Marine litter’s composition and density at Baiya Beach in Palu Bay

D Sulistiawati 1*, K Mansyur 2, A E Putra 2, T Siampa 3, Z R Ya’la 2

1 Animal Husbandry and Fisheries Faculty Tadulako University, Palu Soekarno-Hatta Street Indonesia
2 Aquaculture, Animal Husbandry, and Fisheries faculty Tadulako University, Palu Soekarno-Hatta Street Indonesia
3 Environment Agency Palu City. Kakatua Street, Indonesia

Email: dwisulist@untad.ac.id

Abstract. Sea is a wealth of nature that contains a wide variety of resources, for living things. Marine health is an important thing that must be maintained for sustainable living. Marine litter is a waste from land that goes into the sea and disrupts the ecosystems of marine health, especially materials that cannot decompose such as plastics, glass, and others. The purpose of this research was to determine the waste’s composition and density based on the type of material and to know the trend of type and concentration of marine litter. A sampling of marine litter at Baiya Beach followed the criteria according to the guidance survey of marine litter on the beach. Baiya Beach is located in Palu Bay and meets the criteria in the monitoring of marine litter. The results obtained, there were 10 meso types of wastes (0.5 - 2.5 cm) that dominated by woods, plastics, and glasses & ceramics with density of 57.83 piece m⁻², 20.79 pieces m⁻², 19.90 pieces m⁻² respectively, while the macro type (>2.5cm) contained 25 types that dominated by plastic, wood, and other materials (sanitary) with a density respectively of 9.72 piece m⁻², 3,40 piece m⁻², 160.32 piece m⁻². These results showed that the type and quantity of litter are generally derived from human activity.

1. Introduction
Litter, debris, and solid waste in the marine environment are threats to the world’s oceans, seas and coastal zones as well as to the fish, crab, lobster, corals, sea turtles, marine mammals and other wildlife that occupy these areas [1]. Litter impacts wildlife directly through entanglement and ingestion and indirectly through chemical affects. As the quantity of debris increases in the marine environment [2]. Solid waste is a residual activity of human daily or natural process in the form of solid or semi-solid in the form of organic or inorganic substances are biodegradable or not biodegradable which is considered to be no longer useful and discharged into the environment. At this time, marine waste is a very important and interesting problem to be studied, because the impact caused by marine waste can threaten the survival and sustainability of biota in the waters.

Marine debris is defined as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment [3]. Marine debris is a global issue, affecting all the major bodies of water on the planet – above and below the water’s surface. This debris can negatively impact humans, wildlife, habitats, and
the economic health and stability of coastal communities. Marine litter can lead to loss of biodiversity (e.g., accidental catch by ‘ghost’ nets), loss of ecosystem functions, the provision of services from these ecosystems, loss of revenue (e.g., from reduced catch and reduced tourism revenue), loss of livelihoods of community groups, and increased costs (e.g., beach clean-ups) [1].

Baiya Beach is located in the Bay of Palu, is one of the beaches that became the study location in the shore wastes, located on the east of Pantoloan Port. This port located on the archipelagic sea lane of Indonesia, which is navigated by large container vessels and tankers, and west of the mangrove vegetation, and this area enters the Special Economic Zone of Palu. The purpose of this study are: Estimating the amount of waste associated with land use and / or other parameters, Determining the composition and density of litter by material type.

2. Beach Litter Assessment
The survey was conducted in 16th November 2017, in conjunction with the ongoing west wind season located at Baiya Beach, Baiya Village, Tawaeli District, Palu City, Central Sulawesi Province. To reach the location can be accessed by road using motor vehicle. The coastal biophysics include sandy beach types and ramps with coordinates of 00° 43' 19.6" South Latitude and 119° 51' 31.8" East Latitude. The water recedes at approximately 08.00-12.00 AM and the tidal range is about 10 m, the height of the ± 2 m tidal interval with the coastal slope of 15.8°. The transect area at a minimum of 100 m is parallel to the coastline with width following the coastal boundary the transect area at a minimum of 100 m is parallel to the coastline with width following the pantheon boundary with an area of 100 x 50 m² [1].

