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Research Paper

Determining the Illegal Waste Disposal in Coastal Area using Transect Walk Approach

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Abstract

The increasing population and anthropogenic activities in cities/regencies in Indonesia have caused many waste-related problems, which can trigger environmental and human health. In addition to population growth, rapid economic development has resulted in an increasing amount and type of waste. The coastal area is one area that still needs to get adequate solid waste services. There have been many studies on waste management. However, research has yet to examine the amount and composition of waste generation in coastal areas that have not been served by waste management.. This study shows the waste generation and composition trend in coastal areas that must be served in waste management and determines the appropriate waste management strategy. This research method uses a transect walk survey carried out by following a predetermined route in the area. Paths are made randomly by forming circles or straight lines for 10 km. The composition of illegal waste dumps found included leaves (69.02%), plastic (15.24%), branches and twigs (9.93%), paper and cardboard (3.75%), food waste (1.97%), and rubber (0.1%). At least 1.59 tonnes/day of illegal waste is estimated in Sidorejo Village. While this figure increases at the district level, the amount of unaccommodated waste is estimated at 19.85 tonnes/day. Efforts to handle waste that can be done are changing the mindset and paradigm of the community through an educational approach, improving the waste management system by providing waste facilities and reducing the amount of waste collected through a simple program (Reuses, Reduces, Recycle) that involves the community.

Keywords: *Transect Walk, Waste Generation and Composition, Waste Management, Coastal Area*

INTRODUCTION

Environmental problems are one of the main issues in Indonesia; an example of an ecological crisis is unmanaged waste (Hadi et al., 2021). The increase in population and the diversity of activities in both cities/regencies in Indonesia have resulted in many related waste issues. In addition to population growth, rapid economic development has resulted in an increasing amount and variety of waste (Sailer et al., 2021). The waste problem is one of the city's problems. Currently, it cannot be processed, especially in coastal areas. Because the number of waste increases with altitude, the level of public consumption is related to the people's awareness of protecting the environment. Waste accumulation in coastal areas is from household waste and downstream waste that ends up in the sea. According to the People's Coalition for Fishing Rights, 1.29 million tons of waste is dumped into rivers and ends up in the ocean. It is estimated that around 13,000 pieces of plastic float yearly, increasingly threatening marine ecosystems' sustainability. Although the threat of damage does not only come from plastic waste, the impact caused by plastic waste is also very dangerous. One of the most hazardous pollutants for health is heavy metal. We know that one of the most harmful pollutants is heavy metals. According to the World Health Organization and the Food Agriculture Organization, it is recommended not to eat foods that contain heavy metals. It is because heavy metals have toxins that can accumulate in human organs, resulting in death. So it is necessary to hold services in the area. Some residents who do not receive this service will dispose of their waste by burning it in the field or yard of the house, burial, and indiscriminate disposal (Ramadan et al., 2022).

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Research conducted by (Ramadan et al., 2022) uses the transect walk method to determine the incineration point of waste and the amount of waste generated that was burned. Besides they also conducted the burning test using an incinerator to determine the emissions of burning waste. This study stated that open burning of waste produces carbon monoxide (CO), carbon dioxide (CO_2) emissions, hydrocarbons (HC), and nitrous oxide (NO_x). (Maziya, 2017), in his research stated that carbon dioxide (CO_2), methane (CH_4), ozone (O_3), nitrous oxide (N_2O), methyl chloride and water vapor are greenhouse gases. Greenhouse Gases (GHG) are gases in the atmosphere that absorb and re-emit infrared radiation. The side effects of accumulated greenhouse gases can cause extreme climate change that affects land productivity (Jatmiko et al., 2019).

In addition, research conducted by (Reyna-Bensusan et al., 2019) states that uncontrolled waste burning produces Black Carbon (BC) emissions. Black Carbon is an umbrella term for various carbonaceous substances ranging from partially burnt plant residues to soot (Shrestha et al., 2010). Black Carbon has a global warming potential of up to 5000 times greater than carbon dioxide (CO_2) and has an impact on human health and the environment.

