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STUDY OF COMPOST USE AS AN ALTERNATIVE DAILY COVERIN SUKAWINATAN LANDFILL PALEMBANG

Yudi Hermawansyah[1], *Febrian Hadinata[1], Ratna Dewi[1] and Hanafiah[1]

[1]Faculty of Engineering, Sriwijaya University, Indonesia

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ABSTRACT:The Sukawinatan landfill has been operating with an open dumping for twenty-four years. To extend the operation of the landfill, the landfill mining concept is examined, using compost in the old landfill area as an Alternative Daily Cover. A series of tests on control parameters was performed to determine the suitability of compost as an alternative material. The tests were carried out include: grain size distribution, permeability, Standard Proctor compaction test, plasticity index, pH, temperature, BOD, COD and heavy metal content. The compost sample was taken randomly at two points within the old landfill zone. The sample was filtered through sieve No.04 to remove inert waste and the granules were more than 4.75 mm in diameter. There were five sample variants of compost tested. The soil was taken from one of the locations in Palembang city and identified as organic clays of medium to high plasticity (OH). Based on the results of the test, the compost in Sukawinatan landfill met the requirements in the aspects ofliquid limit, plasticity index, clay fraction, bulk density, permeability, pH dan temperature.The results also showed that the heavy metal content (Pb and Cd) of the compost exceeded the requirements as an organic fertilizer, so if there is landfill mining activity in this landfill, the compost produced is only suitable as an Alternative Daily Cover.

Keywords: Alternative Daily Cover, compost, landfill mining,requirement parameter,

1. INTRODUCTION

Within a period of 24 years, Sukawinatan Landfill has been operating in the city of Palembang with an open dumping scheme. In the future five years, this landfill will be full soon, meanwhile, the construction of new landfill has not been agreed and this will threaten MSW service system in Palembang city. The Sukawinatan landfill is an open dumping landfill, with no daily closure activities that are causing: odor, the development of disease vectors (rats and flies),thepotential for landfill fires, rainfall infiltration into landfills and the rubbish flight to the settlements [1]. Considering that the Sukawinatan landfill is on the plane landing lane, it is very dangerous because it can disrupt the flight, resulting from a fire in the landfill area or the birds that are looking for food in the landfill area. In the other site, there is material within the landfill area itself which is potential to be used as a cover layer. The material is compost soil which is a product of degradation of organic MSW which is the dominant component in MSW of Indonesia [2]. [3] also mentioned that compost can be used as an alternative material of the daily cover layer. In a previous study, [4] found that the wastewater sludge and the water treatment sludge was good enough to serve as an alternative material cover in landfills.

[1]stated that all alternative daily cover materials must meet the standards, that is: have less than 20% of particles smaller than 600 microns, a bulk density greater than or equal to 1 ton per cubic meter, insoluble in water, has a pH between 5 to 10. According to [5], the saturated hydraulic conductivity of the daily covering layer was set to a minimum value of $3.7.10^{-5}$ cm/s, an average value of 1.10^{-3} cm/s, and a maximum value of 4.10^{-2} cm/s.The alternative daily cover material should be a stable material. The stable compost is a compost that has not shown any activity of microorganisms again [6], shown by: BOD/COD ratio of leachate below 0.1 [7], BOD less than 100 mg/ltr and COD less than 1000 mg/ltr [8], as well as the temperature near the ambient temperature and the pH near the normal PH [8]. Soil cover in the landfill must have clay content greater than 10% [9]. Soils used as cover landfill should have a minimum liquid limit of 20% [10; 11] and a maximum of 90% [9]. The plasticity index of the soil cover is at least 7% [12; 13] and a maximum of 65% [9]. Compared to other materials, from the aspect of methane emission reduction, compost is excellent for use as a daily cover because it can oxidize the methane biologically better than ordinary soil [14].