Figure 1. Sampling Location at Beach Baiya Palu Bay.
Subsequent procedures after the litter transect is done is litter collection and classification. Litter classification is done in situ and determined by UNEP (on Waste Classification System). This classification system comprises a list of 10 different material classes and a total of 77 discrete types of litter [1]. Field condition data and sampling result after classified and identified inputted in table format have been provided. Recapitulation results of coastal waste data include:

a. The composition of litter is calculated as percentage, i.e., the weight of garbage per species per overall Litter the survey area.

\[ \% = \frac{X}{\sum_{i=1}^{n} x_i} \]  

where \( x \) = weight of waste per type

b. The garbage density (D) is calculated from the amount of waste per type per m²

\[ D = \frac{\text{type}}{\text{Length} \times \text{Width}} \]  

Length and width are measured in meters

c. The estimate the amount of marine litter Palu Bay is obtained from the multiplication of the average weight of waste with the length of the Coastal Plains. The calculations are differentiated for meso size (0.5cm-2.5cm) and macro size (> 2.5cm).

3. Results and Discussion

   Palu Bay is to the west of the island of Sulawesi, directly adjacent to the Makassar Strait at positions around 0° 36’ - 0° 56” South Latitude and 119°45’ - 121° 1” East Longitude. The bay has a north-south orientation, where the northern part of its mouth meets the Makassar Strait. This bay has a width of about 9 km and a coastline length of about 100 km so that the formation is elongated with the ratio.
between the width of the mouth and the bay length of about 1:11 with an overall area of 206,935,000 m² (207 km²). The biophysical properties of Palu Bay are influenced by the Indonesian Cross Flow that flows from the Pacific Ocean to the Indian Ocean. This water mass flow occurs as a result of the difference in pressure between the two oceans.

Administratively the northern part of Palu Bay area is the authority area of Palu City Government while the southern part is the authority of Donggala District Government, geographically facing directly to Makassar Strait. At the edge of Palu Bay there are currently 4 coastal districts that make Palu city as a whole (North Palu, East Palu, South Palu and West Palu District) with 395.06 km² of land and 4 coastal sub-districts forming part of Donggala District (ie Banawa Sub district, Tanantovea Sub district, Labuan Sub district and Sindue Sub district) with 704.89 km² of land. The land area formed by these 8 sub-districts forms a coastal bay area of 1,099.95 km². The coastal area is the Bay of Palu and the Palu Valley whose height reaches 800 meters from sea level, in addition to the existence of the bay which is semi-enclosed waters have appeal to the development of various activities.

Palu Bay has relatively stable physical characteristics, protected and not as high as the Makassar Strait. This causes the Palu Bay area is growing a variety of community activities. Palu Bay has an elongated shape with wide bay mouth of 9 km and long coastline 100 km. This condition indicates that the effect of land on bay is quite large. The dynamics of shoreline changes are monitored by utilizing Landsat TM and ETM + satellite images in three periods (1983, 2000 and 2014). Based on satellite imagery it is known that there has been a shoreline change, especially in the southern part of the Palu Bay coast from 1983 to 2000 as far as about 60 meters. This shoreline change is caused by abrasion processes that occur along the coast. The changes are still visible from 2000 to 2014. This is due to the circulation of currents inside the bay from Makassar Strait that affect the mass of water in the Palu Bay also caused by various human activities and mining activities that accompanied by reclamation activities.

Land use around the site is:
1. Northwest side: Pantoloan Port;
2. East: Population settlements include goat pens and places fishing boat moorings.
3. Southeast: Vegetation Mangrove dominated by species Avicennia sp.
4. Northwest - South side: Palu Bay’s waters

Habitat located at Baiya Beach is mangrove and seagrass. This beach location is destined for boat moorings, and some local events (sailboat races and horse racing competitions). The waters around the coast are used to anchor the ships that will lean on the Port of Pantoloan. Estimated number of visitors per year ± 3000 people. Garbage clearing activities have been done on local events (sailboat race and horse race race) in 2015.

