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Identification and Distribution of Marine Debris along the West Aceh Coastline

Neneng Marlian, Nurul Najmi, Eka Lisdayanti*, Faliqul Isbah, Teuku Rizqi Fadillah

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ABSTRACT

This study was undertaken in September 2023 in the West Aceh Coastal area with the goal of identifying and analyzing the distribution of marine creatures discovered at the two research sites. The sampling of marine debris was determined using a transect length of approximately 100 m. Transect distances were separated into four categories: 0, 25, 50, 75, and 100 m. Marine debris was detected using Lippiat *et al*. (2013) categories and NOAA (2013) size classifications. The data on the identification and distribution of marine debris was analyzed descriptively. The results revealed that organic waste (wood and its derivatives) was in the highest quantity and composition at both research stations, with 1386 (73%) and 8953 fractions (97.1%). This is followed by the number and composition of inorganic waste (plastic) at the two research stations, which are 492 fragments (26%), and 205 fragments (2.2%). The lowest amount and composition of inorganic waste (non-plastic) were found at both research stations, such metal, glass, rubber, and clothing/other fibers, namely (metal: 6 and 11; glass: 2 and 1; rubber: 2 and 28; clothing and other fibers: 18 and 24) with respective compositions ranging (metal: 0.3% and 0.1%; glass: 0.1% and 0.0%; rubber: 0.1% and 0.3%; clothing and other fibers: 0.9% and 0.3%). A one-way examination of the spatial distribution of marine debris at each research substation (Substations 1, 2, and 3) revealed no significant differences (*p* value > 0.05) between the two research stations.

Keywords: coastal, debris, marine, West Aceh

INTRODUCTION

The economic importance of the complex coastal area has resulted in a variety of ecological stressors along the shore. The growth in solid waste pollution in the form of marine debris has severely harmed the natural system and order of coastal waters, as well as human health and life (FAO 2017, Opfer et al. 2012, Rochman et al. 2015). According to Pawar et al. (2016), marine debris has harmed human health and safety, degraded marine habitats and ecosystems, impacted the fishing and tourism industries, and disturbed the marine navigation system. Marine debris is defined by UNEP 2009 as solid materials produced or processed directly or indirectly, intentionally or unintentionally, and disposed of or abandoned in the marine environment, such as used glass or plastic bottles, cans, bags, balloons, rubber, metals, fiberglass, cigarette butts, and other materials that end up in the sea and along coastlines. Marine debris such as plastics, cans, rubber, and glass can also have an impact on the low number of aquatic biotas, including fish and marine mammals (Uneputty & Evans 1997), whether they are listed on the IUCN red list or not.

University of Teuku Umar, Meulaboh,West Aceh. 23616 Indonesia
* Corresponding Author:
Email: ekalisdayanti@utu.ac.id

Nowadays, many types of marine debris have been discovered around the world, including plastic, cans, rubber, and glass waste, in countries such as Sri Lanka, the Philippines, Indonesia, and nations with lengthy coastlines such as China and Vietnam. In addition to global warming, the hottest topic today is marine debris, particularly inorganic garbage (plastic, cans, rubber, and glass) strewn throughout coastal areas. Several conferences and studies have been conducted around the world to explore the problem of marine debris entering sea waterways. However, study on marine debris entering sea waters is relatively rare in Indonesia, even though the country is the world's second greatest supplier of marine debris, particularly plastic, behind China (Jambeck *et al*. 2015). Marine debris trash, originating from residential waste, has been discovered in different marine environments in Indonesia, including Ambon Island and the Thousand Islands. Marine debris has posed direct and indirect harm to aquatic biota.

