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Cultivation of *Spirulina platensis* and *Nannochloropsis oculata* for Nutrient Removal from Municipal Wastewater

Evi Siti Sofiyah [1*], I Wayan Koko Suryawan [1]
[1] Department of Environmental Engineering, Faculty of Infrastructure Planning Pertamina University
Komplek Universitas Pertamina Jalan Sinabung II Terusan Simprug 12220 Jakarta 12220
* es.sofiyah@gmail.com
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ABSTRACT

Domestic wastewater contains a high average nutrient ammonia-N (NH_3-N) and total phosphate (PO_4^{3-}-P). This nutrient content has the potential to cause eutropication in water bodies. To prevent this eutropication, it is necessary to treat domestic wastewater. Currently, processing technology is needed that is useful for improving the quality of processed wastewater and a small amount of byproduct. One of these technologies is processing with a microalgae system, where the algae can be used to become biodiesel. Two types of microalgae that have the potential to produce biodiesel are Spirulina platensis and Nannochloropsis oculate. The cultivation of the two types of microalgae was carried out in the domestic wastewater media of Jakarta City by providing 24-hour lighting with UV-A and UV-B. The specific growth rates of Spirulina platensis and Nannochloropsis oculate were not much different, namely 0.0279 h^{-1} and 0.0282 h^{-1}. The microalgae Spirulina platensis and Nannochloropsis oculate respectively reduced NH_3-N nutrients by 82% and 80%, while PO_4^{3}-P was 65.2% and 63.7%. The pH value during processing shows in the normal pH range. Total dissolved solids (TDS) in the processing process also decreased in a span of 48 hours.

Keyword: *wastewater, nutrient, algae, NH_3-N, PO_4^{3-}-P*

INTRODUCTION

The amount of domestic wastewater produced increases with the increase of population. When the untreated domestic wastewater discharges into the environment, it deteriotes the quality of the environment. The occured environmental damage could have a detrimental impact to the health of human being who live in that environment (Suryawan & Sofiyah, 2020; Apritama *et al.,* 2020). One of domestic wastewater contents that often causes problems in water bodies is nutrient in the form of NH3-N and PO43--P. Microalgae grows fast in water with high organic and inorganic nitrogen, as the two compounds are the limited substrates for microalgae.

In this study, *Spirulina platensis* and *Nannochloropsis oculate* microalgae are used to treat domestic wastewater. Microalgae Spirulina platensis and is one of the green-blue algae that has been widely researched for its nutritional content, both in the food, health and aquaculture industries (Colla *et al.,* 2015). Nannochloropsis oculate is a type of single-celled microalgae that is included in one of the Eustigmatophyceae classes, which has enormous potential for raw material for triglyceride production. This is due to its ease to cultivate continuously in a short harvest period (Widianingsih *et al.,* 2011).

Microalgae Spirulina platensis not only has a high protein content but also contains amino acids, lipids, fatty acids, carbohydrates, vitamins, minerals, and pigments (Bezerra, *et al.,* 2012). Meanwhile, Nannochloropsis oculata has a fairly large oil content, namely 31-68% (Chisti, 2007). Several studies have also shown that Spirulina platensis has the potential to be a raw material in the manufacture of renewable alternative fuels. Spirulina platensis has the potential to be used as a raw material for making biodiesel even though the lipid content in Spirulina platensis is not as high as in other microalgae. The potential is because of the high growth rate of Spirulina platensis cells (Sumprasit, *et al.,* 2017). Based on this description,

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the aim of this study is to determine the growth and the specific growth rate of Spirulina platensis and Nannochloropsis oculate biomass. The removal efficiency of NH_3-N and PO_4^{3-}-P is also measured to determine the performance of microalgae in removing nutrients.

MATERIAL AND METHOD

Municipal Wastewater

The wastewater used in this research is wastewater taken from the influent of wastewater treatment in a residential area in Jakarta Pusat. The location of the coordinates of the sampling point for wastewater is -6.199090491514039, 106.81782080504. Sampling was done by in-situ direct sampling method at peak hours. The peak hour is taken on Monday at 7 am, which is the time for the largest water use in the study area. The characteristics of wastewater still do not meet the quality standards for wastewater in Jakarta, where NH_3-N still has a concentration above 10 mg/L. Phosphate content in wastewater also does not meet quality standards, which is still above 5 mg/L.

