Evaluation of TPS 3R and Waste Bank Management in Sungai Penuh City

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ABSTRACT

Sungai Penuh City has 16 units of TPS 3R and 1 unit of waste bank that are not operating optimally. The evaluation to determine the condition of TPS 3R and waste bank and the potential reduction obtained if they are operated again. The research began by collecting data on generation of solid waste, composition, and recycling possibilities for household waste. Sampling of waste generation based on SNI 19-3964-1994 in 8 sub-districts in Sungai Penuh City for 8 consecutive days with the household generation of solid waste outcome of 0.328 kg/person/day or 2.789 l/person/day. The composition of household waste in Sungai Penuh City includes 57.74% food waste, 14.38% plastic waste, 11.62% paper waste, 5.19% yard waste, 4.89% other waste, 2.79% glass waste, 2.16% fabric waste and 1.24% metal. Sungai Penuh City has the capacity to recycle household solid waste is 68.90%. TPS 3R and waste bank was evaluated based on the Technical Guidelines for TPS 3R of The Ministry of Public Works and Housing in 2023 and the Regulation by the Minister of Environment and Forestry Number 14 of 2021. The evaluation results show that 3 units of TPS 3R are in the medium category, 4 units of TPS 3R are in the less category and 9 units of TPS 3R are in the bad category. Meanwhile, waste bank is in the bad category. The potential for waste reduction by TPS 3R and waste bank if operated optimally is 23.26% of the total waste generated in Sungai Penuh City.

INTRODUCTION

Sungai Penuh City Government built 16 units of TPS 3R by 2022 with the aim of reducing municipal waste transported to landfill. In addition, a waste bank has also been built in 2015 with the aim of not only reducing waste but also as a means of education and a forum for the community in sorting household waste. Waste that has been sorted can be reused so that waste will be reduced from the source before being transported to the landfill [1]. Currently, TPS 3R and waste bank are not operating properly. Sungai Penuh City, which does not have a definitive landfill, requires optimal waste reduction efforts from the source. One approach to minimize waste generation is through TPS 3R and waste bank [2].

TPS 3R is a form of waste management where the operation, maintenance and management are carried out by the community [3]. Meanwhile, waste bank is implemented with the principle of engineering the social conditions of the community to be interested in waste sorting which involves the culture and habits of the community [4]. To estimate the possibilities for waste reduction using waste bank and TPS 3R, data on generation of solid waste, composition, and recycling possibilities for household waste are needed. Generation of

solid waste data is very important for the development of a good alternative waste management system, because it relates to the elements of waste management. In addition, solid waste generation data is required to determine the sustainable management of waste system [5]. Waste composition is data used to select and determine the method of operation of machinery and equipment and calculate the utilization of waste processing facilities [6].

The goal of this research is to examine generation of solid waste, composition, and recycling possibilities for household waste in Sungai Penuh City and evaluate the existing conditions of household waste management at TPS 3R and waste bank in Sungai Penuh City so that the reduction potential of household waste in Sungai Penuh City is known.

METHODS

The research was carried out with stages of literature study, secondary data collection, primary data collection through sampling measurements of examine generation of solid waste, composition, and recycling possibilities. Furthermore, an evaluation of the existing conditions of TPS 3R and waste bank and an analysis of the potential for waste reduction by TPS 3R and waste bank.

Primary Data

Primary data in the form of a study of the generation of solid waste, composition, and recycling possibilities of household waste in Sungai Penuh City. Furthermore, data on the existing circumstances of TPS 3R and waste bank built in Sungai Penuh City were obtained through interviews and field observations. The sampling method is based on SNI 19-3964-1994 concerning Methods of Taking and Measuring Examples of Urban Waste Generation and Composition. Samples were taken representing 8 (eight) sub-districts in Sungai Penuh City carried out on 8 (eight) consecutive days.