West Aceh's coastal waters are marine waters that face the Indian Ocean and cover a sea area of 295,370 km^2 with a coastline length of 2,666.3 km. The economic importance of the West Aceh shore's waters to the surrounding people has contributed to a rise in marine debris pollution along the shore. This phenomenon has become the primary concern of the community, NGOs, and the local administration in West Aceh Regency. Several studies have been

conducted to identify, determine the composition, and distribution of marine debris on the West Aceh Coast, including Kusumawati *et al*. (2018), where the most common marine debris found in the research location is from plastics, such as plastic cups, straws, and food wrappers; Kusumawati *et al.* (2019), that tourist locations contribute the highest amount of plastic waste with a composition of 75% compared to fishing sites. Rahmayanti *et al*. (2020) stated that plastic garbage continues to dominate coastal areas, accounting for around 79% of all documented rubbish. As a result, more research into marine debris identification is required to assess the distribution of marine debris at two research sites. The goal of this research is to identify and assess the distribution of marine debris at some research sites along the West Aceh Coast.

METHODS

Materials and Instruments

This study's instruments included plastic garbage bags, gloves, tidy ropes, meters, digital scales, digital cameras, and GPS.

Location and Time of Study

This study was conducted in September 2023 along the West Aceh Coastal area. The study sites were chosen by purposive sampling or by considering the facts and circumstances of the research region. Marine debris was collected from the tidal coastline of West Aceh (Figure 1). The research station was separated into two observation stations. Station 1 was in Pasi Lhok Aron Village, Johan Pahlawan District, Meulaboh City, West Aceh Regency which is a densely populated residential area, whereas Station 2 is in Lhok Bubon Village, Samatiga District, Meulaboh City, West Aceh Regency which was a coastal tourism destination. Each station was divided into three substations, 100 m apart. Marine debris was collected once at each observation point. The Integrated Marine Laboratory, Faculty of Fisheries and Marine Sciences, Teuku Umar University, conducted the marine debris identification process.

Sampling Procedure

At each square/repetition, marine debris was collected along the entire tidal coastline (coastal zone to embankment) (Ryan *et al.* 2009). Marine debris collection was determined by the length of the transect (100 m) made parallel to the coastline. Each observation station was divided into three observation substations, each having three transect points at distances of 0, 25, 50, 75, and 100 m, for a total of 36 sample points (Figure 2).

Procedure for Handling Debris Samples

The gathered marine debris was divided into two categories: organic and inorganic. Once separated, the marine debris was identified and photographed for documentation. Furthermore, it was divided into numerous categories, including plastic, metal, glass, rubber, wood, and clothing/other fibers, according to Lippiat *et al*. (2013). NOAA (2013) categorizes marine debris based on its length and width: Mega > 1 m, Macro > 2.5 cm−1 m, Meso > 5 mm−2.5 cm, Micro 1 µm−5 mm, and Nano <1 µm.

Data Analysis

The identification and distribution of marine debris were examined descriptively. The data for identifying marine debris (number of categories, averages, composition, and size) is presented in a table format. Meanwhile, the spatial distribution data of marine trash is displayed as a graph and examined using several fingerprints (one-way) in Microsoft Excel 2010.

