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The effect of nozzle size on dissolved oxygen value using fine bubble aeration. Case study: *Leachate* treatment in Manggar landfill

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Abstract. Leachate is a concentrated liquid that is harmful to soil and groundwater. This liquid comes from the process of decomposition of waste material by microorganisms in landfills. Leachate has the characteristics of high organic content. To reduce the organic content, one of them is to increase the dissolved oxygen in leachate. The method used with the aeration diffuses. Especially, using fine bubble aeration. Based on this background, a leachate water treatment was carried out using the fine bubble aeration system in order to see the effect on the value of dissolved oxygen or DO produced. The method in this experiment using a closed reactor system by varying nozzle diameter as a control variable. They are 1.5 mm, 2 mm and 3 mm. The air pressure use 3 bar. Aeration time from 0 to 120 minutes. The volume of water as much as 25 Litre. The results showed that there was an effect of nozzle size on DO values. The highest increase in DO occurred in 1.5 mm diameter reaching 7.4 mg/L, while the highest 2 mm and 3 mm DO sizes reached 6.6 mg/L and 6.6 mg/L respectively. Based on the comparison of DO values of each diameter, it can be concluded that the 1.5 mm is more effective in increasing the dissolved oxygen concentration in leachate water treatment using fine bubble aeration. According to bivariate analysis, the nozzle diameter as a control variable has a very strong relationship with the DO value indicated by the correlation value approaching 1 (0.701) with the aeration time change scenario.

1. Introduction

The Balikpapan City Manggar Waste Disposal Site is operated on an area of 49.89 Ha using the Sanitary Landfill System which is equipped with a gas controller, leachate channel, and Leachate Management Installation (IPL). Like most landfills, the process of decomposition of organic waste will produce gases (CH_4, NH_3, and H_2S) and leachate. The active installation in leachate management at the Manggar landfill only consists of stabilization ponds, aeration ponds, and bio-filter ponds, hence the leachate management process still has the potential to pollute the surrounding surface and groundwater.

Landfills produce leachate every day. Leachate comes from the decomposition of waste material in the landfill. If leachate which contains high organic matter and ammonia is discharged into the environment, especially water bodies without processing, it will initiate the growth of algae and reduce dissolved oxygen. Eventually, it can cause toxic effects on the environment. According to the previous research [1], the research shows the effects of leachate contamination on the nearest water body. Leachate harms water quality parameters such as reduced dissolved oxygen levels, BOD and COD concentrations become high and pH becomes unsuitable for aquatic organisms. Also, leachate has implications for public health using water bodies around landfills.

Dissolved oxygen (DO) is an essential component that determines the water quality and trophodynamics of an aquatic system. A fluctuation of DO near its saturation indicates relatively healthy waters [2]. DO is one of the parameters most often measured in water studies, but its sources and systems such as atmospheric exchange, photosynthesis or respiration are still rarely known. Dissolved oxygen is measured as milligrams of dissolved gaseous oxygen per Litre of water (mg/L), or parts per million (ppm). Dissolved oxygen in water can range from 0 to 14 parts per million.

According to the previous research, DO is the amount of dissolved oxygen in the water from the photosynthesis process and atmospheric/air absorption [3]. The greater the amount of DO, the better the water quality. Contrarily, if dissolved oxygen is low, it will cause a stench in the water. Oxygen is passed through two ways in this aeration process, one is the mass transfer at the surface of the water, and the other is the mass transfer of the bubble interface [4].

There are many factors that can increase the level of dissolved oxygen in the water. Dissolved oxygen naturally enters the water from the atmosphere and will continue to enter the water until it is saturated. One of the factors influence the level of dissolved oxygen in the water is turbulence. The more turbulence displayed by streams or rivers, such as waterfalls or rapids, the more oxygen is absorbed into the water. Also, turbulence on the surface of water bodies caused by wind tends to increase levels of dissolved oxygen.