Sample size calculation

$$S = Cd\sqrt{Ps} \tag{1}$$

$$K = \frac{S}{n} \tag{2}$$

Cd : housing coefficient
Ps : total population
n : average number of people in one house

Number of people sampled

$$S = Cd\sqrt{Ps}$$
$$= 0,5\sqrt{97.373}$$
$$= 156 \text{ people}$$

Number of houses sampled

$$K = \frac{S}{n} = \frac{156 \text{ people}}{5 \text{ people/house}} = 31 \text{ houses}$$

Waste Generation Calculation

$$q \text{ average} = \frac{(q1+q8)}{2} \tag{3}$$

$$fp = \frac{q \text{ average}}{q1} \tag{4}$$

q1 : first day sampling data

q8   : last day sampling data
q rata-rata   : first and last day sampling average
fp   : correction factor

Waste Composition Calculation

$$\% \text{ waste composition} = \frac{B}{BBBs} \text{ x } 100\% \tag{5}$$

Calculation of Waste Recycling Potential

$$\text{Recycling potential} = \frac{\text{weight of recyclable components}}{\text{total weight of waste from the source}} \text{ x } 100\% \tag{6}$$

Secondary Data
The secondary data required is the population and per capita income of the population of Sungai Penuh City [7].

Evaluation of TPS 3R and Waste Bank
The evaluation was conducted based on the Technical Guidelines for TPS 3R of the Ministry of Public Works and Housing in 2023 and the Minister of Environment and Forestry's Regulation Number 14 of 2021 [8].

Evaluation of TPS 3R
The evaluation of TPS 3R is carried out by comparing the existing conditions with the Technical Guidelines for TPS 3R of the Ministry of Public Works and Public Housing in 2023. By conducting an evaluation in accordance with the technical guidelines, the performance of TPS 3R can be known [9]. TPS3R assessment uses 5 aspects/criteria, where each aspect/criteria has a different number of indicators, namely:
a. The aspect/criteria of supportive regulatory products has 2 indicators;
b. Technical-technological aspects/criteria have 6 indicators;
c. Aspects/criteria of managing institutions have 6 indicators;
d. Financial aspects/criteria have 3 indicators;
e. The participation aspect/criteria has 4 indicators

Each indicator has 3 parameters with the same assessment levels of 5, 3, and 1. Next, determine the indicator value and aspect weight. Calculate the relative value obtained from multiplying the indicator value by the aspect weight. The total relative value will determine the condition of TPS 3R with the following categories:
- >19,0   : good
- $14,3 < N \leq 19,0$: medium
- $9,5 < N \leq 14,3$: less
- $\leq 9,5$: bad

Evaluation of Waste Bank
The Minister of Environment and Forestry's Regulation Number 14 of 2021 on waste management in waste bank guides the examination of waste bank, including aspects:
a. Waste management consists of waste reduction and waste handling;
b. Facilities of waste bank include building area, fixtures, walls, floors; ventilation, ceilings and doors;
c. Implementation of governance including institutional structure, scope of services, customers and SOP.

Table 1 shows the scoring assessment of waste bank based on a Likert scale in the form.

Table 1. Scoring Based on Likert Scale

No.	Description	Score
1.	Implementing waste management in waste bank in compliance with PermenLHK No.14/2021	3
2,	Implementing waste management in waste bank is highly consistent with PermenLHK No.14/2021.	2
3.	Implementing waste management in waste bank is not in accordance with PermenLHK No.14/2021	1

Furthermore, the calculation is carried out to get the percentage of the actual score of each aspect with the following formula:

$$\text{Percentage of actual score} = \frac{\text{Total actual score}}{\text{Total ideal score}} \times 100\% \qquad (6)$$

Table 2. shows the assessment categories for the achievement of waste management in waste bank.

Table 2. Rating Criteria Based on Likert Scale

No.	Percentage (%)	Criteria
1.	33 - 55	Not Good
2.	56 - 77	Good enough
3.	78 - 100	Good

Potential Reduction of Household Waste in Waste Bank and TPS 3R
Household waste reduction potential in percentage form with the following equation:

$$\text{Waste generation reduction} = \text{total waste generation} \times \text{waste recycling potential} \qquad (7)$$

$$\text{Waste reduction percentage} = \frac{\text{waste generation reduction}}{\text{total waste generation}} \times 100\% \qquad (8)$$

RESULTS AND DISCUSSION

Household Waste Generation in Sungai Penuh City
The research was conducted by taking fluctuations in household waste generated per day. Sampling was carried out at 31 points spread across 8 (eight) sub-districts in Sungai Penuh City. Seasonal differences during sampling had no significant effect on dry and wet household waste generation [10]. The calculation of waste generation is divided into 3 (three) categories, namely High Income, Middle Income and Low Income. According to the calculated figures, the average generation of household waste of Sungai Penuh City in 2022 is 0.328 kg/person/day in weight units and 2.789 l/person/day in volume units.