The composition of the waste produced in Sidorejo Village, Indonesia, is the same as in other areas, namely organic waste (food scraps, leaves, wood, paper, cardboard.) and inorganic waste such as cans, plastic, iron and other metals (Simandjuntak, 2004). This waste will cause environmental pollution if it is not managed correctly. For example, plastic waste, a recent study informs that plastic disposed of on or below the soil surface will pollute the environment. The disposal of plastic bags will also turn into nano plastics and have an impact on decreasing soil quality (Park et al., 2013). This situation will hurt aquatic biota and reduce their aesthetic value. Nano- or micro-plastic is very dangerous for living things. A recent study also found this microplastic polluted the seas, rivers, and beaches worldwide (Ng et al., 2018). Therefore, waste must be appropriately managed, reduced, and minimized. Determining the number of illegal waste disposal in the environment may give important information for the policymakers to make an appropriate waste management system in a region.

As said before, a waste management system can be planned appropriately by robust baseline data such as the amount of generation and composition of waste generated in an area (Yusuf et al., 2019). The characteristics and design of this waste depended upon various factors, such as the topography of the site, different seasons, food habits, and the commercial status of the city (Thitame et al., 2010).

There have been many studies on waste management. However, research has yet to examine the amount and composition of waste generation in coastal areas that waste management has not served. This study shows the waste generation and composition trend in coastal areas that must be served in waste management and determines the appropriate waste management strategy. The information presented in this study will be necessary for evaluating policy and legal interventions and the potential benefit of other future research related to detecting unmanaged waste in the coastal area.

LITERATURE REVIEW

Meaning of Waste

Waste, in general, can be interpreted as all that waste resulting from human activity or unwanted animals or reused, either in solid form or half solid (Tchobanoglous, G, Theisen, H., dan Vigil, 1998). Law Number 18 of 2008 concerning Waste Management states that waste is the residue of daily human activities and natural processes in solid form. The managed waste consists of household waste, household-like waste (originating from commercial, industrial, public facilities, and social), and specific waste containing hazardous and toxic materials. According to Morrissey (2004), there are several models in waste management; the first is an optimization model that handles certain aspects of the problem. The newer model is a compromise model, focusing on integrated waste management with sustainable waste management (Morrissey et al., 2004)

Waste Generation

According to (Standar Nasional Indonesia, 2002), concerning operational engineering procedures for urban waste management, waste generation is the amount of waste arising from the community in units of volume or weight per capita, per day, per building area, or per long way. Meanwhile, what is meant by the rate of waste generation is the total amount of waste generated per person every day expressed in volume and weight units.

The generated waste has different specific gravity according to the characteristics of the waste. The specific waste gravity is expressed as weight per unit (kg/m^3). In measuring the specific waste gravity, it must be stated where and under what circumstances the waste is taken as a sampling to calculate the specific weight of waste. The specific waste weight is influenced by geographic location, season, and storage time. It is essential to know the volume of waste processed. The following is Table 1 regarding the specific gravity of each waste characteristic according to (Sulistyoweni, 2022).

Table 1. Specific Gravity of Each Waste Characteristic

No	Waste characteristics	Specific gravity (kg/m3)	
		Range	Typical
1	Food waste	120 - 480	290
2	Paper	30 - 130	85
3	Cardboard	30 - 80	50
4	Plastic	30 -130	65
5	Cloth	30 - 100	65
6	Rubber	90 - 200	130
7	Skin	90 - 260	160
8	Garden waste	60 - 225	105
9	Misc. organic	120 - 320	240
10	Glass	90 - 360	140
11	Tin	160 - 480	195
12	Nonferrous metal	45 - 160	90
13	Ferrous metal	60 - 240	160
14	Urban solid waste	120 - 2000	320
15	Dust, ash and others	320 - 960	480
16	Urban solid waste (Unncompacted compacted)	90 - 180 180 - 450	130 300
17	In landfills (normal solid)	350 - 550	475
18	In landfills (well compact)	600 - 750	600

Source: Sulistyoweni, 2022

Data on the specific gravity of waste in Table 1 was used to determine the volume of waste generation found. When carrying out a transect walk survey, the total amount of waste that was not managed would be known. Table 2 presents the density of solid waste in several countries based on books ("Arab Repub. Egypt Ctry. Environ. Anal.," 2005). As with the specific waste gravity, the waste density also determines the waste weight found during the transect walk survey.

