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THE EFFECT OF SALINITY ON OXYGEN TRANSFER PROCESS IN LEACHATE WITH A LOW INITIAL COD CONCENTRATION

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ABSTRACT

Leachate is one of the results of rainwater infiltration and the degradation of microorganisms in waste. Some leachate types usually contain salinity which is an inhibitor in biological treatment processes. Aerobic biological treatment usually also requires sufficient dissolved oxygen (DO) levels. This study aimed to determine the effect of salinity on oxygen transfer in saline leachate. This study used a DO meter to measure the DO concentration in the 2 L volume reactor. There were two variations, namely leachate without salinity and with salinity 6 ppt, where the processing was carried out with three repetitions. The final oxygen transfer coefficients for the leachate without salinity and with salinity were 0.021 and 0.014, respectively. While the detention time required for leachate without salinity is 47.5 minutes, it takes 71.43 minutes with salinity.

Keywords: *leachate, oxygen transfer, salinity*

I. INTRODUCTION

Waste stockpiled in landfills consists of various compositions and characteristics (Mohajerani et al., 2020). Therefore, the chemical characteristics of the waste serve as a determinant of the processing method to be used. Based on the empirical approach, three types of analysis can be done to predict the factors that influence the value of the heating process. The three types of analysis include physical and chemical composition, proximate analysis, and ultimate analysis (Thipkhunthod et al., 2005).

Leachate can be defined as a liquid resulting from the decomposition of waste influenced by rainfall and groundwater percolation (Kamaruddin et al., 2017; Septiariva & Suryawan, 2021). Several factors influence the chemical characteristics of leachate, the factors that can affect the leachate composition are climate, precipitation, waste characteristics, and landfill age (Renou et al., 2008). The concentration of leachate produced in the dry season is twice as large as that of leachate produced during the rainy season (Kawai et al., 2012). The occurrence of rainwater percolation in landfills can decompose the elements present in the leachate so that the leachate concentration decreases (Yu et al., 2021).

Leachate can be said to have salinity if it has potassium (K+), sodium (Na+), and chloride (Cl-) ions. Chloride inhibits bacterial activity to reduce the COD content (Loncnar et al., 2010). The chloride concentration contained in the leachate as a non-biodegradable parameter ranged from 6,100 – 6,900 mg/L after 120 days and was stable at a concentration of 6,600 mg/L after 250 days (Bilgili et al., 2007).

In aeration, energy is defined as a function of oxygen saturation concentration, bioreactor volume, and KLa i.e. mass transfer coefficient of oxygen. In some technologies, DO concentrations are kept higher to ensure good effluent quality (Wilén & Balmér, 1999). However, this is very expensive and therefore it is often desirable to operate the aeration tank at a low but sufficient DO concentration to reduce energy consumption. Keeping DO constantly is quite difficult because the activated sludge system (Afifah et al., 2020; I. Suryawan et al., 2021; I. W. K. Suryawan, Prajati, et al., 2021) changes due to inflow flow and wastewater composition as well as in other operational parameters such as chemical dosage, rainfall and recirculation flow.

Most control strategies for DO are employed to maintain heterotrophic and autotrophic microbial culture kinetics but little is known about the impact on sludge properties. Lack of oxygen can be seen by increasing the growth of fibrous bacteria (Gaval et al., 2002). Parameters such as level of organic loading and solid size in activated sludge where size is an important parameter that determines sensitivity to low DO concentrations. At high organic load levels the oxygen concentration must be sufficient to allow diffusion or oxygen to be completely mixed through the microbes (Ye & Li, 2009). This study aimed to determine the effect of salinity on oxygen transfer in leachate.

II. LITERATURE REVIEW

The gas transfer is defined as the process by which gas is transferred from one phase to another, usually from the gas phase to the liquid phase (Metcalf & Eddy, 1991). The gas transfer involves contact between air or other gases with water, which causes the transfer of a compound from the gas phase to the liquid phase or the evaporation of a compound from the liquid phase (in dissolved form) into the gas phase escapes into the air. The gas transfer mechanism occurs by diffusion (Benefield, 1982).

The success of the gas transfer process depends on the magnitude of the temperature, oxygen saturation, water characteristics and water turbulence. Several types of aerators used in the gas transfer process are diffuser aerators, mechanical aerators, spray aerators, and gravity aerators (Benefield, 1982). The gas transfer process can be used for drinking water and wastewater treatment, including reducing iron (Fe) and manganese (Mn) dissolved in water (Aziz et al., 2020). The main factors affecting the solubility of gases in water are water temperature, partial pressure of gas in gas phase, the concentration of dissolved solids in the water phase, and the chemical composition of the gas.

Gas transfer occurs due to gas transfer from the gas phase to the liquid phase or preferably where there are three phenomena (Alexander et al., 2019) in it.

