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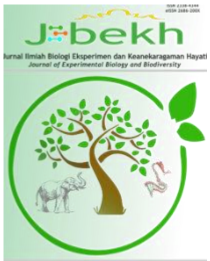

Microplastic Analysis at Sea Water and Sediment in the Mahitam Island Lampung Bay using FT-IR

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Abstract

The amount of garbage that accumulates in the waters causes environmental damage which is getting worse. The breakdown of plastic waste into smaller particles that have been degraded is called microplastic. This study aims to analyze the number of particles, shapes, and types of microplastic polymers found in the water and sediments of Mahitam Island. The research location was determined by purposive random sampling with three stations based on plastic sources, namely Station I, Station II, and Station III, which had different characteristics from laboratory-based testing for seawater and sediment. Microplastic analysis on seawater samples was carried out by adding a solution of 70% ethanol, 30% H_2O_2, and 30% NaCl, and on sediment samples was carried out by adding a solution of $FeSO_4$ (0.05 M), NaCl, and 30% H_2O_2. The content of the number of particles and the shape of microplastics were analyzed using a microscope, while the analysis of microplastic polymers using FT-IR. The first thing to do is to extract microplastics The forms of microplastic found are Fiber, Film, Fragments, and Pellets. The highest number of microplastic particles was the type of film for water samples at Station 1 and Station 2 for sediment samples. The types of polymers found in water and sediments on Mahitam Island are polyvinyl chloride (PVC), polyethylene (PE), polypropylene (PP), and polystyrene (PS) which come from plastic waste. Microplastics are known to originate from the use of plastic originating from tourist activities and originating from the sea currents of Mahitam Island.

Keywords: fiber, film, fragments, pellet

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INTRODUCTION

Marine debris is a problem faced by society because it is a source of pollution in the oceans. Most of the waste that ends up in the ocean is not recycled, which eventually becomes a source of pollution in the ocean and it is estimated that 60-80% of the waste in the ocean comes from plastic waste [1]. According to Widianorko and Hantoro [2] Indonesia ranks second, below China as a contributor of plastic waste pollutants to the ocean with a magnitude of 0.48-1.29 million metric tons of plastic/year.

Plastic waste is one of the particles that is very difficult to decompose in water. Almost 95% of aquatic waste is dominated by plastic waste, from the total waste accumulated along the coastline to the seabed. The breakdown of plastic waste into small degraded particles is called microplastics [3].

Microplastics are plastic particles that are less than 5 mm in diameter. Microplastics are further divided into size categories, namely large (1-5 mm) and small (<0.33) shapes, colors, density, composition, and properties that vary. The potential impact of marine debris will tend to increase as the size of plastic particles (microplastics) decreases through chemical processes [4]. In general, the types of microplastics that enter the waters include fibers, films, and fragments [5].

A common problem with microplastics is that they can damage ecosystems, as they are derived from degraded plastic waste [6]. Compared to larger plastic materials, microplastics are potentially a more serious threat to organisms that inhabit lower trophic levels. Trash that settles in marine waters over time will settle to the seafloor and over time will be covered by sediment and form a new substrate for seagrass plants. In addition to covering seagrasses and sediments, garbage will also enter and accumulate in the body of the biota. Waste pollution in waters results in damage to the ecosystem in the water, for example in organisms that have particles susceptible to the digestive process of microplastics such as plankton, as a result, it can affect higher-level tropical organisms through the bioaccumulation process. The entry of microplastics into seawater and sediments greatly influences the food chain cycle of marine creatures and potentially causing damage to their body.

Microplastics that enter the body of marine biota have the potential to damage organ functions, such as pollution channels, reduce steroid hormone levels, reduce growth rates, affect reproduction, inhibit enzyme production, and can result in exposure to plastic additives [7]. This proves that the potentially more serious threat is microplastics compared to large plastic materials. The abundance of plastics in the waters is determined by environmental factors (tides, wave currents, wind direction, and cyclones) and population density factors around the waters as well as those around Mahitam Island [8]. The purpose of this study is to analyze the number of particles, shapes, and types of microplastic polymers in water and sediment on Mahitam Island.

METHOD

The research was conducted from February 2022 to April 2022 which included sampling on Mahitam Island in February 2022 and sample analysis in March 2022 at the Biomolecular Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Lampung University.

