Indonesia Marine Debris: Banda Aceh Coastal Environment Identification

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Abstract

Banda Aceh City, having an area of 61.36 km² with a coastline of 11 km which covers Ulee Lheu Beach to Alue Naga Beach. The research was carried out to determine marine debris statistics (type, amount and mass) which divided into 7 categories; plastic, metal, glass, rubber, processed wood (organic), clothing, and ceramics. This research also conducted to complement the Indonesian marine debris data which currently incomplete. We choose Banda Aceh as the preliminary location because its area affected by dynamic oceanographic parameters of the Indian Ocean, Bay of Bengal and bordered by several countries that could be a source of marine debris, thus making this research is important to do. Marine debris data were collected from March to May 2019, on the coast and waters surface. Data collection on the beach is carried out every 28 days using the transect method, while on the water surface by riding boats using visual observation techniques. Statistical results show that inorganic litter has the highest percentage and mass, which a mass density reached 288.37 g/100 m^2 at Ulee Lheu Beach and 64.96 g/100 m^2 at Alue Naga Beach. Plastic type dominates the type of marine debris on the beach about 92.2% and 51.4% on the water surface. The amount of plastic especially bottle continues to accumulate, it will not only endanger marine waters ecosystem but also potential to affect and damage the coastal environment. The results of this study are expected to provide input / recommendations for the government and related institutions in waste management in coastal and marine areas and tourism in a sustainable and sustainable way.

Keywords : marine debris; coastal vulnerability; aceh; plastic; coastal environment

INTRODUCTION

Marine waste or currently known as marine debris are a solid object(s) that directly or indirectly thrown away and left just like that in a marine or lake environment (NOAA, 2013). This objects certainly has an impact on the health of organism in the environment, including humans who consume products from the marine/lake environment been polluted.

Indonesia is said to be the second largest contributor of plastic type marine debris after China, with an estimated 0.48 - 1.29 million metric tons per year (Jambeck *et al*, 2015). This was confirmed by Barboza *et al*. (2019) who estimated the increasing of marine debris will be globally occured by 2025 if it not taken seriously. Marine debris problems in Indonesia are generally caused by anthropogenic activities from land which then enter the sea through existing rivers (Lebreton *et al*., 2017). Several studies of coastal and riverine waste in Indonesia have been conducted in Seribu Island and Ambon (Uneputty and Evans, 1997a; Uneputty and Evans, 1997b), on seagrass (Sheavly, 2007) and plastic debris accumulation (Jambeck *et al*., 2015; Sherman and Sebille, 2016; Willoughby *et al*., 1997).

Based on garbage collected by Banda Aceh City Enviromental, Sanitation and Beauty Services officers, it is known that plastic waste in Banda Aceh reaches 20 tons per day. According to the data, only 12 out of 20 tons of plastic waste can be recycled, in the meantime the rest are still scattered in the urban areas, including in the Gampong Jawa

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Landfill. The most dominant type of the plastic waste around the study area are bottles and straws. In fact, 80% of marine debris generated on land and from human activities, and only 20% are from marine activities (http://www.projectaware.org). This study aims to analyze the marine debris distribution both on the beach and the waters.

MATERIALS AND METHODS

This research was carried out in March until June 2019 in two locations, coastal areas and open waters. The beach data collection was held on Ulee Lheu Beach and Alue Naga (Figure 1) by the linetransect method (Figure 2) to determine the type, mass and amount (Hermawan *et al*., 2017)

The collection was conducted 3 times by following the tidal time, with a span of 28 days in between the time (Sheavly, 2007). The data were classified into two classes; inorganic waste (> 2.5 cm in size) and organic waste in the form of wood.

In the beach, the wastes obtained twice in the area of 100-meter along the coastline, divided into 20 transects at a distance of 5 meters, during the lowest low tidal condition and where there is no routine cleaning activity.

