Green Microalgae Growth in Palm Oil Mill Effluent with Nutrient Addition of Urea

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Abstract. This research was conducted to examine the growth of green microalgae in Palm Oil Mill Effluent (POME). Cultivation was done to eliminate nutrients in POME with different concentrations biomass produced by green microalgae. Results showed that the best growth of green microalgae with the highest content of biomass obtained in cultivation in media with 30\% effluent concentration with 4x8 watt lighting for 8 hours. Biomass obtained from this treatment was 1.20 g-dry weight/L. Green microalgae metabolic processes proven to reduce and eliminate nutrients in POME reaches 40-100\% of the concentration of COD and BOD. Based on this research, green microalgae can be used to reduce and eliminate the concentration of organic substances in POME as one of the alternative methods of waste management.

Keywords: green microalgae, Palm Oil Mill Effluent (POME), nutrient, and urea.

INTRODUCTION

Palm Oil Mill Effluent (POME) contains organic substances which are difficult to decompose and affects on dissolved oxygen in the water phase. High content of organic matter in these wastes can increase the concentration of BOD and COD, and total nitrogen up to 500-800 mg/L [1]. The processing of this waste in open ponds can release methane and carbon dioxide into the air causes the increasing of greenhouse emissions. Methane has twenty-one times greater as a global warming potential than carbon dioxide [2]. The study of POME treatment is continuously performed by many researches; one of the works done is utilize microalgae in aquatic environments polluted to deal with the waste directly. This process is often constrained, because microalgae are obtained in the sewage polluted waters are often symbiotic with other microorganisms, so it is difficult to be isolated and controlled microalgae to determine which the most dominant role in wastewater treatment is.

Microalgae have the ability to absorb various forms of nitrogen and phosphor, where these strains can use a variety of organic compounds, especially compounds containing nitrogen and eutrophic phosphor as a carbon source [3]. Microalgae naturally work to reduce the levels of N and P in wastewater agriculture. In uncontrolled circumstances in which agricultural waste or fertilizer residues allow to enter waters or river, it can be fed to algae growth in mass, known as algal blooms and eutrophication in water bodies. In controlled aquatic systems, such as the presence of storage pools agricultural wastewater, algae have become phycoremediasi good example by consuming components of nitrogen and phosphor in the waste. Phosphor and nitrogen in nutrients can be removed from the wastewater through the following methods; through denitrification process that reduces nitrate into nitrogen gas that is released into the atmosphere [4]. Phosfor can also be removed by chemical precipitation using FeCl\textsubscript{3}. However, phosphor and nitrogen can also be removed through the process of assimilation through the growth of photosynthetic bacteria or algae in the wastewater and biomass are then separated [5]. [5] also reported that algal biomass can be grown in large quantities in the process of wastewater treatment with algae. Microalgae have several attractive characteristics, which can be grown easily in conditions that are not suitable for ordinary plants; and can act as a CO2 catcher or greenhouse gases fixation.

Based on this background, this research is directed to examine the growth of green microalgae in POME. Optimized green microalgae growth in effluent concentrations different to provide a strong survival for microalgae
and can utilize the nutrients in the effluent as a source of metabolically intensive, so the nutrient content in the 
POME will decrease in line with the metabolic processes of the cells of green algae.

**METHOD**

Waste taken from the palm oil mill PTPN 1 Cot Girek, North Aceh District and a mixture of microalgae obtained 
from open pond in Banda Aceh. 1 mL of mix culture were inoculated in 9 mL of medium urea (inoculums v/v 
media) and mixed until homogeneous. A total of 0.1 mL of this mixture was re-cultured for 7 days. Microalgae 
were cultured gradually in 100 ml and 500 ml medium urea with continuous lighting and aeration. Chemicals 
obtained commercially from Merck Ltd.

POME sample was made in different concentrations (10%, 30%, and 50% v/v) to study the effect of effluent 
concentration on the growth and ability of microalgae to reduce inorganic substances. Initial pH effluent measured 
with a pH meter while the analysis of BOD, COD, total nitrogen, and oil contains were measured by standard 
methods APHA [7]. TSS parameters measured using a gravimetric tube (hematocrite models) with cultivation 
period of 7 days. The content of biomass was determined by spectrophotometric at 680 nm wavelength.

POME sample filtered and prepared as a growing medium. Microalgae were used as strain has been acclimatized in 
the treatment of wastewater with microalgae by taking an inoculums of 20% (v inoculums/v media) and put into 
the 3000 mL acrylic container containing 1000 ml of liquid medium. Culturing took place at room temperature and 
lighting intensity with continuous air aeration and nutrient addition of urea at a concentration of 25 mg/L per 2 
days. After cultivation for 7 days, cultures were analyzed to observe the growth of microalgae by determine the 
content of dry biomass (dry weight). Water phase were also analyzed to determine the concentration of BOD and 
COD.

**RESULT AND DISCUSSION**

*Characterization of POME.* POME taken from the Cooling Pond PTPN-1 Cot Girek, North Aceh has physical 
characteristics of dark chocolate-colored, pungent odor, temperature range 40-50 °C, and contains high suspended 
sediment organic matter. POME has pH acid in range 4.0-50 and predicted containing high fatty acid. The 
characteristic of POME were tabulated in Table 1.

