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WASTE MANAGEMENT SITES - REDUCE, REUSE, AND RECYCLE (TPS3R) CONSTRUCTION STUDY IN SEKANAK AREA, PALEMBANG CITY

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***Abstract*— In Palembang, one of Indonesia's major municipalities, there were several challenges with the solid waste management system, notably in families. Adopting the 3R strategy to reduce waste production is one way to address the waste problem in Palembang (reuse, reduce, recycle). The Reduce-Reuse-Recycle Waste Management Site, or TPS3R, is located in Indonesia. It follows a pattern of waste management on a local or regional scale. One of the numerous tributaries of the Musi River, a significant river in this city that passes through Palembang, is the Sekanak River. The accumulation of waste in the drainage channel and its tributaries is one of the factors contributing to the decline in river water quality. Near the center of the city, the Sekanak region extends along the river's about 10-meter-wide course. Due to the fact that many residents who live close to rivers neglect waste management, the quality of the river water is damaged. It is projected that the TPS3R construction will be able to address the waste issue in the Sekanak area by looking at social, technological, and TPS3R feasibility development factors. The approach of the feasibility study is made up of the stages of work activities, preparatory activities, field surveys, data collection, analytical activities, and activity plan recommendations. The total investment cost for the 15 m × 20 m facility that makes up TPS3R is IDR 290,824,000. The cost of building the infrastructure and purchasing the equipment are included in this amount. Over the course of four days, the weight of organic waste per person per day ranged from 259.60 to 395.07 grams, with an average of 307.12 grams, whereas the weight of non-organic trash per day ranged from 114.02 to 188.85 grams. Average daily intake is 149.34 grams per person.**

***Keywords*— Solid Waste Management, Water Quality, Reduce-Reuse-Recycle, Feasibility Study**

I. INTRODUCTION

MUNICIPALITY will have a significant burden to prepare new infrastructure in order to avoid slum settlements, environmental pollution, and water puddles owing to solid waste due to the high rate of population expansion [1]. The mismatch between waste production and processing, as well as the declining capacity of nature as a waste dump, are the causes of the waste problem. On the one hand, waste generation is increasing rather quickly, but on the other, waste processing capacity is insufficient. As people's lives improve and trash of all forms and compositions gets more complex, handling and controlling the problem of domestic waste becomes more difficult [2]. An indicator of the evaluation of sustainable development is even how much waste is produced and successfully recycled. The environment and people can be protected by using Municipality System Management Waste (MSMW) and the notion of zero waste [3].

Waste can result from a variety of modes of use, such as something that is no longer useful due to damage, excess of a use (such as excess food), wrapping (packaging) goods that serve to protect goods, leftover food from production activities (such as sawdust, pieces of cloth, etc.), or items that function but are no longer in use because the user has a newer item [4]. There were numerous issues with the solid waste management system, particularly in households, in Palembang, one of Indonesia's major towns. There are many distinct types of households in Palembang, and each type created solid waste with a unique composition [5].

One approach to solving the waste issue in Palembang is to adopt the 3R approach to reduce the amount of waste produced (reuse, reduce, recycle). Regulation No. 13 of 2012 on directions for the application of 3R was released by the Indonesian Ministry of Environment on 2012. (Reduce, Reuse and Recycle). By 2019, the legislation aimed to cut waste production to 20%. The 3R program is anticipated to decrease the amount of garbage disposed to landfills, which can decrease the requirement for landfill availability [6]. Over time, numerous advantages of 3R have been demonstrated. These include energy savings, the preservation of natural resources, a decrease in the amount of waste going to the landfill, the creation of jobs, and a rise in public knowledge of environmental issues. The 3R concept is generally supported by citizens, according to studies from several nations, but there are still some things to take into account before it can be implemented. Restrictive legislation, inadequate technology, a weak economy, and a lack of human resources are a few

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examples [7]. The Reduce-Reuse-Recycle Waste Management Site is called TPS3R in Indonesia which have a pattern of approach to waste management on a local or regional scale, involving the active role of the government and the community, through an awareness creation approach, including for low-income communities and/or living in dense, run-down settlements.