Marine debris collection in the coastal waters of Banda Aceh City was conducted on 30 March 2019 and 1 May 2019 by boat. The method of collecting debris data on surface water follows the method recommended by NOAA in 2013 (Figure 3 and Table 1) with an area of 13.2 km^2.

Table 1. Suggested visual survey transect widths based on observer height above water and ship speed

Observer Height (m)	Ship Speed			
	2 knots	6 knots	10 knots	
1	6 m	4 m	3 m	Transect Width
3	8 m	6 m	4 m	
6	10 m	8 m	6 m	
10	15 m	10 m	5 m	

The boat's path used in data collection on marine debris at sea surface is shown in Figure 4. The conditions used when data collection in the field is the observer height 3 meters from the surface of the water with the speed of the ship 2 knots.

RESULTS AND DISCUSSIONS

Banda Aceh City is on the northern of the Sumatra Island with a position facing directly to the Bay of Bengal and the Indian Ocean. The earthquake and tsunami in 2004 changed the morphology of the Banda Aceh coastal area. With a coastline of 10 km in length, the beach which has sediment in the form of sand is no more than 3 km spread over several beaches with the longest section of only 1.94 meters. Weather conditions when conducting the survey in March - May 2019 were in the transition season, from the wet season to the dry season, and the dominant wind blows from the West to the East.

Wave conditions in the waters of Banda Aceh are dominantly blowing from the Southwest towards the northeast and will turn towards the East after the North coast of Sumatra Island (Figure 5) with a wave height of 1.25-2.50 m. When collecting marine litter data in the waters, the weather conditions are relatively sunny and cloudy.

Tides in the study area have a double daily type, where in one day there are two tides and two neaps. The maximum tides are 2.376 meters and the maximum neap is 0.787 meters above the MSL (Figure 6).

The wind conditions were observed daily during the research activities, from January to April 2019, that showed it dominant towards the Northeast and Southeast with speeds varying from 3 m/s to 8 m/s. Meanwhile, the wind that blow towards the Southeast have the potential to create currents that carry surface debris particles towards the Banda Aceh coast.

The wind that blows from towards the Northeast has the potential to carry light debris particles from the mainland to the Banda Aceh coast. Also seen in the Gampong Jawa sub district, there is a landfill

