Designing of Municipal Solid Waste (MSW) treatment plant in Onggomertan Village, Yogyakarta

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Abstract. There is an undeveloped area as illegal disposal of MSW in Onggomertan because there is no waste load services. The leachate of this illegal disposal may pollute the river and the waste heap decrease the environmental aesthetics. The objectives of this research were to calculate solid waste generation and composition in Onggomertan and design the undeveloped area as MSW treatment plant. The waste sampling method used SNI 19-3964-1994 and manual of calculation procedure of waste generation and composition 2012. The design of MSW treatment plant based on technical guidance of TPS 3R 2017. The result showed that average waste generation in Onggomertan was 0.706 kg/capita/day in weight unit. The composition of the MSW were 22.85% of organic waste, 21.859% of plastics, 14.101% of papers, 3.889% of metal and the remaining 37.302% of other waste like glass, hazardous waste, and residue. Based on waste generation and composition data, required area for MSW treatment plant is 378 m$^2$ of available area 426 m$^2$. This plant consist of waste treatment area 280 m$^2$ and supporting facility area 98 m$^2$. Composting used in MSW treatment plant is hollow brick box technology.

1. Introduction
Nowadays information technology development drives people to have higher consumption level. Many products advertise massively through social media caused someone can get information easily on his smart phone. Increased consumption levels lead to increased waste production in the community. Sleman Regency located in Yogyakarta Province. The central region of Sleman is the agglomeration area of Yogyakarta city includes Depok Districts. Depok categorized as urban area because it is a center of education, trade and services. So, in Depok occur not only rising the population number but also increasing the waste volume.

Based on Sanitation Strategic of Sleman 2015, only 5.92% of waste were transported and disposed to Piyungan Landfill and the 3.37% is waste from urban area. Mostly, the remains waste will be managed by burned, dumped or discard the waste to river. Because of it, Depok is classified a very high sanitation risk on solid waste management (MSW) [1].

Onggomertan is one of villages in Depok districts with area 16 Ha. The population number of Onggomertan is 965. Onggomertan’s people discard their solid waste to the undeveloped area on riverbank. This area becomes an illegal disposal of MSW because there are no waste load services in Onggomertan. The leachate of this illegal disposal may pollute the river and the waste heap decrease the environmental aesthetics. So, government needs innovation and action to handle the increasingly widespread illegal waste disposal especially in urban areas.
Technical guidance of TPS 3R 2017 issued by Ministry of Public Work and Citizen Housing of Indonesia was a comprehensive guidance for citizen and local government to design a MSW treatment plant called TPS 3R or Tempat Pengolahan Sampah by Reduce, Reuse and Recycle principality. TPS 3R is a role of waste management for communal scale by active involving of government and community. The technical guidance contain mechanism of TPS 3R program exertion include planning, implementation, evaluation and monitoring [2].

The objective of this research were to calculate solid waste generation and composition in Onggomertan and then design a MSW treatment plant in undeveloped area based on waste generation. The design of MSW treatment plant referenced to Technical guidance of TPS 3R 2017.

2. Method
Based on Technical guidance of TPS 3R 2017, the waste generation and composition must be calculating before designing a MSW treatment plant in Onggomertan. Waste sampling method referred to SNI 19-3964-1994, Method of Collecting and Measurement of Samples and Composition of MSW and manual of calculation procedure of waste generation and composition 2012 issued by Ministry of Environment and JICA. Based on calculation in this method, there were 4 households chosen as sample in this research. Two households represent high economics level and 2 households represent middle economics level. The waste generation was calculated by load count analysis method. The waste measured in eight days period [3]. Because of the objective of this research was to design MSW treatment plant so for collection step, the waste collected sorted into 5 types include organic, plastic, paper, metal and other. Each category was weighted and mixed it for total weight [4].

The data of waste generation and composition was used as consideration to design MSW treatment plant or TPS 3R. The design of layout MSW treatment plant should contain dropping area, sorting area, chopping machine room, composting area, compost maturation area, and supporting facilities area such as storage room, office, etc.

3. Result and Discussion

3.1 Waste Generation and Composition in Onggomertan
The measurement results of solid waste generation in Onggomertan for 8 consecutive days showed that the average solid waste generation was 0.706 kg/capita/day with volume 0.026 m³/capita/day and a density of 97.839 kg/m³. In Asian countries, one of the factors that influence waste generation is per capita income. The research shows that in developed countries generates more than 1 kg/capita/day while in developing countries with low income generates less than 1 kg/capita/day [5].

Based on the calculation, the waste composition categorized into 5 types, namely organic, plastic, paper, metal, and other.

| Type of Waste | Percent by weight (%) |
|---------------|-----------------------|
| Organic       | 22.850                |
| Plastic       | 21.859                |
| Paper         | 14.101                |
| Metal         | 3.889                 |
| Other         | 37.302                |
| **Total**     | **100**               |

It can be seen in Table 1 that other waste is the highest composition in Onggomertan. Other waste has a percentage of 37.302 % with a total amount of 254.135 kg/day. The high volume of other waste is because this waste consists of glass, hazardous waste and residue. In fact, the glass waste can be sorted and weighed. Another fact that causes other has high percentage is the presence of hazardous
waste like a bulb, tin cans, batteries and residual waste such as wood, diapers, and sanitary napkins that have considerable weight. Residue is waste that cannot be recycled or has no economic value.

The second highest composition is organic waste which has a percentage of 22.85 % with a total amount of 155.675 kg/day. Organic waste in Onggomertan is yard waste, food waste and miscellaneous organics. In developing countries, organic waste generally has the highest volume than the others [5].

