The distribution of marine debris and microplastic in Tidung Kecil Island, Jakarta Bay and Sembilang National Park, Palembang

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Abstract. Plastic waste is one of the marine debris that has negative impacts on the marine environment, such as the death of biota and disturbing the beauty of nature. Plastics can degrade into microplastics. Microplastics in the marine environment can be found in waters and sediments, so they can enter the biota through the food chain. The research aims to examine the distribution of marine debris and microplastics on small islands (Tidung Kecil, Jakarta Bay) and the mainland (Sembilang National Park, South Sumatra). The total marine debris on Tidung Kecil Island (4.04 kg/m²) was greater than that of Sembilang National Plants (0.71 kg/m²). The average abundance of microplastics in the larger size area is greater than in small islands. This is because the substrate is predominantly clayey and muddy with a relatively calm environment, while on small islands the substrate is sand with a dynamic environment. The amount of marine debris found did not correlate with the abundance of microplastics.

1. Introduction
Marine debris is waste originating from an area carried by the rivers to the sea, which appears in other sites on the surface or the seabed. This marine debris goes out to sea during low tide conditions [1], [2]. One of the marine debris materials commonly found in the sea and coast is plastic [3], [4]. 4.8 to 12 million metric tons of plastic produced by 192 countries have entered the marine environment [5]. Plastics that enter the waters endanger the biota that lives in them, such as being eaten and entangled, causing biota death [6]. Marine debris harms marine waters, but the coastal ecosystems on land are affected.

The mangrove ecosystem on the coast becomes a marine debris trap so that large amounts of garbage can be found in that location, including plastic waste. Marine debris can be trapped in the mangrove ecosystem because it is filtered by mangrove roots (pneumatophore) [7]. Plastic contamination in mangrove ecosystems can reduce mangrove health because it triggers pathogens’ emergence [6]. Plastic contamination is not only in the form of marine debris but also in microplastics. Microplastics are pollutants in small particles from the degradation of large plastics [8]. Plastics can be degraded into microplastics by environmental factors (temperature, pH, salinity, etc.) and the activity of microorganisms (bacteria, consortium bacteria, fungi, biofilms, etc.) [9]. Research by [10] showed that ocean acidification (pH 7.7 and 8.1) did not affect microplastic degradation. [11] explained that microplastics could be degraded at temperatures of 20-300 °C.
Several studies have stated that microplastics have been found in mangrove sediments. [12] conducted microplastic research on deposits in mangrove ecosystems and managed to find as many as 520-940 particles/kg dry weight. In another study, located in Southern China [13] stated that mangrove sediments contained 227-2249 microplastic particles/kg. Research results from [14] noted an average of 121 particles/kg of dry weight microplastics in estuaries, China. The research results by [15] show that the estuary area of Wonorejo, Surabaya, is contaminated with microplastics such as polyester, polyethylene, and polypropylene. The average microplastic abundance at that location reached 590 particles/kg dry weight. [16] found polypropylene microplastics in Tambak Lorok Semarang, and [17] found a microplastic type EPS (Expanded Polystyrene) in Banten Bay. The chemicals contained in microplastics are hazardous if they accumulate in biota. Microplastics can contaminate biota by entering the food chain through transfers in the food chain [18,19]. Microplastics have contaminated biota that lives in mangrove ecosystems. Research by [20] stated that fish living in mangrove habitats were contaminated with microplastics from 0.6 to 8 particles/individual. These microplastics are found in the gills, stomach, and intestines. Microplastics that enter the body of organisms will interfere with the digestive, respiratory, and locomotive systems [21].

Several studies have shown that microplastics are both found on coastal lands and found on small islands. The microplastics found on small, uninhabited islands are thought to come from other areas; however, these microplastics may originate from degraded marine debris in the region. Research by [19] found an average of 122.8 67 particles/kg dry weight of microplastics in the small island waters of Bintan, Riau Islands. The types of microplastics found include polyethylene, polypropylene, and polystyrene. Conducted by [22] also discovered microplastics on a small island, Fiji. The results showed that the most extensive microplastic polymers were polyethylene, latex, and polypropylene with fiber and fragment types.

The distribution of marine debris and microplastics in small islands and coastal plains is interesting because so far, researchers have only focused on one of these areas. The difference between marine debris and microplastic characteristics in the two different locations is not known. This research will examine microplastics in small island conservation areas and national parks on the mainland. Tidung Kecil Island is a small island located in the Kepulauan Seribu National Park, which is a marine conservation area for tourism development. Tidung Kecil Island is surrounded by mangrove ecosystems like other small islands in the Thousand Islands. Sembilang National Park is a national park that has an unspoiled mangrove ecosystem. This national park is located in Musi Banyuasin Regency, South Sumatra Province, with 202,896.31 ha.