Ogechukwu Franca Eze [8] has undertaken research on the effects of solid waste on River Usuma water quality. The effects of waste disposal on the River Usuma in Phase IV Kubwa were examined in this study, along with variations in the water's physiochemical and biological characteristics and comparisons of the water's quality to WHO criteria. The study has also provided recommendations for how to deal with the issues it uncovered, including bettering the sanitation in the study area, providing adequate waste management facilities while prioritizing public education, ensuring the availability of clean water in the area, and making efforts to stop trash from being dumped along riverbanks.

According to research done by Aprizal Satria Hanafi [9] in Banjarmasin City, socioeconomic characteristics can influence how solid waste affects river pollution. In order to develop corrective action plans, this study set out to determine socioeconomic and demographic aspects that were connected to family members' awareness, usage, and behavior regarding household waste management. People who reside near a river in the city of Banjarmasin and who match the inclusion and exclusion criteria for the sample make up the study population. This result also found that communities have unsafe knowledge, practices, and behaviors in relation to waste management. This study concludes that promotion of environmental information and public education on proper waste disposal needs to be done to improve the health and safety of the community environment.

The solid waste management system in Indonesia still has issues, particularly in major cities like Palembang City. The Sekanak River is one of the many tributaries of the Musi River, a sizable river in this city that flows through Palembang. One of the causes contributing to the reduction in river water quality is the buildup of waste in the drainage channel and its tributaries.

The idea is to use waste processing facilities, specifically TPS3R, particularly in the Sekanak region, to control waste in the river network and drainage. The Sekanak region is close to the city's core and runs along the Sekanak river, which has a width of around 10 meters. The quality of the river water is impacted because many people who live near rivers do not pay attention to waste management. Despite the area's adequate waste management system, the nearby community's terrible habits result in garbage still being dumped into the river. Building a waste processing facility is the only way to find a way around this. By examining social, technical, and TPS3R feasibility development elements, it is anticipated that the TPS3R construction will be able to resolve the waste issue in the Sekanak area.

II. RESEARCH METHODOLOGY

The stages of work activities, preparatory activities, field surveys, data compilation, analysis activities, and activity plan recommendations make up the methodology of the feasibility study. To determine the characteristics of respondents at the research site so that the questionnaire method can adjust the respondents' characteristics, particularly from the form of questions. Survey techniques and waste sampling were used to determine the characteristics, composition, and rate of garbage generation along the Sekanak river. The findings of the identification of waste creation at different locations along the river will be statistically and descriptively studied to determine the average value, greatest value, and smallest value. The Minister of Public Works Regulation No. 3 of 2013 pertaining to the implementation of waste infrastructure and facilities in the handling of domestic waste and other types of household waste is cited in the TPS3R development study.

III. EXPERIMENT AND RESULT

Using a questionnaire instrument containing the following questions, community involvement in the TPS3R development plan was evaluated:

1) Results of Income and Education Level of Respondents
2) The closest TPS location to my home is about 200 meters away.
3) Your willingness to pay monthly waste fees
4) To avoid odors and illness sources, the TPS is situated distant from your home.
5) Because it is more than 200 meters away, don't throw trash at TPS.
6) Dispose of Waste Aside from TPS

According to the results of the income questionnaire conducted in the area, the community's income level is less than IDR 1,500,000 million by 43.3 percent, between IDR 1,500,000 and IDR 2,500,000 million by 43.3 percent, and over IDR 2,500,000 by 13.3 percent. According to the results of the Education Level Questionnaire in the area, up to 16.7%% of the population has completed elementary school, followed by 30% for junior high schools, 40% for senior high schools, and 13.3% for universities. According to the survey's findings, 13.33 percent of respondents strongly agree, 60 percent agree, 20 percent agree generally, 6.67 percent disagree, and 0 percent strongly disagree about the location of the closest 3R TPS to residents' houses, which is less than 200 meters away. According to the survey results on "Willingness to Pay Contributions Every Month," those who strongly agree, agree, and disagree by as much as 0%, while average respondents agree by as much as 20% and disagree by as much as 80%. According to the survey's findings, the 3R TPS is located away from your home to avoid odors and potential illness sources. Of those surveyed, 10 percent strongly agree, 23 percent agree, 13 percent agree, 53 percent disagree, and 0 percent strongly disagree. According to the survey's findings,