1. Dissolution in which gas transfer occurs which involves the contact of air or other gases with water which causes the transfer of a compound from the gas phase to the liquid phase or the evaporation of a compound from the liquid phase (in dissolved form) to the gas phase (released into the air).
2. Phenomenon of absorption – desorption (sorption) mass transfer of substances from

the gas phase to the liquid phase or vice versa, occurs when there is contact between the surface of the liquid with gas or air.

3. This mechanism occurs by diffusion-dispersion, where the driving force of mass transfer from air to water or vice versa is controlled by differences in the concentration of substances in solution and gas solubility under certain conditions.

The solubility of gases, unlike the solubility of solids in water, decreases with increasing temperature. Therefore, at partial pressures up to 1 atm, the equilibrium concentration of a gas in solution at a given temperature is proportional to the partial pressure of the gas in water, according to Henry's law (Benefield, 1982).

Henry's law is widely used in gases often encountered in water treatment techniques, such as oxygen, methane, carbon dioxide, and hydrogen sulfide (Crone et al., 2016). The last two gases undergo reactions in water. Suppose the surface of the water is exposed to air or gas and there has not been a previous equilibrium. In that case, simultaneously and immediately, the contact area between the phases will be saturated with gas and the gas is transported to a body of water by the following molecular diffusion process:

$$\frac{\partial M}{\partial t} = -D\frac{\partial C}{\partial X} \quad (1)$$

$\frac{\partial M}{\partial t}$= The rate of gas transfer across the surface of the contact area,
D = molecular diffusion coefficient,
$\frac{\partial C}{\partial X}$ = Concentration gradient at interface.

In some cases with gas-to-liquid transfer, we consider transfer from both sides of the at interface. Therefore, the Lewis Whitman model (1923) or the two-film model is as described below. The same assumptions apply to the two films as to the single Nernst film model (Wang & Langemann, 1994). The problem, of course, is that where the problem is to find the interface concentration constant, Cgi or Cli.

$$C_{li} = \frac{\text{Cgi}}{Hc} \quad (2)$$

It is assumed that the resistance to gas transfer is in the gas-liquid fixed film at the gas-liquid interface. The movement of gas across the surface of the gas layer indicates a pressure gradient in the gas layer and therefore the gas pressure at the interface, Pi is lower than the bulk gas pressure, Pg. Gas transfer occurs in two steps.

III. METHODOLOGY

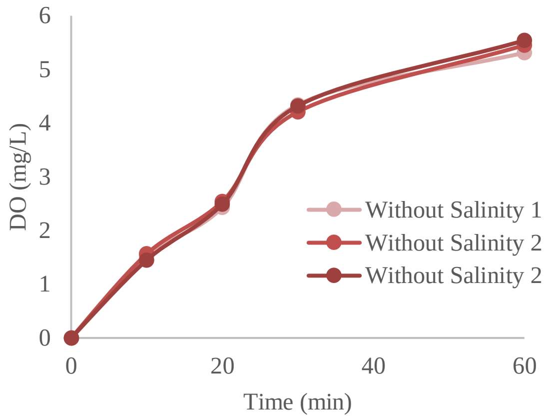
The leachate used in this study is leachate from a temporary garbage collection site in Denpasar City. The oxygen transfer process is carried out in a reactor with a size of 2 L. Where salt is added with the addition of up to 6 ppt, this is adjusted to the existing conditions by research that has been conducted by researchers, which states that the salinity value of leachate in landfills in Indonesia is around 6 ppt (Septiariva et al., 2020). The limitation in this study used an initial COD concentration of 100 mg/L.

By measuring the change in DO value in an experiment using water with low DO and connecting it with DO at saturation (Cs), the KLa coefficient will be obtained. From the experimental data with the initial concentration of oxygen Cs and oxygen concentration in the observed time interval C. Then it can be plotted into graphs of ln (Cs-C) and time (t), then a straight line is obtained with the magnitude of the angle of direction (slope) is KLa (Benefield, 1982).

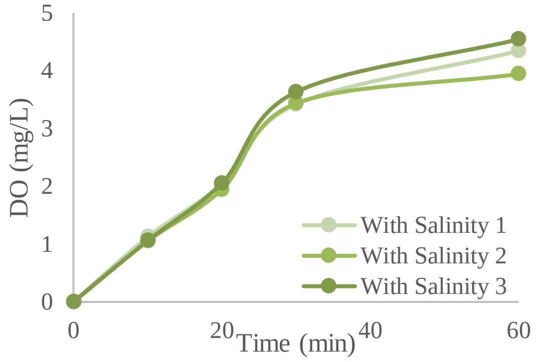
ANOVA is used as an analytical tool to test research hypotheses that assess whether there is a difference in means between groups. The final result of the ANOVA analysis is the value of the F test or F count and the level of significance. Where the hypothesis used is that there is an average between groups so that there is an effect of salinity on oxygen transfer in the waste.

