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IDENTIFICATION OF COMPOST POTENTIAL ON DEGRADED SOLID WASTE IN TPA PIYUNGAN LANDFILL, BANTUL, YOGYAKARTA AS A STEP OF LANDFILL MANAGEMENT OPTIMIZATION BY USING LANDFILL MINING METHOD

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ABSTRACT

Yogyakarta with population of 3.6 million people has a potential to produce waste by 2,953 tons/day, equivalent to 11.996 m^3/day which keeps on increasing along with the rising of the population number, as well as the composition of waste which becomes more complex along with the complexity of society's consumption patterns. This waste will end up in TPA Piyungan landfill located in the administrative district of Bantul. This landfill has been operated since 1995 and should have exhausted its lifetime by 2015. But this landfill is still operated by optimizing zone 1 which previously had been closed/full capacity. However, this operational is estimated to only last 1-2 years, so the expansion of the landfill must have been planned. One method that can be used in order to optimize and realize the sustainable landfill is the method of landfill mining. Potential of soil resulted from waste degradation in the landfill has not been followed by optimum utilization. Hence, this research will examine the potential of the soil to be used as organic compost, but it is necessary to analyze nutrient and metal content in order to fit for use as compost. Sampling method was conducted in four locations of zone 1 by drilling using a Spindle Type core Drilling Rig through a Spindle Stroke with 7cm diameter, in which each are drilled per one meter up to 13 meter. The depth is divided into three groups, i.e. the depth of the samples by 4; 8 and 12 meters, the division will reflect the age of the waste. The results showed that the nutrient content was very low, either content of organic material, phosphorus or potassium. So they do not meet with the requirements of organic compost from SNI 19-7030-2004 Aand Minister of agriculture decree of 70/2012. While the C/N ratio still meets the required values, 10-20 ratio. The analyzed metal parameters in the soil include Zn, Cr, Cu, Cd, Ni, Pb, Hg, Mn and Fe. All metal parameters meets the requirements of organic compost, except Pb that still exceeds the standard grade. The mixing of urban ddomestic waste with hazardous and toxic material derived from domestic activity has caused the possibility of waste mixed with heavy metal. The utilization of degraded soil in Piyungan landfill still requires a preliminary pprocessing in order to increase nutrient content and decrease Pb nutrient to meet the requirement of organic compost.

Keywords: Landfill mining, organic compost, sustainable llandfill
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1. INTRODUCTION

Waste currently has become a problem in many areas in Indonesia, and it is no exception to the province of Yogyakarta Special Region. The region with population of 3.6 million inhabitants (BPS, 2016), has a potential to produce waste of 2.953 ton/day, equivalent to 11.996 m^3/day. The volume of the waste keeps continues as the increasing of population number, as well as the composition of waste which becomes more complex along with the complexity of society's consumption patterns. Waste management in Indonesia is still using the "end of pipe" concept; large amounts of waste would be delivered towards the end of a system, which is the final processing place (landfill). Such management is still used although it is not an effective solution. According to Law 18/2008 on Waste Management, the waste must be managed with environmental perspective, so as to avoid negative impacts on public health and the environment. However, the implementation has not yet to show maximum results. The management of waste in the landfill will deal with technology issues and will culminate in high cost (Putra, 2014).

Province of Yogyakarta Special Region has some landfills; one of them is Piyungan landfill which is located in the administrative region of Bantul. In its management, Piyungan Landfill is jointly managed as regional landfill, serving the urban areas of 3 districts/cities in the Yogyakarta. Piyungan landfill has an area of 12,5Ha with storage capacity reaching 2.7 million m^3 of garbage which is divided into three work zones (Nasa, 2014). This landfill has been operated since 1995, the period of use of 15 to 20 years has made the Piyungan landfill in 2015 exhausted its lifetime. Until 2016, the landfill was still operated by optimizing zone 1 which previously had been closed/full capacity. However, this operational is estimated to only last 1-2 years, so that in 2017 The Yogyakarta provincial Government should have a development plan of the landfill as a place to dump waste produced.

One method that can be used in order to optimize the landfill and realize the sustainable landfill is the method of landfill mining. Landfill mining is an attempt to regain useful materials from the waste (Directorate of PPLP, 2012). The process of extracting minerals or other solid natural resources from the heap of solid waste that has been processed previously in the landfill (Krook et al., 2012). According to Savage et al., (1993) the method of landfill mining was first introduced in Israel in 1953 as a way to get fertilizer for plantation activities. Actually landfill mining is a promising strategy to solve the problems of the increasing quantity of garbage in a city, the limited of the landfills area, and minimizing high cost for the operational activities and for post-operational activities of a landfill (Dickinson, 1995).

