A preliminary study of a landfill as a raw material for RDF: a case study in Medan City

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Abstract. The increase in population is directly proportional to the use of goods/materials, resulting in the volume of waste produced. If it is not processed, an increase in the volume of waste will lead to the emergence of piles of waste and the need for landfill land to accommodate waste is higher. One solution to solve the waste problem is to convert waste into fuel through Refuse Derived Fuel (RDF). This research aimed to study the characteristics of the landfill and its potential as an RDF raw material. The research was conducted at the Terjun Landfill in Medan. This study found that the water content of the waste ranged from 12.88 percent to 38.35 percent, the ash content from 0.625 percent to 1.575 percent, and the calorific value from 12.13 MJ/Kg to 36.58 MJ/Kg. According to the findings, inorganic combustible fraction waste can be used as a raw material for RDF and a substitute for coal.

1. Introduction
Waste is a material or substance that comes from daily human activities and natural processes in solid form. It comes to be in the form of organic (biodegradable) or inorganic (non-biodegradable) substances disposed of into the environment because they are no longer used. Waste must be managed so as not to pollute the environment. If managed properly, waste has many benefits for humans and the environment. On the other hand, if the waste is not managed correctly, it will be detrimental and cause disasters for humans and the environment [1].

In general, the municipal solid waste management system is a collection, transportation, and disposal. First, the waste is collected from the source, then transported to a temporary disposal site, and finally, the waste is processed at the landfill. The last stage of waste management is carried out at the landfill [2]. According to the Law of the Republic of Indonesia No. 18 of 2008 concerning Waste Processing, a landfill is a place to process and return waste to the environment safe for humans. The amount of waste produced results in the amount of waste piled up in the landfill. The increase in the discharge of waste entering the landfill causes the need for landfill land to accommodate the waste to be higher. However, the provision of land needs for a new landfill has not been implemented because a new location for a landfill is challenging to find, requires quite a lot of costs and opening a new landfill is similar to opening up new problems/impacts on the environment [3].

Medan, the capital of North Sumatra province, is one of Indonesia's largest cities, covering 265.10 km2. The population in the city of Medan was 2.12 million people in 2009, which increased to 2.26 million in 2018 [4]. Population growth is one of the factors that affect the environmental balance. The
number of goods or materials used daily has an impact on the amount of waste produced. If not handled, an increase in the amount of waste will become one of the significant environmental issues.

The Terjun landfill, in operation since 1993, is now the only one in Medan city. The Terjun landfill, located in the Terjun village, Medan Marelan sub-district, has 137,563 m³. Based on research conducted in 2015, the average daily volume of waste disposed of in landfills is 3,868.57 m³ [6]. Scavengers manage waste in the landfill, which has a range of volumes of 89.02 m³. After calculating, the range of volume of untreated waste at the Terjun landfill every day is 3,779.55 m³. It can be concluded that waste management carried out by scavengers does not reduce the volume of waste generated at the Terjun landfill. Waste accumulation in Indonesia is a problem that cannot be solved. Piles of waste in the landfill or temporary disposal site could cause disturbances.

Waste management aims to improve environmental quality, protect public health and make waste more useful, namely as a resource with economic value. The utilization of waste can be made into compost, fertilizer, industrial raw materials, or converted into energy sources. Recovery of resources from waste can be one of the technologies for reducing the volume of waste in the future [3]. Converting waste into fuel, also known as Refuse Derived Fuel (RDF), is possible solutions to the physical (thermal) waste problem. RDF can also be interpreted as the result of sorting combustible waste fraction and separated from non-combustible fraction through the process of enumeration, sifting and air classification [6]. RDF can be burned directly into alternative fuels or used as a mixture of coal fuel. Domestic and industrial waste with a high calorific value can be used as raw material for making RDF [7].

According to several studies, landfills have the potential to be used as RDF. Combustible waste has the potential to be reused as an RDF source material [7,8]. They are leaves/wood, paper, plastic bags, PET bottles, and rubber [9]. Because of its high water content, food waste is less effective. Organic and inorganic waste had calorific values ranging from 20.8 MJ/kg to 29.5 MJ/kg [10].

This study conducted a test on inorganic combustible waste fraction originating from Terjun landfill, Medan City. Furthermore, a comparison is made between the results of laboratory tests and the quality standard of RDF. The results of this study are expected to be one of the solutions and strategies for waste management for landfills.

2. Methods
This study took place at the Terjun landfill in Medan, Indonesia. The research began with the acquisition of secondary data and then proceeded to collect primary data.

2.1. Secondary data collection
2.1.1. Waste generation and composition. The generation of waste per person per day was obtained from the Department of Cleanness and Parks of Medan City.

