Performance of Semi-Aerobic Solid Waste Bioreactor in relation to Decomposition Process and Biogas Production

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Abstract. Solid waste which is sent to Jatibarang landfill in Semarang City can reach up to 4000 m^3/day. The composition of solid waste consists of 61.95% of organic waste and 38.05% of inorganic waste. The environmental impacts of solid waste can be reduced using bioreactor methods which being able to accelerate the solid waste decomposition. Large amount of solid waste which is sent to Jatibarang landfill certainly has great potential to environment pollution. Therefore, a technology such as landfill bioreactor is needed to speed up the decomposition process of organic solid waste. Landfill bioreactors are characterized using a range of technologies in order to create an suitable environment for degradation processes. In this study four bioreactors simulated landfills that consist of hybrid bioreactors and anaerobic control bioreactors. The result shows that hybrid bioreactor has increases the decomposition process of organic solid waste. The hybrid bioreactor also produce more methane in subsequent anaerobes.

Keywords: Solid waste; decomposition; bioreactor; landfill.

1 Introduction

Jatibarang landfill is a final waste processing site located in Semarang City. Jatibarang landfill began its operation in 1993 as one of the waste management facilities. Jatibarang landfill receives waste approximately 800 to 900 tons per day or 4000m^3/day. The composition of waste that goes to Jatibarang landfill consists of food waste (43%), garden waste (9%), paper (12%), wood (4%), textile (1%), nappies (1%), plastic and other inert (13%) and other waste (7%).

The waste that goes to the landfill is then being sorted according to organic and inorganic classification. The inorganic waste is collected by scavengers to be recycled, while organic waste is dumped into the landfill. However, it is often found that unmanaged inorganic waste is getting mixed in the landfill. Organic waste in the landfill will decompose aerobically and anaerobically. Anaerobic decomposed waste produces byproducts namely leachate and biogas.

Leachate can be defined as liquid passing through pile of waste and carrying substances from the waste [1]. Leachate contains various solutes such as organic substances, inorganic salts, organic trace pollutant, and heavy metals [2]. Meanwhile, the age of landfill also affects the concentration of contaminants in leachate [3].

Biogas is a renewable energy that can replace fossil fuel. Biogas is rich in methane which can substitute natural gas [4]. Biogas contains 50-80% methane, carbon dioxide (25-50%), nitrogen (0-10%), hydrogen (0-1%), hydrogen sulfide (0-3%) and oxygen (0-2%) [5].

However, the influence of leachate quality which is represented by BOD and COD parameters on methane content in biogas has not been extensively studied. Therefore, this study aims to analyze the effect of BOD and COD values on leachate to biogas production of methane gas.

2 Materials and methods

This study was conducted by comparing the results data from the analysis of BOD and COD values with their effect on methane gas production generated on the reactors. The research was conducted at Integrated Solid Waste Treatment Plant (ISWTP) of Diponegoro University, Semarang. The location of Diponegoro University's Integrated Solid Waste Treatment Plant is in education area of Diponegoro University, as shown in Figure 1.

Fig.1. Location of study

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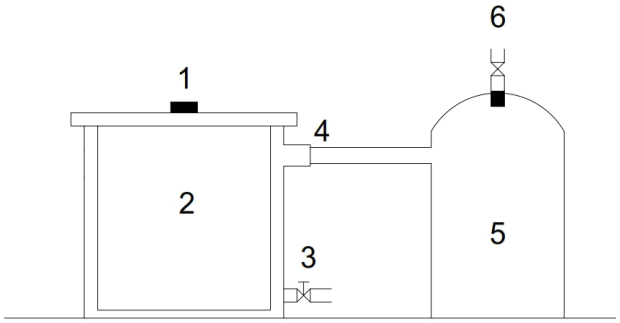
In this study, the value of BOD_5 and COD concentrations is monitored during decomposition process of organic solid waste in all reactors. The generation of methane is also be observed by measuring the level of methane content in biogas. The test results of BOD_5 and COD parameters present on the waste generation in the reactor would be compared to the biogas content in the reactor. From the data it could be seen whether the value of BOD_5 and COD affected the amount of gas produced.



Legend:
1. Feed inlet
2. Digester
3. Sludge & leachate outlet
4. Gas opening
5. Gas collector
6. Gas outlet

Fig.2. Diagram of Reactor

3 Results and discussions

3.1 COD

The COD value of reactors R1, R2, R3, and R4 had an downward trend from day 5 to day 20, then a COD decrease from day 20 to day 60. The COD values of the four reactors at day 5 ranged from 5200 mg O_2/l to 6600 mg O_2/l and at day 60 the COD value decreased to 4400 mg O_2/l to 5200 mg O_2/l. For example, based on figure 3, there was a decrease trend in the value of COD in all reactors after day 20. In the reactor R1, the COD value decreased from day 20 until day 60, from 7230 mg O_2/l to 5200 mg O_2/l. This indicates that young age landfills have a higher COD value than a long established landfill.

