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Assessment of Stranded Marine Debris on Karimunjawa Island

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Abstract. Marine Debris is a common problem in every tourism development area such as the Karimunjawa Islands. In accordance with the title, this study aims to identify the characteristics and density of debris around the Karimunjawa Islands. The method of taking data from this research is using direct-sampling on field observation technique by making transect columns to identify various debris compositions. Debris sampling was taken at four observation points namely Batu Topeng Beach (2 points), Batu Penganten Beach and Cemara Besar Beach. The results of field observation and debris sampling activities which has been done shows that the most common types of stranded marine debris found around the Karimunjawa Islands are plastic, wood, metal, glass and rubber. The highest density level of debris components obtained are the plastic type of debris found at Batu Penganten Beach with the value of density 4,18 plastic debris /m^2 which is followed by the density level at Batu Topeng 1 Beach with a density value of 3,93 plastic debris / m^2. The lowest level of solid debris density calculated is the type of metal found at Cemara Besar Beach, where the density level only reaches 0,02 metals / m^2.

1. Introduction

Marine debris is defined as solid material that is difficult to decompose, manufactured, or processed which is dumped, disposed of, or left in the marine and coastal environment [8]. Types of goods commonly used by humans such as glass or plastic bottles, cans, bags, balloons, rubber, metal, fiberglass, cigarettes, and other items have the potential to become marine debris that can be found along the coast. Fishery activities that use various kinds of fishing gear such as ropes, hooks, buoys, and other materials that are deliberately dumped into the sea also have the potential to become marine debris [6]. In 2010 Indonesia had a coastal population of 187.2 million living within 50 km of the coast and annually produced 3.22 million tons of debris that was not properly managed, and was estimated to result in the debris of 0.48-1.29 million metric tons plastic debris per year to the oceans [10].

Karimunjawa Islands is one of the developing tourism areas and is one of the national park conservation areas, where the development of this sector is followed by an increase in the intensity of debris both from land and shipments from the high seas. At the end of each season, several areas in the Karimunjawa Islands are polluted by a number of marine debris that are stranded on the beach. A number of plastic debris was found at Legon Lele Beach with a composition of plastic in macro size (72%) and meso (81.11%) at the end of the eastern season [3]. Then, marine debris was found that washed ashore weighing 2.5 tonnes in the area of Cemara Besar Beach and Menjangan Kecil Beach at the end of the western season [4]. Stranded marine debris can be classified based on the type of

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material, size, and ability to float at sea level based on its density [9]. The ability to identify and quantify debris based on the above classifications can be useful for knowing the potential types of marine debris that can be transported through the sea surface and stranded in an area [9].

2. Methodology

2.1. Measurement Time and Survey Characteristic

The process of identifying and quantifying stranded marine debris follows guidelines from NOAA's Marine Debris Shoreline Survey book. Observation of debris data in Karimunjawa Islands was carried out on February 28-29 2020. Wind data processing is used to determine the season conditions that affect the time of measurement. The wind data used comes from the ECMWF re-analysis of data during February and March 2020. Google Earth is also used in the planning process and determining the point of measurement for marine debris data. The area which is the main destination for tourism and domestic activities of the Karimunjawa residents is the main consideration in determining the location for measuring marine debris data.

Table 1. Types of Marine Debris Shoreline Survey Based on NOAA Guidelines

Characteristic	Standing-Stock	Accumulation
Debris removed during surveys?	No	Yes
Time required per survey	Less	More
Length of shoreline site	100 m	100 m or longer
Is a set survey interval required (e.g., once per week or month)?	Yes	Yes
Types of data that can be Collected	a. Debris density (# of items / b. unit area) c. Debris material types	a. Debris deposition rate (# of b. items / unit area / unit time) c. Debris material types d. Debris weight

According to the guidebook of National Oceanic and Atmospheric Administration (NOAA) on the measurement of coastline marine debris, survey measurements are divided into two types, namely standing stock and accumulation survey (**Table 1.**). The two types of survey have different objectives as outlined in the table. The debris observation carried out this time is included in the type of standing-stock with the aim of measuring the density of debris and the type of material from marine debris that is stranded on the beach.

