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Excavated waste characteristic from Semarang City landfill sites. Part 1: physical characteristic

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Excavated waste characteristic from Semarang City landfill sites. Part 1: physical characteristic

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Abstract. Globally, Landfill is still the most common method for waste disposal. In most developing countries, the landfill has received municipal waste without going through any separation, even intermediate treatment. Landfill sites have become hidden treasure full of resources. Jatibarang Landfill in Semarang City, Indonesia has been operated since 1992 and received 800 tons of waste daily. This research investigates the characteristic of excavated waste from Jatibarang Landfill. Excavation method was used to obtain a sample from the landfill. The sample will be characterized by its composition and size distribution. Organic waste dominated the composition of waste coming to the landfill, but it was altered after decomposition process in the landfill. Most materials were decomposed and only left the inert material as a majority, undecomposable organic and plastic in the second and third place. It shows that landfill play a significant role in waste decomposition, and by that, there is a possibility to recover recyclable materials or produce solid fuel from the residue.

1. Introduction

The landfill is still become the most popular disposal means for municipal solid waste (MSW) in the world. UNEP counted that in Asia, 51% of disposal process is open dumping while 31% is sanitary landfill. Incineration and recycling only take 5% and 8% of the total, respectively. While, in Africa, 47% adopts the dumping and 29% employs sanitary landfill. On the other hand, in North America, sanitary landfill takes 91% of waste disposal method [1]. While developed countries already closed their landfill and move to other alternative treatments, developing countries still rely on landfill as disposal means for their MSW because it is cheaper compared to other methods [2]. Landfill as disposal methods has several disadvantages such as polluting soil and water body from leachate, release methane which brings worse effect than CO_2 and bothering the neighborhood from its smells. A method to minimize the impact while bringing the benefit is urgently necessary. One of the ideas is by excavating the waste and recovering valuable material.

Krook et al. (2012) address that, despite the idea of landfill mining was started since the 1950s, the research about this topic increased rapidly in 1990s because of stricter new environmental regulation [3]. In the past, landfill mining was only about land reclamation, methane gas collection and metals recovery[4]. The development of more sophisticated waste treatment and recycling programs in early 2000 drastically changed the attention of this issue, until 2007 the idea about the extended concept of landfill mining arose in Europe [5]. To improve the system, the concept of Enhanced Landfill Mining (ELFM) was proposed as one of breakthrough to fully utilize the potential from excavating the waste from old landfill [6]. ELFM concept also answers the issue of increasing prices and declining stocks of natural resources. The landfill was seen as resources stockpile since it contains a massive amount of metals and carbonaceous material [7]. The metals from the landfill could be recycled to become a new product. Carbonaceous materials such as plastics and wood could be used for refused derived fuel (RDF).

Indonesia, with a population of 257million in 2015, shows exponential growth in their GDP and also its waste generation. In 2012, Indonesia generated solid waste up to 151,921 tons per day (tpd), and 7,896 tpd of it was from Jakarta alone [8]. Many people attracted to move to big cities to work because of low employment in the rural area. This urbanization phenomenon put the massive burden for waste management since their landfill capacity is insufficient [9]. Since the enactment of Indonesian Law number 18/2008 on Waste Management, amount of landfill site in Indonesia is increasing rapidly. In 2014 itself, Ministry of Public Works built 110 landfill sites around Indonesia. Currently, local government in Indonesia operates 521 landfills with a total area of 2098 ha, most of them are open dumping landfill [8]. Even though the basic design was sanitary landfill, low commitment from the government for consistent operation turn the landfill into open dumping or at least controlled landfill.

The number of waste generation is growing, the pollution from the landfill is getting worse, and the land area is limited. A strategy to solve landfill problem in Indonesia is needed. This research will investigate the potential of landfill mining to reclaim the land used for landfill. Landfill sites in Semarang City, Indonesia named Jatibarang Landfill was excavated for its material. The method developed for this research will be explained briefly. The composition and particle size analysis will also be explained.

2. Jatibarang Landfill Sites and Semarang City Waste Management

Semarang is the capital city and the main port for the Central Java Province. It is located on the north coast of Java and 540 km east of Jakarta. Current stakeholder responsible for solid waste management is Semarang City Agency for The Environment (BLH). Total waste generated from Semarang City was around 4999 m3 with a total weight around 920 ton every day in 2015's survey. 87% of those waste was collected and transported to the landfill, while the other 13% was burned or being thrown away into the water body by a citizen[10,11].

The local neighborhood did door to door waste collection. The residence must put their waste in a designated place in front of their house. The neighborhood association hires workers to collect the waste and deliver it to the transfer point. In the transfer point, waste coming from a various neighborhood in the same district will gather and wait to be transported to the landfill [12].