The recapitulation of household waste generation in Sungai Penuh City in units of weight can be seen in Figure 3.1. In Table 3, the average household waste generation in units of weight per category of high income, medium income, and low income is 0.396 kg/person/day, 0.338 kg/person/day, and 0.251 kg/person/day.

The recapitulation of household waste generation in Sungai Penuh City in volume units can be seen in Figure 1. The average household waste generation in volume units for each category of high income, medium income, and low income is 3.196 l/person/day, 2.811

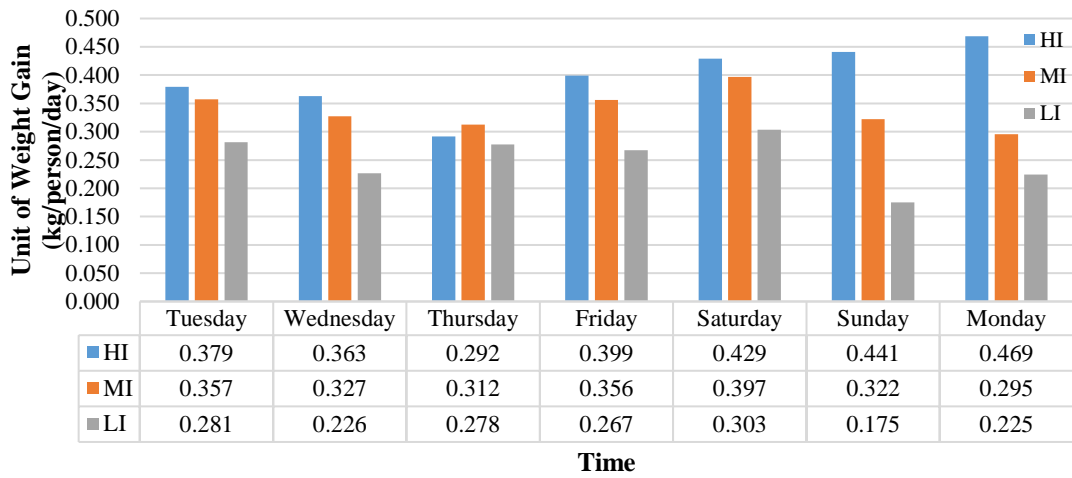l/person/day and 2.360 l/person/day respectively, which can be seen in Table 4.

	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday
HI	0.379	0.363	0.292	0.399	0.429	0.441	0.469
MI	0.357	0.327	0.312	0.356	0.397	0.322	0.295
LI	0.281	0.226	0.278	0.267	0.303	0.175	0.225

Figure 1. Recapitulation of Household Waste Generation by Weight Unit

Table 3. Household Waste Generation by Weight Unit of Sungai Penuh City

Waste Source	Total Generation (kg/person/day)	Average Total Generation (kg/person/day)	Total Population (people)	Sungai Penuh City Waste Generation (ton/day)
HI	0.396	0.328	97,373	31.938
MI	0.338			
LI	0.251			

Table 4. Household Waste Generation Unit Volume Sungai Penuh City

Waste Source	Total Generation (l/person/day)	Average Total Generation (l/person/day)	Total Population (people)	Sungai Penuh City Waste Generation (m³/day)
HI	3.196	2.789	97,373	271.573
MI	2.811			
LI	2.360			