The organic composition of waste in Indonesia is very high compared with other types of waste, which reached 63%. There is a significant relationship between the levels of income of a country with the organic composition of the waste that is produced. The higher the income level, the lower the organic portion and vice versa (Aleluia, 2016). About 47.13% of the waste that goes to Piyungan landfill is food waste, the other organic portion consists of park and garden waste of 20.56%, and wood 3.39% (Adidarma, 2014). The large amounts of organic composition are delivered in to the system of waste dumping in the landfill, in which in a relatively short time the waste will be degraded into soil. Zhou (2014) states that for every landfill mining activities that have been done, the soil becomes the largest part of 50-60%, followed by 20-30%

flammable garbage material, especially plastics, and 10% of inorganic material such as stone and glass, and only a few percentage of metal.

Potential of soil from the degraded garbage in the landfill has not been followed by maximum utilization; this study will examine its various potentials in order to utilize soil derived from degraded waste in the landfill. One of its functions is to make it ready to be used as compost, but we need to know first its organic content, C/N ratio, and the elements/other compounds contained in the soil to meet requirements to be used into compost. Because of the Landfill operational where different types of waste mixed and potential mixture of domestic waste and hazardous and toxic material from domestic waste, it is necessary to analyze the content of heavy metals in the soil.

2. METHODOLOGY

2.1. Sampling Activity

This research is a field research conducted by sampling and followed by experiment in the laboratory. The sampling was conducted in 4 locations in the 1st zone of Piyungan Landfill, Bantul. Samples were taken by conducting a drilling using a Spindle Type Core Drilling Rig through Spindle Stroke with 7cm diameter drilled per one meter up to 13 meter. The samples from waste degradation are weighed and analyzed of its composition. But the waste composition analysis is a separated part of this publication.

2.2. Laboratory Work

The degraded soil samples taken from the surface down to 13 meters in depth, is used in three groups, i.e. the sample with the depth of 4; 8 And 12 meter from the surface. The division of depth is in order to reflect Age of the waste according to period of dumping conducted. Each sample is examined in the laboratory with examination parameters as follow:

Table 1. Examination parameter on degraded soil

No	Nutrient element	No	Metal element
1	Organic material	1	Zinc (Zn)
2	C/N Ratio	2	Chrom (Cr)
3	Phospor (P)	3	Copper (Cu)
4	Potassium (K)	4	Manganese (Mn)
		5	Iron (Fe)
		6	Cadmium (Cd)
		7	Nikel (Ni)
		8	Lead (Pb)
		9	Mercury (Hg)

2.3 Data Processing

Data processing is an analysis of a laboratory examinations on various parameters related to soil nutrient element and heavy metal parameter. This study hypothesized that the degraded soil obtained from waste degradation that has been stored for a long time in a landfill can be used as soil fertilizer (compost) for plants.based on the organic waste in the landfills in Indonesia. The results of the examinations of elements nutrients and heavy metals contained in the soil of various drilling of depth in the landfill were compared with SNI 19-7030-2004 about the specifications of compost from organic domestic waste and the Minister of Agriculture decree (PerMenTan) 70/2011 on organic fertilizer, biological fertilizer and soil enhancement.

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2.4 RESULTS

Analysis of the results is initiated by determining the composition of the waste and period of time the waste heaped in the Piyungan landfill. Since there is no accurate data related to the age of the waste, it is necessary to model the age of waste. Using data of the waste delivered into the landfill per year, the total area of zones 1 is 4 Ha, the weight of this type of waste is estimated to 800kg/m^3, the degradation factor is 30%, soil to cover is 3% (to landfill with sanitary landfill category the ratio of covering soil is 15-20%, a value of 3% is a prediction because Piyungan landfill management in 1995-2000 still not meet the applicable procedures). On this account, it is estimated that the depth of the landfill on operational period are as follows:

Table 2. Modeling of waste depth in Zone 1 of Piyungan landfill

Year	Total (ton/ year)	Total (m^3/ year)	Degra-dation (30%)	Cover Soil (3%)	Total garbage (m^3/year)	Total (m^3/ month)	Total (m^3/ day)	Height (m/ year)	Depth Total (m)
1995	87.500	109.375	32.813	3.281	79.844	6.654	222	2,0	12,9
1996	90.200	112.750	33.825	3.383	82.308	6.859	229	2,1	10,9
1997	93.000	116.250	34.875	3.488	84.863	7.072	236	2,1	8,9
1998	95.900	119.875	35.963	3.596	87.509	7.292	243	2,2	6,8
1999	98.800	123.500	37.050	3.705	90.155	7.513	250	2,3	4,6
2000	102.000	127.500	38.250	3.825	93.075	7.756	259	2,3	2,3