RESULTS AND DISCUSSION

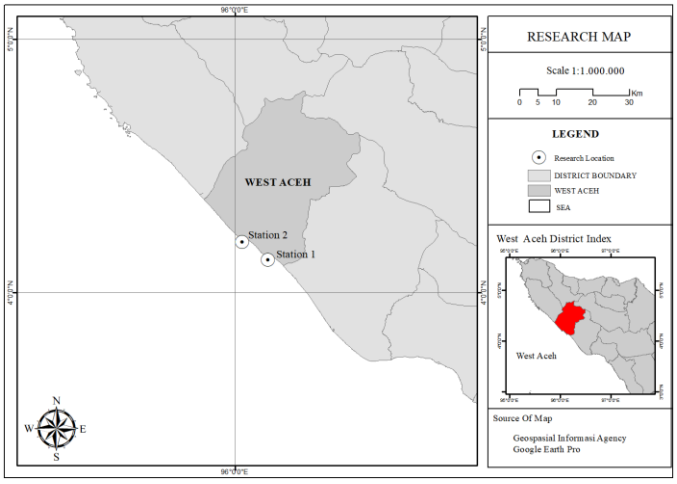

Figure 1 The research site.in the Meulaboh City West Aceh Regency

Marine Debris Identification

According to the findings of two research sites, there were two types of marine debris: organic and inorganic waste. Organic waste included wood waste fragments and their derivatives, and inorganic waste, covering plastic, metal waste, glass, rubber, and fabrics and their derivatives (Tables 1 and 2). Organic waste (wet waste) was made from biological materials (living things) such as plants, twigs, wood, leaves, or dead animal carcasses, as well as food scraps. Organic waste is a material or substance that is easily destroyed (biodegradable) by aerobic and anaerobic bacteria (Damanhuri *et al*. 2006). However, organic waste causes a very terrible stench, ruining the aesthetic value and causing sickness. Inorganic waste (dry waste) is made up of non-biological materials/substances, as well as the byproducts of mining and material processing technologies. Inorganic waste includes plastic, metal/metal waste, rubber, glass, and clothing/other fibers. This form of trash is particularly difficult to disintegrate (undegradable), and some decompose very slowly (Damanhuri *et al*. 2006). Although inorganic waste rarely emits odors, it does interfere with aesthetic value due to pollution that accumulates on the coast or sea and is difficult to degrade in nature, making it difficult to reduce the amount of inorganic waste in the environment, particularly in coastal areas.

The Amount and Composition of Marine Debris

The number of marine debris for the category of organic waste (wet) at Stations 1 and 2 was approximately 1386 and 8953, respectively (Tables 1 and 2). Meanwhile, inorganic (dry) debris was discovered at Stations 1 and 2, with approximately 520 and 269 fragments, respectively. However, the amount of inorganic (dry) waste found at both study stations is less than that found by Kusumawati *et al.* (2018) at the same area, where stations 1 and 2 had 1848 and 2300 fragments, respectively. The increased quantity of inorganic waste particles identified in Kusumawati's 2017 research is thought to

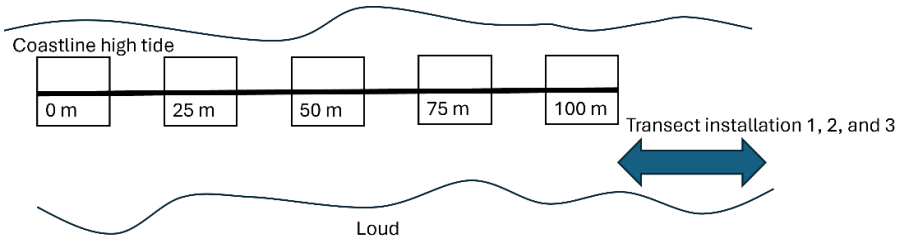

Figure 2 Sketch of the procedure for sampling marine debris in the Meulaboh City West Aceh Regency

Table 1 Type and composition of marine debris found at Station 1 in the Pasi Lhok Aron Village, Johan Pahlawan District, Meulaboh City, West Aceh Regency

Category	Station 1			Sum (Fractions)	Average	Composition (%)
	Sub St. 1	Sub St. 2	Sub St. 3			
Organic						
Wood and its derivatives	396	408	582	1386	462	73
Inorganic						
Plastics	327	113	52	492	164	26
Metal	0	5	1	6	2	0.3
Glass	1	1	0	2	0,7	0.1
Rubber	0	0	2	2	0,7	0.1
Clothing/fiber and others	0	16	2	18	6,0	0.9
Total				1906	318	100

Table 2 Type and composition of marine debris found at Station 2 in the Lhok Bubon Village, Samatiga District, Meulaboh City West Aceh Regency

Category	Station 2			Sum (Fractions)	Average	Composition (%)
	Sub St. 1	Sub St. 2	Sub St. 3			
Organic						
Wood and its derivatives	2658	1235	5060	8953	2984	97.1
Inorganic						
Plastics	82	45	78	205	68	2.2
Metal	7	0	4	11	4	0.1
Glass	0	0	1	1	0	0.0
Rubber	20	1	7	28	9	0.3
Clothing/fiber and others	14	3	7	24	8	0.3
Total				9222	1537	100

be related to the longer sampling technique, which lasted 30 days and yielded more marine debris sample data.

