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Regional Case Study

Analysis of Weight, Composition, Density, and Recycling Potential of Floating Marine Debris in Pasie Nan Tigo Area, Padang City

Rizki Aziz[1]*, Budhi Primasari[1], Cici Amelia Edriani[1]
[1]Environmental Engineering Department, Faculty of Engineering, Universitas Andalas, Kampus Limau Manis Padang 25163, Indonesia
*Corresponding Author, email: rizkiaziz@eng.unand.ac.id

Abstract
Floating marine debris is a solid materials that is produced and disposed of in the marine environment. This study aimed to analyze the weight, composition, density, and recycling of potential marine debris. The samples were taken at three locations on rainy and non-rainy days. Location was selected based on trawl activities, estuary, and public activities. The method of sampling was using trawl. The weight on rainy days was 1.2 to 2.2 g/m², while on non-rainy days was 1.6 to 2.7 g/m². Total weight 689.2 kg non rainy conditions and on rainy conditions 895.4 kg. There were four types of waste obtained, which were plastic, wood, fiber, and rubber. The highest percentage in the composition was plastic, which was 48 to 61%. The density of waste on non-rainy days was 0.1 -1.3 g/m² and on rainy days conditions range 0.2 - 1.7 g/m². The highest density of waste was plastic of 1.6 g/m². The recycling potential of plastic, wood, and fabric was 100% respectively. The recycling potential of plastic, wood, and fabric was 100% respectively. The recommendation for floating marine debris is 3R + 1P (recycling, reuse, recovery, and participant).

Keywords: Composition; density; floating marine debris; pasie nan tigo area; recycling potential weight

1. Introduction

Marine litter or debris is defined as any manufactured material that has made it into the marine environment, including material found on beaches or material that is floating or has sunk at sea (UNEP/IOC, 2009). The International Coastal Cleanup (ICC) program released that in 2019 as many as 32,485,488 pieces of garbage with a total weight of 9,422,199 kg were found in the sea (Ocean Conservancy, 2020). Floating marine debris is generally transported by currents and winds before finally being thrown ashore or sinking to the seabed. Sources of marine debris generally come from beach tourism, household waste disposal, fishing activities, transportation, and industrial waste. Sources of marine debris can also come from toxic wastes and organic compounds that enter the sea through leaks in landfills, garbage dumps, agriculture, rain that carries human waste, and remnants of human activities from land to sea through rivers, floods, and overflow of sewage pipes. (Hetherington et al., 2005). Sources of marine debris can come from people who live and carry out activities in coastal areas, waste sent from the upper mainland that flows from rivers, or ditches that flow to the coast (Renwarin et al., 2015). This marine debris comes from garbage that is on land carried by rivers and garbage that is directly dumped into the sea (Johan et al., 2020).

According to the current Coordinating Ministry for Maritime Affairs and Investment, 80% of Indonesia's marine debris comes from land and 20% come from fish ponds, nets, and waste that is dumped or lost from ships and boats (Patuwo, 2020). Marine debris consists mainly of plastic consisting of baby diapers, plastic bottles, bottle caps, fishing gear, drink cans, tires, and disposable syringes (McGranahan et al., 2007). Plastic is the dominant waste, so macro and microplastic waste accumulation has consistently increased on beaches and sediments over the last four decades (Thompson et al., 2004). World plastic production reached 348 million tons in 2017, an increase of 10 million tons from the previous year (PlasticsEurope, 2018). However, the increase in plastic production is not accompanied by good plastic waste management, so that plastic debris resulting from human activities on land is located and pollutes the waters (Agustina et al., 2020). Marine debris disturbs the environment, health, and economic activities around the coast. Marine debris impacts marine life, damage to marine ecosystems, health problems, communities around the coast, and economic impacts on industries that depend on the coastal and marine environment (McGranahan et al., 2007).

Indonesia has a coastline of 99,093 km and 17,504 islands (Direktorat Jenderal Pengelolaan Ruang Laut, 2021). Coastal areas have many benefits for humans, but coastal areas that are not used and maintained properly can be a problem for the community. One of the coastal areas in Indonesia is the city of Padang. Padang City is located in West Sumatra Province, geographically located on the west coast of Sumatra Island which is located at 00°44'00" – 01°08" 35" South Latitude and 100° 05' 05" - 100° 34' 09" East Longitude with area is 694.96 km2. The city of Padang has an administrative area of 1,414.96 km2 with a land area of 694.96 km2, a sea area of 720.00 km2 and a beach length of 68.126 km outside the surrounding small islands.

