Evaluation Of Solid Waste Handling In Kendari City

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Abstract. The volume of waste generated in Kendari City will increase by 290 tons/day in 2022. Based on Perwali Number 23 of 2022, the percentage of waste transported to the landfill is 91.01% and waste that is not transported reaches 8.99%. Determining the TPS units to be evaluated using the purposive sampling method based on TPS units that have more than one service area. The determination of 2 TPS 3R units to be evaluated was due to the number of existing TPS 3R units in Kendari City. The generation data analysis method uses the Load Count Analysis method and composition measurement uses the quartering method. Evaluation of TPS facilities in Kendari City does not meet SNI 324-2008 standards. TPS 3R specifications meet standards but the level of waste reduction is very minimal. The average waste generation rate in Kendari City is 0.86 kg/person.day. The reduction in existing waste was 21.45 kg/day and after optimization it became 74.2%. With a service percentage of 67%.

1 Introduction

The increasing population rate is followed by an increase in the volume of waste generation in Kendari City. According to the data the amount of garbage generated from the environmental services and forestry of the Kendari city in 2022, the amount of waste generated in 2021 will reach 264 tonnes/day and in 2022 it will reach 290 tonnes/day. The increase in the amount of waste generated is caused by the increase in population and changes in people's consumption patterns, resulting in an increase in the volume, types and characteristics of increasingly diverse waste
[1].

Waste management is the activity of sorting, collecting, transporting, processing and final processing of waste [2]. This Regional Regulation has been realized, one of which is by creating 2 TPS 3R units, namely TPS 3R Punggolaka which was built in 2016 with a capacity of 200 families and TPS 3R Unit Kambu which was built in 2018 with a capacity of 200 families which manages organic and non-organic waste. The Kendari City Government has made handling efforts by increasing the number of waste transport fleets by 65 three-wheeled motorbikes so that they can handle the TPS which is located deep in the alley. Making the City Government's program a success, namely transporting waste using a door to door system, relocating TPS locations, creating 3R TPS facilities and collaborating with the local government to continuously socialize regulations regarding waste management in Kendari City. However, based on existing conditions, waste handling in Kendari City is not yet optimal.

An increase in waste volume that is not accompanied by improvements and improvements in waste management facilities and infrastructure has resulted in waste problems becoming complex [3]. Public awareness and compliance in Kendari City in managing waste is still very lacking, there is rampant dumping of rubbish carelessly (in rivers and coastal roads) and waste disposal is actually carried out outside TPS containers and is not sorted, thus having a negative impact on the aesthetics of the city, the environment and the place. growth of disease vectors. The community still often carries out waste burning activities. Another problem lies in the container system (TPS). Based on the existing conditions from a construction perspective, most TPS in Kendari City do not have covers, their dimensions are inadequate to accommodate waste in the service area, there is no separation between organic waste and non-organic waste, and there is still rubbish dumped on the side of the road or alley. by the community resulting from access to the polling stations and awareness of the community itself. The waste transportation system in Kendari City uses a Stationary Container System, waste at the TPS is transported directly to the TPA. Based on Kendari City Mayor's Regulation No. 19 of 2019, households, offices and business entities must dispose of their waste at 17.30 – 22.00 WITA and 04.30 – 00.60 WITA. According to data from Perwali Number 23

of 2022, the percentage of waste transported to the landfill is 91.01% and waste that is not transported reaches 8.99%.

Stated that the causes of problems in waste management are caused by inadequate operational technical support such as containerization, collection and transportation [4]. data regarding the generation, composition and characteristics of waste is very supportive in developing a waste management system in an area. This data must be available so that a good alternative waste management system can be developed [5]. Based on the existing conditions, it is necessary to evaluate the waste handling system in Kendari City to find out the necessary follow-up from both technical, environmental and institutional aspects as a basis for optimizing Kendari City's more efficient waste handling strategy.

2 Methods

2.1 Determination of the research area

Determining the research area was carried out by dividing the Kendari City area into three sampling sub districts based on population density. Determining sub-district sampling as the study area using the Stratified Sampling method where each sub-district is grouped based on density level, namely high population density, medium population density and low population density.