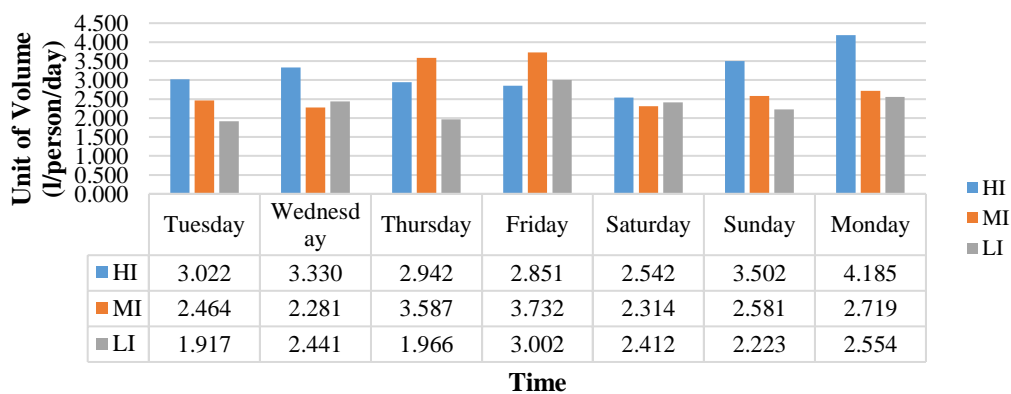|	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday
HI	3.022	3.330	2.942	2.851	2.542	3.502	4.185
MI	2.464	2.281	3.587	3.732	2.314	2.581	2.719
LI	1.917	2.441	1.966	3.002	2.412	2.223	2.554

Figure 2. Recapitulation of Household Waste Generation Unit Volume

In Figure 1 and Figure 2 there are unstable fluctuations in waste generation, where there are conditions where the generation of medium income, and low income is higher than the high income category. This can happen because the composition of waste generated varies quite a lot from various groups of residents in Sungai Penuh City depending on the daily activities of residents. Overall, the average value of household waste generation in Sungai Penuh City can be seen that the high income > medium income > low income category. This is in accordance with BPS Sungai Pernuh City data which shows that the per capita expenditure of the high income category is the highest compared to the other two categories so that the waste generated is directly proportional to the expenditure, which is greater than the other categories. The number of occupants has a significant impact on waste generation, whereas total weight of waste residue does not really affect the total composition of waste [11].

Composition of Household Waste in Sungai Penuh City

The results of the calculation of the waste composition of Sungai Penuh City by income level can be seen in Table 5 while the overall composition of household waste can be seen in Figure 3. Food waste is the most common kind of waste in Sungai Penuh City. When compared based on income, the low income category produces the highest food waste, which is 68.31% compared to high income at 54.19% and medium income at 50.72%. This is influenced by the income level of the population, where the low income category tends to process all food themselves rather than buying food outside. According to Damanhuri and Padmi [4], the simpler the level of life of the community, the more food waste (organic waste) is produced. The next most common types of waste are plastic waste and paper waste, packaging waste is the second most frequent sort of waste in cities. [12].

Table 5. Household Waste Composition of Sungai Penuh City

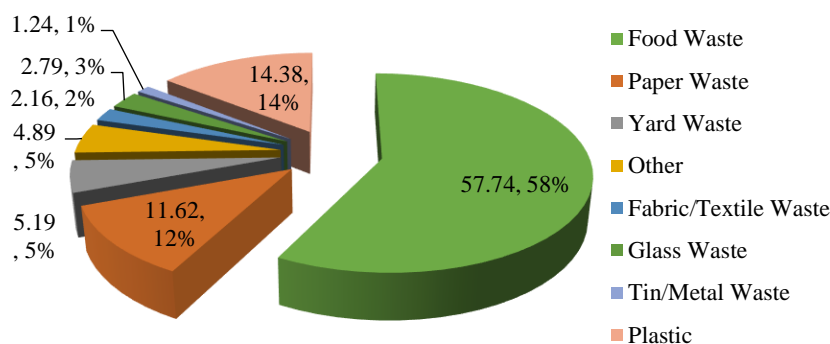| Type of Waste	Waste Composition			Average (%)
	HI	MI	LI	
Food Waste	54.19%	50.72%	68.31%	**57.74**
Yard Waste	5.51%	4.47%	5.58%	**5.19**
Plastic Waste	15.71%	13.69%	13.73%	**14.38**
Paper Waste	13.84%	19.00%	2.02%	**11.62**
Fabric/Textile Waste	2.07%	3.69%	0.70%	**2.16**
Glass Waste	3.02%	2.44%	2.91%	**2.79**
Tin/Metal Waste	0.71%	2.11%	0.89%	**1.24**
Others	4.93%	3.88%	5.86%	**4.89**