Research related to floating marine debris has been carried out in Indonesia. Research on floating marine debris is still limited in publication (Rafsanjani et al., 2021; Asmal et al., 2021; Noya et al., 2020). Research related to floating marine debris has been carried out in Makassar and Ambon. The method used with the net sampling criteria is the waste produced by fishermen, the presence of river mouths, and community activities. Based on this previous research, the waste generated originates from land. Lousy waste management on land causes the waste to be allocated to the sea. The dominant waste found is plastic waste. Plastic waste, if it stays in the sea for too long, will decompose and can become micro plastics. Domestic waste dumped in the sea intentionally or unintentionally is not suitable for disposal into the sea or can harm the marine environment (Convention on Biological Diversity, Scientific and Technical Advisory Panel, 2012).

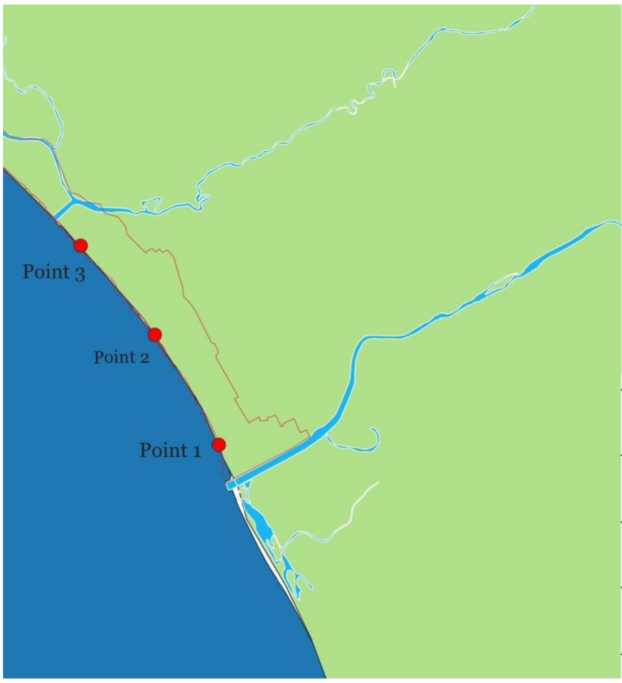
The development of coastal area in Padang City is growing rapidly, it can be seen from the number of settlements, tourism, and economic activities. One of the coastal areas in the city of Padang is Pasie Nan Tigo Village. If this floating marine debris continues, it will become a problem for the community around the Pasie Nan Tigo Village area, namely damaging the aesthetics and causing microplastic pollution in the sea which can be dangerous for marine biota. For this reason, it is necessary to conduct research on the analysis of floating marine debris in the Pasie Nan Tigo area to find out the presence of floating marine debris which refers to the Marine Waste Monitoring Guidebook (Tim Koordinasi Nasional Penanganan Sampah Laut, 2020). This research is expected to provide initial information on floating marine waste management for the government of Padang City. This research is also one of the efforts to support the government's program, namely reducing 70% of plastic waste in the sea by 2025 (Peraturan Presiden Republik Indonesia Nomor 83 Tahun 2018).

2. Methods

This research was conducted from May to June 2022 with the research location in Pasie Nan Tigo, Padang City. The research location is divided into three points which can be seen in **Figure 1**. The basis for selecting the sampling location is that there are river mouths, community activities, and trawling activities. Samples were collected in the morning for each sampling condition. Sampling was carried out under two conditions, namely the first condition was when the sea water receded and the day before sampling it was not raining, and the second condition was when the sea water was normal and the day before sampling was a rainy day. Normal seawater conditions are conditions where the current is between low and high tide conditions.

Sampling methods using a trawl is a type of fishing equipment actively operated by dragging. The trawl equipment is prepared, and at least ten people must pull the trawler. This withdrawal typically involves multiple individuals from both sides. The fisherman pushes the trawler from shore using a machine after it is inserted into the small boat. Two people will be placed at the top of the dipper to spread the trawl nets into the middle of the sea, and then they will be pulled together. From the shoreline, the rope will be pulled in two directions to form a semicircle. The waste sample to be analyzed can be obtained after the trawl is brought up to the beach. The trawl can capture meso- and macro-debris, each with a sub-net size of 5-10 cm.