Palu Bay is the place of the raiding of several rivers to the Palu Bay, where, in the rainy season, the river flow will lead to the buildup of sedimentation in the estuary that impact on changes in the contours of the depth of the Gulf waters. Most of Palu Bay’s waters have relatively sloping basal contours although in some places coastal lines are somewhat steep with water depth ranging from 0-800 meters. The existence of these rivers caused the waters of Palu Bay to get a sufficient supply of fresh water. The source of the garbage comes from the rivers that lead to Palu Bay, with the distance from each sampling location ie Lero River (13.6 km), Labuan River (5.61 km), Wani River (2.68 km), Lambara River (1.47 km), River Taipa (7.13 km), Mamboro River (9.44 km), Loli Oge River (10.30 km), Watusampu River (11.05 km), Buluri River (15 km) and Palu River (18.19 km) Palu community activity with population of 375,020 people [6] that contribute to the abundance of types of marine litter.

Result of monitoring of garbage at Baiya Beach location found 25 types of waste (figure 4 and 5) and not found category of Large Trash (not easy to move or size>1 meter).

3.1. Marine Litter Composition
Meso litter type are 4 material with the composition based on the weight of each wood for the amount of 28 (57.83%), plastic 24 (20.79%), Glass & ceramics (19.90%) and Foam Plastic 1 (1.48%). Meso
litter found 10 types of waste which is dominated by type WD06 (Other wood) weighting 28.000 g. While the least known meso litter was PL07 (Plastic Bag / opaque and clear) weighting 0.022 g.

Macro litter type (figure 4) are 6 material with composition based on the weight of each type for plastics 243 (60.53%), wood amounted to 85 (13.39%), other types (sanitary) 15 (20.33%), glass & ceramics 14 (1.61%) and cloth 4 (0.30%), and rubber 3 (1.38%). Macro litter (figure 5) found 25 types of waste which is dominated by PL24 type (other plastic materials, such as packing laundry soap and plastic sheet) weighing 3,769,000 g. The least-known macro litter is PL11 type (Cigarette, butt and lids) weighting 2,000 g.

![Figure 4. Meso Litter Type Count.](image)

![Figure 5. Macro Litter Type Count.](image)

![Figure 6. Composition of Meso Litter Type.](image)

![Figure 7. Composition of Macro Litter Type.](image)

From the amount of meso and macro litter, an average of 36.1% is organic litter and 63.9% is inorganic litter. For type of inorganic litter originating from households (figure 6 and figure 7), it is known that the composition of litter is dominated by plastics, glass and ceramics, plastic foam, plastic bags, rubber, pampers, cigarette butts lids and other plastic materials. The amount of plastics litter is very much because it is always used by people in daily life. As a container of goods carried plastic is very practical because it can be bagged. For this type of organic litter, in the form of wood corks, wood tools, other pieces of wood and guava fruit, local fruit
3.2. Density of Marine Litter

Meso litter type are 4 material with the density of litter are wood 57.83 pieces m$^{-2}$, Plastics 20.79 pieces m$^{-2}$, Glass & ceramics 19.90 pieces m$^{-2}$, and Foam Plastic (Insulating Packaging) 1.48 pieces m$^{-2}$. Meso litter found 10 types of waste which is dominated by WD06 type (Other wood) percentage 41.546% and density 0.880 pieces m$^{-2}$. While the least known meso litter is PL07 (Plastic Bag / opaque and clear) percentage 0.033% and 0.200 pieces m$^{-2}$.

