Reduction of waste generation to extend the lifetime of landfill: review

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Abstract. The increasing number of people in Indonesia, one of which is the city of Semarang, has led to increased community activities. Increased community activities will affect the increase in the amount of waste production. It will also impact the service life of the landfill, so efforts need to be made to extend the service life of the landfill. Efforts can be made to reduce the amount of waste that goes to the landfill, usually by sorting organic and inorganic waste. Reducing the amount of waste can also be done by utilizing waste that has been buried in the landfill (TPA), then processed into alternative fuels or RDF (Refused Derived Fuel). Waste reduction by sorting organic and inorganic waste has been carried out in several places, namely Putri Cempo TPA, Milangsari, and Sukoharjo, with percentage reductions of 79.6%, 35%, and 58%. Meanwhile, the use of waste into fuel or RDF (Refuse Derived Fuel) can also be used as an effort to extend the service life of the landfill because waste that has been buried for a long time has a high calorific value so that it meets the requirements as fuel for the pyrolysis process.

1. Introduction

Recently, waste has become one of the sanitation problems in Indonesia. The definition of waste is the residue of daily human activities and/or natural processes in the solid form [1]. The increase in population growth, accompanied by an increase in the number of community activities, affects the amount of waste produced. It happens a lot in several areas in Indonesia, one of which is the city of Semarang. Most of the waste produced by the people of Semarang City will enter and be processed at the Jatibarang Landfill.

The city of Semarang provides facilities to manage waste in the form of a final processing site (landfill or TPA), namely the Jatibarang TPA, located in Kedungpane Village, Mijen District, Semarang City. TPA Jatibarang started operating in 1991 with an Open Dumping system, then in 1994 changed to a Controlled Landfill system. The Jatibarang TPA waste management system changed again in 1995 to become a Sanitary Landfill until now [2]. TPA Jatibarang has a capacity of 4.15 million m$^3$ of waste with a volume of 3,750 m$^3$ of waste entering the landfill per day [3]. It is estimated that the capacity of the Jatibarang TPA will only be able to accommodate waste until 2021 [4].

Several activities are carried out in the Jatibarang TPA area, namely processing waste into fertilizer, leachate treatment, waste sorting, utilization of methane gas, methane gas canteen and Waste Power Plant (PLTSa). These activities cause the zone that should be a landfill to be reduced [2]. The lack of land and the...
increasing amount of waste entering the Jatibarang landfill will affect the service life of the landfill, so efforts are needed to extend the service life of the landfill. Efforts that can be made include controlling the amount of waste that will go to the landfill by reducing waste at the source and utilizing waste that has been buried in the landfill.

The Semarang City Government has made several efforts to reduce waste production, one of which is the prohibition on the use of plastic as stated in the Semarang Mayor Regulation Number 27 of 2019 [5]. This regulation is intended to control the circulation of plastic waste from waste-producing sources, which aims to reduce waste products to affect the amount of waste brought to the landfill.

However, this regulation is not practical because many traders in traditional markets use plastic bags as packaging for their merchandise. Besides that, many people still do not care and understand the purpose of this regulation. Then, other efforts must be made to reduce the amount of waste that goes to the landfill. Sorting organic and inorganic waste before being processed at the TPA is one of the efforts that can be done to reduce the amount of waste generated. Sorting can be done at the integrated waste management site. Waste is sorted based on its characteristics; usually, processed waste will be composted to reduce organic waste going to the landfill. As for inorganic waste, scavengers will take it for recycling. Another effort that can be made to extend the service life of the TPA is the use of waste into alternative fuels or often called RDF (Refused Derived Fuel).

2. Methodology

Before analyzing to reduce landfill waste, several data need to be collected, both primary and secondary data. The primary data needed are waste composition, waste generation, waste density, calorific value, field surveys and interviews. Meanwhile, secondary data needed are population data, waste characteristics, waste data on weighbridges and related regulations [6].

A sampling of waste composition and generation is carried out by referring to SNI 19-3964-1994 concerning Methods of Collection and Measurement of Urban Waste Generation and Composition. The waste generation in the TPA is determined by measuring and recording the amount of waste entering the TPA. Meanwhile, the density of waste is measured by taking samples from the type of waste transporting vehicle. It is because each vehicle has a different volume capacity. Measurements were made on the weighbridge to determine the vehicle's empty weight and when the vehicle was filled with garbage [6].

It is necessary to test the calorific value to determine the potential of combustible waste material as raw material for RDF by conducting random sampling spread over 3 points with different depths, namely 0-1 m, 1-2 m, and 2-3 m. After sampling, a bomb calorimeter test was conducted to determine the calorific value of the waste samples taken from the TPA [7].

After obtaining the required data, quantitative and qualitative analysis was carried out. Quantitative analysis is carried out on population projections and waste generation projections using arithmetic methods to analyze the age of the landfill. Meanwhile, the data obtained from surveys and interviews were analyzed qualitatively or descriptively [6].

