Reduction of TSS, COD, Oil and Fat in Palm Oil Mill Waste Using Dissolved Air Flotation Method

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Abstract
This study aims to determine the effect of variations in pressure and contact time of wastewater with air to decrease the parameters of TSS, COD, and oils and fats contained in palm oil wastewater. This study uses a series of Dissolved Air Flotation (DAF) process units with the addition of Poly Aluminum Chloride (PAC) coagulant. This research begins with the manufacture of a series of DAF tanks and flotation tanks. Waste flow is carried out in batches and the air is flowed upflow through the bottom hole of the DAF tank. The pressure variables used in decreasing the parameters of TSS, COD, and oil and fat are absolute 2; absolute 2.5; and absolute 3 atm. The contact time variables for decreasing TSS, COD, and oil and fat parameters were 15, 30, 45, 60, and 75 minutes. The results showed a decrease in each of the tested parameters. The effective pressure to reduce the value of the TSS parameter is the absolute pressure of 3 atm and the absolute pressure of oil and grease is 2.5 atm. While the effective pressure to reduce the value of the COD parameter is an absolute pressure of 3 atm. The best contact time between air and wastewater to set aside the values of the TSS, COD, and oil-fat parameters was 75 minutes.

Keywords: COD, dissolved air flotation, oil and fat, PAC, TSS

1. Introduction
The large area of oil palm plantations will be accompanied by a high volume of exports, this is because world demand for palm oil continues to increase so that the export market is always wide open and can generate large profits. The volume of CPO exports in 2006 was 11 745 954 tons, reaching a value of US$ 4 139 286 000 and in 2009 it increased to 20 615 958 tons or US$ 12 626 595 000 [1].

Waste is waste generated from a production process, both industrial and domestic (household). Waste water or waste water is residual water that is discharged from households, industries, or other public places, and generally contains substances that can be harmful to human health, affect the activities of other living things and can damage the environment. The volume of residual water or waste water is quite large, which is approximately 80% of the water used for human activities in meeting daily needs. The waste water is disposed of in a dirty (polluted) form which will eventually flow into rivers and seas and will be used by humans again [2].
Waste requires processing if it turns out to contain polluting compounds that result in creating damage to the environment or at least the potential to create pollution. An estimate must be made beforehand by identifying: the source of pollution, the use of the type of material, the treatment system, the amount of waste and its type, the use of toxic and hazardous materials contained in the factory. With this estimate, a pollution control and prevention program need to be made. Because the waste, whether in large or small amounts in the long term or in the short term, will make changes to the environment, processing is needed so that the waste produced does not interfere with the structure of the environment. Waste treatment aims to take hazardous goods in it and or reduce/eliminate hazardous and toxic chemical or non-chemical compounds.

2. Material and Method

Samples of palm oil mill effluent were mixed with 1000 mg/l PAC and then poured into the DAF tank. The dissolved air flotation reactor used has a height of 45 cm and a diameter of 20 cm. Then the compressor is turned on and the pressure valve is opened on the compressor tank to regulate the pressure flowing into the DAF tank. The valve is opened to take a sample to be analyzed for its level of decline. Wastewater is channeled into a reservoir with dimensions of 20 x 20 x 35 cm to determine the nature of the floc formed. The source of pressure used in this study comes from a portable mini compressor. The pressure in the DAF tank is measured using a manometer. The pressure coming from the compressor is channeled through the compressor's built-in hose, while to drain the water from the DAF tank, an iron pipe with a dimension of inch is used. The manometer is used as a pressure gauge and the safety or gate valve as a discharger of excess pressure is above the DAF tube. Palm oil mill wastewater in the DAF tank is varied with variations in pressure and contact time of wastewater with air.

**Total Suspended Solid Test Procedure**

[3] To analyze the suspended solids using the method, namely filter paper 934-AHTM circle 90mm, rinsed first with distilled water and heated in an oven for 1 hour. Cool in a desiccator for 15 minutes and then weigh rapidly. The sample that has been shaken evenly, as much as 100 mL is transferred using a pipette, into a filter device that already has filter paper in it and is filtered using a vacuum system. The filter paper was taken from the filter carefully then dried in an oven at a temperature of 105°C for 1 hour in a desiccator for 15 minutes and weighed [4].

**Chemical Oxygen Demand Test Procedure**

[5] The COD method is used to determine the chemical oxygen demand in water and wastewater under closed reflux titrimetrically at levels of 40 mg/L - 400 mg/L. Organic and inorganic compounds, especially organic, in the test sample were oxidized by Cr2O72-in closed reflux for 2 hours to produce Cr3+. Excess potassium dichromate that is not reduced is titrated with a solution of Ferro Ammonium Sulfate (FAS) using a ferroin indicator. The required amount of oxidant is expressed in oxygen equivalents (O2 mg/L).