The main characteristic of fine bubble aeration is the size of the bubble. It is gotten by blowing air from the compressor into the liquid. Fine bubbles can be made with porous media, constant flowing nozzles, and membranes. Small bubbles generated from the system have a high surface area per unit volume, consequently, the contact of oxygen to liquid is better and leads to relatively high oxygen transfer. The diameter of the bubbles released from diffusers is between 1 mm to 2.5 mm. Accordingly the efficiency of oxygen transfer depends on the size of the bubbles produced [5].

A fine bubble diffusion is a form of aeration under the surface. The air will be entered in the form of very small bubbles. They show high oxygen transfer and high aeration efficiency. They produce lower volatile organic compounds than mechanically aerated. However, they are susceptible to chemical or biological contamination that can disrupt transfer efficiency. Consequently, they need regular cleaning [6].

The advantages of using fine bubble aeration are to produce high oxygen mass transfer efficiency, providing high oxygen demand, producing emissions of volatile organic compounds. Meanwhile, the disadvantage of using fine bubble aeration is the high maintenance costs in some applications. Because of the diffuser can be clogged and required large energy. However, pneumatic aeration such as a fine bubble is the most effective use in wastewater treatment plants at present.

There are many studies that have been carried out related to aeration design and bubble diffuser. Research by Neto et al. [7] concerning the injection of air into water with a variety of nozzles. Research by Malovanyy et al. [8], increasing of dissolved oxygen in leachate using aerated lagoon. The results of his study declared optimal aeration for 10 days with DO of 3.91 mg/dm^3. Microorganisms and temperature became the main determining factors. Research by Navisa et al. [9], about the diameter of the nozzle in the aeration process. His research states that the size of the nozzle diameter affects the size of the air bubbles. The smaller air bubbles, consequently, they will transfer oxygen better. Research by Cheng et al. [4] about the effect of the different shapes of air diffusers. The results of his study stated optimal aeration uses an I-shaped diffuser. Research by Marius and Mircea [5], process optimization of aeration in the biological treatment using fine bubble diffusers.

Among the studies, have been done previously. They are rarely found in the application of aeration methods, especially fine bubble aeration for leachate processing. Accordingly, different from previous studies, this study will try to apply the fine bubble aeration method with several variations of design in leachate processing. The purpose of this study is to study at the effect of variations in nozzle diameter in oxygen transfer by measuring dissolved oxygen in leachate.

2. Research methods

2.1. Location sampling

The sampling location is located at the Manggar waste disposal, Balikpapan City, East Kalimantan (Figure 1). The Manggar waste disposal is operating on an area of 49.89 Ha that using the sanitary landfill system. The system is provided with a gas controller, leachate channel, and leachate management installation (Figure 2).

Figure 1. Location sampling of leachate.

Figure 2. Leachate pond in the Manggar landfill.

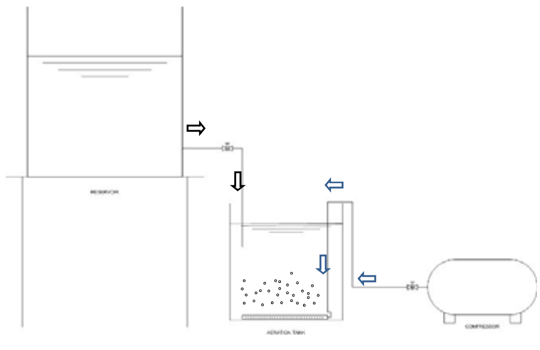

Figure 3. Scheme of fine bubble diffuser reactor.

Figure 4. Fine bubble diffuser reactor.

2.2. Tools and materials
Preparation of tools and materials in this research are diffusers with hole-diameter of 1.5 mm, 2 mm and 3 mm, reservoir, aeration reactor, a compressor with 8 bar specifications, compressor hose to drain air, DO meter, and Thermometer. For ingredients, namely leachate. The scheme of fine bubble diffuser reactor shown in Figure 3.

