



Marine debris in tourism area of Dodola Island Beach, Morotai Island District

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ABSTRACT

Coastal and marine areas are very vulnerable to various pollution threats from human domestic activities (marine debris), industry (fishery management) and other activities. One of the the problems faced in the management of Dodola island tourism was marine debris. This study aims to determine the composition of marine debris generated from tourism activities. Futhermore this study was necessary as basic information to formulate appropriate strategies in managing marine debris. This research was conducted from August to September 2021. Observations were made by visual observation at porposive area. Analysis of the type and weight taken from the observed waste such as the number of pieces, weight, composition and density of solid waste and separated according to the type of organic and inorganic. This result showed inorganic waste such as plastic bottles and cups, plastic packages, Styrofoam, sandals/shoes, glass bottles, diapers, cardboard and aluminum cans with a total of 664 items or 58% pieces, while for organic waste consisting of wood, bamboo, coconut and nipa fruit and banana leaves, with the number of pieces as much as 473 items or 42%. Organic waste has a weight of 203,422 grams or 85% and organic marine waste is 35,915 grams or 15%. The types of organic waste with the highest and heaviest amounts were bamboo 70.51% and 73.77%. Meanwhile, the type of inorganic waste with the highest amount was plastic bottles/cups 79.17% and the heaviest type of waste was glass bottles 55.08%.

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Introduction

Indonesia is the second country of most garbage disposal in the world after China (Jambeck *et al*, 2015). The coastal area and marine are an easy area got affected by waste disposal from mainland (Cordova, 2017). The marine debris as solid persistent, producing or produced by human, direct or indirect, purposely or accidentally, abandoned fishes on sea invironmet (NOAA, 2013). The gained of pollution on coastal and marine because of the lefts from human domestic activities besides from natures. The garbages got into the sea, flown by the stream, and followed to sea stream that called marine garbage (Kusumawati *et al*, 2018).

The beach on Dodola Island is one of the most destined by tourists and the icon of Morotai Island district. It located on subdistrict of South Morotai with the vast of 64 acres. Dodola Island was divided into two area, small Dodola and the mainland that

connected with a long spread-out or a rug sand area. The number of tourist visiting Dodola Island in 2018 was 2719 people and in 2019 there were 3647 people (Dispar Kabupaten Pulau Morotai 2020). Dodola Island recently become a part of the tourism benefits zone in the conservative territorial waters of Rao Island – Dehegila Cape District of Morotai island Province of North Maluku Year 2020. The set of problems that faced for the Dodola Island tourism management is marine garbage (*Marine debris*) that caused pollution and affected to the cleanliness and convenience on the tour location. The coastal and marine pollution gained more form. the lefts of human's activities and got accepted by the sea nature that got flown by the waters from farming area, household wastes, refuse, ship materials, oil spills and more materials wasted in the sea (Elyazar *et al*, 2007). According to Mohee *et al*, (2015) The analysis of Marine debris is important to provide the

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information of each item. This research was purposed to know the composition of marine debris in tourism areas, so that can be used as basic information to formulate the right strategy of marine debris management.



Figure 1. Map of research location on tourism area of Dodola Island in district of Morotai Island.

Materials and Methods

Location and time of research

This research was held from August to September 2021 in Dodola Island subdistrict of South Morota. The observation used the early survey with visual observation to see the point location that have a scrap heap. The observation of point location was marked with GPS. The observation result got 3 stations there are station 1 (the front of mainland Dodola), station 2 (small Dodola Island), and station 3 (the back of Dodola Island), (Figure 1 and Table 1).

Table 1. Observation Location.

Station	Station Names	Positions
1	Front Mainland Dodola	2°5.112'N and 128° 11.679'E
2	Small Dodola	2°4.716'N and 128° 11.673'E
3	Back Mainland Dodola	2°5.190'N and 128° 11.388'E

Data analysis

The types and weight of analysis was taking from observed debris as like the pieces, weight, composition and the density of solid debris on the tourism area of Dodola Island and divided to organic, inorganic types that according to Tangdesu (2018); Johan *et al* (2020), then divided again in keeping with categories of plastic, rubbers, metals, glasses, woods, and the its derivatives (Djaguna *et al.* 2019). The area of each station is 1000 m², where the length of the stretch drawn parallel to the shoreline is 100 m and the width from the lowest tide to land is 10 m, modification Lippiatt *et al* (2013).