The collected waste samples were cleaned with clean water and then dried in the sun to dry. The waste is weighed to determine its weight of the waste Then for the composition, density, and potential for recycling waste, the waste is grouped by type, weighed, and the results are recorded.



Research Location	Coordinate
Point 1	0.8606° S
	100.33098° E
Point 2	0.85398° S
	100.3275° E
Point 3	0.84231° S
	100.31675° E

Figure 1. Sampling points.

2.1. Research Preparation

Research preparation includes tools and materials needed during the research. The tools and materials used in this study can be seen in **Table 1.**

Table 1. Research tools and materials.

Tools and materials	Function
Trawl net	As a sampling medium
Stationary	To write the garbage data obtained
Scales	To measure the mass of waste
Bucket	As a sample washing container
Tarpaulin	As a place for drying
Trash bag	As a garbage collector
Clean water	To clean the garbage sample
Junk Sample	As the main object or object of research

2.2. Measurement and Sampling

Measurement of data on weight, density, composition, and recycling potential of floating litter in the Padang coastal area was then analyzed. Analysis of floating litter density data was carried out based on the quantity of floating litter in the Padang coastal area by considering the waste source. The composition of floating litter includes plastic waste, metal, rubber, glass, wood, clothing, and others The recycling potential of floating litter was determined to see the percentage of floating litter utilization and recommend the appropriate management of floating litter. The analysis was carried out by calculating the percentage of recycling potential.

2.3. Data Analysis

Weight analysis data processing, composition analysis, density analysis, and recycling potential analysis are needed to support this research.

1. Waste weight analysis.
   The weight of marine debris is carried out by measuring the weight of marine debris. Garbage data is calculated based on the length of the drag of the trawl.
   $$\text{Weight } (g/m^2) = \frac{\text{Total weight of floating waste (g)}}{\text{trawl length (m) x net width (m)}} \quad (1)$$
2. Composition analysis
   The percentage of marine debris is calculated, namely the weight of waste per type in the *sampling* unit.
   $$\text{Composition}(\%) = \frac{\text{Weight of floating waste per type}}{\text{Total weight of floating waste}} \text{x100\%} \quad (2)$$
3. Density analysis
   The percentage of marine debris density is calculated, namely the weight of waste per type in the *sampling* unit.
   $$\text{Density } (g/m^2) = \frac{\text{weight of floating waste per type (g)}}{\text{trawl lenght (m)x net width (m)}} \quad (3)$$
4. Analysis of waste recycling potential
   $$\text{Recycling } (\%) = \frac{\text{Recycleable of floating waste}}{\text{Total weight of floating waste}} \text{ x 100\%} \quad (4)$$

3. Result and Discussion

The results and discussion contain the results of research findings and the scientific discussion. Write scientific findings obtained from the results of research that has been done but must be supported by adequate data. The scientific findings referred to here are not the research data obtained. These scientific findings must be explained scientifically including:

3.1 Weight of Marine Debris

The analysis of the weight of marine debris was carried out at three points with two conditions, namely rainy and non-rainy conditions. The graph of the results weight of floating marine debris can be seen in **Figure 2.**

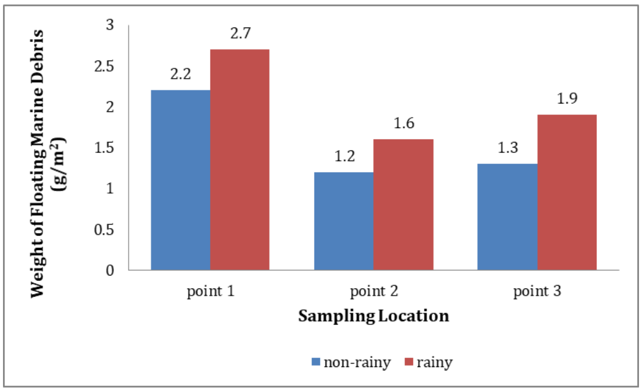


Figure 2. Weight of floating marine debris

The weight of the waste at point 1 is 2.2 – 2.7 g/m². Point 1 has the largest waste weight of the two conditions, this happens because point 1 is near Muara Panjalinan. The number of community activities around the river is also the reason the weight of waste at point 1 is more than at other points. Point 2 is the location in the middle. Point 2 is that there is no river estuary near point 2. According to Djaguna et al. (2019), floating marine debris can be transported by ocean currents and wind from one place to another, and can even travel great distances from its source. The waste obtained at point 2 is the smallest weight, 1.2 – 1.6 g/m². The weight of the waste at point 3 is 1.3 -1.9 g/m². Point 3 is a location close to Muara Pasia Jambak. Marine debris obtained at point 3 comes from the mouth of the river. Point 3 is not the biggest contributor to the weight of waste due to the branching between Muara Pasia Jambak and Muara Anai which makes waste distributed between the two estuaries. The existence of community activities around the mouth of the river is one of the reasons for the presence of marine debris.

