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Daily Accumulation and Impacts of Marine Litter on The Shores of Selayar Island Coast, South Sulawesi

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Abstract - *West coast of Selayar facing solid marine litter during west monsoon period December until March, marine litter come from floating litter, carried by sea surface current and deposited along the west coast. Marine litter deposited on the west coast affected social, economic and ecological. This study aims to determine type, weight, density and distribution of marine litter; the impact of litter on water quality; the impact of economic, social and environmental ecosystems. Retrieved data using line transect at 7 observation points. Litter size were observed (> 2.5 cm) or macro litter. Floating litter and daily incresing of litters were also analyzed. Inorganic waste density is 14.3 ± 2.97 items/m² for the number of pieces and 564.8 ± 196.1 g/m² for waste weight. Daily accumulation was about 1 445 ± 1 743 g/m/day, the number of pieces 14.3 ± 8 item/m/day, cubication 0.0187 ± 0.019 m³/m/day. The impacts on seagrass and biota such as broken leaves, crushed and organism rafting on floating litter some types of coral such as Favia fragum, types of crustaceans such as Balanus. sp, Lepas. sp, Dosima. sp which affect the bio-diversity.*

Keywords *– marine litter, Selayar island, management, impact, ecology.*
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1. Introduction

Selayar island is an island of Selayar Islands, South Sulawesi. Facing directly with the Java sea, Selayar island is dependent on seasonal winds and currents. West monsoon periods from December to March, East monsoon between May and August and transition periods of April until the middle of May and half of September to November but it is very difficult to predict the seasons (Bandiyono et al., 2007; BPS, 2015; Krishnamurthy and Kinter, 2003). The wind drives surface currents carry floating litter(Choy and Drazen, 2013; Vikas and Dwarakish, 2015). According to (Critchell et al., 2015; Critchell and Lambrechts, 2016) wind and surface currents greatly affect to litter distribution at the sea. During west monsoon floating litter drive towards Selayar island west coast, and stranded at beach and affect of social, economic and ecologic. This research observed these phenomena scientifically.

Many researches in Indonesia recorded on the beach and river litter in Palu, Central Sulawesi (Walalangi, 2012), marine litter in the Thousand islands and the Ambon (Uneputty and Evans, 1997a; Uneputty and Evans, 1997b), on seagrass (Mandasari, 2004) and plastic debris (Jambeck et al., 2015; Sherman and Sebille, 2016; Willoughby et al., 1997). Impacts of marine litter on Indonesia less in data. This research aims to determine the composition and density of beach litter; to determine daily rate of increase of marine litter; the impacts of marine litter against the ecology on Selayar island west coast.

2. Materials and Methods

Research location shown in Figure 1. This research was conducted in February to March 2016. The point of observation represented at 7 monitoring site by the character of coastal. On Figure 1 shows the length of the beach and the observation site.

Marine litter data was collected by line-transect method to determine of types, weights, quantities and spreads of area. The size of samples that were observed > 2.5 cm or macrolitter. Sampling in transect with 5 m width and length by following the beach width. Observations was conducted at low tide water level and repeated 3 times plot every site (Lippiatt et al., 2013). Observation of floating litter according to (UNEP, 2009) with a visual survey. Marine litter was taken and counted on the ground. Floating litter was observed with line transect method by start from coast to slope and 2 m width, observed by snorkeling. Daily accumulation rate of marine litter determined by line transect method. Observed during 17 days, from 5 to 22 March 2016. Stranded marine

litter were taken and sorted, then analyzed the amount, types, weights, density and composition of marine litter (Eriksson et al., 2013; Walalangi, 2012)

