Plastic pollution on the beaches of outer Ambon Bay

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Abstract. Plastic pollution in the marine environment is a global problem, which is currently in particular concern because this pollutant can be a negative impact on ecosystems. Identification of group plastic can be a solution to plastic debris management strategy throughout Outer Ambon Bay (OAB). The purpose of this study was to determine and analyze the composition and percentage of plastic debris in OAB and analyze the density of plastic debris in OAB according to the plastic group. The research findings from 20 sampling sites showed that the plastic debris category found was mostly plastic packaging, 86% on the coast of the Jasirah Leitimur and 78% on the Jasirah Leihitu. The highest density of plastic waste was found at Tantui and Mardika shores located in Jasirah Leitimur. The sampling site in Jasirah Leihitu shows that Rumahtiga and Liliboy have the highest density of plastic. Overall, the dominant group of plastic found on the shores of Outer Ambo Bay is plastic packaging.

1. Introduction

Marine debris is defined as solid material that is produced or processed, disposed and tends to be left in coastal and marine environments, including rubbish that is deliberately discharged into the marine environment such as plastic, wood, metal, glass, rubber, clothing and paper [1]. Plastic is the commonly found type of waste, and has become a severe pollution problem. Indonesia is the second producer of marine plastic debris (0.48-1.29 million metric tons/year) after China [2]. Now we are living in the era of plastic where plastic material tends to replace glass and metal materials, also because of plastic is a corrosion resistant material [3]. These are proven by the world plastic production in 2015 amounting to 322 million tons and plastic dominates marine debris [4].

Plastic pollution is not only a global pollution problem but also a local one in Outer Ambon Bay (OAB), a part of the Ambon Bay located on Ambon Island. This water surrounded by residential areas with various activities, offices, school, and traditional market. The topography of Ambon City with hilly and sloping areas, allows this water to receive upland activity impacts. In addition, there are several rivers that flow in to this water, which is how plastic debris get to the sea. OAB with sandy and rocky beaches is also affected by tidal currents and thus the potential for plastic debris accumulates. The relatively narrow condition of Ambon Bay allows tidal currents to dominate the current patterns in these waters [5]. Current and tides contribute to the accumulation marine debris along shoreline. Outer Ambon Bay waters have a high chance of receiving debris as a result of upland activities as well as ones carried away by the current from outside Ambon Bay. Focus of this study is to determine and analyze the composition and percentage of plastic debris in the beaches of OAB. Besides that, analyze
the density of plastic debris according to the group of plastic. Density and sources of plastic debris are the data which are important for mitigation plastic pollution [6].

2. Material and methods

2.1. Sites study

The study area took place on two sites of Outer Ambon Bay named Jazirah Leitimur located at 3°47’54.97“-3°38’11.69” LS and 128°5’52.22”-128°14’55.86” BT and Jazirah Leihitu located at 3°47’40.60“-3°34’57.27” LS and 127°57’17.18”-128°10’57.74” BT. Survey on plastic debris was conducted on 20 beaches on the Jazirah Leitimur dan Jazirah Leihitu (see Figure 1).

![Figure 1. Map of study sites](image)

2.2. Debris collection, categorization and assessment

Data was collected in May 2018 for a week; the method used is adopted from [7], where 100m transect run perpendicular to the shoreline from water edge to the back of shoreline. Plastic debris item collected at least 2.5 cm in length size dimension. Plastic debris from each location then separated according to a group of plastic such as plastic consumer, plastic packaging, plastic from fishing activities, plastic foamed, and others. Identification based on Tangaroa blue foundation, 2016. Plastic debris density is calculated with the formula proposed by [7].

\[ D = \frac{N}{(W \times I)} \]

D is the density plastic items, N is the total number, W is width of transect in meter, and I is the transect length (100 m) in meter. The source of plastic debris referred to ocean based determined through the type of plastic debris originated from fishing activity. Land-based source is plastic debris identified comes from land activities.

3. Result and discussions

Based on the data from Jazirah Leitimur, total of 2046 items plastic debris was collected and Plastic packaging is the most significant percentage (see Figure 2). Plastic waste is the most prominent contributor in the composition of marine debris which is 60-80% [8]. Plastic resulting from daily activity estimated 10% discharged through the river and eventually to the sea [9]. In 2018 world plastic production achieved 359 million tonnes and 51% of it came from Asia [10].
Ambon City is a small island city with most of the population living in the coastal area. With the consumption pattern of people who use a lot of packaged consumer goods, this allows plastic packaging to dominate the composition of marine debris found on the beach of outer Ambon Bay. The biggest demand for plastic converters in 2018 in Europe is plastic plastic packaging compared to other segments[10], this means that plastic packaging will dominate marine debris globally.

