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THE PLANNING OF REDUCED, REUSE, AND RECYCLE-BASED TEMPORARY DISPOSAL SITE

Okik Hendriyanto CAHYONUGROHO[1,*], Euis Nurul HIDAYAH[1], Emeraldi FIRDAUS[1], Kusnul KHOTIMAH[1]

[1] Department of Environmental Engineering, Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia.
[*] corresponding author: okikhc@upnjatim.ac.id

Abstract

The community-based waste management methods through reduce, reuse and recycle-based temporary disposal sites (3R-TDS) was one of the possible municipal solid waste management strategies for reducing the volume of waste. The aims of this studied were to planned and design 3R-TDS in densely populated areas by combining various 3R-based waste management methods for obtaining a reducing volume of municipal solid waste to FDS. This studied was conducted into five main steps, that were collected primary data, calculated the density and composition of municipal solid waste, designed the 3R-TDS to determine the appropriate space based on functional processing. The results had identified the waste generation 4,454.72 kg/day or 0.431 kg/person/day, and it was predicted up to 8,930 kg/day within 10 years. The highest percentage of municipal solid waste was organic food waste 58%, and the lowest composition was leather 0.2%. Design of 3R-TDS could been applied to managed municipal solid waste had been the concept of 3R-TDS leads to arrange 973 m^2, which provided area for in ordered to facilitate dropping, separating, sorting, waste processing for plastic, inorganic, organic, residue, leachate, and supporting area.

Keywords:

Disposal site;
Organic waste;
3R concept;
Waste generation;
Waste composition.

1 Introduction

One of the environmental problems is the increasing quantity of municipal solid waste due to the increasing population. Municipal solid waste is unwanted residual materials from human activities after the end of a process, and those residuals are abandoned by being disposed. Some of the problems in municipal solid waste management are the high amount of waste generated, the low level of service management, the limited number of landfills, the authority of waste management institutions, cost issues, and low public awareness to participate in reducing the amount of waste and the importance of maintaining a clean environment [1]. Due to many factors that affect the quantity and quality of municipal solid waste, integrated waste management is required to control the abundance of solid waste. Technically, solid waste management is a systematic, comprehensive, and sustainable activity that includes waste reduction and handling, starting from the process of collecting waste from settlements or other sources of waste, transporting waste to be disposed of in a Temporary Disposal Site (TDS), and the final disposal will be processed in the Final Disposal Sites (FDS). Sanitary landfill and open dumping is the most commonly used solid waste management system at FDS, although these systems are less environmental friendly [2-3]. It is because of the potential for pollution of groundwater and has the potential to contribute to Greenhouse Gas (GHG) emissions with the dominating gases being CH_4, CO_2, and N_2O [4]. In addition, the landfill's condition is threatened with being unable to operate fully due to the high amount of residue. As a result, the amount of waste in landfills is increasing day to day because of an unbalanced of low recycling rate, solid waste is difficult to recycle, and it accumulates in the landfill eventually [5-6].

The community-based waste management methods through Reduce, Reuse, and Recycle-based Temporary Disposal Sites (3R-TDS) is one of the municipal solid waste management strategies for reducing the volume of waste. This method applied the approach of 3R-TDS infrastructure for reducing, utilizing, and processing municipal solid waste from its source on a communal scale, which is carried out through collection, sorting, reuse, and recycling activities by involving the role of government and

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society [3,7]. Indonesia has established hundreds of 3R-TDS, however only 10% of 3R-TDS performed well. According to the 3R-TDS Technical Guidelines 2017, about 30% of the performance of 3R-TDS is determined by the technical-technological aspect, including volume of municipal solid waste managed, condition of buildings and infrastructure, type of management, condition of equipment, compost production, and volume of waste residue transported to landfill [8]. Therefore, pre-planning, planning, and design of 3R-TDS plays an important role, starting from determining data on municipal solid waste volume influenced by population, amount of municipal solid waste accumulation, land area requirements, design of building room functions, waste management flow, design of 3R-based waste processing units for plastic waste, inorganic waste, organic waste, and residual waste, and its supporting facilities. In addition to the 3R-TDS method, the other strategic program is the garbage bank, which forces people to segregate the waste from its source and come to the garbage bank to make a deposit based on their waste's value [7,9]. Shortly, this innovative idea shaped the circular economy concept, which could create new jobs and increase the community's income, especially for the poor. Referring to municipal solid waste issues and strategic management methods, this study aims to plan and design 3R-TDS in densely populated areas by combining various 3R-based waste management methods to reduce the volume of municipal solid waste in FDS.