Jatibarang Landfill was located on the west side of Semarang City in a mountainous area, surrounded by forest. It has been operated since May 1992 and has a total area of 46 ha. The landfill was equipped with fertilizer factory which produces 250 ton of granule fertilizer per day. The leachate generated from the landfill was collected and treated in the leachate pond before discharged to Kreo River. The surrounding forest was conserved and used as a buffer zone to protect the residential area. In the south border of the landfill site, a river was flowing from the city’s water intake. 1.5 km to the south, there is the lake that used for drinking water sources by local drinking water company. Figure 1 shows the location of Semarang City and Jatibarang Landfill [13,14]. Figure 2 shows the site plan of Jatibarang Landfill[14].

Figure 1. The Location of Semarang City and Jatibarang Landfill

Figure 2. Site Map of Jatibarang Landfill

About 350 scavengers are residing in the surrounding area work in Jatibarang Landfill. They collect recyclables and do some pretreatment before sending to recycling factory. Some of them also raise cattle and grazing their cattle in dumping site. The total of livestock population was around 1300.

The presences of the landfill may contaminate air, water, land and living organism in the surrounding area if not managed correctly. In the case of Jatibarang Landfill, the management has not applied sanitary landfill procedure in daily operational. Land cover was not spread every day cause a leakage of methane gas into the atmosphere. The leachate is hard to control and potentially harm the river nearby. The toxic material might also contaminate the cattle grazing in the landfill from consuming organic material from waste.

3. Excavation And Sampling Process

Before the excavation process, we did a preliminary survey to check the waste characteristic coming to the landfill for a week. The survey was done by sampling trucks before they dump the waste. The average composition of waste coming to the landfill is shown in figure 3. The results show that food waste still dominates the majority of waste, followed by plastic and garden waste.

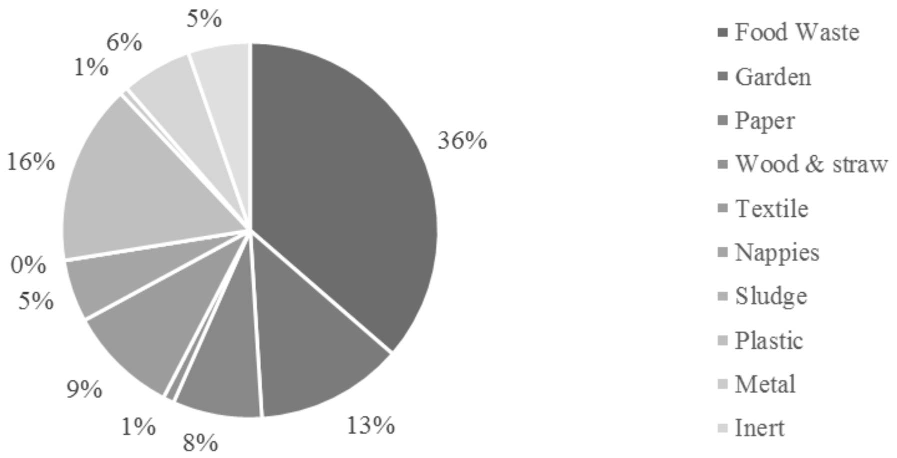


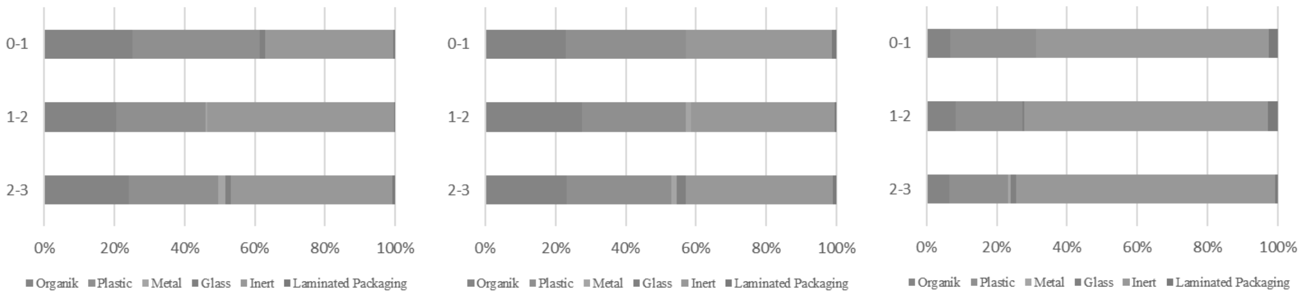
Figure 3. Average Composition of Waste Coming to The Landfill

From the preliminary survey, we could catch a glimpse about the composition of waste inside the landfill. Most of the organic waste will probably be decomposed and become inert material after being stored for a long time in the landfill.

