundance of microplastics for all stations in the waters of Tuapejat Village, Mentawai Islands, is 468.89 particles per liter of water, with a standard deviation of 179.06. The highest abundance of microplastics was at the port, namely 623.33 particles per liter, while the lowest abundance of microplastics was at fish landing port, namely 286.67 particles per liter. The highest abundance of microplastic fiber types is in the port, with an abundance concentration of 340 particles per liter. While the lowest fiber was found in fish landing port with a concentration of 63.33 particles per liter. The highest abundance of microplastic types of fragments was in the port, with an abundance concentration of 156.67 particles per liter. While the lowest fragments were in fish landing port with a concentration of 140 particles per liter. The third type of microplastic found was film type; the highest abundance concentration was found in Pantai Jati with an abundance of 166.67 particles per liter and the lowest in fish landing port with an abundance concentration of 83.33 particles per liter.

The mean abundance of microplastics by station and type in marine sediments in Tuapejat Village, Mentawai Islands, can be seen in Table 2.

Table 2. Abundance (mean ± std. deviation) of microplastics in sediments

Station	Abundance (Particle/Kg)			Total
	Fiber	Fragment	Film	
1	120.00±20.00	293.33±50.33	166.67±100.66	580.00±124.90
2	213.33±23.09	440.00±170.88	366.67±80.83	1020.00±270.55
3	206.67±61.10	520.00±40.00	226.67±61.10	953.33±23.09
Mean	180±56.569	417.78±135.072	253.33±114.018	851.11±253.99

Based on the data presented in Table 2, it can be seen that the abundance of microplastics for all stations in the waters of Tuapejat Village, Mentawai Islands, was 851.11 particles per kg of sediment with a standard deviation of 253.99. The highest abundance of microplastics was at the port with an abundance concentration of 1020 particles/kg, and the lowest abundance of microplastics was at fish landing port with an abundance concentration of 580 particles/kg.

The highest abundance of microplastic fiber types was at the port, with an abundance concentration of 213.33 particles/kg. While the lowest fiber is found in fish landing port with a concentration of 120 particles/kg. The highest abundance of microplastic types of fragments was at Pantai Jati, with an abundance concentration of 520 particles/kg. While the lowest fragments were at fish landing port with a concentration of 293.33 particles/kg. The third type of microplastic found was film type; the highest abundance concentration was in Port with a concentration of 366.67 particles/kg, and the lowest was in TPI with a concentration of 166.67 particles/kg. Measurement of oceanographic parameters was carried out at three station points in the waters of Tuapejat Village, Mentawai Islands. The results of measuring oceanographic parameters can be seen in Table 3.

Table 3. Oceanographic parameters

Station	Temperature (°C)	pH	Transparency (%)	Salinity (ppt)	Current speed (m/s)
I	32	7	100	30	0,02
II	32	7	100	30	0,02
III	33	7	100	34	0,08

Based on Table 3, the average range of oceanographic parameters at the time of sampling is not much different. Oceanographic parameters at the study site were 32 °C, pH 7, brightness 100%, salinity 30-34 ppt, and currents 0.02-0.08 m/s. Based on the results of the analysis of the sediment fraction, the type of sediment in the waters of Tuapejat Village, Mentawai Islands, can be determined. Sediment type can be seen in the average data in Table 4.

Table 4. Sediment fraction analysis

Station	Sampling point	Tipe Sediment
	1	Mud
1	2	Mud
	3	Mud
	1	Gravel
2	2	Gravel
	3	Gravel
	1	Sand
3	2	Sandy mud
	3	Sand

Based on Table 4, the sediment type at Station 1 is mud sediment, Station 2 has a gravel sediment type, and Station 3 has sand and muddy sand sediment types.