The research location was determined based on the source of plastic waste, namely Station I, Station II, and Station III (Figure 1). Each station was sampled three times by random sampling. Preparation of tools, implementation of research, and analysis of the abundance, shape, and type of microplastics in water and sediment were carried out at the Biomolecular Laboratory. The following are 3 points of sediment and seawater sampling locations on Mahitam Island:

1. Station 1: An area that is very crowded with tourist activities with coordinates 5°35′30 "S; 105° 14'34'E.
2. Station 2: Areas of little tourist activity with coordinates 5°35′30 "S; 105° 14'30'E.
3. Station 3: Areas away from the tourist crowd 5°35′30 "S; 105° 14'40'E.

The tools used in this research are a Ziplock, cool box, whip, cellphone camera, 250 ml measuring cup, 500 ml Erlenmeyer, 500 ml beaker glass, drip pipette, analytical balance, oven, microplastic Digital Microscope 1600x Microscope Inspection Service 600, cellphone GPS, petri dish, 30 cm ruler, filter paper, Fourier Transform Infrared (FT-IR) [9]. While the materials used are distilled water, 70% ethanol, NaCl, $FeSO_4$, H_2O_2, water samples, and sediments [10].

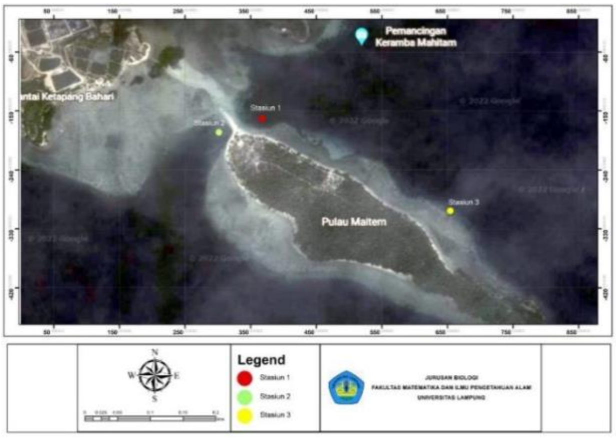


Figure 1. Research location

The implementation of the research was carried out by taking samples which included water and sediment sampling. Water sampling was taken at sea level using a sample bottle. Each location was taken with 3 replicate points of 200 ml. Sediment samples were taken at the seabed with a depth of 1-2 meters. At each point was taken 200 grams of samples using a shovel. When sampling, GPS is used to determine the coordination point of sampling [10]. The next stage is sample testing and analysis Sample analysis aims to determine the number, shape, and type of microplastic polymers present in water and sediments. The following are the stages of sample testing and research data analysis: drying stages, volume reduction, density separation, screening, and visual sorting [11]. The stored sediment samples were analyzed for particle number and shape using a potable microscope while the polymer type was analyzed using FT-IR.

The results of microplastic research at each research location station will be analyzed descriptively and displayed in the form of tables, graphs, and images. Sample observation results will be distinguished based on the number of particles, shape, and type of microplastic polymer. Wavelength data from the FTIR test results will be adjusted to the standard spectrum wavelength for the polyethylene, polystyrene, and polypropylene polymer database. Microplastic abundance data is obtained in units of particle number/200 ml seawater for seawater microplastics on Mahitam Island and for the abundance of microplastic particles in sediments on Mahitam Island in units of particle number/200 grams of sediment dry weight. For data analysis, it was processed using MS. Excel software.

RESULTS AND DISCUSSION

Number of Microplastics in Seawater

Microplastics in water that dominate at each sample point are film-type microplastics. Then the second dominating form of microplastics is the fiber type with a total of 50 particles, followed by the Fragment type microplastics with a total of 25 particles. While the least microplastic findings found were the Pellet type which amounted to 2 particles found at Station 1. The graph of the number of microplastic particles in seawater is presented in Figure 2 and the percentage of the number of microplastic particles is presented in Figure 2.

