Marine debris monitoring in the coastal area of the District of Banyuwangi, Indonesia: Characterization of the debris type and composition

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Abstract. This study was aimed to monitor and collect the data on marine debris in the coastal area of the District of Banyuwangi, Indonesia. The survey was conducted in two periods, i.e., July and October of 2020 in Cemara Beach and Syariah Beach. The coastal marine debris sampling was done in accordance with the guideline published by Indonesian Ministry of Environment and Forestry. In terms of number of debris/m², the result shows that plastic was the dominant coastal marine debris. The density of macro plastic and meso plastic debris in July 2020 are 1.96 – 5.44 debris/m² and 0.28 – 0.80 debris/m², respectively; while in October 2020, the density of macro plastic and meso plastic debris are 1.24 – 3.24 debris/m² and 0.56 – 2.24 number of debris/m², respectively. The information on the characteristics of marine debris could assist the authority in formulating the proper strategy to overcome the problem as well as support the government in planning a good sustainable coastal management.

Keywords: Banyuwangi, coastal management, marine debris, plastic waste.

1. Introduction
Indonesia has the second longest coastline in the world with nearly 60% of the population lives in the area around 60 km from the coastline. The large coastal area comes with abundant renewable and nonrenewable resources [1] and could be advantageous for the country. Nevertheless, this potential would not be beneficiais without a good sustainable coastal management.

Due to the high human activity and increasing population, improperly disposed waste in coastal area is one of the complex problems faced by coastal cities [2]; [3]. Currently, marine debris has become a national and global concern as it travels ocean wide and harmful to the organisms and human [4]. Marine debris can bring negative impacts such as habitat damage, wildlife entanglement and ghost fishing, ingestion, vessel damage and navigation hazard, as well as alien species transport. Furthermore, the presence of marine debris can spoil the beauty of the coastal environment, which in turn, leads to an economical loss if the coastal area is a tourist destination [5]; [6].

Marine debris is defined as any persistent, manufactured or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment. It is then mainly categorized into
Based on its size, there are four types of marine debris, i.e., micro- (< 0.5 cm), meso- (0.5-2.5 cm), macro- (2.5 cm-1 m), and mega- (> 1 m) debris [8].

The coastal area of the District of Banyuwangi, East Java, Indonesia, has become a famous tourist destination. Therefore, a monitoring on marine debris in this area is required to preserve the coastal environment so that it can continue to bring the economic benefit to surrounding communities. Moreover, Indonesia has declared to reduce 70% of its marine plastic debris by 2025 [6].

This research aimed to provide information and data on marine debris in the coastal area of the District of Banyuwangi. The data can be used to enhance the policy and support the law enforcement as it is one of the main pillars of Indonesia’s Plan of Action on Marine Plastic Debris 2017 – 2025. The data can also be used to plan a better sustainable coastal management. Information and data collected from this research were the type of marine debris as well as the composition based on mass, amount, and density.

2. Materials and Methods

This research was conducted in two periods, in accordance with The Guideline for Marine Debris Monitoring by The Ministry of Environment and Forestry of The Republic of Indonesia [7]. The first one was on July 17th, 2020 and the second was on October 10th, 2020. The location were at Cemara Beach (8°15’50.68″S 114°22’23.35″E) and Syariah Beach (8°13’6.35″S 114°23’10.34″E), located in the District of Banyuwangi. The location of the study can be seen in Figure 1.

![Figure 1](image1.png)

**Figure 1.** Location of Cemara Beach and Syariah Beach taken from Google Earth

The surveys for this study were conducted along the shoreline of Cemara Beach and Syariah Beach. The sampling area were marked with four points as shown in Figure 2 and 3. A transect with the length of 100 m and width of 7 m is laid out parallel to the shoreline of Cemara Beach, while on Syariah the size of the transect is 100 m x 10 m. The marine debris then collected using a sieve from each transect. Sampling area and sketch of the transect in both beaches can be seen in Figure 2 – 5.
Figure 2. Satellite image of sampling area in Cemara Beach