Organic waste had a higher composition than inorganic garbage in the two sites, accounting for approximately 73% and 97.1% (Tables 1 and 2) of total existing waste, respectively. The amount of organic waste composition is thought to be caused by residual waste disposal of solid waste from residential areas, tourist activities, and the weathering of mangrove trees and coastal trees in coastal regions. Furthermore, run-off from floods or excessive rainwater flow transports fragments of tree waste, wood, twigs, and dead plants from the environment near the shore, contributing to the accumulation of organic waste in coastal areas. Subekti (2017) stated the same thing: during the rainy season, debris enters the water body, increasing river water output. The waste is washed away and carried by water to the river mouth, then to the sea and the area around the coast. The two observation stations are necessary because Indonesia continues to use plastic-packaged products in daily life, such as cold drink bottles, snack/food containers with plastic packaging, ropes, plastic bags, and plastic tarpaulins, which include plastic bags. Furthermore, plastic waste is difficult to decompose (it takes a long time) and relatively light, so it is easily distributed by currents and waves. This is in accordance with the opinion of Prabhakar *et al.* (2016), that the lifestyle of the local community and the behavior patterns of people who live around the coast affect the composition of waste. Indonesia itself is the second largest contributor to the composition of plastic waste in the sea after China (Jambeck *et al.* 2015).

Meanwhile, the amount and composition of non-plastic inorganic waste, such as metals, glass, rubber, and other clothing/fibers, were in smaller quantities at the two consecutive research stations, namely (metals: 6 and 11; glass: 2 and 1; rubber: 2 and 28; clothing and other fibers: 18 and 24), with the respective compositions ranging (metals: 0.3% and 0.1%; glass: 0.1% and 0.0%; rubber: 0.1% and 0.3%; clothing and other fibers: 0.9% and 0.3%) (Tables 1 and 2). However, this does not imply that there is no waste contamination along the shore of West Aceh. It is well recognized that inorganic waste pollution is extremely difficult to degrade (undegradable); its presence on the shore has caused harm to mangrove, seagrass, and coral reef ecosystems. This contamination has an influence both worldwide and locally, because of human activities that spread from mangrove ecosystems, beaches, and open oceans. Contamination happens because of liquid waste pollution or solid trash, which includes plastic, metal, glass, rubber, and paper (Abu Hilal & Al Najjar 2009).

The size range of organic waste at both research stations was the same, ranging from more than 2.5 cm to 1 m (Table 3). The range of trash sizes fell below the category of macro waste. Waste collection on the surface of coastal sand is thought to be a factor contributing to the magnitude of marine debris at both stations in the macro waste category, as macro waste is located on the soil/sand surface and spread along the coastline of coastal areas. Micro trash is most usually found in sediment or beneath the sand layer. The increased microbial activity beneath the sand layer allows organic waste to be easily degraded and decomposed. According to NOAA (2015), macro waste is visible waste, is commonly seen around coastal locations.

