Method of Calculating the Value of Retribution and Engineering of Waste Transport in Waste Management Effort in the City of Pekanbaru

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Abstract. Waste is one of the problems in national and local studies.In this case, comprehensive and integrated waste management is needed from upstream to downstream to provide economic benefits while at the same time healthy for the community and safe for the environment. This study aims to get the model calculation retribution by using the model of investment theory and survey demand involving the community in determining the value of garbage retribution in the city of Pekanbaru. The research method used is a combination of quantitative and qualitative methods. Determining transport engineering in waste management refers to SNI 3242:2008 on waste management in settlements and calculation of economic benefits from waste management using waste calculation method and waste transport engineering method. The results revealed that the cost of waste levy required for Zone 1 includingTampan, PayungSekaki, and MarpoyanDamai sub-district isRp. 202,232.68 / ton of garbage, while those for zone 2 includingSukajadi, Senapelan, Pekanbaru, Lima Puluh, Sail, Bukit Raya, and Tenayan Raya sub-district is Rp. 213,587.94 / ton of garbage. The method of waste management engineering in Pekanbaru City includes waste collection, waste collection pattern and waste transport method with zone division consisting of priority zone and cooperation service zone.

1. Introduction

Since 2010, Pekanbaru has become the third city that has the most population on the island of Sumatra, after Medan and Palembang. The rapid pace of economic growth in Pekanbaru has contributed to the rate of population growth in this city. The increase in population is also accompanied by an increase in activities carried out, potentially increasing the amount of waste produced. This condition encourages the city government to look for waste management solutions that are environmentally friendly. The amount of waste generated by Pekanbaru City reaches 500 tons / day where every single person in Pekanbaru City produces up to 2.6 kilograms of waste per day (Pekanbaru Sanitation Agency, 2018).

Waste is the residual product that is no longer consumed, and waste that is formed continuously and accumulates can have a negative impact on individuals, society and the environment. Therefore, waste management is a necessity that cannot be delayed because every day the waste generated / produced by living things and the natural process continues to increase. However, waste management conditions, especially in the city of Pekanbaru, are still based on the rules set by the government without conducting a demand survey from the community, especially those related to the payment of waste retribution. Location of waste generation in the city of Pekanbaru is spread over various criteria for generation sources, including: residential areas, offices, markets, inns, restaurants, entertainment venues, tourist attractions, shopping centers, public facilities, hospitals, industries, and shophouses. Waste generation from each generation source produces different volume and characteristics of waste. This needs to be

studied more deeply to see the potential retribution and other economic potential that can be obtained from the potential volume and characteristics of existing waste generation.

With the enactment of Law Number 18 of 2008 concerning Waste Management and elaborated among others by Government Regulation No. 81 of 2012 concerning Household Waste Management and Household-like Waste, the waste management policy for more than three decades only relies on the transport-gathering approach (end of pipe) by relying on the existence of a landfill. It is changed with the approach to reduce resources and recycle resources through the implementation of 3R (Reduce, Reuse, and Recycle). The application of 3R is expected to be one form of waste management by changing the method of processing waste. Through the sorting and utilization of organic waste program, it is possible that only organic and recycled waste is feasible to be disposed of in the landfill. This process can save landfill land and the life of the landfill can be extended. This waste reuse process can create economic benefits in waste management that can be measured by using an analysis of economic benefits. All levels of society are expected to change their views and treat waste as an alternative resource whenever possible to be used again.

In addition, in order to realize the city of Pekanbaru free from waste, of course, it requires a method of engineering waste management and also a method of calculating the value of waste retribution based on community demand surveys. In the waste management method [1, 2] it is done by managing the waste transport system that is adjusted to the garbage collection system that is carried out communally with a garbage cart. From the results of the analysis and calculation, many equipments / landfills, collection equipments, garbage transport vehicles and landfill are needed. That is why, the appropriate method is a controlled disposal method, with the equipment of 1 (one) bulldozer. In addition, the transport container system is more productive than the fixed container system in terms of personnel and waste transported per ritation [3].