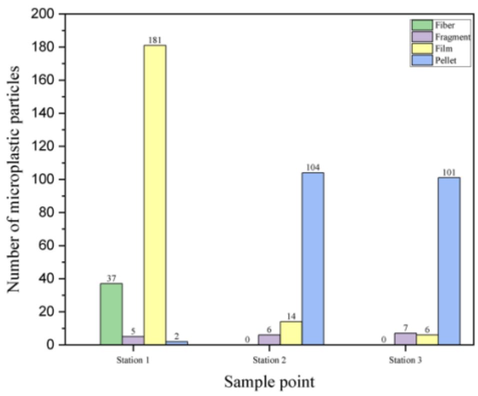


Figure 2. Microplastic particle counts in seawater

Form of Microplastics

The shape of microplastics found in water and island sediments is dominated by film shapes. The characteristics of the film form found are thin and irregular with various types of colors. The forms of microplastics found at each sampling station are presented in Table 1.

Table 1. Form of Microplastics

Location	Water	Sediment
Station 1	Fiber, Fragmen, Film, Pellet	Fiber, Fragmen, Film, pellet
Station 2	Fiber, Fragmen, Film	Fiber, Fragmen, Film, pellet
Station 3	Fiber, Fragmen, Film	Fiber, Fragmen, Film, pellet

The shapes of microplastics in sediment and water found in Mahitam Island Waters are presented in Figure 3.

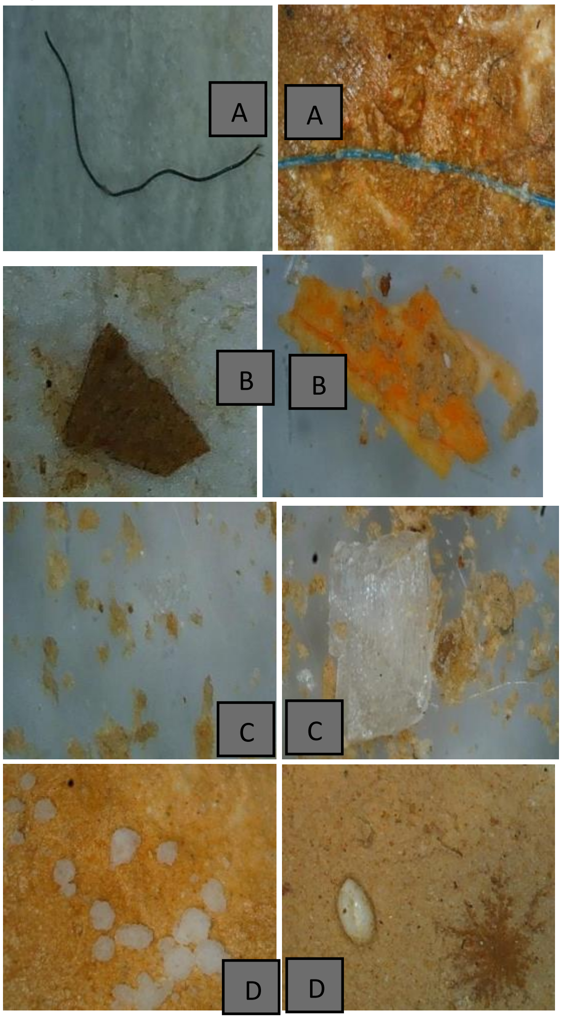


Figure 3. Form of microplastics in water and sediment. (a) fiber (b) fragment (c) film (d) pellet

Number of Microplastics in Sediment

Microplastics in sediments that dominate at each sample point are film-type microplastics with a total of 556 particles. The second largest microplastic finding is the Fiber type with a total of 173 particles and then the Fragment type microplastics with a total of 96 particles. While the least microplastic findings identified are the Pellet type, which is a total of 10 microplastic particles. The number of microplastics in the sediment is presented in Figure 4 & 5 and the percentage of the number of microplastic particles is presented in Figure 6 & 7.