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33 percent of respondents highly agree, 63 percent agree, 3 percent are normal, 0 percent disagree, and 0 percent strongly disagree with the statement Don't Dispose of Garbage at TPS since it is more than 200 meters away. Which according to survey's findings on disposing of waste somewhere other than the TPS, 10 percent of respondents highly agreed, 30 percent agreed, 23 percent were normal, 37 percent disagreed, and 0 percent strongly disagreed.

Several samples are taken at the work site in order to measure waste generation and composition according to SNI 19-3964-1994 [10], specifically dependent on the kind of house. 50 families that live close to the potential TPS3R building site were randomly selected to receive waste samples. The sampling of waste creation is done over the course of four days, with working days and weekends being the days that are chosen. This aims to determine the volume and weight trends of waste produced by locals close to the study site. According to the measurement results Table-1, an average individual produces 4.53 liters of organic waste per day, while an average person produces 2.52 liters of non-organic waste per day.

Fig. 1. solid waste samples at the research site

The weight of organic waste measured (Table-2) over the course of four days ranged from 259.60 to 395.07 grams per person per day, with an average of 307.12 grams, whereas non-organic waste ranged from 114.02 to 188.85 grams per person per day, with an average of 149.34 grams per person per day.

Table -1 Waste volume measurement results

Sample	**Vol of organic waste (ltr/person/days)**				**Vol of non-organic waste (ltr/person/days)**			
	Mo	**Th**	**Sa**	**Su**	**Mo**	**Th**	**Sa**	**Su**
Non-Permanent House	3.46	5.94	4.22	6.84	2.24	2.11	3.48	2.43
Semi Permanent House	3.5	3.42	4.53	6.43	2.43	2.34	2.12	2.22
Permanent House	5.6	1.42	2.54	6.4	3.33	3.31	1.45	2.76
Average	**4.19**	**3.59**	**3.76**	**6.56**	**2.67**	**2.59**	**2.35**	**2.47**
	4.53				**2.52**			
Total	**7.05**							

Table -2 Waste weight measurement results

Sample	**Weight of organic waste (gram/person/days)**				**Weigh of non-organic waste (gram/person/days)**			
	Mo	**Th**	**Sa**	**Su**	**Mo**	**Th**	**Sa**	**Su**
Non-Permanent House	278.4	232.1	344.3	442.8	134.5	110.3	124.3	122.3
Semi Permanent House	277.5	257.9	232.2	360.3	155.42	120.45	99.52	233.4
Permanent House	300	375.5	202.3	382.1	139.3	111.32	230.4	144.3
Average	285.30	288.50	259.60	395.07	143.07	114.02	151.41	188.85
	307.12				149.34			
Total	**278.4**							

Table -3 Comparison the average waste weight with others study

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Comparison subjects	**Current study**	**Putri, et al (2020) [10]**	**Ananda, et al (2019) [11]**	**Pratiwi, et al (2019) [12]**
Number of samples	50 houses	383 persons	3-unit houses	2 pillars of neighbour
Sampling time	4 days	7 days	7 days	2 days
Sample category	Non-Permanent House, Semi Permanent House, Permanent House	Low income, middle income, high income	-	-
The result of average solid waste weight (grams/person/day)	278.4	290.95	725.5	460.0

Table 3 compares the solid waste weight results from the current investigation and other studies. The table displays the various solid waste weight results and the various sample times. This is a result of variations in the sampling characteristics used to dispose of the waste [13].
Fig.1. show the solid waste sampels, the most common type of waste is organic waste, which is composed of kitchen scraps or food waste on average to the extent of 67.27 percent, while non-organic waste, which is composed on average of 32.73 percent plastic waste (food wrappers, bottles, and glass), paper waste, and cloth waste, is produced in smaller amounts. Each household's trash collection is mixed together and has not been broken down by trash kind.

