Microplastic in Beach Sediment of Nasi Island, Aceh Besar Regency, Indonesia

Sri Agustina[1,2*], *Diva* Cesarylla Darmawan[1], *Ichsan* Setiawan[1], *Syahrul* Purnawan[1], *Sofyatuddin* Karina[3], *Muhammad* Irham[1], and *Maria* Ulfah[1]

[1]Marine Science Department, Faculty of Marine Science and Fisheries, Universitas Syiah Kuala, Banda Aceh, Aceh, Indonesia, 23111.

[2]Research Centre of Marine Science and Fisheries, Universitas Syiah Kuala, Banda Aceh, Aceh, Indonesia, 23111.

[2]Research Centre of Marine Science and Fisheries, Universitas Syiah Kuala, Banda Aceh, Aceh, Indonesia, 23111.

[3]Laboratory of Marine Chemistry and Fisheries Biotechnology, Faculty of Marine Science and Fisheries, Universitas Syiah Kuala, Banda Aceh, Aceh, Indonesia, 23111.

Abstract. Microplastic might be a small size of plastic that is directly released into the environment or the result of larger in size of plastic degradations. The presence and effect of microplastic have been reported globally. However, the existence of microplastic trapped in beach sediment of Nasi Island is limited. This research was conducted to analyse the type of sediment, abundance and type of microplastic polymer found in beach sediments in Nasi Island, Aceh Besar Regency, Aceh Province, Indonesia. Sampling was carried out in April 2022 at Nipah Beach and Alue Riyeung Beach in Nasi Island, Aceh Besar Regency. Sediment type was analysed by dry sieve method, using a stratified sieve shaker while the observation of microplastic and its polymer were identified by microscope and Fourier Transform Infrared Spectroscopy (FTIR), respectively. The results showed that the types of sediment at both beaches belonged to the sand type. There were three types of microplastics found, namely fragments, films, and fibres. The highest abundance of microplastics was found in a 0.063mm filter at Nipah Beach with an amount of 2651 Particles/Kg while the lowest was found in a 0.125mm filter with an amount of 8 Particles/Kg at Alue Riyeung Beach. As the polymer types, it is found that fragment type microplastics are likely to have PETE (Polyethylene Terephthalate) polymers, film type microplastics are likely to have PS (Polystyrene) polymer types and Fibre microplastics are likely to have LDPE (Low-Density Polyethylene) polymers.

1 Background

Pollution of plastic have dominated the marine ecosystem which is up to 75% of the pollutant accumulates in rivers, beaches, sea surfaces and seabed [1][2]. Plastic bags, fishing equipment, food and drink containers are the most common observed categories of plastics

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* Corresponding author: sri_agustina@usk.ac.id

covering on beaches with percentage more than 80% wash up on beaches [3]. Its nature, which is difficult to degrade (non-biodegradable), makes this waste categorized as the largest contributor to pollution and causes damage to the natural balance [4]. Due to its properties which is difficult to degrade, the use of plastic in large quantities and continuously will certainly have a significant impact on human health and also the environment.

Plastic debris thrown into the sea will gradually degrade into small particles that might be consumed by marine organism accidentally. Particles with a size of <5 mm are defined as microplastics. Microplastics can float or sink because the density of microplastics is lighter than seawater's, such as polypropylene as the basic material for plastic bottles which will float and spread widely in the ocean. Other microplastics such as methyl methacrylate which is an acrylic base material that is denser than sea water and is likely to accumulate on the seabed, this means that large amounts of microplastics can eventually accumulate in the deep sea and then settle in sediment and ultimately disrupt the marine food chain [5].

Nasi Island, which is administratively included in the Aceh Besar Regency, has a good ecosystem because it is supported by its position between the Andaman Sea, the Indian Ocean and the Strait of Malacca. Nasi Island is a fishing area for fishermen and also for recreation activities. High fishing activities also have an impact on increasing debris release in the waters. Research on marine debris in Aceh is still relatively limited, especially regarding data on the abundance of microplastics. Therefore, this research aims to analyse the presence of microplastics in two waters in Aceh, namely Alue Riyeung Beach and Nipah Beach, Nasi Island, Aceh Besar.