![Figure 2. Percentage of plastic categories found on the beaches](image)

Jazirah Leitimur is a location with variety of upland activities that are quite varied such as center of traditional market, offices, schools, hotels, restaurants, and sea ports. These activities also contributed to the presence of plastic debris in the beaches. This water is the estuary of several rivers such as Wai Batumerah, Wai Tomu, Wai Batugajah, and Wai Batugantung. The rivers in the rainy season will carry a number of debris that settles in the river during dry season, because in the dry season the river discharge is very small so most of the debris will be stuck in the river body. The rivers are one of the ways as to how plastic debris enter the beaches [11]. One of the people's habits is to throw away the waste in the river because when the rainy season ends, the river is clean again. What is not known is that the debris carried by the river has arrived at the sea and will stay for a very long time.

Plastic packaging also is the most substantial percentage on the beaches in Jazirah Leihitu with the total 3951 items was found. The upland of the water dominated by residential areas. Thus the activity of the community will contribute to plastic debris on the beaches. Now the patterns of consumption of society are more dominated by goods ready consume, where the packaging will be garbage that is disposed into the environment. Furthermore, plastic items are more preferred than metal because of cheaper; the condition will contribute to plastic packaging debris. Plastic is widely used for consumer goods because of inexpensive [12], therefore afforded by people’s buying ability. Another thing that plastic is also used in non-consumption packaging. The research shows that plastic is the dominant item found in marine debris and the category which has the largest percentage is plastic packaging [13].

The coast of Jasirah Leihitu has a larger number of debris items compared to Jasirah Leitimur which is the center of economic activity. This is expected to happen due to the effects of currents which carry garbage from another place, considering that Ambon Bay is relatively small that debris will be easily carried from one location to another. The coast of Jasirah Leihitu has a larger number of debris items compared to Jasirah Leitimur which is the center of economic activity. This is expected to happen due to the effects of currents which carry garbage from another place, considering that Ambon Bay is relatively small that debris will be easily carried from one location to another. The coast of Jasirah Leihitu has a larger number of debris items compared to Jasirah Leitimur which is the center of economic activity. This is expected to happen due to the effects of currents which carry debris from another place, considering that Ambon Bay is relatively small that debris will be easily carried from one location to another.

The percentage of plastic debris also shows that both plastic consumer and plastic foamed are found in large quantities. Those plastics are items related to daily needs of the community. The
condition indicates that plastic debris along the beaches is land-based source. Waste originated from upland has more related to human activities, conversely sea-based source from fishing, and shipping [14]. Sources of plastic waste on 20 study sites are more dominated by land-based source, respectively Jazirah Leitimur (99.01%) and Jazirah Leihitu (98.77%), the others are sea-based source. The large amount of waste produced is related to the size of the population and the country with the largest waste production usually has a large number of residents living on the coast [15]. Ambon is the city with many settlements on the coast if waste handling in Ambon city is not carried out properly, more and more trash will arrive at Ambon Bay. The population in the districts around Teluk Ambon has a fairly high population density, including the Nusaniwe district with a population density of 1073.03 per km², Sirimau district 1868.75 per km², Teluk Ambon Baguala district 1484.39 per km², and Teluk Ambon district 483.81 per km² [16]. In 2010 an estimated 4.8.-12.7 million metric tons of plastic enter the marine environment is land based sources and predicted will rise in the next decade [2].

Composition of plastic packaging found at the 20 study sites consists of cleaner bottles, personal care & pharmaceutical packaging, plastic bags supermarket, container nonfood like oil, sealant, chemical, drink bottles like mineral water, juice, milk, soft drink, plastic food packaging, plastic drink glass, sack, cosmetic bottle, bottle food packaging, bottle cap, nonfood packaging. These types of plastic are included in the category of plastic which takes a long time to compose [17].

Plastic packaging was the dominant category and the higher density found on Jazirah Leitimur are Tantui (10.27 item/m²) and Mardika (8.20 item/m²) beaches (see Figure 3). Both locations have a high density of population who live around the beaches, which tends to throw the garbage directly into the sea. At the location, there is also a traditional market center, that used plastic as packaging. The waste generated from the market activity is generally disposed directly on the beach in front of that place by the local merchant. Some waste is disposed to nearby river, Wai Batumera. Plastic Density on the beach of Jazirah Leitimur also shows that the sampling site close to the urban center inclined to have a high number for instance Tantui, Kapaha, Mardika and Benteng, the research was done in California found as well [18].

| Density (item/m²) | Sampling site |
|------------------|---------------|
| 0.00             | Tantui        |
| 5.00             | Kapaha        |
| 10.00            | Mardika       |
| 15.00            | Waibang       |
| 20.00            | Benteng       |
| 25.00            | Air Salobar   |
| Other            | Ambuang 1     |
| Foamed           | Ambuang 2     |
| Fishing          | Eric          |
| Packaging        | Silade        |

