Study of Household Solid Waste Generation in Seberang Ulu Region Palembang City

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Septi Rika Putri, Khalida Muda, Anis Saggaff, Hendrik Jimmyanto

Abstract— A key environmental pressure indicator, the development of municipal solid waste (MSW) per capita, is a useful measure to determine the rate of solid waste generation and to assess the intensities between cities or countries. Solid waste management is the biggest environmental issue in Palembang, highly dependent on land filling as the main method of disposal in managing this steady increase in the production of solid waste annually. Therefore, this research aims to measure the amount of solid household waste generation in the rainy season and dry season, and to correlate it with several housing types using ANOVA test. Measurement of waste generation in the form of waste weight, volume and composition refers to SNI 19-3964-1994 by means of a measuring instrument in the form of a 40-liter capacity tank, digital and also a ruler. The result of this paper show the amount of organic waste is more prevalent than other waste types, which is an average of 357.68 grams per person per day for rainy season and 79.04 grams per person per day for dry season. The non-permanent house group produces the largest volume of organic solid waste in both seasons but produces the smallest volume of non-organic solid waste in the dry season. From the result of ANOVA, there is a significant difference between household solid waste and season (rainy and dry). ANOVA's result for differences in house type groups, it can be said that there is a considerable difference between house types. Sub-districts of Seberang ulu I and Kertapati obtain the assessment of each district, the weight category of' high' solid waste, while other districts are given a' low' solid waste category.

Keywords— solid waste weight, solid waste composition, solid waste volume, household, municipal solid waste .

1 Introduction

Increasing population growth, globalization, urban development, economic growth and the increase in community living standard have dramatically increased the pace of municipal solid waste generation in developing countries [1, 2]. Household waste is produced regularly from several sites where variable human activity is observed. Many studies indicate that a large part of the urban solid waste from developing countries comes from households [3, 4]. Weather, social culture, per income per capita and rate of urbanization and industrialization are factors that influence MSW's characteristics. The issues associated with the management of solid waste are complicated due to a variety of indicators, such as the volume and composition of waste generated [5]. MSW composition as obtained may vary considerably based on geographic region and season [6].

Designing and implementing an adequate MSW management system involves accurate estimation of potential amounts of waste generation [7]. The development of urban solid waste (MSW) per capita, a key environmental pressure indicator is a useful measure to determine the rate of solid waste generation and to assess the intensities between cities or countries [8].

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Solid waste management is Palembang's biggest environmental problem, highly dependent on land filling as the main method of disposal in handling this steady increase in solid waste generation annually. The city of Palembang is divided into two areas separated by a wide Musi River river, namely Seberang Ilir and Seberang Ulu. The region in this analysis is the Seberang Ulu area that consists of sub-districts Seberang Ulu I, Kertapati, Seberang Ulu II, and Plaju. Selection of Seberang Ulu research sites is focused on the many problems which occur [9, 10]. Jimmyanto, et al[4] and Putri, et al[11] conducted research on the study of waste generation in household at Palembang city in the generation of household solid waste, many types of organic waste are produced by non-permanent household, while non-organic waste is mostly produced by permanent household. The study showed that there are some variations in the household solid waste management system. The weight and amount of low income household waste production is 0.91 kg / person / day, and 1.51 liters / person / day. The weight and amount of high-income waste is 0.79 kg per person per day and 1.63 liters per person per day. The low income households generate more organic waste than households with high incomes. Solid waste generation is needed to determine the characteristics of household solid waste. This research therefore aims to measure the amount of household solid waste generation in the rainy season and dry season and to correlate it to several types of houses. The research will use descriptive analysis, and ANOVA.

2 Methods of Research

The research location is in the Seberang Ulu area of Palembang City which consists of 4 sub-districts, namely Seberang Ulu I, Kertapati, Seberang Ulu II and Plaju. The research area can be seen in Fig. 1. The total population in this case the number of families in the study area can be seen in

Table 1. The total population in the study was 107,142 families and many samples were calculated based on the Slovin formula with e = 10% described as follows:

$$n = \frac{N}{1 + N\,e^2} = \frac{107142}{1 + (107142\,x\,(10\%)^2)} = 99.9 = 100\ samples$$