3. Result and discussion

Efforts to reduce the amount of waste generation can be made by sorting organic and inorganic waste. Waste sorting can be done at the TPA or from the TPS. Waste sorting at TPS is called TPST or MRF (Material Recovery Facility), which is defined as a place where waste separation and processing activities occur centrally [8]. MRF is an alternative to TPS (Temporary Shelter), where there is a process of sorting organic and inorganic waste before the waste is sent to the TPA [9]. Organic waste will be composted, while inorganic waste separated will be carried by scavengers or the recycling industry. Recycling program in informal sector brings positive impact to the waste reduction sector. According to Samadikun et al. [10], 3R program implemented for paper waste in the informal sector provides economic benefits and also supports
paper waste reduction with a percentage reduction of 15.9% [10]. Meanwhile, separated waste that cannot be composted or recycled will be taken to the TPA for further processing. MRF planning begins with analyzing the generation and composition of waste and seeing the recycling potential of the generated waste. Then the calculation of recovery factor and mass balance of the material is carried out, which aims to determine the amount of waste that can be processed with the material recovery facility. Treatment with MRF can increase the economic potential of the waste [11]. In addition, centralized waste management may reduce costs and the resulting greenhouse gas emissions [12].

Methods of sorting organic and inorganic waste have been carried out in several areas to reduce the amount of waste to the landfill. The Surabaya State Shipping Polytechnic has done sorting by the MRF method. The results show that the waste processed is 54% of the total waste produced [13]. Waste reduction efforts are said to extend the life of the landfill because it has reduced the volume of existing waste. The research results conducted at the Putri Cempo TPA said that the reduction process could reduce the volume of waste by 79.57%. In 2013, the volume of waste in the Putri Cempo TPA Surakarta City was 206,028.96 m³. Then after efforts to reduce the waste that went to the TPA, the volume of waste became 42,085.51 m³ [14]. The process of sorting waste can be done by the composting method. This method can reduce waste by up to 10% to reduce the burden of the landfill [15]. Reducing the amount of waste generated by the composting method has been carried out at TPA Milangsari, Magetan Regency. The results show that the previous volume of waste was 11,116.38 m³ after composting 35% of organic waste; the volume of waste became 7,225.65 m³. It also impacts land requirements, which initially required an area of 16,129 m² in 2025 only required an area of 10,484 m² [15]. To extend the service life of Sukoharjo TPA, the 3R (Reuse, Reduce, Recycle) process has been carried out. The study results show that after sorting the waste, the service life of the TPA, which was initially only available until 2022, can be extended to 2025. In addition, the 3R process at TPA Sukoharjo shows significant comparison results after sorting the waste. In 2028, waste generation is predicted to be 24,821,724 kg, while after sorting, waste generation will be reduced to 14,401,796 kg [6]. Waste sorting can be done by composting and recycling, both of which can be done at the source of the waste through the community, such as a waste bank. If composting and recycling are carried out in a landfill, it will require land to carry out both activities [16-18]. However, if recycling and composting are done at the source, it will get several advantages, including saving transportation costs, temporary waste storage, and reducing land requirements [19-20].

The increasing amount of urban waste production, the increasing waste generation in the TPA results in the shorter life of the TPA. It is necessary to optimize the waste management in the landfill to extend its life, one of which is by making waste as alternative energy (Waste to Energy). RDF (Refuse Derived Fuel) is a waste management technique by converting waste into something useful, namely fuel [7]. RDF production aims to change the combustible fraction from non-combustible waste [21].

Analysis of the potential for RDF (Refused Derived Fuel) has been carried out in several TPAs, including the Murareja TPA, Tegal Regency. In this TPA, plastic waste is processed by pyrolysis using Refuse Derived Fuel (RDF) sourced from the TPA waste. TPA Murareja waste used as RDF material consists of paper waste, rubber or leather waste, cloth waste, wood and plastic waste. Based on the research that has been done, the average calorific value of TPA Murareja waste is 4,819.22 kcal/kg. As fuel for the pyrolysis incinerator, the calorific value of RDF required is 3,248.8 kcal/kg, so it can be said that the Murareja TPA waste meets the requirements as fuel for the pyrolysis incinerator [21]. RDF potential analysis has also been carried out in the active zones I and II and the passive zone of the Jatibarang TPA. In this study, samples were taken at a 0-3 meters depth by random sampling method. The results obtained, the calorific value in the active zone I and II, the passive zone at a depth of 0-1 meters is 6.07 kcal/ton, 5.69 kcal/ton, and 5.25 kcal/ton. At a depth of 1-2 meters, the calorific value is 5.55 kcal/ton, 6.07 kcal/ton, and 5.76 kcal/ton, while at a depth of 2-3 meters, the calorific value is 5.55 kcal/ton, 5.94 kcal/ton, and 6.31 kcal/ton. From this research, it can be seen that the lower the depth of the waste, the higher the calorific value, so that it has the
potential as raw material for RDF (Refuse Derived Fuel) produced by combustible waste [7,22-23]. Although RDF has the benefits of reducing waste generation and replacing fossil fuels to reduce the emission burden, it also has disadvantages, namely high production costs and limited management in terms of storage and transportation. RDF has also been implemented in several countries in Europe, including Austria and Italy. RDF fuel substitution in Austria reaches 63%, while in Italy, it is only 8% so that to develop the RDF market, the policy authorities must limit the level of the incentive system so that RDF has a price. There needs to be a monitoring body to ensure consistent product quality. The government should also simplify producing RDF and provide policies for companies investing in this sector to maintain the environmental sustainability. Although RDF has the benefits of reducing waste generation and replacing fossil fuels to reduce the emission burden, RDF also has disadvantages, namely high production costs and limited management in terms of storage and transportation [24].

4. Conclusion

Based on previous research, it can be said that sorting organic and inorganic waste effectively reduces the amount of waste to more than 20% of the original waste generation. Utilization of waste into alternative fuels or RDF (Refused Derived Fuel) is also effective in reducing waste generation in the TPA because the calorific value produced meets the fuel requirements for the pyrolysis process. So it can be said that these two efforts can extend the service life of the landfill.

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