The excavation takes place in July 2017 for about three weeks. There are many challenges during the excavation due to harsh environment and weather. We use mid-size excavation machine for our sampling process. Firstly, nine random points spread throughout the landfill area was chosen. In each point, the excavator dug the landfill for 3 meters with an interval of 1 meter. Few scoops of waste were taken until spread evenly in working sheets. The waste was divided into four parts. Each part will be treated for different analysis. This paper will focus on the first and second part only; waste composition and sieve analysis. Ultimate analysis and moisture analysis will be discussed in the next paper. The first part was going for composition analysis. The waste was characterized into six different types; organic, plastic, metal, glass, inert and laminated packaging. The second part was going for particle size analysis. Using three sizes of sieve (7.5 mm, 5 mm and 2.5 mm), the excavated waste was manually sieved by hand. Figure 6 shows the sampling process, waste separation, and sieve analysis.

4. Result and Discussion

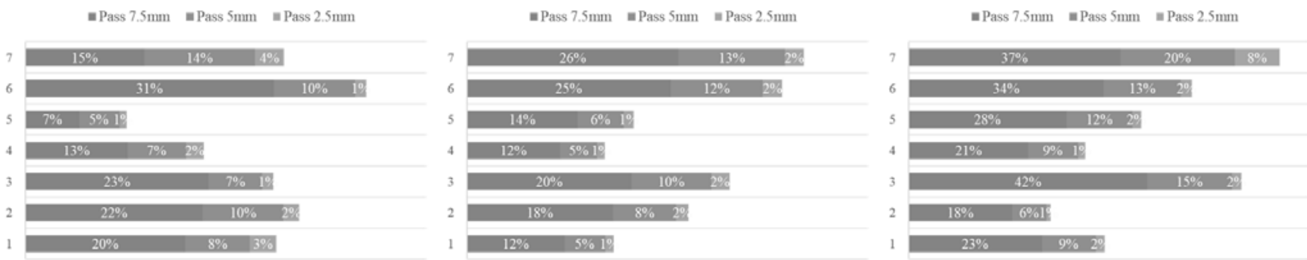
From composition analysis, we can learn that the major components of excavated waste are inert material. These findings confirm our hypothesis in the previous chapter. Most of the waste coming to the landfill is an organic decomposable waste. After years of decomposition process in the landfill, organic waste will turn into carbon dioxide and methane through the aerobic and anaerobic process. Those process left residue in the form of inert material which consists of carbon and heavy metals. Figure 4 shows the average composition in different landfill area based on activity intensity and depth.



(a) (b) (c)

Figure 4. (a) waste composition in the area with the highest activity; (b) waste composition in the area with less activity; (c) waste composition in the area with no activity

We categorize the composition based on the activity intensity because we want to see whether the activity has effects on the decomposition process under the landfill or not. Figure 4 (a) and (b) show a similar trend. While inert dominate the composition, plastic and organic still show significant value due to new waste still coming and mixed with old waste. Figure 4 (c) shows decreasing percentage in the amount of organic fraction and very high amount inert material. In that area, old waste has been dumped for a long time without any new waste coming. The organic material was gradually decomposed and turn into the inert material as seen on decreasing fraction as the depth increase.



(a) (b) (c)

No.	Remarks
1	Point 1 Depth 0-1 m
2	Point 1 Depth 1-2 m
3	Point 1 Depth 2-3 m
4	Point 2 Depth 0-1 m
5	Point 2 Depth 1-2 m
6	Point 2 Depth 2-3 m
7	Point 3 Depth 0-1 m

Figure 5. (a) sieve analysis in the area of the highest activity; (b) sieve analysis in the area with less activity; (c) sieve analysis in the area with no activity

Sieve analysis will tell us about the average size of the excavated material. Data no 1 – 6 was acquired from the excavation process in the flat land up in the hill area while data no 7 was from slope area. In the slope area, the material which larger than 7.5 mm was likely more presents other than another area. The decomposition process in that area did not go well because of disruption from a landslide. Material which is larger than 7.5 mm was not only come from the undecomposable organic material but also from large size plastic material. In the deepest part, while all organic material was likely to be decomposed, the percentage of material larger than 7.5 mm increase again because at that point plastic waste also dominates the composition. Because we do the sieve analysis manually, there are troubles when the clumps of soils clog the sieve. This condition reduces the precision of the analysis.

5. Conclusion

Jatibarang Landfill in Semarang City was excavated to analyzed its characteristic. It was found that biochemical process in the landfill could alter the waste composition before being dumped and after dumped in different depth. The most organic material was decomposed and become inert material. The plastic waste composition was not significantly changed and still could be found in the deepest part. The most excavated material has size over 7.5 mm. Big size material was consist of undecomposable organic and plastic. All inert material passed through 7.5 mm sieve. This research explains half part of the whole experiment. The next paper will explain possible energy recovery from excavated material.

6. Acknowledgment

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