2 Material and method

This research was carried out on Nasi Island, Aceh Besar Regency in April 2022 (Figure 1). Samples were taken at 2 stations, namely Nipah Beach and Alue Riyeung Beach with 3 repetitions at each station. There were 3 analyses carried out for each sample, namely sediment classification, identification of microplastic types, and determination of microplastic polymers.
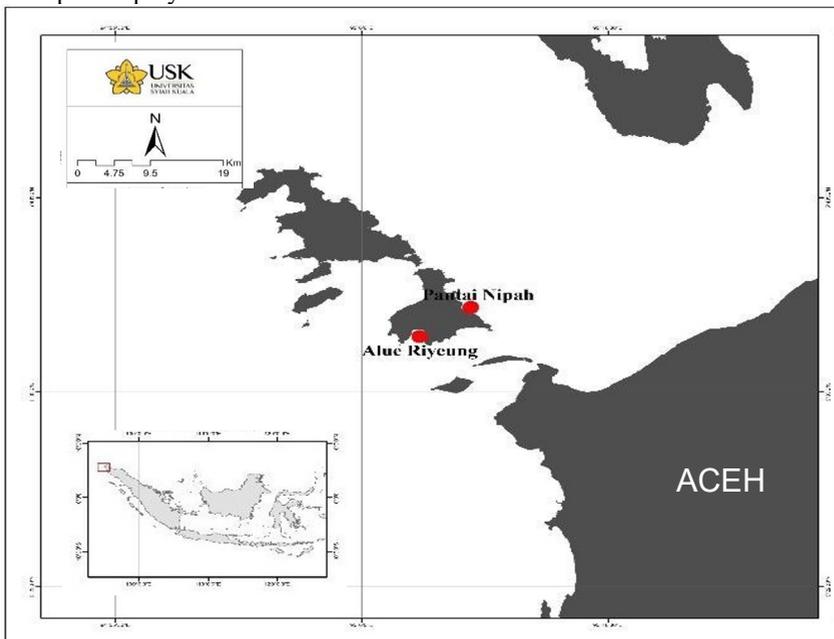
Fig. 1. Study Area of Nasi Island, Aceh Besar Regency. Red dots represent the sampling stations.

2.1 Sediment classification

A total of 200g of sediment samples were sieved using a sieve shaker for 10 minutes with stratified sieve of 2mm, 1mm, 0.5mm, 0.25mm, 0.125mm, 0.063mm and 0.038mm separation mesh sizes. The sediment samples left at each level was weighed to calculate the percentage of each fraction following the formula on equation 1. Then, the sediment classification referred to the Folk Triangle [6].

$$Percentage\ of\ weight = \frac{fraction\ weight}{Total\ weight\ of\ sample} x100 \qquad (1)$$

2.2 Identification of microplastic type

The sieved sample of each fraction was added to a 1:1 H_2O_2 solution to destruct the organic matters. After 30 minutes of heating at 90°C, the sample is removed and cooled to room temperature. Density separation was carried out using saturated NaCl solution for 24 hours. Samples were filtered using 0.45 μm cellulose nitrate filter paper to collect all the floating matters. The identification of microplastic by a binocular microscope with a lens magnification of 4x/0.10 was carried out to see the presence of microplastics in filtered samples [7]. Microplastic abundance was calculated using the following formula on equation 2.

$$Microplastic\ abundance = \frac{Number\ of\ microplastic}{Total\ weight\ of\ sediment} \qquad (2)$$

2.3 Determination of microplastic polymer

The spectroscopic method was used to obtain the chemical structure of microplastics from sediment samples. Sediment samples that have been identified using a microscope are then combined into the similar type, namely fragment, fibre and film. Polymer analysis is conducted by the FTIR method based on the wave number value at each spectrum peak.