Macro litter type are 6 material with the density of litter are glass & ceramics 160.32 pieces m$^{-2}$, plastics (PL) 9.72 pieces m$^{-2}$, wood 3.40 pieces m$^{-2}$, other types (sanitary) 0.60 pieces m$^{-2}$, cloth 0.16 pieces m$^{-2}$, and rubber 0.12 pieces m$^{-2}$. Macro litter found 24 types of waste which is dominated by PL24 type (other plastic materials, such as packing laundry soap and plastic sheet) 22.49% and density 3.080 pieces m$^{-2}$. The least-known macro litter is PL11 type (cigarette, butt and lids) 0.012% and 0.040 pieces m$^{-2}$.

The persistence of many types of litter in the marine environment, particularly glass and plastics, is widely accepted [3] but differing interpretations of when ‘degradation’ occurs mean that estimates of breakdown rates vary widely to fragmentation and the eventual chemical decomposition of litter items. Different studies, however, pinpoint different stages of this process as when ‘degradation’ occurs resulting in the range of estimates of breakdown rates [4]. Plastics illustrate this well as they fragment to micro plastics over timescales of hundreds of years but the length of time required for their full chemical decomposition is unknown [5]. In practice, degradation rates can also vary substantially due to varying UV levels, temperatures, oxygen levels, wave energy and the presence of abrasive factors such as sand or gravel [3].

In general, the waste found in this location comes from human activities along the river that empties into the Bay of Palu and settlements along the coast of Palu Bay. The lack of awareness and behavior of clean and healthy living in the area around Palu Bay is thought to be one of the main factors for the abundant amount of waste found along the Palu Bay coast. This can be seen from the type and abundance of waste that generally comes from household waste. Considering the length of time the marine litter, waste management is also required. Regulation on garbage problem in Palu City is regulated by Palu City Local Regulation Number 11 2005 year about Waste Restitution, Palu City Local Regulation Number 12 2005 year about Management of Hygiene and Decision of Mayor City number 17 2007 year about Devolving part of garbage affairs to Urban Village level at Palu City. Implementation of waste management policy in Palu has not been maximized because the resources have not been able to overcome the waste problem. For human resources there are no experts in the field of waste management that affect the performance of policy implementation. For operational costs are still less so still need to be added in order to achieve the goal of waste management policy in the
Palu City. The facilities and infrastructure in waste management are still lacking which resulted in the level of waste management service is not optimal and cause more waste generation in the Temporary Disposal Site [8], and still many people throw the garbage into the water channel, which finally passes the river to the sea.

Table 1. Estimate Degradation Rates Material Litter Discovered at Baiya Beach

| Material Discovered                                      | Degradation Rate (Years) | Reference          |
|---------------------------------------------------------|--------------------------|--------------------|
| PL1 (Bottle caps and Lids)                              |                          | Thomson et al 2004 [7] |
| PL2 (Bottles <2 L)                                      |                          |                    |
| PL3 (Bottles, Drums, Jerycans & Buckets >2 L)           |                          |                    |
| PL4 (Knives, forks, spoons, straws, stirrers (cutlery)  | 450                      | Thomson et al 2004 [7] |
| PL5 (Drink package rings, six-pack rings, rings carriers |                          |                    |
| PL6 (Food containers : fast food, cups, lunch boxes & similar) |                          |                    |
| PL7 (Plastic bags: opaque & clear)                       | 10-20                    | Thomson et al 2004 [7] |
|                                          | 20-30                    | Cheshire et al 2009 [3] |
| PL11 (Cigarettes, butts & filters)                      | 1-5                      | Cheshire et al 2009 [3] |
|                                          | 10-12                    |                    |
| PL16 (Sheeting: tarpaulin or other woven plastic bags, pallet wrap) | 450                      | Thomson et al 2004 [7] |
| PL18 (Monofilament line)                                | 600                      | Thomson et al 2004 [7] |
| PL21 (Strapping)                                        |                          |                    |
| PL22 (Fiberglass fragments)                             | 450                      | Thomson et al 2004 [7] |
| PL24 (Other: specify)                                   |                          |                    |
| FP04 (Foam: insulation & packaging)                     | 450                      | Thomson et al 2004 [7] |
| CL05 (Carpet & Furnishing)                              | 450                      | Thomson et al 2004 [7] |
| GC02 (Bottles & jars)                                   |                          |                    |
| GC04 (Light globes/bulbs)                               |                          |                    |
| GC05 (Fluorescent Light Tubes)                          |                          |                    |
| GC07 (Glass & Ceramic Fragment)                         |                          |                    |
| RB02 ((Footwear: flip-flops)                            | 450                      | Thomson et al 2004 [7] |
| WD01 (Corks)                                            |                          | Naturally bio-gradation[7] |
| WD04 (Processed timber and pallet crates)               |                          |                    |
| WD06 (other; specify)                                   |                          |                    |
| OT02 (Sanitary: nappies, cotton buds, tampons, pads, toothbrushes) | 450                      | Thomson et al 2004 [7] |
| OT05 (other; guava, local fruits)                       | 6 month                  | Naturally bio-gradation[7] |

