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Research article

Identification Types of the Marine Debris and Factors Related them in Semarang City

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Abstract

Beach waste pollution can have an impact on human health in these areas. Beach waste data is needed to determine the solution for preventing beach/marine pollution. This study aims to estimate beach waste density, identify types of beach waste and factors of beach waste distribution in Semarang. The method used was descriptive observational with a cross-sectional research design. The sample was determined by purposive sampling and available 7 points of beach spread over four districts at Semarang. Beach waste samples took at each beach along 100m the width adjusts to the beach's width. The highest beach waste was found on Baruna Beach (North Semarang), with a total of 3,243 waste (227.4 kg). Moreover, the lowest beach waste was found on Mangkang Kulon (Tugu), with a total of 711 pieces of waste (63kg). From the 7 sample points of the beach, the average density of waste is 5.3 kg/m^2. Most waste types are plastics and woods. The different levels of waste on the beach area due to wind patterns and tidal conditions. This study's conclusion is the dominant factors of the beach waste levels are the pattern of wind, seawater currents, and density of river flow waste, while population density and urban economic growth affect the level of the city solid waste.

Keywords: waste, beach, marine pollution, waste density, Semarang

1. Introduction

Waste is a severe problem in almost every country in all parts of the world. Waste is a remnant of everyday human activities and a solid residue of natural processes (Citrasari *et al.*, 2012). The amount of waste always increases from year to year and the increasing population (Azkha, 2006). This increase will impact the balance of ecosystems and living things (Azkha, 2006; Citrasari *et al.*, 2012). The largest type of waste is plastic waste, followed by construction waste (Geyer *et al.*, 2017). Plastic waste is usually disposed of by landfill or scattered in the surrounding environment and ends up in the sea (Lebreton *et al.*, 2018).

Marine debris or marine litter, is a persistent solid that is disposed of directly or indirectly and ends up in the sea or coast (Hardesty, 2007). Marine debris includes all solid objects of natural origin, residual products from production activities, and processed products in the form of solids (Stevenson, 2011). Examples of marine debris include plastics, wood, glass, paper, leaves, metal, tires, bones, rubber, clothing/textiles, nets, and other solid waste (Hermawan, 2017). The rubbish will float on the sea surface (floating litter), sink to the bottom of the sea (benthic litter), or be stranded on the coast (beach litter) (Hardesty, 2007). Ocean pollution is caused by 60-80% of plastic waste from all marine debris (Moore, 2008).

Indonesia is a country that is ranked second after China which has problems in land waste management (Jambeck *et al*., 2015). Based on the Ministry of Environment and Forestry's marine debris monitoring report in 2017, around 80% of the total weight of marine debris floating in Indonesian waters comes from land waste that does not receive solid waste management services and waste carried by rivers canals. About 20% of the rest is waste originating from the sea, namely trash from ships, damaged fishing nets, and waste due to the tsunami disaster. The impact of waste pollution, especially plastic waste, for the marine ecosystem itself is that it can kill 100,000 marine mammals and 2 million seabirds every year. In 2017, it was estimated that the generation of marine debris along the coast of Indonesia was 1.2 million tons, and 41% was plastic waste. Data from the Ministry of Environment and Forestry explains that Indonesia's average percentage of waste collection only reaches 45-50% of the total waste (Kementerian Koordinator Bidang Kemaritiman, 2018).

Semarang BPS data explains the results of the calculation of population projections in 2018, the total population of Semarang City is recorded at 1,786,114 people with an average annual population growth rate from 2015-2018 of 1.64% (Badan Pusat Statistik, 2019). Semarang is a city with high GDP and economic growth, so it is estimated that it produces higher inorganic waste such as plastic and paper than organic waste. Semarang is in third place after Balikpapan and Makassar, with the highest percentage of plastic waste in Indonesia's city water flows (Kementerian Koordinator Bidang Kemaritiman, 2018).

The fact of the problem and its impact, research is needed that provides data on the amount of plastic waste generation along the coast of Semarang City and explains the size of plastic waste. The results of this study will present data on beach points that have a large enough waste generation and the factors of the size of the beach waste generation in the city of Semarang.

