Trends in composition and density of marine litters on the Mamboro Beach

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Abstract. The coastal zone is an intermediate area between land and sea which is very vulnerable to being contaminated by litters. The density and composition of marine litters is strongly influenced by environmental factors and human activities. The research objective was to monitor trends in composition and density of litters on the Mamboro Beach in 2019 and 2020. The sampling method is based on marine litter guideline monitoring formulated by the Ministry of Environment and Forestry which was adopted from UNEP and NOAA. The results showed that the total litter weight for macro size (> 2.5 cm) has decreased by 4303.29 g (56.23%) from 2019 to 2020. Likewise, meso size (0.5-2.5 cm) has decreased by 902.25 g (18.42%) from 2019 to 2020. Meanwhile, both litter sizes have increased in density for macro size by 14.12 pieces/m² and meso size by 18.92 pieces/m² from 2019 to 2020. The decline in the trend of macro and meso litter in 2019-2020 period is not always directly proportional to the litter density on the Mamboro beach. Apart from anthropogenic and infrastructure factors, geomorphological characteristics, weather conditions and oceanographic parameters also have an influence on the composition and density trends of litter in coastal areas.

1. Introduction

The territory of Indonesia, which is two-thirds of which is the sea, has an abundance of natural and non-living resources. Relief Indonesia which is very rich in islands makes Indonesia has a long coastline, exceeding 99 thousand km. Unfortunately in some places, both the sea and the coast are like that cause for concern. If neglected, various coastal and marine ecosystem services will continue to decline.

One of the serious threats is marine litters. These litters come from various anthropogenic activities and various land uses. Tons of trash can be transported in a ‘Clean Beach’ event. Cigarette butts, various types of plastics, glass, rubber, various types of bottles, food packaging, wood, textiles, and metals are easily encountered. The litters can float in the sea, get entangled on the seabed or strand on the beach. Litters in coastal and marine ecosystems is not only a direct threat to the biota in these ecosystems, but also reduces the quality of the waters which can lead to a decline in environmental status and community welfare. Marine litter has accumulated rapidly and is becoming a major environmental concern, yet quantitative and regular observations and exploration that track litter origins are limited [1].

Mamboro sea waters play an important role in supporting the needs of some people, especially fishery commodities. Meanwhile, Mamboro beach is also a strategic area in the marine services sector through the existence of a port used by several companies that obtain raw materials using sea transportation. This activity causes a lot of ship activity to enter and exit the Mamboro beach area, not only loading and
unloading activities but also refueling activities. Not to mention the activities of community members who live around the Mamboro coast and several rivers that empties into the Mamboro beach such as the Mamboro river, Taipa river, Pajeko river and Palu river which can trigger sea water pollution. With these activities, it can be estimated that the Mamboro sea waters have changed their natural conditions.

Marine debris pollution is a very serious problem to deal with, because it harms the environment and ecosystem in general [2].

Currently, the problem of marine debris pollution, especially in coastal areas, has become a concern of the world community and is one of the main issues related to coastal and marine environmental problems in Indonesia. In the last decade research and monitoring activities related to marine debris, including plastic waste, have received important attention in developed countries in the world. However, there are not many research or monitoring activities related to marine litter in Indonesia. Through the Ministry of Environment and Forestry, Indonesia has committed to reduce 70% of marine litters by 2025. One of the supports for this policy is through efforts to determine the level of marine litters pollution, especially waste deposited onto the coast. This information will be very useful in controlling pollution and environmental damage in coastal and marine areas, especially due to garbage. This study aims to determine the characteristics of the Mamboro beach litter pile in the form of composition based on the type and density, both large (> 2.5 cm) and litters medium (0.5-2.5 cm).

2. Materials and methods
Monitoring is carried out at Mamboro Beach, North Palu District periodically from 2019 to 2020. Mamboro Beach was chosen as the sampling unit because it fulfills several criteria, namely: characteristics of a sandy beach, more than 100 meters long, a sloping beach slope (18.3°) and there are no barrier structures such as breakwater, and jetty. The sampling unit is located at the same coordinate point to obtain a valid trend of composition and density of litters.