Based on the calculation results, the following analysis results are obtained:

1. The population density in the range 3956-5717 is high density. The sub-district that is included in this range is Kadia Sub-district, so sampling will be carried out in Kadia Sub-district for TPS evaluation. 2. Population density in the range 2194-3955 is medium density. The sub-district that is included in this range is Wua-wua Sub-district, so sampling will be carried out in Wua-wua Sub-district for TPS evaluation. 3. Population density in the range 432-2193 is low density, the sub-districts included in this range are Nambo, Baruga, Kambu, Puuwatu, Abeli, Poasia, Mandonga, Kendari and West Kendari sub-districts. The sub-districts that will be used as sampling locations are Kambu sub-district and Puuwatu sub-district, this is because in each sub-district there are TPS 3R and TPS units that will be evaluated.

After carrying out measurements and analysis in the sampling sub-districts, it will then be generalized to all sub districts according to their respective levels in order to obtain general results in Kendari City. After obtaining three research areas, the TPS and TPS 3R sampling points were then determined using the purposive sampling method. TPS were chosen based on the availability of collection vehicles and service areas, while TPS 3R was chosen based on the number of existing TPS 3R in Kendari City. The distribution of sampling points can be seen in **Table 1**.

Table 1. Research Locations

TPS/TPS 3R	Research District
Kadia TPS and Pondambea TPS	Kadia
Haeba TPS and Jati Raya TPS	Wua-wua
TPS Kambu	Kambu
Tobuuha TPS	Puuwatu
TPS 3R Kambu	Kambu
Punggolaka TPS 3R	Puuwatu

The TPS and 3R TPS facilities that have been determined are evaluated for existing conditions and then compared against ideal standards.

2.2 Measurement of Generation, Density, and Composition

Waste generation is analyzed using the Load Count Analysis method [6]. Waste collected from sources by collection fleet officers at TPS and TPS 3R is weighed for 8 days. The calculation of the rate of waste generation is determined by the number of residents (people) served by waste collection officers and then divided by the amount of waste transported by the collection fleet. The equation used to calculate the rate of waste generation is as follows:

$$\textit{Waste Generation } (\textbf{Kg/people/day}) = \textit{[Weight Waste } (\textbf{kg/Day}) \textit{ / amount of people]} \quad (1)$$

Apart from weighing the weight of the waste at the collection device, measuring the volume of the waste is also carried out to obtain the density of the waste. Waste density is the ratio between the weight of waste in kilograms and the volume of waste in cubic meters. The equation used to calculate the rate of waste generation is as follows:

$$\textit{Waste Density } (Kg/m^3) = \textit{[Weight Waste } (\textbf{kg}) \textit{ / Volume Waste } (\textbf{m}^3) \quad (2)$$

Next, the waste composition was calculated using the quartering method. Waste is sorted according to the type of waste and each type is weighed. The equation used to calculate the composition is as follows:

$$\textit{Waste Composition } (\%) = \textit{[Type of Waste } (\textbf{kg}) \textit{ / Weight Waste } (\textbf{kg})\textit{] x 100 } \% \quad (3)$$

2.3 Mass balance

Mass Balance calculations are carried out by knowing the amount of waste generation, waste composition and Recovery Factor [7]. Mass Balance analysis aims to determine the potential for waste reduction at TPS 3R in Kendari City. Recovery Factor can be calculated using the following equation:

$$Rf = \textit{[Manage Waste } (\textbf{kg}) \textit{ / Weight Waste } (\textbf{kg}] \textit{ x 100 } \% \quad (4)$$

By knowing the recovery factor percentage, waste reduction can be calculated. The equation used to calculate waste reduction is as follows:

$$\textit{Waste Reduction } (\%) = \textit{[Manage Waste } (\textbf{kg}) \textit{ / Waste Generation } (\textbf{kg})\textit{] x 100 } \% \quad (5)$$

After calculating the recovery factor and waste reduction values, the mass balance can then be calculated using the following equation:

$$\Sigma \textit{ Entering waste} = \Sigma \textit{ Waste Reduction} + \Sigma \textit{ Weight Residue} \quad (6)$$

2.4 Service percentage

The service percentage is intended to determine the amount of waste served by TPS and TPS 3R in Kendari City. The level of service can be determined by multiplying the number of TPS and TPS 3R by the number of residents served by the collection fleet and then generalizing to determine the level of service in Kendari City.