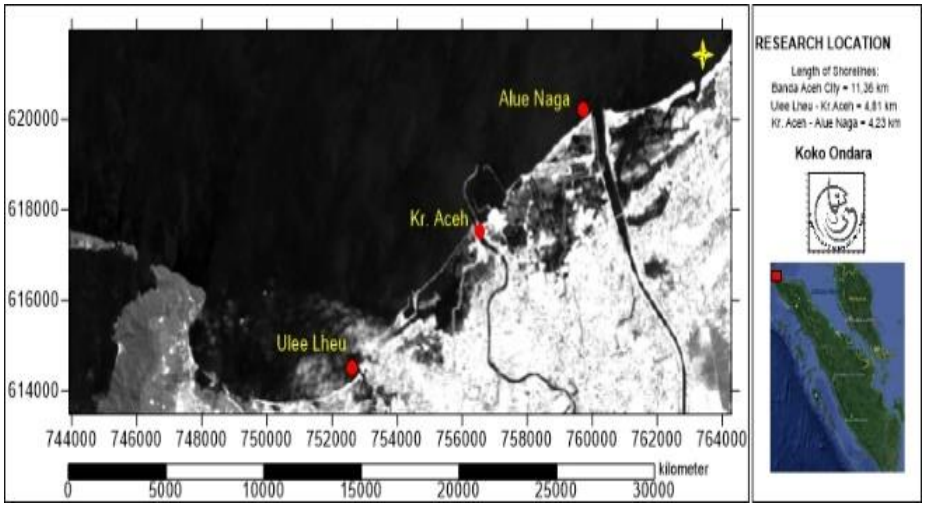


Figure 1. Research location in the coastal area of Banda Aceh

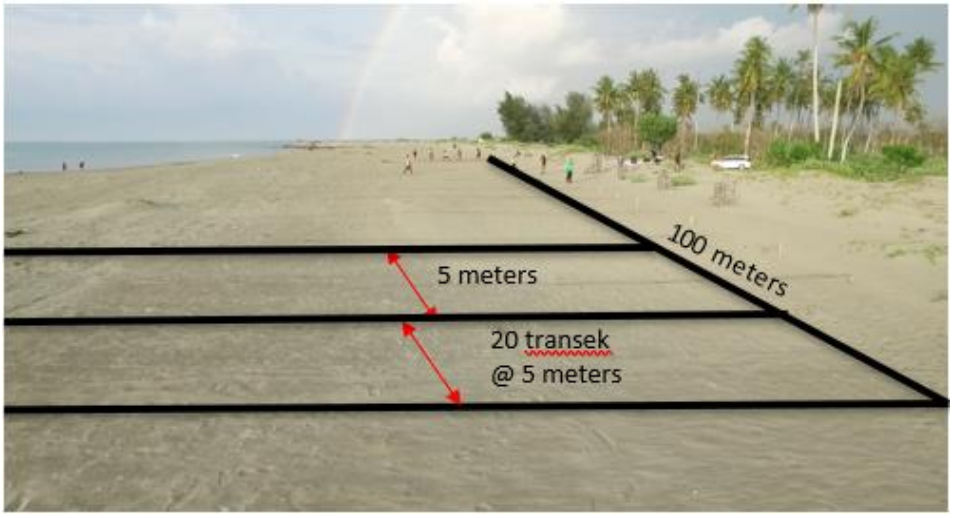


Figure 2. Linetransect applied in the beach debris collection

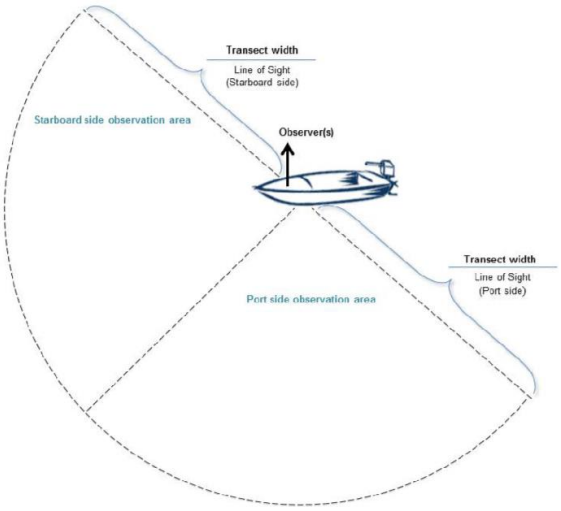


Figure 3. During visual surveys, observers are responsible for visually scanning the sea surface

