The Generation Rate and Composition of Municipal Solid Waste in Slums

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Abstract— The problem of MSW is closely related to slums, where houses in slums are stilt house and near the river, and making area under the house as the place of the garbage disposal place which is relatively difficult to clean. The slums that exist today are in leave from accumulation of waste everywhere. As long as people continue to do activities, waste will continue to be produced and will continue to increase because the volume of waste will be directly proportional to the population. The study aims to measure the generation rate and composition of MSW in slums of Lawang Kidul Village at Palembang City, and then to measure average generation rate and composition of MSW at several cities in Indonesia. MSW generation rate is measured at 0,45 kg/person/day. The composition of MSW is dominated by organic waste (61,35%), followed by inorganic waste (38,13%), and residu (0,52%). The average of MSW generation rate in Indonesia was 0,351 kg/person/day. The average composition of MSW at several cities in Indonesia is dominated by food waste (63,92%).

Index Terms— *average*, *composition*, *generation rate*, *Indonesia*, *MSW*

1 INTRODUCTION

URBAN population growth from year to year continues to increase, as well as improved life levels. The rapid development in urban areas become the attraction of urbanization because it provides a lot of ease and also better facilities, but this is not accompanied by the provision of basic infrastructure for society. If basic infrastructure is not fulfilled, it will cause the growth of slums [1]. Slums is a poor quality environment, where the conditions of housing are not clean and unworthy, vulnerable to crime, synonymous with poor people, and densely populated [2]. The problem of MSW is closely related to slums, where houses in slums are stilt house and near the river, and making area under the house as the place of the garbage disposal place which is relatively difficult to clean, even not infrequently throw garbage into rivers and waterways. It is often done by the society because unavailability of household-generated bins, unavailability of communal waste transportation facilities, and unavailability of communal waste collection facilities [3].

Lawang Kidul is a village that has the largest slum area among other villages and located on the edge of Musi River at Palembang City [4]. One cause of slum is a problem of household waste that is not routinely transported to the garbage disposal place around 62,48%, causing garbage to scattered around the resident houses, even not infrequently throw garbage into rivers and waterways [5]. The slums that exist today are in leave from accumulation of waste everywhere. As long as people continue to do activities, waste will continue to be produced and will continue to increase because the volume of waste will be directly proportional to the population [6].

Each city produces a different number of generation rate of MSW, for urban waste dominated by household waste and generation rate of MSW in Nassiriya City is measured at 0,68 kg/capita and the composition of MSW is dominated by food waste around 70,18% [7]. In Sangamner City of India, organic waste from masket is dominant around 61% and inorganic waste around 39% is dominated by stone and sand [8]. The generation rate of MSW in Mosul City, Irak, is measured at 0,68 kg/person and the composition of MSW is dominated by organic waste and food waste [9]. The average generation rate of MSW in Sultanate of Oman is 0,97 kg/day/person with total organic waste of 71,20% and 65,80% collected during winter and summer, and dominated by food waste [10]. The generation rate of MSW in Tuz Khurmatu, Irak, is measured at 0,574 kg/capita/day [11].

Research on accumulation and MSW composition has also been conducted in several cities in Indonesia from 2012 to 2019. Based on Table 1, the generation rate of MSW in several cities was different and dominated by food waste.

TABLE 1
GENERATION RATE AND COMPOSITION OF MSW IN INDONESIA

References	MSW Generation Rate	Dominant Waste (%)
[12]	0,23 kg/person/day	Food waste (76,21%)
[13]	0,44 kg/person/day	Food waste (71,23%)
[14]	0,23 kg/person/day	Food waste (79,4%)
[15]	0,19 kg/person/day	Food waste (56,06%)
[16]	0,38 kg/person/day	Food waste (75%)
[17]	0,486 kg/person/day	Food waste (68%)
[18]	0,40 kg/person/day	Food waste (34,31%)

MSW can be grouped into organic waste (wet waste from kitchen activities) and inorganic waste (dry waste such as bottles, paper and plastic), with the density of MSW at sources ranging from 0,01-0,2 tons/m^3 [19]. The study aims to measure the generation rate and composition of MSW in slums of

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Lawang Kidul Village at Palembang City, and then to measure average generation rate and composition of MSW at several cities in Indonesia.

