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Potential reduction of non-residential solid waste in Sukomanunggal district West Surabaya

I D A A Warmadewanthi*, S A Reswari

Environmental Engineering Department, Faculty of Civil Environmental and Geo Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

*Corresponding Author: warma@its.ac.id

Abstract. Sukomanunggal district a development unit 8 with the designation as a regional trade and services, industrial, education, healthcare, offices, and shopping center. The development of this region will make an increasing solid waste generation, especially waste from non-residential facilities. The aims of this research to know the potential reduction of waste source. The method used is the Likert scale questionnaire to determine the knowledge, attitude, and behavior of non-residential facilities manager. Results from this research are the existing reduction of non-residential solid waste is 5.34%, potential reduction of the waste source is optimization of plastic and paper waste with the reduction rate up to 19,52%. The level of public participation existing amounted to 46.79% with a willingness to increase recycling efforts amounted to 72.87%. Efforts that can be developed to increase public awareness of 3R are providing three types of bins, modification of solid waste collection schedule according to a type of waste that has been sorted, the provision of the communal bin.
Keywords: likert, potential reduction, solid waste

1. Introduction

Sukomanunggal district was the region with the highest population density in West Surabaya, located in 7.2643° S, 112.6973° E. District Sukomanunggal is development unit 8 which attended for trade and services, office, education, healthcare, industrial and shopping center. There is currently no related data contribution of non-residential solid waste in contributing to the amount of waste in the District Sukomanunggal. In the handling of non-residential solid waste should each source of waste both residential areas, commercial areas, industrial areas, special areas, public facilities, social facilities and other facilities required to carry out the sorting of waste and in collecting required to provide transfer station, 3R facilities and or transporter to transfer station or transported to the landfill if waste generated more than 30 m^3/month [1], [2] but in the implementation are still many sources of non-residential facilities that burdening collection facilities and public transfer station. The aims of this research to know the potential reduction of waste source.

2. Research Method

There are three subdistricts were selected to be the location of the study, including the subdistrict of Simomulyo, Simomulyo Baru, and Sukomanunggal. Public facilities used as the sample is education, worship house, healthcare, offices, industrial, sweep streets and commercial areas consisting of a hotel, restaurant, minimarket and traditional market. To determine the potential reduction which may occur in any source of waste is carried out with a Likert scale questionnaire. The number of samples to be determined by the formula slovin in equation 1 with the result 163 units samples.

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$$\boldsymbol{n = N / (1 + N e 2)} \quad (1)$$

Information:
n = number of samples
N = number of population
e = Limit fault tolerance

Using a four-point Likert scale or more questions to re-measure the behavior of individuals to respond to the 5 point choice on any of the questions, strongly agree, agree, not deciding, disagree, and strongly disagree combined to form a value that represents the nature individual, knowledge, attitudes, and behaviors [3], [4].

3. Results and Discussion

3.1. Existing of non-residential solid waste reduction in Sukomanunggal District

The analysis conducted in this study is an analysis of existing conditions and simulation reduction efforts in accordance with the will of society. An existing condition that is needed in this research includes generation conditions, the composition and the reduction of non-residential solid waste.

3.1.1. Total Generation and composition of Non-Residential Solid Waste. Waste generation is the amount of waste generated from waste sources expressed in units of mass or volume or weight per capita or per unit time or per unit area [5]. Total waste generation type of household waste is 21109.707 kg/day, with details such as Table 1. The composition of waste that most of the organic waste 57.31%, the second largest is plastic waste 19.98% and the third largest is paper waste 14.20%. The reduction of the waste composition will be significant if done on organic waste by composting or recycling of plastic and paper. Diagram composition of non-residential solid waste presented in Figure 1.

Tabel 1. Total waste generation of non-residential solid waste.