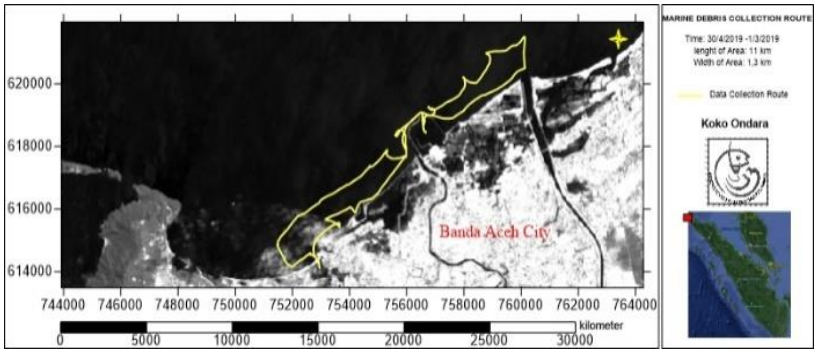


Figure 4. Map of marine debris collection route

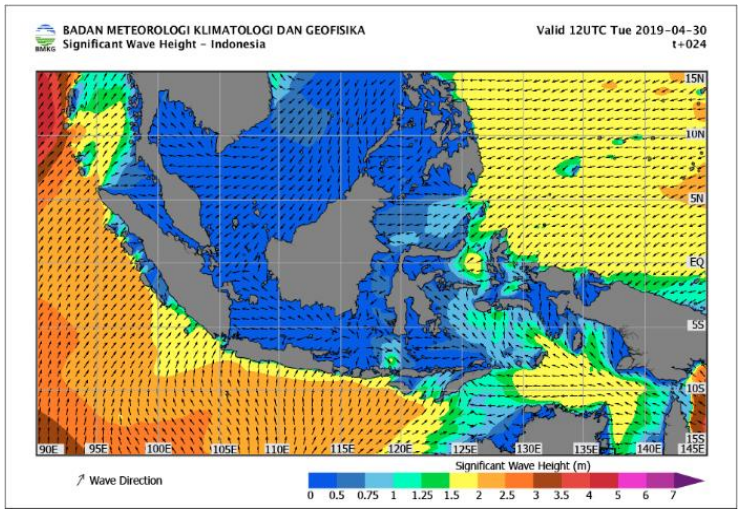


Figure 5. Forecast map of height and waves direction (BMKG, 2019)

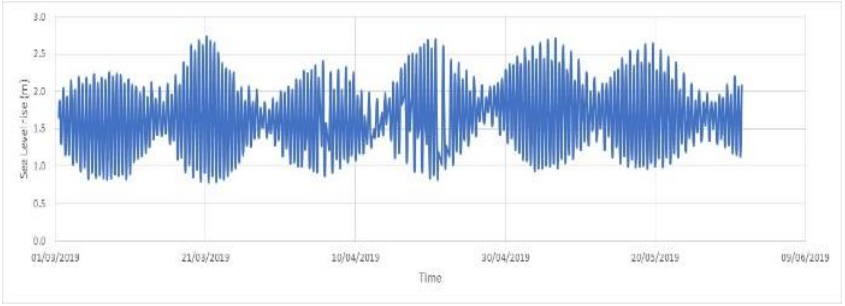


Figure 6. Tidal fluctuation of Aceh waters

managed by the Banda Aceh City Sanitation Department (Figure 7).

Marine Debris Composition

Based on observations at the research location, there are 3 types of marine debris: mega, macro and meso debris. Marine debris in the study location based on the nature of its decomposition is divided into organic (wood) and inorganic. The focus of this observation only limited to organic waste in the form of wood >2.5 cm and processed wood, and inorganic waste, which divided

into 6 categories namely plastic, metal, glass, rubberclothing and ceramics as displayed in Table 2. Organic and inorganic marine litter can be dangerous for ecosystem life in coastal areas. The number of waste types were found at the sampling locations shown in the table below.

It can be seen in Table 3 and Table 4, the amount and mass of marine debris that dominates the coastal of Banda Aceh, especially in Alue Naga Beach, is inorganic waste which includes plastic, glass, metal, clothing, rubber and ceramics. Whereas processed wood waste is considered as organic which will decay over the time.

The type of marine debris that is most commonly found comes from plastic waste which is very easily found either located on the coast and buried under the sand. Plastic waste found is generally still intact and not decomposed. This finding is in line with previous study in South Sulawesi which observed plastics were repeatedly found at 6 beaches; Tanjung Tayang, Lae-lae, Akkarena, Bodia, Mandi, and Karama (Tahir *et al*., 2019). The following is the complete composition of waste found in Banda Aceh waters.

Marine debris concentration based on number of items (Figure 9a) and mass (Figure 9b) show that plastic have 44.7 item/100 m^2 and 264.37 gr/10 m^2. Also can be seen from the Figure 9 that plastic has the highest percentage among other types of marine debris on the coastal area of Banda Aceh City, which is 92.2% (Figure 8). While the type of debris with the smallest percentage, 0.31%, is in the form of metal groups consisting of glass, cans, nails, bottle caps, and medicine containers. The following graph shows the variety of plastic waste collected during observation in the field:

Based on the amount, plastic bags, bottles and plastic ropes / small nets are the most common types of plastic waste with a total percentage of each type of 23.9%, 14% and 13%. However, only plastic bags and plastic ropes/small nets produce a percentage of the amount that is directly proportional to the percentage of mass, which is 22.4% and 11.9%, while the percentage of the mass of the bottle only reaches 8.1%.