2 Research Methodology

The study area was conducted in Wonorejo District at Surabaya City, Indonesia, which has a high-density population, as seen in Fig. 1. The existing area is about 1 ha, and it is only equipped with a composting area of 200 m^2. Therefore, this study is designed to develop the area into Temporary Disposal Sites (TDS) with Reduce, Reuse, and Recycle (3R) concept. The first stage of the research began with the collection of primary data, including the total population and municipal solid waste volume in the planned area, to determine the solid waste generation in the next 10 years. Municipal solid waste generation was obtained using the load count analysis method, by measuring the weight and volume of solid waste transported by carts to the TDS for 8 consecutive days. Solid waste generation per person was obtained by dividing the total solid waste weight by the number of people in the planned area. Further, the total solid waste generation was obtained by multiplying the result of solid waste generation per person by the total population of the planned area [2,7].



a) b)

Fig. 1: Study area of TDS Wonorejo District, Surabaya City, Indonesia. a) existing area of TDS; b) detailed of TDS.

The second stage was to calculate the density and composition of municipal solid waste based on the SNI 19-3964-1994 method, the Indonesian National Standard for Sampling and Measuring of Solid Waste Generation [10]. The third stage was to design the 3R-TDS in terms of determining the building space based on functional processing and structural building, then it was performed as a layout of the building. The calculation of the size of the building is carried out according to the needs and the volume determined by the Technical Analysis [7,11]. The fourth stage was the flow process of solid waste management in the TDS based on the volume of waste in the existing conditions that have been used. The last step was to plan the cost budget plan to know the economic value of the temporary disposal site, then The government could determine the service fee charged to the community, and the service fund could be used for TDS operational and maintenance [8]. Shortly, the procedure included

planning techniques including warehousing planning, such as volume, quantity, placement, and cost budget plan; collection, such as trolley volume, route determination, and collection time; and temporary disposal sites, such as dimensions, construction, and cost budget plan.

3 Results and Discussion

3.1 Generation, density, and composition of municipal solid waste

According to the observation, collected data, and calculation, this study found that the average solid waste generation was 4,454.72 kg/day, while the average per person was 0.431 kg/person/day. The total solid waste generation per day was 8,930 kg in the next 10 years. This data was obtained from the sum of solid waste generation data from human activities in the study area. Density or ratio of weight and volume of solid waste was 100.71 kg/m^3. The density value was used to determine the volume or capacity of containers used and the area of the temporary disposal site to be used. The density value was obtained by weighing the weight of municipal solid waste in one cart and comparing it with the amount of solid waste volume based on the waste carrier [2]. Fig. 2 presents the composition of municipal solid waste, which is classified into organics, inorganics, plastics, and sanitary waste.