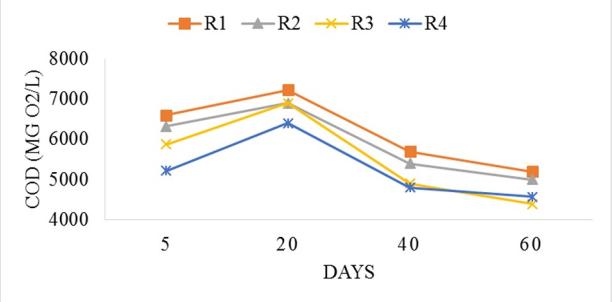


Fig.3. COD value

The COD value is affected by the occurrence of biological activity. The process of decomposition of organic materials by microorganisms produces biogas that contains methane gas and carbon dioxide. High COD concentration indicates that the anaerobic decomposition occurs at the first stage. At this stage the complex organic compounds are converted into water-soluble organic acids. Whereas low COD concentration indicates that the decomposition process takes place at the second level. The decomposition process will continue until a stable COD concentration is achieved [6].

3.2 BOD

According to figure 4, BOD_5 values of all reactors tend to increase along with the increase of composting time. The initial concentration of BOD_5 value of R2 and R4 reactor have the same value of 70 mg O_2/l while concentration in R1 and R3 are is 65 mg O_2/l and 60 mg O_2/l respectively. At the day 40, the COD concentration of R1 drops back to 65 mg O_2/l before increase to 80 mg O_2/l at day 60. The highest concentration at day 60 of BOD_5 is shown by reactor R3 with the value of 108 mg O_2/l. In reactor R4, the increment of BOD_5 concentration is relatively constant, starting from 70 mg O_2 / l in day 5 and gradually increases to 95 mg O_2 /l in day 60.

Increasing BOD_5 concentration was influenced by high organic and moisture content causing biological activity to increase. High BOD_5 and COD values were present along with Total Fatty Acid (TFA) which indicated the degradation occurring was low [7]. In this study the total of BOD_5 decrease reached 80%.

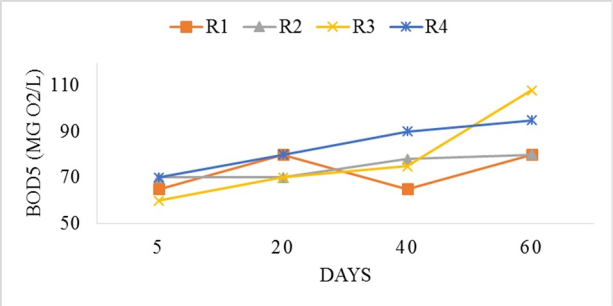


Fig.4. BOD value

The percentage of CH_4 on R1, R2, R3 and R4 reactors fluctuated with increasing decomposition time. The percentage of CH_4 in the four reactors ranged from 31.2% to 55.37%. The percentage of CH_4 in R1 had a tendency to increase with decomposition time, from 31.2% in September increasing to 36.88% in November. The percentage of CH_4 in R2 tended to increase from September to October, but the CH_4 percentage decreased in November. The percentage of CH_4 in R3 tended to decrease from September to October and then increased in November. While the percentage of CH_4 in R4 in September, October, and November tended to have the same value of 48%.

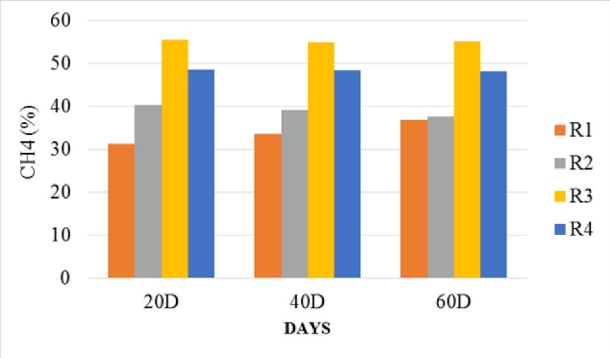


Fig.5. CH_4 value

4 Conclusion

Leachate characteristics resulting from the decomposition process had BOD_5 values ranging from 60-110 mg O_2/l, COD values ranging from 4400 to 6600 mg O_2/l. The longer the decomposition time of the waste, BOD levels tend to increase along with the increase in volume and production of leachate. However, the opposite happened for COD parameter. The value of COD decreased as the rate of waste decomposition increased. Meanwhile, the biogas produced in the reactor contained methane of 31.2 - 54.99% and shows an increase trend.

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References

1. S.M. Raghab, A.M. Abd El Meguid, H.A. Hegazi, HBRC J. (2013)
2. C.M. Moody, T.G. Townsend, Waste Manage. (2017).
3. S. Renou, J.G. Givaudan, S. Poulain, F. Dirassouyan, P. Moulin, J Hazard Mater. (2008).
4. P. Weiland, App Microbiol Biotechnol. (2010).
5. C. Mao, Y. Feng, X. Wang, G. Ren, Renew Sust Energy Rev, **45** (2015).
6. M.A. Budihardjo, E. Sutrisno, M. Fatimah, MATEC Web Conf. **159** (2018)
7. F. Fantozzi, C. Buratti, Bioresource Technology 102 (2011)