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## EFFECT OF AGE OF MUNICIPAL SOLID WASTE ON QUANTITY AND QUALITY OF LEACHATE GENERATION BY COLUMN-LANDFILL EXPERIMENT

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### Abstract

Leachate is a liquid that is generated by the degradation of solid waste in land fill, which in quantity and quality is potential to pollute to the environment. Quantity and quality of leachate generation on landfill is influenced by several factors such as: composition and characteristics of the solid waste, the operating system, final cover, age of the waste and climatology. On this research aims to determine the effect of age of landfill waste to the quantity and quality of leachate generation. In order to obtain the objectives of the study, the method used is to use four column-landfill experiments. Each column-landfill are operated using refuse of different age, that are age <1 years (R1), 1-2 years (R2), 2-5 years (R3) and > 5 years (R3). As parameters of quantity is the amount of leachate generated, while the parameters of quality are pH, TSS, BOD, and COD.

Based on the experimental results was showed that the age of the waste a considerable influence on the quality of leachate generation. The quality of leachate on age <1 year is the highest compared to the solid waste with older age. This is demonstrated by the concentration of TSS, BOD and COD in leachate from age < 1 year (R1) is higher than the concentration of the leachate from the waste age > 2 years. While the age of the solid waste in landfill shown that no significance effect on quantity of leachate generation. The experiment is known that the infiltrations of water into the column to be leachate are 86.91%, 86.29%, 85.78 and 85.89 respectively R 1, R 2, R3 and R4.

## **INTRODUCTION**

Landfill site must result in leachate due to solid waste degradation. The degradation occurs through complex processes including biological, chemical and physical process that will result in gas and liquid emission. The liquid emission is called as leachate. It is very possible that leachate resulted from solid waste degradation will move through pores that will mix with groundwater.

Leachate is liquid waste that may result from external water entering into solid waste stockpile. It dissolves and rinses the dissolved material including organic material resulted from biological decomposition process. It may be that there is various and fluctuating quantity and quality of leachate (Tchobanoglous, et al, 2004). Factors influencing leachate quality

are precipitation water, evapotranspiration, water content in solid waste, density and field capacity (Tchobanoglous, et al, 2004 & Jaramillo, 2003).

Precipitation water is water from rain and infiltrates into garbage. The amount of water is influenced by rainfall and run off coefficient of surface layer. In calculation of landfill leachate generation, surface water is very important factor that should be considered (Jaramillo, 2003). Precipitation is factor that significantly influence leachate flow rate in which in high infiltration will result in high leachate flow. Low infiltration will result in water redistribution and more interaction with solid waste that lead to increase in solved material in leachate (Zeiss et al 1995). Evapotranspiration occur due to evaporation in surface and

transpiration that is plant respiration in covering soil layer. In rainy season, evapotranspiration percentage is lower due to high humidity and low temperature (Jaramillo, 2003). Water in solid waste came from water entering simultaneously with waste volume placed in landfill. Water content may be from water attaching in waste absorbed from atmosphere and rainfall during transportation or other causes. Other cause of water content in waste is water addition at processing with water recirculation. Water content in municipal solid waste ranges about 15 to 35% depending on local climate. A study indicates that leachate addition through recirculation in waste will increase resulted leachate, indicated with greater BOD and COD concentration for waste recirculated (Bilgili, et al, 2008).

Waste compactness is stated in waste density, where waste density influence absorption capability, porosity, hydraulic conductivity, and quantity of leachate resulted. Waste density relates directly to cavity and pore geometry and it depends on waste composition, water content and compacting strength. Compacting increase

waste density and decrease in waste porosity. Powerie and Beaven (1999) indicated that increase of density from 876 to 1303 kg/m<sup>3</sup> reduce porosity from 0.555 to 0.455. Similarly, increase in density resulted in decrease of saturated hydraulic conductivity and decrease in leachate.

Factors influencing leachate quality are waste characteristic, waste age, temperature, and water content of waste. Waste characteristic was determined based on distribution of its particle size and composition. Influence of waste size on leachate generation quality is significant. Waste with various granule sizes will influence density level that in turn will influence water capillary rate in landfill. Variety in waste will cause pore in various sizes that may relate to each other or not relate that will channel water. Variety in waste compositions also causes porosity capacity, early water content, saturated hydraulic conductivity, which will influence field capacity and water movement. Result of research on influence of waste granule with small scale landfill column indicated that greater waste volume is along with degradation phase change. Similarly shear

modules change along with increase in waste age (Hossain, et al, 2008).

