The potential of household solid waste reduction in Sukomanunggal District, Surabaya

I D A A Warmadewanthi*, S Kurniawati

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

*Corresponding Author: warma@its.ac.id

Abstract. The rapid population growth affects the amount of waste generated. Sukomanunggal Subdistrict is the densest area in West Surabaya which has a population of 100,602 inhabitants with a total area of 11.2 km². The population growth significantly affects the problem of limited land for landfill facilities (final processing sites). According to the prevailing regulations, solid waste management solutions include the solid waste reduction and management. This study aims to determine the potential reduction of household solid waste at the sources. Househould solid waste samplings were performed for eight consecutive days. The samples were then analyzed to obtain the generation rate, density, and composition so that the household solid waste reduction potential for the next 20 years could be devised. Results of the analysis showed that the value of waste is 0.27 kg/person/day, while the total household solid waste generation amounted to 27,162.58 kg/day or 187.70 m³/day. Concerning the technical aspects, the current solid waste reduction in Sukomanunggal Subdistrict has reached 2.1% through the application of waste bank, composting, and scavenging activities at the dumping sites by the garbage collectors. In the year of 2036, the potential reduction of household solid waste in Sukomanunggal Subdistrict has been estimated to reach 28.0%.

Keywords: community participation, household solid waste management, reduction

1. Introduction

Surabaya City has a strategic position and becomes the development center of the eastern part of Indonesia. The rapid population growth considerably affects the amount of solid waste generated each day. Sukomanunggal district is the densest region in West Surabaya where the landfill (the final processing site) for solid waste resides. Subdistrict Sukomanunggal including in the area of West Surabaya, with a population of at most that was recorded in year 2013 as many as 98,401 inhabitants [1]. The development plan Surabaya contained regulation [2] states that regional Development Unit (UP) VIII Dukuh Pakis used for settlements, trade and services, industry, national defense and security, with the area of the development center located at Segi Delapan, Segi Delapan of the areas included in the District of Sukomanunggal.

The rapid population growth a major effect on the amount of waste generated each day. The increasing amount of garbage produced each year, it will be a big problem on landfill capacity and the difficulty to expand the landfill area. Waste management has a complex and lengthy process, not only regarded as a technical problem, but also as a management paradigm [3].

Based on [4], solid waste management solutions include the solid waste reduction and management. The solid waste reduction can be accomplished through the restriction of waste, waste recycling, and waste reuse. This study aims to determine the existing condition of household solid

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI. Published under licence by IOP Publishing Ltd
waste management and reduction potential in Sukomanunggal Subdistrict. This research can provide benefits in the form of information related to the potential reduction of household waste and the improvement efforts that can be developed.

Waste Bank is one of the community-based waste management systems which enable citizens to participate actively in managing the environment. According to regulation [5] explained that the bank is a sorting trash and waste collection that can be recycled and or reused with economic value. Community-based waste management in the city of Surabaya conducted by processing organic waste into compost, inorganic waste sold to collectors or used into amterial recycling, as well as the development and improvement of home composting [6]. Sukomanunggal sub-district currently has 10 units of waste bank with an active status located in 3 villages. Moreover, in the District of composting reactor Sukomanunggal have had as many as 11 reactors. Based on the results of analysis of waste in the number of waste bank customers 2016, there were 492 customers, waste bank customers in the district Sukomanunggal has increased from previous years. As for the composting activities, community participation in the activities of composting is still low, it is evidenced by the few number Sukomanunggal composter in the district that is not functioning properly. One of them, in the Village Sukomanunggal that there are several units composter help from an agency that is not working anymore. The solution to this problem it is necessary to further study the causes of decrease in community participation.

2. Research Method
This study began with the data collection which aims to gather all the information related to the research. Data were collected in the form of primary and secondary statistics. Primary data were obtained by direct observations in the field through distributing questionnaires, conducting interviews, measuring the household solid waste generation, and assessing the reduction of household solid waste. The measurement of waste generation has been carried out for eight days. Sampling was conducted on 110 families with the assumption that one family produces 1 kg of solid waste per day. Wet volume (m³/day) and wet weight (kg/day) were used as the units of the solid waste.