Some other items, such as containers, cigarette boxes, cigarette butts, fishing lines, toothbrushes and medical plastics also have a mass percentage that matches the percentage of the total items found. In contrast, food wrappers, bottle caps, cups, straws, pampers, sacks and fragments differ greatly between the mass percentage and the total item. This shows that the large amount of a type of waste cannot be directly related to the mass (Walker *et al*., 2006).

Based on the sampling conducted 3 times during the period of March to June 2019 (Figure 11), it was seen that there was a buildup of new marine litter for each data collection. Visually, plastic waste dominates in two different areas in each sampling. The predominance of plastic waste in coastal and marine areas has also been demonstrated by several studies in various countries (Zettler *et al*., 2013 in the North Atlantic; Uneputty in Ambon, Nash, 1992 in Alaska; Reisser, 2013 in Australia; Evans *et al*., 1995 in Eastern Indonesia).

Moreover, marine debris were also obtained from the water surface. We found that of 366 items there were 51.4% plastic, 0.5% glass and others 48.1% (Figure 12). It was clear plastic was the dominant type collected both on water surface and beach area (Figure 14). In the process of collecting data (Figure 13), it appears that in the estuary area there is more debris collection than in the open waters. Wood debris can also be This plastic bottle waste if left to continue and will accumulate in number, will be dangerous for aquatic ecosystems (Laville *et al.*, 2017). Plastic debris on the surface is not only dangerous for the marine ecosystem, but also has the potential to move towards the coast and will cause damage to the coastal environment (Maximenko *et al*, 2012). Marine seen in the sea around the estuary when it is in low tide. The wood waste is generally small in size with a length less than 1 meter and it appears generally clustered on the surface of the water. This collection of wood debris can also collect other types of debris so that it becomes a large group of marine debris of various types.

Figure 7. Landfill location near the ocean

Table 2. Categories of marine debris at the study site

Categories	Item
Plastic	Food wrapper, bottles, jugs/containers, bottles/container caps, cigarettes, disposable cigarettes lighters, plastics ropes/small net pieces, fishing lures and lines, cups, personal care products, straws, diapers, tooth brush, plastic fragments, medical equipment, sack
Metal	Cups, cans, nail, bottles caps, medicine jugs
Glass	Bottles, jugs/containers, glass fragment
Rubber	Flip-flops, ball, rubber fragments, shoe sole
Processed Wood	cardboard, paper
Cloth/Fabric	Clothing, shoes, net pieces (non-nylon), mask, synthetic cotton, fabric fragments
Ceramic	ceramics, porcelain

Source: modification from NOAA, 2013

Table 3. Density of organic and inorganic marine debris

Location	Number density (item/100 m^2)		Mass density (g/100 m^2)	
	Organic	inorganic	Organic	inorganic
Alue Naga	0.38	40.30	14.60	288.37
Ulee Lheu	0.17	7.63	1.49	64.96

Table 4. Percentage of organic and inorganic marine debris

Location	Number percentage (%)		Mass percentage (%)	
	Organic	inorganic	Organic	inorganic
Alue Naga	0.9	99.1	4.8	95.2
Ulee Lheu	2.1	97.9	2.2	97.8

debris that is in an open environment such as in a coastal area, has a detrimental impact on the coastal ecosystem. Micro-sized marine debris particles can be consumed by tropical biota (Wright *et all* 2016; Derraick, 2002) and result in the death of micro-sized aquatic organisms that are very important in maintaining the food chain (Rocman *et al*,

2016), disrupting marine biota such as turtles in finding food (Carr, 1987). The use of plastic that is not in accordance with the requirements will cause various health problems, because it can cause cancer triggers and tissue damage to the human body (carcinogenic). In addition, plastic is generally difficult to be degraded (described) by micro-organisms (Keswani, 2016).