3 Results and Discussion

The data processed is data related to evaluation of existing conditions, analysis of generation, density, waste composition and percentage of waste services.

3.1 Evaluation of the existing conditions of TPS and TPS 3R in Kendari City

Based on the results of direct surveys in the field for each sampling sub-district in Kendari City, compared with

the TPS technical criteria, it can be seen in **Table 2**.

Table 2 Comparison of TPS Technical Criteria with Existing Conditions

No	TPS	Type of TPS	Service Capacity			Age	Information
			Vol	K.K	Soul		
1.	Pondambea TPS	Brick building (Permanent)	1.8	304	1520	±10 years	Not suitable for TPS Types 1,2 and 3
2	Bende TPS	Brick building (Permanent)	2.7	254	1270	±7 years	Not suitable for TPS Types 1,2 and 3
3	Haeba TPS	Brick building (Permanent)	2.25	390	1957	±10 years	Not suitable for TPS Types 1,2 and 3
4	Jati Raya TPS	Brick building (Permanent)	1.44	321	1608	±7 years	Not suitable for TPS Types 1,2 and 3
5	TPS Kambu	Brick building (Permanent)	1.8	250	1250	±7 years	Not suitable for TPS Types 1,2 and 3
6	Tobuuha TPS	*Containers*	6	450	2250	2 years	Not suitable for TPS Types 1,2 and 3

Based on **Table 2**, after comparing the ideal 3R TPS conditions and existing TPS conditions in the Kendari City sampling district, there are no TPS whose specifications meet SNI 324-2008 standards. Tobuuha TPS uses a TPS base in the form of a 6 m^3 armroll truck container. If you look at the volume of existing TPS, TPS in Kendari City are more like communal containers with a volume range of 0.5-1 m^3. The relatively small volume of the TPS serves a fairly large service area so that the waste entering the TPS always exceeds capacity. The TPS service area served by the collection fleet is 75-200 families so that unserved areas carry outindependent collection at the TPS.

Based on the results of interviews and questionnaires with TPS 3R managers, it is known that no composting activities were carried out. The cause of not composting is the low participation of management members in sorting organic and non-organic waste. The only waste that is sorted is plastic waste and then sold to collectors.

Table 3 Comparison of TPS 3R Technical Criteria with Minister of Public Works Regulation No. 3 of 2013

No	**Aspect**	**Existing**	**Standard Criteria**	**Information**
TPS 3R Kambu				
1	Capacity	267 families	>200 kk	Fulfil
	TPS 3R area	200 m2	200-500 m2	Fulfil
	Recycling Facility			

	Recycling Area	Available	Available	Fulfil
	Weighing Equipment	Available	Available	Fulfil
	Storage Space	Available	Available	Fulfil
2	Availability of Composting Facilities	Available	Available	Fulfil
3	Warehouse and Office	Available	Available	Fulfil
4	Buffer Zone	Available	Available	Fulfil
Punggolaka TPS 3R				
1	Capacity	200 families	>200 kk	Fulfil
	TPS 3R area	200 m2	200-500 m2	Fulfil
	Recycling Facility			
	Recycling Area	Available	Available	Fulfil
	Weighing Equipment	Available	Available	Fulfil
	Storage Space	Available	Available	Fulfil
2	Availability of Composting Facilities	Available	Available	Fulfil
3	Warehouse and Office	Available	Available	Fulfil
4	Buffer Zone	Available	Available	Fulfil

According **Table 3**, the specifications and dimensions of TPS 3R Kambu and TPS 3R Punggolaka meet the requirements as stated in the Regulation of the Minister of Public Works Number 3 of 2013 concerning the organization of waste facilities and infrastructure in handling household waste and similar types of household waste. TPS 3R is intended for RW scale services with a capacity of > 200 families.

