

Effect of leachate recirculation and bulking agent on leachate quality

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Effect of leachate recirculation and bulking agent on leachate quality

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Abstract. The purpose of leachate processing is to reduce pollutants in leachate without using equipment that requires high investment and complicated maintenance. This research aims to determine the impact of leachate recirculation and bulking agents on leachate quality. Fresh solid waste recirculated using artificial leachate with a continuous flow of 1 L/h. The study is conducting for 14 days on a laboratory scale. On the 14th day, combination recirculation and bulking accelerate the increased pH value. Leachate recirculation increases the potential for contact between methanogenic bacteria and dissolved organic matter and contributes to buffering pH during the hydrolysis process. R3 produces a higher Electric Conductivity (EC) value than other reactors since the 7th day. This increase is probably due to the addition of dissolved salts from solid waste decomposition. The role of the bulking agent may not be too significant for changes in the EC value. On day 14, TDS at R1 was 11,748 mg/L, R2 was 12.144 mg/L, and R3 was 14.916 mg/L.

1. Introduction

The rapid population growth, economic growth, urbanization, and industrialization have led to an increase in waste generation, volume, type, and increasingly diverse waste characteristics [1]. The community can process about 5% of the total waste. The remaining 95% is taken to the Final Processing Site (TPA), while the land for the TPA is minimal [2]. In most countries, sanitary landfill is currently the most commonly used method for treating municipal solid waste (MSW) [3]. The substantial volume of waste and high rainfall produces large amounts of leachate as well. For example, Jatibarang landfill, a final waste treatment facility in Semarang City, manages 4,000 tons of waste every day with a composition of 61.95% organic waste from the total municipal waste (MSW) generated [4]. The existing treatment unit has not yet produced effluent quality following the quality standard. Visually, the watercolor in the inlet channel is not much different from the outlet [5]. Researches on leachate treatment are still less attentive nevertheless it contains highly polluted materials [6]. Leachate from the landfill needs to managing appropriately to not cause pollution to groundwater, surface water, and the environment.

WWTP Design for Banyuroto Landfill, Kulon Progo Regency consists of initial holding ponds, facultative ponds, and pond outlets with water hyacinth plants [7]. The Supit Urang IPAL pond, Malang, uses a stabilization pond, aeration pond, and a maturation pond [8]. The Bantar Gebang Integrated Waste



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Processing Site (TPST) in 2018 used equalization tanks, facultative tanks, aeration tanks, polishing ponds, settling tanks, chemical and biological treatment tanks, mud pools, and sand filters [9]. The leachate treatment system applied at the Cipayung TPA, Depok-West Java, uses a stabilization pond consisting of an anaerobic pond, a facultative pond, and a maturation pond [10]. Based on the results of surveys and measurements in the field, analysis, and evaluation of the data obtained by Sarimin's research [11], TPA Putri Cempo has a Waste Water Treatment Plant (WWTP) that is not feasible and cannot be used, the condition of the WWTP building has damaged, and the location of the WWTP is far from active waste piles. Fitria et al.[12] found landfill leachate found at depths of 4, 9, 15, 20, 30 m in TPA Gampong Jawa Banda Aceh. The leachate treatment system reduces pollutants in leachate without using equipment that requires high investment and complicated maintenance.

Recirculation is an attractive alternative for leachate treatment because it is effective in improving leachate quality. It is not only an inexpensive option for leachate disposal but, at the same time, accelerates the waste stabilization process. The leachate recirculation method saves off-site disposal costs, increases methane gas production, and increases the use of clear added value for communities that utilize methane [13]. By comparing the development of leachate processing technology in recent years, recirculation of leachate treatment is an excellent prospect to be applied in Indonesia.

2. Methodology

15 kg of urban solid waste samples were taken from a temporary household waste shelter in Banyumanik, Semarang, Central Java. Inorganic substances are separated manually to ensure an average particle size of 1.0-1.5 cm. The percentage of each component is calculated (% by weight). The leachate recirculation process uses artificial leachate made from fresh solid waste. A total of 1 kg of cabbage was soaked in 10 liters of distilled water and allowed to stand for 24 hours. The leachate was separated from the solid, then used for the recirculating process. 5 kg of a bulking agent comes from the passive zone in the Jatibarang landfill, Semarang.

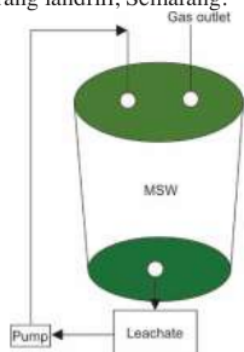


Figure 1. Reactor scheme equipped with MSW inlet, gas outlet (top), and leachate outlet (bottom).

