

Municipal Solid Waste Management Using Bioreactor Landfill in the Treatment of Organic Waste from Jatibarang Landfill, Semarang-Indonesia

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Abstract. Landfilling is one of the easiest methods to be applied in the management of municipal solid waste (MSW). In its development, bioreactor landfill methods that have various advantages over conventional landfill emerge. This experiment aims to study the use of bioreactor landfills for the management of organic waste in Jatibarang Landfill, Semarang-Indonesia. There are 4 bioreactor landfills operated: 2 anaerobic bioreactors with leachate recirculation and addition of water, and 2 aerobic bioreactors. Different results are shown from these two types of bioreactor, where aerobic bioreactors reach peak temperatures (55°C each) faster even though anaerobic bioreactors reach higher temperatures (60°C and 61°C respectively). Anaerobic bioreactors reach a higher final pH value than aerobes while the accumulation of nitrogen content from an aerobic bioreactor is 2 times higher than anaerobes.

Keywords: **Landfilling; Bioreactor Landfill; Aerob; Anaerob.**

1 Introduction

The Jatibarang Landfill, which is the final waste treatment facility in Semarang City, manages 4000 tons waste daily with a composition of 61.95% organic waste from the total municipal solid waste (MSW) produced. The Jatibarang Landfill still uses landfilling method as the waste management system, which still has an impact on the environment that affects water, soil, and air. This method is still often used due to the consideration of its use in managing organic and inorganic waste and low-cost requirements [1], [2]. Without better management, the resulting municipal waste can cause various kinds of environmental problems or become vectors of diseases caused by leachate, landfill gas, and municipal solid waste itself.

Landfill bioreactor appears as one of the appropriate technologies and is widely used to manage waste biologically, especially organic. The biodegradation process that occurs in the bioreactor of landfills can be accelerated by reusing the leachate produced to be recirculated back into the reactor. With this recirculation leachate, the quantity and quality of the leachate produced can be improved and the production of methane gas can be optimized, which can be reused to become alternative renewable energy [3,4,5]. Renewable energy from methane gas can be used to support the daily activities of people living near landfill locations.

There are various parameters taken into account in the biodegradation process that occurs in bioreactor landfills. Water content and pH level play an important role in conditioning the environment to make an ideal

condition for bacterial activity. With leachate recirculation and addition of water and aeration, these ideal conditions can be achieved [6]. These two factors also distinguish bioreactor landfills and conventional landfills [7]. In ideal conditions, the stabilization of solid waste can be reached faster because the development of bacteria rapidly occurs [8]. Faster biodegradation can give an impact on the rise of methane gas generation that can be reused and also reduce landfill usage [5]. According to [9], there are 3 types of bioreactor landfills, namely aerobic, anaerobic, and hybrid. Among them, anaerobic bioreactor is often used because the presence of methane gas generation during the biodegradation process, the second is aerobic bioreactor, able to support the occurrence of faster biodegradation due to the addition of aeration, while the hybrid bioreactor is a method that is still used in small amounts [6], [10].

The aim of this study is to investigate the quality of leachate formed during the decomposition process of leaves and vegetables, which was obtained from Jatibarang landfill, using aerobic and anaerobic landfill bioreactor. Some parameters to be examined are the temperature, pH value, and ammonia (NH_3). This method is expected to be able to manage the potential of pollution from solid waste and leachate produced in Semarang City to the environment.

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2 Methodology

2.1 Materials

This study used 4 landfill bioreactors with 2 anaerobic bioreactors (R1 and R2) and 2 aerobic bioreactors (R3 and R4). R1 and R3 use leaf waste while R2 and R4 use vegetable waste. Leachate recirculation and addition of water are only given to anaerobic bioreactors. The addition of water is done once a day during the study by pumping the water with the flow of 2 L/day. Leachate recirculation was carried out by manually storing leachate produced during the study through the top of the bioreactors daily. The leachate of each reactor is recirculated since day-3 because of the leachate is generated on the same day.

Bioreactors use plastic-based drums that have a volume of 120 L with a diameter of 50 cm and a height of 1.5 m. Air injection and leachate channels are below the bioreactors by making 2 holes while the addition of water is done through the top of the bioreactors. In the middle of the bioreactors, a hole is also given for testing the temperature. Bioreactors are given a layer of PE (polyethylene), stretch film, and aluminum foil on the outer part to maintain the condition in the inside of the reactor, which prevents outside influences. Before the study began, the feasibility of the bioreactors was tested in advance to check if it is impermeable to water and air.

The municipal solid waste used is organic waste taken from TPA Jatibarang, Semarang, Indonesia, in the form of 1-week-old leaf waste and vegetable waste. The study was conducted at the Environmental Engineering Laboratory for 60 days. Test parameters in the form of temperature and leachate pH were carried out every day while leachate NH₃ was carried out every 5 days. The temperature test was carried out directly into the temperature checking hole in the bioreactors landfill while pH and NH₃ from the leachate were carried out by leachate sampling and laboratory tests, which analyzed in duplicate.

3 Result

3.1 Temperature

Figure 1 shows the temperature changes that occur in each reactor during the study. On day 1, each reactor starts at room temperature (around 29°C). R3 and R4 increased rapidly to reach the peak temperature (55°C), which happened on day-12 for leaf waste and day-16 for vegetable waste. After reaching its peak temperature, the temperature of bioreactor drop until it reaches room temperature again. This rise and fall also occur in R1 and R2, but with different time frames. The increase in temperature occurs slowly until it reaches the peak temperature on day-37 for R1 and day-35 for R2 with the amount of 61°C and 60°C respectively. Although R2 reaches peak temperature faster, the peak temperature of R1 is higher.