The second step was the calculation of household solid waste composition to determine the characteristics of the solid waste, performed after the measurement of solid waste generation by taking as many as 100 kg samples of waste. The sampling method referred to [7] about the Method of Measurement Sample Collection and Urban Waste Generation and Composition. The solid waste can be characterized by sorting the type of materials including organic waste, paper, plastic (e.g., HDPE plastic bottles, aluminum, LDPE, PET, styrofoam, and PP), glass, metal, fabric, wood, and others. The reduction can be assessed in advance after collecting data on the number and type of reduction facilities. A survey was then conducted to determine the amount of solid waste that can be reduced. The subjects of domestic solid waste reduction in Sukomanunggal Subdistrict are waste bank and scavengers in TPS.

The data of community participation in reducing solid waste were obtained from questionnaires related to the will of society. The number of respondents was 110 people, which had been adapted to the calculation of the required number of solid waste samples. The sampling was conducted by the random sampling system. Public participation in reducing solid waste can be judged from the interest in sorting and reusing household solid waste. Moreover, the community contribution to solid waste management activities was assessed as well. As for the secondary data, they were gathered from relevant agencies. Finally, when all the information had been collected, the analysis and discussion were performed to reach a conclusion. The purpose of this study is to determine the existing condition of the reduction of household solid waste in Sukomanunggal Subdistrict, obtained from the data of technical aspects. Subsequently, it also aims to determine the potential reduction of household solid waste based on the community participation in terms of behavior and attitude.
3. Results and Discussion
The questionnaires were analyzed to assess the score weight based on the Likert scale. It was examined based on the technical aspects as well using the method of dynamic models with Stella 9.1.3 software. The discussion below presents each aspect analyzed by the dynamic system optimization of Stella 9.1.3 software.

3.1. Analysis of household waste generation
The analysis of solid waste generation was conducted by collecting the household waste for eight consecutive days (Table 1). The sampling was carried out from the same sources of residential solid waste. Furthermore, the analysis of the amount of solid waste was calculated referring to [2] about the Method of Measurement Sample Collection and Urban Solid Waste Generation and Composition. The results showed that the average of solid waste generation per person per day in Sukomanunggal Subdistrict is 0.27 kg/person/day. The calculation of household solid waste generation can be seen in Table 1.

Table 1. Household waste generation.

| Day | Total Weight of Solid Waste (kg) | Total Sample | Solid Waste Generation (kg/person/day) |
|-----|----------------------------------|--------------|----------------------------------------|
| 1   | 108.49                           | 387          | 0.28                                   |
| 2   | 98.79                            | 387          | 0.26                                   |
| 3   | 110.70                           | 387          | 0.29                                   |
| 4   | 108.20                           | 387          | 0.28                                   |
| 5   | 98.90                            | 387          | 0.26                                   |
| 6   | 99.76                            | 387          | 0.26                                   |
| 7   | 109.40                           | 387          | 0.28                                   |
| 8   | 99.80                            | 387          | 0.26                                   |
|     | Average                          |              | 0.27                                   |

The solid waste generation per person per day was used as the basis for determining the household solid waste generated in Sukomanunggal Subdistrict. The total population in this area in the year of 2017 is 100,602 inhabitants. This number was multiplied by the number of solid waste generation of 0.27 kg/person/day to calculate the amount of household waste generated in Sukomanunggal Subdistrict of 27,162.58 kg/day.

3.2. Analysis of the composition and density of household solid waste
The reference used in the calculation of the solid waste composition was [2] about the Method of Measurement Sample Collection and Urban Solid Waste Generation and Composition. This analysis had been performed for eight consecutive days as well. Results of the field measurements showed that the composition of household solid waste in Sukomanunggal Subdistrict was predominantly food scraps and garden waste with the total percentage of 71.68% (67.99% food scraps and 3.69% garden waste) (Figure 1). The garden waste was yielded partly from individual street cleaning activities by residents and janitors.
Density measurement of household waste in the District Sukomanunggal conducted over three days. The purpose of measuring the density of household waste is to determine the volume of waste generated at the source of waste and the volume of waste that goes to the polling stations. Based on field sampling in mind that not all rubbish weighing 100 kg, can be entered into the box density. This is due to the type of household waste is currently very diverse and has a large volume, such as bottles, plastic cups, and the rest of other packaging. The density of household waste in the District Sukomanunggal of the analytical results ranged between 134.61 kg/m$^3$ to 147.98 kg/m$^3$ with an average density of household waste amounted to 142.03 kg/m$^3$.