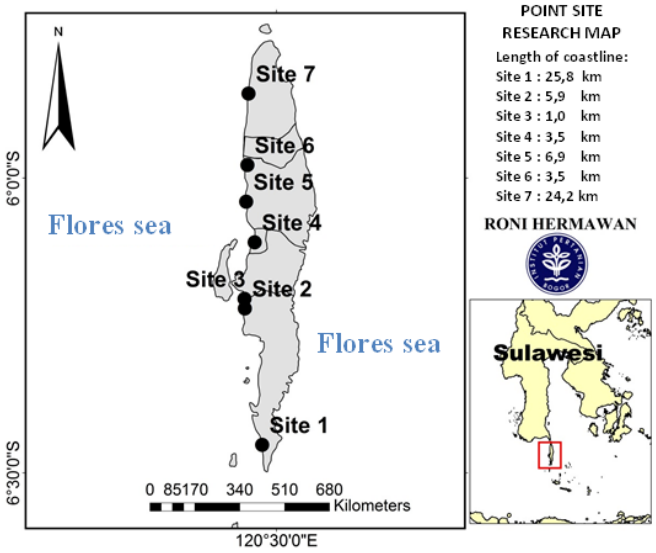


Figure 1. Point Site Research Map

3. Results and discussion

3.1 General conditions

Selayar island from north to south about 108 km, facing directly the Java Sea in the west and the Makassar Strait in the north have a direct impact on ocean currents from the west monsoon. The west monsoon drives the current surface and carries floating materials to Selayar island west coast. West monsoon caused by high air pressure in Asia and low pressure in Australia, the wind carrying moist air during December to March become the rainy season in Indonesia(Aprilleria et al., 2015).

3.2 Wind Drive and Ocean Surface Currents

Ocean surface current influenced by the direction and strength of wind drive (Lei et al. 2000). Based on data obtained from (Wyrtki, 1961; Balitbang KP , 2016; ECMWF, 2016). Wind patterns and currents took in December 2015 to April 2016 to describe wind patterns and currents at the time of the season. Wind drive and surface currents analyzed for determine floating litter movement around the Selayar island during west monsoon.

Based on wind drive on December from the Java Sea toward south Sulawesi and several small islands, wind drive on Selayar island ranged from 0.03 to 1.55 m s^{-1}. The movement of the wind also occurs from the direction of the Makassar Strait and the island of Kalimantan, head South Sulawesi island and the island of Selayar at speeds between 1.56 to 2.65 m s^{-1}. In February, is the highest wind speed with average speed on the island of Selayar 3.29 up 5.37 m s^{-1}, which leads from the Java Sea and Makassar Strait directly to Selayar Islands. In April is the start of the season the East wind began to change direction, the wind speed average in Selayar Island between 3.05 till 5.57 m s^{-1} moves from the Banda Sea to the Java Sea, direction or moving from East to West, the island of Selayar island of Selayar. Based on (Goldberg, 1997) surface current in December of the current air speed between 0.25 to 0.38 m s^{-1} from the Java Sea and the Makassar Strait to the South Sulawesi, surface current speed in February increased from 0.38 to 0.75 m s^{-1} in the south Sulawesi including Selayar Islands, in April the movement flow began turn over to the Java Sea from the Banda Sea at speeds of 0.25 m s^{-1} is the start of east monsoon season or transition period.

3.3 Density of Marine Litter

The composition of marine litter were divided into two categories organic litter and inorganic litter. Based on the average numbers of marine litter compared to organic and inorganic. By weight, organic more than inorganic (Table 1 and 2). Inorganic litter lighter than organic litter because most of the inorganic litter materials are plastic, styrofoam and rubber that lighter material than organic litter.

Table 1. Density of Marine Litter by Amount (items/m^2) and by Weight (g/m^2).

Site	Total (items/m^2)		(%)	
	Organic	Inorganic	Organic	Inorganic
Site 1	7.4	19.1	28	72
Site 2	5.4	11.7	31	69
Site 3	6.9	12.8	35	65
Site 4	11.3	12.4	48	52
Site 5	7.4	18.1	29	71
Site 6	7.1	13.0	35	65
Site 7	8.3	13.2	39	61

Site	Weight (g/m^2)		(%)	
	Organic	Inorganic	Organic	Inorganic
Site 1	11 698.1	853.9	93	7
Site 2	2 359.4	457.4	84	16
Site 3	1 303.6	276.1	83	17
Site 4	5 552.3	493.9	92	8
Site 5	4 599.8	768.1	86	14
Site 6	4 015.8	498.7	89	11
Site 7	5 319.2	605.6	90	10

3.4 Spread of Marine Litter

Marine litter spread along the west coast, the spread of marine litter are affected by water currents (Realino et al., 2006). The spread of marine litter based on quantity of amount, weight and cubication are presented in Figure 2a, 2b, 2c, 2d, 3e and 2f. Distribution based on the highest weight of organic litter and inorganic litter was site 1. Site 1 was located at the southern tip of the Selayar island, sea-water current in the southern part of the island was stronger than the northern part. Less number of local population at site 1, so the stranded of marine litter had not bothered.