Table 2. The Density of Solid Waste

Country	The Density of Solid Waste (kg/m³)
Developed Countries	
United State	100
United Kingdom	150
Developing Countries	
Tunisia	175
Nigeria	250
Thailand	250
Indonesia	250
Egypt	300
Pakistan	500
	500

Source: Arab republic of egypt, national environmental action plan, cairo, 1992

Waste Composition

Composition is the physical waste components such as food scraps, cardboard, wood, textiles, rubber, leather, plastic, ferrous-non-ferrous metals, glass and others (e.g., soil, sand, stone, ceramics). The most common grouping of waste is based on its composition, expressed as % by weight or % by volume of paper, wood, rubber, plastic, metal, glass, cloth, food and other waste (Damanhuri, 2010). According to (Tchobanoglous, G, Theisen, H., dan Vigil, 1998), the waste composition can be divided into two groups, namely:

1. Physical composition of waste

Physically it consists of wet waste, yard waste, garden waste, paper, cardboard, cloth, rubber, plastic, wood, glass, metal, dust, and others. Information on the physical composition of waste is needed to select and determine how to operate each piece of equipment and other facilities, estimate the feasibility of recovering resources and energy from waste and plan final disposal facilities.

2. Chemical composition of waste

In general, the chemical composition of waste consists of the elements carbon, hydrogen, oxygen, nitrogen, sulfur, phosphorus, and other elements found in proteins, carbohydrates and fats.

Waste Management

According to the Law of the Republic of Indonesia Number 18 of 2008 concerning waste management, waste management is a systematic, comprehensive and sustainable activity, including waste reduction and handling. Waste management aims to improve public health and environmental quality and convert waste into resources.

Factors influencing the urban waste management system according to SNI 19-2454 concerning operational and technical procedures for municipal waste management 2002, namely population density and distribution, physical environmental and socio-economic characteristics, waste generation and characteristics, cultural attitudes and behavior of the community, distance from the source of waste to the final disposal site, spatial planning and city development, facilities for collecting, transporting, processing and final disposal of waste, financing, and applicable local regulations.

Indonesia is famous for its two waste management models: landfill and piles. This landfill model is generally carried out in areas that produce a manageable volume of waste. In this model, waste is disposed of in valleys or basins without further treatment, meaning that it is thrown away and abandoned (Kahfi, 2017). This model is a very simple waste management model that slightly changes the initial paradigm of the general public towards waste.

The second model is piled, which tends to be more advanced. The waste management model with piles is equipped with drainage units for exhaust, air exhaust for exhaust (leachate) and access to the combustion of methane gas (flora). A model like this already meets environmental requirements and is widely applied in big cities. Still, unfortunately, this stack model is only partially dependent on financial conditions and associations of local officials for environmental and community health (Kahfi, 2017).

The Transect Walk Method

Transect walk is one of the field sampling methods by exploring the research area to obtain some information. In addition, these transect walks can provide excellent information that can be used for specific review and evaluation purposes (Zeeuw et al., 2004). Before the survey, transect walk routes are determined randomly, with routes approximately 10 km long and can be either loops or straight lines. Repeated roads are not counted anymore, and distance calculations are only done once (Nagpure et al., 2015).

The volumetric transect results are converted into weight units after determining the specific gravity of the pile. The estimated waste weight for each route is divided by the transect area to determine the density, as seen in the following equation (see Eqs. 1, 2, 3) (Han et al., 2015; Remigios, 2016; Velis et al., 2021a).

$$\sum M_a = \sum V_a \times \rho_a \quad (1)$$

$$TrA_a = TrL_a \times SS \quad (2)$$

$$M_b = \frac{\sum M_a}{TrA_a \times 1000} \quad (3)$$

M_a = weight of waste in each sub-district representing each sub-district (kg)
V_a = waste volume in each sub-district representing each sub-district (m^3)
ρ_a = *solid waste compaction density* (kg/m^3)
TrA_a = transect area (m^2)
TrL_a = transect path length (m)
SS = maximum sightseeing distance (m)
1000 = conversion factor from kg to tons
M_b = estimated specific gravity of waste ($tonnes/km^2$)

The waste density for each cluster (Mc) is determined by dividing the total estimated thickness of the surveyed area (Mb), representing the number of sub-districts in each collection.