The use of plastics will pollute the environment because it cannot be broken down by bacterial decomposers and if the bias is broken down it will take up to hundreds of years. The method of waste management carried out by the people of Palu City still uses the concept of being dumped in another
place, burned around the house, and taken by the janitor. Garbage can be managed simply by hoarding and weathering it so that waste can be a useful material for soil waste and plants called compost. But the process of decomposition of waste takes quite a long time and the waste generated is not just organic waste but also inorganic (plastic) waste that is not easily decomposed. Furthermore, the important thing in managing waste is to reduce of plastic’s using, change to the plastic with environmentally friendly materials, reuse the garbage, recycle the garbage to be reused and not to dispose of waste into the sea.

Introduction

4. Conclusions

Meso litter type at Baiya Beach are 4 material found 10 types with the composition based on the weight of each wood, plastics, Glass & ceramics, and Foam Plastic, which is dominated by type WD06 (Other wood) and the least was PL07 (Plastic Bag / opaque and clear). The density of Meso litter type is dominated by WD06 type (Other wood) and the least is PL07 (Plastic Bag / opaque and clear). Macro litter type are 6 material found 24 types with composition based on the weight of each type for plastics, Wood, Other types (sanitary), Glass & ceramics, Cloth, and Rubber. The density of macro litter o is dominated by PL24 type (other plastic materials, such as packing laundry soap and plastic sheet) and the least is PL11 type (Cigarette, butt and lids). The type and abundance of Marine litter that generally comes from household waste.

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References

[1] Ten Brink P, Lutchman I, Bassi S, Speck S, Sheavly S, Register K, and Woolaway C 2009 Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter (Virginia: Institute for European Environmental Policy (IEEP) Brussels Belgium and Sheavly Consultants) 60
[2] CSIRO 2014 Marine Debris: Sources, Distribution and Fate of Plastic and Other Refuse – and Its Impact on Ocean and Coastal Wildlife (www.csiro.au.)
[3] Cheshire A C, Adler E, Barbière J, Cohen Y, Evans S, Jarayabhand S, Jeft ic L, Jung R T, Kinsey S, Kusui E T, Lavine I, Manyara P, Oosterbaan L, Pereira M A, Sheavly S, Tkalin A, Varadarajan S, Wenneker B, and Westphalen G 2009 UNEP Regional Seas Reports and Studies No. 186 (IOC Technical Serious No. 83)
[4] Mouat J, Lozano R L, and Bateson H 2010 KIMO International 171
[5] Andrady A 2005 Plastics in the Marine Environment: A Technical Perspective. White Paper for the Plastic Debris Rivers to Sea Conference (California: Redondo Beach)
[6] BPS-Statistics of Palu Municipality 2017 Palu Municipality in Figures 2017 (Palu: Published BPS-Statistics of Palu Municipality Printed By Rio)
[7] Thomson R C, Olsen Y, Mitchell R P, Davies A, Rowland S J, John A W G, McGonigle D and Russell A E 2004 Science 304 838
[8] Thalib 2014 e-Jurnal Katalogis 2 15 -22