**Oil and Fat Test Procedure**

Oils and fats are the main components of foodstuffs which can also be found in wastewater. Oil has a specific gravity smaller than water so it will form a thin layer on the surface of the water. Oils and fats are one of the compounds that can cause pollution in a water so that their concentration must be limited [6].

[7] The principal method for testing oils and fats is to extract them with organic solvents in a separatory funnel and to remove the remaining water, anhydrous Na2SO4 is used. Oil and fat extracts were separated from organic solvents by distillation. The residue left in the distillation flask is weighed as oil and fat.

3. Results and Discussion

The liquid waste from the palm oil mill comes from the steaming process unit (sterilization), the clarification process and the effluent from the hydrocyclone. Liquid waste from palm oil mills contains very high organic matter, resulting in high levels of pollutants in the liquid waste produced. In this study, the initial characteristics of palm oil mill effluent were tested from PTPN IV Dolok Sinumbah, Bandar sub-district, Simalungun to determine the initial value of palm oil mill effluent before processing. Sampling of the tested water is taken at the outlet of the liquid waste disposal. The quality standard used is [8]. The characteristics of palm oil mill effluent before processing are shown in Table 1.
Table 1. Initial characteristics of palm oil mill liquid waste

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Concentration</th>
<th>Quality standards</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>25.520</td>
<td>350</td>
<td>Exceed</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/l</td>
<td>18.370</td>
<td>250</td>
<td>Exceed</td>
</tr>
<tr>
<td>Oil and fat</td>
<td>mg/l</td>
<td>44.890</td>
<td>25</td>
<td>Exceed</td>
</tr>
</tbody>
</table>

Source: Minister of Environment Regulation Number 5 of 2014

3.1. Chemical Oxygen Demand Analysis (COD)

Figure 1 shows the removal of COD value against flotation time by giving treatment in the form of a pressure of 2 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60, and 75 minutes, the COD content decreases. For 15 minutes, the COD content is 19,760 mg/l with a removal percentage of 22.57%. Meanwhile, for 30 minutes, the COD content was 18,680 mg/l with a percentage of removal of 26.80%. Meanwhile, for 45 minutes, the COD content was 17,240 mg/l with a removal percentage of 32.44%. Meanwhile, for 60 minutes, COD levels were 16,970 mg/l with a removal percentage of 33.50% and at the end of the 2 atm variable run for a contact time of 75 minutes, COD levels were 15,830 mg/l with a removal percentage of 37.97%.
Furthermore, Figure 2 shows the removal of COD value against flotation time by giving treatment in the form of a pressure of 2.5 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60, and 75 minutes, the COD levels tend to fluctuate, for 15 minutes the COD levels are 18,350 mg/l with a removal percentage of 28.09%. Meanwhile, for 30 minutes, the COD content was 17,130 mg/l with a percentage of removal of 32.89%. Meanwhile, for 45 minutes, the COD content was 19,370 mg/l with a removal percentage of 24.09%. Meanwhile, for the time of 60 minutes, the COD level was 14,350 mg/l with a removal percentage of 43.76% and at the end of the 2.5 atm variable run for a contact time of 75 minutes, the COD level was 14,000 mg/l with a removal percentage of 45.14%.

Then in Figure 3 shows the removal of COD value against flotation time by giving treatment in the form of a pressure of 3 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60, and 75 minutes, the COD levels tend to fluctuate, for 15 minutes the COD levels are 19,240 mg/l with a removal percentage of 24.60%. Meanwhile, for 30 minutes, the COD content was 18,640 mg/l with a percentage of removal of 26.95%. Meanwhile, for 45 minutes, the COD content was 17,510 mg/l with a removal percentage of 31.38%. Meanwhile, for 60 minutes, the COD level was 15,710 mg/l with a removal percentage of 38.44% and at the end of the 2.5 atm variable run for a contact time of 75 minutes, the COD level was 14,550 mg/l with a removal percentage of 42.98%.

3.2. Total Suspended Solid Analysis

Figure 4 shows the removal of TSS value against flotation time by giving treatment in the form of a pressure of 2 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60 and 75 minutes, the TSS content decreases, for 15 minutes the TSS level is 13,980 mg/l with a percentage removal of 23.89%. Meanwhile, for 30 minutes, the TSS level was 13,390 mg/l with a removal percentage of 27.10%. Meanwhile, for 45 minutes, the TSS level was 13,180 mg/l with a percentage of removal of 28.25%. Meanwhile, for a time of 60 minutes, the TSS level was 12,830 mg/l with a percentage of 30.15% and at the final run for the variable 2 atm for a time of 75 minutes, the TSS level was 11,320 mg/l with a removal percentage of 38.37%.
Figure 5. Removal of TSS at a pressure of 2.5 atm

Figure 6. Removal of TSS at 3 atm pressure

Furthermore, Figure 5 shows the removal of the TSS value against the flotation time by giving treatment in the form of a pressure of 2.5 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60 and 75 minutes, the TSS content tends to fluctuate. For 15 minutes the TSS level is 13,830 mg/l with a percentage removal of 24.75%. Meanwhile, for 30 minutes, the TSS level was 12,220 mg/l with a percentage removal of 33.47%. Meanwhile, for 45 minutes, the TSS level was 13,510 mg/l with a percentage removal of 26.45%. Meanwhile, for 60 minutes, the TSS level was 12,130 mg/l with a percentage of 33.96% and at the final run for the 2.5 atm variable for 75 minutes, the TSS level was 11,430 mg/l with a removal percentage of 37.77%.