3.2 Analysis of waste generation, density and composition

According the results of measurements of waste generation at sampling points, the rate of waste generation in Kendari City was obtained0.86 kg/person/day, so that the weight of waste generated in Kendari City is obtained based on population density classification which can be seen in the following table:

Table 4 Kendari City Household Waste Generation

Density	**Subdistrict**	**Total population**	**Waste generation**	**Total Waste Generation**
			(kg)/person/day	**(Kg/day)**
Tall	Kadia	37,431	0.93	34,810.83

Currently	Wua-wua	34,671	0.9	31,203.90
Low	Nambo	11,422	0.77	8,794.94
	Baruga	35,342		27,213.34
	Kambu	25,162		19,374.74
	Puuwatu	41,868		32,238.36
	Abeli	17,583		13,538.91
	Poasia	43,058		33,154.66
	Mandonga	38,081		29,322.37
	Kendari	29,153		22,447.81
	West Kendari	42,976		33,091.52

Density	**Subdistrict**	**Total population**	**Waste generation**	**Total Waste Generation**
			(kg)/person/day	**(Kg/day)**
Total		**356,747**	**0.86**	**285,191.38**

Density measurements are needed to determine the volume of waste produced in the Sampling District. In this research, 8 average density data were obtained from each waste source, namely TPS Bende, TPS Pondambea, TPS Haeba, TPS Jati Raya, TPS Kambu, TPS Tobuuha, TPS 3R Kambu and TPS 3R Punggolaka. The density values at each TPS and TPS 3R can be seen in **Table 5**.

Table 5 Kendari City Household Waste Density

Source Type	**Waste Density**	**Average Density**
	kg/m³	**kg/m³**
Bende TPS	173.4	**165.3**
Pondambea TPS	182.5	
Haeba TPS	170.9	
Jati Raya TPS	171.7	
TPS Kambu	172.0	
Tobuuha TPS	174.4	
TPS 3R Kambu	106.6	

Punggolaka TPS 3R	171.1	

According to the results of density measurements at TPS and TPS 3R in the sampling district, it is known that the average waste density is 165.3 kg/m3. Waste density data is used to calculate the volume of household waste produced by each TPS and TPS 3R.

If based on the results of composition measurement sampling, the average waste composition in Kendari City can be seen in **Figure 1**.

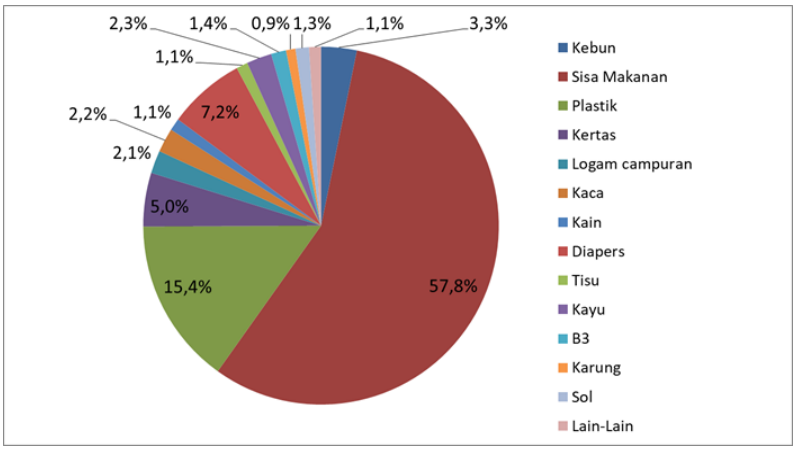

Figure 1. Composition of waste in Kendari city

Based on **Figure 1**, it can be seen that the largest dominance of waste in Kendari City comes from organic waste, namely food waste. The second dominant is plastic waste consisting of PET, HDPE, PVC, PP, PS, multilayer, screen-printed plastic and LDPE. From the composition above, it is known that the potential for reducing waste by using appropriate handling is very possible.

3.3 Mass balance analysis

Waste management is carried out through handling and reducing waste [7]). Waste reduction activities must be carried out as much as possible from the source. Based on the existing conditions of waste processing in Kendari City, if evaluated in terms of TPS and TPS 3R, existing waste reduction activities are only carried out at TPS 3R, namely TPS 3R Kambu and TPS 3R Punggolaka. The existing condition of Mass Balance in Kendari City can be seen in **Figure 2**.