2.2. Density Assessment

Transects made at each debris observation point follow the NOAA [5] and UNEP [9] marine debris measurement manual. The idea of measurement used is to calculate the amount of trash that was seen in the transect by walking straight from the direction of the transect and back to the starting point of measurement. The total debris that has been calculated is then divided by the transect area to obtain the density value according to the equation **(1)** [2].

$$c = \frac{n}{LW} \tag{1}$$

Where the density of marine debris symbolized by (c) with the units of amount of debris/m^2, that consist of units of litter amount (n) divided by area of transect with transect length (L) multiple by transect width (W).

The debris that is counted are classified based on the type of material. In the observations made, debris is classified based on the type of plastic, glass, metal / metal, rubber and wood. The collected debris data is then documented using a data sheet from NOAA [5] . The result of this survey is evaluated further to obtain indication of the main activity that produces the debris and the potential source location.

3. Result and Discussion

3.1. Observation Field Condition

Karimunjawa waters consist of several island clusters as shown in **Figure 1.** The areas shown are the areas designated as transect locations for identification and measurement of marine debris data. The Karimunjawa Islands are one of the main destinations for marine tourism in the north of Jepara Regency and are designated as one of the national park conservation areas in Indonesia. Tourism activities commonly carried out by tourists are beach tourism, snorkeling, diving, boating, and bird watching in the national park conservation area.

In this study, the area that is determined as the location for measuring marine debris data is an area in the western part of Karimunjawa Island. The areas that were determined as locations for the transect of waste were Batu Topeng Beach (5,840^{o}LS - 110,415 ^{o}BT) which was to the east of Karimunjawa Island, Batu Penganten Beach (5,773^{o}LS - 110,415^{o}BT) to the north of Karimunjawa Island, and Cemara Beach. Large (5.805876^{o}LS - 110.374383^{o}BT) is in the west of Karimunjawa waters. These three areas are one of the main destinations of tourism activities in Karimunjawa. Batu Topeng Beach and Batu Penganten Beach are close to residential areas, while the Cemara Besar Beach area is on an uninhabited island. This is a consideration in choosing these locations as places for measuring waste data.

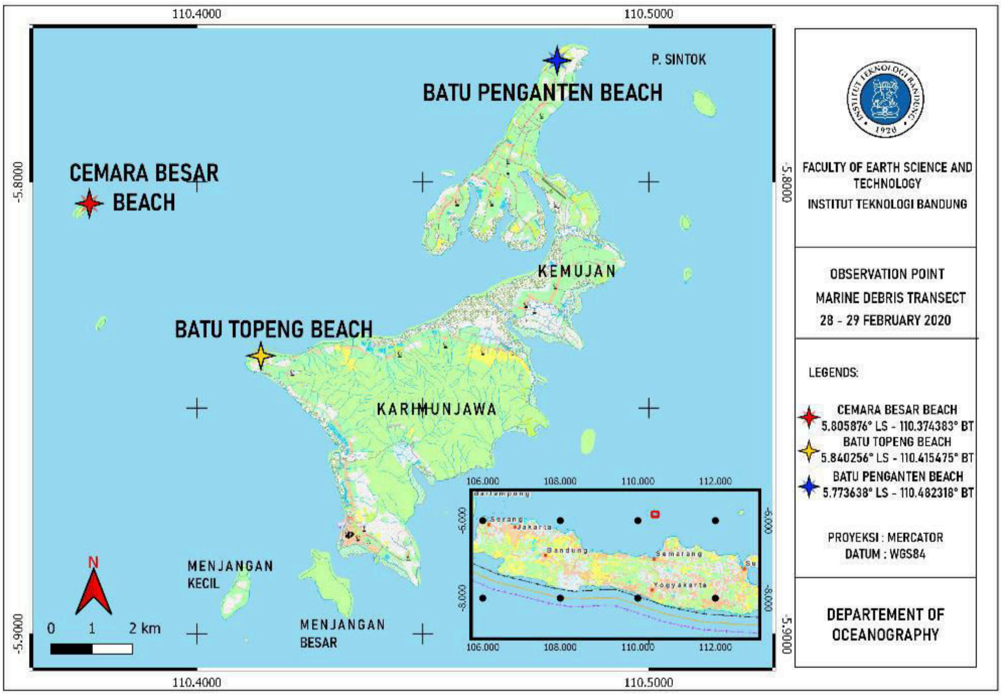

Figure. 1. Observation Point in Karimunjawa Island and its surrounding (source: RBI)

In **Figure 2.,** in more detail, depicted the point and time of making marine debris transects in the Batu Topeng Beach area which consists of 2 points (**Figure 2. (a)**) made on February 28 2020 at 15: 06 - 15:31 (point 1) and 15: 35-15: 51 (point 2) (GMT + 7) with transect areas of 30 m_2 and 72 m^2 respectively. Transect construction at Batu Penganten Beach is shown in **Figure 2. (b)** with the transect construction time on February 28, 2020 at 17: 18-17: 52 (GMT + 7). The transect size covers an area of 300 m_2(100 m x 3 m).

