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Effect of Leachate Recirculation on Settlement and Leachate Generation of Municipal Solid Waste from Landfill Lysimeter

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***Abstract* --**The objectives of this study are to Determine the settlement and leachate generation from landfill lysimeters of municipal solid waste. Two lysimeters with a diameter and height of 0.70 m and 2.40 m, respectively, were prepared. The lysimeters were operated with and without leachate recirculation. The settlement and leachate generation were quantified every day. The analisys of settlement were used with the hyperbolic fungtion and curve fitting.

Based on the experiments it is known that garbage pile settlement in lysimeter conducted leachate recirculation (L-2) shown a greater settlement than lysismeter without recirculation (L-1) either the hiperbolic function and curve fitting. The ultimate settlement (S_{ult}), for L-1 and L-2 use the hiperbolic function determined as 0.487 m, and 0.53 m, respectively. Meanwhile S_{ult} determined use the curve fitting 0,487 m, and 0,53 m for L-1 and L-2 respectively. The lysimeter conducted with recirculation of leachate shew the quantity of leachate generated larger than the lysimeter without recirculation

Keywords: MSW, settlement, landfill lysimeter, leachate generation

I. Introduction

In the developing countries of Asia, due to the lack of technical knowledge, economic and infrastructural arrangements, 70 - 90% of the solid waste is disposed in open dumps [12]. In Indonesia, the amount of municipal solid waste is normally dominated by the organic compositions (more than 55% by weight) that mainly come from food scraps type of waste. This amount contrubutes to about 65% of the water content of MSW. Plastic and paper forms are the two next major items. They are mainly composed of pckaging/wrapping materials and food, beverage etc. Wood and textiles are the next two important components [5].

Prediction of MSW landfill settlement is critical to design cover systems and ensure the safety of appurtenant structures placed within the waste and structures constructed over the landfill [1]. Settlement of municipal solid waste (MSW) landfill continues over a long period time after landfill closure because of several complicated mechanisms, such as physical action, chemical action and biological action. It is of great importance to determine or predict the settlement because it may damage foundations and associated facilities built on the top of the landfill [13]. Settlement in MSW landfills results in several problems, such as crack formations in the cover and liner system, damage to the liquid and gas collection and drainage system. Therefore, accurate prediction of landfill settlement is the key issue in the design and construction of landfills and also an integral part towards final closure of a site and its ultimate usage [4]

Landfill lysimeters with liquid addition, in the form of leachate or water, experienced lower primary settlements and higher secondary settlements than conventional fills, where no liquid addition was practised. Modified secondary compression indices for MSW in lysimeters with leachate recirculation and flushing were 30%–44% higher than that for lysimeters where no liquid addition was done. Secondary settlements in bioreactor landfills were found to vary exponentially with time [11]. The main difference between the recirculated and nonrecirculated aerobic landfill operations is determined in leachate quantity. Leachate quality does not show considerable changes in both aerobic landfill operations. The positive effect of leachate recirculation is more clearly in anaerobic landfill operation than aerobic landfills [3].

II. Materials and Methods

A. Lysimeter Preparation and Solid Waste Filling

Two lysimeters made of concrete were prepared in this study. The feature of each lysimeter is shown in Fig. 1. The heights and diameters of all lysimeters were 2.40 m and 0.70 m, respectively.

The upper part consisted of a perforated pipe for adding infiltration water. The lower part contained a gravel layer that served as the waste base and allowed the leachate to store and flow through the effluent pipe.

All lyisimeter in filled with solid waste taken from Landfill Piyungan, Bantul regency, Yogyakarta province. One lysimeters were operated by only providing artificial rain. While one another lysimeter operated with an additional recirculation of leachate generated of the bottom. Given the amount of rain water on each lysimeter adjusted with rainfall in Yogyakarta is 2200 mm / year with a duration two hours each breast. The amount of leachate recirculated at 15% of the waste volume. The characteristics and components of solid waste characterised were biodegradable organic 69,60 %, plastic 20,40 %, paper 7,64 %, glass 0,93 %,cape 0,57 % and textile 0,86 %. The initial of water content is 35 %, while the density of waste is 320 ton/m^3.