Figure 3. Density of plastics debris on the beach in Jazirah Leitimur

Like Jazirah Leitimur, plastic packaging also dominates the other category in Jazirah Leihitu (see Figure 4). That beaches tend to have vast tidal areas than jazirah Leitimur, with upland predominantly settlements area. The highest density is found in Rumah Tiga beach (16.99 item/m²), this is because there were many plastic sheets of aqua glass cover. The condition suspected from community who lives around the beaches. The marine debris condition on the beach of Rumah Tiga is not a permanent condition because it depends on tides and currents. At other times the beach will look somewhat clean because the debris are carried under the current to another place.
Liliboy is the second sampling site as well high density of plastic packaging (14.45 item/m$^2$), although the location is far from the urban center. It is assumed that plastic debris source from the local community and some are carried by currents from other places. Loliboy has a sloping beach with rocky gravel substrates to granual rock. That is cau,

![Graph showing density of plastics debris on the beach in jazirah Leihitu](image)

Figure 4. Density of plastics debris on the beach in jazirah Leihitu

The study shows that plastic packaging is the dominant category on both Outer Ambon Bay sites, indicating that utilizing plastic packaging is very high. Globally plastic production approximately 9% per year and 50% are disposable plastic such as packaging, 20-25% for plastic with long-term use as cable coating, pipes, and other materials [20]. The largest plastic production is packaging because change of global demand from reusable to disposable plastic, the resulted in plastic waste increase by 10% from 1960 to 2005 in countries with medium to high income level [15]. As a result plastic production in the last 65 years has exceeded from other materials. It means that the pollution of plastic debris is a long term problem of marine environment.

Plastic pollution has become a global problem, and this is proven by researches such as [7,21,22,23]. Furthermore plastic will break into smaller pieces called microplastic [24], then it will be consumed by animals which will endanger marine life [25]. Another thing which makes plastic to be dangerous for marine life because of resistance to degradation therefore it usually takes time hundreds up to thousands years of degradation [11]. Many marine animals get entangled in plastics or even consume plastics found in the marine environment, besides that, many studies have proven that fish have been consuming plastic [12]. The elevated use of plastic packaging by community will contribute to density of plastic debris that reaches the marine environment, due to lack of plastic waste management. On one hand, Outer Ambon Bay has a potential of marine resources like mangrove, seagrass, algae, mollusk and fish. This phenomenon is a menace to marine resources in the whole Ambon Bay, because plastic debris from the Outer Ambon Bay will also enter to Inner Ambon Bay. Plastic debris will move to other places by the influence of wind, current and [6].

The impact of plastic pollution on marine life has been documented, including limited fiding, digestive ulcers, and starvations because the digestive tract is full of plastic [18]. Besides impact on the organism, plastic also changes the ecological system in the marine environment [26]. Plastic as well as medium for the organism movement, so that the potential for the spread of invasive species
and diseases [27]. The study proves that marine resources in Ambon Bay face the threat of plastic pollution which indirectly also impacts on society.

XLSTAT 2014 was used to calculate the similarity of the plastic category from each sampling site (see Figure 5). Results show that there are 3 groups. The first group consists of Rumah Tiga, Laha, Alang. The second group are Waihaong, Hatiwe-1, Hatiwe-3, Liliboay, Tawiri, while the third group is Hatiwe 2, because of this sampling site is far from residential areas. Activities based on land and sea are contributing factors to the marine debris build-up [28].

![Figure 5. Similarity between sampling site based category of plastics (A) jazirah Leihitu dan (B) jazirah Leitimur](image)

There are still three groups from Jazirah Letimur with group one are Tantui, Amahusu-2, Silale, and Eri. Group two consist of Kapaha, Waihaong, Mardika dan Batumerah. The Last Air Salobar dan Amahusu-1. Overall, the similarity level tends to be high on jazirah Leihitu, this might be due to the less variation in upland activities, on the other hand, there are variations in similarity on the beach of Jazirah Leitimur. This is because Jazirah Leitimur is the center of urban activity and the central government of Ambon city. The population of Ambon city is concentrated in Sirimau district which is located in Jazirah Leitimur with a population density rate of 1,868.75 people per km². [16]. The high similarity in Jazirah Leihitu is due to the likeness of the dominant environment which is a community residential environment while in the Jazirah Leitimur it is more diverse because there are economic facilities, offices, government centers and sea transportation facilities.

4. Conclusions

Based on the plastic category obtain on sampling site, plastic packaging is dominated and almost plastic debris land based sources. This study suggests that a plastic waste management strategy must be developed urgently to improve conditions throughout Outer Ambon Bay.

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