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Analysis of Microplastic at Sea Water and Sediment in the Pasaran Island Bay Using FT-IR

(Analisis Mikroplastik pada Air dan Sedimen di Pulau Pasaran menggunakan FT-IR)

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Abstrak

Pencemaran laut akibat sampah, terutama limbah plastik, memeiliki dampak ekologis yang besar secara global. Sampah plastik mendominasi pencemaran laut dan secara bertahap terurai menjadi mikroplastik. Penelitian ini menganalisis jumlah partikel, bentuk, dan jenis polimer mikroplastik di air dan sedimen sekitar Pulau Pasaran. Penelitian dilakukan di empat stasiun (Stasiun I, II, III, dan IV). Mikroplastik pada sampel air laut diekstraksi menggunakan larutan 70% etanol, 30% H_2O_2, dan 30% NaCl. Sedimen diproses dengan $FeSO_4$ (0,05 M), NaCl, dan H_2O_2 30%. Jumlah dan bentuk partikel diidentifikasi menggunakan mikroskop digital, dan jenis polimer ditentukan melalui Fourier Transform Infrared Spectroscopy (FT-IR). Bentuk mikroplastik yang diamati meliputi serat, fragmen, film, dan pelet, dengan serat sebagai jenis yang paling banyak dan pelet paling sedikit. Polimer yang terdeteksi termasuk poliamida (PA), polietilena (PE), polipropilena (PP), polivinil klorida (PVC), polistiren (PS), dan politetrafluoroetilena (PTFE), yang berasal dari penggunaan plastik lokal dan aliran laut di sekitar Pulau Pasaran.

Kata kunci: mikroplastik, air laut, sedimen, FT-IR.

Abstract

Marine pollution from ocean garbage, particularly plastic waste, has significant ecological impacts globally. Plastic debris dominates marine pollution and graadually breaks down into microplastics. This study analyzes microplastic particle count, shapes, and polymer types in water and sediiment around Pasaran Island. Research was conducted across four stations (Station I, II, III, and IV). Microplastics in seawater samples were extracted using solutions of 70% ethanol, 30% H_2O_2, and 30% NaCl. Sediments were treated with $FeSO_4$ (0.05 M), NaCl, and 30% H_2O_2. Particle counts and shapes were identified with a digital microscope and polymer types were determined via Fourier Transform Infrared Spectroscopy (FT-IR). Microplastic forms observed included fibers, fragments, film, and pellets, with fibers being the most abundant and pellets the least. Detected polymers included polyamide (PA), polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), and polytetrafluoroethylene (PTFE), originating from both local plasstic use and seawater flow around Pasaran Island.

Keyword : microplastic, sea water, sediment, FT-IR.

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INTRODUCTION

Ocean waste is a major source of marine pollution and a global cause of various ecological impacts [1]. This waste includes plastics, rubber, metals, industrial textile remnants, paper, fishing gear, waste from ship operations, and other items that are lost or discarded into the sea. Over time this continues pollution accumulates into what is known as marine debris. Much of this waste originates from human activities on land and eventually makes its way into coastal and marine areas.

This study was prompted by the large amount of waste, especially plastic, on Pasaran Island due to local human activity. Plastic waste that enters the water can degrade its quality. Over time plastics in the water can brak down into tiny particles known as microplastics which are less than 5 mm in size. Microplastics are generally classified into two main types : primary and secondary. Primary microplastics are manufactured in small particle form like the microbeads found in skincare products. Secondary microplastics by contrast originate from the fragmentation of larger plastic objects [2].

Microplastics in the ocean impact marne ecosystems and aquatic ecology. Over time waste that settles in marine areas accumulates on the seafloor eventually becoming covered by sediment and forming new subtrate for seagrass. Beyond covering seagrass and sediment this waste is also ingested and accumulates in marine organisms, disrupting the ecological balance of coastal and marine ecosystems. Microplastics can harm coral health, destabilize marine ecosystems, and negatively affect marine organism by impairing organ functions such as the digestive system. They can also reduce steroid hormone levels, stunt growth, disrupt reproduction, inhibit enzyme production, and expose organisms to harmful plastic additives [3] .