Table 1. Coordinate points for transects and sub transects at the monitoring location

| No  | Point Code | Latitude   | Longitude  |
|-----|------------|------------|------------|
| A   | High Tide  |            |            |
| 1   | A1P point  | -0.797596  | 119.871554 |
| 2   | A2P point  | -0.797642  | 119.871545 |
| 3   | Sub transect A | -0.797587 | 119.871518 |
| 4   | Sub transect B | -0.797551 | 119.871419 |
| 5   | Sub transect C | -0.797515 | 119.871348 |
| 6   | Sub transect D | -0.797506 | 119.871285 |
| 7   | Sub transect E | -0.797470 | 119.871186 |
| 8   | E1P point  | -0.797443  | 119.871141 |
| 9   | E2P point  | -0.797488  | 119.871132 |
| B   | Low Tide   |            |            |
| 1   | A2S point  | -0.797642  | 119.871545 |
| 2   | A3S point  | -0.797687  | 119.871527 |
| 3   | Sub transect A | -0.797633 | 119.871500 |
| 4   | Sub transect B | -0.797615 | 119.871401 |
| 5   | Sub transect C | -0.797588 | 119.871321 |
| 6   | Sub transect D | -0.797570 | 119.871240 |
| 7   | Sub transect E | -0.797533 | 119.871159 |
| 8   | E2S point  | -0.797488  | 119.871132 |
| 9   | E2S point  | -0.797561  | 119.871105 |
2.1 Sampling method
The sampling method is based on the guideline for monitoring Marine Litter released by the Directorate of Pollution and Coastal Damage Control, Ministry of Environment and Forestry in 2017. The guidelines were prepared by combining the UNEP Survey and Monitoring of Marine Litter method and NOAA's Marine Debris Monitoring Assessment. Sampling is done by determining the transect area at a minimum length of 100 m parallel to the coastline with a width following the back boundary of the beach [3]. At 100 meters the transect area is divided into 5 sub-transects, with a distance between each sub-transect of 20 meters. Furthermore, on each sub-transect a 5x5 meter box is plotted, which will then be randomly selected 5 boxes 1x1 meter as a litter collection area with the help of a 1x1 meter transect quadrant and a 2.5 cm pore diameter macro filter and a 0.5 cm pore diameter meso filter. Macro and meso litters are collected in plastic sampling, then weighed and identified. The sampling stage was carried out in 2 areas, namely the highest tide area and the lowest tide area [4].

2.2 Data analysis
The percentage of litters composition, namely the weight per litters type per total weight in the survey area is calculated using the formula:

\[ \text{percentage(\%)} = \frac{X}{\sum_{i=1}^{n} X_i} \times 100\% \]  \hspace{1cm} (1)

Solid litters density (D), namely the amount per litters type per square meter is calculated using the formula:

\[ D = \frac{\text{type}}{\text{Length} \times \text{Width}} \] \hspace{1cm} (2)

The calculation is differentiated for macro (> 2.5 cm) and meso sizes (0.5-2.5 cm).

3. Results and discussion
3.1 Litter composition
In general, the litter composition of the macro (> 2.5 cm) found on Mamboro beach shows a trend of decreasing volume of 56.23%. In 2019, the total weight of the macro size was 13833.17 g and decreased in 2020 to 9529.88 g. The most dominant litter type found on the Mamboro beach both in the 2019 and 2020 monitoring periods is the type of wood (WD). Even though the composition trend has decreased, from 65% in 2019 to 40% in 2020, this litter type of wood is still the most common type of wood found.
on Mamboro beach. Apart from wood, other litter types that experienced a downward trend in composition were metal (ME) at 4% and other (OT) by 3%. Several litter types of macro group that experienced an increase in composition from 2019 to 2020 were cloth (CL), namely 13%, plastic (PL) 12%, glass (GC) 3%, foam (FP) 2%, and paper (PC) 2%. Meanwhile, the type of rubber litter (RB) shows a static trend of 5% in the two monitoring periods (Figure 2).

The meso size (0.5-2.5 cm) also showed a trend of decreasing composition, namely 18.42%, where in 2019 the litter weight of the meso reached 1253.37 g then decreased to 351.12 g in 2020. The composition of wood types is still became the most dominant in the meso litter group both in the 2019 and 2020 monitoring periods despite experiencing a very significant downward trend in composition, namely as much as 52%. Apart from wood, other litter types also decreased by 3%. Litter types that experienced an increase in composition in the meso group were glass by 30%, plastic 19%, metal 4%, foam plastic 2%, and rubber 2%. Meanwhile, the types of paper and cardboard have a static composition in the meso litter for the 2019 and 2020 monitoring periods (Figure 3).