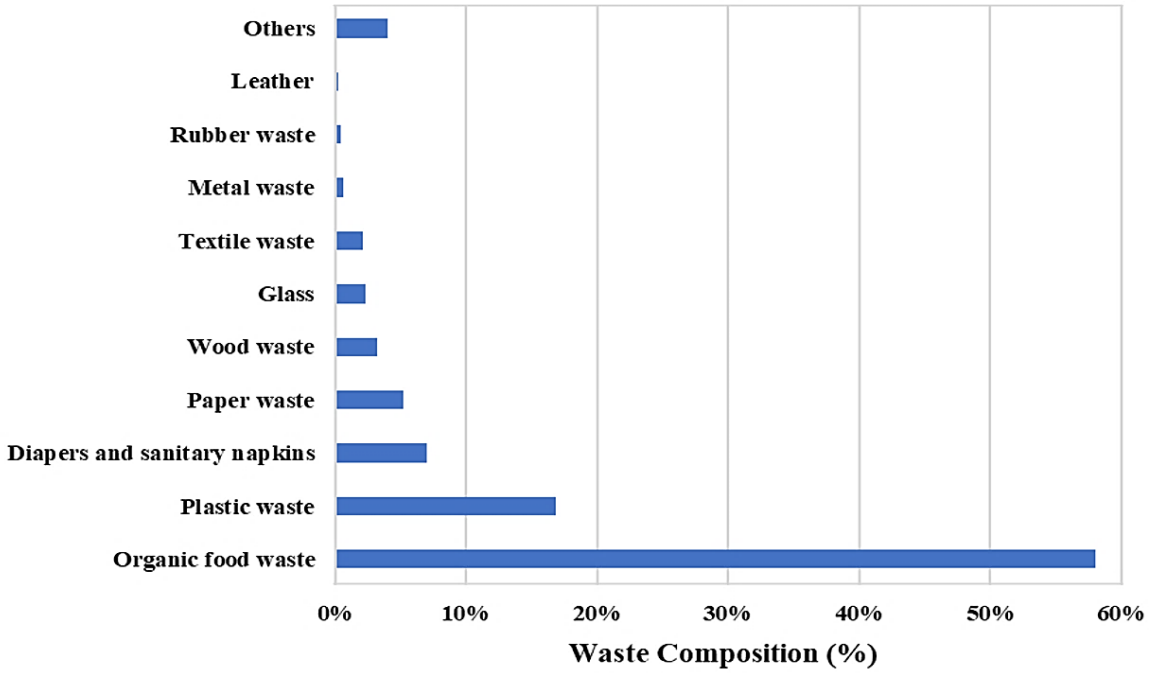


Fig. 2: Identification of percentage municipal solid waste composition in the study area.

The largest solid waste composition is wet waste about 58%, which is produced from kitchen waste or organic food items. The high value of wet waste composition is caused by household activities every day, a lack of treatment for wet waste by the community, and wet waste has a very high water content which can cause a heavier mass of waste [3,5,12]. The second largest solid waste composition is a plastic waste with 16.8%. The composition of plastic waste could be reduced by reusing plastic items, or each house can sort and collect plastic waste to be utilized by plastic waste collectors. In some residences, scavengers are prohibited from entering and collecting plastic waste due to safety reasons in the residence area. Nevertheless, a campaign against using plastic waste materials is recommended to reduce the use of plastic goods. This study found that the composition of plastic waste is mostly made from HDPE plastic, bottles, aluminum, styrofoam, and other types of plastic. The third largest solid waste composition is disposal nappies, which consist of diapers and sanitary napkins with a composition of 7%. The sanitary pads will be disposed of in two ways, that are either buried in landfills, which takes hundreds of years to decompose, or burned in incinerators that release toxic fumes like dioxins, phuron, and other carcinogenic compounds into the atmosphere [4,13]. The other waste compositions are paper waste with a percentage of 5.20%, wood waste at 3.20%, textile waste with a percentage of 2.10%, metal waste at 0.61%, rubber waste at 0.40%, leather 0.20%, glass 2.30%, and other waste. Currently, the available data regarding furniture and electronic waste in Indonesia prove to be inadequate and a

study is needed to increase public awareness and concern. However, some efforts to reuse and recycle used furniture materials, such as selling to secondhand stores or waste collectors, donating to those in need, change the shape of the furniture into something needed or cycled. Electronic waste is returned to the waste collector or sent to the original seller for recycling purposes.

3.2 Temporary Disposal Site-Based 3R Design

Based on the volume of waste generated per year and referring to the percentage of waste composition, this research proposed a design of 3R-TDS for solid waste management. The 3R-TDS has been arranged in a 973 m^2 area, which consists of dropping area, separating area, sorting area, plastic waste processing area, inorganic waste processing area, organic waste processing area, leachate collection basin, residue disposal area, and other supporting areas. The specifications and technical details of each area are described in Table 1. The dropping area is the first area to receive waste that will be transported to the TDS or to place waste temporarily. A sorting area is an area for sorting waste that has been segregated or unsorted waste from the source of waste and transportation. Waste sorting is carried out based on the type of solid waste, such as plastics, paper, glass, metals, organic waste, and others. The sorting area is equipped with a conveyor belt, which is a walking machine that can move waste material. This makes it easier to sort waste according to its type. The plastic waste processing area consists of four main areas, namely the storage area, sorting area, washing and drying area, and milling area. Plastic waste storage area is used to unload plastic waste after passing the waste sorting process. Collected plastic waste is being sorted according to its color and type in the plastic waste sorting area, and this study found the plastic waste capacity to be processed by 75%. The Washing and drying area of plastic waste aims to remove dirt or other materials by washing and drying, to produce plastic that is ready to be milled. A plastic waste milling area is provided for the plastic waste that has been dried and then put into a plastic milling machine to be processed into plastic ore or pellets and the results will be packaged and sold to plastic ore buyers [1,14].