Certain community activities can disrupt marine ecosystems and marine life as observed on Pasaran Island. The island is at risk of microplastic pollution due to high fishing activity and plastic waste. As the amount of plastic waste in the ocean increases, so does the presence of microplastics in the water. Therefore this study aims to assess the quantity, shape, and types of polymers found in the water and sediment around Pasaran Island.

METHODS

The research was conducted from August 2023 to October 2023 with sample collection on Pasaran Island in August 2023 and sample analysis in September 2023 at the Biomolecular Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Lampung.

The research locations were determined through random sampling with four stations selected: Station I, Station II, Station III, and Station IV. Equipment preparation and the analysis of microplastic types and forms in water and sediment were carried out at the Biomolecular Laboratory. These are the four sampling locations for sediment and seawater on Pasaran Island:

a. Station 1 : Coordinates 5º 27’43.6 ” S ; 105º 15’54.3’E.
b. Station 2 : Coordinates 5º27’47.4” S ; 105º 15’57.1”E.
c. Station 3 : Coordinates 5º 27’54.6” S ; 105º 15’48.6’E.
d. Station 4 : Coordinates 5 º 27’34.2” , 105 º 15’56.7’E.

The equipment used in this study included zip lock bags for storing sediment samples, sample bottles, cool box, scoops or ladles, camera, 250 ml graduated cylinder, 500 ml Erlenmeyer flask, 500 ml beaker, dropper pipette, analytical balance for weighing samples, portable microscope for microplastic identification, Global Positioning System (GPS) for determining coordinates, Petri dishes, sieves, filter paper, and Fourier Transform Infrared Spectroscopy (FT-IR) for identifying the polymer types in microplastic samples.

The materials used in this study included aquades for sterilizing laboratory equipment, 70 % ethanol to kill bacteria, NaCl to separate microplastics from other particles, $FeSO_4$ to reduce the water sample solution, and H_2O_2 to remove organic matter from the samples, water, and sediment [4].

The research involved sampling water and sediment. Water samples were collected from the surface using a scoop, with three 250 ml replicates taken at each location. Sediment samples were obtained from the seafloor at depths of 1-2 meters with 250 g taken from each point using a shovel. GPS coordinates were recorded for each sampling point. The samples were then tested and analyzed to determine the quantity, shape, and polymer types of microplastics in the water and sediment. The analysis included steps such as drying, volume reduction, density separation, filtration, and visual sorting [5]. Sediment samples were analyzed for particle count and shape using a portable microscope and polymer types were identified using FT-IR.

The results of the microplastic analysis at each research station will be presented descriptively in tables, graphs, and images. Samples will be categorized based on particle count, shape, and polymer type. The FTIR wavelength data will be compared to standard spectra for polyethylene, polysterene, and polypropylene. Microplastic abundance will be measured as the number of particles per 200 ml of seawater for samples from Pasaran Island and as particles per 200 g of dry sediment for sediment samples.

RESULT AND DISCUSION

Microplastic Forms

The microplastic forms found in both water and sediment on Pasaran Island are predominantly fibers. These fibers are elongated, resembling threads, and come in various colors. The specific microplastic forms found at each sampling station are presented in Table 1.

Table 1. Microplastic Forms on Pasaran Island

location	water	sediment
Station 1	Fiber, fragment, film, pelet	Fiber, fragment, film, pelet
Station 2	Fiber, fragment, film	Fiber, fragment, film
Station 3	Fiber, fragment, film	Fiber, fragment, film
Station 4	Fiber, fragment, film	Fiber, fragment, film

The microplastic forms are presented in Figure 1.