**Figure 2.** Litter Composition of macro on the Mamboro beach 2019-2020

**Figure 3.** Litter Composition of the meso on the Mamboro beach 2019-2020
3.2. Litters density

The solid litter density of the macro group (> 2.5 cm) shows a fairly large increasing trend, from 20.96 pieces/m² found in 2019 to 35.08 pieces/m² in 2020. The litter type of plastic (PL) is the densest, namely 23.24 pieces/m² or 66% of the total litter found in 2020. When compared to 2019, the litter density of plastic appears to have increased significantly in 2020 by 30%. Likewise, glass and ceramic (GC) increased by 3.8 pieces/m², paper and cardboard (PC) 1.04 pieces/m², rubber (RB) 0.6 pieces/m², metal (ME) 0.44 pieces/m², cloth (CL) 0.36 pieces/m² and foamed plastic (FP) 0.24 pieces/m². The dominant litter type of wood (WD) was found in 2019, namely 8.72 pieces/m² or 42% of the total litter decreased sharply in 2020, which was only 0.96 pieces/m². The decrease in density also occurred in other litter types (OT), which decreased by 0.24 pieces/m² (Figure 4).

An increasing trend also occurred in the meso litter (0.5-2.5 cm) in the 2019-2020 period, namely 18.92 pieces/m². The highest density is shown by the type of plastic litter, which is 19.36 pieces/m² or equal to 64% of the total litter found in 2020, where this amount has increased by 2% compared to 2019. Another litter type that has increased is glass type 4 pieces/m², foamed plastic 1.68 pieces/m², wood 0.92 pieces/m², rubber 0.48 pieces/m² and metal 0.4 pieces/m². Meanwhile, the litter types that experienced a decreasing trend in density were paper and cardboard 0.4 pieces/m², other 0.32 pieces/m² and cloth 0.16 pieces/m² (Figure 5).
3.3. Discussion

This research was conducted to analyze the extent to which the tendency of the litter composition and density in the coastal area of Mamboro was consistent from 2019 to 2020. The litter sizes sampled were macro and meso. Macro is the litter size that ranges from > 2.5 cm to < 1 m which is generally found at the bottom and surface of waters as well as in coastal areas. Meanwhile, meso size is marine litter measuring > 5 mm to < 2.5 cm which is generally found on the surface of the water or mixed with sediment. The main ingredients of macro and meso litter are plastic or styrofoam products with a very slow degradation rate which has the potential to threaten the sustainability of the aquatic environment [5].

The results showed that the composition of the macro size (> 2.5 cm) found on the Mamboro beach showed a trend of decreasing volume of 56.23%. In 2019, the total weight of the macro size was 13833.17 g and decreased in 2020 to 9529.88 g. Likewise with the meso size (0.5-2.5 cm) which also showed a downward trend in composition, namely by 18.42%, where in 2019 the weight of the meso size reached 1253.37 g then decreased to 351.12 g in 2020. Trends The decline in the composition of macro and meso size does not actually reflect that the litter problem at Mamboro beach has been well managed because other facts show that the amount of litter found in the sampling unit has increased both macro and meso. There were 524 types of macro size found in 2019, increasing to 877 types in 2020. The same goes for the 285 kinds of meso size found in 2019 to 758 types in 2020. A decrease in the composition of the weight of macro and meso litter on the beach Mamboro is suspected because the coastal area of Mamboro is still unstable after the Tsunami at the end of 2018 so that it still has an influence on the accumulation of litter around Mamboro beach. Meanwhile, in the period 2019 to 2020 the local government and non-governmental organizations have made efforts to normalize the coastal area of Palu Bay including Mamboro beach so that the volume of litter in 2020 is relatively reduced.

The highest composition found from 2019 to 2020 was the litter type of wood in both macro and meso size. In 2019, 65% of the type of wood was found and its composition decreased in 2020 to 40%. The litter types of wood found in the sampling unit were pieces of blocks and boards. This type of wood is often found because the sampling station is a mooring location for fishing boats which is also used as a place for ship repair and even as a place for assembling fishing boats. The reduction in the composition of wood species found in 2020 is due to the decline in fishing boat building activities around the Mamboro coast, especially after the Tsunami disaster that occurred at the end of 2018. However, the presence of wood waste at the sampling station is actually not that worrying because of the nature of the material that is easily biodegradable weathering process.