2 METHODOLOGY

Measurements were carried out for 8 days, 28 July 2019 till 4 August 2019. Measurements of the generation rate and composition of MSW were carried out by directly measuring the volume of MSW in 8 bloks of slums area in Lawang Kidul Village, which are blok 7, 9, 10, 11,15, 16, 18, and 21. In order to calculate the volume of MSW, the generation rate survey is done by 100 respondents in simple random sampling [20].

Fig. 1. Map of Lawang Kidul Village. The greys are slums area

There are 9 components of MSW that are measured (food waste, paper/cardboard, wood, cloth/textile products, rubber/leather, plastic, metal, glass, etc.) [19].

The weight and volume of MSW are recorded, so the generation and density of MSW were measured based on the dimensions and volume of the MSW container. Then, waste composition was expressed as a percentage of wet weight. The sorting of MSW was carried out based on the types of MSW that have been determined (food waste, paper/cardboard, wood, cloth/textile products, rubber/leather, plastic, metal, glass, etc.) in every waste container. Sorted MSW is weighed and recorded according to the type of waste. The MSW fraction (% of wet weight) for each components was calculated by diving the total wet weight of each MSW component with total weight of MSW [21].

3 RESULTS

3.1 MSW Generation Rate

Sampling was carried out for 8 days, 28 July 2019 till 4 August 2019 and sampling was carried out in 8 bloks of slums area in Lawang Kidul Village, which are blok 7, 9, 10, 11,15, 16, 18, and 21. The calculated waste is household waste. The rate of waste generation was obtained from the weight of the waste divided the number of people in sampling location.

TABLE 2
HOUSEHOLD WASTE GENERATION RATES

Day of Measurements	Weight of MSW (kg)	Number of Persons	MSW Generation Rate (kg/person/day)
Day-1	210,35	435	0,48
Day-2	212,00	435	0,49
Day-3	190,34	435	0,44
Day-4	182,23	435	0,42
Day-5	189,36	435	0,44
Day-6	176,32	435	0,41
Day-7	189,23	435	0,44
Day-8	221,93	435	0,51
Total	1571,76	3480	0,45

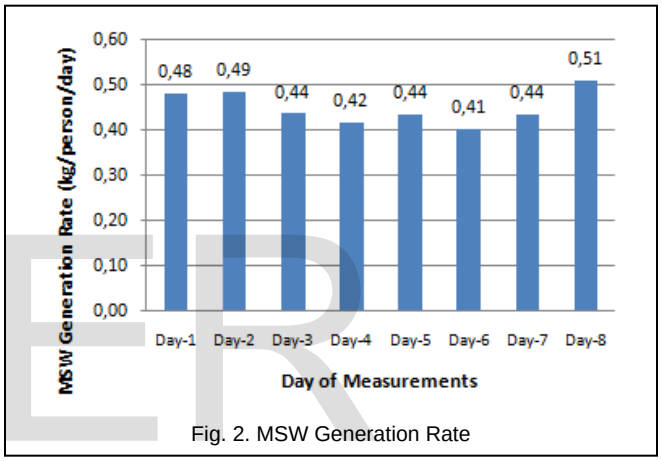

Fig. 2. MSW Generation Rate

From the results of measurements, the highest MSW generation rate is found in the last day (0,51 kg/person/day) and the lowest MSW generation rate is found in the sixth day (0,41 kg/person/day). The average rate of MSW generation was 0,45 kg/person/day. The condition of MSW generation rate on weekday was lower than on weekend. That is because of people works outside the house, which generally for lunch does not eat at home and reduce the production of household waste produced.

3.2 MSW Composition

There are 9 components of MSW that are measured (food waste, paper/cardboard, wood, cloth/textile products, rubber/leather, plastic, metal, glass, etc.). The measurement of waste composition was carried out for 8 days, indicates that food waste is greater than other waste components. MSW in Lawang Kidul Village was dominated by organic waste (61,35%), followed by inorganic waste (38,13%), and residu (0,52%).