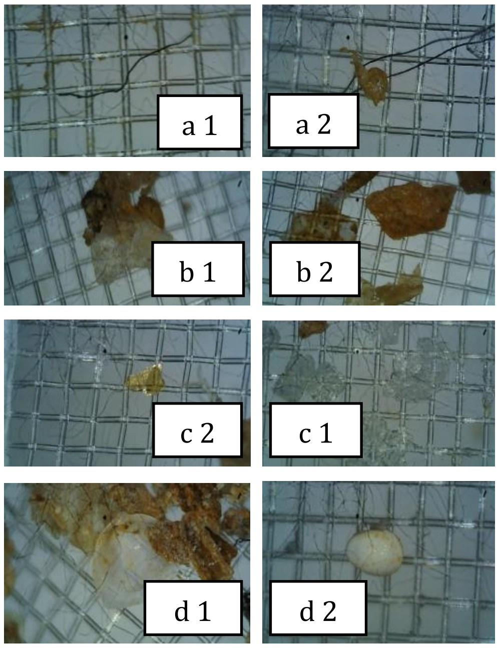

Figure 1. Microplastic Forms in Water (1) and Sediment (2). (a) Fiber (b) Fragment (c) Film (d) Pellet

Microplastic Count in Seawater

The dominant microplastics type in each sampling point was fiber with a total of 537 particles. The second most common type was fragment with 198 particles followed by film with 65 particles. The least found microplastic was pellet with only 4 particles. The graph of microplastic particle counts in seawater is shown in Figure 2.

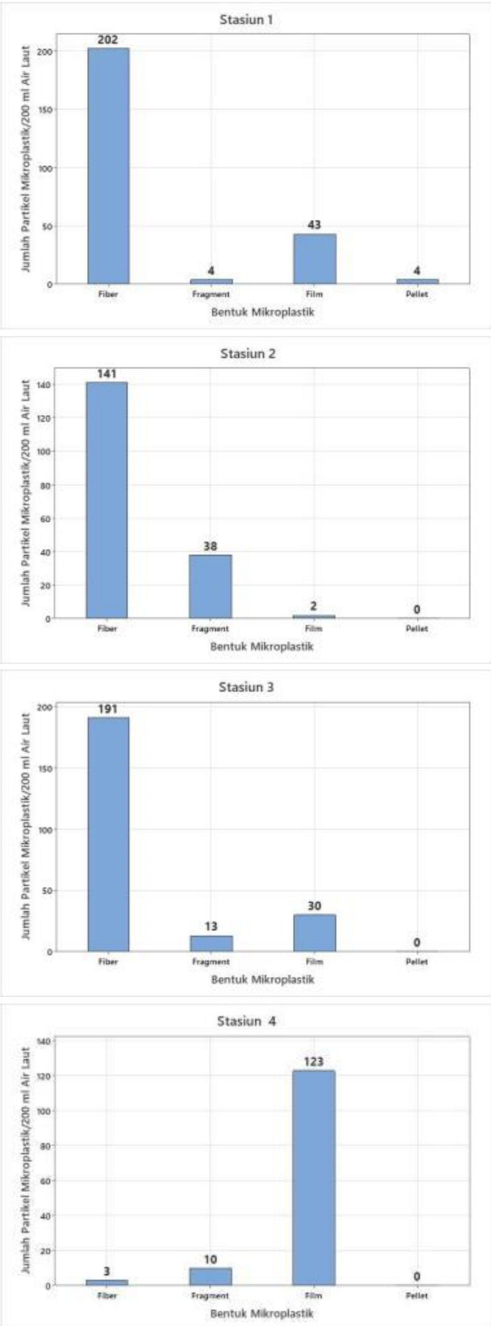

Figure 2. Microplastic Particle Count in Seawater on Pasaran Island

Microplastic Count in Sediment

Fiber microplastics were the most prevalent type found in sediment across all sample points, totalling 242 particles. Fragments followed closely with 238 particles while film microplastics accounted for 50 particles. Pellets were the least common with only 3 particles identified. Figure 3 provides an overview of the microplastic count in ssediment.