Fig. 1. Seberang Ulu Region, Palembang City

TABLE 1
TOTAL POPULATION OF SEBERANG ULU REGION, PALEMBANG CITY

No	District	Non-Permanen/ Low Income	Semi-Permanen/ Middle Income	Permanen/ High Income	Total Family
1	Seberang Ulu I (SU-I)	3,911	15,552	8,185	27,648
2	Kertapati	5,277	9,084	15,960	30,321
3	Seberang Ulu II (SU-II)	3,306	11,884	13,554	28,744
4	Plaju	4,559	11,391	4,479	20,429
TOTAL		17,053	47,911	42,178	107,142

This research defines three groups of waste-based sampling measurements based on Central Bureau of Statistics Indonesia, 2008 [12] namely:

1) permanent type of high income with income above 3,500,000 IDR and has characteristics of a house built with concrete construction (Fig. 2a)
2) semi-permanent middle income, with income between 2,500,000 - 3,500,000 IDR and has characteristics of houses built with concrete and wood construction (Fig. 2b.)
3) non-permanent low income with an income under 1,500,000 IDR and has the characteristics of house build with timber construction (Fig. 2c.)

Fig. 2a. Permanent House/high income

Fig. 2b. Semi-permanent house/middle income

Fig. 2c. Non-permanent house/low income

The proportion of the sample (Table 2) based on the type of income / type of house according to SNI 19-3964-1994 criteria as follows:

Sample of non-permanent house/low income (S1):

$$S_1 = \frac{17053}{107142} x100\% = 15.9\%\ x\ 100 = 16\ samples$$

Sample of semi-permanent house/middle income (S2):

$$S_2 = \frac{47911}{107142} x100\% = 44.7\%\ x\ 100 = 45\ samples$$

Sample of permanent house/high income (S3):

$$S_3 = \frac{42178}{107142} x100\% = 39.4\% x\ 100 = 39\ samples$$

TABLE 2
NUMBER OF SAMPLES FOR EACH TYPE OF HOUSING / INCOME

No.	District	Group of samples		
		S1	S2	S3
1	Seberang Ulu I (SU-I)	4	11	10
2	Kertapati	4	11	10
3	Seberang Ulu II (SU-II)	4	11	10
4	Plaju	4	11	10
	Total	16	44	40

Note :
S1 = Sample of non-permanent house/low income
S2 = Sample of semi-permanent house/middle income
S3 = Sample of permanent house/high income

Measuring waste generation in the form of waste weight, volume and composition refers to SNI 19-3964-1994 using a measuring instrument in the form of a 40-liter capacity tank, digital and also ruler. In the dry season and rainy season the calculation of waste weight in the specified sample is conducted for 7 consecutive days. Weight measurements of dry season household waste are carried out in August and rainy season in January.

In general, 9 components of solid household waste are measured (food / organic waste, paper / cardboard, wood, cloth / textile products, rubber / leather, plastic, metal, glass, others) [4, 13]. The type of waste component found in this research, however, is organic from food waste, LDPE (low-density polyethylene), PET (polyethylene terephthalate), PP (polypropylene), metals, paper and others.

Statistical analysis in the form of variance analysis (ANOVA) will be carried out to assess significant differences in the rate of solid waste generation among different groups [4, 14]. To measure the volume of solid household solid waste generation at each site, the scoring system approach categorizes solid waste generation because there are no guidelines limiting the categorization of solid waste generation to the level of the author's understanding. The scoring system approach applies to Pungky et al[15] as consisting of:

$$X < (\mu - (p\ .\sigma)) \qquad (1)$$

High or medium category is determined from:

$$(\mu - (p\ .\sigma)) \leq X < (\mu + (p\ .\sigma)) \qquad (2)$$

High or very good categories are determined from:

$$X \geq (\mu + (p\ .\sigma)) \qquad (3)$$

Where :
X = the value of each district
μ = theoretical average
σ = standard deviation
p = probability using the normal distribution table

To determine the probability of a normal distribution at each value, use the formula :

$$Z = \frac{X-\mu}{\sigma} \qquad (4)$$

Where:
Z = Z value
X = the value of each district
σ = standard deviation
p = probability using the normal distribution table

3 RESULT AND DISCUSSION

The results of measurements of household solid waste for the rainy season can be seen in Table 3. Table 3 shows that the amount of organic waste is more dominant than other types of waste, which is an average of 357.68 grams / person / day while the type of waste paper is the smallest amount of waste when compared to other types of waste are an average of 4.72 grams / person / day. The type of organic waste identified was food waste and leaves, while non-organic waste (LDPE, PET, PP, Metals, Papers, Others) in the form of plastic bottles, food packaging, glass bottles, food cans and cloth.