TABLE 3
MSW COMPOSITION

Day of Measurements	Organic Waste (kg)	Inorganic Waste (kg)	Residue (kg)
Day-1	126,36	83,04	0,95
Day-2	132,22	78,37	1,41
Day-3	114,12	75,02	1,20
Day-4	110,85	70,98	0,40
Day-5	121,33	66,86	1,17
Day-6	113,56	61,22	1,54
Day-7	113,13	75,10	1,00
Day-8	132,63	88,65	0,65
Total	964,20	599,24	8,32
MSW Fraction	61,35 %	38,13 %	0,52 %

TABLE 4
THE AVERAGE OF MSW GENERATION RATE

Location	MSW Generation Rate (kg/person/day)
Lawang Kidul Village, Palembang	0,45
Kenjeran Coastal Settlement, Surabaya	0,23
Padang Panjang City	0,44
Tanah Datar Regency	0,23
Tampan Sub-district, Pekanbaru	0,19
Sukolilo Sub-district, Surabaya	0,38
Rungkut Sub-district, Surabaya	0,486
Pahandut Village, Palangka Raya	0,40
Average	0,351

3.3 The Average of MSW Generation Rate

The average of MSW generation rate is calculated by collecting data from several cities in Indonesia from 2012 to 2019. There were 7 cities in Indonesia, including Lawang Kidul Village in Palembang City, which is used to calculate the average of MSW generation rate in Indonesia. The average of MSW generation rate in Indonesia was 0,351 kg/person/day.

3.4 The Average of MSW Composition

The average of MSW generation rate is calculated by collecting data from several cities in Indonesia from 2012 to 2019. There were 7 cities in Indonesia, including Lawang Kidul Village in Palembang City, which is used to calculate the average of MSW composition in Indonesia. The average of MSW composition in Indonesia was dominated by food waste (63,92%).

TABLE 5
THE AVERAGE OF MSW COMPOSITION

No	Components of MSW	MSW Composition (%)								
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	$\overline{X}$
1	Food waste	51,13	76,21	71,23	79,4	56,06	75	68	34,31	63,92
2	Paper/cardboard	6,19	5,33	4,44	3,31	11,21	7	10,8	21,93	8,78
3	Wood	0,42	1,21	15,14	0,21	0	1	3,7	2,36	3,01
4	Cloth/textile products	2,59	2,27	0	1,43	8,05	1	0,4	3,44	2,40
5	Rubber/leather	1,02	0,23	0	0	0,21	0	0,1	0	0,19
6	Plastic	36,39	10,83	7,18	15,3	19,75	11	12,6	22,64	16,96
7	Metal	0,68	0,44	0,51	0,12	0,46	1	1	0,25	0,56
8	Glass	1,06	0,82	0	0,22	4,25	1	0,3	2,31	1,25
9	Etc.	0,53	2,58	1,50	0	0	1	0,4	11,88	2,24

Note :
X_1 = Lawang Kidul Village, Palembang
X_2 = Kenjeran Coastal Settlement, Surabaya
X_3 = Padang Panjang City
X_4 = Tanah Datar Regency
X_5 = Tampan Sub-district, Pekanbaru
X_6 = Sukolilo Sub-district, Surabaya
X_7 = Rungkut Sub-district, Surabaya
X_8 = Pahandut Village, Palangka Raya

4 Conclusion

Based on the results, MSW generation rate is measured at 0,45 kg/person/day. The composition of MSW is dominated by organic waste (61,35%), followed by inorganis waste (38,13%), and residu (0,52%). The average of MSW generation rate in Indonesia was 0,351 kg/person/day. The average composition of MSW at several cities in Indonesia is dominated by food waste (63,92%). Several cities in Indonesia that are shown in this research are not enough to represent the entire city in Indonesia. The average results of MSW generation rate and

MSW composition will be different when the whole city has calculated MSW generation rate and MSW composition. Further research is necessary to calculate the MSW generation rate and MSW composition in each city so that the average results of MSW generation rate and MSW composition in Indonesia can be more accurate than now.

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