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The effect of microbubbles on the reduction of Biochemical Oxygen Demand (BOD) of Palm Oil Mill Effluent (POME)

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ABSTRACT

Palm Oil Mill Effluent (POME) is a wastewater discharged from the palm oil industry. It contains large quantity of organic matter in the form of total suspended solids (TSS), volatile suspended solids (VSS), total solids (TS), oil and grease which is the major contribution to the water resources pollution especially rivers or lakes if left untreated. Raw POME has high value of Biochemical Oxygen Demand (BOD) which is more than 30,000 ppm, thus it must be treated before it can be discharged to the water resources. Therefore, this paper presents a new method of POME treatment using microbubbles. Microbubble is selected due to its high oxygen transfer coefficient at a low air flow rate that can give a major impact on reducing the BOD of POME. Thus, microbubble can be a factor on reducing the BOD of POME. The POME sample was collected and handled according to APHA standard. The duration of treatment was carried out for 120 minutes by analysing the BOD at the following time intervals; 0, 30, 60, 90, and 120 minutes with introduction of microbubble. The BOD results were measured using Five-Day Biochemical Oxygen Demand method (APHA 5210 B). The lowest flowrate of microbubbles performed better in reducing the Biochemical Oxygen Demand (BOD) with reduction of 26% of BOD at 60th minutes retention time. It is due to the lowest air flowrate produced the smallest size of microbubble whereas the bubble size is one of the key factors with significant impacts on floatation and mixing that affect aeration process.

Keywords:
Wastewater, microbubbles, Palm Oil Mill Effluent (POME), Biochemical Oxygen Demand (BOD), treatment time, microbubble flowrate

1. Introduction

Palm Oil Mill Effluent (POME) is a highly polluting wastewater with a large quantity of organic matter in the form of total suspended solids (TSS), volatile suspended solids (VSS), total solids (TS), oil and grease that is responsible to the high level of biochemical oxygen demand (BOD) and chemical oxygen demand (COD). This condition could lead to severe pollution to the environment, typically

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pollution to the water resources if it is discharged untreated [1]. It has generated the highest pollution load into rivers throughout the country mainly in Malaysia [2].

Generally, COD and BOD are essential parameters used as indicators of composition and environmental impact of wastewaters. It was reported that raw POME in Malaysia contained BOD for more than 30,000 ppm. Department of Environmental Malaysia (DoE) has set up parameters discharge effluent limit at 100ppm. Although POME is a non-toxic liquid waste with unpleasant smell, its COD and BOD values are high enough to cause serious pollution and environmental problem to the rivers and also to forms of life in water [3].

POME contains higher concentrations of various pollutants and such may be categorized as a high strength wastewater, which required effective treatment before being discharged into the environment mainly for supplying clean water resources. Therefore, treatment of POME is required and for this purpose, various technologies have been conducted and are being developed. The treatment has been shifted from conventional aerobic POME treatment (i.e. ponding system, open digester tanks) to closed digester tanks. These anaerobic digesters could reduce only 70% of BOD in POME.

Microbubble has unique characteristics such as large gas-liquid interfacial area, longer duration time in liquid phase and fast dissolution rate. Microbubble can be generated in three various method which are i) compressing a gas to higher pressure followed with releasing it using specially design nozzle, ii) ultrasonic and iii) through oscillating the fluid either by mechanical vibration or fluidic oscillator [5].

Microbubble can eliminate huge amount of TSS, BOD, and COD in tested samples treatment including oily wastewater (produced by cleaning the hull of a tanker ship), treatment of laundry water and treatment of fish water pond [6]. The characteristics owned by the microbubbles enable it to provide a homogenous mixing and maintain the uniformity. Besides that, microbubbles able to enhance mass transfer coefficients, mixing efficiency and energy efficiency [5]. Microbubbles is a new element which contributed in wastewater treatment as it can produce small bubbles as smallest than 50 µm with huge interfacial area, long stagnation time, lower bubble rising speed and high interior pressure.

2. Methodology

2.1 Sample Collection

Raw POME has been collected from palm oil mill at Labu, Negeri Sembilan. The sample is collected from final discharge station and placed in a sterile container. It was transported back to the laboratory in a portable freezer at temperature of 4°C (APHA 2005).