The reactor is cylindrical with 270mm x 380mm x 380mm (Fig.1). The reactor consists of an MSW inlet, a gas outlet (top), and a leachate outlet (bottom). The MSW inlet and gas outlet holes are closed during operation to ensure anaerobic reactor conditions.

In this study, various treatments were carried out. R1 was a control reactor containing MSW as a sign of the recirculation process, 2 contains MSW with continuous recirculation treatment with a discharge of 1 L/min. R3 contains an MSW+bulking agent with a ratio of 70:30 (v/v). Each reactor is filled with 5,000 g of solid waste. The recirculation process on R2 and R3 uses leachate with a flow rate of 1 L/min continuously for 14 days. R1 without any recirculation process as a control. Leachate samples were taken on the first, third, seventh, and fourteenth days to analyze leachate quality. The reduction in leachate volume due to the sampling of the test was added manually to the original volume.

The quality of leachate is known from the parameters of pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS). Measurement of pH using a pH meter (Walklab TI 9000, Singapore) with an

accuracy of 0.01. The pH measurement method is based on potentiometric/electrometric measurements of hydrogen ion activity. The pH meter was calibrated using pH 4.0, 7.0, and 10.0 buffers according to the tool's work instructions every time it would take measurements. The pH meter electrode is immersed in the test sample until the pH meter shows a constant reading. The EC value was measured using a digital conductivity tester (Trans Instrument, Singapore) with one micro-Siemen (μS) precision. While TDS is measured using a TDS meter.

3. Results and discussion

3.1. Formation of leachate

We illustrate a water source produced from a research reactor. We use the water balance illustrated in Figure. 1. The main components involved in the water balance are (1) the water entering the solid waste cell from above (recirculation), the moisture in the solid waste, and the moisture in the bulking agent, and (2) the water leaving the reactor as saturated water vapor. And as leachate. So, the leachate that comes out through the reactor outlet comes from leachate used for recirculation, water from solid waste, and water from bulking agents. At the beginning of the study, reactors R1, R2, and R3 were added with 3.5 liters of leachate. The leachate in this study was artificial leachate made by soaking 2 kg of cabbage in 11 liters of distilled water for 24 hours. The characteristics of artificial leachate are shown in Table 1. The existence of a leachate recirculation process will affect the solid waste decomposition process.

Table 1. Characteristics of artificial leachate used for the recirculation process.

Parameters	Unit	Results
COD	mg/L	4620
Ammonia	mg/L	3.54
Nitrate	mg/L	15.28
pH	-	2.90
TDS	mg/L	994
EC	S/cm	1.83

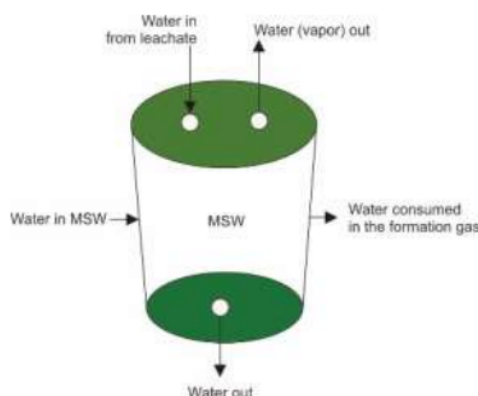


Figure 2. Illustration of the water balance produced from the research reactor, including leachate.

3.2. Pondus Hydrogenii (pH)

During 14 days of research, the pH value of leachate ranged from 2.90 to 4.02 (acidic). If leachate with an acidic pH is directly discharged into water bodies, it will impact aquatic biota and affect chemical-physical-biological processes in water bodies. Acidic pH indicates that solid waste undergoes hydrolysis

and acidogenesis, where this process produces a lot of VFA (Volatile Fatty Acid) [14]. In hydrolysis, complex organic polymers are reduced to simple soluble molecules such as amino acids, long-chain fatty acids, and sugars [15].

The impact of recirculation and bulking agent on the pH value is measured on the 14th day. The pH value at R3 is 4.02, while R1 is 2.90 and R2 is 3.54. R3 tends to increase, while R1 tends to be static (Fig. 2). The increase in pH value at R3 is a positive impact on the recirculation process and bulking agent. Recirculating leachate increases the potential for contact between methanogenic bacteria and dissolved organic matter and reduces the pH drop during the hydrolysis process. If the pH value of the leachate reaches the range of 6.8-7.2, then biogas production during the anaerobic process can be optimum, meaning stable biogas production from all stages of decomposition [16].