2. Methodology

This type of research is descriptive observational with a cross-sectional research design, which means that measurement or observation of the research variables is carried out only once during the study. This study's population includes the coastline from the west to the east of the city of Semarang. A sampling of the number of beaches in this study was carried out by using the purposive sampling method. The criteria for beach samples are sandy and/or gravel, have a minimum length of 100m, are easily accessible, have no waste management, do not have breakwaters, docks, and jetties, and are not sensitive habitats (Kementerian Lingkungan Hidup dan Kehutanan, 2017). The research locations include Tugu, West Semarang, North Semarang, and Genuk Districts. Data were collected from July to August 2020. Figure 1 is a map of the research location.

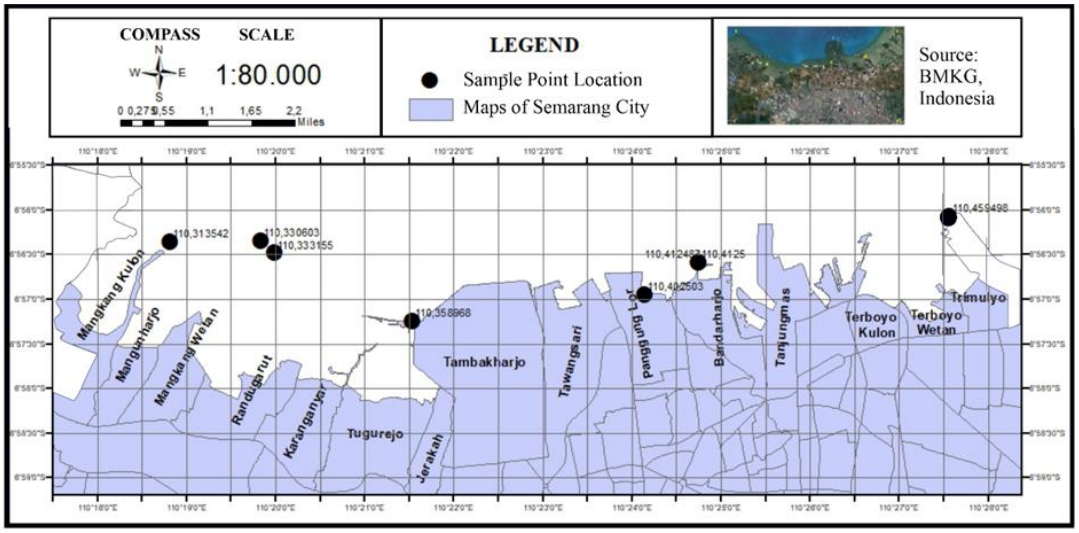

Figure 1. Distribution of the beach sample point

Sources of data used by researchers are primary data and secondary data. Secondary data comes from data from BPS Semarang City, DLH Semarang City, UPTD TPA Jatibarang, and online data from BMKG. Primary data includes the coordinates of each beach location and the amount of waste generation on each coast. Researchers collected primary data by conducting a survey of coastal waste at seven beaches of Semarang City, as in Figure 1. The survey of coastal waste was only conducted once at each sample location in the morning or evening. Collection and calculation of beach waste samples are carried out at each beach point by making a 100-meter long transect box with the transect width adjusting the beach width. The research instruments included transect ropes, GPS, compass, wheel gauge, hanging scale, clinometer app, observation sheet, and camera. Data management uses the ArcMaps application, and data are presented in tables and map images. Furthermore, the data were analyzed by researchers with spatial and descriptive analysis.

3. Result and Discussion

There are 14 sub-districts in Semarang City that have natural boundaries with the Java Sea. There are seven beach points (50%) were found that met the inclusion criteria and were used as samples of research locations, namely Mangkang Kulon Beach, Mangunharjo Beach, Mangkang Wetan Beach, Tirang Beach (Tugurejo), Baruna Beach (Panggung Lor), Cipta Beach (Bandarharjo), and Trimulyo Beach. The remaining seven urban villages did not meet the study's inclusion criteria because they no longer had beaches due to abrasion and demanding access to the beach. Two of the seven beaches sampled are tourist beaches, namely Mangkang Kulon beach and Tirang beach. The remaining five beaches are non-tourist beaches and are only used by the local community for fishing. Coastal waste generation in Semarang City is as shown in Table 1.