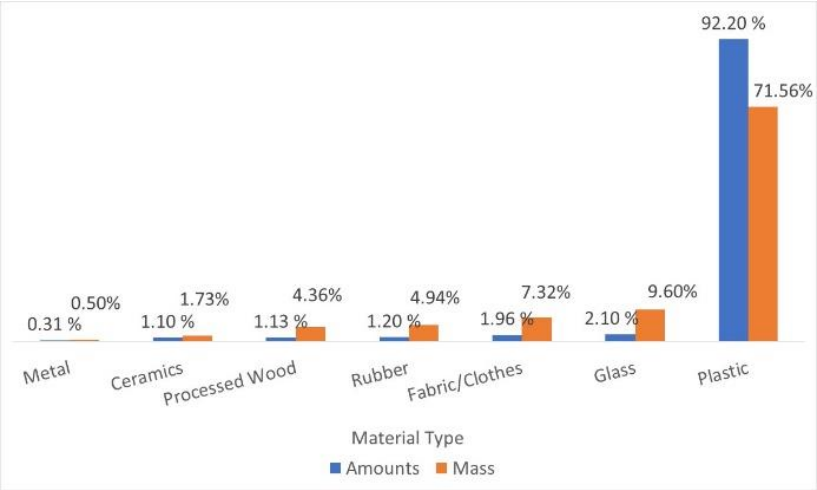
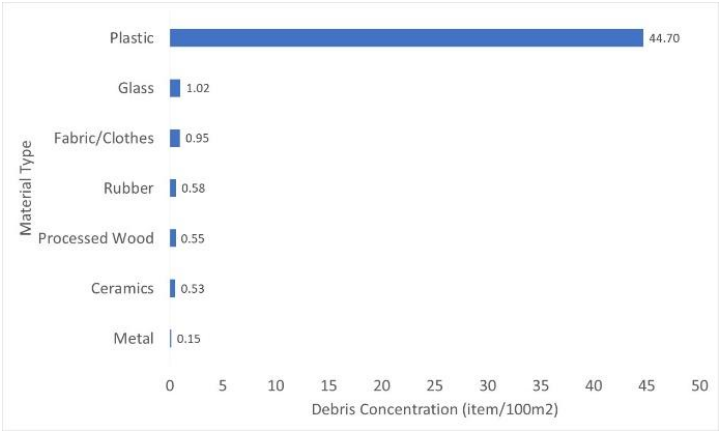
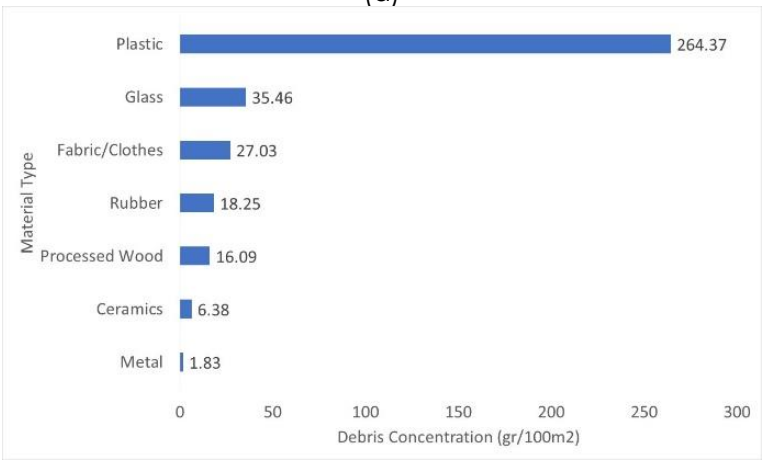


Figure 8. Percentage of amount and mass of marine debris



(a)



(b)