TABLE 3
RESULT OF SOLID WASTE AVERAGE WEIGHT (GRAM/PERSON/DAY) IN RAINY SEASON

Districts	Average weight (gram/person/day) in rainy season						
	Organic	LDPE	PET	PP	Metals	Papers	Others
Seberang Ulu I	472.90	96.34	9.59	3.68	7.82	6.71	15.58
Kertapati	476.60	70.26	25.75	9.75	7.71	3.99	6.71
Seberang Ulu II	232.48	27.89	10.07	13.92	4.51	8.16	12.31
Plaju	248.75	84.98	6.02	3.80	0.00	0.00	0.00
Avg.	357.68	69.87	12.86	7.79	5.01	4.72	8.65

Table 4. shows the results of measurements of household waste generation in the dry season. The type of waste that is

produced the most is organic waste with an average of 79.04 grams / person / day while the type of metal waste is the smallest type of waste, which is an average of 0.23 grams / person / day. The types of organic and non-organic waste produced by research respondents tend to be the same as the type of waste in the rainy season.

TABLE 4
RESULT OF SOLID WASTE AVERAGE WEIGHT (GRAM/PERSON/DAY) IN DRY SEASON

Districts	Average weight (gram/person/day) in dry season						
	Organic	LDPE	PET	PP	Metals	Papers	Others
Seberang Ulu I	55.17	3.29	2.15	2.24	0.08	0.45	4.78
Kertapati	75.60	8.60	3.44	8.33	0.00	1.86	4.29
Seberang Ulu II	87.82	9.53	5.79	7.55	0.48	4.22	19.06
Plaju	97.56	11.52	7.51	7.77	0.34	21.97	9.92
Avg.	79.04	8.24	4.72	6.47	0.23	7.13	9.51

Fig. 3 shows a comparison of the results of measurements of household solid waste in the rainy season and dry season. Fig. 3 shows that the weight of solid waste in the rainy season is greater than in the dry season for all types of waste. In the rainy season, people in the scope of research do more activities inside the house, they buy more food and other needs so that the amount of waste in the rainy season also increases. But in the dry season they are more active outside the home so that the potential to reduce the amount of solid waste. From the statement above, it can be said that the season has the potential to affect the amount of solid household solid waste generation.

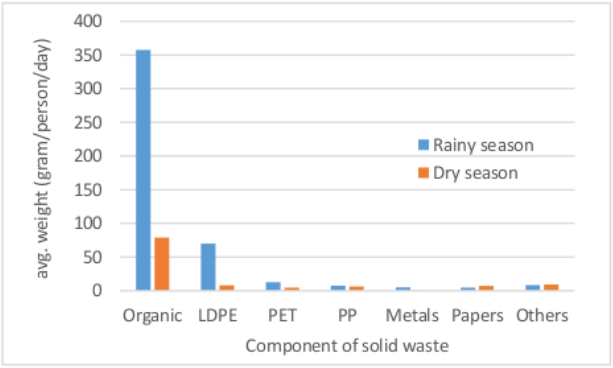

Fig. 3. Comparison of solid waste weight

Table 5 and Table 6 show the results of the composition of waste in the rainy and dry seasons. Table 5 shows the composition of the largest weight of organic waste is in the semi-permanent house (S2) group at 77.76% while the smallest organic waste weight composition is the permanent house (S3) group at 73.47%. The calculation result of the composition of the weight of non-organic waste is obtained that the permanent house (S3) group has the largest composition of 26.53% followed by the other groups.

TABLE 5
RESULT OF COMPOSITION WEIGHT IN RAINY SEASON

Districts	Composition of weight (%) in rainy season					
	S1		S2		S3	
	A	B	A	B	A	B
Seberang Ulu I	84.64	15.36	79.05	20.95	71.14	28.86
Kertapati	83.84	16.16	72.73	27.27	79.99	20.01
Seberang Ulu II	83.56	16.44	84.05	15.95	69.49	30.51
Plaju	58.47	41.53	75.19	24.81	73.26	26.74
Average	77.63	22.37	77.76	22.25	73.47	26.53

Note :
A = organic solid waste and B = non-organic solid waste (LDPE, PET, PP, Metals, Papers, Others)
S1 = Sample of non-permanent house/low income
S2 = Sample of semi-permanent house/middle income
S3 = Sample of permanent house/high income