Figure 3. Household Waste Composition of Sungai Penuh City

Recycling Potential for Household Waste in Sungai Penuh City

The components of each waste composition are used to determine the sorts of waste that can be recycled. Sungai Penuh City can recycles food waste, yard waste, paper waste, plastic, glass, and metal.. A recapitulation of recyclable waste based on waste components can be seen in Figure 4.

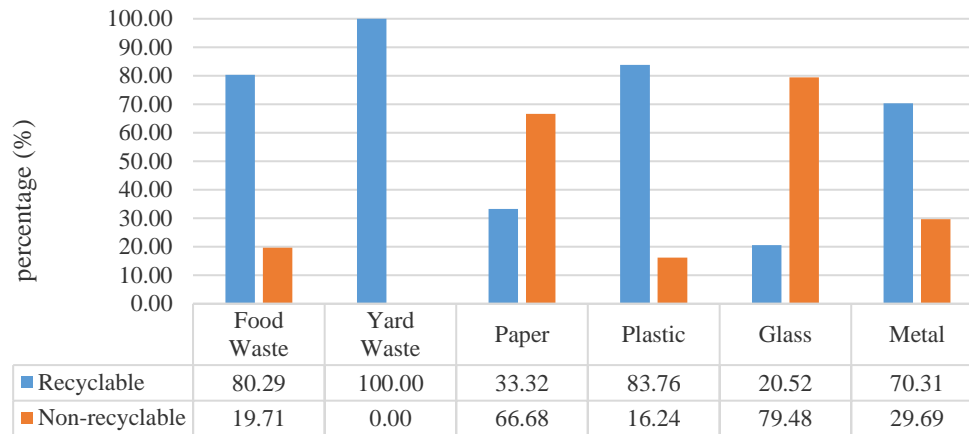|	Food Waste	Yard Waste	Paper	Plastic	Glass	Metal
■ Recyclable	80.29	100.00	33.32	83.76	20.52	70.31
■ Non-recyclable	19.71	0.00	66.68	16.24	79.48	29.69

Figure 4. Household Waste Recycling Potential per Composition of Sungai Penuh City

Based on the recycling data of each type of household waste component, it is known that yard waste has much higher percentage than other types of recycled waste, which are 100%. Food waste and yard waste can be recycled into compost. Compost can have economic value, minimize waste output, and lower the operational expenses of transporting waste to the landfill. [13].

The overall recycling potential of household waste in Sungai Penuh City can be found by calculating the data of waste that can be recycled and those that cannot be recycled compared to the average waste generation of Sungai Penuh City, so that the recycling possibilities of household waste in Sungai Penuh City is 68.90%, Table 6 shows more details.

Table 6. Calculation of Household Waste Recycling Potential of Sungai Penuh City

Waste Component	Generation (kg/day)	Average Waste Composi-tion (%)	Recycling (%)		Recycling (kg/day)		Percentage of Recycling Potential to Total Generation (%)
			Recyclable	Not Recyclable	Recyclable	Not recyclable	
Food Waste		57.74	80.29	19.71	14,807.05	3,634.80	46.36
Yard Waste	31,938.34	5.19	100.00	0.00	1,656.76	0.00	5.19
Plastic Waste		14.38	83.76	16.24	3,846.16	754.72	12.04
Paper Waste		11.62	33.32	66.68	1,236.30	2,474.08	3.87

Textile Waste		2.16	0.00	0.00	0.00	688.36	0.00
Glass Waste		2.79	20.52	79.48	182.87	708.14	0.57
Metal Waste		1.24	70.31	29.69	278.30	117.52	0.87
Others		4.89	0.00	0.00	0.00	1,562.28	0.00
Total		100.00					**68.90**