Plastic has a percentage of 21.859 % with a total amount of 148.923 kg/day. This waste is consists of a large number of food packaging, soft drink bottles and damaged household appliances. Table 1 also shows that paper waste has a percentage of 14.101 % with a total amount of 96.068 kg/day. The generation of paper waste is dominated by white paper and cardboard. Metal is the lowest composition in Onggomertan. Metal waste only has a percentage of 3.889 % with a total amount of 26,945 kg/day.

After the waste composition known, this data is then used to design MSW treatment plant, especially in composting organic waste. Based on technical guidance of TPS 3R, there many kinds of composting technology such as bamboo aerator system, hollow brick box, stacked takakura, drum composter, and bokashi. Hollow brick box technology is chosen for composting of organic waste because it advantages are high capacity and easy maintenance.

3.2. Designing of MSW Treatment Plant (MSWTP)

The design of the MSWTP was carried out to improve the waste management in Onggomertan and convert the location of illegal dumping into useful land which is MSWTP. The design has area 378 m² of available area 426 m². Before the MSWTP was built, waste in the location of illegal disposal should be cleaned up independently by the community. This waste will be sorted based on its economic value. Then the residue will be transported and disposed to the Piyungan Landfill. MSWTP consist of 2 main parts namely waste management area and supporting facility area like office, parking lot and garden. The waste management area is divided into areas of dropping and sorting, composting area, inorganic storage, compost storage, residual waste room, hazardous waste room, parking of motorized pedicab, equipment warehouse and rest corner.

The first main space at the MSWTP is the sorting area which has an area of 36 m² with 6 meters in length and width. This sorting area is the first place for waste dropping after collected from residential. In this area, waste will be sorted by type and economic value. The sorting is done manually. After sorting, the organic waste will be composted in the composting area. However, before being composted, large-sized organic waste is chopped using the chopping machine. This machine is put on 6 m² area. This area is also used to put a sieving machine for mature compost. The composting area has an area of 84 m² with 14 m length and 6 m width. Based on the calculation, the requirement of composting area is 79.8 m². Composting in this MSWTP uses hollow brick box technology. Based on organic waste volume and the calculations that refer to the technical guidance of TPS 3R, the requirement of hollow brick boxes is 5 units. The dimensions of hollow brick boxes are 4.5 meters length, 2 meters width and 1 meter height. Organic waste in hollow brick boxes is stacked in layers with 15 cm of thickness. One brick box unit can accommodate 9 m³ of organic waste. The composting time is set at 30 days. The composting process will take 3 weeks and the maturation process of compost will take approximately 1 week. Hollow brick box design can be seen in Figure 1.
After the composting process is completed, compost is used for fertilizing plants around the MSWTP area and the rest is packed for sale. Packaged compost is then stored in compost storage. This place is 12 m² with 2 meters in length and 6 meters in width. In this place compost is put in open shelves.

Inorganic waste is sorted according to its specific type such as paper, plastic, glass, metal, etc. Sorted plastic waste such as plastic and paper should be compacted or pressed to reduce the dimensions. Sorted plastic waste can be chopped by chopping machine to produce a small size. This small size can save space and increase its economic value for recycling. Furthermore chopped plastics are packaged and sold to recycling factory. Paper waste can be put into a press machine to compress it size. Compressed paper will be stored in inorganic storage before sold to recycling factory. The area of this inorganic storage is 36 m² with 6 meters in length and width.

Residual waste room has a function as storage for residue. Whereas hazardous waste room has a function as storage for waste contains toxic substances. The residue and hazardous waste will be transported to the Piyungan Landfill for further treatment. The residual room has same size as hazardous room which is 6 m² with 3 meters length and 2 meters width. These rooms are designed as a closed room in order to reduce odors, enhance aesthetics and isolate the uneconomical waste.

Motorized pedicap is an operational transportation at MSWTP. The parking area for motorized pedicap is located next to the equipment warehouse which is 25 m². Then the width of the equipment warehouse is 15 m². The last part in waste management area is the rest corner for the workers to take a rest. This rest corner is 24 meters² with 6 meters length and 4 meters width. Total space for waste management area is 280 m². The design of MSWTP in Onggomertan is presented in Figures 2, 3 and 4.
Figure 2. Layout of MSWTP in Onggomertan

Figure 3. Top view of MSWTP in Onggomertan
It can be seen in figure 2, a part of MSWTP is the office. Office is the operational center in MSWTP. This office has an area of 16 m$^2$ with 4 meters in length and width. In the west of the office there are 2 toilets for sanitary facility for the workers in 3 m$^2$ of each. In the north of the office there is a 14 m$^2$ garden for enhancing aesthetics and improving the air quality of MSWTP. The south of garden there is a parking lot. Office, sanitary facility, garden and parking lot are supporting facility in MSWTP with total of 98 m$^2$.

4. Conclusion
The average waste generation in Onggomertan Hamlet is 0.706 kg/capita/day. The highest composition of waste is other waste 37.302 % consisting of glass waste, residual waste and hazardous waste. The second is organic waste 21.859 %. For the lowest composition is metal.

Based on organic waste composition, the composting design at MSWTP in Onggomertan uses 5 units of hollow brick boxes. And the total area of the designed MSWTP is 378 m$^2$ include waste management area 280 m$^2$ and supporting facility area 98 m$^2$. Waste management area consist of dropping and sorting area 36 m$^2$, composting area 90 m$^2$, compost storage 12 m$^2$, inorganic storage 36 m$^2$, residual waste room 6 m$^2$, hazardous waste room 6 m$^2$, motorized pedicap parking 25 m$^2$, equipment warehouse 15 m$^2$ and rest corner 24 m$^2$. Supporting facility consist of office 16 m$^2$, toilets 6 m$^2$, garden 14 m$^2$, and parking lot 62 m$^2$.

References
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