[15] mentioned degraded MSW density of 1.4-2 ton/m^3 while [16] obtained a compost density of 1.24 ton/m^3. As for permeability, [16] obtained anunsaturatedcompost permeability value of $2.57.10^{-5}$ cm/s, in which the sample was tested under maximum density conditions and optimum moisture content. Based on the grain size distribution, [16] obtained the diameter of compost

granules smaller than 0.075 mm was 13.71%.

This study examines the feasibility of compost in Sukawinatan landfill to be used as an alternative daily cover in the landfill. Utilization of this compost can be a solution to extend the age of landfill and overcome the environmental disturbance due to the operation of open dumping Sukawinatan landfill.

2. METHODOLOGY

2.1 The Sampling Method

A random sampling of compost in Sukawinatan landfill was done under disturbed conditions. Samples were excavated at a depth of 0-2 m from the surface, at two points in the old landfill zone. Figure 1 shows the location points of compost soil sampling. While the cover soil was taken from a zone that has been more than 10 years old. Moisture content (average) of compost and soil samples that were taken, respectively 65.81% and 25.93%.

2.2 Sample Preparation

At the old landfill zone location, the sample was excavated and filtered with a 1cm diameter hole sized sieve to separate compost from inert, fiber and wood waste.The samples were taken to the Soil Mechanics Laboratory of Sriwijaya University. Then, the sample was dried until dry air conditions. The wooden hammer was used to break the compost without destroying the sample granules. The separated sample was filtered with sieve No. 04 (grain size of less than 4.75 mm), this was done because a kind of sand material (grain size more than 4.75 mm could not be used as daily cover material).And then, the sample was stored in a sample box and was ready to be used as a test object.The soil sample was treated same as the treats on compost sample. five sample variants are prepared as follows: (a) compost, (b) cover soil, (c) compost + 10% soil, (d) compost + 20% cover soil and (e) compost + 50% cover soil.

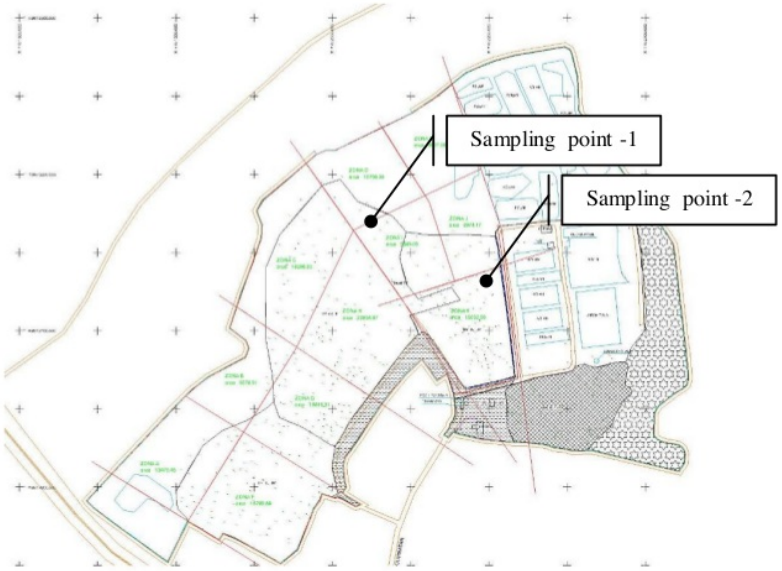

Fig. 1 Location of compost sampling in Sukawinatan landfill

2.3 Laboratory Test

For the next step, the samples that have been prepared were tested. The plastic limit test, to determine the moisture content limit, in which the sample had plastic character. The test was carried out by grinding the sample (which passes sieve No. 30) by hand up to 3mm in diameter and cracked. While the plastic limit described the moisture content when the soil milled was cracked. The test was performed twice on each sample variant and the mean values were taken. The test was performed with ASTM D4318-17 test guides.The liquid limit test, aimed at determining the moisture content in which the sample (which passes sieve No. 30) began to show the character as a flow object. Soil sample for this Atterberg limit tests was taken from samples that passed the sieve no. 30. The liquid limit was obtained by

interpolating on the graph of the relationship between the number of strokes (where the separated sample began to unite) and the moisture content of the specimen, thus obtained the moisture content at the number of strokes 25. The test was carried out by the ASTM D 4318-17 test guide. Based on the liquid limit and plastic limit values, the plasticity index can be calculated based on the difference between the liquid limit and the plastic limit.