3 Results and discussion

3.1 Sediment classification

Sediment at both locations (Nipah Beach and Alue Riyeung Beach) on Nasi Island is classified into 2 types of sediment, namely sand and gravel (Table 1). Both beaches tend to have the same type, namely sand. There is 1 station on Nipah Beach which shows a different type, namely the gravel sand fraction, and the table above also shows that there is no type of sand that is very fine or classified as mud on both beaches where sediment samples were taken.

Table 1. Sediment classification in Nasi Island

Sampling points	Percentage of sediment fraction			Type of sediment
	Gravel	Sand	Mud	
AR1	0	100	0	Sand
AR2	0	100	0	Sand
AR3	0	100	0	Sand
NP1	22.69	77.31	0	Gravelly sand
NP2	3.80	96.20	0	Sand
NP3	0	100	0	Sand

Note: AR1= sample from Alue Riyeung Beach at point 1; AR2= sample from Alue Riyeung Beach at point 2; AR3= sample from Alue Riyeung Beach at point 3; NP1= sample from Nipah Beach at point 1; NP2= sample from Nipah Beach at point 2; NP3= sample from Nipah Beach at point 3.

3.2 Microplastic identification

Figure 2 shows the abundance of microplastics in different sediment sizes. The highest abundance was found in filters with a size of 0.125mm on Nipah beach with a total of 2651 particles/Kg, while at the same size Alue Riyeung beach only had 172 particles/Kg. Meanwhile, the lowest abundance was found in the 4mm filter at Alue Riyeung beach, where there was no abundance of microplastics at that sediment size, and at the same size, Nipah beach had an abundance of 470 particles/Kg.
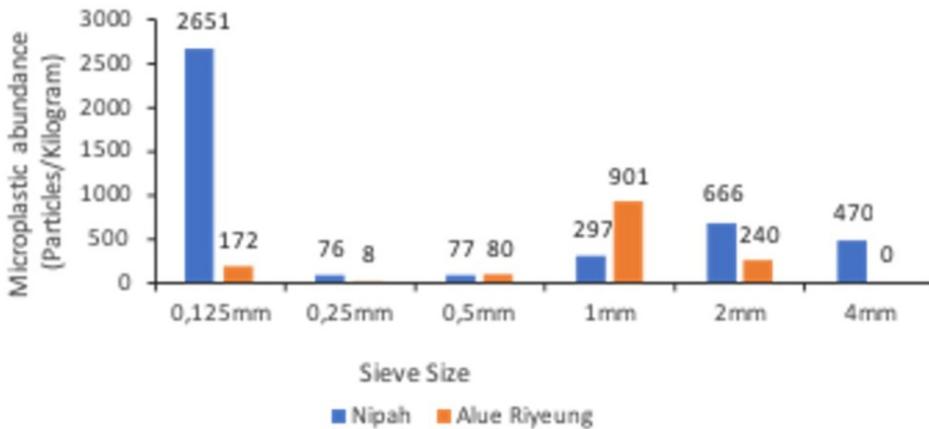

Fig. 2. Microplastic abundance in different sieve size.