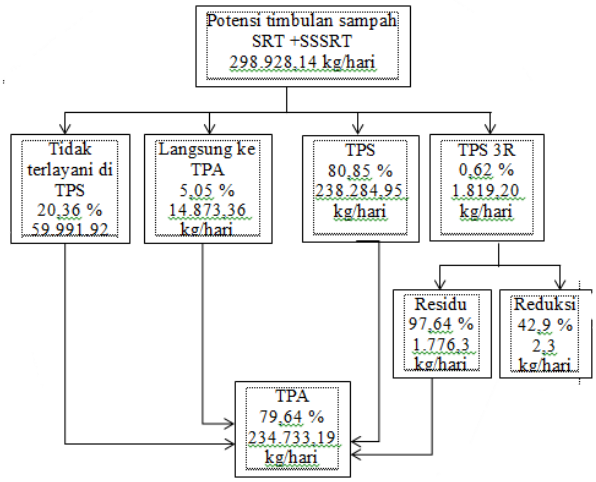

Figure 2 Kendari City's Existing Mass Balance

TPS3R is a waste disposal facility that applies the 3R concept. TPS3R is one of the Kendari City government's efforts to deal with waste problems and reduce the total generation of waste that goes to landfill. Based on the TPS 3R technical instructions, waste management at TPS 3R consists of composting and reducing economically valuable non-organic waste to be sold to collectors for recycling. There are 2 TPS 3R units in Kendari City, namely TPS 3R Kambu and TPS 3R Punggolaka, these two TPS 3R are in Puuwatu sub-district and are areas with low population density. Based on the calculation results, the reduction in existing waste in Kendari City can be seen in the following table:

Table 6 Reducing Existing Waste in Kendari City

No	Types of Waste at Source	Waste Type	Composition (%)	Waste Generation (kg/day)	Waste Reduction (kg/day)	%existing RF
1	Garden	Compostable	49.80%	508.91	0.00	0.00%
2	Leftovers					
3	PET	Plastic		229.93	13.2	5.74 %
	HDPE					
	PVC		22.50%			
	PP					
	PS					
	Multilayer					

No	Types of Waste at Source	Waste Type	Composition (%)	Waste Generation (kg/day)	Waste Reduction (kg/day)	%existing RF
	Screen Printing Plastic					
	LDPE					
4	White paper	Paper	8.00%	81.75	10.4	12.72 %
	Duplex					
5	Alloy	Metal		0.00	0.00	0.00%
6	Glass	Glass		0.00	0.00	0.00%
7	Bag	Plastic		0.00	0.00	0.00%
8	Sol	Rubber		0.00	0.00	0.00%
Waste Reduction (kg/day)						**23.6**
Residue (kg/day)						**998.3**
%Existing RF						**2.36 %**

Based on **Table** 6, it is known that the reduction in existing waste at TPS3R is quite low. This happens because TPS 3R does not reduce waste due to a lack of participation and human resources in managing and sorting waste generation. Waste utilization is only carried out on inorganic waste.

3.4 Service percentage

Based on the existing conditions of waste services in Kendari City, waste services are not evenly distributed in all places. Generalization was carried out to determine the level of waste services in Kendari City.

Table 7 Percentage of Waste Services in Kendari City

Density	Subdistrict	Number of polling stations	K.K	Number of residents served (people)	Waste generation at TPS (kg/person/day)	Waste generation in Kendari City (kg/person/day)
High	Kadia	28	168	23,520.00	21,873.60	34,810.83
Currently	Wua-wua	23	123	14,145.00	12,730.50	31,203.90
Low	Nambo	189	217	205,065.00	157,900.05	219,176.65

	Baruga					
	Kambu					
	Puuwatu					
	Abeli					
	Poasia					
	Mandonga					
	Kendari					
	West Kendari					
Average					**192,504.15**	**285,191.38**
Service Percentage						**67%**

According **Table 7**, the level of waste service in Kendari City reaches 67% served and 33% of it is unserved waste.

4 CONCLUSION

The existing conditions of TPS and TPS 3R are not yet ideal in accordance with SNI 324-2008 and Minister of Public Works Regulation No. 3 of 2013. The waste generation rate of 0.86 kg/person/day is still in line with medium city waste generation. The % Recovery factor is only 2.48% and after optimization with the ideal % Recovery factor it reaches 74.2%. The percentage of waste service at TPS and TPS 3R is 67%.

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