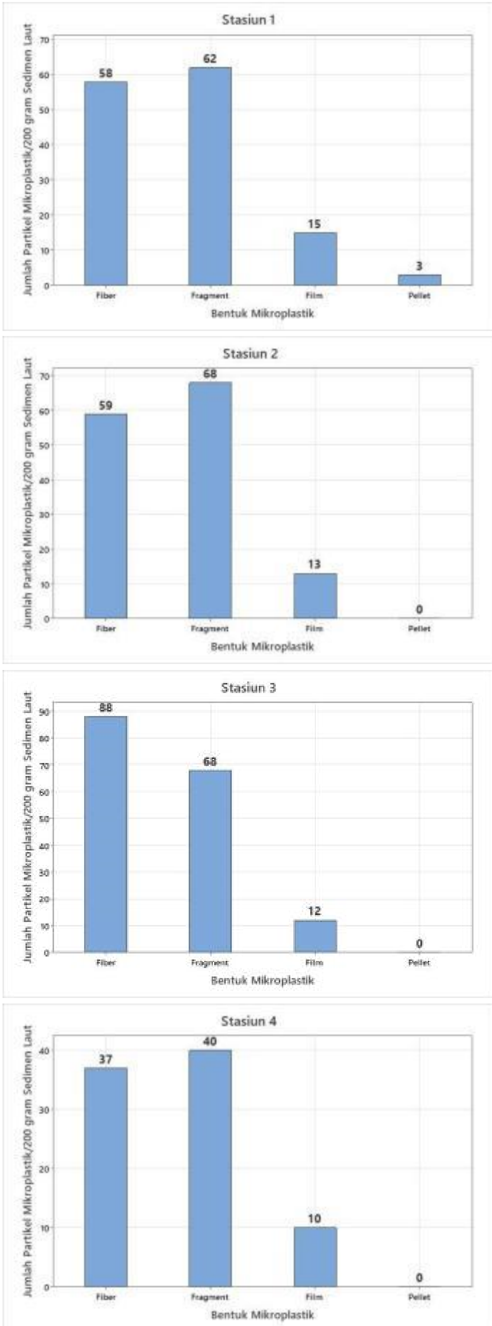

Figure 3. Microplastic Particle Count in Sendiment on Pasaran Island

Fourier Transform Infrared Spectroscopy (FT-IR) Test Analysis

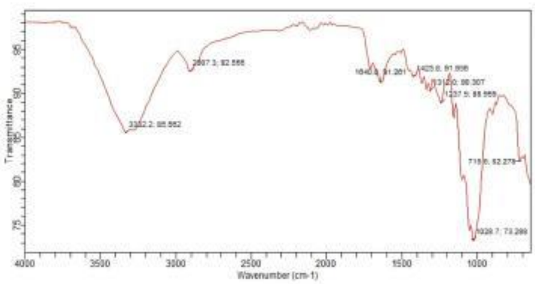

Figure 4. FT-IR Test Results for Seawater Microplastics on Pasaran Island

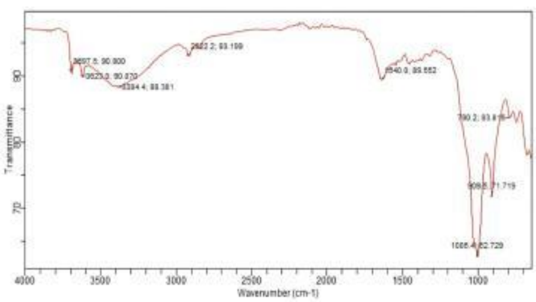

Figure 5. FT-IR Test Results for Sediment Microplastics on Pasaran Island

The prevalence of fiber-type microplastics in seawater around Pasaran Island is likely due to fishing boat ropes. In residential areas fiber-type microplastics can originate from clothing, ropes, fabrics, nets, plastic sacks, raffia cords, fiberglass, and other sources. This is supported by Hiwari's (2019) statement that fiber microplastics can also be influenced by fishing activities as fibers may come from fishing lines and nets [6]. The second most common microplastic found was film which is likely sourced from thin plastic sheets. In Pasaran Island plastic waste is seen piling up, either intentionally or accidentally discarded along the island's shores, potentially contributing to film-type microplastic pollution. This is further supported by Azizah's (2020) statement that film-type microplastics are often influenced by people's habits and behaviour in using single use plastic bags and other plastic based materials [7]. The third most common microplastic type found was fragments which come from trash such as bottles, jars, buckets, PVC pipes, and other items. Kapo (2020) supports this stating that fragments are microplastics formed from the fragmentation of waste such as jar pieces, gallon containers, hard plastics, and small sections of PVC pipes and plastic bottles, all originating from daily human activities [8]. The identified microplastics of the pellet type were fewer in number compared to other types. The most abundant microplastic particles in sediment were fibers, fragments, films, and pellets.