Waste composition is various depending on waste source, society behavior characteristic and economic condition as well as waste management process. In waste management process, particularly biological processing, waste composition is determined based on its biodegradation level. Based on its biodegradation composition, waste consists of fast, moderate and non biodegradable. A Study by Kim. et al (2007) indicated that leached organic material underwent fluctuation in one year and begin to be stable after ten years for anaerobic landfill. In aerobic landfill it occurs faster, as presented in following figure. Leachate quality is influenced by landfill age. Leachate quality will be maximal at 2-3 years after placed in landfill and gradually decrease until undetermined time. However, leachate quality parameters did not occur in same time. BOD and COD after 10 years have high concentration and then decrease gradually (FCSHWM, 1998). Temperature in landfill will influence quality of resulted leachate. It may be due to uncontrolled temperature,

so leachate generation will fluctuate. In rainy season and dry season, temperature is different greatly. Every microorganism has optimal growth temperature. NaCl solvability will increase along with temperature. However, a number of compounds in leachate such as CaCO<sub>3</sub> and CaSO<sub>4</sub> indicate decrease in solvability with increase in temperature (FCSHWM, 1998). The greatest COD concentration occurs in thermophilic condition, followed with mesophilic condition and the lowest psychrophilic condition (Wang and Pelkonen, 2008).

Leachate will be generated gradually and will follow liquid within waste. Capability of waste to store liquid is 20% to 35% over the volume (Oweis, et al. 1990). Water content and temperature in landfill influence greatly waste degradation that in turn influence leachate generated (Wall et al, 1995). A study indicated that addition of leachate through recirculation in waste will increase in waste degradation process. It is marked with greater BOD and COD for waste recirculated (Bilgili, et al, 2008).

## **MATERIALS AND METHODS**

Experiment done in this research is based on landfill application approach in field, particularly landfill Piyungan Bantul. Four Landfill columns were made with (R1, R2, R3 and R4) with 100 cm height, 15 cm diameter and 17.68 liter volume. Main material is 15 cm diameter PVC. The four landfill columns were intended to describe each waste age in landfill; R1 operated with 0-1 year waste, R2 1-2 year waste, R3 2-5 year waste and R4 more than 5 year waste. Water addition in simulated landfill column was done by considering rainfall in landfill Piyungan, evapotranspiration and run off. Distribution of water addition is based on calculation of daily rainfall.

Waste material used in this experiment consisted of four types based on stockpile

age taken in Piyungan landfill. Waste taking point is based on data on pilling up in landfill Piyungan. Waste sample was examined on its characteristic including waste composition, water content, density and taking elevation. Leachate testing was done in laboratory on some parameters such as pH, TSS, BOD, COD and iron. The parameters are dominant constituent in leachate generation in landfill.

## RESULT AND DISCUSSION

### Characteristic of Waste Sample

Measurement and characterization of waste sample taken from landfill Piyungan Bantul indicates its characteristic as presented in table 1

**Table 1. Characteristic of waste in landfill-Piyungan in various ages**

No	Component	waste age (year)			
		<1	1-2	2-5	>5
1	Humus/soil (%)	20	35	40	45
2	Organic material (%)	40	25	20	10
3	Inorganic material (%)	40	40	40	45
4	Water content (%)	33.33	63.0	46.0	58.0

Result of test on soil humus indicated that humus content increase with increase in waste age increase in the landfill. The increase in humus content occurs due to degradation process of organic waste that is increasingly perfect.

Organic material indicated decrease trend. It accords to degradation of more organic material. Decrease in organic material is expected run faster in transition phase and acid forming phase. Then, it is stable after maturation phase. Time required until the organic material gone is 50 years (Tchobanoglous, et al, 2004).