Table 1. Marine Debris Data in Semarang City Based on Weight (kg)

Beach Point	Types and Weight of Marine Debris (kg)									Total weight of every point
	Fabric	Plastic Foam	Ceramic and glass	Metal	Paper and carton	Plastic	Rubber	Wood	Others	
Tugu Sub-District										
Mangkang Kulon	**13.9**	**3.4**	**7.0**	**0.2**	**2.3**	**4.6**	**2.1**	**27.3**	**2.2**	**63.0**
Mangunharjo	12.8	4.4	9.1	1.1	0.0	11.4	17.9	114.6	2.2	**173.4**
Mangkang Wetan	11.2	3.8	7.4	0.8	0.5	12.3	18.1	77.9	4.9	**136.9**
Tugurejo	21.7	7.6	11.2	1.0	4.0	14.2	15.8	75.8	4.3	**155.5**
North Semarang Sub-district										
Panggung Lor	**20.0**	**7.8**	**39.6**	**3.1**	**9.4**	**38.5**	**21.3**	**79.0**	**8.8**	**227.4**
Bandarharjo	9.2	3.5	10.8	3.3	0.7	14.9	8.2	38.4	3.5	**92.4**
Genuk Sub-district										
Trimulyo	2.8	3.9	10.3	0.1	0.0	10.2	3.4	39.8	0.9	**71.4**
Jumlah Per-Jenis	**91.5**	**34.3**	**95.3**	**9.6**	**16.9**	**106.1**	**86.8**	**452.8**	**26.8**	**920.2**
Rata-Rata	**13.1**	**4.9**	**13.6**	**1.4**	**2.4**	**15.2**	**12.4**	**64.7**	**3.8**	**131.5**
Persentase	**10%**	**4%**	**10%**	**1%**	**2%**	**12%**	**9%**	**49%**	**3%**	**100%**
Kepadatan (Kg/m^3)	**5.23**	**1.96**	**5.45**	**0.55**	**0.97**	**6.06**	**4.96**	**25.87**	**1.53**	**52.58**

Table 1 explains that the weight of waste generation found from coastal waste survey activities in July 2020 at seven beaches was 920.2 kg. On average, on each beach, there is a beach waste generation of 131.5 kg. Moreover, the average density of waste (kg / m^2) on each coast is 5.3 kg / m^2. The beach with the

highest findings of waste generation is Baruna Beach, Panggung Lor Village, Kec. North Semarang is amounting to 227.4 kg. Meanwhile, the beach with the lowest waste found is Mangkang Kulon Beach, Kec. The monument is 63 kg. The significant difference in weight of the waste's findings was that during the survey at Baruna Beach, North Semarang, the beach's condition was receding, so there was much rubbish on the beach. Meanwhile, during the survey in Mangkang Kulon, Tugu, the condition of the beach was high tide, so that only a small amount of trash could be found because the beach was covered by high tide. It is estimated that the number of waste survey findings in Mangkang Kulon will exceed 63 kg if the survey was conducted during low tide. Apart from the weight of the waste, the researchers also tried to classify beach waste items with a high percentage. Figure 2 and Figure 3 are the percentages of coastal waste types based on the amount and weight.