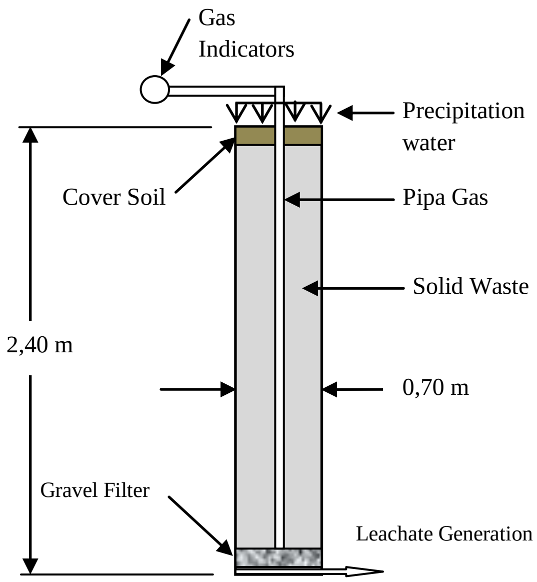

Figure 1. Schema of Landfill Lysimeter

B. Rainfall Addition, Settlement Measuring and Analysis

The study was carry out in Yogyakarta, where the precipitation water done by rainfall simulation. In this study focused only on the rainy season when high amounts of leachate are generated. The daily precipitation data from November 2012 to January 2013 of Yogyakarta province were used to simulate rainfall in this study. To simulate the actual infiltration through the landfill, providing of the rainfall simulation with intensity range from 20 to 50 mm / hours and rainfall every day and 3 days. While the water is used as a simulation is water to be taken from the water surface around the campus of the Islamic University of Indonesia, Yogyakarta.

The data was taken include settelement and measured every day. In this study, the analisys of settlement compare with model fungtion hyperbolic, its was proposed by [8] and [9]. In order to predict a long-term settlement of a MSW landfill, they applied the following hyperbolic function used to predict a settlement from embankment in a soft-ground soil condition as follows:

$$S = \varepsilon(t).H_0 = \frac{S_{ult}}{1 + S_{ult}/(\rho_0 t)} \qquad (1)$$

Here S = settlement (m); H_0 = initial height of MSW landfill (m); $\varepsilon(t)$ = strain; t = time duration of interest (day); ρ_0 = initial of settlement (at t = to) and S_{ult} = ultimate strain (i.e., as $t \to \infty$). Eq. (1) could be transformed into t/S versus t relationships in order to determine the empirical parameters ρ_0 and S_{ult}. The plot of t/S versus t results in a straight line, and the slope and intercept of the best-fit line yield values of ρ_0 and S_{ult}, respectively

$$\frac{t}{S} = \frac{1}{\rho_0} + \frac{t}{S_{ult}} \qquad (2)$$

III. Results and discussion

A. Settlement of Waste

Fig.2, summarizes the best-fit parameters in the hyperbolic function model derived from the landfill settlement data are plotted. Note that r is the coefficient of correlation. There are very good agreement between the measured and fitted values, with a coefficient of correlation close to 0,9929 and 0,9933 for L-1 and L-2, respectively. This is seen from the calibrated t/S versus t and S relationship. The ultimate settlement (S_{ult}), for L-1 and L-2 were determined as 0,3963 m, and 0,4174 m, meanwhile initial settlement rate as 0,0234 m/day and 0,0278 m/day, respectively.