IV. RESULT AND DISCUSSION

This research was conducted by measuring DO up to the saturation stage. Figure 1 shows the difference in DO changes during the gas transfer process. Oxygen transfer in leachate without salinity can reach 5.31 - 5.54 mg/L within 60 minutes. While in leachate the salinity can reach 3.9 – 4.5 mg/L in a detention time of 60 minutes. This can be seen the difference in concentration that can be achieved.



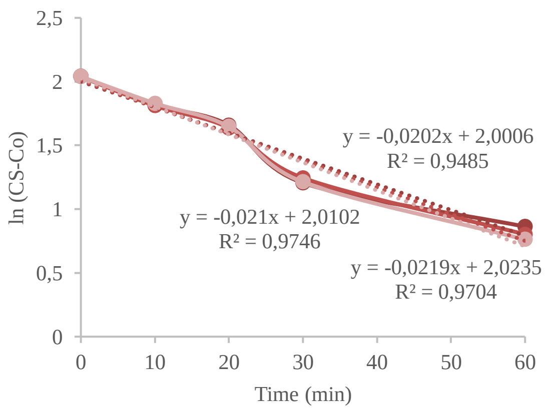
(a) Without Salinity



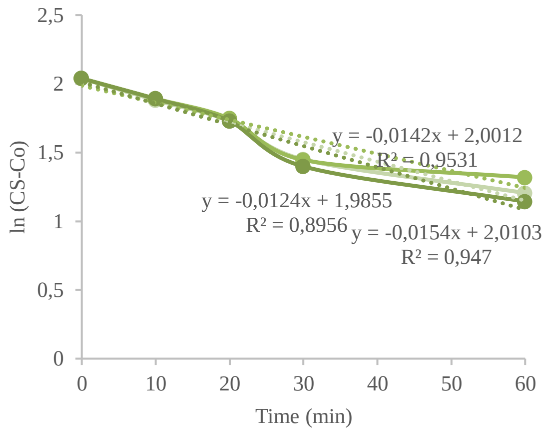
(b) With Salinity

Figure 1. Measurement of DO Value Changes During the Oxygen Transfer Process.

A plot between ln (Cs-C) and time (t) is needed to obtain gas transfer kinetics in the leachate aeration process. Cs used in this study were 7.68 mg/L. The saturation concentration of oxygen (Cs) in water depends on the temperature and partial pressure of the oxygen in contact with the water. Theoretically, the concentration of dissolved oxygen in water at a pressure of 760 mmHg. The calculation of gas transfer kinetics can be seen in Figure 2.



(a) Without Salinity



(b) With Salinity

Figure 2. KLa Calculation

The value of KLa is very influential on the design of aerobic treatment. So far, the contribution of oxygen in aerobic processing has not been widely reported, even though the presence of oxygen cannot be ignored. Several researchers have shown that the greater the presence of biomass will require more oxygen supply, reducing the aeration capacity that already exists in the biological system. Furthermore, increasing the concentration of activated sludge suspension will cause an increase in the viscosity of the liquid (Meng et al., 2006; Nittami et al., 2013; Ratkovich et al., 2013; I. W. K. Suryawan, Helmy, et al., 2021). This condition can cause inhibition of oxygen transfer into the water and then into microbes. For this reason, it is also necessary to pay attention to the hydraulic retention time (HRT) in planning to ensure sufficient oxygen availability. Table 1 shows the results of HRT calculations in leachate without salinity faster than in the presence of salinity in leachate.

Table 1. Calculation Results of KLa and HRT in Oxygen Transfer Process

Variation	KLa (/min)	KLa average (/min)	HRT (min)
Without Salinity	0.0202	0.021	47.54
	0.0219		
	0.021		
With Salinity	0.0142	0.014	71.43
	0.0124		
	0.0154		

At a certain level of salt, it is called a passive condition so that the salt solution can act as a catalyst (trigger/accelerator) and an inhibitor (Son et al., 2010). In this case, it can be seen that the results of the ANOVA test on variations showed the effect of salinity on KLa in the leachate gas transfer process (Table 2).

Table 2. Calculation Results of KLa and HRT in Oxygen Transfer Process

Variabel		Sum of Squares	df	Mean Square	F	P-value
Between Groups	(Combined)	0.267	1	0.267	49.413	0.002
	Linear Term	0.267	1	0.267	49.413	0.002
Within Groups		0.022	4	0.005		
Total		0.289	5			

V. CONCLUSION AND RECOMMENDATION

The gas transfer coefficient test results in saline leachate show a slower value than leachate without salinity. This also affects the hydraulic residence time in the process, so a larger reactor volume is also needed. The results of the ANOVA test also showed a significant p-value for variations in salinity.

Further research is needed for larger reactor volume variations and different flow rates. In addition, because the initial concentration given in this study was only 100 mg/L, a more considerable variation was needed because the leachate concentration in field conditions was much higher.

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