The highest of amount distribution organic litter pieces on 4 site which were the estuaries. The high number of the inorganic litter pieces at 1site and 5 site, at 5 site had sloping shore so marine litter easily stranded. The local communities utilize litter wood for household scale blacksmith so the amount of organic litter low number at the 5 site. The highest of distribution organic and inorganic litter cubication at the 7 site. Organic litter at the 7 site was dominated by a large wood timber, inorganic litter in the 7 site was dominated by bottles and rubber sandals by cubication.

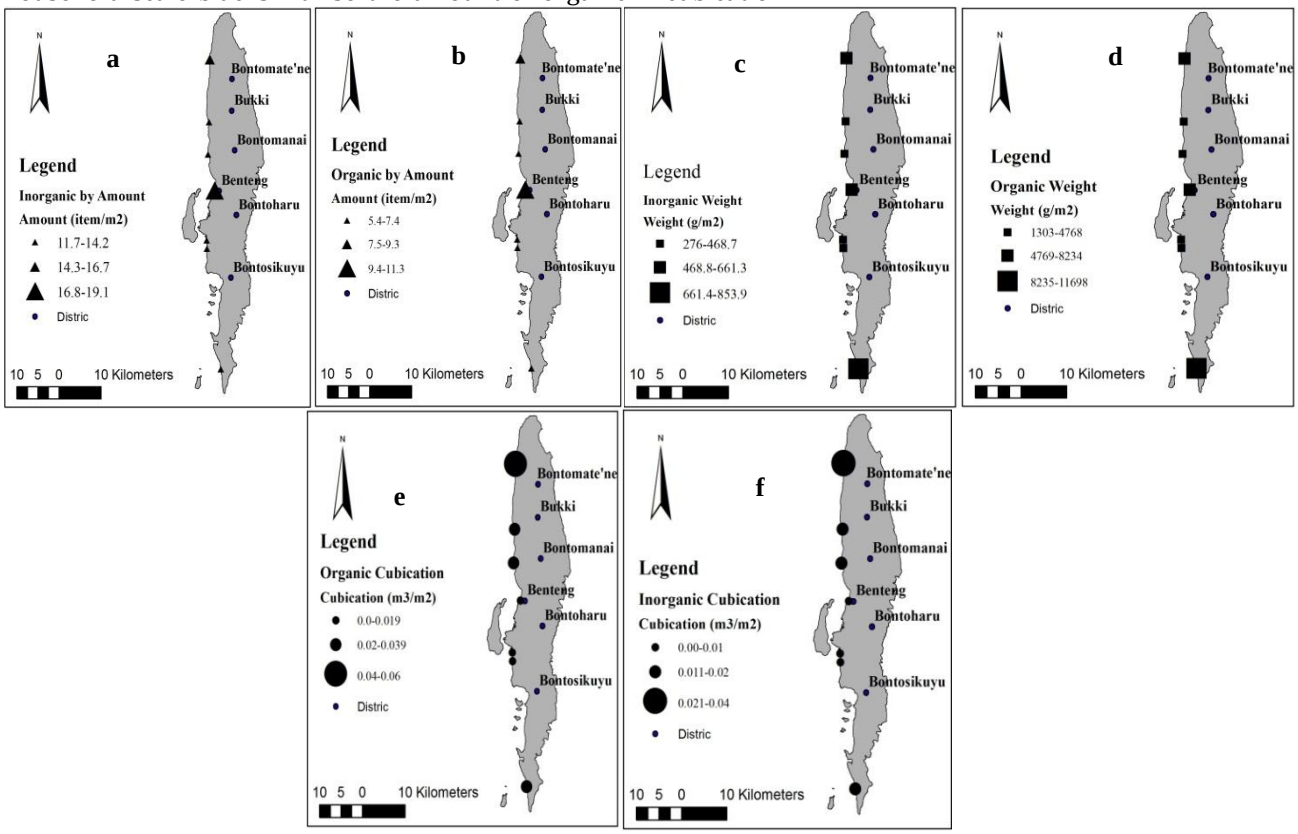


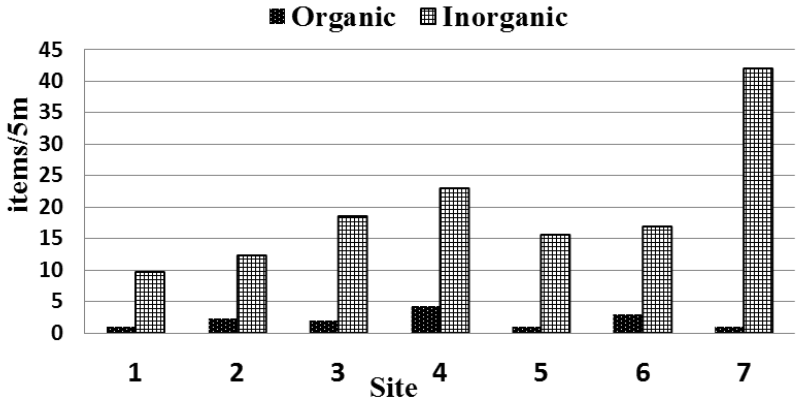
Figure 2 (a) (b) Spread of Marine Litter by Amount; (c) (d) by Weight; (e) (f) Spread by Cubication