Marine Debris Distribution

The average distribution of wood waste fragments and their derivatives at Station 2 of Lhok Bubon Village, Samatiga District, Meulaboh City, West Aceh Regency was higher, at roughly 2984 fragments (Table 2 and Figure 4), than at Station 1 of Pasi Lhok Aron Village, Johan Pahlawan, District. Meulaboh City West Regency, which had around 462 fragments (Table 1 and Figure 3). Station 2 of Lhok Bubon Village, Samatiga District, Meulaboh City, West Regency is a tourist destination with a sloping, bayed beach and several mangrove vegetation zones spread along the coast of Lhouk Bubon Village, including *Rhizophora apiculata*, *R. mucronata*, *R. stylosa*, and *Sonneratia alba* (Gazali 2019, Jufia *et al*. 2021). In addition, there are several abandoned fish and shrimp

Table 3 Marine debris size data at Station 1 in the Pasi Lhok Aron Village, Johan Pahlawan District, Meulaboh City, West Aceh Regency and Station 2 in the Lhok Bubon Village, Samatiga District, Meulaboh City, West Aceh Regency

Category	Station 1 Pasi Lhok Aron village Johan Pahlawan District West Aceh Regency Size	Category	Station 2 Lhok Bubon Village Samatiga District West Aceh Regency Size	Category
Organic				
Wood and its derivatives	> 2.5 cm–1 m	Macro	> 2.5 cm–1 m	Macro
Inorganic				
Plastics	> 2.5 cm–1 m	Macro	> 2.5 cm–1 m	Macro
Metal	> 2.5 cm–1 m	Macro	> 2.5 cm–1 m	Macro
Glass	> 2.5 cm–1 m	Macro	> 2.5 cm–1 m	Macro
Rubber	> 2.5 cm–1 m	Macro	> 2.5 cm–1 m	Macro
Clothing/fiber and others	> 2.5 cm–1 m	Macro	> 2.5 cm–1 m	Macro

ponds along the coast. Fragments of wood waste and its derivatives are dominated by pieces of leaves, twigs, and wood from various species of mangroves, as constituents of coastal vegetation zoning, and come from coastal trees. The piles of leaves, twigs, and wood are not adequately maintained, and are left dispersed on the beach rather than burned or thrown away by the neighboring population. Furthermore, the lack of landfills and vehicles to pick up leaf trash, twigs, and pieces of wood contributes to the accumulation of marine debris along the coastline of Lhok Bubon Village, Samatiga, District, Meulaboh City, West Aceh Regency. Meanwhile, Station 1 of Pasi Lhok Aron Village, Johan Pahlawan District, Meulaboh City, West Regency is located on a densely populated beach with the characteristics of an open sea sandy beach (ocean), which is barren, has minimal vegetation along the beach, with only coconut trees constituting the coastal vegetation zoning, and lacks a mangrove ecosystem. This is assumed to be why organic trash, such as leaves, twigs, and pieces of wood, is less commonly found on the beach. Jayantri *et al*. (2021) stated that organic trash on the coast, such as wood and its derivatives, is derived from natural waste, such as accumulated leaves, twigs, and wood trees. Several problems can contribute to organic waste accumulation, including visitor unawareness, a lack of appropriate garbage disposal locations, waste from villages along the coast, and poor waste management (Jayantri *et al*. 2021).

The average distribution of inorganic trash (plastic garbage) at Station 1 was 164 fragments (Table 1, Figure 3), which was more than the distribution of the amount and composition of plastic waste at Station 2 (68 fragments) (Table 2 and Figure 4). This is allegedly due to Station 1's location on the coast, which is densely populated, as well as the number of residents, as opposed to Station 2, which is far from residential housing and is only inhabited by the owners of small local cafes and restaurants. As a result of homeowners' beach garbage disposal, Station 1 has a greater distribution of plastic waste. The distribution of plastic garbage in the water is influenced by human activities and population density, particularly in high-population nations such as China and Indonesia (Jambeck *et al*. 2015). The buildup of human-made trash particles is strongly connected with population growth, particularly in the equatorial region near the poles (Barnes *et al.* 2009). Furthermore, Schuyler *et al*. (2021) discovered a link between population density and socioeconomic characteristics and garbage dispersal in the water after doing research in numerous nations including China, Kenya, North Africa, South Korea, Sri Lanka, Taiwan, and Vietnam. Furthermore, Schuyler *et al*. (2021) reported that waste rises in line with the per capita income of the middle and lower classes. However, the findings of a different study, conducted by Kusumawati *et al*. (2019), on the distribution and