RESEARCH METHOD

This study seeks to estimate the generation and composition of waste in coastal areas not served by sub-district waste management in Sidorejo Village, Indonesia. The transect walk survey method was modified from the previous method used in India (Nagpure et al., 2015), Mexico (Das et al., 2018), Nepal (Reyna-Bensusan et al., 2018), and Indonesia (Ramadan et al., 2022).

Tools and Materials

In the implementation stage of this research, several tools are needed, including the application of map markers, meters, scales, and sacks. The map marker application is used to mark the points of open burning of waste that are found along the transect walk route. The meter measures the unmanaged waste pile's dimensions or length, height and width. Scales are used to get the weight of an unmanaged pile of waste—sacks to collect and transport waste samples from one of the heaps found. In addition to using the tools to obtain the data mentioned above, several other things need to be done during the transect walk, namely estimating the distance of unmanaged piles of waste from the road and conducting short interviews with residents who dump waste indiscriminately. Short interviews were conducted to obtain information regarding the reasons and objectives of the residents for carrying out the practice of haphazard waste disposal.

Study Area

Sidorejo Village is one of the Villages in Sayung District. Sidorejo Village is bounded by Banjarsari Village to the north, Batu Village to the south, Tugu Village to the west, and Rejosari Village to the east. The Sidorejo Village is 6.33 km^2, consisting of six community units and 31 neighbourhood units. The population of Sidorejo Village is 5,454 people.

Figure 1. Research location

Since this district is located remotely, people still do illegal waste disposal, such as open burning, burial, or waste disposal anywhere. The data relating to the amount and composition of uncollected waste generation in Sidorejo Village has yet to be discovered, so further research is needed. A transect walk was employed to determine the amount and composition of uncollected waste generation in an area. A village or sub-district, Sidorejo Village, was chosen as the study area since it is included in the coastal area that has not been served by waste management. It also does not yet have inventory data regarding the composition and generation of waste. Then, the results of the transect walk were scaled up to a district level representing the coastal area in Java Province. Figure 1 shows the research location.

Preparation of Field Surveyors

The surveyors selected for this study received an orientation from the research team. A trial survey is conducted and repeated until the surveyor is knowledgeable and skilled enough to collect field data independently. A field study was conducted from September to October 2022 in Sidorejo Village. The survey was carried out in the morning and evening. One of the waste piles found in the study area will be taken as a sample to determine the generation and composition of the piece.

Estimation of the Pile Density

The waste pile samples are characterized based on their composition. First, the design of each waste pile was recorded by visual inspection. Second, the initial mass of the debris was weighed using digital scales. Third, measurement of the volume of each bank was done and measured by using a ruler (e.g., length, width, and height)

Transect Walk Survey Method

The transect walk survey method followed the method used in the previous case study by (Das et al., 2018; Nagpure et al., 2015; Ramadan et al., 2022). A transect walk survey is carried out by following a predetermined route in the area. This survey area was conducted in the Sidorejo Village. Courses are made randomly by forming loops or straight lines along 10 km in each village. The survey was done through the main road and residential areas at that location. The route made will not go through the same road repeatedly; even if it must be passed more than once, it will only be counted once. Courses are made using the Google Earth application using the existing maps in the application as a guide. Figure 2 shows the transect walk survey route.

The sampling activity lasted 14 days, from 21 September to 4 October 2022. Sampling was carried out in the morning and evening with the assumption that the burning of waste was higher than during the day, considering that the community was working or carrying out other activities. Sampling was repeated one week apart to obtain data validation. The survey team records the geographic coordinates of the pile and measures the dimensions (i.e., length, width, and height) of all the stacks so that the total volume can be estimated. The number of waste piles is the sum from the beginning to the end of the transect walk survey.