The method of calculating the value of waste retribution based on demand surveys [4,5] in price fixing is closely related to the amount of demand, transportation, differences in community income levels and social status of the community. So the solution in determining the price of a retribution that is rational is based on the characteristics of the household through a survey. There are still many obstacles regarding the implementation of the garbage retribution policy which impacts on solid waste handling services. It can be seen in which solid waste services are still not optimal, because of the limited availability of the budget [6,7]. It is also about the calculation of waste retribution by knowing the dependence of the value of willingness to pay by the community [8].

2. Methods

In studying about the method of waste management engineering and also the method of calculating the value of waste retribution based on community demand surveys, a more in-depth discussion is needed on the two methods.

2.1. Calculation of Waste Productivity

2.1.1. Projection of Landfill

In order to project the landfill for the next 10 years, the method of generation rate of waste per year can be used with an increase of 0.02 ltr / person / day.

$$\text{Midden} = \text{total population} \times \text{rate of waste generation} \quad (1)$$

Determination of the size of the volume weight is closely related to the type of transport that is used and the strength of the road body that is followed. In planning, it is necessary to know the production of waste for the future. Estimates of waste production for the coming year must be in accordance with the level of activity and production productivity and income per capita.

2.1.2. Projection of Population Development

The increasing number of population and housing will have an impact on the level of production of waste that will keep increasing. The Pekanbaru City Government in anticipating the landfill and handling it in the next few years needs to calculate the population in order to calculate the projected landfill. This calculation uses geometry methods and exponential growth (Sembiring, 1995):

$$\text{Geometry growth: Pn} = \text{Po}\ (1 - r)^n \quad (2)$$

where Pn is the population number, Po is the initial population, r is the annual population growth rate, n is the period of time in a year.

$$\text{Exponential growth: Pn} = \text{PoX}e^n \quad (3)$$

where e = a number of 2,718282

Classification of waste management based on the existing residential environment is: 1 Neighborhood with a population of 150-250 people (30-50 houses); 1 Hamlet consists of 2500 people (± 500 houses); 1 Urban Village consists of 30,000 people (± 6000 houses) and 1 subdistrict consists of 120,000 people (National Standardization Agency: 2008).

2.2. Engineering Method of Waste Transport

Before the transport process is carried out, the garbage is collected first at the Temporary Disposal Site (TPS). The TPS classification consists of 1) TPS type 1: a place for transferring garbage from the collection tool to the garbage conveyor equipped with sorting rooms, warehouses, waste disposal sites equipped with contained foundation and land area of ± 10-50 m^2. 2) TPS type II: a place for transferring waste from the collection equipment to the garbage transport equipment equipped with a 10 m^2 sorting room, composting of 200 m^2 organic waste, 50 m^2 warehouse, waste transfer place equipped with 60 m^2 container base and land area of ± 60-200 m^2.3) TPS type III: a place for transferring waste from collection equipment to garbage transport equipment equipped with 30 m^2 sorting room, composting of 800 m^2 organic waste, warehouse 100 m^2 , a place for transferring garbage equipped with a 60 m^2 container base and a land area of> 200 m^2 (National Standardization Agency: 2008).

Waste transport engineering method is used to calculate the amount of waste generation using SK SNI M-36-1991-03, about the average volume per neighboorhood per day, the average weight per neighboorhood per day and the weight percent of per-component waste.

$$\textbf{Waste Generation Volume} = \frac{\mathbf{V_s}}{\mathbf{u}} \quad (4)$$

$$\textbf{Solid Waste Generation} = \frac{\mathbf{B_s}}{\mathbf{u}} \quad (5)$$

where Vs is the volume of waste measured and u is the number of waste generating units.