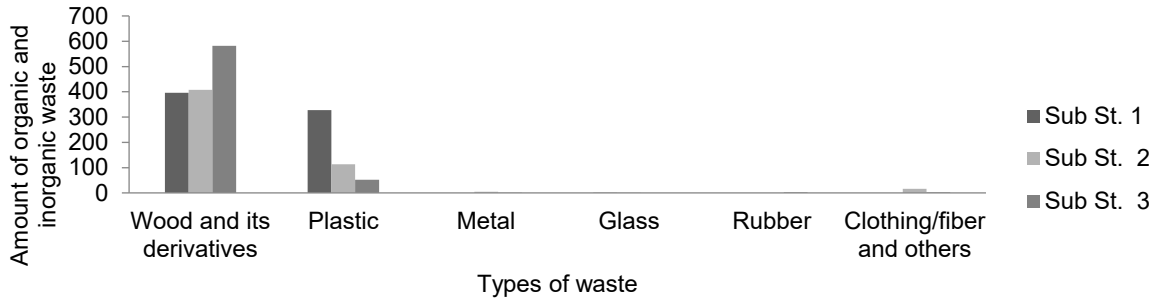

Figure 3 Distribution of marine debris at Station 1 in the Pasi Lhok Aron Village, Johan Pahlawan District, Meulaboh City, West Aceh Regency.

Figure 4 Distribution of marine debris at Station 2 in the Lhok Bubon Village, Samatiga District, Meulaboh City, West Aceh Regen

composition of coastal marine debris in the Shore District, Nagan Raya Regency, revealed that the amount and composition of plastic waste amounted to 10,692 fragments, while wood waste and its derivatives amounted to 2,448 fragments. Plastic garbage dominates the distribution of Kusumawati's research, as opposed to wood waste and its derivatives. Differences in coastal characteristics, mobilization of community activities, and population density surrounding the shore all influence the spread of plastic trash, wood waste, and their derivatives. The lack of control over trash disposal leads to the direct and indirect spread and introduction of marine debris. Furthermore, most large-scale industrial activities, factories, and community economies are in coastal locations, and almost all these communities discharge garbage into the sea (Loulad *et al.* 2019).

Other inorganic waste, such as metals, glass, rubber, and other clothing/fibers, were distributed with a very low value pattern at the two research stations (metals: 2 and 4; glass: 0.7 and 0; rubber: 0.7 and 9; clothing/fiber: 6 and 8) (Figures 1 and 2). Non-plastic inorganic waste pollution occurs in lower quantities and compositions. This scenario demonstrates that the use of plastic materials remains more prevalent among the general people, whereas the use of metal/metal materials/products, glass, rubber, and clothing/fiber is limited due to high production costs. In contrast to plastic materials, which are flexible and very inexpensive, they are used in all aspects of people's lives. Kusumawati *et al*. (2019) discovered that the distribution and composition of non-plastic waste fragments in the Coast of Nagan Raya Regency were lower than the fractions of plastic waste in which the number of plastic waste was consecutive (plastic: 3442; metal: 236; glass: 104; rubber: 262; clothing and fiber; 151).

However, a one-way fingerprint analysis revealed that there was no significant difference (p value >0.05) in the spatial distribution of marine debris in each of the research substations (Substation 1, 2, and 3) in both research sites, including those found at Station 1 (representing densely populated areas) and Station 2. This is because the distribution of marine debris at each research sub-station on the West Aceh Coast follows a nearly identical pattern, with wood waste and its derivatives being distributed first, followed by plastic waste, and finally by non-plastic waste, which remains low in each research substation.

