The reduction of carbon dioxide emission at 3R Superdepo Sutorejo waste processing unit (TPS), Surabaya

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Abstract. This research aims to know waste volume, waste composition, and emission reduction through sorting and without sorting at Superdepo Sutorejo Waste Processing Unit (TPS), Surabaya. The calculation of waste volume and composition was carried out in accordance with SNI 19-3964-1994, while the calculation of carbon dioxide emission was based on the United States-Environmental Protection Agency (US-EPA). The results showed that the solid waste volume in Superdepo Sutorejo Waste Processing Unit was 0.7 kg/person/day with organic waste composition percentage of 63%, plastic waste of 15.22%, paper of 5.36%, aluminium of 2.22%, glass of 1.31%, rubber 0.78%, and residual waste of 12.09%. Carbon dioxide emission without waste sorting was amounted to 9,087.05 MTCO2E/year while carbon dioxide emissions through waste sorting was amounted to 8,512.5 MTCO2E/year. Therefore, the sorting at 3R Superdepo Sutorejo Waste Processing Unit (TPS) Surabaya could store the emission of carbon dioxide by 6.3%.

1. Introduction

Population growth in Indonesia, especially in Surabaya, which continues to grow is not only one of the reasons why urbanization is increasingly high, but also a cause of changes in consumption patterns and lifestyles which ultimately results in more types of waste, the volume of waste, and waste characteristics [1,2].

Surabaya produces waste around 9,712.05 m³/day [3] with a composition of organic waste of 54.31%, plastic waste of 19.44%, paper of 14.63%, wood of 1.61%, fabric of 1.47%, leather of 1.19%, rubber of 1.14%, kava of 1.12%, B3 of 0.86%, metal of 0.48%, ceramic of 0.17% and others of 3.59% [4].

Constitution number 18 year 2008 about waste management implies the changes of waste management towards waste management and waste reduction. Waste reduction can be conducted by limiting the volume of waste, recycling, and reusing waste which is known as reduce, reuse, and recycle (3R).

3R Waste Processing Unit is a place where the activity of collecting, sorting and using waste in regional scale are conducted. The waste found in Waste Processing Units is brought to 3R Waste Processing Unit, and the residual waste from the 3R Waste Processing Unit is then disposed to the landfill.

3R Superdepo Sutorejo Waste Processing Unit has an area of 1.400 m² and receives waste from Dukuh Sutorejo vvillage (4253 KK) and Kalisari (4311 KK) village which reaches to 250 – 300 ton/month [5].
According to the Constitution No. 18 Year 2008 concerning on Waste Management, types of waste are as follows:

1. Household Waste
   Household waste is solid waste originating from the rest of daily activities in the household, not including specific feces and garbage, and from natural processes that originate from the household environment. This waste is sourced from home or from a housing complex.

2. Household-like Waste
   Household-like waste is a household waste which originates not from household and household environment, but from other sources like traditional markets, trade centers, schools, offices, hospitals, restaurants, hotels, terminals, seaports, industries, city parks, and others.

3. Specific Waste
   Specific waste is household waste or household-like waste which because of its nature, concentration and/or amount, it requires special treatment. It includes waste containing hazardous and toxic materials (B3) such as used batteries, used toner, etc., waste containing B3 waste (medical waste), disaster-related waste, debris, waste which is technically not yet able to be processed, and periodic waste that arises (waste from community service).

The increasing community needs caused an increasing amount of waste generated from its activities. Waste which is accumulated and buried in a relatively long time will experience decomposition and produce gas that is classified as greenhouse gas and spreads in the air [6].

The further efforts to achieve good environment are treatment improvement and waste volume reduction. Thus, the occurrence of waste reduction will also reduce carbon gas emissions and reduce the impact of global weather changes.

2. Methods
   2.1 Determining the volume rate and the composition of waste
   The measurement of volume rate and composition of waste was conducted in accordance with SNI 19-3964-1994 [7]

   2.2. Calculating carbon dioxide gas emissions according to US-EPA
   Calculating CO₂ gas emissions can be done by multiplying CH₄ and 1 emissions – volume fraction of CH₄ per volume fraction of CH₄ substituted with oxidation factor with molecular weight of CO₂ per molecular weight of CH₄ [8].

3. Result
   Waste volume per unit of population was obtained from the amount of waste that enters the 3R Superdepo Sutorejo Waste Processing Unit per population served by 3R Superdepo Sutorejo Waste Processing Unit. Superdepo Sutorejo 3R Waste Processing Unit serves two villages in Mulyorejo Subdistrict, namely Dukuh Sutorejo village and Kalisari village which have a total population of 31,585 people [9].