TABLE 6
RESULT OF COMPOSITION WEIGHT IN DRY SEASON

Districts	Composition of weight (%) in dry season					
	S1		S2		S3	
	A	B	A	B	A	B
Seberang Ulu I	83.81	16.19	86.39	13.61	71.89	28.11
Kertapati	68.36	31.64	82.49	17.51	73.53	26.47
Seberang Ulu II	76.92	23.08	73.74	26.26	50.16	49.84
Plaju	51.46	48.54	62.86	37.14	100.00	0.00
Average	70.14	29.86	76.37	23.63	73.90	26.11

Note :
A = organic solid waste and B = non-organic solid waste (LDPE, PET, PP, Metals, Papers, Others)
S1 = Sample of non-permanent house/low income
S2 = Sample of semi-permanent house/middle income
S3 = Sample of permanent house/high income

On the other hand, Table 6 shows the composition of the weight of waste in the rainy season. The semi-permanent house (S2) group produced the largest composition of organic

solid waste weight which was 76.37% while the smallest composition of organic solid waste weight was in the non-permanent house (S1) group of 70.14%. This is different from the calculation of the weight composition of solid waste in the dry season. However, the largest weight composition of non-organic solid waste in the dry season was produced by the group of non-permanent houses (S1) by 29.86% while the largest composition of the weight of non-organic solid waste in the rainy season was produced by the Permanent House (S3) group. The difference in weight composition of solid waste is due to differences in activity and income levels between groups that affect the consumptive nature of the group. The composition of solid waste in household is directly affected by a variety of factors: socio-economic status of households, cultural conditions, food habits, season, geographical locations, etc [14, 16].

Fig. 4 and Fig. 5 show the results of measuring the volume of waste in the dry and rainy seasons using the SNI 19-3964-1994 method. From Fig. 4 and Fig. 5 it can be seen that the volume of organic solid waste and the volume of non-organic solid waste in the rainy season is greater than in the dry season. Non-permanent house (S1) group produces the largest volume of organic waste in the two seasons but in the dry season produces the smallest volume of non-organic waste. In the dry season, the permanent house (S3) group produces the largest volume of non-organic waste than in other groups.

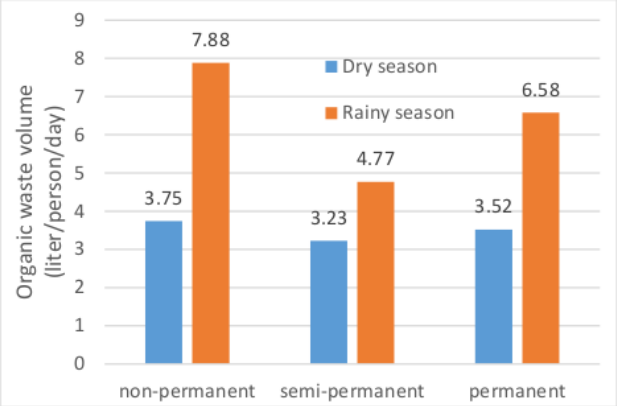

Fig. 4. Comparison of organic waste volume

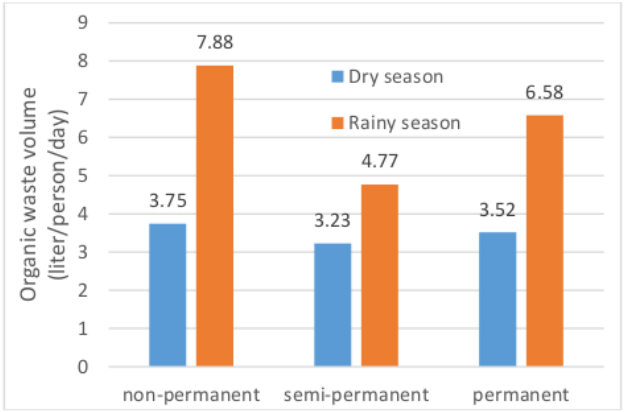

Fig. 5. Comparison of non-organic waste volume

Therefore, it is necessary to test whether the two groups and seasonal differences have averages that are considered equal or not to be the same. Anova research reflects on the variance of the results of each group in this case the group of home type and the group of seasons. In this study using Anova one way analysis with a significant 5 percent level where the results of the tests can be seen in Table 7. And Table 8.

Table 7 is the findings of the One Way Anova Season Group Difference Test. From this table, it was found that the F value was 250,748 with a significant value of 0,00 (< 0.05). This shows that there is a significant difference between the solid waste household during the rainy season and the dry season.