The sieve analysis was intended to determine the distribution of fine aggregate grains and coarse aggregates by means of a sieve. The smallest sieve was No. 200 (grain diameter pass less than 0.075 cm). The grains that passed the sieve No. 200 were further tested in the hydrometer analyze. The tests were performed based on ASTM D 422-63 guideline.

Standard Proctor Compaction, aimed to determine the maximum dry density and optimum moisture content of the sample. Gradually, the moisture content of the sample was increased in such a way that the addition of water reduced the density of the sample. Furthermore, a graph of the relationship between dry density and moisture content was obtained so as to obtain the maximum dry density and optimum moisture content. The sample on the permeability test would be conditioned in maximum density conditions and this optimum moisture content. The test was performed with an ASTM D558-82 guide.

Permeability test was done with falling head method. The test was intended to determine the permeability of the sample in a laboratory manner. The test was done by falling head method, according to ASTM D2434-68 guide.

Especially for the compost sample, due to concern about the stability and environmental effects caused by this material, additional tests were performed.Heavy metal test, which was intended to measure the concentration of heavy metals in compost. The test parameters included Pb and Cd with a guide of SNI 2354.5: 2011.Then, atest of BOD and COD of leachate, which was done to see the compost stability. Test guide was SNI-6989.72-2009 for BOD test dan SNI-6989.2-2009 forCOD test.And then, pH and temperature, which aimed to see the compost stability, measured by pH meter and thermometer with SNI 06-6989.11-2004 dan SNI 06-6989.23-2005 guide.

3. RESULTS AND DISCUSSION

3.1 Laboratory Test Result

3.1.1 Liquid Limit and Plastic Limit Test Results

Based on the test methods described in Chapter 2.3 (a) and 2.3 (b), Table 1 shows the values of liquid limit, plastic limit,and plasticity index of the five sample variants. Of the five sample variants, it appeared that the Liquid Limit value was quite high, and the sample variant indicated the high organic content in the sample.

Table 1 Test results of liquid limit and plastic limit

Sample Variant	Liquid Limit	Plastic Limit	Plasticity Index
Compost	79.90%	66.71%	13.19%
Soil	56.90%	34.11%	22.79%
90% Compost + 10% soil	72.20%	57.97%	14.23%
80% Compost + 20% soil	68.00%	54.08%	13.92%
50% Compost + 50% soil	50.80%	31.85%	18.95%

3.1.2 Test Results of Sieve Analysis

For each variant, 200 grams of sample was used for grain size distribution analysis. Samples were filtered with sieve No.04 (grain diameter passed less than 4.67 mm) up to sieve No.200 (grain diameter passed less than 0.075 mm). Figure2shows the percentage of grain size of the five sample variant that was smaller than 0.075 mm (clay fraction). Based on [18], compost is a soil with high organic content (PT), and soil that is added to compost, identified as organic clays of medium to high plasticity (OH).

3.1.3 Standard Proctor Compaction Result

The compaction test was carried out on the five sample variants, based on the test procedure as described in Chapter 2.3 (f). The dry density of the sample varied between 1.17 ton/m^3 (compost) to 1.74 ton/m^3 (soil), which showed that the density increased with the increase of soil content in the compost-soil mixture. The test results are shown in Table 2 and Figure 3.

3.1.4 Permeability Test Result

The sample was tested for permeability at optimum moisture content and maximum dry density. The test results of the permeability by the falling head method for the five sample variants are given in Figure4. The permeability of five samples varied from 10^{-2} to 10^{-3} cm/s.