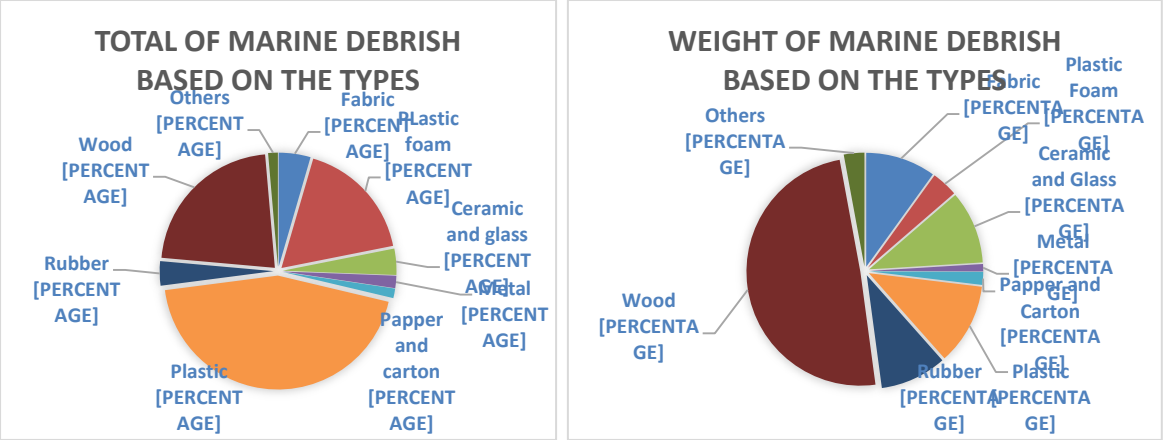

Figure 2. Percentation of marine debrish total and weight base on waste types

The types of beach waste collected are divided into 8 types: plastic, wood, cloth, plastic foam, metal, rubber, paper and cardboard, glass and ceramics, and other types of materials. The classification of this type of waste refers to the marine debris survey guidebook issued by the Ministry of Environment and Forestry. Figure 2 explains that plastic waste is the most common waste found on the beach, which is 44% of the 10,352 items. Meanwhile, if it is calculated based on weight, wood waste is beach waste with the highest weight percentage, which is 49% of the 920.2 kg of waste found.

The most common trash found during the survey on the coast of Semarang is plastic bags, plastic bags leftover from food and beverage packaging, plastic bottles, straws, cigarette butts, wooden twigs, bamboo, tires, sandals, shoes, clothes, diapers, and corks. The increasing use of plastic by the community, the community's lack of concern for the impact of plastic on the environment, and the large number of daily necessities produced in small packages (sachets), also affect the increase in plastic use (Rahardyan *et al*., 2015).

3.1. Factors of the Distribution of Waste on the Beaches of the City of Semarang

3.1.1 Wind Direction, Wind Speed, and Sea Water Surface Flow Direction

Wind direction data and maximum wind speed data are obtained through online secondary data from the Meteorology, Climatology, and Geophysics Agency (BMKG) website. It consists of data from three stations, namely the Ahmad Yani Meteorological Station, the Semarang Climatology Station, and the Tanjung Mas Maritime Meteorology Station, which are then processed using the ArcMap application. Table data of average wind direction and average maximum wind speed in Semarang City in July 2020 is shown in Table 2. Figure 3 is a map of wind direction and maximum wind speed in the city of Semarang in July 2020 due to data processing with Arcmap.

Table 2. Average Data of Wind Patterns and Wind Speed in Semarang City on July 2020

Station	Wind Pattern (°)	Max Speed (m/s)
Meteorologi Ahmad Yani	148,1	5,6
Klimatologi Semarang	157,2	5,0
Meteorologi Maritim Tajung Mas	96,7	4,3
Rata-rata	**134,0**	**4,97**