CONCLUSION

The marine debris discovered on the West Aceh Coast is made up of organic waste (wood, twigs, leaves, and their derivatives) and inorganic garbage (plastic and its derivatives). The West Aceh Coast's organic waste is derived from fragments of dead trees, which increases the amount of organic garbage. Plastic waste generates the most waste when compared to cans, fiber, glass, and their derivatives. The spatial distribution of marine debris in both research areas followed the same pattern. Wood waste and its derivatives were found to be more widely distributed, followed by plastic waste, and finally non-plastic waste, which continued to decline at both research sites on the West Aceh Coast.

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REFERENCES

Hilal AA, Al Najjar T. 2009. Marine litter in coral reef areas along the Jordan Gulf of Aqaba, Red Sea. *Journal Environ Manage*. 90(2): 1043–1049. https://doi.org/10.1016/j.jenvman.2008.03.014

Barnes DK, Galgani F, Thompson RC, Barlaz M. 2009. Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of The Royal Society B*: Biological Sciences*. 364(1526): 1985–1998. https://doi.org/10.1098/rstb.2008.0205

Cozar A, Echevarria F, Gordillo JIG, Irigoien X, Ubeda B, Leon SH, Palma AT, Navarro S, De Lomas JG, Ruiz A, De Puelles MLF, Duarte CM. 2014. Plastic debris in the open ocean. In: *Proceedings of the National Academy of Sciences*. 111(27): 10239–10244. https://doi.org/10.1073/pnas.1314705111

Commonwealth Scientific and Industrial Research Organization (CSIRO). 2014. Marine debris: Sources, distribution and fate of plastic and other refuse and Its impact on ocean and coastal wildlife. https://www.csiro.au/en/research/natural-environment/oceans/Marine-debris

Damanhuri E, Padmi T. 2006. *Pengolahan Sampah*. Bandung (ID): Institut Teknologi Bandung.

Evans SM, Dawson M, Day J, Frid CLJ, Gill ME, Pattisina L, Porter J. 1995. Domestic waste and TBT pollution in coastal areas of Ambon Island (Eastern Indonesia). *Marine Pollution Bulletin*. 30(2): 109–115. https://doi.org/10.1016/0025-326X(94)00182-9

FAO. 2017. Microplastic in Fisheries and Aquaculture: Status of Knowledge on their Occurrence and Implications for Aquatic Organisms and Food

Safety. Rome (IT): Food and Agriculture Organization

Gazali M. 2019. Eksplorasi vegetasi mangrove di Pesisir Lhok Bubon Aceh Barat. *Jurnal Laot Ilmu Kelautan*. 1(1). 1–12. https://doi.org/10.35308/jlaot.v1i1.1070

Gall SC, Thompson RC. 2015. The Impact of debris on marine life. *Marine Pollution Bulletin*. 92(2): 170–179. https://doi.org/10.1016/j.marpolbul.2014.12.041

Jambeck R, Roland JG, Chris W, Theodore R, Miriam SP, Anthony A, Ramani N, Kara L. 2015. Plastic was inputs from land into the ocean. *Journal Science.* 347(6223): 768−771. https://doi.org/10.1126/science.1260352

Jayantri AS, Ridho MA. 2021. Strategi pengelolaan sampah. *Jurnal Kajian Ruang*. 1(1): 1–13. https://doi.org/10.30659/jkr.v1i2.20021

Jufia T, Gazali M. Marlian N. 2021. Struktur komunitas mangrove di Pesisir Lhouk Bubon, Aceh Barat. *Jurnal Laot Ilmu Kelautan*. 3(2): 1–17. https://doi.org/10.35308/jmk.v3i1.2281

Kusumawati I, Mita S, Salena YI. 2018. Identifikasi komposisi sampah laut di Pesisir Aech Barat. *Jurnal Perikanan Tropis*. 5(1): 1–12. https://doi.org/10.35308/jpt.v5i1.1026