The FTIR peak results for seawater samples from four locations in Pasaran Island showed wavelength values at 3332,2 cm^{-1}, 2907,3 cm^{-1}, 1640 cm^{-1}, 1423,8 cm^{-1}, 1312 cm^{-1} which correspond closely to the standard wavelengths for polypropylene. The 1640 cm^{-1} peak is indicative of polyamide (PA) polymers [9]. The 2907.3 cm^{-1} wavelength corresponds to polyvynil chloride (PVC) as reported by Hamid et al. (2015) for the 1254-2957 cm^{-1} [10]. The 1640 cm^{-1}, 1423,8 cm^{-1}, 1312 cm^{-1} peaks are associated with polyester (PES) polymers. Thus the seawater around Pasaran Island contains microplastics of polyamide (PA), polypropylene, polyvinyl chloride (PVC), and polyester (PES).

FTIR peak results for sediment samples from Pasaran Island showed wavelengths at 3697,5 cm^{-1}, 3623 cm^{-1} , 3384,4 cm^{-1}, 2922,2 cm^{-1}, and 1640 cm^{-1}. The 3697,5 cm^{-1}, 3623 cm , and 3384,4 cm^{-1} peaks are close to the standard wavelengths for polystyrene (PS) and polypropilene (PP). According to Subramani & Sepperumal (2016) the presence of O-H hydrogen bonds at wavelengths between 3600-3200 cm^{-1} is charasteristic of polystyrene (PS) [11]. The 1640 cm^{-1} peak suggests polyamide (PA) while the 909,5 cm^{-1} and 790 cm^{-1} peaks indicate polytetrafluoroethylene (PTFE).

Piwowarczyk (2019) notes that PTFE polymers are identified by C-F absorption in the 1150-100 cm^{-1} range [12]. Therefore Pasaran Island sediments contain microplastics of polyamide, polypropilene, polystyrene, and polytetrafluoroethylene.

Microplastics can enter the human body through respiration and the food chain when consuming organisms contaminated by them. They can also enter directly via inhalation, as microplastics can remain airborne. Major sources include synthetic textile dust, car tire debris, and other plastic products. Microplastics can reach the digestive system indirectly when humans consume animals lower in the food chain. Due to their small size microplastics are ingested by various aquatic animals either accidentally (e.g., fish filtering seawater, shellfish, and plankton) or intentionally (e.g., birds or larger fish mistaking microplastics for prey). This leads to biomagnification and humans as apex consumers are exposed to microplastics secondarily [13].

Nanoplastics pose environmental and health risks due to their small size which allows them to cross cell membranes and disrupt cellular functions. They have been shown to cross fish epithelial membranes, accumulating in organs like the gallbladder, pancreas, and brain [14]. The harmful effects of nanoplastics on organisms, including humans, are not well understood. In zebrafish, polysterene nanoplastics trigger stress response pathways, altering glucose and cortisol levels, which may be linked to behavorial changes during stress [15].

CONCLUSION

The conclusions from this study are as follows:

1. In seawater (200 ml) a total of 804 microplastic particles were found with the highest to lowest counts being: Fiber (537 particles), Film (198 particles), Fragment (65 particles), and Pellet (4 particles). In sediment (200 grams) a total of 553 microplastic particles were found with the highest to lowest counts being: Fiber (242 particles), Fragment (238 particles), Film (50 particles), and Pellet (3 particles).
2. The microplastic shapes found in both sediment and seawater on Pasaran Island were Fiber, Fragment, Film, and Pellet.
3. The types of polymers found in the water and sediment on Pasaran Island were polyamides (PA) Polyethylene (PE), Polypropylene (PP), Polyvinil Chloride (PVC), Polystyrene (PS) dan Polytetraflouroetilena (PTFE).

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