The density of debris pieces

The density analysis and relative density of debris was suggested to Coe and Roger (1997); Johan *et al* (2020) which is:

$$\text{Density (pieces of marine debris)} = \frac{\text{The Number of Pieces in Category (item)}}{\text{Area (m}^2\text{)}}$$

$$\text{Density (weight of marine debris)} = \frac{\text{The Weight Pieces per Item in Category (gram)}}{\text{Area (m}^2\text{)}}$$

$$\text{Relative Density (pieces of marine debris)} = \frac{\text{The Number of Pieces in Category (item)}}{\text{Total Weight of Pieces per Item in Category (item)}} \times 100\%$$

$$\text{Relative Density (weight of marine debris)} = \frac{\text{The Weight Pieces per Item in Category (gram)}}{\text{Total Weight of Pieces per Item in Category (gram)}} \times 100\%$$

Results

Types and compositions of marine debris in Dodola

There are two types of marine debris from the observation result, which are organic and inorganic debris. The organic debris consist of wood and bamboo, coconuts and banana leaves. Meanwhile the inorganic debris consist of plastic bottle and glass, plastic bag, styrofoam, sandals/shoes, beverage bottle, diapers, cardboard cartons, and aluminium/tin can (Table 2).

Based on the calculation result of marine debris types that organic and inorganic according to the pieces of each item to all stations which is station 1, station 2, and station 3, got the value of organic marine debris with 42% and inorganic marine debris with percentage 58% (Figure 2). The weight percentage of organic and inorganic marine debris from the whole stations that found that the value percentage for organic marine debris is 85% and inorganic marine debris is 15% (Figure 3).

Table 2. Types of marine debris in research location.

Types of Marine Debris (Competition)		St 1	St 2	St 3	Figure
Organic	Wood	√	√	√	
	Bamboo	√	√	√	
	Coconut and Nips fruit	√	√	√	
	Banana fruit		√		
Inorganic	Plastic bottle and glass	√	√	√	
	Plastic bag	√	√	√	
	Styrofoam	√	√	√	
	Sandals/shoes	√	√	√	
	Beverage bottle	√	√	√	
	Diapers	√	√		
	Cardboard cartons	√	√		
	Aluminium/tin cans	√		√	

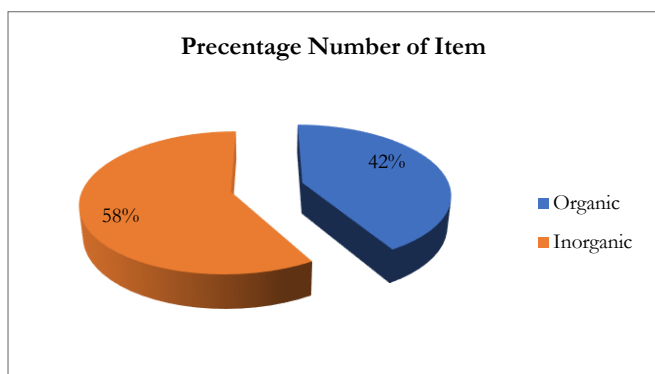


Figure 2. The percentage of marine debris based on item pieces.

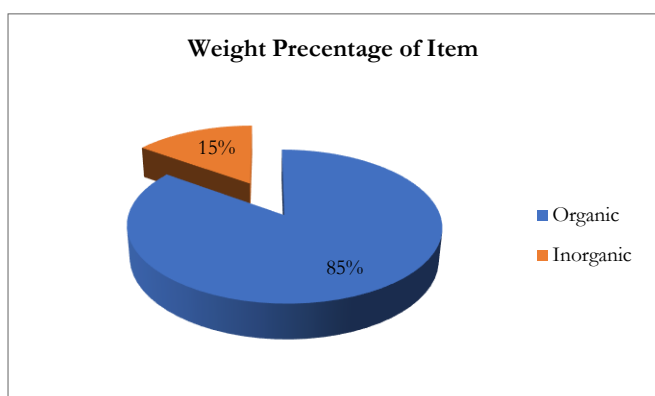


Figure 3. Marine debris percentage based on the weight of item pieces.

The total pieces per items and weight of marine debris

The total of organic marine debris is less than inorganic marine debris, the total of organic marine debris in station 1 is 78 items which is more less than in station 2 with 175 items and station 3 with 220 items. Meanwhile for the total of inorganic, station 1 have the most number which is 360 items, then in station 2 is 160 items and station 3 with 144 items (Figure 4).

The total of organic marine debris is more less than inorganic marine debris, the total of organic marine debris in station 1 is 78 items which is more less than in station 2 with 175 items and station 3 with 220 items. Meanwhile for the total of inorganic, station 1 have the most number which is 360 items, then in station 2 is 160 items and station 3 with 144 items (Figure 4).