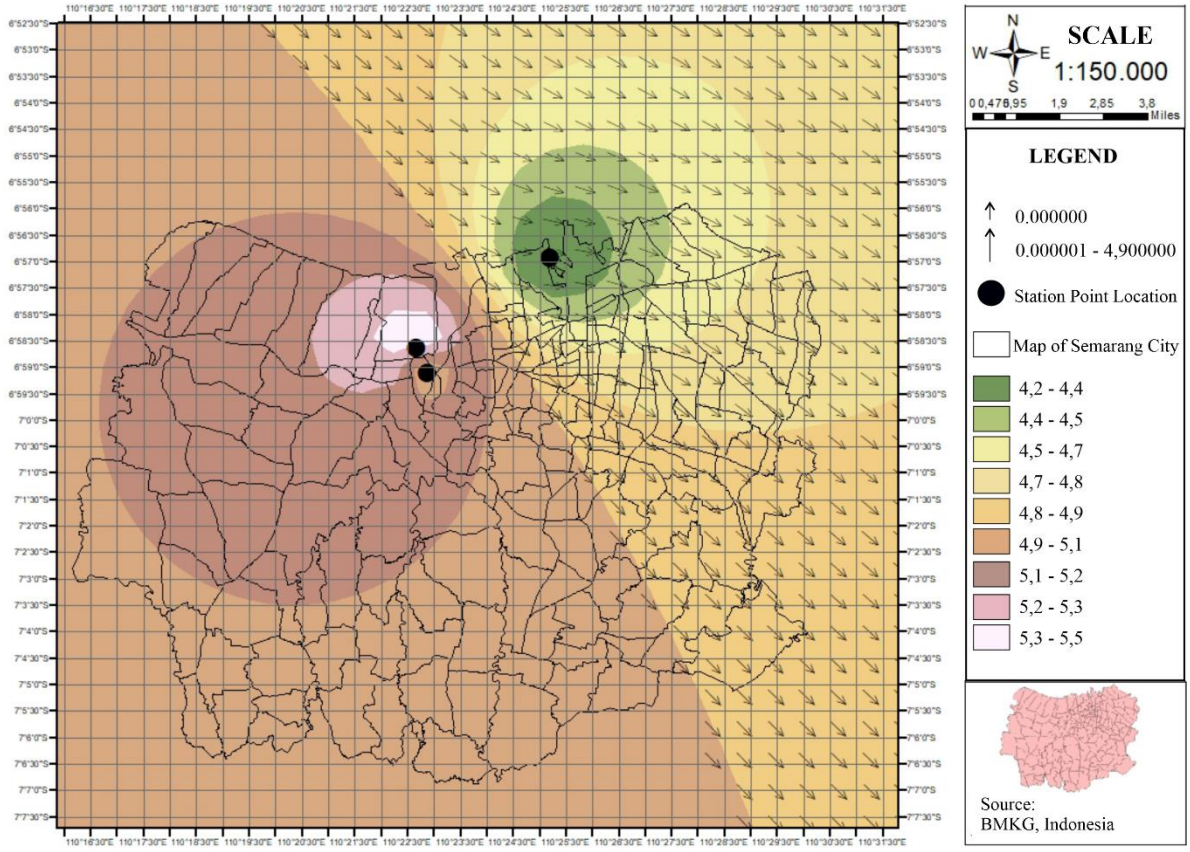

Figure 3. Overlay of wind patterns, wind speed, and tidal condition

The colors on the map represent the wind speed (m / s), the order of the wind speed in each area based on the order shown in the map legend. The green color in the area with the lowest wind speed of about 4.2-4.4 m / s, while the area with the light pink color has the most incredible wind speed, which is around 5.2-5.5 m / s. The arrows on the map depict the wind direction or wind movement pattern. Figure 4 shows that the wind pattern moves from the northwest (WestNorth) to the southeast (EastSouth). The direction/pattern of the wind gusts will affect the direction/pattern of sea surface water currents. This is because the current is the flowing motion of a mass of water caused by wind gusts, differences in density, or movement of long waves (Grivina dan Andri , 2016).

Data collection for this study was conducted in July 2020, Indonesia is experiencing an east monsoon period, and based on Figure 4, it is found that the direction and speed of the wind blowing from north to south. The wind direction also tends to move obliquely from west to east. On the map, it is also known that the direction of sea surface currents is in line with the wind direction, namely from the direction of the island of Kalimantan to Java. It is predicted that the pattern of east monsoon gusts and sea surface currents moves to carry floating waste material towards the coast of Semarang City. This affects the results of the waste survey findings; the amount of plastic waste found on beaches in Semarang City, especially Baruna Beach, is also caused by wind and current factors. The nature of

plastic waste that is light and not easily destroyed causes plastic waste to easily be carried by currents and winds from one area to another (Zulkarnaen, 2017).