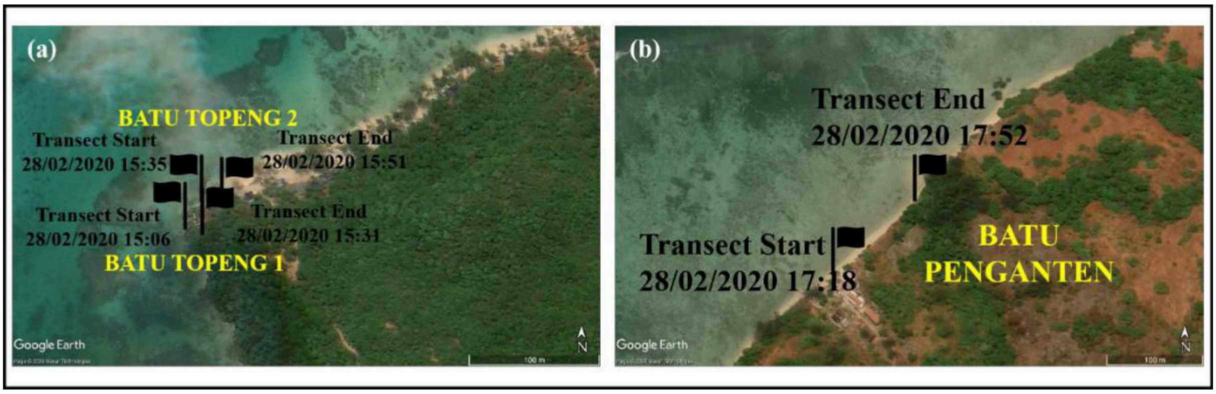

Figure. 2. (a) Time and survey area in Batu Topeng Beach (2 Points), (b) Time and survey area in Batu Penganten Beach (source: Google Earth)

The construction of marine debris transects in the Cemara Besar Beach area is shown in **Figure 3.** With details made on February 29, 2020 at 13: 50-14: 31 with a transect area of 300 m^2 (100 m x 3 m). Cemara Besar Beach is one of the white sand beach tourist destinations outside the Karimunjawa Island area, so a ship is needed to access the Island area. In addition, Cemara Besar Beach is located on an uninhabited island, so the potential for accumulation of marine debris due to domestic activities around the island is very small.

The study, which aims to calculate the intensity of marine debris around the Karimunjawa Islands, chooses a period when the rain intensity is quite high because the air pressure in the Asian region is higher than in Australia, so the wind from west (west monsoon) blows a lot of water vapor towards Australia [1]. **Figure 4. (a)** shows the wind conditions in the Karimunjawa Islands from February to March 2019. It can be seen that the wind speed ranges from 0-9 m/s. Winds that come from the west and northwest and blow to the east have the highest magnitude compared to other directions. This explains that in these months, there are dominant wind gusts that come from the west and move to the east. Thus, it can be indicated that the dynamics of the waters in the Karimunjawa Islands during that period were still influenced by the western winds (west monsoon).

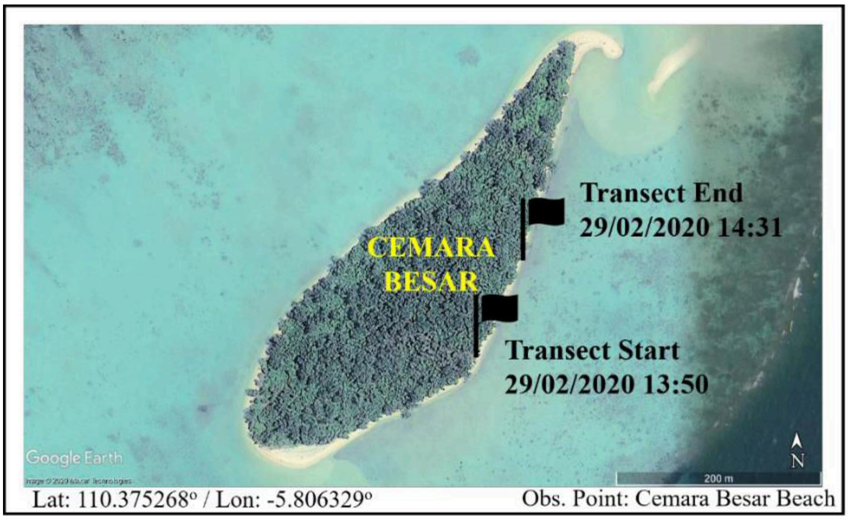

Figure. 3. Time and survey area in Cemara Besar Beach.
(source: Google Earth)