2.3. Step of research
The first step in the research is to develop the aeration reactor and diffuser (Figure 4). The next step is to install a diffuser with a hole-size of 1.5 mm diameter which is connected to the compressor. Set the pressure compressor of 3 bar. Recording temperature.at before and after the aeration process. After that, take measurements DO at minute 0, 10, 20 until 120 with the DO meter (Lutron DO-5509). Repeated all stages for the data on the 2 mm and 3 mm diffuser, consequently.

2.4. Analysis
In the analysis stage, the effectiveness of aeration will be measured DO value every 10 minutes until 120 minutes. After the DO data is obtained, the data is entered in a chart and described. Data DO will be analyzed bivariate. Bivariate analysis using the partial correlation method. The analysis is carried out on two variables that are thought to be correlated for DO value. The variables are nozzle diameter as a control variable and aeration time as an independent variable.

3. Results and Discussion

3.1. Effect of aeration time on dissolved oxygen
The results showed that from the variation of aeration time that lasted from 0 to 120 minutes and the nozzle diameter as a control variable that was tested. It is turned out that treatment by giving air pressure at 3 bar caused dissolved oxygen (DO) levels to increase (Figure 5).

Viewed from Figure. 5, under the variations of the aeration time. Maximal dissolved oxygen at aeration time of 120 minutes for 1.5 mm, 2 mm, 3 mm nozzle diameters respectively are 7.4 mg/L, 6.6 mg/L and 6.6 mg/L. It shows to us that the longer the aeration time can cause a greater amount of oxygen in contact with the leachate. Consequently, the concentration of dissolved oxygen in the leachate is increased. However, oxygen concentration can reach its saturation point. So that, at that condition the aeration does not affect the amount of dissolved oxygen.

According to Wang and Zhang [10], with increasing of the aeration time will increase DO value. It can be shown from organic mater gradually reduced, while the organic removal rate gradually increased. In the line with Anat [11], the results of his research indicate water quality, especially for DO and BOD with aeration time of 8 hours per day, is much better than with aeration time of 4 hours per day and without surface aerator surgery.

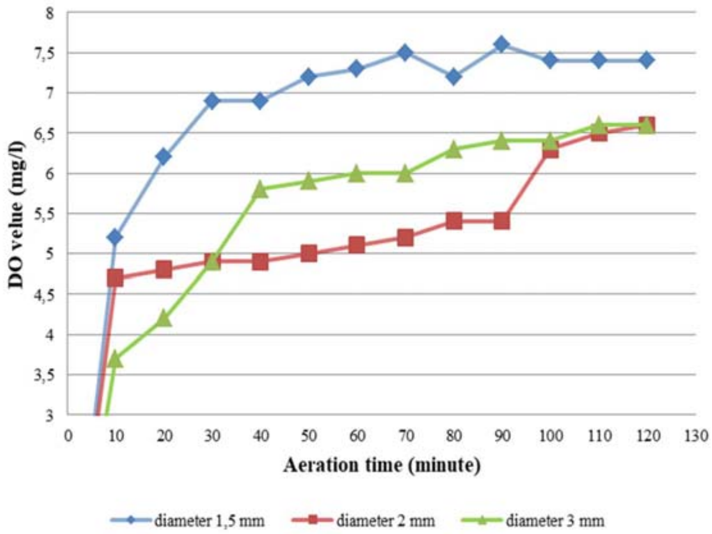

Figure 5. The dissolved oxygen in different aeration times.

3.2. *Effect of different size of nozzle diffuser on dissolved oxygen*

Changes in the size of the nozzle produce changes in dissolved oxygen in leachate (Figure 6). This shows that, in our experiments, regardless of the nozzle diameter as a control variable, the optimal aeration efficiency is a nozzle diameter of 1.5 mm, and then 2 mm and the last one is 3 mm in size.