The National Standardization Agency (2008) explained the calculation of waste transport engineering. To calculate the number of collection equipment (cart / garbage rickshaw / motorbike garbage / car tub) the capacity of 1 m^3 in the housing can use:

$$\frac{(\textbf{Amount of Organic Waste in (A+B+D)}+(\textbf{number of Ts in C})+\%\ \textbf{yard waste}}{\textbf{Kk x fp x Rk}} \quad (6)$$

To calculate the number of direct collection tools (Trucks), the formula is:

$$= \frac{(\textbf{Ts road})+(\textbf{Ts Park})/\textbf{Day}}{\textbf{Truck capacity x 1,2 x Ritation}} \quad (7)$$

To calculate the number of containers for housing needs, the formula used is as follows:

$$\mathbf{CP} = \frac{\mathbf{(30\ until\ 40)\%\ x\ the\ number\ of\ Ts}}{\mathbf{Container\ capacity\ x\ Fp\ x\ Rk}} \quad (8)$$

The formula to calculate the number of containers for commercial needs and public facilities is:

$$\mathbf{CPN} = \frac{\mathbf{The\ number\ of\ Ts\ in\ (Commercial\ area+Public\ facility)}}{\mathbf{KC\ x\ Fp\ x\ Ritation}} \quad (9)$$

Where A is the number of luxury houses, B is the number of medium houses, C is the number of modest houses, D is the number of people in the flats, Kk is the capacity of the collecting device, Fp is the factor of solidification of the tool = 1.2, Rk is the ritation of the collecting device, Ts is waste generation.

2.3. Waste Calculation Retribution Method

Determination of waste retribution cost uses investment cost theory as follows:

Investment cost = Land and Building Cost + Main Equipment+Supporting Equipment (10)

3. Result and discussion

3.1. Method of Engineering Waste Management in the City of Pekanbaru

Waste management is related to the activities of handling waste generation problems and managing vehicle needs in the process of transporting waste. Garbage generation can be obtained by sampling (estimation) based on available standards. This waste generation can be calculated using a unit of weight (kg / o / day; kg / m^2 / day; kg / bed / day and so on) and volume unit (L / o / day; L / m^2 / day; L / bed / days and so on). However, the use of volume units can cause errors in interpretation because there are compaction factors that must be taken into account. Forecasts of waste generation both now and in the future are the basis of planning, designing, and assessing solid waste management systems. The average estimate of solid waste generation is the first step that is usually done in solid waste management.

Waste management in the city of Pekanbaru continues to be pursued in order to create a clean and healthy environment. Garbage in the city of Pekanbaru comes from residential areas and non-residential areas. Settlements are part of the people residence who in the process of daily living activities becomes permanent contributors to the category of household waste. Likewise, in every sub-district in the city of Pekanbaru, the non-settlement area also becomes a contributor to waste which greatly affected the amount of waste generation in Pekanbaru City. Non-residential areas consist of hotels, banks, restaurants, tourist attractions, shops, education areas, health care providers, shopping centers, markets, and industrial areas.

Several studies provide the number of municipal solid waste generation in Indonesia ranging from 2-3 liters / person / day with a density of 200-300 kg / m^3 and the composition of organic waste 70-80%. Meanwhile, the amount of production / generation of waste per person in the city of Pekanbaru for each sub-district, the composition of waste produced in settlements consists of the composition of food waste, paper waste, yard waste, plastic, textile / fabric, rubber, wood, glass, metal, B3 (Hazardous and Toxic Materials) and other ingredients (diapers, stereoforms, etc). Analysis of residential waste generation is based on population in the planned year. The calculation of the population needs to consider the population growth rate each year to see the average population growth rate. The population of the city of Pekanbaru is always increasing according to the development of the city. This population growth rates are caused by birth and migration rates. The amount of migration is still greater than the birth rate. The projection of the amount of residential waste generation in the City of Pekanbaru for 2018 reveals that the sub-district which will be the largest producer of waste generation is Tampan District at 182,770

tons / day. Data collection of these settlements includes simple residential areas, middle settlements and luxurious settlements. Subsequently, the sub-district which is the biggest contributor to waste generation after the Tampan District is Tenayan Raya District. This sub-district contributes 95.422 tons / day of solid waste generation for simple, medium and luxury residential categories.

Next, the total generation of waste produced in Bukit Raya Subdistrict is 52,678 tons / day. In this sub-district, simple settlements produce waste amounting to 35,622 tons / day, intermediate area produces 6,045 tons / day of waste and the luxury area produces 11,011 tons / day of waste. Likewise, Marpoyan Damai Subdistrict produces waste with a total of 52,597 tons / day with details for simple residential areas producing waste of 37,608 tons / day, the middle area producing 6,268 tons / day of waste and the luxury area producing 8,721 tons / day of waste.