The distribution of marine debris both in the open ocean and along the coastline is largely governed by surface currents where the movement pattern depends on seasonal circulation patterns and annual variability inherent in the mainstream system around the study area [7].

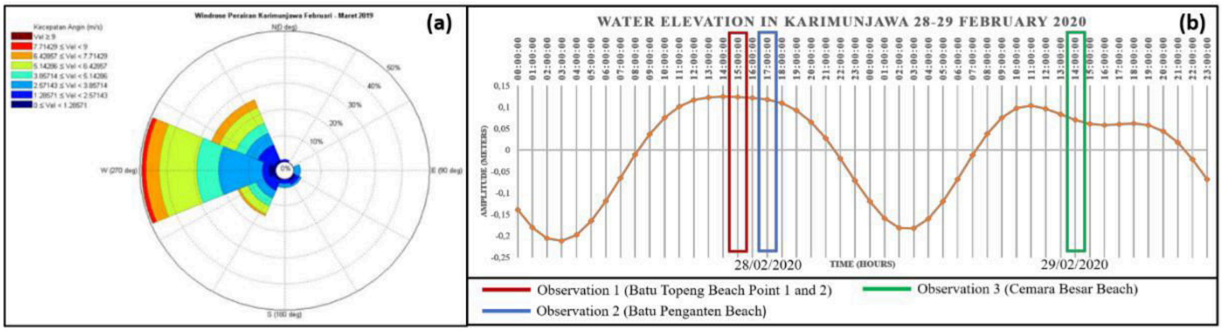

Figure. 4. (a) Windrose for February and March 2020 (source: ECMWF Re-analysis), (b) Sea surface elevation profile from BIG hydrodynamic simulation of February 28-29 2020 (GMT+7)

Figure 4. (b) presents the tidal elevation conditions on February 28 and 29, 2020 plus the specific time for making waste transects to carry out the process of measuring marine debris data. It can be seen that the water conditions are experiencing high tide when the measurement process is carried out at Batu Topeng Beach and Batu Penganten Beach on February 28, 2020. The measurement conditions at Cemara Besar Beach the following day also experienced the same conditions (high tide).

3.2. Amount and Density of Debris Based on Materials

Based on the results of observations of marine debris carried out at four main research points (Batu Topeng Beach [2 points], Batu Penganten Beach, and Cemara Besar Beach), a description of the intensity of debris can be obtained which can then be quantified for each type of sample taken. Types of debris that are used as material for observation include plastics, wood, metal / metal, glass, and rubber. Plastic type debris is reclassified based on its characteristics, namely hard plastic, foam, fiber, and layers of film.

Table 2. Marine Debris Amount and Percentage in Batu Topeng Beach Based on its Materials

Materials	Marine Debris Observation: Batu Topeng Beach			
	Total Amount (#item)		Total Amount (#item)	
	Obs. Point 1	Obs. Point 2	Obs. Point 1	Obs Point 2
Plastic	118	162	69.4	51.4
Wood	40	111	23.5	35.2
Metal	2	3	1.2	1.0
Glass	8	22	4.7	7.0
Rubber	2	17	1.2	5.4
Total	**170**	**315**	**100**	**100**

Table 3. Marine Debris Amount and Percentage in Batu Penganten Beach and Cemara Besar Beach Based on its Materials

Materials	Marine Debris Observation: Batu Penganten and Cemara Besar Beach			
	Total Amount (#item)		Percentage (%)	
	Batu Penganten	Cemara Besar	Batu Penganten	Cemara Besar
Plastic	1255	744	88.8	73.4
Wood	116	203	8.2	20.0
Metal	11	6	0.8	0.6
Glass	17	33	1.2	3.3
Rubber	15	28	1.1	2.8
Total	**1414**	**1014**	**100**	**100**