2.2 Experimental Set Up

The experiment was set up and carried out at Vehicle System Engineering (VSE) Laboratory, University Technology Malaysia (UTM). Figure 1 illustrates the experimental set up which functioning as Palm Oil Mill Effluent (POME) treatment. Microbubble diffuser is connected to the air compressor, which is used as air supplier of the system. The pressure of the air is controlled by the pressure regulator. The pressure of the microbubble is monitored to not exceed the pressure limit of 50 psi, as this would affects the size of bubble produced. The air flowmeter indicates the air flow reading with the units of L/min. The pressure gauge shows the reading of pressure in the air flow system with the units of psi. The microbubble diffuser model 1DMBDC100 with bubble ranged of 100 – 500 µm is used to supply air into the POME.

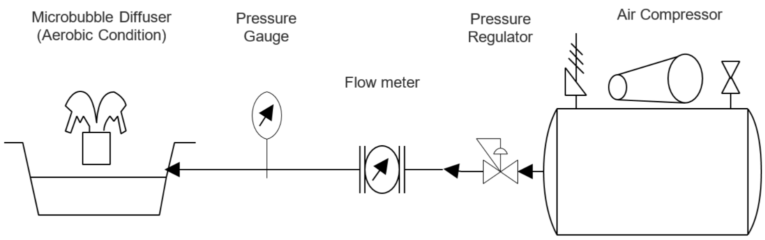

Fig. 1. Microbubble Diffuser Set Up

2.3 Apparatus/BOD Measurement & Characterization

The BOD was characterized by outsource laboratory. The influent and effluent were determined with 5210B method, APHA standard. It is a bioassay procedure that measures the oxygen consumed by bacteria from the decomposition of organic matter.

2.4 Analytic Techniques

The process involved in the measurement of BOD is the level of Dissolved Oxygen (DO) before and after the incubation period.

$$BOD = DO_i - DO_f \tag{1}$$

The percentage of BOD removal can be calculated as per following:

$$Percentage\ of\ removal\ (\%) = \frac{DO_i - DO_f}{DO_i} x100\% \tag{2}$$

where DO_i is the level of initial dissolved oxygen in the sample and DO_f is the final dissolved oxygen contain in the water sample after incubation period.

3. Results and Discussion

A test to study the effect of microbubbles on the reduction of biochemical oxygen demand (BOD) of palm oil mill effluent (POME) treatment has been performed at different flowrates and at several retention time. Results obtained are as per illustrated in Figure 2. The graph shows the BOD against time.

Figure 2 shows the trend of BOD is decreasing against time. The lowest flowrate used for the test which is 0.5 L/min decreasing abruptly for the first 60 minutes of retention time compared to the other flowrates, 2.5 L/min and 4.5 L/min. The test observation is assumed that flowrates which also affect the bubble size imposed significance effects to the removal of BOD and this was proved in the experiment where lowest flowrate of microbubbles performed better in reducing the Biochemical Oxygen Demand (BOD) with reduction of 26% of BOD at 60 minutes retention time.

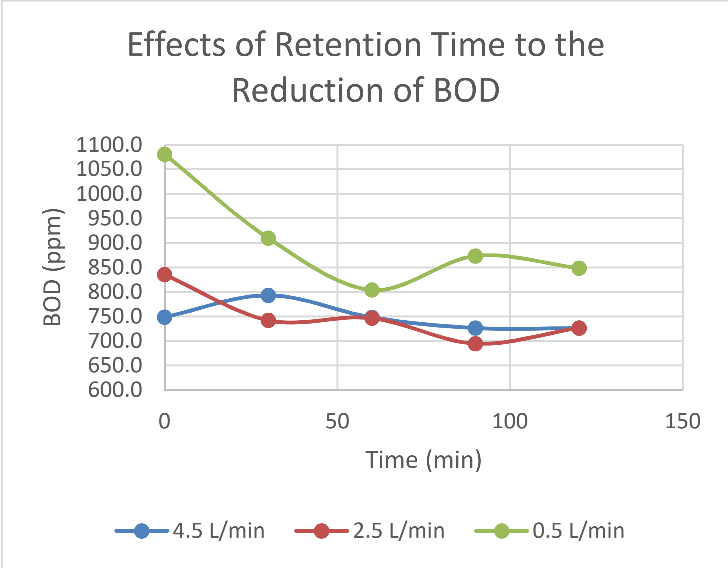

Fig. 2. Effects of Retention Time to the Reduction of BOD

For the BOD percentage removal, the graph in Figure 3 shows that the lowest air flowrate for has the highest percentage removal of BOD at the minute of 60. The pattern of the graph indicates the BOD percentage removal is lower with higher. This is also shown in Figure 4 with the highest percentage of BOD removal against flowrate.