2.1.2. RDF standard. The Italian standard is applied as the RDF quality standard for the calorific, moisture, and ash content criteria. The Italian standard has a lower value and may be tailored to the characteristics of the Terjun landfill waste. The calorific value of RDF obtained is modified according to SNI 13-5014-1998 on Coal Resources and Reserves Classification.

2.2. Primary data collection
Data collection in the field was carried out by drilling at the Terjun landfill to collect waste and soil in the active zone with a depth of ± 5 meters. The sample to be tested is a combustible inorganic fraction aged a day and 0-2 years from C zone, 2-10 years from B zone and > 10 years from A zone. Primary data for this research are the value of the water content, the value of the ash content and the calorific value of the landfill.
Table 1. Age of the Terjun Landfill’s zones

| Zone | Estimated age (years) | Estimated age (days) |
|------|-----------------------|----------------------|
| A    | >10                   | 3650                 |
| B    | 2 - 10                | 1825                 |
| C    | 1 - <2                | 365                  |
| C’   | 0                     | 10                   |

Waste was sampled in four zones: zones A, B, C, and C’, each with two sampling locations. The random sampling approach was used for the sampling technique.

Figure 1. Sampling locations

3. Result and discussions

The most composition of waste is plastic, which is 32%, followed by organic 24%, soil 16%, cloth/cotton/diaper 11%, others (nails, glass and iron) 9%, paper 4%, rubber/leather 2% and styrofoam which is 2%. In general, RDF is an alternative fuel obtained from the separation of non-combustible waste and combustible waste such as plastic, rubber/leather, cloth/textile, synthetic resin, paper, wood, as well as the results of wastewatertreatment in the form of mud [11,12]. In this research, inorganic combustible waste includes plastic, paper, rubber/leather, cloth/cotton/diaper, and styrofoam. Meanwhile, non-combustible waste is organic waste and other waste, namely metal, iron and glass. Based on the composition of waste data, the Terjun landfill waste has consisted of 50% combustible inorganic waste, 34% non-combustible waste and 16% soil. The composition of the Terjun landfill waste is shown in figure 2.

Figure 2. Composition waste at Terjun landfill
This study found that the average water content of waste is 12.88% in the A zone, 25.90% in the B zone, 38.35% in the C zone, and 32.93% in the C’ zone. Figure 3 shows that only the sample of waste from A zone can be used as raw material for RDF because it has a moisture content of less than 25%, 12.88%.

![Figure 3. Water content](image)

Based on the ash content test results, the average value of zone A is 0.8%, 0.625% for zone B, 1.575% for zone C, and 1.125% for C’. Waste samples from all zones can be used as raw materials for RDF since their ash content is less than 20%, as shown in Figure 4. As a result, no extra processing is needed to lower the waste sample's ash content.

![Figure 4. Ash content](image)

For the calorific value, zone A has a heating value of 36.58 MJ/Kg, 32.9 MJ/Kg for zone B, 12.13 MJ/Kg for zone C and 22.61 MJ/Kg for zone C’. The calorific value results show that there is only one waste sample, namely the sample from zone C, which cannot be used as raw material for RDF because it has a calorific value less than 15 MJ/Kg, which is 12.13 MJ/Kg.

![Figure 5. Caloric value](image)
Terjun landfill generated 1,007 tons of waste per day in 2019. According to this analysis, the landfill's inorganic combustible waste was 50% or 503.5 tons per day. Based on the average data, the calorific value of the Terjun landfill is 30.65 MJ/kg of waste. Terjun landfill is estimated generated energy up to 15,432,275 MJ/day. This energy has the potential to be used as a substitute fuel or a mixture of coal.

4. Conclusion
Each zone's combustible fraction waste characteristics are A, B, C, and C' zones, with an average water content of 12.88 percent, 25.90 percent, 38.35 percent, and 32.93 percent, respectively. The average ash content of waste was 0.800%, 0.625%, 1.575%, and 1.125%, respectively. Waste has calorific values of 36.58 MJ/Kg, 32.90 MJ/Kg, 12.13 MJ/Kg, and 22.61 MJ/Kg, respectively. According to this study, inorganic combustible waste at Terjun Landfill has the potential to be used as RDF, generating power in the average of 30.65 MJ/Kg or 7320.63 Kcal/Kg, slightly higher than the energy produced by coal, which is 7000 Kcal/Kg. The water content, ash content, and calorific value of waste in zone A (waste older than ten years) can all be confirmed to be within acceptable limits. Waste older than ten years is the most potential to be used as RDF.

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