Table 1: Detail engineering design of 3R-TDS.

Area	Capacity [%]	Loading rate [m^3/hour]	Dimension (L x W) m	Total Area [$m^{2]}$]	Supporting equipment
Dropping area	100%	5.71	10.0 m x 10.0 m	100.0	
Sorting area	100%	5.71	10.0 m x 10.0 m	100.0	Conveyor belt
Plastic waste processing area	16.8% over 100%			30.0	
Storage area	16.8% over 100%	0.96	5.0 m x 2.0 m		
Sorting area	75% over 16.8%	0.72	2.0 m x 2.0 m		
Washing area	75% over 16.8%	0.72	2.0 m x 2.0 m		
Drying area	75% over 16.8%	0.72	3.0 m x 3.0 m		
Milling area	75% over 16.8%	0.72	2.0m x 1.5 m		Milling Machine
Inorganic waste processing area	18.2% over 100%			13.0	
Storage area	18.2% over 100%	1.04	3.0 m x 3.0 m		
Sorting area	90% over 18.2%	0.936	2.0 m x 2.0 m		
Organic waste processing area	58% over 100%	3.32		342.0	
Shredding area	75% over 58%	2.5	3.0 m x 2.0 m		Shredding Machine
Composting area	75% over 58%	2.5	3.5 m x 3.5 m		Bamboo aerator
Sieving and Packaging area	50% over composting volume	1.25	6.0 x 6.0 m		Sieve and press machine
Leachate collection basin and buffer zone		0.04	2.0 m x 2.0 m 2.0 m x 2.0 m	8.0	inlet and outlet piping
Residual disposal area (including container and pick-up zone)	7% over 100% 25% over 16.8% 10% over 18.2% 25% over 58%	0.4 0.24 0.104 0.83	10.0 m x 10.0 m	100.0	
Supporting area				280.0	

The inorganic waste processing area is equipped with a storage and sorting area. A storage area is provided to accommodate various inorganic wastes other than plastic waste and the volume of waste is around 0.96 m^3/hour. In the sorting area, plastic waste is sorted and collected based on worth selling and not worth selling, which is conducted manually by workers. Inorganic waste is sorted into each container, namely yellow containers for paper waste, blue containers for metal waste, red containers for glass waste, and green containers for fabric waste. The categorized inorganic waste is then packaged and stored in the storage room to wait for the buyer's pickup [5,15]. Meanwhile, waste that is not suitable for sale is distributed to the residue area for disposal to landfill. The organic waste processing area has two main areas, the shredding area and the composting area. The shredding area is equipped with a shredding machine that will be used to cut the organic waste into shreds. For example, food waste organic waste is chopped into smaller sizes, so that it can speed up the composting process with the planned time. The composting area is provided to process chopped organic waste into compost with the addition of bioactivators [2,16]. The composting process is also assisted by using bamboo aerators, the composted products will be sifted and packaged for marketing. The leachate collection basin is designed to collect leachate from the organic waste processing area in the composting process and the dropping area through a closed channel. Further, leachate is used as a compost waterer because it contains carbon, nitrogen, phosphorus, potassium, and trace elements that are useful for composting [8, 16]. A residue disposal area is provided to place residual waste in several areas after the sorting process. Supporting areas consist of an office area, guard post, container garage, toilet, laboratory, and storage warehouse used to store compost products, plastic ore products, and inorganic waste that are worth selling [11]. Fig. 3 shows the layout of 3R-TDS, which describes the flow of solid waste from the dropping area to the residual disposal area.