Figure 3. Satellite image of sampling area in Syariah Beach

Figure 4. The sketch of transect, sub-transect, and sub-sub-transect on Cemara Beach
3. Result and Discussion

3.1 Analysis of Marine Debris Sources
The activities and condition surrounding Cemara Beach and Syariah Beach were varied from each other. There were many fishponds and settlement area in the surrounding of Cemara Beach confined by a river. The sampling area at Cemara Beach was in the southern part near the estuary, therefore the marine debris at Cemara Beach possibly came from that river that carries terrestrial waste. Meanwhile, the surrounding of Syariah Beach was settlement area which directly adjacent to the beach. The illegal and improper waste dumping is feasibly the source of the marine debris at Syariah beach. Aside from those sources, the marine debris on the beach also came from debris washed ashore from the sea.

3.2 Characterization of Marine Debris on Cemara Beach

3.2.1 Macro Debris on Cemara Beach. Based on the sampling result conducted in the first period, there were 136 macro-debris found in Cemara Beach. The composition was dominated by fabric (42.56%), plastic (13.11%), and others (36.12%). As many as 60 debris found were plastic food packaging, 34 debris were plastic bag, and 16 debris were cleaning products plastic packaging. Those were three main specific type of marine debris dominating macro-debris in Cemara Beach from the first period. Meanwhile, in the second period, the composition of macro-debris in Cemara Beach consisted of rubber (65.23%), plastic (20.25%), fabric (10.66%), and plastic foam (3.86%). The macro plastic found from the second period were as many as 81 debris, with 3 main specific type came from the plastic food packaging (37 debris), other plastic (22 debris), and plastic bag (9 debris). Plastic foam found as many as 15 debris with 7 debris of them were instant food packaging, 7 debris were sponge fraction, and 2 debris of baby mat foam. Fabric found as many as 4 debris of clothing fabric and rubber found as many as 4 debris of rubber sandal. The macro-debris composition based on mass, number, and density from the first and second survey period can be seen in Figure 6 – 11.

Figure 10 shows density of macro debris from the first period. The density of plastic was 5.44 debris/m², with the density of plastic food packaging was 2.4 debris/m², 1.36 debris/m² of plastic bag, and 0.64 debris/m² of cleaning product plastic packaging. The density of other was 0.48 debris/m². Meanwhile, the density of fabric was 0.4 debris/m², with the density of clothing fabric was 0.32 debris/m², 0.04 debris/m² of bag fabric, and 0.04 debris/m² of rope fabric. Figure 11 shows the density of debris from the second period, where the density of plastic was 3.24 debris/m², with density of plastic food packaging was 1.48 debris/m², other plastic was 0.88 debris/m², and density of plastic bag was 0.36 debris/m². The density of plastic foam was 0.60 debris/m², with specific density of instant food packaging and coolers foam was 0.24 debris/m², density of baby mat foam was 0.08 debris/m², and density of sponge was 0.04 debris/m². Apropos of fabric and rubber, their density was each 0.16 debris/m².
Figure 6. Composition based on mass of macro-debris in Cemara Beach in the first period

Figure 7. Composition based on mass of macro-debris in Cemara Beach in the second period

Figure 8. Composition based on the number macro debris in Cemara Beach in the first period

Figure 9. Composition based on the number of macro debris in Cemara Beach in the second period

Figure 10. Density Based on the type of macro debris in Cemara Beach in the first period

Figure 11. Density based on the type of macro debris in Cemara Beach in the second period
3.2.2 Meso Debris on Cemara Beach. Meso-debris found in Cemara Beach was dominated by plastic which were as many as 90.34% in the first survey and 74.16% in the second survey. Plastic debris found in the first survey consisted of plastic food packaging (12 debris), other plastic (6 debris), plastic rope (1 debris), and plastic raffia (1 debris). Meanwhile, in the second survey, it consisted of plastic food packaging (43 debris), other plastic (10 debris), and plastic bag (3 debris). Other constituent found in meso-debris from the first period were plastic foam (instant food packaging), fabric (rug fabric), and rubber; found as many as 1 debris each. As for the second period, other constituent found in meso-debris were instant food packaging (3 debris), cooler foam (2 debris) and ceramic (3 debris).