3.1.2 River Flow

The entry of rubbish originating from land eventually ends up on the coast or the sea can occur through river flows. From the results of a survey of the presence of waste in the river flow of Mangunharjo Village, it was found that plastic waste had been generated that had united with river sediment. Based on the results of interviews with the community, it is known that the waste in the river does not only come from community activities around the downstream of the river. The people's habits or behavior upstream of the river still throw waste into the river, and then the waste is carried away by the river water and finally, the waste ends on the sea or the northern coast of Semarang. The impact is that the river and coastal environment become polluted by waste; the community cannot use the river water because it is brown and full of waste. Further research is needed regarding pollutants contained in rivers, especially microplastic content. Not only in Semarang, based on data from the 2018 Marine Debris Survey Report, major cities in Indonesia also have many problems with the entry of land waste into the sea through river flows (Kementerian Koordinator Bidang Kemaritiman, 2018). It is predicted that there are still many small rivers that end into the sea carrying waste material, and the absence of a waste filter net in each river mouth has resulted in the generation of waste entering the beach and sea. The movement to protect rivers from waste also needs to be encouraged by the government so that there is a change in people's behavior to no longer throw waste in the river flow.

3.1.3 Population Density and Economic Growth of the City of Semarang

Total population, population growth, population movement from one region to another, industrial growth, and economic growth in a region will cause a significant increase in the total solid waste of an area, especially urban areas around the world. (Kaushal *et al*., 2012). Data on population, area, and population density in the four Districts are the research areas shown in Table 3.

Table 3. Population, area, and population density in research location

Sub-district	Population (Person)	Area (Km^2)	Population Density (person/Km^2)	Marine Debrish Weight (kg)
Mangkang Kulon	3.885	3,5	1.110	63.0
Mangunharjo	6.002	6,3	953	173.4
Mangkang Wetan	6.632	2,6	2.551	136.9
Tugurejo (Tirang Beach)	6.837	8,6	795	155.5
Panggung Lor (Baruna)	12.756	1,4	9.111	227.4
Bandarharjo (Cipta Beach)	19.129	3,4	5.626	92.4
Trimulyo	4.017	3,5	1.148	71.4

Source: Population projection of Semarang City 2010-2020

The highest population density is in Panggung Lor Village, with a population density of 9,111 people / km^2. Table 3 shows that the highest beach waste generation is also at Panggung Lor, namely at Baruna Beach, amounting to 227.4 kg. The finding of beach waste in Mangkang Kulon was only 63 kg even though Mangkang Kulon had a higher population density than Mangunharjo; this happened because it was conducted when the beach trash survey was conducted Mangkang Kulon Beach conditions were high. Whereas in Mangunharjo, although the population density is small, high beach waste is found; this is because the Mangunharjo beach is close to a river with a high density of waste. The river becomes the entry route for land waste to the sea/coast in Semarang.

Semarang City Regional Regulation Number 11 of 2014 concerning Semarang City Spatial Planning 2011-2031, Panggung Lor Village has a high population density because it is included in the

BWK (City Division Plan) III area, which has the primary function as an office, trade, and service area as well as air transportation and sea transportation. The increase in the community's purchasing power for basic needs and technology products can also affect the quantity and quality of waste produced in an area (Jaelani *et al.*, 2014). The increase in solid waste shows a unidirectional relationship with increasing economic development on a world scale (Kaushal *et al*., 2012). Semarang City is included in the MP3EI (Master Plan for the Acceleration and Expansion of Indonesia's Economic Development), an economic transformation program to accelerate economic growth to increase competitiveness. The economic growth of Semarang City in 2019 reached 6.52%, an increase in the last five years (Badan Pusat Statistika, 2020). This economic growth will always be directly proportional to the amount of municipal waste generated (Sahil *et al*., 2016). This MP3EI program must be balanced with the improvement of good municipal solid waste management to avoid negative impacts on health and the environment (Rahardyan *et al.*, 2015).

3.1.4 Waste Management on Land

Waste management by DLH Kota Semarang is still using a new paradigm, where waste is collected, transported, then disposed of. Waste management is carried out when the waste enters the Jatibarang TPA. The total waste generation in TPA Jatibarang Semarang City can be seen in Table 4.