TABLE 7
ANOVA TEST RESULTS WEIGHT VS SEASON

	Sum of Squares	Mean Square	F	Sig.
Between Groups	6110311.693	6110311.693	250.748	.000
Within Groups	4654355.092	24368.351		
Total	10764666.785			

Table 8 is also the result of the One Way Anova test for differences in house type groups. The table shows the results of the F value of 4.940 with a significant value of 0.008 (< 0.05) so that it can be said that there is a significant difference between the house types.

TABLE 8
ANOVA TEST RESULTS WEIGHT VS GROUP SAMPLES

	Sum of Squares	Mean Square	F	Sig.
Between Groups	532043.015	266021.507	4.940	.008
Within Groups	10232623.770	53855.915		
Total	10764666.785			

Table 9 illustrates a comparison of the results of waste weight measurements from several studies conducted in Palembang City in 2017 and 2019. The table shows that the three researchers use the same measurement methods, namely SNI 19-3964-1994, but the number of samples and measurement times are different.

Previous studies did not measure the weight of waste in the city of Palembang for the rainy season and dry season. Jimmyanto, et al [12] measured the weight of solid waste for types of low-income and high-income housing but did not measure the weight of middle income solid waste. Ananda, et al [17] and Pratiwi, et al [13] measured the weight of solid waste in community residential samples and pillars where the effects of direct weight measurements were separated by the number of residents, rather than each house See Table 9 that the own study has a different method where previous studies, such as the number of samples, group samples, seasons and time of measurement, have not been carried out.

TABLE 9
COMPARISON OF RESEARCH RESULTS WITH OTHERS STUDY IN PALEMBANG CITY

Comparison	Own study	Jimmyanto, et al (2017)	Ananda, et al (2019)	Pratiwi, et al (2019)
Number of samples	383 person	120 person	3 unit residential	2 pillar of neighbor
Sample category	Low income, middle income and high income	Low income and high income	-	-
Season	Dry and rainy	-	-	-
Waste measurement method	SNI 19-3964-1994	SNI 19-3964-1994	SNI 19-3964-1994	SNI 19-3964-1994
Time of research	Now	2017	2019	2019
Measurement time	7 days	3 days	7 days	2 days
Average waste weight (kg / person/days)	High income = 2.88 Middle income = 1.75 Low income = 1.61	High income = 0.91 Low income = 0.79	0.7255	0.46

A scoring system approach is used to measure the weight and volume of the wastes to assess the waste generation category at each study area using Eq. 1-4. Zmax and Zmin values in the weight of the solid waste received by 0.94 and -1.07, in order to obtain the overall probability value of 0.3577. Whilst the maximum waste volume probability value is 0.3749. Table 10 is the outcome of the assessment of each district's scoring system process. The weight category of' high' solid waste is obtained by sub-districts of Seberang ulu I and Kertapati while other districts are given a' low'.

Contrary to the waste volume, the' high' level of waste is located in the districts of Seberang Ulu I and Plaju, while the' low' category is for the other sub-districts. From the Table's results it can be said that the weight of solid household waste over 300 grams / person / day is included in the' high' category, while the volume of solid household waste over 11 liters / person / day is also included in the' high' category.

TABLE 10
ASSESSMENT OF WASTE GENERATION AT THE STUDY AREA

Districts	avg. weight solid waste	Category	avg. volume solid waste	Category
Seberang Ulu I	340.39	High	12.59	High
Kertapati	351.45	High	9.81	Low
Seberang Ulu II	221.90	Low	10.05	Low
Plaju	250.07	Low	11.73	High
Average	290.95		11.04	

4 CONCLUSION

Research on solid waste generation has been successfully completed in the Palembang City area of Seberang Ulu. From the results of this study there are several conclusions to draw:

1. The amount of organic waste is more prevalent than other waste types, which is an average of 357.68 grams per person per day for rainy season and 79.04 grams per person per day for dry season. The difference in weight of solid waste is due to differences in activity and level of income between groups which affect the group's consumerist reality.
2. The non-permanent house group produces the largest volume of organic waste in both seasons but produces the smallest volume of non-organic waste in the dry season
3. From the result of ANOVA, there is a significant difference between household solid waste during the rainy season and dry season. ANOVA's result for differences in house type groups, it can be said that there is a considerable difference between house types.
4. Sub-districts of Seberang Ulu I and Kertapati obtain the assessment of each district, the weight category of' high'

solid waste, while other districts are given a' low' solid waste category

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