FINDINGS AND DISCUSSION

Transect Walk Results

The recapitulation of the transect walk's result in the form of unmanageable waste points and waste pile samples is calculated and analyzed to determine the characteristics of the waste. Visual observations were made during the transect walk activities to assess the waste composition. After the waste samples were sorted and grouped according to their design, the pile's density was obtained. Waste density is determined to be approximately 60 kg/m^3. Table 3 shows the waste pile characteristics. Based on the transect walk survey results, the waste composition consisted of food waste, branches and twigs, paper and cardboard, plastic, metal, textiles, rubber, glass, leaves, hazardous waste, and others.

Table 3. Composition of Waste from the Transect Walk Survey

Composition	Weight (grams)	%
Food waste	123	1.97
Branch and twig	620	9.93
Paper and cardboard	234	3.75
Plastic	952	15.24
Metal	0	0
Textiles	0	0
Rubber	6	0,1
Glass	0	0
Leaves	4.310	69,02
Hazardous waste	0	0
Others	0	0

Table 3 shows the leaves' waste composition dominates the unmanaged waste sample in Sidorejo Village by 69.02%. In contrast, the most plastic, textiles, glass, and hazardous waste is the least found during the transect walk survey with a value of 0%. It happens because if we see from the geographical aspect of the Sidorejo Village area, there is still a lot of land cover and trees. In addition, residential areas are still dominated by large yards, so leaf litter is often found.

The following is an example of calculating the proportion of waste weight in the type of leaf waste.

Leaf waste weight = 4.310 (grams)
Total waste = 6,245 (grams)

So that,
Percentage (%) = Weight of leaf waste x total waste x 100%
= 4.310 (grams) x 6.245 (grams) x 100
= 69.02%

Scale-up of Transect Walk Results

During the transect walk activities, visual observations were made to determine the composition of the unmanaged waste. In addition to knowing the composition of the unmanaged waste, a transect walk survey was conducted to determine the status of the number of people living in the lanes not served by waste management and whether they participate in the rubbish collection. A total of 16 points of waste piles were identified during the transect walk survey (See Table 4 and Figure 2).

Table 4. Location Points of the Waste Pile

Latitude	Longitude	Pile Dimensions			Sightseeing (cm)
		Length	Width	Height	
-6.90041	110.56021	90	65	15	10
-6.90007	110.55992	65	40	20	15
-6.89752	110.55992	105	60	10	45
-6.89751	110.55891	70	35	5	20
-6.89017	110.55549	80	50	10	140
-6.88987	110.55536	75	40	5	140
-6.88912	110.55508	80	35	25	120
-6.88549	110.55355	50	25	15	150
-6.88521	110.55347	40	20	10	25
-6.88446	110.55324	55	45	15	105
-6.88388	110.55306	40	25	20	10
-6.89053	110.55557	55	35	20	80
-6.89159	110.55473	25	35	15	15
-6.89328	110.55306	85	50	10	10
-6.89679	110.54378	75	55	20	50
-6.89733	110.54337	75	45	25	60