3.3 Determination of microplastic polymer

Polymer type analysis is carried out by interpreting data produced by FTIR waves. The microplastics that have been identified are then separated according to type for the FTIR process. In this research, the results of the analysis show the possibility that fragment type microplastics have a PETE (Polyethylene Terephthalate) type polymer, film type microplastics have a PS (Polystyrene) type polymer, and fibre type microplastics have an LDPE (Low-Density Polyethylene) type polymer (Table 2).
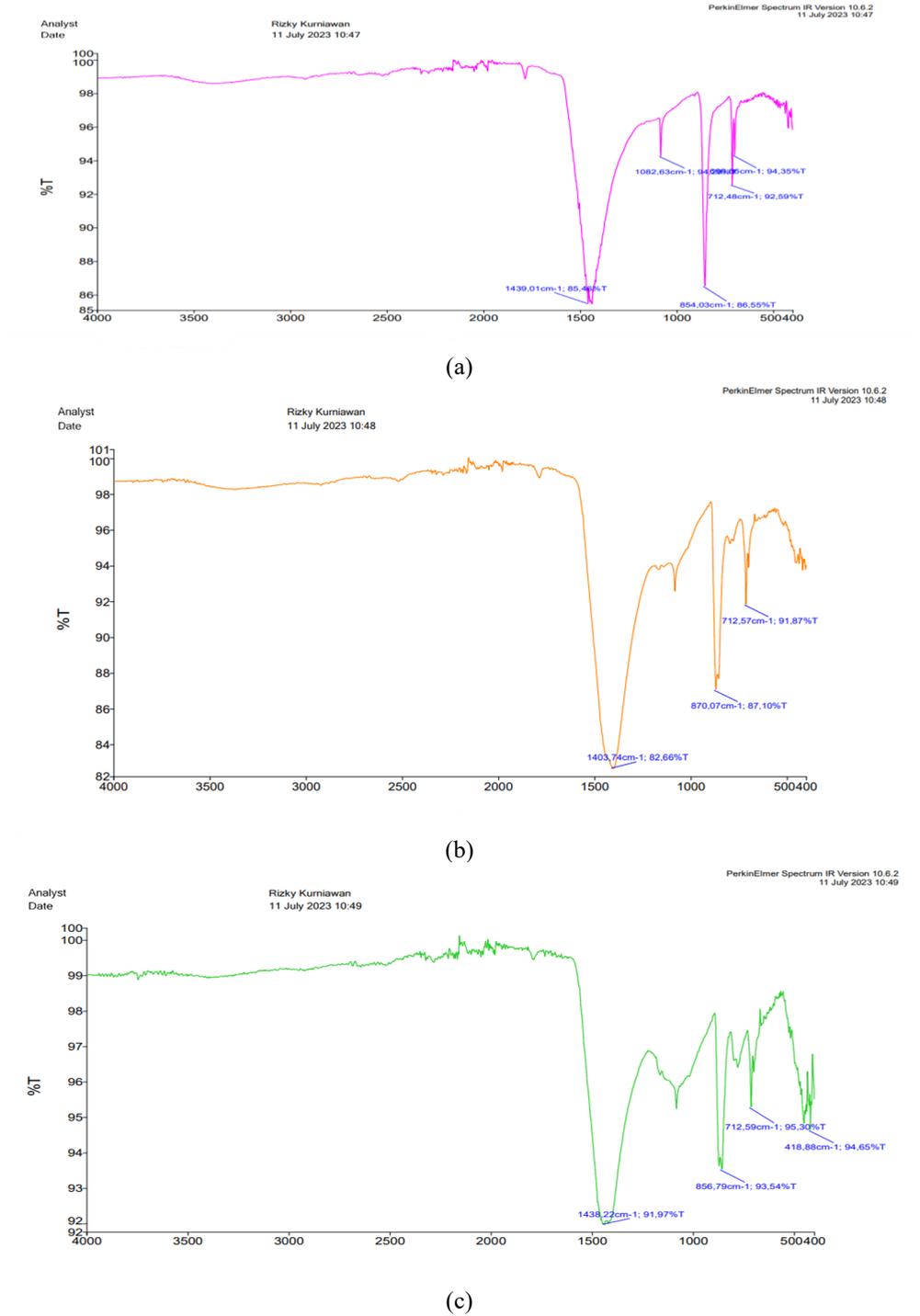
(a)

(b)

(c)

Fig. 3. The FTIR Spectrum of Microplastic Type: (a) Fragment; (b) Film; (c) Fibre.

3.4 Discussion

In this study, 3 types of microplastics were found in the samples, namely Fiber, Fragment and Film with the amounts listed in table 4.2. Microplastics on Nipah beach were dominated by the film type, where the total number of film type microplastic particles was found to be 221 particles, followed by the fragment type with a total of 77 particles and then the fiber type with a total of 43 particles. In contrast to Nipah beach, on Alue Riyeung beach, fiber type microplastics occupy the first position with a total of 53 particles, followed by film type microplastics with a total of 20 particles and fragment type with a total of 2 particles. The types of microplastics that commonly enter the waters are fragment, fiber and film microplastics [9]. These three types are also found on both beaches. Microplastic fragments are another result of cutting plastic products with very strong synthetic polymers. Fragments come from plastic consumer products. The origin of these fragments can be cosmetic bottles, fishing lines, industrial raw materials, polymer plastic fragments that can be decomposed by oxidation.