Kusumawati I, Nasution AM, Alamsyah. 2019. Distribusi dan komposisi sampah laut pesisir di Kecamatan Kuala Pesisir Kabupaten Nagan Raya. *Jurnal Laot Ilmu Kelautan*. 1(1): 1–15. https://doi.org/10.35308/jlaot.v1i1.1073

Lippiat S, Ofter SC, Arthur. 2013. *Marine Debris and Monitoring Assesment*: *Recommendations for* Monitoring Debris Trends in the Marine Environment. National Oceanic and Atmospheric Administration Technical (NOAA) Memorandum NOS-OR&R-46 https://repository.oceanbestpractices.org/bitstream/handle/11329/1210/Lippiatt%20et%20al%202013.pdf?sequence=1&isAllowed=y

Loulad S, Haussa R, Ouamari NEL, Rhinane H. 2019. Quantity and spatial distribution of seafloor marine debris in the Moroccan Mediterranean Sea. *Marine Pollution Bulletin*. 139(139): 163–173. https://doi.org/10.1016/j.marpolbul.2018.12.036

National Oceanic and Atmospheric Administration (NOAA). 2015. Turning the tide on trash: A learning guide on marine debris. National Oceanic and Atmospheric Administration Pacific Islands Fisheries Science Center. Coral Reef Ecosystem Division (NOAA PIFSC CRED). https://marinedebris.noaa.gov/curricula/turning-tide-trash

Nor MNH, Obbard JP. 2014. Microplastics in Singapore's coastal mangrove ecosystems. *Marine Pollution Bulletin*. 79(1–2): 278–283. https://doi.org/10.1016/j.marpolbul.2013.11.025

Opfer S, Courtney A, Sherry L. 2012. NOAA Marine Debris Shoreline Survey Field Guide NOAA Marine Debris Program. Maryland (US): Silver Spring

Pawar PR, Shirgoankar SS, Rahul BP. 2016. Plastic marine debris: sources, distribution and impact on coastal and ocean biodiversity. *Publication of Biological Science*, 3(1): 40–54.

Rahmayanti F, Diana F, Najmi N, Riani E, Yulianto G, Munandar. 2020 Analisis kelimpahan, komposisi dan sumber sampah laut: Studi kasus pada pantai Kuala Batu, Desa Pulau Kayu, Kabupaten Aceh Barat Daya. *Laot Journal of Marine Science*. 2(1): 1–11. https://doi.org/10.35308/jlaot.v2i1.2361

Rochman CM, Akbar T, Susan LW, Dolores VB, Rosalyn L, Jeffrey TM, Foo–Ching T, Shinta W, Swee JT. 2015. Anthropogenic debris in seafood: plastic debris and fibers from textiles in fish and bivalves sold for human consumption. *Scientific Report.* 5(14340): 1–10. https://doi.org/10.1038/srep14340

Ryan PG, Moore CJ, Van Franeker JA. 2009 Monitoring the abundance of plastic debris in the marine environment. *Philosophical Transactions of the Royal Society Biological Sciences*. 364(1526): 1999–2012. https://doi.org/10.1098/rstb.2008.0207

Schuyler Q, Wilcox C, Lawson TJ, Ranatunga RRMKP, Hu CS. 2021. Human population density is a poor predictor of debris in the environment. *Frontiers in Environmental Science*. 9(583454): 1−9. https://doi.org/10.3389/fenvs.2021.583454

Subekti S. 2017. Pengelolaan sampah rumah tangga 3 R berbasis masyarakat. *Jurnal Teknik Lingkungan*. 2(1): 24–30.

UNEP (2009). *Marine Litter: A Global Challenge*. Nairobi (KE): United Nations Environment Programme.

Uneputty PA, Evan SM. 1997. Accumulation of beach litter on islands of the Pulau Seribu Archipelago, Indonesia. *Marine Pollution Bulletin*. 34(8): 652–655. https://doi.org/10.1016/S0025-326X(97)00006-4