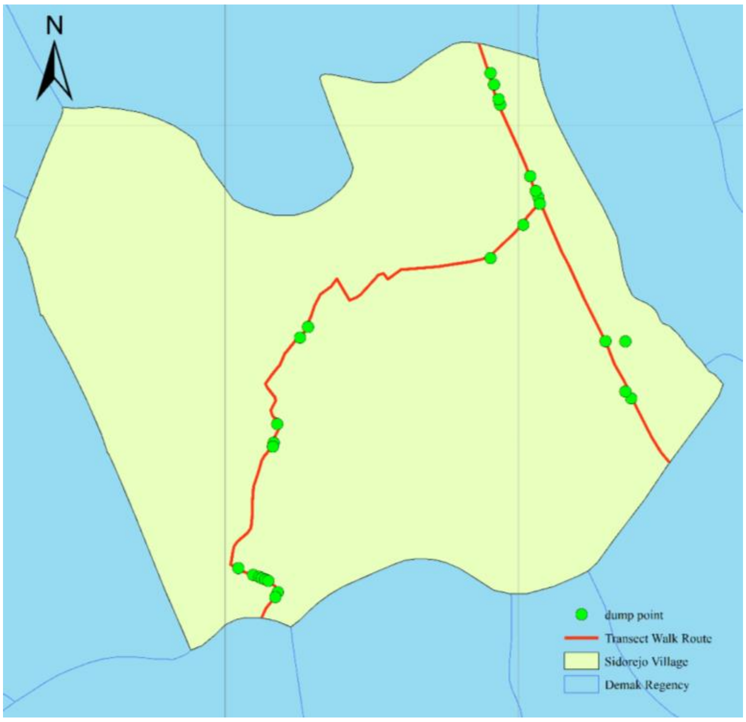

Figure 2. Dumping points and transect walk survey route

Figure 2 shows the number of points and the location of the waste mounds at the transect walk survey conducted in Sidorejo Village. Sidorejo Village is one of the villages in Sayung District, Demak Regency. Sidorejo Village has an area of 6.33, which was used as a survey area because of its strategic location and easy passage. The number of waste mounds found during the survey was 16 different sizes. Later, the transect walk survey results in the Sidorejo Village will be calculated to determine the amount of unmanaged waste generation in other areas, in Sayung District.

Unmanaged Waste Generation in Sayung District

The unmanaged waste point data obtained through the transect walk survey in Sidorejo Village is then calculated to estimate the total unmanaged waste in Sayung District. The composition of the waste generated based on the transect walk survey is mainly found in food scraps, branches and twigs. Therefore, plastic waste is the third largest illegal waste accumulation accounting for around 15.24%. The estimated littering by the Sidorejo sub-district is 1.59 tons/day.

Thus, the number of illegal waste disposal in other sub-districts in the Sayung District can be estimated, as shown in Table 5. The total illicit disposal waste generated in Sayung District is 19,85 tons/day. Since illegal waste generation is high, several strategies must be developed to reduce the amount of waste disposed of illegally. Waste collection services must be improved to serve all waste generation in Sayung District. The absence of waste management services encourages people to throw their waste anywhere and burn it (Velis et al., 2021b). Therefore, a policy may be required to provide decentralized waste management services in rural and coastal areas (Orhorhoro et al., 2017). All sizes should support proper waste recycling because the high service area limits domestic waste collection recycling activities such as composting, waste bank, or other practices.

Tabel 5. Total Waste Generation in Sayung District

Villages	Area (Ha)	Sub-district area (km2)	Piles (tons)
Jetaksari	142	1.42	0,36
Dombo	132	1.32	0,33
Bulusari	263	2.63	0,66

Villages	Area (Ha)	Sub-district area (km2)	Piles (tons)
Perampelan	223	2.23	0,56
Karangasem	154	1.54	0,39
Kalisari	343	3.43	0,86
Sayung	456	4.56	1,15
Tambakroto	345	3.45	0,87
Pilangsari	294	2.94	0,74
Loireng	315	3.15	0,79
Gemulak	412	4.12	1,04
Sidogemah	544	5.44	1,37
Purwosari	393	3.93	0,99
Sriwulan	402	4.02	1,01
Bedono	739	7.39	1,86
Timbulsloko	461	4.61	1,16
Tugu	513	5.13	1,29
Sidorejo	633	6.33	1,59
Banjarsari	606	6.06	1,53
Surodadi	510	5.10	1,28
Total			**19,85**

After calculating all the unmanaged waste in each area, it can be seen that the Bedono Village area is the largest contributor to unmanaged waste, namely 1.86 tons of the total unmanaged waste in Sayung District. The lowest estimate point for unmanaged waste was found in Dombo Village, which was 0.33 tonnes of the total unmanaged waste in the Sayung District.

The following is an example of calculating unmanaged piles of waste in Sidorejo Village is known:

Pile Density = 0,25 (tons/km^2)
Sub-district area = 6,33 (km^2)
so that,

$$\sum M_a = \sum V_a \times \rho_a$$

= 0,25 (tons/km^2) x 6,33 (km^2)
= 1,59 tons

Waste Management Framework

Most waste management based on transect walk surveys is open burning activities in the field or yard of the house, burial and random disposal. It is linear to research conducted by (Ramadan et al., 2022) that some residents who do not get waste management services will carry out simple management such as open burning, burial and dumping. If this activity continues, it will negatively impact environmental and human health. The following presents a waste management framework that can be applied in Sidorejo Village.