In rainy conditions, the weight of the waste is greater than it is not raining. According to Enggara et al. (2019), rain causes garbage that is in the drainage to overflow quickly, be carried away by the flow of water, then enter the river body and empty directly into the sea. The location close to the river mouth is the highest point of solid waste. Based on the research of Johan et al. (2019) the sea near the river mouth will have more waste because the waste on land will end up in the sea through the river mouth. The results of research by Rafsanjani et al. (2021) on Barrang Lompo Island found that the weight of waste was 0.2 – 0.5 g/m ². The results of research by Asmal et al. (2021), on Barang Caddi Island, the weight of the waste obtained was in the range of 0.1 – 0.3 g/m². The difference is quite significant because Rafsanjani et al. (2021) and Asmal et al. (2021) conducted sampling on the high seas where there were no river estuaries and previous research was conducted on an island with a less dense population.

The calculation results show that the weight of floating marine debris in no rain conditions is 4.7 g/m2 and in rainy conditions it is 6.1 g/m². The average weight of marine debris floating under conditions of non rainy is 1.6 g/m² and in rainy conditions is 2.1 g/m². The area of the study area is 440,000 m² with a total length of 2,400 m and an average trawl length of 183 m, so the total weight of floating marine debris in Pasie Nan Tigo Village, Padang City, is known, namely 689.2 kg in no rain conditions and 689.2 kg in non rainy conditions. rain 895.4 kg.

3.2. Composition of Marine Debris

Based on the results of the research, there are 4 types of marine debris in the Pasie Nan Tigo Village area, namely plastic, wood, rubber, and cloth. The results of the composition of marine debris can be seen in **Figure 3** and **Figure 4.**

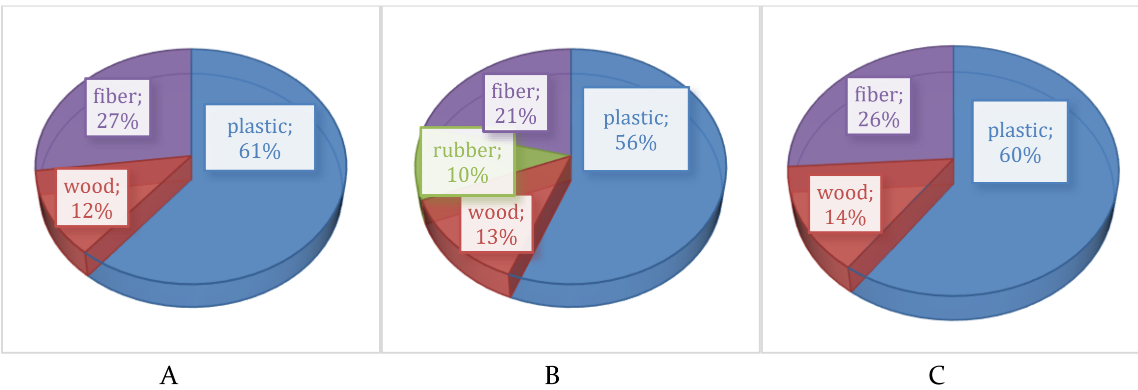


Figure 3. Composition of marine debris (A) point 1 (B) point 2 and (C) point 3 for non rainy condition