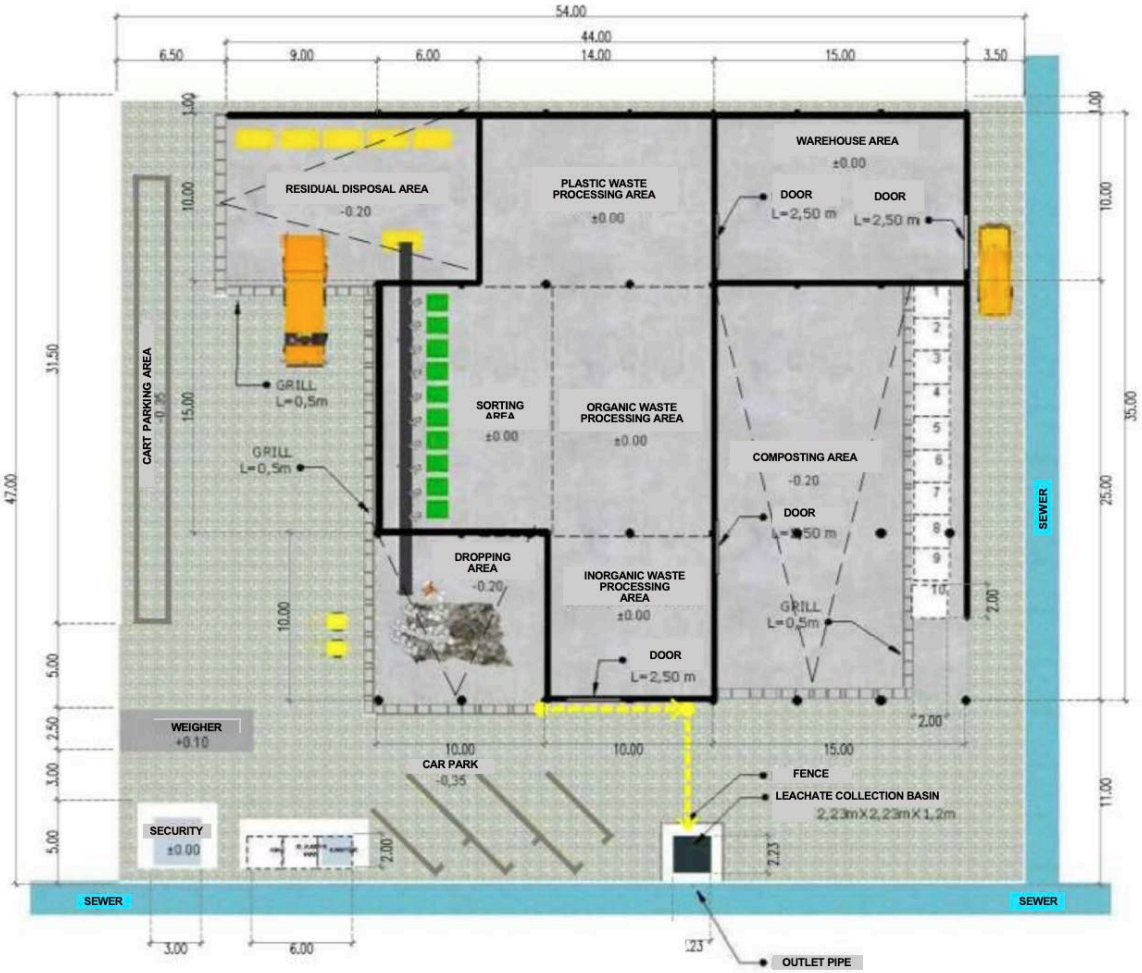


Fig. 3: Layout of 3R-TDS of Wonorejo District for municipal solid waste management.

Concept 3R-TDS has been set up in several cities in Indonesia, as follows in the website https://sipsn.menlhk.go.id/sipsn/. It means that the TDS is running to manage solid waste and to improve

environmental quality especially in the high density population. Government supports the design of 3R-TDS to be implemented and managed based on community empowerment. Therefore, this action is part of the sustainable development goals (SDGs), largely contributed to SDG 1 : no poverty, SDG 3: well-being and good health, SDG 8 : decent work and economic development, and SDG 11: sustainable cities.

4 Conclusion

This study found that the study area generated an average solid waste of about 4,454.72 kg/day or equal to 0.431 kg/person/day. The total solid waste increased in the following 10 years to 8,930 kg/day. The highest percentage of municipal solid waste was organic food waste 58%, and the lowest composition was leather 0.2%. This study applied Temporary Disposal Site Based, in terms of Reduce, Reuse, and Recycle-based Temporary Disposal Sites (3R-TDS). The concept of 3R-TDS leads to arranging a 973 m^2 area for dropping area, separating area, sorting area, plastic waste processing area, inorganic waste processing area, organic waste processing area, leachate collection basin, residue disposal area, and other supporting areas. Some supporting equipment will be installed in the particular area to perform a high-efficiency reduction, reuse, and recycling of solid waste, instead of reducing waste volume in the final disposal site.

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