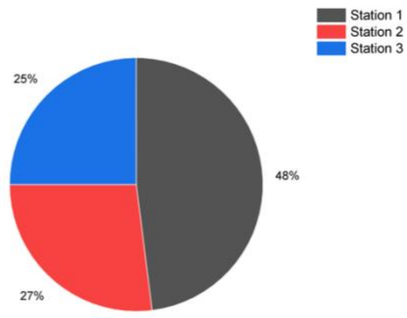


Figure 4. Number of microplastic particles at each station

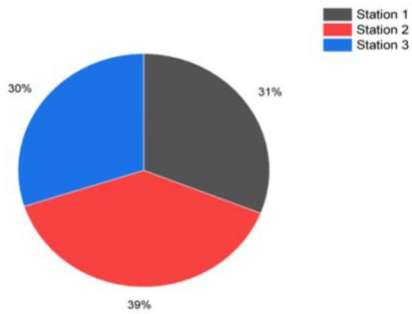
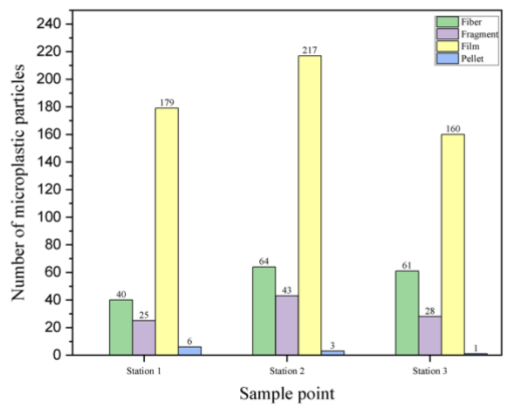


Figure 6. Number of microplastic particles in sediment at each station

Figure 5. Number of microplastic particles in



sediment

FT-IR (Fourier Transform Infrared) Test Analysis

The results of FTIR testing for seawater samples on Mahitam Island from the three sampling locations with wavelengths (Figure 7) include 3332.2, 2914.8, 2117.1, 1640, 1431., 1312 cm^{-1} close to the standard wavelength for Polypropylene. The wavelength number 2914.8 cm^{-1} is a type of polyvinyl chloride (PVC) polymer. In previous research, according to Hamid et al [12] 1254-2957 (1312) cm^{-1} is the wave value of PVC type. The wavelength numbers 2117.1, 1640, 1431.3, and 1312 cm^{-1} include Polyester (PES) polymer type. Therefore, Mahitam Island seawater contains microplastics of Polypropylene, Polyvinyl Chloride (PVC), and polyester (PES) types.

Peak results from FTIR testing for Mahitam Island sediment samples from the three sampling locations with wavelengths include (Figure 8): 3391.9, 2922.2, 2072.4, 1789.1, 1640, 1446.2, 1028.7, 857.3, 708.2 cm^{-1}. These wavelengths are close to the standard wavelengths for polyethylene (PE), polypropylene (PP), and polystyrene (PS) polymers. According to Arlofa and Herutomo [13], PE and PP polymer types are located in the wavelength range of 1254-2957. Research conducted by Fang et al, [14] states that the wavelength of 720 cm^{-1} is close to the wavelength of the benzene ring which is one of the groups owned by Polystyrene. The wavelengths of 756 and 698.2 indicate substituents in the benzene ring. Therefore, Mahitam Island sediments contain microplastics of polyethylene, polypropylene, and polystyrene polymer types.