From the result, marine debris cut's weight on the research location showed that the organic debris weight is more big than inorganic debris. The wight of organic debris in station 1 is 26.302 gram, on station 2 is 64.490 gram and for station 3 is 112.200 gram. Meanwhile for inorganic marine debris in station 1 is 17.882 gram, station 2 with 7.733 gram and for station 3 is 10.300 gram (Figure 5).

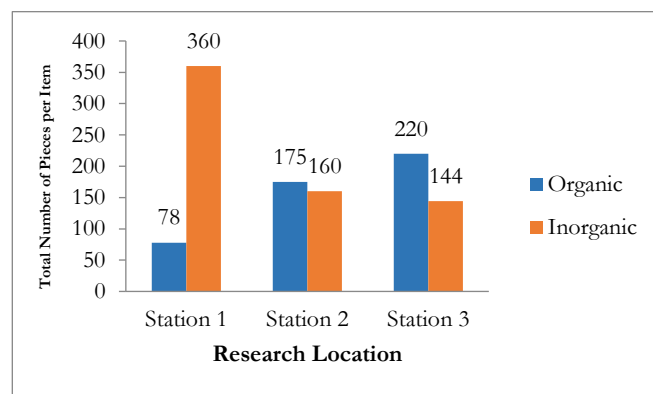


Figure 4. The total number of pieces per item.

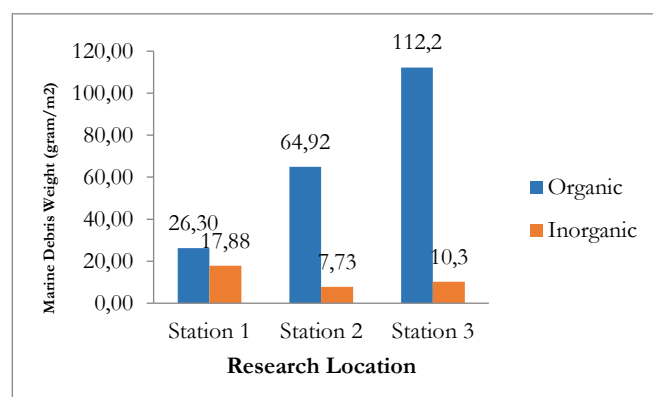


Figure 5. Total number of derbis weight (gram) on each station organic (a) and inorganic (b)

The density of marine debris

The composition of marine debris per square feet showed that the highest value for number of pieces is inorganic debris at station 1 which is 0.36 (item/m²) while the lowest was on the organic marine debris type at sation 1 with 0,08 (item/m²). Wherase for based on the number of weight per item of marine debris on research location (Figure 7) organic debris weight have a quite hig weight number from inorganic which is 112.2 (gram/m²) at station 3, 64,92 (gram/m²) for station 2, and 26,30 (gram/m²) in station 1. It is happened because the characteristic of organic derbis that pervade water rather that inorganic debris that have the number of weight 17,88 (gram/m²) in station 1, then 7,73 (gram/m²) for station 2 and in station 3 with 10,3 (gram/m²) (Figure 7).

The relative density of marine debris

The relative density is the percentage for the amound of the debris for the total of debri. From the observation result of organic debris, it was dominated with bamboo 70.51% and then wood debris which is 67.43% (Figure 8,a). For the inorganic debris got more to plastic bottle and plastic glasse with the value 65,56% in station 1 and 74,38 for station 2 meanwhile station 3 with the value 79,17% (Figure 8,b).

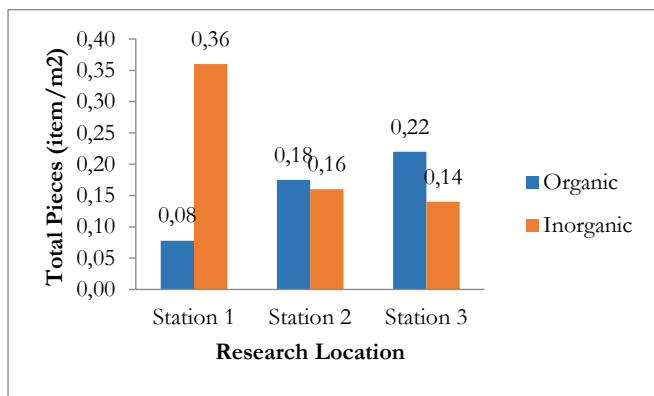


Figure 6. The density according to the total pieces per item organic (a) and inorganic (b).