Fig. 2. Existing condition of waste collection in Sekanak

According to the findings of waste generation in the research region, the volume of waste disposed of each day per person surpasses the current standard The Minister of Public Works Regulation No. 3 of 2013 of 3 liters/person/day, indicating a significant amount of waste generation. It is required to construct TPS3R to minimize and process waste in the study area because the impact of the high volume is that there may be unlawful waste dumping, which could affect the aesthetics of the surrounding environment.
The waste collection system has the infrastructure and facilities to handle waste, including sorting waste according to kind. According to the existing circumstances in the study's vicinity (Fig.2.), there are a number of waste collecting sites (TPS) in the shape of concrete tanks with dimensions of 1 m x 1 m x 1 m and a volume of 1 m^3 for mixed waste. The reservoir does not meet SNI 19-2454-2002's standards, for example, the volume of waste that cannot handle domestic waste, according to the technical specifications.
Reduce, Reuse, and Recycle Waste Management Site (TPS 3R) is being implemented to benefit a community group in the Sekanak region that consists of 400 households or household heads (including in low-income community areas). Waste management is a sequence of storage, collection, transportation, processing, and final processing subsystems in its implementation, with the processing subsystem including the 3R TPS infrastructure. The 300 m^2 TPS3R plan under consideration has dimensions of 20 meters in length and 15 meters in breadth, and the area satisfies the minimal TPS standards based on The 2017 TPS3R Technical Guidelines by the Ministry of Public Works Director General of Human Settlements Indonesia. The recommended TPS 3R building design with an area of 300 m^2 measuring 15 m x 20 m where there are several areas or facilities including:

a) Reception area
b) Area for sorting organic and inorganic waste
c) Compost warehouse
d) Temporary storage of inorganic waste
e) Residual garbage collection (unused)

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f) TPS3R pengelola management office
g) Toilets and clean water facilities
h) Simple leachate treatment plant

It takes about 3 weeks to transform organic waste into compost so that it satisfies quality requirements and can be used effectively for plant nutrition according to Compost Specifications from Domestic Organic Waste governed by SNI: 19-7030-2004. The following will be a description of the organic waste space required plan:
The volume of incoming organic waste = 7.05 liters/person/day x 400 families x 4 people x 67.27% = 7.59 m^3/day
Waste density = waste weight : waste volume = 456.46 gram/day : 7.05 liter/day = 64.75 kg/m^3
Weight of organic waste produced = solid waste density x volume of organic waste per day = 64.75 kg/m^3 x 7.59 m^3/day = 491.46 kg/day
So space requirement = volume of organic waste: design height = 7.59 m^3/day: 1.2 m = 6.4 m^2/day. The space used is in the form of a tub with a concrete construction which has dimensions of 2.6 m long x 2.6 m wide x 1.2 m high.
Following to the results of the calculation of the volume of trash and the composition of waste in the study area, a special operating room is needed to manage organic waste that will enter the TPS3R in order to facilitate the sorting activity between organic waste and inorganic garbage. Inorganic (non-organic) waste space requirements are calculated as follows:

Incoming volume of non-organic waste = 7.05 liters/person/day x 400 families x 4 people x 32.73% = 3.7 m^3/day
Waste density = waste weight : waste volume = 456.46 gram/day : 7.05 liter/day = 64.75 kg/m^3
Weight of non-organic waste produced = solid waste x volume of non-organic waste per day = 64.75 kg/m^3 x 3.7 m3/day = 239.58 kg/day
Space requirements for non-organic waste = volume of non-organic waste: design height = 3.7 m^3/day: 1.2 m = 3.1 m^2/day. The space used is in the form of a tub with a concrete construction which has dimensions of length 1.8 m x width 2.6 m x height 1.2 m.
The technical requirements of the building on the planned TPS3R must be changed to account for the area that will be constructed in as well as local material considerations for the various types of work that will be done, such as main building work, roofing work, preparatory work, foundation work, earthwork, painting work, and mobilization of tools and equipment. In this feasibility study there are several works that will be carried out for the construction of this TPS3R (Fig.3.), namely:

a) Construction of floor slabs with dimensions of length 15 m x width 20 m as a barrier between soil and garbage so that soil contamination does not occur.
b) The work of making space for processing organic waste as compost storage is as many as 8 tubs according to the previous calculation.
c) Construction of the reception and sorting area with the collection tank.
d) Roof/hangar work to cover the reception, sorting and compost processing areas
e) Construction work for TPS3R management office
f) Construction of toilets and clean water facilities
g) The construction work of simple leachate treatment.
h) Leachate drain work
i) Drainage work
j) Fence work

The estimated costs incurred for some of these TPS3R construction works are:

a) Floor slab construction work costs IDR 900,000/m^3, so the total cost of floor slabs is IDR 32,400,000
b) Making masonry compost bins with a cost of IDR 200,000/m^2, so the total cost is IDR 20,800,000.00
c) Making a brick masonry inorganic waste collection tank requires IDR 200,000/m^2, so the total cost is IDR 3,024,000.00
d) Light steel roof/hangar work with requires a cost of IDR 150,000/m^2, so the total cost is IDR 18,000,000.00
e) Office work is estimated to cost IDR 10,000,000.00
f) The toilet construction work is estimated to cost IDR 5,000,000.00
g) Construction of a simple leachate treatment is estimated to cost IDR 5,000,000.00
h) The leachate drain work is estimated at IDR 2,000,000.00
i) Drainage work is estimated at IDR 2,000,000.00
j) BRC type fencing work with a length of 70 m at a cost of IDR 500,000/m, so the total cost is IDR 35,000,000.00

Since the computation of this cost each month assumes that it will last for 10 years, the investment cost of TPS3R infrastructure development is IDR 13,322,400.00/year. As a result, the total cost of TPS3R infrastructure development is IDR 133,224,000.00 for the first year. It is important to buy supporting equipment, such Table-3, in order for this TPS3R to function. Equipment costs are only issued once for the beginning of the year with an estimated cost of Rp. 157,600,000.00 so that the calculation of this cost per month is assumed to last for 10 years at Rp. 15,760,000.00/year.

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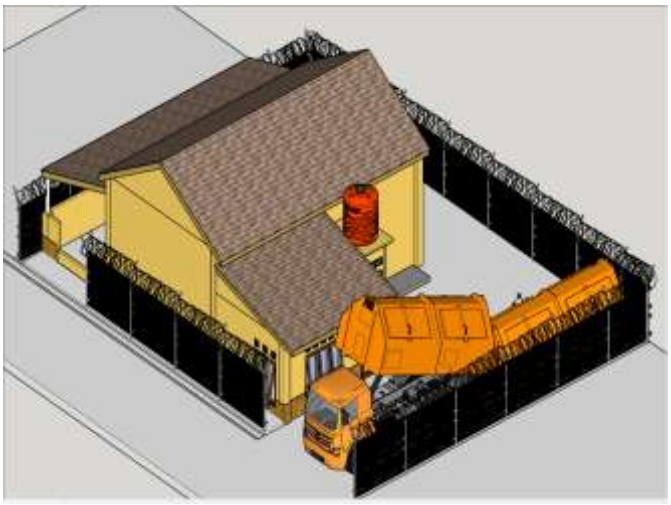