   Waste volume of this area which was handled by 3R Superdepo Sutorejo Waste Processing Unit was 0.7 kg/person/day.

   The biggest waste composition in 3R Superdepo Sutorejo Waste Processing Unit was kind of waste that can be composed, which was 63%. This kind of waste was the largest composition because daily household activities produced food waste or domestic waste.

   The second position was plastic waste of 15.22% with the composition of plastic types as follows: mixed plastic of 6.56%, LDPE plastic of 4.66%, PET bottle of 2.06%, and HDPE plastic of 1.94%. The third position was residual waste, which was then followed by paper of 5.38%, can of (aluminium) 2.22%, glass of 1.31%, and rubber 0.78%.
Table 1. The Calculation Result of CO2 Emissions Through Sorting and Without Sorting at 3R Superdepo Sutorejo Waste Processing Unit

| CO2 Emission Without Sorting at 3R Superdepo Sutorejo Waste Processing Unit |
|--------------------------------------------------|
| 1. The total of waste produced                     |
| 2. CO2 Emission                                   |
| 9.087,05                                          |

| CO2 Emission With Waste Sorting at 3R Superdepo Sutorejo Waste Processing Unit |
|--------------------------------------------------------------------------------|
| Types of Plastic                                                               |
| 3. LDPE Plastic                                                                |
| 4. Mixed Plastic                                                               |
| 5. PET Plastic                                                                 |
| 6. HDPE Plastic                                                                |
| 7. Paper                                                                       |
| 8. Can (aluminium)                                                             |
| 9. Organic Waste                                                               |
| 10. Total                                                                      |
| 156,685                                                                        |

CO2 Emission with waste sorting (CO2 Emission without waste sorting – Total)
8,512,5

4. Discussion
Surabaya is included as a metropolitan city because it has a population of more than 2 million people. According to SNI-3242-2008, metropolitan cities have waste volume reaching 3 L/person/day. The rate of waste volume in Surabaya is 3.2 L/person/day or 0.96 kg/person/day [3]. This means that the waste volume at 3R Superdepo Sutorejo Waste Processing Unit is lower, it is only 0.7 kg/person/day.

The composition of the waste is mostly in the form of organic waste, then followed by the type of plastic waste and residue respectively (Fig 1).

Figure 1. Waste Composition at 3R Superdepo Sutorejo Waste Processing Unit

The residual waste in question is mixed waste which is not sorted by TPS 3R Superdepo Sutorejo Waste Processing Unit, such as: diapers, tissue papers, fabrics, glasses, rubbers, and organic waste which are not composed (durian skin, corn, etc).

3R Superdepo Sutorejo Waste Processing Unit does not sort residual waste, glasses, and rubbers so that they will be disposed directly to the landfill.

The biggest number of plastic waste composition is mixed plastic waste, followed by LDPE, PET, and LDPE plastic waste (Fig 2)
Figure 2. Plastic waste composition at 3R Superdepo Sutorejo Waste Processing Unit

The calculation result of CO2 greenhouse gas without waste sorting at 3R Superdepo Sutorejo Waste Processing Unit is 9.087.05 MTCO2E/year. While, it is 8.512.5 MTCO2E/year through waste sorting.

CO2 greenhouse gas emission which is stored from waste sorting activity at 3R SuperDepoSutorejo Waste Processing Unit is 574,512 MTCO2E/year. The minus (-) value in all calculations indicates the amount of gas stored by waste material and is not released into ambient air.

Therefore, waste sorting activity at 3R Superdepo Sutorejo Waste Processing Unit is able to reduce 574,512 MTCO2E/year or by 6.3%.

5 CONCLUSIONS
1. The rate of waste volume generated by the villages served by 3R Superdepo Sutorejo Waste Processing Unit Surabaya is 0.7 kg/person/day. Waste composition at 3R Superdepo Sutorejo Waste Processing Unit is the type of organic waste of 63%, plastic waste of 15.22%, residual waste of 12.09%, paper of 5.38%, can (aluminium) of 2.22%, glass of 1.31%, and rubber of 0.78%.
2. CO2 greenhouse gas emission at 3R Superdepo Sutorejo Waste Processing Unit with waste sorting is 8.512.5 MTCO2E/year. While CO2 greenhouse gas emission at 3R Superdepo Sutorejo Waste Processing Unit without waste sorting is 9.087.05 MTCO2E/year, so that waste sorting activity at 3R Superdepo Sutorejo Waste Processing Unit can store carbon dioxide emission of 574,512 MTCO2E/year or 6.3% from the total of emission of carbon dioxide without waste sorting.

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