The results of the observation of measuring the amount of debris with different types can be seen in **Table 2.** and **Table 3.**, where it can be seen that plastic debris commodity is the most common type of debris and most found at each observation point. The highest intensity of plastic debris was found at Batu Penganten Beach with a total of 1255 (88,8%) items followed by Cemara Besar Beach (73,4%), Batu Topeng beach point 2 and point 1. Type of debris in the form of wood is the next type of debris most often found in the coastal area of the observation point. Overall, these types of debris were mostly found stranded on the shores of Batu Penganten Beach with a total of 1414 debris, followed by Cemara Besar Beach with 1014 debris, Batu Topeng 2 Beach with 315 debris, and Batu Topeng 1 Beach with 170 amount of debris.

Table 4. Density of Marine Debris Measured on four observation point

Materials	Density of Debris (#item/m2)			
	Batu Topeng 1	**Batu Topeng 2**	**Batu Penganten**	**Cemara Besar**
Plastic	3.93	2.25	4.18	2.48
Wood	1.33	1.54	0.39	0.68
Metal	0.07	0.04	0.04	0.02
Glass	0.27	0.31	0.06	0.11
Rubber	0.07	0.24	0.05	0.09
Total	**5.67**	**4.38**	**4.71**	**3.38**

The calculation result of marine debris intensity based on the amount of debris found are then further processed to calculate the density level of each type of debris. It can be seen in **Table 4.** that the highest density level of marine debris components is plastic type debris found at Batu Penganten Beach with a density value of up to 4.18 debris / m^2 which is then followed by the density level at Batu Topeng 1 Beach with a density value of 3.93 debris / m^2. The lowest level of solid debris density calculated is the type of metal which is very rarely found at Cemara Besar Beach, where the density level only reaches 0.02 metals / m^2.

Table 5. Amount and percentage of plastic debris types in Batu Topeng Beach (2 point)

Types of Plastic Debris	Observation Point			
	Batu Topeng 1		**Batu Topeng 2**	
	Amount (#item)	**Percentage (%)**	**Amount (#item)**	**Percentage (%)**
Hard	6	4.9	13	8.0
Foam	91	74.0	71	43.8
Fiber	21	17.1	68	42.0
Film	5	4.1	10	6.2
Total	**123**	**100**	**162**	**100**

Table 6. Amount and percentage of plastic debris types in Batu Penganten Beach and Cemara Besar Beach

Types of Plastic Debris	Observation Point			
	Batu Penganten		**Cemara Besar**	
	Amount (#item)	**Percentage (%)**	**Amount (#item)**	**Percentage (%)**
Hard	288	22.9	287	38.6
Foam	491	39.1	81	10.9
Fiber	388	30.9	277	37.2
Film	88	7.0	99	13.3
Total	**1255**	**100**	**744**	**100**

As previously explained, plastic debris is classified into 4 categories consisting of hard debris, foam, fiber, and film layers. **Table 5.** And **Table 6.** shows the plastic composition at each observation point. Foam-shaped plastic is the most dominant type at both Batu Topeng Beach and Batu Penganten Beach, with 91, 71, and 491 amount of debris respectively. Then, hard plastic and fibers became the most dominant at Cemara Besar Beach with a quantity of 287 (38,6%) and 277 (37,2%) debris. Film-shaped plastic was the type that was rarely found at the four debris observation points.

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4. Conclusion

Based on field observation activities and analysis of the results obtained, several conclusions were obtained from the study, where the dominant characteristics of debris were found in 4 observation points, the dominant types of plastic, wood, metal / metal, glass, and rubber. The highest amount of marine debris was found on the edge of Batu Penganten Beach which reached 1414 amount of debris. The highest level of debris density is plastic type debris at Batu Penganten Beach with a value of 4.18 debris /m^2. During the western season, a number of marine debris were found stranded on the western coasts of the Karimunjawa Islands. In addition, debris sorting and recycling activities can be highly recommended in the processing process, because the most dominant type of debris was plastic.

The results of field observations on the marine debris calculation in this study indicate that there is a large amount of garbage accumulation at the end of the west season towards the transition. The researcher recommends that further research be carried out that can visualize / model the movement of debris around the waters of the Karimunjawa Islands. It is hoped that this follow-up research can be useful for effective steps in marine debris management before accumulation of marine debris occurs on each of the western coast of the Karimunjawa Islands.

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