Evaluation of TPS 3R in Sungai Penuh City

Based on data obtained from the Sungai Penuh City Environmental Agency (DLH), TPS 3R in Sungai Penuh City in 2023 amounted to 16 units spread across 8 (eight) sub-districts in Sungai Penuh City with the location of TPS 3R as follows:

1. TPS 3R Desa Koto Tengah, Pesisir Bukit;
2. TPS 3R Desa Koto Duo, Pesisir Bukit;
3. TPS 3R Desa Sumur Gedang, Pesisir Bukit;
4. TPS 3R Desa Dujung Sakti, Koto Baru;
5. TPS 3R Desa Sri Menanti, Koto Baru;
6. TPS 3R Desa Pelayang Raya, Sungai Bungkal;
7. TPS 3R Desa Sungai Ning, Sungai Bungkal;
8. TPS 3R Desa Sumur Anyir, Sungai Bungkal;
9. TPS 3R Desa Koto Tinggi, Sungai Bungkal;
10. TPS 3R Desa Karya Bakti, Pondok Tinggi;
11. TPS 3R Desa Lawang Agung, Pondok Tinggi;
12. TPS 3R Desa Ulu Air, Kumun Debai;
13. TPS 3R Desa Sanggaran Galeh, Kumun Debai;
14. TPS 3R Desa Paling Serumpun, Hamparan Rawang;
15. TPS 3R Desa Pasar Baru, Sungai Penuh;
16. TPS 3R Koto Dumo, Tanah Kampung.

The overall evaluation value of TPS 3R based on the TPS 3R technical guidelines issued by the Directorate General of Human Settlements in 2023 shows that there are 3 units of TPS 3R in the medium category, namely TPS 3R Sumur Gedang, TPS 3R Sumur Anyir and TPS 3R Lawang Agung. TPS 3R with the less category amounted to 4 units, namely TPS 3R Sungai Ning, TPS 3R Koto Tinggi, TPS 3R Karya Bakti and TPS 3R Pasar Baru. A total of 9 other TPS 3R units are in the bad category. The TPS 3R is inactive due to the inactivity of the TPS 3R manager in operating TPS 3R.

In general, the problems faced by all TPS 3R in processing waste are the low competence of managers and staff, the lack of personnel who are interested in operating TPS 3R, unbalanced operational costs and revenues and most importantly the absence of an active role of the surrounding community to sort waste. The construction age of all existing TPS 3R is still young and the condition of the equipment is still functioning properly, supposedly with this condition all TPS 3R units can process waste into compost and some are sold to collectors so as to reduce the amount of waste sent to landfills. All TPS 3R units in the medium, less, or bad categories can generally be planned to be developed again at a minimal cost because the condition of the facilities, both equipment and buildings are still suitable for use.

Evaluation of Waste Bank in Sungai Penuh City

Sungai Penuh City has 1 (one) waste bank unit called Mapan Waste Bank. Mapan Waste Bank was established in 2015 with funding from the Special Allocation Fund (DAK) with a building area of 200 m2. This waste bank serves the residents of Desa Gedang in Sungai Penuh City. The obstacles encountered during the operation of the waste bank are the absence of a manager who is serious about managing the waste bank and the lack of competence of officers, even though regular coaching and training have been carried out. In addition, there is no clear and organized management and procedures in the operation of the waste bank. An operational system of procedures that can run well is very important in the sustainability and functioning of the waste bank program [14]. To implement the operational system of procedures requires competent human resources.

Mapan Waste Bank was evaluated from 3 aspects and then averaged to see the overall evaluation results of the waste bank. In Table 3.5, it is known that the average value of the waste bank evaluation results is 54.2%, which is included in the unfavorable category. When viewed from the highest evaluation value, namely in the facilities aspect, it is known that there is potential to reactivate Mapan Waste Bank. The existence of facilities that are still functioning properly makes it possible for Bank Sampah Mapan to be operated in accordance with the provisions stated in The Minister of Environment and Forestry's Regulation Number 14 of 2021