### 3.3. Reduction of household waste

The composition data can be used to determine the reduction value of household solid waste in Sukomanunggal Subdistrict. The analysis of household solid waste reduction was carried out by observing and calculating the amount of waste sorted by the community before being transported to TPS and TPA.

Potential reduction of waste at source can be determined from the data waste bank. Subdistrict Sukomanunggal own trash banks since 2012. The majority of the waste bank active status. The number of banks in the district trash Sukomanunggal has increased every year. Currently there are 10 waste bank with an active status, but not every village has a waste bank.

Data reduction of waste from the waste bank obtained from interviews with bank officials related trash. Waste bank in the District Sukomanunggal most have good administration system, data on the number of customers and the amount of waste sorting has been recorded periodically. On average recapitulation conducted every month. The amount of waste is reduced by waste banks can be seen in Table 2.

![Figure 1. Percentages of household solid waste composition in Sukomanunggal Subdistrict.](image-url)
The recycling activities are influenced by the rate of increase in recycling and composting activities. This reduction was planned within a period of 20 years. Reduction in this scenario is to describe the magnitude of the reduction of the value of household waste when it is done with recycling and composting activities. Reduction value of each type of waste is influenced by the rate of increase in PF (Participation Factor) and RF (Recovery Factor).

### Table 2. Total Waste Reduction by Waste Bank.

| No | Name Waste Bank | Address | The number of customers (kk) | Weight reduction of waste (kg/month) | Weight reduction of waste per household (kg/kk/month) |
|----|-----------------|---------|------------------------------|--------------------------------------|---------------------------------------------------|
| 1  | Tanjung Mandiri | Tanjungsari | 37                           | 196.40                               | 5.31                                              |
| 2  | Karya Mulia     | Simomulyo Baru | 25                           | 78.20                                 | 3.13                                              |
| 3  | Tanjung Jaya    | Tanjungsari | 25                           | 157.90                                | 6.32                                              |
| 4  | Wartun Sejahtera | Simomulyo Baru | 245                          | 368.70                                | 1.50                                              |
| 5  | Karya Usaha Bersama | Simomulyo Baru | 35                           | 147.80                                | 4.22                                              |
| 6  | Cahaya Asa     | Simomulyo | 25                           | 216.73                                | 8.67                                              |
| 7  | Mandiri        | Simomulyo | 25                           | 69.60                                 | 2.78                                              |
| 8  | Prima          | Simomulyo | 25                           | 91.40                                 | 3.66                                              |
| 9  | Pelangi        | Simomulyo | 25                           | 73.20                                 | 2.93                                              |
| 10 | Amanah         | Simomulyo | 25                           | 120.50                                | 4.82                                              |
|    |                 |          |                              | 492                                   | 1520.43                                           |
|    | Amount         |          |                              | 49,2                                  | 152.04                                            |

### Table 3. Potential reduction by recycling and composting.

| Year | Waste bank reduction (ton/year) | Composting reduction (ton/year) | Total reduction (ton/year) | Total Generation (ton/year) | Residues in TPA (ton/year) | % reduksi |
|------|---------------------------------|---------------------------------|----------------------------|-----------------------------|---------------------------|------------|
| 2016 | 115.55                          | 0.56                            | 116.11                     | 9730.50                     | 9614.39                   | 1.2%       |
| 2017 | 150.19                          | 62.79                           | 212.98                     | 9914.34                     | 9701.36                   | 2.1%       |
| 2018 | 187.87                          | 130.92                          | 318.79                     | 10098.18                    | 9779.39                   | 3.2%       |
| 2019 | 228.62                          | 204.93                          | 433.55                     | 10282.02                    | 9848.47                   | 4.2%       |
| 2020 | 272.41                          | 284.85                          | 557.26                     | 10465.87                    | 9908.61                   | 5.3%       |
| 2021 | 319.27                          | 370.65                          | 689.92                     | 10649.71                    | 9959.79                   | 6.5%       |
| 2022 | 369.18                          | 462.34                          | 831.52                     | 10833.55                    | 10002.03                  | 7.7%       |
| 2023 | 422.14                          | 559.93                          | 982.07                     | 11017.39                    | 10035.32                  | 8.9%       |
| 2024 | 478.16                          | 663.41                          | 1141.57                    | 11201.23                    | 10059.66                  | 10.2%      |
| 2025 | 537.23                          | 772.79                          | 1310.02                    | 11385.07                    | 10075.05                  | 11.5%      |
| 2026 | 599.36                          | 888.05                          | 1487.41                    | 11568.92                    | 10081.51                  | 12.9%      |
The results show that in 2016 the reduction of household waste recycling and composting activities reached 1.2% and increased in 2036 to reach 28%. This increase was influenced by the value of people's behavior in the conduct of the recycling / waste banks and composting. Recycling has been done but the community composting activities are still few who do. Based on the results of the questionnaire known why people who do composting at least one of them is they do not understand how to compost and equipment that they have not had. However, some places are already doing composting activities also could not run because of lack of assistance and motivation given to the public.