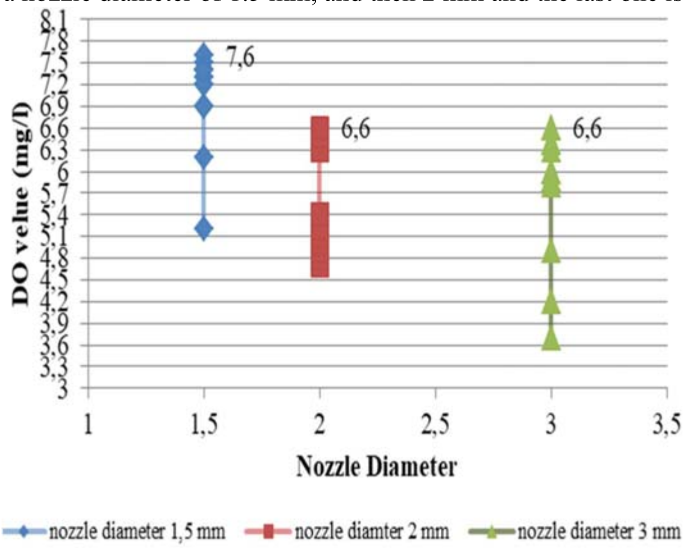

Figure 6. The dissolved oxygen in different sizes of nozzle diffuser.

Viewed from Figure 6, under the three variations of the nozzle size, the increase in DO of all variations is always positive. The maximum increase values of the 1.5 mm, 2 mm and 3 mm nozzle diameters are 7.6 mg/L, 6.6 mg/L, and 6.6 mg/L, respectively. On the contrary, the lowest DO values at the 1.5 mm, 2 mm and 3 mm nozzle diameters were 5.2 mg/L, 4.7 mg/L, and 3.7 mg/L.

Figure. 6 also shows that the diameter of nozzle diffuser also influences the concentration of dissolved oxygen. DO is greater in the nozzle with the smallest size of 1.5 mm. In the line with Navisa et al. [9], that the smaller the nozzle diameter used, the longer the residence time of bubbles in the water, consequently, the diffusion of oxygen from the air into the water can be maximal.

This is due to the smaller diameter of the nozzle will produce greater turbulence. In accordance with the statement of Bennefield and Randall [12], that turbulence will increase the rate of change of oxygen transfer on the surface of the contact area, which results in the entire contact area will remain constant in capturing oxygen until saturation is achieved. According to Roman and Muresan [13], bubbles provide good oxygen which leads to relatively high oxygen transfer efficiency values.

It can be seen from Table 1, the results of the bivariate analysis use a partial correlation method in which the nozzle diameter as a control variable has a very strong relationship with the DO value indicated by the correlation value approaching 1 (0.701) with the aeration time change scenario. The higher the aeration time, the higher the DO value.

Table 1. Correlation between nozzle diameter and aeration time.

Control Variable			Aeration Time	Dissolved Oxygen
Nozzle Diameter	Aeration Time	Correlation	1.000	0.701
		Significance (2-tailed)	.	0.000
		Df	0	36
	Dissolved Oxygen	Correlation	0.701	1.000
		Significance (2-tailed)	0.000	.
		Df	36	0

4. Conclusion

Based on the purpose of this research can be taken conclusions. Fine bubble diffuser aeration can increase DO values in leachate. Varying the nozzle diameter and the aeration time greatly affect the increase in DO values. The maximum increase values of the 1.5 mm, 2 mm and 3 mm nozzle diameters are 7.6 mg/L, 6.6 mg/L, and 6.6 mg/L, respectively. On the contrary, the lowest DO values at the 1.5 mm, 2 mm and 3 mm nozzle diameters were 5.2 mg/L, 4.7 mg/L, and 3.7 mg/L respectively. Leachate treatment by adding pressurized oxygen can increase the amount of dissolved oxygen quickly. Aeration time and nozzle diameter affect the increase in dissolved oxygen. We will continue this research by looking at the effect of processed leachate discharged into the environment such as water bodies by means of simulations.

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