Source : Putra et al., 2015

Degraded soil samples taken from the surface to a depth of 13 meters, is used in three groups. It is the sample to a depth of 4; 8 and 12 meter to represent the age of the waste 15-16; 17-18 and 19-20 years. Overall the soil portion has dominated the degraded waste composition in the three variant of depth, reaching to 55.71% (Putra dkk, 2015). In order to utilize the soil of the degraded garbage it is necessary to do an analysis on nutrient and metal elements contained.

3.1. Nutrient Element

Soil fertility is determined by the presence of nutrients in the soil, either macro nutrients, secondary nutrients or micro nutrients. This study examines the four components that reflect the condition of the nutrients contained in the soil of degraded garbage, namely organic materials, the C/N ratio, phosphorus and potassium. Organic materials such as stimulus for granulation improve soil aeration and increase the ability to retain water. SNI 19-7030-2004 has required minimum 27% and maximum 58% for organic materials contained in the compost's. C/N ratio is an indicator showing the process of mineralization-immobilization of N by microbial decomposers of organic material; regulate the amount of carbon and nitrogen in the soil. Thus, it is required to improve the productivity and sustainability of the age of the plant. SNI requires the range between 10 to 20, while Ministry of Agriculture Decree (PerMenTan) 70/2011 determine the ratio to C/N ranged from 15 to 25. Phosphorus in the compost is required in the transport of metabolic energy to the plant, stimulating the blossoming of the plant, seed formation and fertilization of at least 4% (Minister of agriculture decree of, PerMenTan 70/2012) to 10% (SNI 19-7030-2004). Meanwhile, potassium will play a role in photosynthesis and increase plant immunity to disease. Minimal compost has a potassium value of 0.2% (SNI 19-7030-2004) or 4% (ministry of agriculture decree of 70/2012).

Table 3. Results of the nutrient element examination on each depth in four sampling points of Piyungan landfill

Parameter		Organic material		C/N			P$_2$O$_5$			K		
Sampling point	Depth (m)	Exam result (%)	SNI Min. 27% Max. 58%	Exam result	SNI Min. 10 Max. 20	Per-Men-Tan 15-25	Exam result (%)	SNI Min. 10%	Per-Men-Tan Min. 4%	Exam result (%)	SNI Min. 0,20%	Per-Men-Tan Min. 4%
1	4	28,13	✓	9	■	■	0,0211	■	■	0,25	✓	■
	8	12,52	■	13	✓	■	0,014	■	■	0,042	■	■
	12	6,78	■	8	■	■	0,0087	■	■	0,044	■	■
2	4	6,85	■	16	✓	✓	0,0163	■	■	0,07	■	■
	8	22,65	■	10	✓	■	0,0184	■	■	0,15	■	■
	12	6,51	■	14	✓	■	0,017	■	■	0,13	■	■
3	4	7,23	■	9,3	■	■	0,0005	■	■	0,0151	■	■
	8	17,29	■	16	✓	✓	0,0005	■	■	0,0547	■	■
	12	10,66	■	13	✓	■	0,0006	■	■	0,0475	■	■
4	4	25,94	■	14	✓	■	0,0075	■	■	0,0579	■	■
	8	30,35	✓	16	✓	✓	0,0042	■	■	0,0561	■	■
	12	25,91	■	12	✓	■	0,0006	■	■	0,0575	■	■

Note : ✓ = comply with quality standard; ■ = not comply with quality standard

The examination results showed that the organic materials contained in the soil of the degraded waste in the landfill Piyungan are very low. Only two samples have organic material as required by SNI 19-7030-2004, that is in the sampling point 1 of 4 m depth and in the sampling point 4 in the depth of 8 m. There is a correlation that the organic content and the oxygen in the soil are directly proportional to the number and types of microorganisms (Notodarmojo, 2005). It is different to the ratio of C/N which largely meets the requirements of SNI which has a minimum ratio of 10, while only 3 samples with ratio C/N meets the requirements of Regulation of 70/2012. In general the C/N ratio showed a relatively low compared to the requirements of organic compost. Kurniasari et al., (2014) conducted an analysis of degraded soils by digging a heap of waste at a depth of ±2 m of some landfill in West Java, the examinations show results as follows: TPA Jelekong Landfill has a C/N ratio of 23, TPA Pasir Impun (8), TPA Leuwi Gajah (29), and Sarimukti landfill (9). The two landfills, TPA Jelekong and Leuwi Gajah have a high C/N ratio, even exceeds the quality standards required in organic compost. While the two other landfills, that is TPA Pasir Impun and Sarimukti have a low C/N ratio as contained in the Piyungan landfill. Similarly, the low content of phosphorus and potassium in the sample, generally the four components of nutrients elements as indicators showing low content and does not meet the standards of quality required.