In addition to residential areas, non-residential areas are also a source of waste generation. The highest level of waste generation in the hospitality area is in Lima Puluh Subdistrict, which is 13.56 tons / day. The restaurant becomes the biggest contributor, namely in Marpoyan Damai Sub-district of 23.44 tons / day. The shopping area that makes up 12.43 tons / day of solid waste generation is in Payung Sekaki District. The education area consisting of elementary school, junior high school, senior high school / vocational school and university is the highest waste generation in Tampan Sub-district at 11.86 tons / day until 23.44 tons / day. The area providing health facilities consisting of intermediate hospitals, large hospitals, health centers or clinics and pharmacies that produce the largest waste generation is in Marpoyan Damai Sub-district of 8.40 tons / day.

The shopping center area produces the biggest waste generation, namely Senapelan District 19.28 tons / day. The market area produces waste which consists of large markets, medium markets, small markets and traditional markets, namely Tampan Sub-district at 12.84 tons / day. Payung Sekaki Subdistrict is an industrial area of solid waste generation with a volume of 4.27 tons / day. The projected solid waste generation in the city of Pekanbaru for 2019 is the largest in Tampan Sub-district at 209.46 tons / day and for 2020 at 245.71 tons / day. Marpoyan Damai Subdistrict in 2019 is 85.40 tons / day and in 2020 is 88.06 tons / day. It is estimated that in 2019 the sub-districts considered as the smallest waste generation contributors are Sail Sub-district, which is 22.24 tons / day and in 2020 is 23.21 tons / day.

Based on the generation of waste generated by each sub-district, it is necessary to carry out a technical analysis of waste transportation which includes the storage system, collection patterns and transportation methods. It can be done through the development of storage facilities by paying attention to cheap and practical storage, utilization of unused goods for storage, socialization of storage by sorting waste. Individual containers equipped with a lid and placed in an easily accessible place can be in the form of 10-40 liter plastic bags, easily lifted trash cans 40-60 liters and permanent trash cans. The collection process will run effectively if the TPS facility is available and making TPS at a low cost. Furthermore, the City Government carries out data collection and registration to both individuals and institutions that carry out garbage collection and can facilitate collection facilities for individuals or institutions working in garbage collection. Garbage collection vehicles can be in the form of garbage motorcycles, garbage carts or pickup cars.

In the method of transportation in waste management in the city of Pekanbaru, there is a division of waste transport zones, namely priority zones and service cooperation zones. Priority zones are closely related to the 2014 Pekanbaru City Solid Waste Master Plan report that has set priority zones. Determination of priority areas for solid waste services is done based on considerations including population density and population distribution, physical and social economic characteristics, generation and characteristics of waste, cultural attitudes and behavior of people, distance from waste sources to garbage landfills, urban spatial planning and development, means of collection, transportation and processing, available costs and willingness to pay local contributions and regulations. From the map of the distribution of buildings in the city of Pekanbaru, it can be seen that the priority of handling is the area with built areas that cover the entire area, namely all Mining Areas or Service Areas I, which include Subdistricts of Pekanbaru Kota, Senapelan, Sukajadi, Sail and Lima Puluh. In addition to

Region I, there are also other high priority areas that have high density, namely Tampan Urban Village and East Labuh Baru Urban Village in Payung Sekaki Subdistrict, Tangkerang Tengah Urban Village in Marpoyan Damai Subdistrict, Tangkerang Utara Urban Village and Tangkerang Timur Urban Village in Bukit Raya Subdistrict. The second priority scale is the Built Area which still has open space, namely the areas in the Subdistricts of Tampan, Bukit Raya and Marpoyan Damai. The third priority scale is the area with built land with a small percentage, namely the Subdistricts of Tenayan Raya, Rumbai and Rumbai Pesisir.