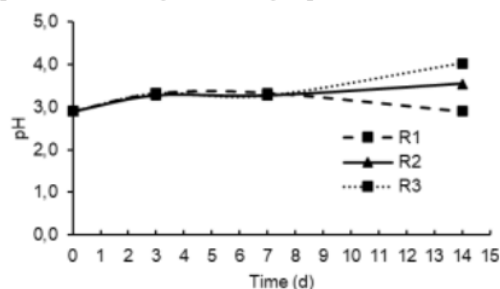


Figure 3. pH values at R1, R2, and R3 during the 14 days of the study. R3 tends to increase, while R1 tends to be static.

3. 3. Electrical Conductivity (EC)

The EC changes at R1, R2, and R3 are shown in Fig. 3. The initial EC leachate value used for the recirculation process is 1.83 mS/cm increased compared to the EC of the initial leachate. On the 3rd day, EC R1 is 23.49 mS/cm, R2 of 20.59 mS/cm, and R3 of 20.66 mS/cm. The R3 reactor produced a higher EC value than other reactors since the 7th day. This increase is likely due to the addition of dissolved salts from solid waste decomposition [17]. On the 14th day, the EC value of R3 is more than 27.72 mS/cm, higher than R1 and R2. We assume that the solid waste used has a homogeneous composition, so the possibility of increasing EC R3 due to the solid waste decomposition process in R3 is faster than other reactors. If we look at the EC pattern on R2 and R3, it tends to be stable between the 7th and 14th days. According to Adhanom, Hughes, and Odindo [18], using soil for leachate recirculation continuously does not change the EC value significantly. It indicates that soil has minimal impact on leachate EC after continuous recirculation. In this study, the role of the bulking agent may not be too significant for changes in the EC value. The increase in EC R3 is probably due to the decomposition process of solid waste in R3, faster than other reactors.

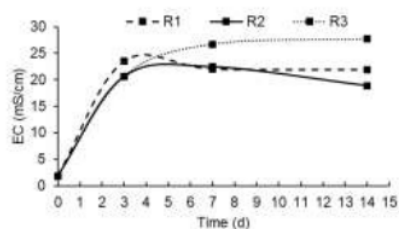


Figure 4. The EC changes at R1, R2, and R3 during the 14 days of the study.

3. 4. Total Dissolved Solid (TDS)

The artificial leachate used for the recirculation process contains a TDS value of 994 mg/L (Table 1). On the 3rd day, the TDS of leachate increased in both R1, R2, and R3 respectively by 12,804 mg/L, 11,154 mg/L, and 11,220 mg/L (Fig. 4). The increase in TDS is likely to come from solid waste that

undergoes biological decomposition. Recirculation increases the solubility of fresh waste and more quickly forms methanogenic conditions [19]. The recirculation process on R2 and R3 tends to increase the TDS value. Adding bulking agent caused the TDS value of R3 on day 3 to be higher than R1 and R2. On the 14th day, the TDS in each reactor increased, but not significantly. The TDS of R1 was 11,748 mg/L, R2 was 12,144 mg/L, and R3 was 14,916 mg/L.

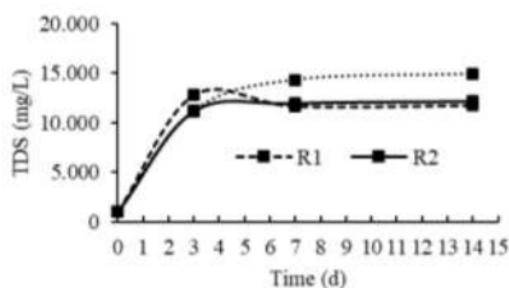


Figure 5. TDS values at R1, R2, and R3 during the 14 days of the study.

4. Conclusion

The impact of leachate recirculation and bulking agents on the leachate quality of MSW conduction. Combination recirculation and bulking accelerate the increased pH value on the 14th day. Leachate recirculation increases the potential for contact between methanogenic bacteria and dissolved organic matter and contributes to buffering pH during the hydrolysis process. R3 produces a higher EC value than other reactors since the 7th day. This increase is probably due to the addition of dissolved salts from solid waste decomposition. The role of the bulking agent may not be too significant for changes in the EC value. On day 14, TDS at R1 was 11,748 mg/L, R2 was 12,144 mg/L, and R3 was 14,916 mg/L. This research tells us that the recirculation process and bulking agent accelerate the increase in the pH value to reach the optimum condition to produce methane gas quickly. In addition, MSW in passive zone landfills can use as a bulking agent inactive zone landfills.

Acknowledgement

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