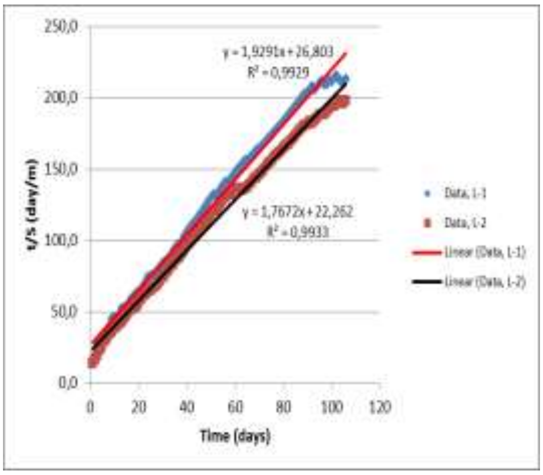

Figure 2. Fitting of t/S ratio of lysimeter

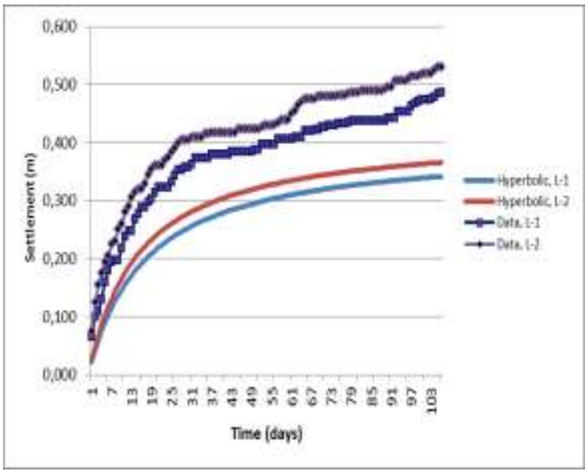

Figure 3. Settlement of MSW in the lysimeter

Fig. 3 shows the settlement characteristics of MSW in the lysimeter. Settlement of wastes can be a result of series of mechanisms like introduction of liquid into waste, including lubrication of contacts in the waste, softening of flexible porous materials, increasing the unit weight of the waste, and biodegradation [2]. MSW settles due to physical, chemical, and biological processes, and the total settlement is commonly assumed to consist of mechanical compression, me chanical creep, and biodegradation-induced compression [1]. Indicated that the leachate recirculation significantly effect to the rate of settlement. It is generally known that the presence of leachate recirculation rate of settlement becomes faster. The settlement of the lysimeter occurred rapidly due to low compaction and recirculation of leachate. The settlement indicated the biodegradation and physical movement of material in the lysimeter (Gamage et al., 2010).

Based on the measurement data known that a decrease at days 100 was 0.473 m and 0.517 m, while the settlement with hiperbolics function was 0.339 m and 0.363 m at L-1 and L-2, respectively. In percentages, the settlement was 19.70% and 21.54% for lysimeter measurements data, whereas the settlement by hiperbolics function 14.12% and 15.12% for the L-1 and L-2, respectively. This value is slightly different as stated by [14], that is the waste decomposition can cause settlement in the order of 30 to 40% of the original landfill depth, and on average, settlement of about 15 to 20% of the original landfill thickness is expected due to waste decomposition.

B. Leachate Generation

The control of leachate quantity and quality is the basis for long-term landfill operation and leachate treatment. To secure long-term dewatering of landfills and reduce treatment costs it is necessary to control leachate quantity and quality. In the landfill management, leachate recirculation is a potential solution for on-site control and treatment. Based on lysimeter experiment shown that cumulative leachate generation from the lysimeter is shown in Fig. 4.

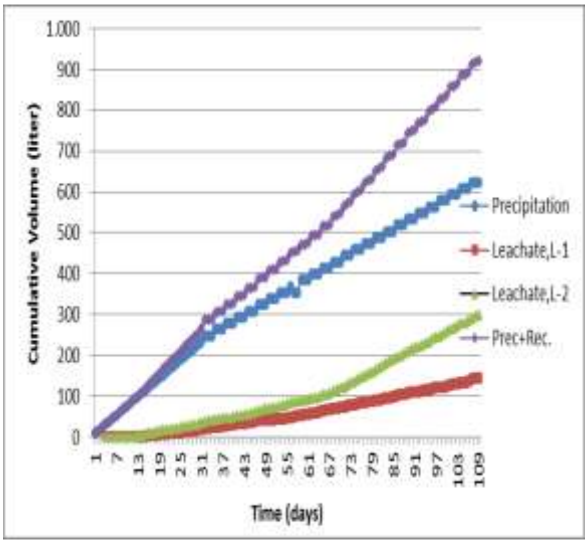

Figure 4. Precipitation water and leachate generation on lysimeter

On days 50, the leachate generated from lysimeter without recirculation (L-1) and with recirculation (L-2) were 36.40 L, 59.00 L, while the precipitation of water at 307.50 and 59.00 L respectively for L-1 and L-2. As for days 100 leachate produced 123.4 and 258.00 L respectively for L-1 and L-2. While the infiltration of water for L-1 and L-2 were 577,5 and 835.50 L, respectively. All lysimeter showed that the percentage of leachate generated are increasing. This is caused the water content of waste in lysimeter is low (<40%), so that the initial stage of water precipitation detained in a stack of refuse. However, if the predicted water levels reached > 40% water content, leachate generation will generate constantly [5]. In percentage of leachate generated from the L-1 (without recirculation) is smaller compared to the amount of leachate L-2 (recirculation).

IV. Conclusions

Base on the landfill lysismeter experiment to know settlement and leachate generation can be conclused as follows:

- In general known that the pattern of settlement between the experimental data with the hydraulic functions have the same pattern of both experimental data and hyperbolic functions
- The magnitude of settlemet on a hydraulic function is less than the settlement lysismeter experimental data both with and without recirculation of leachate recirculation
- The main difference between the recirculated and nonrecirculated of leachate on landfill operations are quantity of leachate generation
- Leachate recirculation will increase the rate of settlement, so that the same time magnitude of waste settlemet to be larger

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