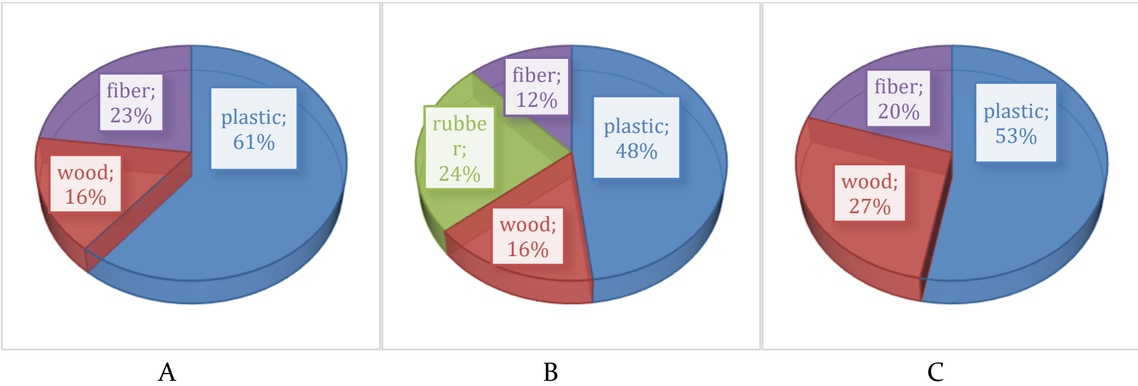


Figure 4. Composition of marine debris (A) point 1 (B) point 2 and (C) point 3 for rainy condition

According to NOAA, there are six compositions of marine debris, namely plastic, wood, glass, rubber, cans/metal, and other uses. In this study, there were 4 categories, namely plastic 48 - 61%, wood 12 - 27%, cloth 12 - 27%, and rubber 10 - 24%. The dominant waste obtained in this study is plastic waste. The wood waste obtained is waste that comes from trees, namely twigs and tree branches. The cloth waste obtained is pieces of cloth that are thought to have come from community activities. Rubber waste is the smallest waste obtained, rubber waste obtained is rubber sandals and pieces of motorcycle tires. The results of the study by Bangun et al. (2019), found that there are 6 categories of waste composition that were plastic, rubber, wood, glass, clothing, and metal. The difference in composition obtained is due to differences in the sea area where this research was carried out in the floating sea and Bangun et al., carried out on the beach. Rafsanjani et al.'s research (2021) at Baranglompo, the composition obtained was plastic, cardboard, plastic foam, wood, and other materials. In line with the composition obtained in this study, namely plastic, wood, and cloth, the composition is similar because it was carried out in the floating sea.

The dominant waste obtained is plastic waste. According to NOAA (2016) which states that the results of research on marine waste found in all world waters, the type of plastic waste is the most common type and is often found in waters. Much plastic waste at these 3 points is due to community activities around the river estuary and the coast. According to the research of Cauwenberghe et al. (2013), approximately 10% of plastic materials used by humans will end up in the sea which is flowed through rivers and continues to the estuary. Research by Noya and Tuahatu (2021), the plastic waste found in the waters of the Outer Ambon Bay is 93.44%. The results of Bangun et al. (2019) show that plastic waste is the most dominant waste, about 58.2%. Moreover, according to research of Jangga et al. (2021) at Malaka Beach of Nusa Tenggara Timur Province and Rahmayanti et al. (2020) at Kuala Batu Beach of Aceh Province in Indonesia, plastic was the highest portion of marine debris that reached 76% and 79%, respectively. In line with this research result, the plastic waste obtained comes from land trash that empties into the sea. The floating nature of plastic waste makes it the most common type of waste found in water (Noya & Tuahatu 2021). Cans and glass waste were not found in this study. According to Ryan et al. (2009), the lighter the waste material, the easier it is for the waste to move in the seawater column. Usually, materials made of glass and metal will sink to the bottom of the water.

3.3. Density of Marine Debris

The density of marine waste obtained 4 types of waste, namely plastic, wood, cloth, and rubber. The density of marine debris is carried out in two conditions, namely rain and no rain. The graph for calculating the density of marine debris in non-rainy conditions can be seen in **Figure 5** and the graph for calculating the density of marine debris in rainy conditions can be seen in **Figure 6.**