Based on the result in the first period, the density of plastic was 0.8 debris/m², with the majority of it came from plastic food packaging (0.48 debris/m²), followed by other plastic (0.24 debris/m²) also plastic rope and raffia (0.04 debris/m²/2 each). The density of plastic foam, fabric, and rubber were 0.04 debris/m². The second period result showed that the density of plastic was 2.24 debris/m², where the majority was plastic food packaging (1.72 debris/m²), followed by other plastic (0.4 debris/m²) and plastic bag (0.12 debris/m²). As for the density of plastic foam found in the second period was 0.20 debris/m² and the density of glass and ceramic were 0.12 debris/m². The meso-debris composition based on mass, number, and density from both survey periods can be seen in Figure 12 – 17.
3.3 Characterization of Marine Debris on Syariah Beach

3.3.1 Macro Debris on Syariah Beach. Based on the result of the first and second survey period, macro-debris found in Syariah Beach was dominated by plastic and fabric. In the first period, based on mass composition, there were 85.24% of plastic and 14.76% of fabric, meanwhile in the second period there were 72.65% of plastic and 27.35% of fabric. The macro-debris composition based on mass can be seen in Figure 18 and 19.

Figure 16. Density based on the type of meso-debris in cemara beach in the first period

Figure 17. Density based on the type of meso-debris in cemara beach in the second period

Figure 18. Composition based on mass of each type of macro-debris in Syariah Beach in the first period

Figure 19. Composition based on mass of each type of macro-debris in Syariah Beach in the second period
The number of macro-debris found in Syariah Beach was less than that found in Cemara Beach in both periods. In the first one, there were 49 macro-debris and in the second period there were 31 macro-debris. The specific plastic found in Syariah Beach in the first survey was dominated by plastic food packaging (20 debris), other plastic (16 debris), and plastic bag (6 debris). In the second survey it was dominated by plastic food packaging (19 debris), other plastic (3 debris), and plastic ribbon (3 debris). Meanwhile, for fabric debris, there were 2 debris of patch fabric and 1 debris of clothing fabric from the first period, and 3 debris of patch fabric from the second period.

Based on the result of macro-debris density calculation from the first survey there were 1.96 debris/m² of macro plastic which consisted of plastic food packaging (0.8 debris/m²), other plastic (0.64 debris/m²), and plastic bag (0.24 debris/m²). The result of the second survey showed that the density of marine plastic debris for the macro-debris on Syariah Beach was 1.24 debris/m², which consisted of plastic food packaging (0.76 debris/m²), other plastic (0.16 debris/m²), and plastic ribbon (0.12 debris/m²). In the first survey period, specific density of macro-fabric was 0.12 debris/m² which consisted of 0.08 debris/m² of patch fabric and 0.04 debris/m² of clothing fabric. The density of macro-fabric debris found in the second period was also 0.12 debris/m². The macro-debris composition based on the amount and density on Syariah Beach can be seen in Figure 20 – 23.
3.3.2 Meso Debris on Syariah Beach. Similar to the macro-debris, meso-debris that was found on Syariah Beach in the first survey period was also dominated by plastic and fabric. Meanwhile, in the second period, the meso-debris was dominated by glass and ceramic, plastic, as well as fabric. The percentages can be seen in Figure 24 and 25, while composition based on number and density can be seen in Figure 26 – 29.

Figure 24. Composition based on mass of each type of meso-debris in Syariah Beach in the first period

Figure 25. Composition based on mass of each type of meso-debris in Syariah Beach in the second period

Figure 26. Composition based on the number of each type of meso-debris in Syariah Beach in the first period

Figure 27. Composition based on the number of each type of meso-debris in Syariah Beach in the second period
Figure 28. Density based on the type of meso-debris in Syariah Beach in the first period

Figure 29. Density based on the type of meso-debris in Syariah Beach in the second period

Figure 26 shows that there were 7 debris of meso plastic found in the first survey that consisted of 5 debris of other plastic, 1 debris of lighter and cigarette butts. As for fabric, there were 2 debris of clothing fabric. Meanwhile, Figure 27 shows that there were 14 debris of meso plastic found in the second survey that consisted of 13 debris of plastic of food packaging and 1 debris of other plastic. From Figure 28 also known that there were 3 glass debris and 2 debris of clothing fabric.