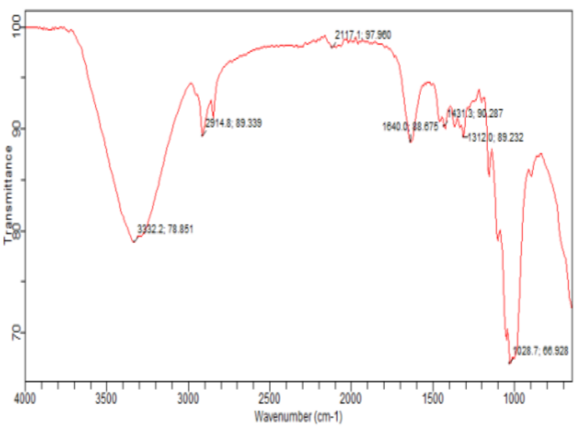


Figure 7. Seawater microplastics

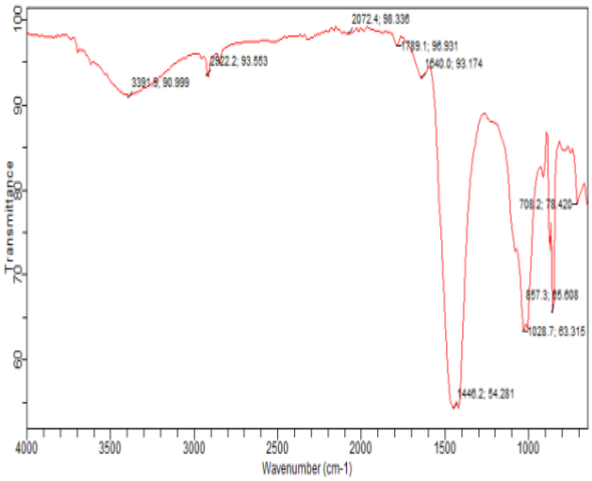


Figure 8. Sediment microplastics

Discussion

The cause of the many findings of microplastics of the Film type identified in seawater on Mahitam Island is that they come from plastic sheets, one of which is from plastic bags or plastic discarded by tourists around the island. Floating microplastics with irregular shapes tend to be attracted to water bodies and retained in water bodies [15]. Therefore, particles with a film shape tend to be found in seawater. The second highest number of microplastic particles found is the fiber type, which is most likely sourced from boat ropes that stop around the island when delivering tourists. This ship rope experiences friction and then breaks down into very small particles and is then carried by the current into the waters. This is following the research of Nor and Obbard [16] which states that fiber-type microplastics come from fishermen's activities both from fishing gear and from ropes from ships that have decomposed and undergone a degradation process until they enter the waters.

According to GESAMP [17], fiber has a thin shape and size which causes the fiber to often be found floating on the surface of the water. Research [18] in the Mediterranean Sea also showed the presence of microplastics that were seen floating on the sea surface. It is suspected that the distribution of microplastics is influenced by currents and wind. This is supported by the statement of Oliveira et al. [19] that strong currents and winds can transport waste away from its source. The third highest number of microplastic particles is the fragment type, this microplastic comes from beverage bottles. Pellet-type microplastics identified were few compared to other types of microplastics. this is to the research of Laila, et al [20] which states that the few findings of this type of pellet are because the microplastics have been destroyed into fragment-type microplastics.

The highest abundance of microplastics was found at station 1 with a total of 223 microplastics/200 ml of water with a percentage of 48%, where this station is a sampling point with many tourist activities around the station and including stations that have high currents compared to station 3. This is what causes the findings of microplastic particles at station 1 more than at other stations. The next highest abundance of microplastics is station 2 with 124 microplastics/200ml of water with a percentage of 27%. This is because station 2 is close to tourist activities and plastic waste is found around the sand close to the sampling point, besides that station 2 has a fairly large current. The sampling point with the least microplastic particle findings compared to other stations is station 3 with 114 microplastics/200ml of water with a presentation of 25%. This is because this station has a calm current and is far from the crowds of tourists and residents around the island.

The highest number of microplastic particles in the sediment was in Station 2 with a total of 330 particles/200 grams of microplastics with a percentage of 39% compared to Station 1 with a total of 258 particles/200 grams of microplastics with a percentage of 31% and Station 3 with a total of 250 particles/200 grams of microplastics 30%. The high number of microplastic particles in Station 2 compared to other stations can be caused by several factors, one of the main factors is that it comes from plastic waste disposed of by tourists around Station 2 and the high current at this station.

Peak results from FTIR testing for seawater samples on Mahitam Island from the three sampling locations with wavelengths including 3332.2, 2914.8, 2117.1, 1640, 1431.3, and 1312 cm^{-1} close to the standard wavelength for Polypropylene. The wavelength number 2914.8 cm^{-1} is a type of polyvinyl chloride (PVC) polymer. In previous research, according to Hamid et al [12]1254-2957 1312 cm^{-1} is the wave value of PVC type. The wavelength numbers 2117.1, 1640, 1431.3, and 1312 cm^{-1} include Polyester (PES) polymer type.

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Types of polymers have an impact on health, namely polypropylene and polyethylene terephthalate polymers, in general, these types of polymers are used for packaging and drinks. Nylon polymers are used as fishing strings and nets. The polymer-type polyethylene terephthalate can potentially cause cancer in humans. Polymer-type polyester fiber or filament can irritate the eyes and respiratory tract. Polymides can cause dizziness, and headaches [8].

CONCLUSION

The conclusions obtained from this study are the form of microplastics found in sediments and seawater on Mahitam Island, namely the form of Film, Fiber, Fragments, and Pellets. Microplastics in seawater were found in a total of 463 particles with the number of types from highest to lowest, namely Film, Fiber, Fragments, and Pellets. The types of polymers found in water and sediments on Mahitam Island are polyvinyl chloride (PVC), polyethylene (PE), polypropylene (P, P), and polystyrene (PS) which come from plastic waste.

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