Different flowrate gives a different bubble size. Therefore, the bubble size is one of the key factors with significant impacts on floatation. The smaller the bubble sizes, the more pollutant material will be removed and the shorter time the process takes [7]. Mass transfer rate and mixing are the key factors that affect aeration process, hence this could be an advantage in waste water industry [5]. However, the retention time for the treatment is currently to be seen as insignificant to the entire treatment process. The optimum time for BOD percentage removal is at the 60th minute of retention time for 0.5 L/min of flowrate.

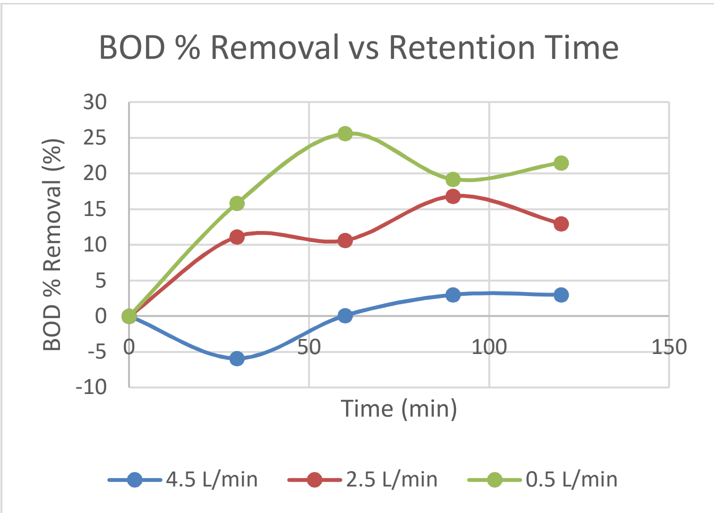

Fig. 3. Graph of BOD % Removal vs Retention Time

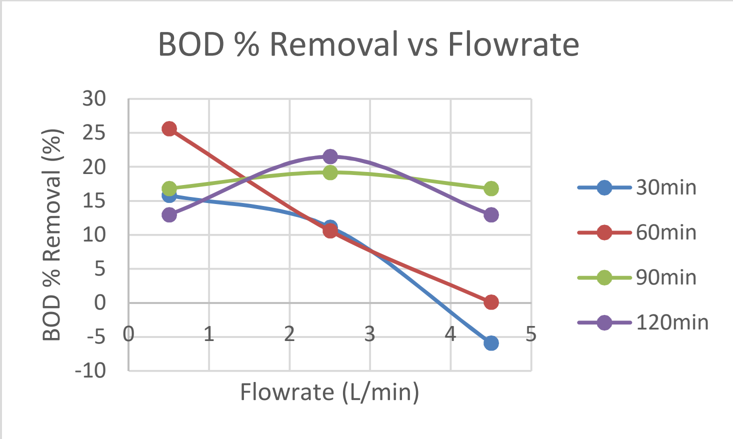

Fig. 4. Graph of BOD % Removal vs Flowrate

4. Conclusion

In this study, the treatment of palm oil mill effluent (POME) in reducing the level of BOD by introducing microbubble has been evaluated with different air flowrates and at several treatment period. Flowrate has been proved to significantly affect the pollutant removal, which has been obtained at flowrate of 0.5 l/min. The optimum retention time is obtained at 60 minutes with total BOD removal of approximately 26%. It has been proved that the lowest air flowrate resulting the highest BOD percentage removal due to the optimum size of the bubble. However, further investigation and study should be done on the effects of the retention time for deeper understanding on its effect towards the BOD removal and how to determine the optimum retention time in the treatment process.

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