3.5 Composition, Density and Distribution of Floating Marine Litter

Based on floating litter observation (Figure 3) spread unevenly, the larger number on intertidal area. The highest amount was on the 7 site about 42 items/5m for inorganic litter. Site 7 with length of beach to slope was 302 m and facing the sea directly so floating litter larger on this site. Plastic litter was dominating the inorganic litter especially plastic bag or plastic wrapper. Plastic litter was lightweight, strong, durable and corrosion resistant, mainly used as wrapping food. The food product is very dependent on the quality of wrapper, so the manufacturers improve quality of plastic wrapper. On seagrass ecosystem was not found litter on seagrass ecosystems, except near the intertidal area. March was the end of west monsoon, water currents and wind drive were not too strong, floating litter become decrease. The composition of floating litter was dominated by timber, coconut and plastic litter.

3.6 Daily Accumulation of Marine Litter

Daily accumulation of marine litter determine at the



beach with counting and weighing the stranded beach litter for 17 days from 5 to 22 March 2016. Based on the observations, the litter consists timber, plastic cups, plastic wrap, styrofoam, rubber sandals and plastic bottles. Based on the calculation of weights, numbers and cubication were analyzed in graph (Figure 4a, b and c). Daily increase of marine litter decline due to water currents and wind speeds toward the end of March, which lower the speed wind and current. The number of stranded marine litter decreased over a slowdown of sea water current, thus daily increasing litter was getting lower. Late March or early April was the transition period (Realino et al., 2006). A transitional season was marked by a decrease of seawater current and wind speed, it was usually coastal waves become calm. Based on the calculation of average daily increase by weight about 1 445 ± 1 743 g/m/day, the number of pieces of 14.3 ± 8 item/m/day, cubication 0.0187 ± 0.019 m^3/m/day.