Table 2. Absorption bands of microplastic in Nasi Island.

Microplastic type	Absorption bands (cm^{-1}) {8]	Absorption bands (cm^{-1}) (this study)	Assignment	Polymer
Fragment	1440	1439	CH$_2$ Bend	PETE
	1094	1082	C-O stretch	
	840	854	CH$_2$ rock, C-CH$_3$ stretch	
	717	712	CH$_2$ rock	
Film	1409	1403	Aromatic ring stretch	PS
	840	870	CH$_2$ rock, C-CH$_3$ stretch	
	717	712	CH$_2$ rock	
Fibre	1440	1438	CH$_2$ Bend	LDPE
	840	857	CH$_2$ rock, C-CH$_3$ stretch	
	717	712	CH$_2$ rock	

Fiber is a type of microplastic that has a thin, elongated shape and size. Fiber type microplastics come from synthetic materials such as thread, fishing line and fishing nets [10]. Film-type microplastics have the characteristics of being shaped like sheets or plastic fragments, generally this type is used as material for making plastic bags or plastic packaging [11]. Film has a lower density than other types of microplastics so it is easier to transport. Microplastic particles in the form of fragments are easier to find because they have a low mass so they float on the surface of the water and the fragments are also formed by plastic fragments that flow in low temperature waters and are exposed to ultraviolet light.

The highest abundance of microplastics based on sediment level was produced by Nipah beach which was found on a 0.125 mm sieve with a total of 2651 particles/kg, in contrast to Alue Riyeung beach on the same sieve size, which only had an abundance of 172 particles/kg. Meanwhile, the lowest was produced by Alue Riyeung beach with a filter size of 4mm which did not contain any microplastics. According to {12], a higher percentage of mud (soft sediment) can cause microplastics to be trapped very tightly. Meanwhile, sand sediments have gaps that are less dense and allow microplastics to not easily be retained due to the influence of strong wave energy in the coastal area.

Analysis of polymer types obtained 3 polymer results from the 3 types of microplastics found. Fragment type microplastics may contain PETE/PET (Polyethylene Terephthalate) type polymers. PET is a thermoplastic resin from the polyester group. PETE is widely produced in the chemical industry and is used in synthetic fibers, beverage bottles and food containers, thermoforming applications, and combined with glass fibers in engineering resins. The increasing amount of PET use causes the amount of PET waste to quickly increase

as well. Even though PET is not a harmless material, PET is a type of plastic that is non-degradable so it can cause environmental problems [13]. The results of further analysis show that film type microplastics likely contain PS (Polystyrene) type. Polystyrene is a polymer with styrene monomer, a liquid hydrocarbon made commercially from petroleum. At room temperature, polystyrene is usually a solid thermoplastic, melting at higher temperatures. Styrene is classified as an aromatic compound. Fiber type microplastics show the possibility of containing LDPE (Low-Density Polyethylene) polymers. This type of plastic can be said to be the parent plastic because it can still be recycled into other types of plastic. LDPE has a density value smaller than pure water, around 0.920 g/cm^3 [14,15].

4 Conclusion

It can be concluded that Nipah and Alue Riyeung beaches have the same type of sediment, namely sand, but there is one part of Alue Riyeung beach that shows gravelly sand. The results of the analysis of the presence of microplastics on both beaches stated that there were 3 types of microplastics on both beaches, namely Fiber, Fragment and Film. The abundance of microplastics based on sediment size shows that the highest abundance is found in filters with a size of 0.125 mm on Nipah beach with the majority being film types and the lowest is found on filters with a size of 4mm on Alue Riyeung beach with a total of 0. Fragment type microplastics are likely to have PETE (Polyethylene) type polymers. Terephthalate), film type microplastics may have a PS (Polystyrene) type polymer and fiber type microplastics may have an LDPE (Low-Density Polyethylene) type polymer.

Acknowledgments

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