Figure 9. Marine debris concentration based on number of items (a) and mass (b)

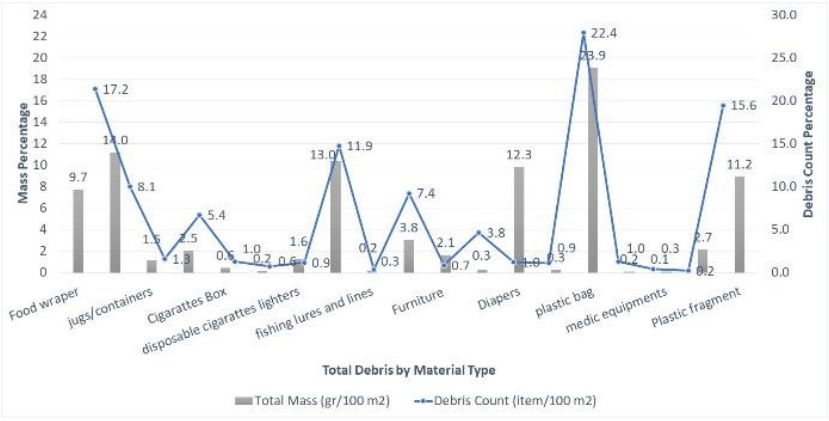


Figure 10. Debris flux (number of items/100 m^2) by material type of plastic

Figure 11. Marine debris that has been collected from the transect area

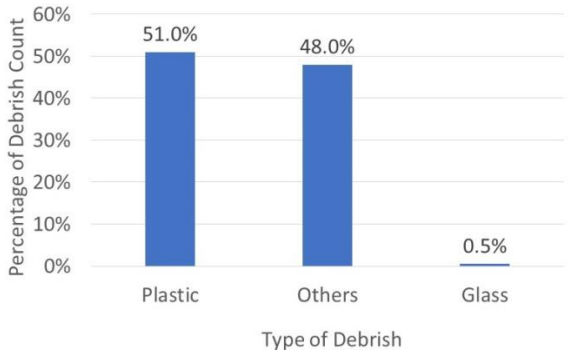


Figure 12. Marine debris on the waters surface

Figure 13. The process of collecting marine debris data on the surface of the water

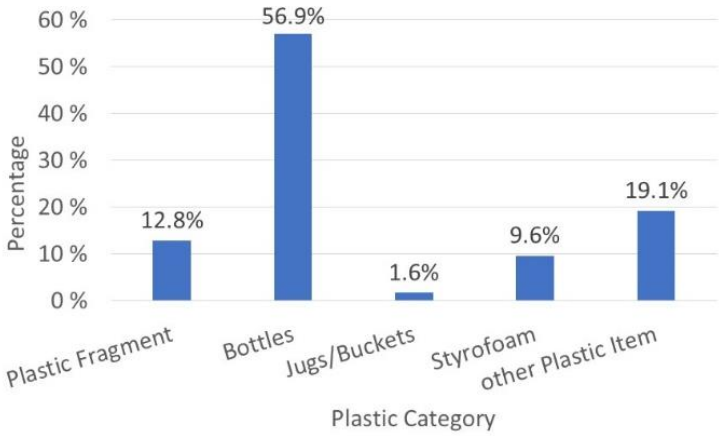


Figure 14. Percentage of plastic categories on the surface of the water

CONCLUSION

Most of the debris found on the coast of Banda Aceh City, both on the beach and at sea surface, comes from the type of plastic waste. The amount of plastic waste found on the beach area 44 items/100 m^2, is directly proportional to the total mass of plastic collected on both beaches. The dominant types of marine debris are plastic waste as much as 92.2% (beach) and 51.4% (sea surface) which shows that plastic waste still ranks number one in the coastal area of Banda Aceh City. The total percentage of items (98.5%) and mass (96.5%) of inorganic waste, especially plastic waste, shows the widespread use of disposable plastics and a lack of community awareness of coastal cleanliness.

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