Public Facilities	**Solid waste generation (Kg/day)**	**Density (Kg/m^3)**
Worship House	79,11	92,15
Education	877,16	140,26
Office	7719,99	107,14
Hotel	1828,58	107,22
Restaurant	1302,50	140,95
Minimarket	132,29	81,82
Traditional market	6830,95	210,84
healthcare	230,41	105,06
Industry	1076,99	185,64
Street sweeping	1031,73	214,14
Total	21109,71	138,52

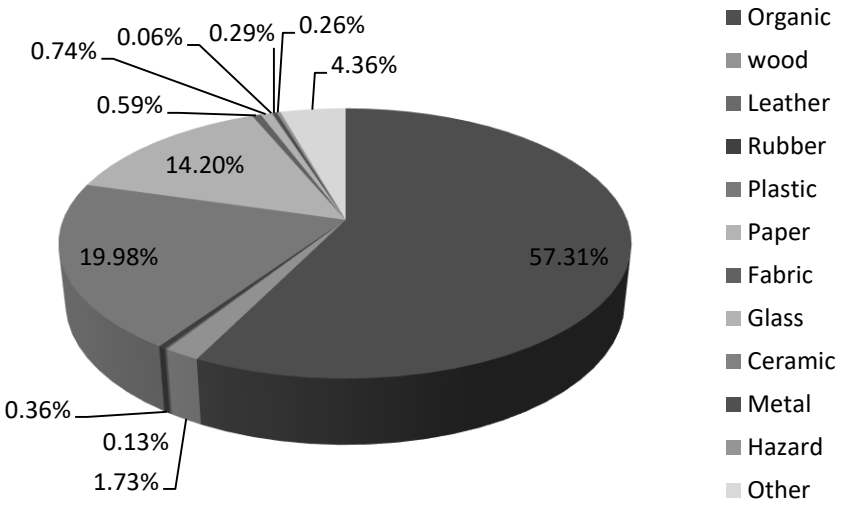

Figure 1. The composition of non-residential solid waste.

3.1.2. Existing Reduction of Non-Residential Solid Waste.

Waste processing that can be done by waste sources such as composting and recycling material [6], [7]. Recycling can reduce the amount of waste generated by the community, recycling efforts are quite prominent and generally involve the informal sector [8]. From the research, it can be seen that waste reduction activity is done in the sources and in transfer stations. The reduction done in the waste source is composting and recycling plastic and paper. Reduction done in transfer station is the sorting of plastic waste and paper by informal sector to be sold to the collectors. The existing level of reduction in Sukomanunggal District is 5.34% where the reduction in resources 1.57% and 3.77% reduction in the transfer stations. Reduction of non-residential solid waste is summarized in Table 2.

Table 2. Existing reduction of non-residential solid waste.

Public Facilities	Solid waste generation (Kg/day)	Total reduction (Kg/day)	
		source	transfer station
Worship house	79.11	1.59	3.73
Education	877.16	34.31	48.11
Office	7719.99	178.18	50.77
Hotel	1828.58	25.08	31,29
Restaurant	1302.50	38.79	120.21
Minimarket	132.29	12.85	9.91
Marker	6830.95	-	399.57
Healthcare	230.41	-	4.71
Industry	1077.00	41.13	56.59
Street sweeping	1031.73	-	71.85
Total	21109.71	331.93	796.73

Recovery Factor

Recovery factor is the percentage of segregated garbage that can be utilized on the total weight of waste overall. Public facilities with potential for composting are educational facilities, offices, markets, healthcare and street sweeping. Garbage can be reduced by composting activities amounting to 37.35% of a total non-residential solid waste in Sukomanunggal.

Plastic waste can be reduced include PET (1) such as beverage bottles, HDPE (2) such as *shampoo* bottles, PP (5) such as glass bottled mineral water, Other (7) such as *shampoo* packaging plastic *sachets*. Based on the interview almost all public facilities are willing to do the sorting and utilization of plastic waste garbage can be reduced by recycling plastic for 7.74% of a total non-residential solid waste in Sukomanunggal.