Fig. 3. Planned TPS3R in this study

Table -3 Equipment Purchase Cost

Equipment Purchase Cost	**Amount**	**Unit cost**	**Total cost**
405 kg capacity garbage truck	1	IDR45,000,000	IDR 45,000,000
Container capacity 6 m^3	2	IDR 30,000,000	IDR 60,000,000
0.3 kW water pump engine	1	IDR 500,000	IDR 500,000
Street lamps and poles 7 meters solar cell	1	IDR 2,500,000	IDR 2,500,000
Room lighting	6	IDR 100,000	IDR 600,000
Composting machine	1	IDR 7,000,000	IDR 7,000,000
Tedmon	1	IDR 2,000,000	IDR 2,000,000
Plastic crushing machine	1	IDR 40,000,000	IDR 40,000,000
		TOTAL	IDR **157,600,000**

In the aspect of the feasibility study of the TPS3R development plan, it is also reviewed regarding the operational financial aspects per year to find out the costs that must be incurred and also to find out the amount of fees or waste retribution charged to the community. The details of operational costs are in Table-4. The cost that must be spent annually is IDR 13,322,400.00 + IDR 15,760,000.00 + IDR 183,132,000 = IDR 212,214,400 per year = IDR 17,684,534/month.

The amount of fees paid for TPS3R services is IDR 17,684,534 : 400 houses = IDR 44,212/house/month.

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Table- 4 Operational Cost

Operational cost	**Amount**	**Unit cost**	**Total cost**	**Description**
Operator salary	4	IDR 3,200,000	IDR 153,600,000	For 1 year
Gasoline	4	IDR 7,000	IDR 10,080,000	For 1 year
Garbage motorbike maintenance costs	1	IDR 750,000	IDR 750,000	3% per year
Engine fuel Garbage motorbike	3	IDR 9,400	IDR 10,152,000	For 1 year
Waste Processing maintenance costs	1	IDR 1,350,000	IDR 1,350,000	For 1 year
Electricity cost	1	IDR 10,000,000	IDR 10,000,000	For 1 year
Water cost	1	IDR 1,200,000	IDR 1,200,000	For 1 year
		TOTAL	**Rp183,132,000**	For 1 year

Mathematical estimates are utilized to calculate the payback period or BEP in the TPS3R planning by comparing annual income/income with annual expenses (Table-5). The contribution capacity of locals is estimated to be IDR 50,000/house/month, translating to an annual total income of IDR 240,000,000. The data on income (revenues) and expenses are initially compiled into a tabular form to be used in the analysis to determine the payback time. From the results of the calculation of mathematical estimates, it is found that the payback period is 5-6 years if the income per year is IDR 240,000,000.00.

Table- 5 Payback period analysis

Period (year)	**Income**	**Expenses**	**Gain**
0	0	IDR290,824,000	-IDR290,824,000
1	IDR 240,000,000	IDR183,132,000	-IDR233,956,000
2	IDR 240,000,000	IDR183,132,000	-IDR177,088,000
3	IDR 240,000,000	IDR183,132,000	-IDR120,220,000
4	IDR 240,000,000	IDR183,132,000	-IDR63,352,000
5	IDR **240,000,000**	**IDR183,132,000**	**-IDR6,484,000**
6	IDR **240,000,000**	**IDR183,132,000**	**IDR50,384,000**
7	IDR 240,000,000	IDR183,132,000	IDR107,252,000
8	IDR 240,000,000	IDR183,132,000	IDR164,120,000
9	IDR	IDR183,132,000	IDR220,988,000

	240,000,000		
10	IDR 240,000,000	IDR183,132,000	IDR277,856,000

IV.CONCLUSION

Considering that research on TPS3R has been well-conducted, the following conclusions can be drawn:

1) According to the measurement results, an average person produces 4.53 liters of organic waste daily, compared to 2.52 liters of non-organic waste
2) The weight of organic waste, as measured over the course of four days, ranged from 259.60 to 395.07 grams per person each day, with an average of 307.12 grams, whereas non-organic waste weighed between 114.02 and 188.85 grams per day. 149.34 grams per person per day on average.
3) The overall investment cost for the building of TPS3R, which has dimensions of 15 m x 20 m, is IDR 290,824,000. This sum includes the cost of developing the infrastructure and the cost of purchasing the equipment.

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