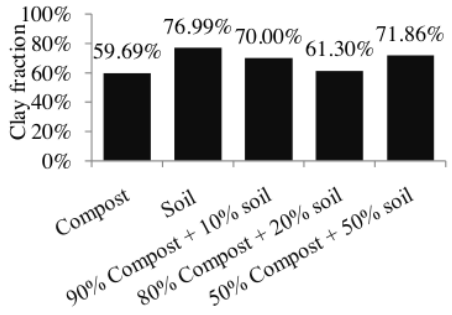

Fig 2 Test results of the clay fraction

Table 2 The value of maximum density and optimum moisture content

Sample variant	Maximum density (ton/m^3)		Optimum moisture content
	dry	wet	
Compost	1.17	1.64	40%
Soil	1.74	2.04	17%
Compost + 10% soil	1.21	1.57	30%
Compost + 20% soil	1.32	1.66	26%
50% Compost + 50% soil	1.49	1.85	24%

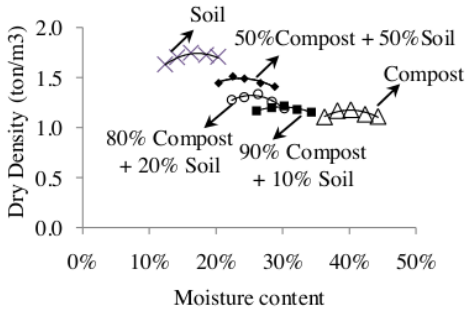

Fig. 3 The compaction test results in the five sample variants.

3.1.5 Other Test Result

A test of several environmental parameters was performed to determine the suitability of variant characteristics of compost as an alternative daily cover, as mentioned in Chapter 1. The environmental parameters tested are shown on Chapter 2.3 (i), 2.3 (j), 2.3 (k) and 2.3 (l). The test results are presented in Table 3. This parameter test was not performed for soil samples.

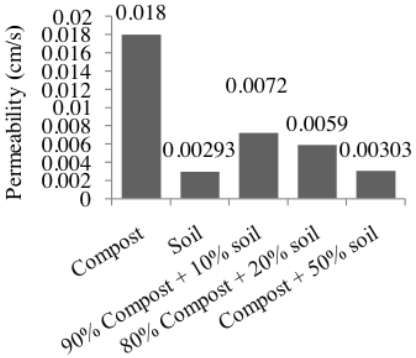

Fig 4 The coefficient of permeability of the five sample variant

Tabel 3 Test results of several environmental parameters

Parameters	Quantity	Unit
Heavy metal content:		
- Pb	275.18	ppm
- Cd	109.58	ppm
BOD	1,115	mg/l
COD	1,695	mg/l
pH	7.90	-
Temperature	27	^{0}C

3.2 Test Result Analyses to the Alternative Daily Cover Requirements

Analyzes was performed on the four sample variants, including: (a) compost, (b) compost + 10% soil, (c) compost + 20% soil and (d) compost + 50% soil. The soil variant was not included in the analysis because the soil was a regular daily cover material and not an alternative daily cover material.

3.2.1 Liquid Limit and Plastic Limit

The liquid limit of cover material in landfills should be within the range of 20% [10; 11] to 90% [9]. While the Plasticity Index was in the range of 7% [12; 13] to 65% [9]. Table 1 shows that the Liquid Limit value of the compost sample and compost sample + soil meet the requirements as Alternative Daily Cover, with Liquid Limit value ranging from 50-80% (above 10%).

3.2.2 Grain Size Distribution

The compost material and/or compost material + soil were suitable for alternative daily cover if having a clay content of at least 10% [9]. Based on the sieve analysis (Figure 2), the percentage of clay obtained from the five sample variants as presented in Table 4. The test results showed that compost and compost + soil variants had a clay content (grain diameter <0.075 mm) above 10%, making them suitable for use as the Alternative

Daily Cover material.