Inorganic material in solid waste also undergoes changes. But contrary to organic material, percentage of inorganic material in landfill will increase along with increase in waste age in landfill. As to inert material in later degradation process, inorganic material has greatest percentage. Water content in waste in various age undergo various changes. In less than one year, it is the lowest. It is due to relatively small field capacity compared with older waste age.

#### Quantity of Leachate Generation

By running landfill column for 30 days, volume generated from separated landfill column did not change from time to time, as presented in figure 1. Result of measurement indicated that 86.91% infiltrated water changed to be leachate at <1 year age, 86.29% at 1-2 year and 85.89% at >5 years. It agrees with low field capacity for less than one year waste. Waste thickness will influence water absorption volume. In separated landfill column, 1.0 m waste thickness is used.

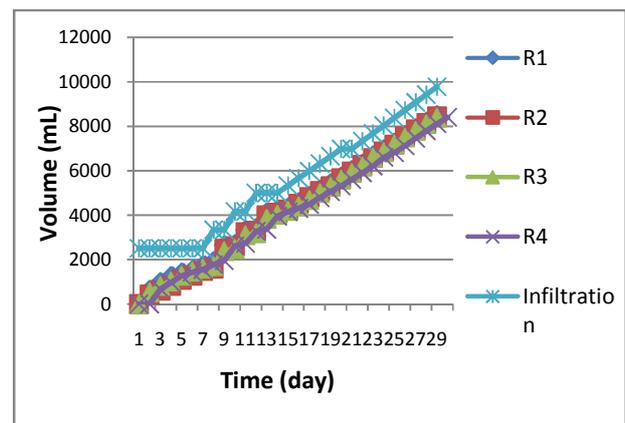


Figure 1 Profile of Water Infiltration and Leachate Generation in Column-Landfill

#### Quality of Leachate Generation

In this research, parameters to identify leachate generation quality are pH, BOD, COD, and TSS. Based on laboratory

measurement each parameter, following results is presented.

### pH

pH testing in leachate indicated that pH in less one year waste is the lowest. It

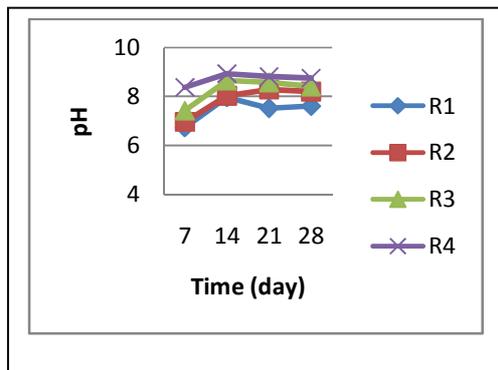


Figure 2 pH of Leachate Generation in Column-Landfill

### BOD

BOD (Biochemical Oxygen demand) is amount of oxygen needed by aerobic microbe to breakdown organic material. Result of testing indicated that BOD concentration is lesser with greater waste age. For every landfill column, leachate concentration increase in first week to fourth week and then decrease in fifth week and sixth week. It may be due to common characteristic of waste age

indicated that in less one year degradation process occur faster than in other ages. Then, with increase in age pH tend to increase. pH was 7.2 in week 1 and 8.3 in week 4, as presented in figure 2.

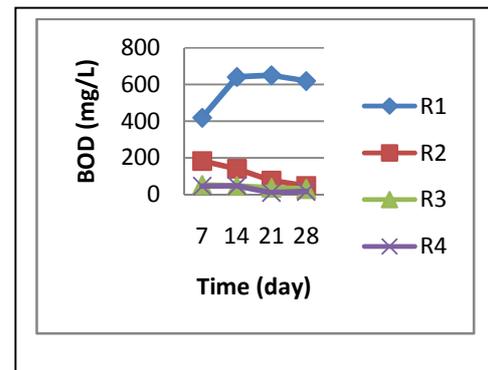


Figure 3 BOD of Geachate Generation in Column-Landfill

influence on generated leachate concentration.

Figure 3 indicated that high BOD is influenced by composition of its pollutant. Fresh leachate has relatively high BOD because has more organic material. The high BOD occurred because fresh waste has different characteristic compared with old waste. Fresh waste is classified in acid genesis phase where organic content (COD/BOD) is higher than that of methanogenesis phase. Beside waste age

factor, high BOD in R1 column may be due to water infiltration of upper landfill column and is influenced by soil cover layer that can filter and absorb organic and chemical material in leachate. While, low BOD in landfill column R2, R3, and R4 is expected due to methanogenesis phase.