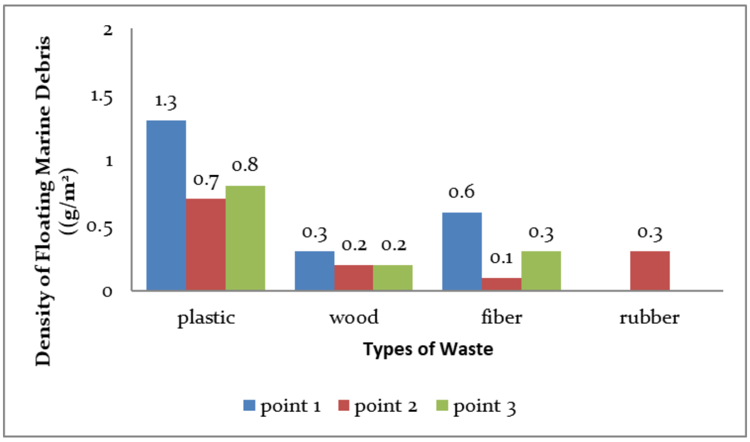


Figure 5. Density of marine debris on non-rainy conditions

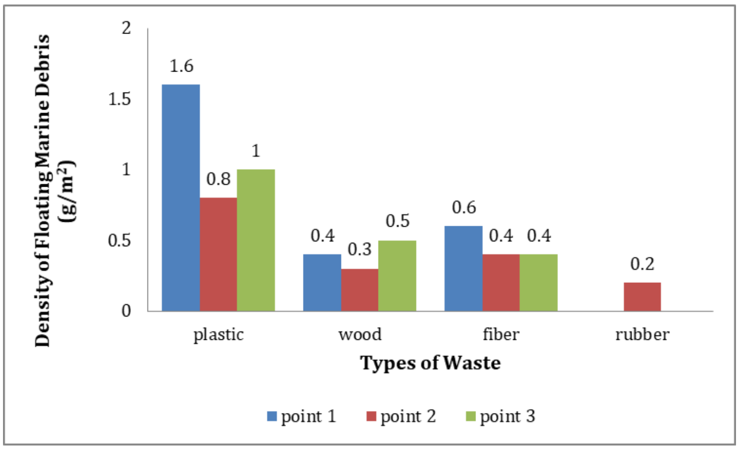


Figure 6. Density of marine debris on rainy conditions

In this study, the highest solid waste density was in non-rainy conditions, namely plastic in the range of 0.7 – 1.3 g/m². According to Subekti (2010), when it rains, there will be more waste because the waste drifts towards the estuary and ends up in the sea, this is following research conducted in the Pasie Nan Tigo area, Padang City. In this study, the density of plastic obtained was in the range of 0.8 – 1.6 g/m². The floating nature of plastic waste makes it the most common type of waste found in waters. (Noya & Tuahatu 2021). According to Ribic et al. (2012) Every year 6.4 million tons of waste are dumped into the sea at Midway Atoll, of which 91% is plastic waste or 4.94 kg/m². The research of Ningsih et al. (2020) reinforces this condition, the density of waste with the highest value is plastic, namely 5.52 g/m². Research by Johan et al. (2020), plastic waste is the dominant waste obtained, namely 14.88 gr/m². The difference in marine debris density results obtained is because Ningsih et al. (2020) and Johan et al. (2020) carried out sampling on the beach. This condition makes the amount of trash density very significant.

The density of wood waste obtained in this study was 0.2 – 0.4 g/m². The results of the research by Johan et al. (2020), the wood density obtained was 4 – 12 g/m². This significant difference occurs due to differences in monitoring between floating marine debris and coastal marine debris. Fabric waste has a density of 0.1 – 0.7 g/m². The fabric waste is proof that marine debris originates from the mainland. The fabric density is the second highest density after plastic. The smallest waste density is rubber waste 0.2 – 0.3 g/m².

3.4. Recycling Potential of Floating Marine Debris

The waste recycling potential will be obtained through the percentage of waste composition based on the waste components from the research, then used to determine the waste recycling potential of each waste component. Recycling potential is done by comparing the weight of each component of waste that can be recycled with the total weight of each component. Based on the analysis data that has been obtained, the types of waste that can be recycled from floating marine debris in the Pasie Nan Tigo Village area, Padang City, are plastic, clothing, wood, and rubber waste. The following types of waste that can be recycled are plastic waste in **Table 2.**

Table 2 types of waste that can be recycle

Types of Waste	Recycling Potential
PETE (polyethylene terephthalate)	7%
LDPE (low Density polyethylene)	82%
PP (polypropylene)	11%
Total	100%
Wood	100%
Fiber	100%

Many types of LDPE are produced because most people who sell and shop generally use plastic bags. Plastic waste that has the potential to be recycled is packaging bottles and plastic sacks. Plastic waste can be recycled into handicrafts, plastic pellets, and petroleum. The wood obtained can be used as firewood after drying in the sun to dry. Fiber waste recycling can be processed into works of art. Unused fabrics can be recycled by reusing them into pillow or doll fillings to reduce fiber waste. In the study there a waste that could not be recycled. Rubber waste that cannot be recycled is 100% worth it. The rubber waste obtained is very difficult to recycle. Rubber waste is difficult to recycle because the amount of waste obtained is not much.