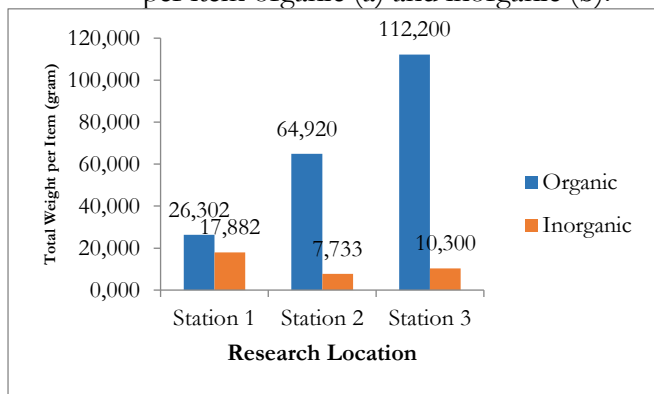


Figure 7. The density of debris weight pieces per item organic (a) and inorganic (b).

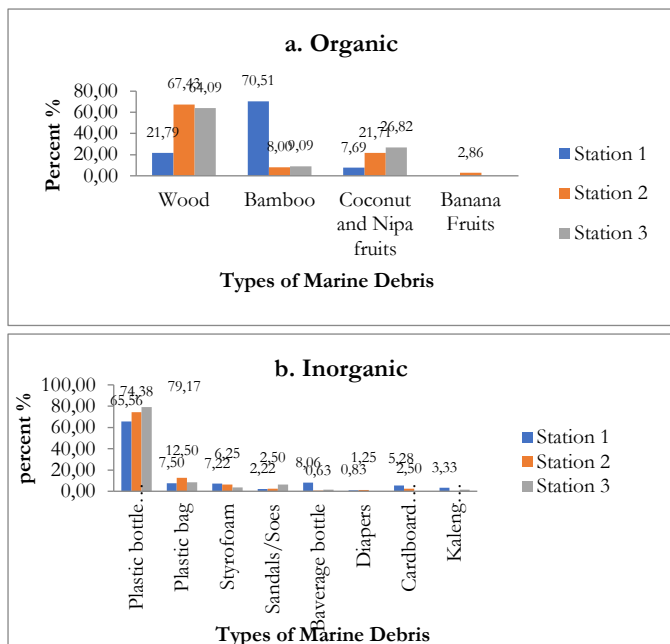


Figure 8. The relative density number of debris pieces organic (a) and inorganic (b).

Relative density for debris weight that received for organic debris type in station 1 with highest value is to bamboo pieces which is 73.77% meanwhile the lowest is wood with the value 7.60%. The relative density for station 2 with highest value is from wood type with value 52.68%, then the less is 2.93% from

palm mangrove (Figure 9,a). The relative density of inorganic debris weight in station 1 was dominated with 55.08% and the less is plastic bags which is 2.24%. The relative density of debris weight in station 2 is 45.56% which is the highest value from plastic bottle, then the lowest is from cardboard cartons with value 4.01%. In station 3 the highest relative density was dominated with plastic bottle & glasses with value 48.54% and the lowest to styrofoam type with value 3.88% (Figure 9,b).

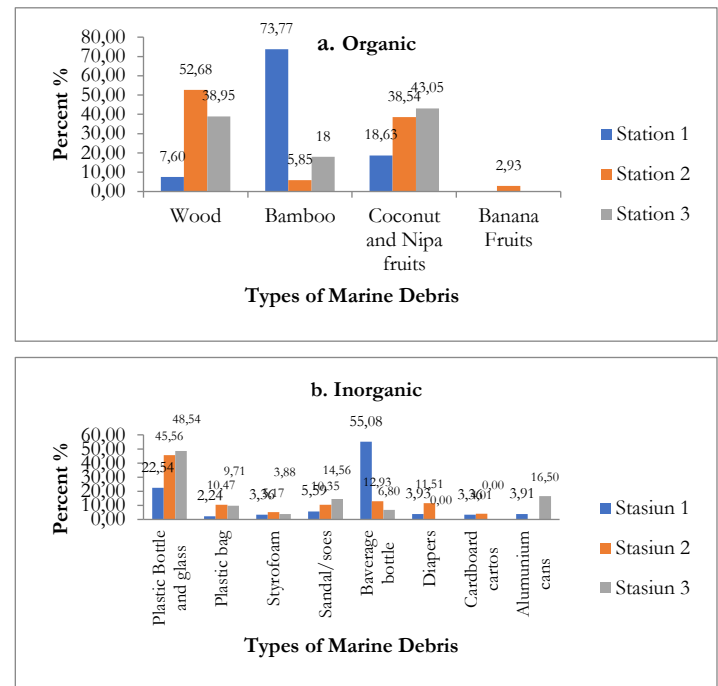


Figure 9. The relative density of debris weight organic (a) and inorganic (b).