<table>
<thead>
<tr>
<th>Column Header</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>4.54</td>
</tr>
<tr>
<td>N Total</td>
<td>%</td>
<td>369.6</td>
</tr>
<tr>
<td>BOD₅</td>
<td>mg/L</td>
<td>8.400</td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>15.600</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>16.300</td>
</tr>
<tr>
<td>Oil contains</td>
<td>mg/L</td>
<td>2.100</td>
</tr>
</tbody>
</table>

The high organic substances in the POME lead to increase COD and BOD in waste. TSS content of the product is 
high due to the large colloidal suspension of the processing of fresh fruit bunches. The condition of the wastewater 
must be treated before discharged into the waters because it can potentially contaminate the environment. High 
organic matter in the POME led the high COD and BOD. High content of TSS due to the magnitude of the colloidal 
suspension of the processing of fresh fruit bunches. The condition of POME must be treated before discharged into 
the waters because it can potentially contaminate the environment.
Influence of Media Concentration on the Growth of Microalgae. Study for the growth of microalgae in a variety of media was done by implanting inoculums into the growing medium. 20% (v inoculums/v media) of algae were inoculated using 3000 mL acrylic glass container containing 1000 ml of liquid medium. POME that has been filtered used as a growth media of microalgae with various concentrations (10%, 30%, and 50%). Cultivation was conducted by using light intensity with 4x8 watt and 3x20 watts fluorescent lamps and aeration for 8 hours and 24 hours in the fixed condition. Cultivation performed for 7 days with the addition of urea 2 days to obtain dry biomass of microalgae and the results were performed in Figure 1. Result shows that the growth of microalgae was better in POME media concentration 30% compared with 10% and 50%, where the biomass increased up to 6 days of cultivation. Furthermore, the biomass of microalgae in POME media with concentration 10% and 50% was found decreasing due to microalgae have not been able to adjust density of waste. The declining of biomass in the lag phase tends to be caused by the competition of microalgae with waste contaminants. Figure 2 (a) and (b) shows the characteristics of green microalgae grown in POME media.

![Figure 1 (Influence of media concentration on the growth of microalgae)](image1)

**FIGURE 1.** Influence of media concentration on the growth of microalgae (lighting intensity 4x8 watt).

![Figure 2 (Microalgae in POME medium)](image2)

**FIGURE 2.** Microalgae in POME medium.

COD and BOD Concentration in POME. Cultivation of microalgae in POME medium leads to lower nutrients in the water phase because most of the nutrients were utilized by microalgae as food to cell growth. Examination of the pH and temperature of the POME was done directly in the field (in-situ analysis), whereas for the BOD and COD parameters analysis conducted in the laboratory. Cultivation of microalgae in POME medium after 7 days with...
lighting variations cause a decrease in BOD and COD as shown in Table 2 and Table 3. The decrease of COD and BOD with intensity of 4 x 8 watts for 8 hour lighting cycle indicates very good compared to others, in which the initial value of COD and BOD, respectively from 80.45 mg/L and 210.0 mg/L that be decreased to 39.63mg/L and 149 mg/L after one week of cultivation with the percentage decrease of 100% and 40%. In the continuous treatment of 24-hour lighting cycle, the decline was lower, which initial BOD and COD respectively 61.7776 mg/L and 218 mg/L after 7 days cultivation this value reduced to 41.4542 mg/L and 153 mg/L with the percentage decrease of 33% and 30%, respectively.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>4 x 8 watt</th>
<th>3 x 20 watt</th>
<th>No light</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 hours</td>
<td>24 hours</td>
<td>8 hours</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>80.45</td>
<td>61.78</td>
<td>78.04</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>210</td>
<td>218</td>
<td>224</td>
</tr>
</tbody>
</table>

TABLE 3. POME characteristics after 7 days microalgae cultivation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>4 x 8 watt</th>
<th>3 x 20 watt</th>
<th>No light</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 hours</td>
<td>24 hours</td>
<td>8 hours</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>39.63</td>
<td>41.45</td>
<td>52.11</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>149</td>
<td>153</td>
<td>152</td>
</tr>
</tbody>
</table>

In the lighting intensity of 3x20 watts, the decreasing of BOD and COD was lower. In the 8-hour lighting cycle of treatment with 7 days of cultivation, BOD and COD concentration decreased from an initial value of each 78.04 mg/L and 224 mg/L into 52.11 mg/L and 152 mg/L, respectively with percentage decrease of 33% and 47%. Furthermore, after 24-hour exposure, the percentage reduction of BOD and COD were 29% and 26%, respectively after 7 days of cultivation. Cultivation without lighting conducted a reduction of BOD and COD very low with only 20% and 14% decreasing.

The decreasing of BOD and COD indicates that retrieval of chemicals by microalgae contained in POME. Optimal growth of microalgae occurs contaminant degradation can run smoothly. The results showed that the reduction in BOD value was higher than the value of COD. The value of BOD was affected by the speed of microalgae activity in decomposing organic materials, quantity, and condition of microorganisms as well as a good supply of dissolved oxygen from the air and photosynthesis. The presence of microorganisms in the wastewater fluctuates and will also affect the amount of oxygen required by aerobic microorganisms. The highest BOD value is demonstrated by the high organic matter degraded biologically [6]. The number of aerobic microorganisms is affected by available organic matter. The number of available organic material in the wastewater will increase the growth of microorganisms. High reduction in BOD is due to high levels of oxygen in the water. High levels of oxygen are supplied by microalgae as a result of photosynthesis. In addition, the presence of continuous air aeration also increases oxygen levels in the effluent.

CONCLUSION

The best growth of microalgae with the highest content of biomass obtained in cultivation in media with 30% effluent concentration with 4x8 watt lighting for 8 hours. Biomass obtained from this treatment was 1.20 g-dry weight/L. Microalgae metabolic processes proven to reduce and eliminate nutrients in POME reaches 40-100% of the concentration of COD and BOD. Based on this research, microalgae can be used to reduce and eliminate the concentration of organic substances in POME as one of the alternative methods of waste management.
REFERENCES