Types of paper waste that can be reduced include cardboard, paper, cardboard, newspapers. As well as plastic waste, almost all public facilities willing to conduct utilization of waste paper bins except sweep the street waste that can be reduced with the utilization of paper waste amounted to 5.32% of the total waste generated by the public facilities in the district Sukomanunggal.

Simulation recovery of these factors produces the optimum reduction effort in which all public facilities would perform reduction in the form of composting and recycling plastic and paper waste. The reduction that can be achieved next 20 years is 50.20%.

Potential Reductions by the will of society.

The existing reduction is too small to achieve the reduction in accordance with the recovery factor, for that, we need a scenario with a reduction in composting or recycling plastic and paper waste. From the result of Likert scale questionnaire known that the average attitude towards the source of waste reduction efforts with a composting plan ranges from 52.98% or less agree with the composting plan. Attitude toward the sources of waste plastic recycling effort and paper reached 72.87% or agree with the reduction of recycling plastic and paper.

Judging from existing conditions, a source of garbage composting at 24.52% while the source of garbage to recycle as much as 46.79%. Comparison of public attitudes toward waste reduction efforts plans presented in Figure 2.

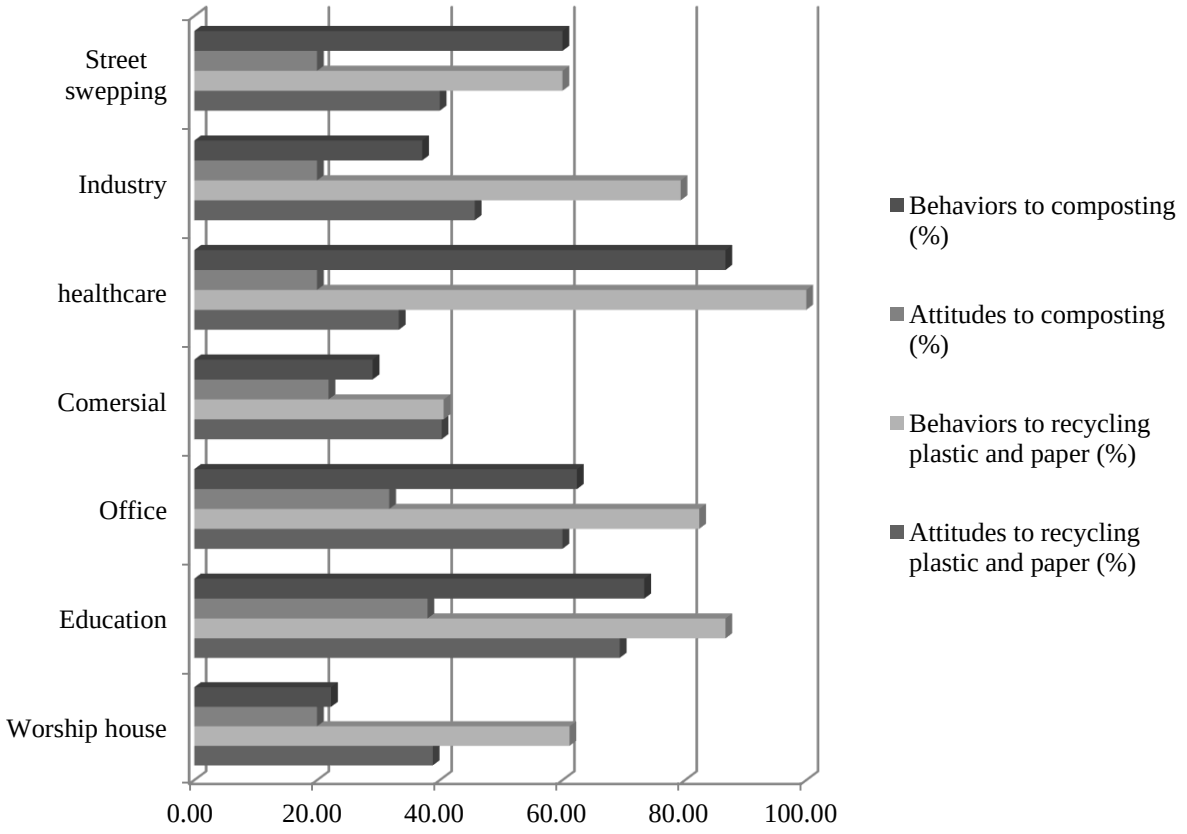

Figure 2. Comparison of public attitudes and behaviors to reduce solid waste.