The fact that needs special attention is the increasing composition of plastic, glass and foamed plastic in both the macro and meso groups which can disrupt the balance of the ecosystem due to the nature of the material which is difficult to decompose and even takes hundreds of years for the decomposition process [6]. The composition of plastic litter, which was previously only found on an average of 10% in 2019, increased to an average of 25.5% in 2020, both macro and meso litter. Likewise with glass which composition increased from an average of 4.5% to 21% and foamed plastic which increased by an average of 3% in 2020, both macro and meso litter. The distribution of plastic, glass and foamed plastic on the Mamboro beach is significantly influenced by anthropogenic factors. Mamboro Beach is located very close to residential areas whose activities are relatively dense. In general, people who live in the coastal area of Mamboro work as fishermen and traders. So that the Mamboro beach is relatively often exploited as a berth for fishing boats and buying and selling transactions of local people's fishing products. These activities and conditions can directly increase the presence of plastic, glass and foamed plastic such as drink bottles, plastic cups, plastic bags, snack wrappers, glass bottles and Styrofoam in the Mamboro beach area. This situation is also exacerbated by the lack of waste disposal facilities that are far from the sampling unit on the Mamboro beach.

In contrast to the litter composition, the litter density of both macro and meso size on Mamboro beach shows an increasing trend from 2019 to 2020. Macro litter groups increased from 20.96 pieces/m² in 2019 to 35.08 pieces/m² in 2020 Likewise with the meso group litter which shows an increasing trend, where in 2019 the density was 11.4 pieces/m² to 30.32 pieces/m² in 2020. Plastic litter is the type with
the highest density both in the macro and meso groups, which is averaged 21.30 pieces/m² or 65% 64% of total litter found in the 2019-2020 period. In the macro size, the type of glass litter increased by 3.8 pieces/m², paper 1.04 pieces/m², rubber 0.6 pieces/m², metal 0.44 pieces/m², cloth 0.36 pieces/m² and foamed plastic 0.24 pieces/m². Meanwhile, the glass type meso group increased by 4 pieces/m², foamed plastic 1.68 pieces/m², wood 0.92 pieces/m², rubber 0.48 pieces/m² and metal 0.4 pieces/m². Although anthropogenic factors greatly affect the litter density on the Mamboro beach, the geomorphological characteristics, weather conditions and oceanographic parameters cannot be completely eliminated because they contribute to the litter density on the beach. Mamboro Beach is strongly influenced by the characteristics of the waters of Palu Bay, which is closed sea water. This characteristic makes it possible for Mamboro beach to receive consignment of garbage continuously from other areas around Palu Bay. The tides of Palu Bay are of mixed type with a tendency to double daily, where there are two times the tide and two times the low tide a day. This condition allows garbage carried by the current to strand on Mamboro Beach. Moreover, Mamboro beach is quite close to several rivers that empty around Palu Bay such as Mamboro river, Taipa river, Pajeko river, and Palu river. The existence of these rivers causes the coastal waters of Mamboro to receive a supply of waste material carried by the river water. Especially during the rainy season, the river will transport the piles of waste from the population to the sea and in the end it will be distributed to the Mamboro coastal area through currents, waves or wind.

Besides that, the main wind pattern that takes place in Palu Bay also allows a rate of increasing litter density in its coastal area. The variation of marine litter is strongly influenced by the monsoon winds, which blow to the northeast and southwest. Wind patterns that do not blow in the same direction with different forces will change the circulation or transportation of macro debris in the sea [7]. From February to August the wind blows from the Southeast, where in this period the waters of Palu Bay are generally calm, the sea level is not too high, and the average wave period is relatively slow. This is because the wind blowing from the Southeast is protected by the hills surrounding Palu Bay so that it does not have much influence on the waters of Palu Bay. Therefore, during this period, fishermen also carried out many fishing operations because the fish catch was more optimal. The relatively slow profile of currents, waves and winds causes the waste not to be distributed too far from its source. The opposite occurs from September to January. In this period, the waters of Palu Bay were greatly influenced by the wind blowing from the West into the bay mouth directly so that the wave height increased, the highest tide occurred and the rainfall increased sharply. This condition can increase the rate of solid litter density in the coastal areas of Palu Bay, including Mamboro beach.

4. Conclusion
The decline in the trend of macro litter composition of 56.23% and meso 18.42% in the 2019-2020 period is not always directly proportional to the litter density on the Mamboro beach. In fact, the litter density on Mamboro beach has actually experienced an increase in the trend of 14.12 pieces/m² macro and 18.92 pieces/m² meso size in the 2019-2020 period. Apart from anthropogenic and infrastructure factors, geomorphological characteristics, weather conditions and oceanographic parameters also have an influence on the composition and density trends of litter in coastal areas.

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