The thermophilic phase (45°C-60°C) can be achieved by aerobic or anaerobic bioreactors which indicates that in this phase the biodegradation process happens rapidly [1]. On the other hand, a decrease in temperature indicates that bacterial activity begins to decrease, which also affects the biodegradation process.

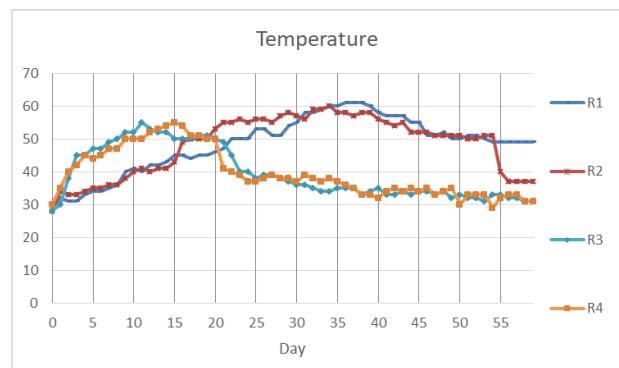


Fig. 1. The Changes of Temperature

3.2 Leachate pH

Figure 2 shows the leachate pH fluctuations that occur during the study. In the beginning, the pH value of R1 and R2 decreased to around 4.7-4.9 on the day-11. This shows that there is acid production that occurs in anaerobic bioreactors caused by the hydrolysis process [10]. After a decline, the pH value increased gradually until the end of the study, which reaches 7.5 on R1 and 7.7 on R2. On the other hand, there is no difference in the fluctuations in pH values that are striking between leaf waste and vegetable waste. Meanwhile, in aerobic bioreactors, the pH value rises significantly until day 3 to reach 6.7 for R3 and 6.3 for R4. The addition of aeration causes aerobic bacteria to tend to reduce acidic organic compounds so that there are not many acids formed which can reduce the pH of leachate [4]. After the increase, the pH value continued to rise until it reached 7.9 and 8.0 at the end of the study. The pH value of all reactors has entered the stabilization phase, which is in the pH range 7.5-8.9 [2].

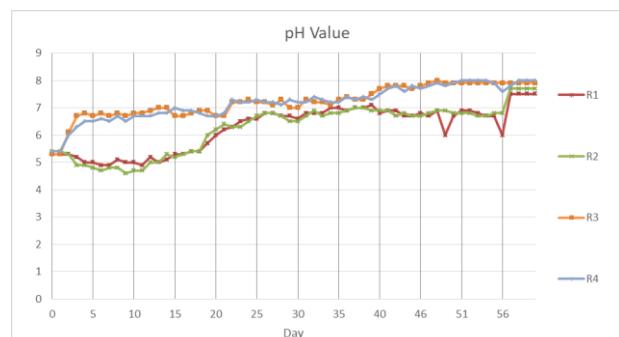


Fig. 2. The Changes of pH Value

3.3 Ammonia

Ammonia, together with leachate pH, is a parameter that determines the quality of the leachate produced. Fig 3. illustrates the changes that occur in ammonia from

leachate produced by each bioreactor. A significant increase in ammonia concentration on R1 and R2 was seen since the day-20. Ammonia concentration in anaerobic bioreactor continued to increase until the end of the study, which reached 0.89 mg/L and 1.18 mg/L for R1 and R2. This concentration is smaller than aerobic bioreactor. Ammonia concentration has continued to increase since the 5th day until the end of the study which reached more than 1.50 mg/L.

Ammonia concentration in this leachate continues to accumulate because of the absence of ammonification that occurs during the biodegradation process in anaerobic bioreactors [10]. In addition, the recirculation of leachate increases accumulated ammonia concentration because of higher level of ammonification level. On the other hand, higher ammonia concentrations in aerobic bioreactors are the result of biodegradation of organic waste, which is promoted by aeration [4].

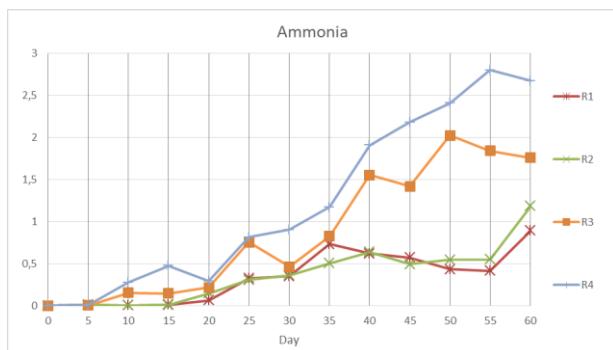


Fig. 3. The Changes of Ammonia Concentration

4 Conclusion

In this study, anaerobic and aerobic bioreactor landfills showed different results based on the parameters investigated. Anaerobic bioreactor is given the addition of water and recirculation of leachate while the aerobic bioreactor only uses air injection to accelerate the biodegradation process. The biodegradation process in aerobic bioreactors occurs faster than anaerobes due to the aeration factor, which is also characterized by faster rise of the temperature and pH of leachate. Nevertheless, the accumulation of ammonia in the aerobic bioreactor is higher so the potential for pollution is also higher. However, further investigation with broader scope for the application of this method to the Jatibarang landfill.

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