Based on the willingness of the community to do the approximate reduction of over 20 years using composting and recycling plastic and paper. The calculations show that with the development of the reduction effort using waste composting that can be reduced is 28.13%, while the reduction with plastic and paper recycling is 19.52%. Composting reduction level is greater with plastic and paper recycling, this is caused by the composition of wet garbage that can be composted is much larger than the composition of the plastic and paper waste that can be recycled. However, based on the will of society with a reduction potential of recycled plastic and paper is greater when compared to composting. Given the reduction potential that you want to upgrade is the potential at the source of waste then the best alternative that can be done to achieve a sustainable reduction is by recycling plastic and paper waste. Table 3 shows the potential reduction every year with plastic and paper reduction efforts.

Table 3.Potential reduction by recycling plastic and paper.

Year	Total Generation (Ton/Year)	Residues in TPA (Ton/Year)	Reduction (Ton/Year)	Reduction (%)
2017	7705.04	7293.44	411.59	5.34
2018	8262.90	7557.88	618.25	7.56
2019	8889.61	7987.23	715.11	8.22
2020	9594.10	8463.34	827.08	8.90
2021	10386.49	8991.84	956.12	9.61
2022	11278.23	9579.75	1103.78	10.33
2023	12282.34	10232.8	1273.95	11.07
2024	13413.59	10959.26	146.,17	11.82
2025	14688.73	11767.87	1692.92	12.58
2026	16126.79	12668.33	1949.2	13.33
2027	17749.39	13671.49	224.61	14.09
2028	19581.09	14789.46	2578.44	14.85
2029	21649.83	16039.1	2959.41	15.58
2030	23987.35	17452.49	3375.52	16.21
2031	26629.76	19030.12	3851.12	16.83
2032	29618.17	20796.69	4389.49	17.43
2033	32999.35	22746.04	5028.37	18.10
2034	36826.56	24976.13	5705.31	18.60
2035	41160.47	27517.35	6430.02	18.94
2036	46070.18	30418.64	7198.69	19.14
2037	51634.47	33594.42	8147.81	19.52

Strategy to Increase Recycled Plastics and Paper

Basically, there are five technical waste management criteria such as waste reduction, waste treatment location, human resource availability, ease of application of technology and economic value [9]. The efficiency of waste treatment site and application of technology so as to bring economic value can increase public participation in waste reduction. The strategy that can be done is by modifying the operational pattern of integrated waste management which consists of warehousing, collection, transportation, final disposal [10], [11]. Warehousing waste is a temporary waste collection activity in a waste source comprised of individual and communal bins [10]. Modification bins can be done by requiring each source of waste to provide three types of waste bins for waste paper, plastic, and others.

Communal bins can be provided at public facilities such as markets and parks, these communal bins are also separated for paper, plastic, and others. The recommended strategy in the collection is the scheduling of waste collecting according to the type of waste that has been sorted. This Collecting has been carried out since the removal of garbage from the bins to the transfer station while still guaranteeing the separation of waste according to the type of waste [12]. To ensure the sustainability of the program, the government should conduct public awareness programs on the importance of waste reduction for an environmental and public health [13].

4. Conclusion

Based on result data and discussion, the conclusion of this research is the existing non-residential solid waste reduction rate in Sukomanunggal district is only about 5.4% and potentials that can be developed to increase the reduction of non-residential solid waste in Sukomanunggal district are recycled paper and plastic waste with the reduction potential of 19.52%.

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