Discussion

Types and compositions of marine debris in Dodola

According to NOAA (2013) the marine debris is a solid item that produced or processed by human, directly or indirectly wasted to waters area. Meanwhile for Yogiesti, (2010) argue the debris in the sea was flown to the stream then moved through it that called marine debris. Marine debris came from the leftover products that throw to the sea by human whether it is accidently or not, also to the objects that poured to the sea through river and the waste disposal channel form household and industries. From the result in Table 4 found the different on the type of organic debris which is the banana leaves, that assumed that in station 2 received many derbis from another close island or the derbis that flown from upper to down corse of river and estuary and went to the sea. Meanwhile for the inorganic debris there is a difference of type which is in station 1 that have

many aluminium can, that assumed from human activities that accidentally throw or not or left in marine area. (Subekti 2017) said that when rainy, the debris will get into the water that rose the water discharge, that washed away and estuary and then the sea.

The percentage number of pieces and weight for each item of marine debris in the research location showed that there is difference from total and weight which is for inorganic debris is outnumbered but lighter than organic debris that have a less number but more on the weight. This condition happened that organic debris is coming from river therefore it got piled up in the estuary and also because of the human domestic activities near the research location. NOAA (2016) said that the result from the research about marine debris in waters area in the world, that plastic debris is the most general type to find and the most risk cause give a serious damage for ocean organism. According to Kemenperin (2013) plastic debris is a big problem in Indonesia that predicted about 165.000 tons of plastic/year will empty to Indonesia's waters area.

In principally that the difference of marine debris on each station is because of station 1 is the mainland that got visited more by tourists that indirectly contributed to give inorganic debris. In line with research conducted by Utama *et al* (2022) in the coastal area of Mang Kalok beach tourism in the Bangka Belitung Islands, that the density of waste at the station which is a tourist area is higher in density compared to other stations

In accord with NOAA (2013) that the more of coaster and sea pollution happened right from the nature itself or human activities that make the debris get into the sea, or flow from the river to the sea, then called with marine debris that purposely left or not. The number of marine debris came and affected from the activities and the total of human population, as like in the highest numbers in society. (Jambeck *et al.*, 2015).

The number of organic debris in research location is from the high human domestic activities. According to (Johan *et al* 2020) the causes is from throwing the debris in upper to down course of river that followed to estuary then get into the sea. While the inorganic marine debris was sent from other island or from the tourists that mostly left the debris on their tour. As like Asia and Arifin (2017) find that the debris source that indicate the production is from household activities, ecotourism, fishers, merchants, industries, and transportation.

The relative density of marine debris

Johan *et al* (2020) stated that the relative density based on marine debris pieces that dominated to big sized wood because of the research stations that closed to the estuary that slope slightly that it deposited to the beach or intertidal area. The high rate of inorganic debris from plastic bottle and glass come from the society whether from the tourists or the household activities. According to Wright *et al.* (2013) about 10% of all plastic, become a debris in the sea of world from the accidentally or purposely and the incorrect management. Plastic become the dominant of marine debris (CBD-STAP, 2012). Meanwhile to Cordova (2017), the types of marine debris are plastic, cloth, foam, styrofoam, glass, marmer, metal, paper, and wood. The same things also have done research by Purba *et al* (2018) who is found that the debris that collected in beach are came from tourist, fishers, and from the near area. (Purba. *et al* (2020). Research Djaguna *et al.* 2019 at Tongkaina Beach and Talawaan Bajo, North Sulawesi shows that the activities of local tourist objects have a high impact on the amount of waste.

Conclusion

The marine debris in research location for the number of pieces were composing per item that dominated by inorganic debris as like bottle and glass, plastic bag, styrofoam, sandals/shoes, diapers, cardboard and aluminium can with the total pieces 664 or 58%, meanwhile for organic debris consist of wood, bamboo, coconut, and nipa fruit as like banana leaves, with the total pieces 473 or 42%. And if seen from the total weight of marine debris that leaned more to organic debris than inorganic, organic debris weight 203.422 grams or 85% and organic marine debris is 35.915 grams or 15%. Types of organic debris with most weight is bamboo. Meanwhile inorganic with the most number is plastic bottle and glass, then the inorganic debris with the most weight percentage is glass bottle.

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