Age of the sample will affect the quality of the nutrients it contains. Samples were derived from the degradation of organic waste coming from urban activity in the Yogyakarta area, along with the process of waste heaping in the landfill for 15-20 years. During this length of time, the organic material which is contained in the form of carbon was depleted, causing low content of nutrient element. If this soil will be used as organic fertilizer/compost,it will require preliminary process in order to improve nutrient element before being applied to the plants.

3.2. Metal Content

Landfill receives waste from different locations with various composition of waste every day. It is possible that the waste will contain metal element, including heavy metals.

Tabel 4. Result of metal content examination Zn, Cr, Cu, Cd dan Ni
In each depth in the 4 sampling points of TPA Piyungan.

Parameter		Zn (mg/kg)			Cr (mg/kg)		Cu (mg/kg)		Cd (mg/Kg)			Ni (mg/kg)	
Lo-cation	Depth (m)	exam result (mg/ kg)	SNI Max 500 mg/kg	Per-Men-Tan Max 5000 mg/ kg	exam result(mg/ kg)	SNI Max210 mg/ kg	exam result (mg/ kg)	SNI Max. 100 mg/kg	exam result (mg/ kg)	SNI Max3 mg/ kg	Per-Men-Tan Max. 2 mg/kg	exam result (mg/ kg)	SNI Max62 mg/ kg
1	4	47	✓	✓	57,62	✓	70	✓	0,75	✓	✓	6,36	✓
	8	40	✓	✓	55,37	✓	21	✓	td	✓	✓	4,12	✓
	12	18	✓	✓	9,29	✓	17	✓	td	✓	✓	5,72	✓
2	4	32	✓	✓	11,26	✓	8	✓	td	✓	✓	57,10	✓
	8	28	✓	✓	12,64	✓	4	✓	0,34	✓	✓	6,36	✓
	12	18	✓	✓	11,90	✓	4	✓	td	✓	✓	2,99	✓
3	4	10	✓	✓	<0,12	✓	9	✓	0,04	✓	✓	3,44	✓
	8	40	✓	✓	33,04	✓	9	✓	0,54	✓	✓	4,94	✓
	12	30	✓	✓	11,68	✓	6	✓	0,25	✓	✓	3,67	✓
4	4	37	✓	✓	6,73	✓	4	✓	0,47	✓	✓	2,42	✓
	8	34	✓	✓	5,85	✓	2	✓	0,59	✓	✓	4,45	✓
	12	33	✓	✓	1,46	✓	3	✓	0,25	✓	✓	3,17	✓

Note: ✓ = comply with quality standard; td = undetected

Heavy metals can be divided into two parts; it is an essential metal and non-essential metal. Essential metal is a metal which is very useful in the physiological processes of living things because it help the enzyme in the formation of organs. On the contrary, the non-essential metal is a metal element in which the role in the body of the living thing is not yet identified. Its content in the living thing is very small, and if the high content is high it will damage the organs of the living body. Metals that can cause poisoning are non essential types of heavy metals such as Cu, Zn, Se while, non-essential metals are as Hg, Pb, Cd and As.

Table 4 shows the results of examination of the metal content in a degraded soil samples obtained from the drilling of 13 meters depth. Based on the quality standard of the metal content in the SNI 19-7030-2004 and the PerMenTan regulation 70/2012, parameter of Zn, Cr, Cu, Cd and Ni have met the quality standards of both of the quality standard. Similar with the nutrients content that have been described in the previous section, the duration of the garbage heaped in the landfill has a huge effect on the quality of soil obtained. By duration that reaches 20 years, metal content contained may have became soluble and flowed with wastewater to the water treatment plant.