4.3 Differences in microplastic abundance between stations

The results of one-factor ANOVA analysis showed that the abundance of microplastics in the water between stations in the waters of Tuapejat Village, Mentawai Islands, showed a p value of 0.034 (< 0.05), and microplastics in the sediments of each station in the waters of Tuapejat Village, Mentawai Islands, showed a p value of 0.041 (<0.05). The value of one-factor ANOVA analysis explains that the abundance of microplastics in the waters of Tuapejat Village and Mentawai Islands in water and sediment is significantly different between stations. This can be interpreted as meaning that each station has different topography and characteristics, so that the average abundance of microplastics at each station is different.

The LSD test analysis showed that the microplastic content in the water between station 1 and station 2 was significantly different, station 1 and station 3 had no significant difference, station 2 and station 1 were significantly different, station 2 and station 3 were not significantly different, and station 3 with station 1 and station 2 had no significant difference (p <0.05). Analysis of the LSD test for microplastic content in sediments between station 1 and station 2 was significantly different; station 1 and station 3 had no significant difference; station 2 and station 1 had a significant difference; station 2 and station 3 did not differ significantly; and between station 3 and station 1, there is a significant difference; and between station 3 and station 2, there is no significant difference where p <0.05.

4.4 Relationship of microplastic abundance in water and sediments

The results of a simple linear regression analysis of the abundance of water microplastics with the abundance of sedimentary microplastics obtained the equation y = 264.328 + 1.269x, the coefficient of determination R2 was 0.898, and the correlation coefficient (r) was 0.807.

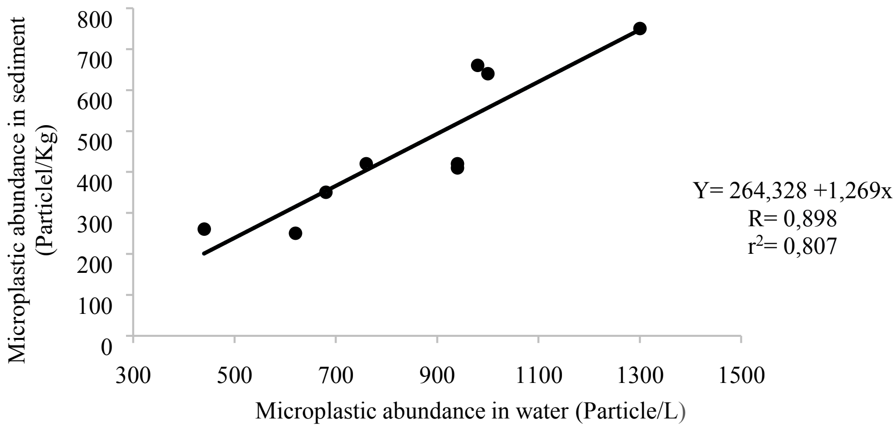

Fig.3. Relationship between microplastic abundance in water and sediment

The analysis of microplastic data in water and sediment in this study aims to determine the relationship between the abundance of microplastics in water and sediment. The results of the linear regression test explained that the abundance of water microplastics and the abundance of sediment microplastics had a positive relationship (Figure 3). The coefficient of determination has a value of R2 = 0.89, which means that the abundance of microplastics in water affects the abundance of microplastics in sediments. The value of r is 0.81. The effect of the abundance of microplastics in water on the abundance of microplastics in sediments is 89.8%, while another 10.2% is determined by other factors. The regression coefficient is positive; this is because the more microplastics in the water, the more microplastics in the sediment. Microplastics that were previously in the water column will settle to the bottom of the water on the sediment surface.

5 Conclusion

There are three types of microplastics found in water and sediments in the waters of Tuapejat Village, Mentawai Islands, namely fiber, film, and fragments, of which fiber is the most common. The highest abundance of microplastics in water and sediment was at the commercial port, and the lowest at the fish landing port. The abundance of microplastics in water and sediment between stations in the waters of Tuapejat Village was significantly different ($p<0.05$). The quantity of microplastics in sediments and the quantity of microplastics in water are positively correlated.

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