The respondent data of the questionnaires can be analyzed to determine the potential reduction of solid waste in Sukomanunggal Subdistrict. The analysis results stated that the current reduction of household solid waste in Sukomanunggal Subdistrict reached 2.1%. Based on the analysis of public participation, it is known that the increased willingness of Sukomanunggal residents to reduce the household solid waste will potentially lead to the value of waste reduction of 28.0% in 2036.

4. Conclusion
Based on the results and discussion above, it can be concluded that the total household solid waste generation in Sukomanunggal Subdistrict in 2017 amounted to 27,162.58 kg/day. The total reduction of household solid waste in Sukomanunggal Subdistrict today reached 2.1% and the total reduction of household waste in Sukomanunggal Subdistrict in 2036 was estimated to reach 28.0%.

| Year | Waste bank reduction (ton/year) | Composting reduction (ton/year) | Total reduction (ton/year) | Total Generation in TPA (ton/year) | Residues (ton/year) | % reduksi |
|------|--------------------------------|--------------------------------|--------------------------|-----------------------------------|-------------------|-----------|
| 2027 | 664.54                         | 1009.21                        | 1673.75                  | 11752.76                          | 10079.01          | 14.2%     |
| 2028 | 732.78                         | 1136.26                        | 1869.04                  | 10936.60                          | 10067.56          | 15.7%     |
| 2029 | 804.07                         | 1269.21                        | 2073.28                  | 12120.44                          | 10047.16          | 17.1%     |
| 2030 | 878.42                         | 1408.04                        | 2286.46                  | 12304.28                          | 10017.82          | 18.6%     |
| 2031 | 955.83                         | 1552.77                        | 2508.60                  | 12488.12                          | 9979.52           | 20.1%     |
| 2032 | 1036.29                        | 1703.39                        | 2739.68                  | 12671.97                          | 9932.29           | 21.6%     |
| 2033 | 1119.80                        | 1859.91                        | 2979.71                  | 12855.81                          | 9876.10           | 23.2%     |
| 2034 | 1206.37                        | 2022.31                        | 3228.68                  | 13039.65                          | 9810.97           | 24.8%     |
| 2035 | 1295.99                        | 2190.61                        | 3486.60                  | 13223.49                          | 9736.89           | 26.4%     |
| 2036 | 1388.67                        | 2364.80                        | 3753.47                  | 13407.33                          | 9653.86           | 28.0%     |

The 4th International Seminar on Sustainable Urban Development  IOP Publishing
IOP Conf. Series: Earth and Environmental Science 106 (2018) 012068 doi:10.1088/1755-1315/106/1/012068

References
[1] Badan Pusat Statistik Kota Surabaya. 2015. Kecamatan Sukomanunggal dalam Angka
[2] Surabaya City Spatial Plan, 2014
[3] Wijayanti, D. R., dan Suryani, S. 2015. Waste Bank as Community-based Environmental Governance: A Lesson Learned from Surabaya. Procedia-Social and Behavior Science. 184: 171-179.
[4] Undang-Undang No.18 on Waste Management. 2008.
[5] Peraturan Menteri Lingkungan Hidup No.13 Tahun 2012 tentang Reduce, Reuse, and Recycle Implementation Guidelines
[6] Surabaya Environmental Status Report, 2012
[7] SNI 19-3964-1994. Methods of Measuring and Sample Measurement of Waste Generation and Urban Composition. 1994