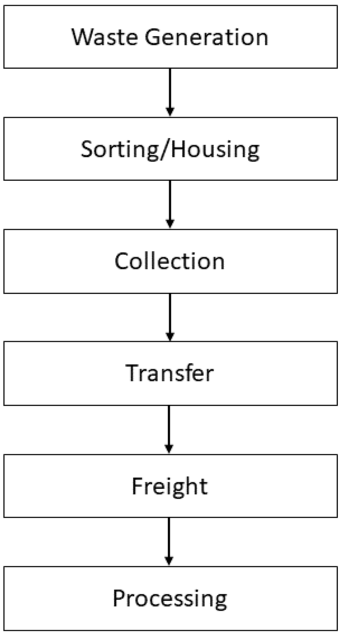

Figure 3. Waste management framework

Based on Figure 3 above, it is clear that the waste management that can be carried out in Sidorejo Village is by holding containers. It is better if the community has applied the 3R principles (Reuse, Reduce, Recycle) before waste generation can be reduced. It is supported by the study of Riswan, which states that active community participation in waste management dramatically determines the success of its implementation (Riswan et al., 2015). After that, the collection is carried out at the TWS (Temporary Waste collection Site), which is then transferred to the TPST and transported to the TPA for processing. So, implementing this waste management system can reduce the indiscriminate disposal of waste, which can harm the health of the environment and society.

Recommendations for addressing unmanaged waste in Sayung District are by looking at waste management and processing conditions in Sayung District. Inadequate facilities and infrastructure, wrong people's mindset in processing waste, and low public awareness of environmental hygiene and health. Based on these considerations, efforts that can be made, according to (Octavia et al., 2001), are:

1. Provision of waste facility services

Providing waste facilities in an area is also necessary to support a change. The main facility is a container tub or TWS, a temporary waste storage area. The results of field observations show that several areas still need TWS. So it is necessary to add a container tub facility to accommodate waste. In addition, retribution services with a consistent transportation schedule are also required so that waste can be transported properly. This form of procuring solid waste services can be carried out by related agencies such as the Demak Regency Environmental Service.

2. Implementation of 3R (Reuse, Reduce, Recycle) / Simple Recycling Culture

An important point in dealing with unmanaged waste is reducing the waste generated at the source. This effort can be carried out through the simple application of 3R (Reuse, Reduce, Recycle) by involving the community. If you want to avoid making reuse and reducing efforts personally, other processing strategies can be applied to each village by creating a Waste Bank.

3. Educative Approach

This type of countermeasure can be implemented by providing various environmental knowledge to improve understanding and change behavior. Several approaches can be taken, such as providing socialization regarding waste and the impact of burning waste on the environment, as well as educating the community about the application of 3R in daily life. Various parties, including the government, environmental activists, researchers, or institutions working in the environmental field, can take this approach.

CONCLUSIONS

The highest composition of illegal waste disposal found during the transect walk was branches, twigs, food waste, and garden waste. Plastic waste was also found, indicating the potential for higher emissions into water. Therefore, most of it is burned, and a small part is dumped directly into the environment. According to the findings in this study, around 1.59 tons/day in the Sidorejo Village, out of 19.85 tons/day of waste generated in Sayung District, pollutes the environment significantly. The recommendations for addressing unmanaged waste in Sayung District are as follows: changing the mindset and paradigm of the community through an educational approach, improving the waste management system by providing waste facilities and reducing the amount of waste generated through a simple program (Reuse, Reduce, Recycle) that involves the community.

LIMITATION & FURTHER RESEARCH

The limitation of this study is that it only uses the transect walk survey method to determine the composition and generation of unmanaged waste. Hence, the strategy recommended is only the study literature. Therefore, future research should incorporate additional methods, such as surveys targeting the public to identify the reasons for littering. It will allow for a more appropriate waste management strategy and waste management system design.

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