In Figure 28 can be seen that the density of meso plastic found in the first survey was 0.28 debris/m² which consisted of 0.2 debris/m² of other plastic and 0.04 debris/m² of lighter and cigarette butts. Also, the density of meso fabric was 0.08 debris/m². Figure 29 shows the result of density analysis in the second survey period. The density of meso plastic was 0.56 debris/m² which consisted of 0.52 debris/m² of plastic food packaging and 0.04 debris/m² of other plastic. The density of meso glass and ceramic was 0.12 debris/m² and the density of meso fabric was 0.08 number of debris/m².

3.4 Marine Debris in the District of Banyuwangi

The data of marine debris survey in Cemara Beach and Syariah Beach was then compiled to determine the density range of each marine debris type which was shown in Table 1 and 2.

Table 1. The density range of each marine debris type from the first survey period

| No | Type of Debris          | Density Range (Number of Debris/m²) |
|----|-------------------------|-------------------------------------|
|    |                         | Macro  | Meso  |
| 1  | Plastic                 | 1.96   | 0.28  |
| 2  | Plastic Foam            | 0.00   | 0.00  |
| 3  | Fabric                  | 0.12   | 0.04  |
| 4  | Glass and Ceramic       | 0.00   | 0.00  |
| 5  | Metal                   | 0.00   | 0.00  |
| 6  | Paper and Cardboard     | 0.00   | 0.00  |
| 7  | Rubber                  | 0.00   | 0.00  |
Table 2. The density range of each marine debris type from the second survey period

| No | Type of Debris | Density Range (Number of debris/m²) |
|----|----------------|-------------------------------------|
|    |                | Macro     | Meso     |
| 8  | Wood           | 0.00      | 0.00     |
| 9  | Others         | 0.00 – 0.48 | 0.00     |

From the survey in July and October 2020 it was determined that there were ten major types of others marine debris and plastic found in the District of Banyuwangi in 2020. The result can be seen in Figure 30 and 31.

Figure 30. Ten major specific type of marine debris in the coastal area of the District of Banyuwangi in 2020
Figure 30. shows that the majority type of marine debris found on the coastal area of the District of Banyuwangi were dominated by fabric, various type of plastic, and rubber. A very similar result to this research found in a research on marine debris in the eastern coast of Surabaya City. It was found that the dominant type of marine debris there were fabric, various type of plastics, rubber, and building materials [9]. Both coastal area of the District of Banyuwangi and eastern coast of Surabaya City were in East Java Province.

Also, in a study on various research on marine debris in different coastal area in Indonesia between 1986 – 2018, various type of plastics found to be the dominant marine debris type [10]. These similarities present a clearer guide and additional information in how local and national policy and law enforcement should be enhanced.

4. Conclusion

The dominant composition of macro-debris on Cemara Beach based on mass is fabric in the first survey period (July 2020) and rubber in the second survey period (October 2020). Meanwhile plastic debris was the most number and density in both survey periods. As for meso-debris, plastic has the highest mass, number, and density in both survey periods.

In the first survey period, macro debris and meso debris on Syariah Beach, based on mass, amount, and density, are dominated by plastic. Meanwhile, in the second survey period, macro-debris on Syariah Beach, plastic was the highest mass, number, and density. As for meso-debris, glass and ceramic were the highest mass while plastic was the highest number and density.

Based on the result of both survey in July and October 2020, marine plastic debris has the highest density compared to the other types. The density of macro plastic and meso plastic debris in July 2020 are 1.96 – 5.44 debris/m² and 0.28 – 0.80 debris/m², respectively; while in October 2020, the density of macro plastic and meso plastic debris are 1.24 – 3.24 debris/m² and 0.56 – 2.24 number of debris/m², respectively.

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