Table 5. Analysis on chemical characteristic of compost derived from landfill mining

Parameter	Jelengkong Landfill	Pasir Impun Landfill	Leuwi Gajah Landfill	Sarimukti Landfill
Cu (ppm)	7,00725	12,1166	12,3735	12,2879
Cr (ppm)	1,65529	3,1280	3,7935	4,5102
Zn (ppm)	9,74202	4,4761	4,2712	4,6744
Pb (ppm)	4,76249	14,1736	15,2153	14,9236
Cd (ppm)	0	0,2755	0,4057	0,3201

Source : Kurniasari et al., 2014

Table 6. Result of metal content examination of Pb, Hg, Mn dan Fe
In each of depth in 4 sampling point of TPA Piyungan

Parameter		Pb (mg/Kg)			Hg (mg/kg)			Mn (%)			Fe (%)		
Lo-cati on	Depth (m)	Exam result (mg/ kg)	SNI Max. 150 mg/kg	Per-Men-Tan Max. 50 mg/ kg	Exam result (mg/ kg)	SNI Max. 0,8 mg/ kg	Per-Men-Tan Max 1 mg/kg	Exam result (%)	SNI Max 0,10 %	Per-Men-Tan Max. 5000 ppm	Exam result (%)	SNI Max 2,00 %	Per-Men-Tan Max. 8000 ppm
1	4	232	■	■	0,1362	✓	✓	0,012	✓	✓	0,0465	✓	✓
	8	89	✓	■	0,0394	✓	✓	0,009	✓	✓	0,0355	✓	✓
	12	21	✓	✓	0,0989	✓	✓	0,008	✓	✓	0,0355	✓	✓
2	4	29	✓	✓	0,0343	✓	✓	0,0034	✓	✓	0,017	✓	✓
	8	30	✓	✓	0,0084	✓	✓	0,012	✓	✓	0,0476	✓	✓
	12	16	✓	✓	0,0093	✓	✓	0,0054	✓	✓	0,0244	✓	✓
3	4	5	✓	✓	0,0059	✓	✓	0,022	✓	✓	0,0037	✓	✓
	8	79	✓	■	0,0293	✓	✓	0,024	✓	✓	0,0066	✓	✓
	12	30	✓	✓	0,0281	✓	✓	0,021	✓	✓	0,0037	✓	✓
4	4	172	■	■	0,5396	✓	✓	0,018	✓	✓	0,0036	✓	✓
	8	138	✓	■	0,097	✓	✓	0,016	✓	✓	0,0044	✓	✓
	12	126	✓	■	0,1168	✓	✓	0,016	✓	✓	0,0046	✓	✓

Information : ✓ = Comply with quality standard; ■ = not comply with quality standard

In the compost resulted from landfill mining process, there is heavy metals content because compost from landfill mining is derived from the landfill and mixed with various sources of waste, such as.; household waste, markets, commercials and other sources where the waste are not filtered and sorted so that it is possible to contain heavy metals. The study shows the parameters of Cu and Pb which has a higher content than other parameters (Table 5) (Kurniasari dkk, 2014).

The content of other metals, such as Hg, Mn and Fe has also shown the examination results are in accordance with the required quality standards (Table 6). Except the parameters of Pb, there are several samples that have not met the standard. Lead (Pb) is very possibly contained by the urban waste in Indonesia because the mixture of domestic waste management and hazardous waste and toxic material were also resulted in domestic activities. According to a research conducted by Quaghebeur et al., (2013) in the Remo landfill, Belgium, there is a possibility of Pb in a large number that reached 440 mg/kg (for the period of dumping since 1980-1985), 330 mg/kg (1985-1990), 54 mg/kg (1990-1995), and 380 mg/kg (1995-2000). Remo landfill is operated to accommodate urban and industrial waste, so that the possibility of lead in the degraded waste becomes higher.

5. CONCLUSION

Based on sampling activities in order to utilize the degraded waste obtained from TPA Piyungan, one of which as compost, it is necessary that the analysis of various parameters is associated with nutrient element and metal content in the soil. Here are some points that can be concluded from this study:
The depth of sample shows age of the waste; 4 meters from the surface represent the age of waste heaped which is 15-16 years, 8 meters (17-18 years), 12 meters (19-20 years).
The contained nutrient content is very low, either the content of organic matter, phosphorus or potassium. So it does not comply with the requirements of organic compost in SNI 19-7030-2004 and with ministry of agriculture decree 70/2012. While the C/N ratio is general is still comply with the required range of values of SNI 19-7030-2004 which is 10-20 ratio.
The analyzed parameters of metals in the soil include Zn, Cr, Cu, Cd, Ni, Pb, Hg, Mn and Fe. All parameters of the metal content are comply with the requirements as organic compost, except Pb which still exceeds the quality standards. The mixture of urban domestic waste with hazardous waste coming from domestic activity causes a possibility that the waste contained heavy metals.
Utilization of degraded soils in Piyungan landfill required preliminary processing in order to increase the nutrient content and to decrease its Pb content to comply with the requirement of organic compost.

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