In the Cooperation Service Zone, the Pekanbaru City Government through the Pekanbaru City Environment and Hygiene Agency in 2018 divides the Waste Management Zone into 3 Zones. Zone 1 includes the Subdistricts of Tampan, Payung Sekaki, and Marpoyan Damai with an estimated population in 2018 totaling 554,376 people and an estimated amount of waste generation after 30% reduction reaches 339 tons per day. Zone 2 includes Subdistricts of Sukajadi, Senapelan, Pekanbaru Kota, Lima Puluh, Sail, Bukit Raya and Tenayan Raya with an estimated population of 2018,702 in 2018 and the estimated number of waste generation after the reduction reaches 349 Tons per day. Zone 3 covers Subdistricts of Rumbai and Rumbai Pesisir with an estimated population in 2018 reaching 146,156 people and an estimated amount of waste generation after 30% reduction reaches 54 tons per day.

The results of this study are in line with research from [2] analyzing transportation of waste transport supported by the transport container system and the productivity of waste management activities ranging from storage systems, garbage collection and garbage collection methods.

The pattern of solid waste services is carried out from the source of waste to the landfill in Muara Fajar. From the source of garbage collection, it is carried out using motorized vehicle carts and pickup cars. Herobak motorbike collects waste from the waste source to the TPS, while pickup collects waste from the waste source to Trans Depo. Garbage transportation is carried out from the waste source using a small size dump truck directly to the landfill. For TPS with container bin, transport is carried out using an arm roll truck. While large trucks are used to transport from Trans Depo to the landfill. This is in line with the results of research conducted by [1] which states that the waste transport system is adjusted to the garbage collection system that is carried out communally with a garbage cart. The transport container system is more productive than the fixed container system in terms of personnel and the transported waste per vehicle. From the results of the analysis and calculation, many equipments, collection equipments, garbage transport vehicles and landfills are needed.

Analysis of the number of vehicles is also a support in the waste management of the city of Pekanbaru. The vehicles used in the process of transporting waste include motorized tricycle vehicles, pick-ups, dump trucks, dump trucks / communal dump trucks, large dump trucks, large dump trucks, armrolls and becho loaders. Sub-districts that require the largest number of garbage transport vehicles in 2018 are Tampan, which requires 20 units of vehicles, followed by Payung Sekaki for 13 units and Marpoyan Damai for 12 units of garbage transport vehicles. From distribution of the number of vehicles based on the zone, it can be seen that zone 1 requires 45 units of vehicles and zone 2 requires 46 units of vehicles. Total garbage transport vehicles reaquired for Pekanbaru City are 91 units in 2018.

3.2. Method of Calculating Waste Retribution Value in the City of Pekanbaru

Analysis of vehicle operating costs in solid waste management includes the cost of analyzing vehicle rental, which is hourly operating costs. All costs will be converted based on prediction and summary analysis to be used in hours. Recapitulation of the analysis of operational costs per Subdistrict for 2018 can be seen as follows:

Based on the details of the recapitulation of the analysis of operational costs in 12 sub-districts in the City of Pekanbaru, the details of the operational costs are divided into two zones. The first zone includes the Subdistricts of Tampan, Payung Sekaki, and Marpoyan Damai. In the first zone, the cost per day is Rp. 65,612,722, - with a monthly fee of Rp. 1,968,381,663, while the need per year for zone 1 requires a fee of Rp. 23,948,643,577. In the second zone, it consists of Subdistricts of Sukajadi, Senapelan,

Pekanbaru Kota, Lima Puluh, Sail, Bukit Raya and Tenayan Raya. The need for vehicle operating costs per day is Rp. 70,532,929, - with a monthly fee of Rp. 2,115,987,877, while the need per year for zone 2 requires a fee of Rp. 25,744,519,180. The total demand for vehicle operating costs for these two zones is Rp. 49,693,162,758, -.

The method of calculating waste restribution value is mainly for two zones, zone 1 and zone 2. Zone 1 includes Subdistricts of Tampan, Payung Sekaki, and Marpoyan Damai while Zone 2 includes Subdistricts of Sukajadi, Senapelan, Pekanbaru Kota, Lima Puluh, Sail, Bukit Raya and Tenayan Raya. The total cost required for the two zones in the first year, 2018, is Rp. 52,726,100,447.39, while in 2019 the total cost required for both zones is Rp. 56,630,866,725.39. In the third year, 2020, the total cost required is Rp. 67,233,230,103.67. The total cost required for the three budget years is Rp. 197,249,217,004.10.