Then in Figure 6 shows the removal of the TSS value against the flotation time by giving treatment in the form of a pressure of 3 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60 and 75 minutes, the TSS content decreases. For 15 minutes the TSS content is 12,830 mg/l with a removal percentage of 30.15%. Meanwhile, for 30 minutes, the TSS level was 12,450 mg/l with a removal percentage of 32.22% and for 45 minutes, the TSS level was 11,200 mg/l with a removal percentage of 39.03%. Meanwhile, for 60 minutes, the TSS level was 10,890 mg/l with a removal percentage of 40.71% and at the end of the run for the variable 3 atm for 75 minutes, the TSS level was 10,310 mg/l with a removal percentage of 43.87%.

3.3. Oil and Fat Analysis

Figure 7 shows the removal of the value of Oils and Fats against the flotation time by giving the treatment in the form of a pressure of 2 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60, and 75 minutes, the oil and fat content decreases. For 15 minutes the oil and fat content is obtained at 37,970 mg/l with a removal percentage of 15.41%. Meanwhile, for 30 minutes, the oil and fat content were 36,360 mg/l with a percentage of removal of 19%. Meanwhile, for 45 minutes, the Oil and Fat content of 36,070 mg/l was obtained with a percentage of removal of 19.64%. Meanwhile, for a time of 60 minutes, the oil and fat content were 35,820 mg/l with a removal percentage of 20.20% and at the final run for the 2 atm variable for a time of 75 minutes, the oil and fat content was 35,260 mg/l with a removal percentage of 21.22%.
Furthermore, **Figure 8** shows the removal of the value of Oil and Fat on the flotation time by giving treatment in the form of a pressure of 2.5 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60, and 75 minutes, the oil and fat content decreases, for 15 minutes the oil and fat content is obtained at 34,820 mg/l with a percentage removal of 23.68%. Meanwhile, for 30 minutes, the oil and fat content were 34,130 mg/l with a percentage of removal of 23.96%. Meanwhile, for 45 minutes, the oil and fat content were 35,380 mg/l with a percentage of removal of 21.18%. Meanwhile, for a time of 60 minutes, the Oil and Fat content of 34,270 mg/l was obtained with a removal percentage of 23.65% and at the final run for the 2.5 atm variable for a time of 75 minutes, the Oil and Fat content of 33,090 mg/l was obtained with a removal percentage of 26.28%.

Then in **Figure 9** shows the removal of the value of Oil and Fat on the flotation time by giving treatment in the form of a pressure of 3 atm. It can be seen that as the time of the flotation process increases, namely 15, 30, 45, 60, and 75 minutes, the oil and fat content decreases, for 15 minutes the oil and fat content of 35,650 mg/l is obtained with a percentage removal of 20.58%. Meanwhile, for 30 minutes, the oil and fat content were 34,730 mg/l with a percentage of removal of 22.63%. Meanwhile, for 45 minutes, the oil and fat content were 34,120 mg/l with a percentage of removal of 23.99%. Meanwhile, for the 60-minute period, the Oil and Fat content of 33,810 mg/l was obtained with a removal percentage of 24.68% and at the final run for the 3 atm variable for 75 minutes, the oil and fat content of 33,030 mg/l was obtained with a removal percentage of 26.42%.
4. Conclusion

The effective pressure to reduce the value of the TSS parameter is the absolute pressure of 3 atm and the absolute pressure of oil and fat is 2.5 atm. At this pressure there has been the formation of air bubbles that are able to bind to solids and fat molecules. While the effective pressure to reduce the value of the COD parameter is an absolute pressure of 3 atm where at that pressure the organic matter has been removed by air bubbles with a small diameter obtained.

The best contact time between air and wastewater to set aside values for the parameters of TSS, COD, and oils – fats is 75 minutes. The TSS removal was greater at a contact time of 75 minutes due to the length of contact between PAC and air bubbles to form flocs. The removal of COD is greater at a contact time of 75 minutes because the contact between the particles in the wastewater is longer, causing the suspended solids that increase the COD value to float and are removed. The removal of oil and fat was greater at a contact time of 75 minutes because the length of contact time caused the air bubbles to dissolve the molecules and float them to the surface.

5. References

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