3.2.3 Bulk Density

From the standard Proctor test, it was known that compost or compost+soil meet the requirements as the Alternative Daily Cover. As a minimum requirement limit, [1] stated that all alternative daily cover materials must have a minimum bulk density of 1 ton/m^3. Table 4 shows the bulk density that can be achieved by all four samples at optimum moisture content, ranging from 1.57 to 1.85 ton/m^3.

3.2.4 Permeability

[5] required that all daily alternative cover materials should have a permeability between 10^{-2} to 10^{-5} cm/s to minimize infiltration and erosion. Figure4 shows that the permeability of the compost and compost+soil variant still meet the value suggested by [5], i.e. at about 10^{-2} to 10^{-3} cm/s.

3.2.5 Other Test Result

The test results from several environmental parameters (BOD, COD, ratio BOD/COD, pH,and temperature) indicates that the compost sample has not shown the required stability (Table 4). For stable compost, the BOD and COD values are expected to be less than 100 and 1000 ppm[8]. This may be due to the magnitude of the organic component in Indonesian MSW, which is managed by open dumping scheme. Further research is required to review the test result of BOD and COD of compost in this landfill. The soil sample was not tested for environmental aspect because it was not expected to have an impact on the environment.

In addition, this study also detected the heavy metal content (Pb and Cd) in compost, where Pb content was measured at 275.18 ppm and Cd content of 109.58 ppm. These results indicated the importance of using compost as an Alternative Daily Cover, since the compost in this landfill cannot be used as fertilizer because it exceeds the standard of organic fertilizer, ie maximum Pb 150 ppm and maximum Cd 3ppm [17].

Table 4 Comparison of test results of compost and compost+soil to the required value of Alternative Daily Cover

Parameters (Unit)	Requirements		Test Result			
	Quantity	Reference/ literature	Compost	90%Compost + 10% soil	80%Compost + 20% soil	50%Compost + 50% soil
Liquid Limit (%)	20-90	[9; 10; 11]	79.90	72.20	68.00	50.80
Plasticity Index (%)	7-65	[9; 12; 13]	22.79	14.23	13.92	18.95
Clay fraction (%)	> 10	[9]	59.69	70.00	61.30	71.86
Bulk density (ton/m^3)	> 1	[1]	1.64	1.57	1.66	1.85
Permeability (cm/s):						
- Minimum:	$3.7x10^{-5}$					
- Average:	$1x10^{-3}$	[5]	$1.80x10^{-2}$	$7.20x10^{-3}$	$5.90x10^{-3}$	$3.03x10^{-3}$
- Maximum:	$4x10^{-2}$					
BOD (mg/l)	<100	[8]	1,115	N/A	N/A	N/A
COD (mg/l)	<1,000	[8]	1,695	N/A	N/A	N/A
BOD/COD	< 0.1	[7]	0,658	N/A	N/A	N/A
pH	≈ 7	[8]	7.90	N/A	N/A	N/A
Temperature (^{0}C)	≈ room temperature (= 29)	[8]	27	N/A	N/A	N/A

Note: N/A = There was no test conducted to the sample variant.

4. CONCLUSION

Based on the above study, it can be concluded that compost in Sukawinatan landfill is suitable to be used as Alternative Daily Cover. The value of liquid limit, plasticity index, clay fraction, bulk density, permeability, pH and temperature of compost and compost sample + soil are still within the specified range. However, it should be noted that the compost is still not stable, because the BOD and COD value is still above the specified threshold. The value of BOD and COD may be related to the number of organic components of MSW in Indonesia or open dumping operational scheme that was conducted to this landfill., further research is needed for these findings.

The soil composition increasing in the soil-compost mixture is able to lower the liquid limit, so it is advisable to add soil to compost that still has a liquid limit above the required value.The test results also show that the heavy metal content (Pb and Cd) of the compost exceeded the requirements as an organic fertilizer. So, if landfill mining is

done in the landfill, the compost of the mine can only be used as an alternative daily cover. For further research, a phytoremediation study is needed in leachate ponds, to reduce the heavy metal content that may come from this compost.

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