Cost details for zone 1 which includes Subdistricts of Tampan, Payung Sekaki, and Marpoyan Damai from 2018 to 2020.

Cost necessities are based on the transport contract. A waste transport contract is a unit price where payments are made based on the volume of waste transported each day which is accumulated every month or in accordance with the provisions stipulated in the implementation contract.

Payment for 3 years (Multy Years) a budget of Rp 96,785,402,830 is prepared, - which was paid in the amount of Rp. 25,518,201,117, - for payments in Fiscal Year of 2018 and Rp. 27,944,112,000, - for payments in Fiscal Year of 2019 and 34,524,416,727, - for payments in 2020.

Payments are made based on the tonnage of transported waste from Zone 1 to Muara Fajar Landfill at a price of: a) Payment of waste retribution from Zone 1 to Muara Fajar Landfill of Rp. 213,588, - per year in 2018; b) Payment of waste retribution from Zone 1 to Muara Fajar Landfill of Rp. 217,781 per ton in 2019; c) Payment of waste retribution from Zone 1 to Muara Fajar Landfill of Rp 219,203, - per ton in 2020. Whereas the ceiling of the provided funds is: 349 tons per day or 127,385 tons for 1 year in 2018, 361 ton per day or 131,723 tons for 1 year in 2019 and 372 tons per day or 135,651 tons for 1 year in 2020.

Payment for Zone 2 which includes Subdistricts of Sukajadi, Senapelan, Pekanbaru Kota, Lima Puluh, Sail, Bukit Raya and Tenayan Raya.

The breakdown of costs for waste retribution in zone 2 for three years, namely the period 2018 to 2020 (multy years), a budget of Rp. 97,463,814,174 is prepared, -. In the 2018 fiscal year, the total cost of this first year is Rp. 27,207,899,329, -. In 2019 the total need for waste retribution costs is Rp. 28,686,754,724, -. In 2020 the total cost required is 32,708,813,376.

Payments are made based on the tonnage of transported waste from Zone 2 to the Muara Fajar Landfill with Price; a) Payment of waste retribution from Zone 2 to Muara Fajar Landfill of Rp. 206,233, - per ton in 2018; b) Payment of waste retribution from Zone 2 to the Muara Fajar Landfill of Rp 208,006, - per ton in 2019; c) Payment of waste restribution from Zone 2 to Muara Fajar Landfill of Rp 209,396, - per ton in 2020.

The budget ceiling provided for 349 tons per day or 127,385 tons for 1 year in 2018.

In 2019 the budget ceiling is 361 tons per day or 131,733 tons for 1 year in 2019 and in 2020 the budget ceiling is 372 tons per day or 135,651 ton for 1 year in 2020. This research is in accordance with a research conducted by [4], [5,7,8]. The results of his research finding state that demand surveys in price fixing are closely related to the magnitude of demand, transportation, differences in community income levels and community social status. Therefore, the solution in determining the price of a retribution that is rational based on the characteristics of the household is through a survey. The implementation of the garbage retribution policy still faces a lot of obstacles which impact on solid waste handling services

which are still not optimal. This is because of the limited availability of the budget.

4. Conclusion

Based on the results of the research on the method of calculating the value of retribution and engineering of garbage transport in solid waste management efforts in Pekanbaru, it can be concluded that the engineering method of solid waste management in the city of Pekanbaru includes waste storage, garbage collection patterns and methods of garbage transportation by dividing zones consisting of priority zones and cooperation service zones. The cost of waste collection needed for Zone 1 including Subdistricts of Tampan, Payung Sekaki and Marpoyan Damai is Rp. 206,232.68 / ton of waste, while for zone 2 including Subdistricts of Sukajadi, Senapelan, Pekanbaru Kota, Lima Puluh, Sail, Bukit Raya and Tenayan Raya is Rp. 213,587.94 / ton of garbage.

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