Table 7. Recapitulation of Evaluation Results of Mapan Waste Bank

No.	Aspects	Skor (%)
1.	Waste Management	54,2
2.	Waste Bank Facilities	73,8
3.	Waste Bank Governance	34,7
Average		**54,2**

Analysis of the Potential for Reducing Household Waste Generation at TPS 3R and the Sungai Penuh City Waste Bank

Household waste generation in Sungai Penuh City per person is 0.328 kg/person/day. The coverage of TPS 3R services is the entire population in the village of each TPS 3R location, so that the amount of waste generation served can be known by multiplying the population of each village's TPS 3R service with waste generation data. Likewise with the Mapan Waste Bank that serves Gedang Village, with data on the population of Gedang Village, The quantity of waste served at the Mapan waste bank can be determined. Furthermore, the total waste generation that has been known at TPS 3R and waste banks is calculated how much potential waste can be processed using data on the waste recycling potential of Sungai Penuh City of 68.90%.

In Table 8, it can be seen that the amount of waste generation served by 16 units of TPS 3R and Mapan Waste Bank is 10,780 tons/day from the total amount of waste generation in Sungai Penuh City of 31,938 tons/day. If all TPS 3R and waste bank are activated or operated optimally, then the amount of waste generation transported to the landfill has the potential to be reduced by If all TPS 3R and waste bank are activated or operated optimally, the amount of waste generated that is transported to the landfill can potentially be reduced by:

Waste generation reduction = total waste generation x waste recycling potential
= 10,780 tons/day x 68,90%

$$= 7{,}43 \text{ tons/day}$$

$$\text{Waste reduction percentage} = \frac{(7{,}43 \text{ tons/day})}{(31{,}938 \text{ tons/day})} \; x \; 100\% = 23{,}26 \%$$

To achieve the waste reduction potential of Sungai Penuh City, good management of TPS 3R and waste bank that are already available in Sungai Penuh City is needed. Waste processing in waste bank needs to be improved by using environmentally friendly technology [15]. In addition, it is necessary to establish a management structure for TPS 3R and waste bank that are integrated with each other [16]. Good management of TPS 3R and waste bank will assist limit the amount of waste transferred to the landfill and extend its life.

Table 8. Total Household Waste Generation Service Coverage of TPS 3R and Waste Bank

No.	Name	Population (people)	Waste Generation (kg/day)
1	TPS 3R Desa Koto Tengah	977	320.456
2	TPS 3R Desa Koto Tuo	1,507	494.296
3	TPS 3R Desa Sumur Gedang	1,021	334.888
4	TPS 3R Desa Dujung Sakti	2,664	873.792
5	TPS 3R Desa Sri Menanti	1,080	354.240
6	TPS 3R Desa Pelayang Raya	2,103	689.784
7	TPS 3R Desa Sungai Ning	1,620	531.360
8	TPS 3R Desa Sumur Anyir	1,708	560.224
9	TPS 3R Desa Koto Tinggi	1,182	387.696
10	TPS 3R Desa Karya Bakti	2,064	676.992
11	TPS 3R Desa Lawang Agung	4,569	1,498.632
12	TPS 3R Desa Ulu Air	879	288.312
13	TPS 3R Desa Sanggaran Galeh	1,595	523.160
14	TPS 3R Desa Paling Serumpun	1,638	537.264
15	TPS 3R Desa Pasar Baru	859	281.752
16	TPS 3R Desa Koto Dumo	2,559	839.352
17	Mapan Waste Bank	4,841	1,587.848
Total of Waste Generation			1,0780.048
			10.780 tons/day

CONCLUSION

Based on the findings of the assessment analysis of TPS 3R and waste bank management in Sungai Penuh City, it can be concluded that of the 16 TPS 3R units, there are 3 TPS 3R units in the medium category, 4 TPS 3R units in the less category and as many as 9 TPS 3R units in the bad category. Overall, only 3 units of TPS 3R are operating well which is included in the medium category. Meanwhile, waste bank in Sungai Penuh City are also in the bad category. If all TPS 3R and waste bank are operated optimally, the waste reduction potential will reach 23.26% of the total generation of solid waste in Sungai Penuh City which is 0.328 kg/person/day or 2.789 l/ person/day.

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