3.5. Recommendations for Floating Marine Debris Management

Based on the results of research that has been done, the source of floating marine debris comes from land that empties into rivers. Marine waste management is a movement to increase public awareness of not throwing garbage into rivers. Organizing a national socialization movement regarding the negative impacts of marine debris, especially plastic, on health and ecosystems. This activity is to increase the understanding of the people in coastal cities and watersheds regarding the impact of marine debris. Organizing outreach to reduce plastic waste and being able to reuse it. The government can work with fishermen to trawl along Pasie Nan Tigo area to regularly collect floating marine debris. Environmental affair agency can also guarantee the availability of communal garbage containers at points prone to waste disposal into waters and guarantee waste collection. Application of waste management at the source and community-based waste management so that people are aware of the economic value and benefits of waste so that people do not throw garbage into the waters.

The following was a recapitulation of the analysis of strategies used in floating litter management based on the 3R + 1P strategy. Solid waste management with the 3R concept aims to reduce waste from the source, reduce environmental pollution, benefit the community, and change people's behavior towards waste. The 3R concept is straightforward to implement. The success of the 3R concept is determined by participation by changing their behavior influenced by socio-cultural characters and socio-economic characters that color community life (Puspitawati & Rahdriawan, 2012). Using the 3R+1P concept can inspire residents to create an independent level of waste management that will help the government create a healthy, clean, and comfortable environment (Ristya,2020).

1. Recycling
   Recycle waste into more useful items. The dominant floating marine debris found in this study isplastic. The plastic found is a plastic bag that cannot be recycled. The recommendation for the management of floating marine debris that is possible is to convert plastic waste into fuel oil. Plastic bags are included in the LDPE plastic type. The method that is widely used to convert plastic bags into fuel is pyrolysis. In the study of Sarker et al. (2012), LDPE plastic waste was processed into kerosene by the Pyrolysis method with temperatures between 150°C and 420°C. The results obtained were

around 30% kerosene. In the research conducted by Fatimura et al. (2019) carried out two pyrolysis processes. Plastic bag waste in the first process for 140 minutes reached a temperature of 256.4°C, obtained 13 ml of oil, and the second process for 60 minutes achieved a temperature of 369°C, obtained 180 ml of oil. The oil yields obtained are close to kerosene and gasoline.

2. Reuse
   Reusing items into something more useful. The wood waste obtained in this study can be reused. Using wood waste obtained to become firewood and other fishing activities.
3. Recovery
   Recovery of floating marine waste is beneficial for the community because it can be used as firewood for their daily needs. Types of waste that can be used as recovery are wood or twigs. The use of this type of wood floating marine waste needs to be maintained so that it can be utilized properly and does not have an impact on the environment.
4. Participant
   Community participation is of course very much needed in marine waste management. Sustainability in managing marine waste will be difficult without community participation. The way to attract community participation is by carrying out counseling and holding dialogues so that there is feedback and a common perception of the good management of floating marine waste. Community participation is also influenced by the government's role in facilitating marine waste management.

4. Conclusions

The weight of marine debris in Pasie Nan Tigo Area on non-rainy days at point one 2.2 gr/ m^2 and 2.7 gr/ m^2 on rainy days. While at point two, the weight was 1.2 gr/ m^2 in non- rainy days and 1.6 gr/ m^2 in rainy days. At point three, on non-rainy days 1.3 gr/ m^2 and 1.9 gr/ m^2 on rainy days. Total weight of floating marine debris was 895.4 kg on rainy days and 689.2 kg on non-rainy days. The composition of floating marine debris was plastic, fabric, wood and rubber. Plastic was the most composition it was 48 -61%, wood 12 -27%, fibber 12 -27 % and rubber 10 - 24 %. The density of floating marine debris was dominated by plastic, in the range of 0.7 – 1.6 gr/ m^2, followed by wood 0.2 – 0.4 gr/ m^2, fiber 0.2 – 0.7 gr/ m^2 , and rubber 0.2 – 0.3 gr/ m^2. The recycling potential of plastic, wood, and fabric was 100%, 100%, and 100% respectively. The recommendation for floating litter is the 3R + 1P (recycling, reuse, recovery, and participant).

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