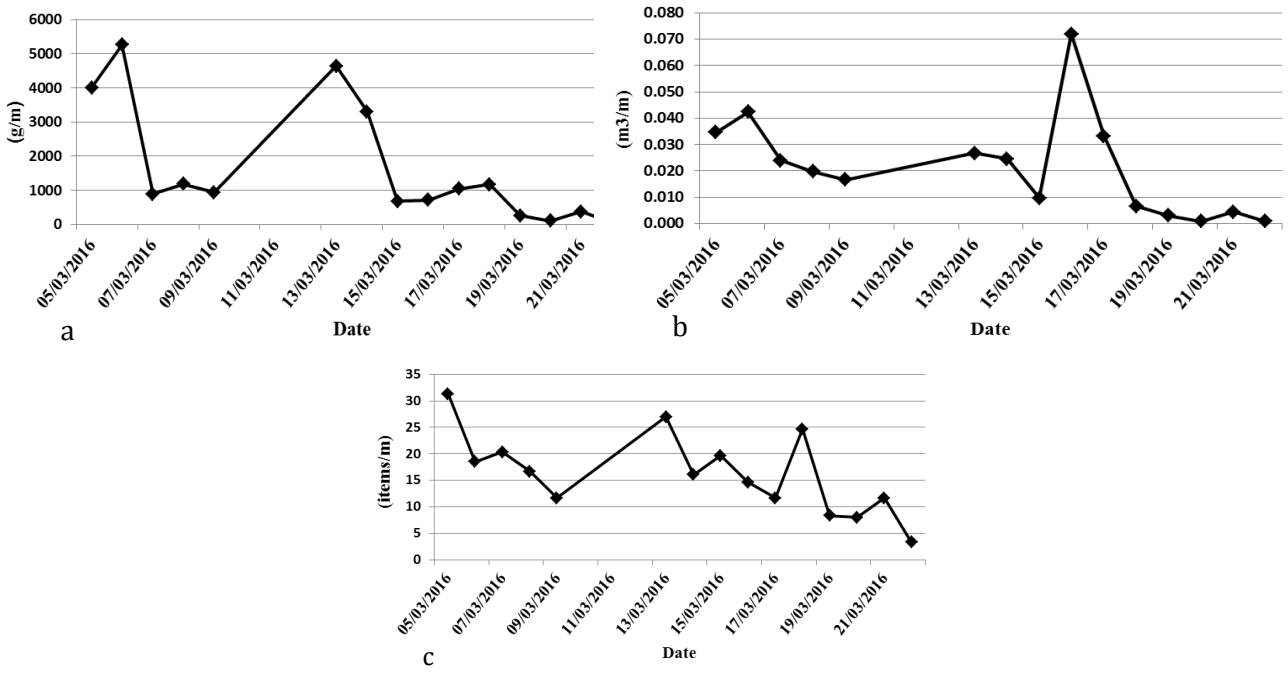


Fig. 4 Daily Increase of Marine Litter by (a) Weight; (b) Cubication; (c) Amount

3.7 Marine Litter impact to Ecosystems and Biotic

Impact on the ecology in the waters especially in the intertidal, the impact arising from floating litter that stranded in the intertidal area. Litter piled up on the beach, covering the seagrass and organism, covered by plastic wrap, timber and glass bottles. Plastic wrappers and timber lots in the area found on the intertidal. Some of timbers and floating materials were sinks in the intertidal area. During low tide floating materials were covered and pilled up on vegetation or organism. Impact on seagrass and organism that are covered and pilled up such as broken leaves, tissue abrasion causing partial or mortality. Effected and broken seagrass leaves become litter and washed away by water current to the beach. The damaged seagrass leaves and accumulate along the coast, on observations at sites 1, 2 and 4 of seagrass leaves litter weight about 2.68 to 23.6 kgs.

There was a sea cucumber that associated with plastic bag, some types of plastic litter will sink to the sea bottom of the waters and rotted or overgrown with algae. Pelagic plastic debris is ideally suited for rafting due to its abundance, buoyancy, and persistence, and has rapidly become a common substrate (Goldstein, 2012). Some organism were attracted by marine litter that float or sink in the water. They seek shelter so using litter for association. Some biota such as fish, crustaceans, mollusk and others used plastic litter as a new substrate habitat(Gall and Thompson, 2015). According to (Allsopp et al., 2006) that plastic litter covered more than 50% would affect the foraging ability of Gastropods. Some of stranded marine litter had associated by multiple types of coral *Favia fragum*, kind of like crustaceans such as *Balanus* sp and *Lepas* sp (Figure 5). Associated with coconuts, glass bottles, plastic bottles, plastic wrap, bouy, nets, ropes and timber. Some marine organism used floating marine litter for rafting (Bergmann et al., 2015) Wright et al. 2013). Uncontrolled dispersion due to ocean currents.

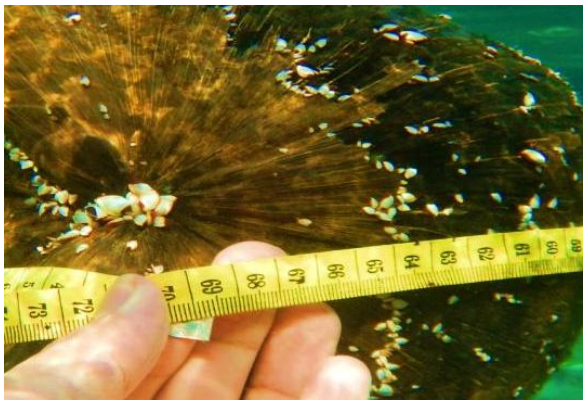


Fig. 5 Lepas sp. associated with floating coconut litter

According to (Kiessling et al., 2015) who have reviewed 82 scientific publications stating that there were 387 species using marine litter as a media to migrate (rafting), where 244 species have been identified and 143 taxa. Invasive species can be a major impact to sea ecosystem and biodiversity (Grassle et al., 1991). This biotic mixing is becoming a widespread problem due to human activities, and it is a potential threat to native marine biodiversity. According to some studies estimate, the diversity of species decreased to 58% if there is a mixing biota in the whole world (McKinney, 1998).

4. Conclusion

Marine litter spread along of Selayar island west coast about 70.78 km. Daily accumulation on Selayar island west coast by weight about 1 445 ± 1 743 g/m/day, the number of pieces of 14.3 ± 8 item/m/day, cubication 0.0187 ± 0.019 m3/m/day. Marine litter becomes a problem due to human activities, threat biodiversity by increase rafting of invasive species.

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