### **COD**

COD (Chemical Oxygen Demand) is water pollution parameter by organic material that can be oxidized naturally through microbiological process and result in decrease in dissolved oxygen in water. Leachate from old landfill is near neutral, relatively decrease organic carbon and mineral content and decreased BOD/COD ratio.

Result of COD test indicated that difference in COD concentration in leachate is based on characteristic of waste age entered in landfill column and change in its concentration on biodegradation process duration. COD testing was done in leachate resulted each week in week 1, 2, 3, and 4. Results indicated that COD concentration decrease in each waste landfill column. In column 1 (waste <1 year) COD

concentration is relatively very high in week 1 to week 4 (8200-100 mg/L), as presented in figure 4. The high COD is due to fresh waste have different characteristic from old waste. In young waste, the waste is in acidogenesis, which has higher organic content than methanogenesis phase. High COD content in landfill column may be influenced by water infiltration in landfill column above it.

In first years (<5 years) solid waste in landfill is in acidogenic phase and generated leachate is fresh leachate or carbon based leachate because it has organic carbon content. Solid waste in landfill with >5 years age was in methanogenic phase and generated leachate is old or nitrogen based. The description may be seen from testing in landfill column 2 and 4. Due to age factor, lower COD is due to capability of covering soil and the solid waste in filtering chemical material contained in leachate permeation from above layers. For example, clay can resist leachate permeation through landfill base and can absorb some chemical elements.

### **TSS**

TSS (Total Suspended Solid) is one of leachate quality parameter. It should be tested because TSS will be used in design of next processing system. The highest TSS occurred in 1-2 year. It indicated that after

great degradation in less one year age, solid particle is carried by leachate flow. Then, at increasing age, TSS score tend to be small. TSS at <1 year was 1800 while at >5 years it was 40 mg/L, as presented in figure 5.

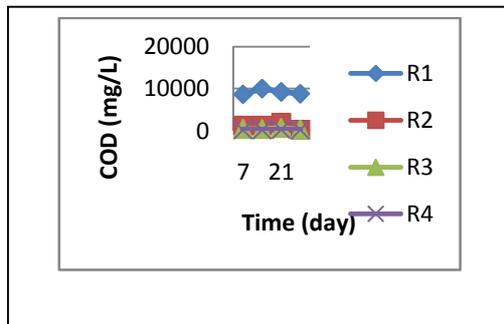


Figure 4 COD of Leachate Generation in Column-Landfill

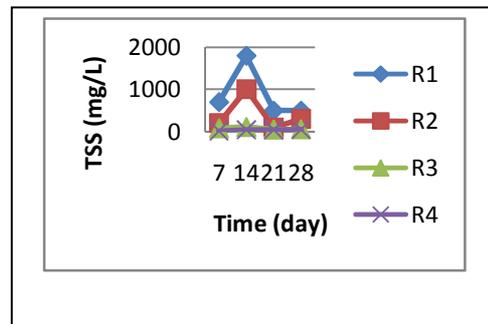


Figure 5 TSS of Geachate Generation in Column-Landfill

## CONCLUSION AND RECOMMENDATION

### Conclusion

Based on experiments, followed with measurement, testing, analysis and discussion on waste characteristic, quantity and quality of leachate, following conclusions can be drawn.

a. Solid waste characteristic including organic material, inorganic, humus material and water content will be influenced by waste age

- b. Waste age influence leachate generation lower than waste thickness/height
- c. Leachate quality based on pH, TSS, BOD, and COD is influenced by waste age. The greater waste age, the less leachate quality.

### RECOMMENDATION

In order to make more perfect and continuous research that can be applied in field, following things should be done

- a. Further research using waste sample from landfill Piyungan must contain various complex materials such as inhibitory material in degradation process, therefore special study should be done on characteristic of inhibitor in the degradation process.
- b. After study on waste composition in landfill Piyungan, further research with characterized material and research with testing of quantity and quality of leachate generation in field should be done.

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area and their findings in the professional literature.

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