Sembilang is still found marine debris, especially near residential areas. In this study, Tidung Kecil Island represents a small island and Sembilang National Park represents the mainland. This research is expected to know the differences in the characteristics and distribution of marine debris and microplastics in the two locations and the relationship between microplastics and the abundance of biota and grain size of the sediments. This study aimed to assess the distribution of marine debris and microplastics in Tidung Kecil Island and Sembilang NP. Besides, the relationship between marine debris and microplastics and sediment fractions and microplastics was found.

2. Methods
2.1. Study site
The first sampling was carried out in October 2019 in the Sembilang National Park area, Banyuasin, South Sumatra, to be precise in three regions, namely the Bungie River estuary, the Solok Buntu River, and the Barong River. The determination of sampling points in this study was done randomly at as many as ten stations. The second sampling was held in December 2019 in Tidung Kecil Island, Thousand Islands. The samples were taken randomly at as many as 5 stations representing the entire island area.
2.2 Sampling method

2.2.1 Marine debris sampling. Marine debris collection was carried out in Sembilang NP using a transect 25 x 25 m and in Tidung Kecil Island using transects quadrat 5 x 5 m. Marine debris is collected using the trash bag, then weighed and seen the type. The categories of marine debris used include glass, cans, plastics, and styrofoam.

2.2.2 Microplastic observation. The sampling technique was based on [23], which has been modified using a PVC core with a diameter of 7 cm and a length of 20 cm in Sembilang National Park and using a transect squared 25 cm x 25 cm with a depth of 5 cm in Tidung Kecil Island. Samples were taken by randomly purposive sampling, representing the station with 5 draws. All examples in one station were composite, and sediment samples were taken for microplastic and benthos analysis.
The fractionation method used according to [24] has been modified. Sediment samples from Sembilang National Park and Tidung Island were composited. The sediment was fractionated using a sieve shaker using a mesh size of 1 mm, 0.5 mm, 0.25 mm, 0.125 mm, 0.063 mm, <0.063 mm. The sample is inserted into the largest mesh filter to the smallest mesh size. The filter is shaken for 2 minutes to make sure the sediment can separate. Sediment samples that have been filtered in each filter are weighed to calculate the percentage by weight. The sediment samples obtained from Sembilang National Park will be pipetting analysis, while the sediment samples from Tidung Kecil Island will not be analyzed for pipetting because sediment on Tidung Kecil Island is dominated by large sand.

Microplastic extraction was carried out using a modified flotation method. The sediment samples used for microplastic extraction were not fractionated [14]. 100 gr of dry sediment was added with NaCl solution at a concentration of 1.2 g/ml. Samples are shaken for 2 minutes at a 200 rpm speed then left to stand for 24 hours. Samples were filtered with 0.45 µm Whatman paper [13]. The microplastics that had been filtered on Whatman were observed under a stereomicroscope with different shapes, colors, and sizes.

3. Research results and discussion

The site location on Tidung Kecil Island is divided into 5 stations. Marine debris samples were taken from the five stations using the same transect, namely 5 x 5 meters. [25] classify marine debris into 7 categories: plastic, wood, paper, metal, rubber, cloth, and glass/ceramics. This study does not include a paper in the marine debris group because the paper is easily destroyed, so there are only 6 categories.

| Site | Plastics | Wood | Metal | Rubber | Cloth | Glass | Weight (kg) |
|------|----------|------|-------|--------|-------|-------|-------------|
| 1    | √        | -    | -     | √      | √     | -     | 4.05        |
| 2    | √        | -    | √     | √      | -     | √     | 2.62        |
| 3    | √        | -    | -     | √      | √     | -     | 4.15        |
| 4    | √        | -    | √     | √      | √     | √     | 8.40        |
| 5    | √        | -    | √     | √      | √     | √     | 2.82        |
|      |          |      |       |        |       |       | Average: 4.40 |

Station 5 is the station that is mostly found by marine debris compared to the other four stations with 8.4 kg. Marine debris that can potentially be degraded into microplastics includes plastics, rubber, and fabrics. The five stations were found plastic and rubber.

| Site | Plastic | Wood | Metal | Rubber | Cloth | Glass | Weight (kg) |
|------|---------|------|-------|--------|-------|-------|-------------|
| 1    | -       | -    | -     | -      | -     | -     | 0           |
| 2    | -       | -    | -     | -      | -     | -     | 0           |
| 3    | -       | -    | -     | -      | -     | -     | 0           |
| 4    | -       | -    | -     | -      | -     | -     | 0           |
| 5    | -       | -    | -     | -      | -     | -     | 0           |
| 6    | √       | -    | √     | -      | -     | -     | 0.1         |
| 7    | -       | -    | -     | -      | -     | -     | 0           |
| 8    | -       | -    | -     | -      | -     | -     | 0           |
| 9    | √       | -    | √     | -      | -     | -     | 1           |
| 10   | √       | -    | -     | -      | -     | -     | 7.0         |

Average: 0.71
The sampling location in Sembilang NP was divided into 10 stations. Marine debris at stations 1-8 is measured on a 25x25 m transect. Marine debris was still rare found in these eight stations because it is classified as an unspoiled mangrove area. The marine debris found at stations 1-8 is thought to have come from visitors who came to that location. This is because the research location is far from residential areas and far from the coast, where the suspicion of sending waste from other sites is very small. Stations 9 and 10 are near residential areas, station 9 is in the mangrove ecosystem, while station 10 is on the shoreline. These two stations are often found in marine debris due to their high anthropogenic activity. The marine debris sampling at these two stations is different from the other stations because so much marine debris found that the transects used are smaller than the others. Marine debris is mostly found at station 10. In the 1x1 m transect, marine debris is found weighing 7 kg with plastic and metal types.