Table 4. Total of the weight waste in 'TPA Jatibarang' Semarang City

Month	2016 (ton)	2017 (ton)	2018 (ton)	2019 (ton)	2020 (ton)
Jan	18.092,0	25.708,0	23.999,2	33.045,4	8.068,6
Feb	22.321,2	23.405,8	20.586	33.045,4	23.408,6
March	23.361,6	25.182	22.832	41.000,5	25.150,6
April	23.561,1	8.837,2	21.882,8	36.885,6	24.862,3
Mey	10.309,6	1.019,0	21.615	38.912	23.691,5
Jun	23.943,2	19.272,6	20.028,8	30.595	21.649,8
Jul	22.960,8	22.687,2	23.392	30.462,8	23.488,7
Agust	23.194,8	22.144,9	23.090,0	27.951,6	N/A
Sept	24.804,9	22.497,8	22.328,6	27.611,3	N/A
Oct	26.193,9	23.517,9	29.517,6	26.691,6	N/A
Nov	26.103,4	17.106,9	30.510,9	N/A	N/A
Dec	10.815,6	18.917,9	32.771,9	N/A	N/A
Total	**239.379,3**	**207.633,4**	**292.554,8**	**326.201,2**	**150.320,1**
Average/month	**19.948,3**	**17.302,8**	**24.379,6**	**32.620,1**	**21.474,3**

*N/A : Empty Data
Source: Secondary data of 'UPTD TPAS' Semarang City

In Table 4, it can be seen that the highest average weight of municipal waste that enters the Jatibarang TPA is in 2019, amounting to 32,620.1 tons in one month. Data from the BPS of Semarang City in 2020 states that the total population of Semarang City in 2019 is 1,814,110 people. The provisions of SNI 3242-2008, in which areas included in big cities are estimated to produce as much as 3L of waste/person/day or around 0.7 kg/person / day. If calculated, then the city of Semarang in 2019 has a daily waste generation of 1,269.9 tons, and in one month, it produces 38,096.3 tons of waste. From the data above, it can be seen that in 2019, the percentage of waste transportation to the Jatibarang TPA reached approximately 85% of all waste generated by residents of Semarang City.

The slight difference between the total city waste generation and the total waste entering the Jatibarang TPA can also indicate the lack of community participation in processing and sorting their waste. Secondary data from the Jatibaranng TPA states that 62% of the Jatibarang TPA waste is organic waste. Regional Regulation No. 6/2012 on waste management states that everyone is expected to reduce and manage waste, including sorting waste from its source. The lack of strict implementation of the obligation to sort waste at the household level has resulted in many people not doing waste sorting.

In the financing aspect, the sources of waste management costs are divided into two, namely APBD funds and income from user fees. In 2012, the two funds' ratio, between APBD funds and retribution funds, was 81% to 19%, with a growth rate of 6.29% (Syukriya *et al*., 2014). Retribution income funds are still low when compared to the amount of APBD funds. This indicates the subordinate role of the community in paying fees for their waste generation. The retribution payment system is carried out by involving field officers, and it must be clear, orderly, and recorded so that there will be good feedback between the community and the local government that is tasked with managing municipal waste.

4. Conclusion

The total findings of coastal waste in Semarang City in July 2020 on seven beaches were 920.2 kg of waste. On average, on each beach, there is a beach waste generation of 131.5 kg. Moreover, the average density of waste (kg / m^2) on each coast is 5.258 kg / m^2. Collected beach waste is divided into 9 types: plastic, wood, cloth, rubber, metal, plastic foam, glass and ceramics, paper and cardboard, and other materials. The type of waste that is most often found in plastic, while the heaviest waste is wood. The high level of plastic waste on the beach is due to the large amount of land waste entering the beach / sea through rivers and wind direction, and current direction factors. The easy transition of plastic waste movement means that the plastic waste found does not only come from Semarang but can also be caused by other municipal waste being carried away by the current. The factors of population density and economic growth also encourage an increase in waste generation in Semarang. The model for reducing coastal waste that can be done is by sorting waste directly from its source, routine coastal cleaning or river flow programs, and encouraging the buying and selling program for used goods that are fit for use.

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