Marine debris in Indonesia can come from domestic land and sea or come from outside Indonesia. Local waste sources come from household waste, coastal tourism activities, and fishery activities such as aquaculture and fishing. [26] According to [27] the source of marine debris on a small island comes partly from activities on the island and its surroundings. Tourism activities on Tidung Island are one of the largest sources of waste generation. 83.86% of the main proportion of marine debris found on Tidung Island is plastic waste. The second and third largest marine waste proportions are glass and cloth, amounting to 5.00% and 4.25%. Apart from tourism activities, marine debris can also come from other areas due to currents and winds that carry it. According to [28], the main factor in distributing marine debris is surface currents. This surface current can carry marine debris to other areas.

3.1 Abundance of microplastics in Tidung Kecil Island and Sembilang National Park
The abundance of microplastics in Tidung Kecil Island is shown in picture 1. The average abundance of microplastics in Tidung Kecil Island was 142 particles/kg dry weight. The highest abundance at station 2 was 400 particles/kg dry weight, followed by station 3 with 130 particles/kg dry weight, and station 4 with 80 particles/kg dry weight. The lowest abundance of microplastics is station 5 as much as 40 particles/kg dry weight. These five stations are located around Tidung Kecil Island. This island is adjacent to Tidung Besar Island, which is the center of tourism. Station 5 is the closest location to Tidung Besar island but has the smallest abundance. The substrate of these five locations is dominated by sand. The sand substrate is easily washed by water so that the abundance of microplastics found is affected by it.
Figure 3. The Abundance of microplastics (a) in Tidung Kecil Island, (b) in Sembilang NP.

The sampling location in Sembilang NP is divided into 10 stations. The abundance of microplastics at this location is shown in graph 1b—the average abundance of microplastics in Sembilang NP is 151 particles/kg dry weight. The highest abundance of microplastics in the sediment was at station 3 as much as 710 particles/kg dry weight, followed by station 1 as many as 200 particles/kg dry weight, and station 2 as many as 190 particles/kg dry weight. The lowest abundance of microplastics is at station 8, as many as 10 particles/kg dry weight. Stations 1 to 8 are located far from the anthropogenic activities, this location is still very natural and rarely visited, while stations 9 and 10 are close to residential areas. The sediment substrate at stations 1-9 is dominated by mud, while station 10 is dominated by sand because it is located on the shoreline. Station 1, 2, and 3 found a higher abundance of microplastics than station 10, which is close to the residential. This is presumably because the substrate at stations 1, 2, 3 which is dominated by mud can precipitate microplastics, resulting in microplastic accumulation, while at station 10 the substrate is in the form of sand and is still influenced by currents so it is easily washed.

3.2. Correlation between marine debris and microplastics

The result of the Spearman correlation between marine debris and the abundance of microplastics in Tidung Kecil Island is -0.01 with a significant value of 0.873 (table 3), which means that the level of relationship (correlation) is both very weak and unidirectional (negative) and does not have a significant relationship. In contrast to the results of the correlation between marine debris and microplastics in Sembilang NP, which is worth 0.5 with a significant value of 0.667, means that the correlation between the two is moderate and has a unidirectional relationship (positive) and there is no significant relationship because it has a value of more than 0.05 (95%).

| Location            | Correlation value | Sig(2 tailed) |
|---------------------|-------------------|---------------|
| Pulau Tidung Kecil  | -0.01             | 0.873         |
| Sembilang NP        | 0.5               | 0.667         |

The abundance of marine debris and microplastics has a weak correlation because it is suspected that plastics take a long time to degrade. In addition, the presence of microplastics in this small island is more influenced by high hydro-oceanographic factors (tides, currents) so that the degraded marine debris does not settle in the same location. As a result, the abundance of marine debris and microplastics obtained at this location did not influence each other. The abundance of microplastics and mesoplastics had a very strong correlation (0.878, p <0.01). Base on research [29] macroplastic (≥25 mm) and mesoplastic
(5–25 mm) abundances were more correlated than the abundances of microplastics (1-5 mm) and macroplastics.

4. Conclusion
The total marine debris on Tidung Kecil Island was greater than that of Sembilang NP. The average abundance of microplastics in the mainland is greater than that of small islands. This is because the substrate is predominantly clayey and muddy with a relatively calm environment, while on small islands the substrate is sand with a dynamic environment. The correlation of microplastic and marine debris is weak in Tidung Kecil Island and moderate in Sembilang NP.

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