Microalgae Seeds

Spirulina platensis and *Nannochloropsis oculate* seeds were obtained from algae farmers in Jakarta. These microalgae are then grown in the Integrated Chemical Laboratory at Universitas Pertamina. This is done to adapt the algae to new environmental conditions. The growth rate of microalgae biomass in the log growth phase can be expressed as equation 1.

$$\frac{dX}{dt} = \mu \cdot X \text{......................(1)}$$

Where X = biomass concentration (mg/L) and μ is the specific growth rate (growth rate per biomass unit, units/day).

Experimental Set-up

The reactor used in microalgae growth is a glass reactor with a volume of 3 L with a medium of 2 L of waste water (Figure 1). Then the reactor flowed air with a flow rate of 1.5 LPM. During the processing process, lighting was also carried out with UV-A and UV-B lamps.

Sampling was carried out within a period of 48 hours with a time period of 0; 4; 8; 12; 24; and 48 hours. Sampling was carried out with a volume of 200 mL for testing for total suspended solid (TSS), Ammonia-N (NH_3-N), Total Phospate (PO_4^{3-}-P). The pH value and total dissolved solid (TDS) were measured as control parameters. Table 1 shows the test method for each parameter.

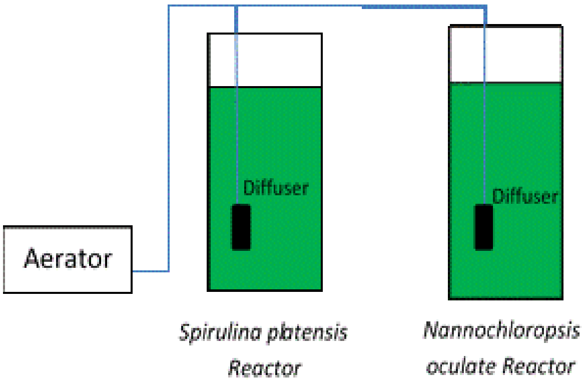

Figure 1. Experiment Set-up in Microalgae Cultivation of *Spirulina platensis* and *Nannochloropsis oculate* in Domestic Wastewater Media

Tabel 1. Test Method of Each Parameter

No	Parameters	Test method
1	TSS	Gravimetric
2	NH_3-N	Phenate
3	PO_4^{3-}-P	Acid Persulfate Digestion
4	TDS	Gravimetric

RESULTS AND DISCUSSION

Biomass Production

The calculation of the specific growth rates of *Spirulina platensis* and *Nannochloropsis oculate* with equation 1 (Figure 2) showed an increase at 48 hours of cultivation. *Spirulina platensis* showed a specific growth rate of 0.0279 h^{-1}, while *Nannochloropsis oculate* showed a specific growth rate of 0.0282 h^{-1}.

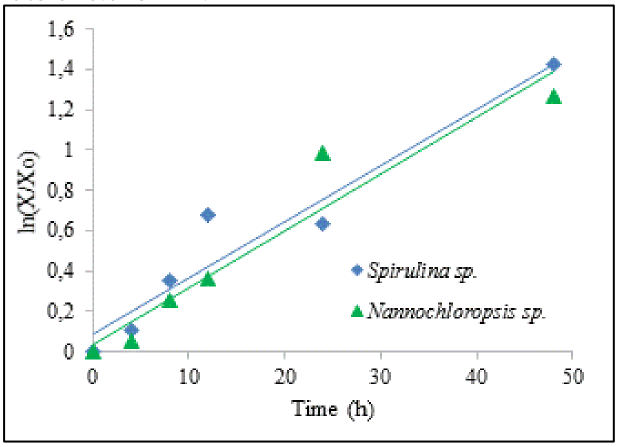

Figure 2. Graph of Growth Equation for Microalgae *Spirulina platensis* and *Nannochloropsis oculate* in Domestic Wastewater Media

Cultivation results of *Spirulina platensis* vary widely from low to high values. *Spirulina platensis* cultivated in 0.5 dm^3 Erlenmeyer flasks only produced a specific growth rate value of 0.044 day^{-1} (Lodi *et al*., 2003). Better results were found in the cultivation of *Spirulina platensis* using transparent jars media, polyethylene bags and raceway ponds with specific growth rate values of 0.32, 0.21 and 0.20 day^{-1}, respectively (Göksan, *et al*., 2007). Cultivation of *Spirulina platensis* in tofu wastewater media also produces a specific growth rate which is quite high, namely 0.15-0.29 day^{-1} (Hadiyanto, 2018).

The growth results of Nannochloropsis oculata in this study were close to the highest specific growth rate (μmax) of 0.037 h^{-1} (Ra *et al*., 2016). Cultivation techniques (Franco, 2014) with microalgae Chlorella sorokiniana showed values of 0.085 and 0.053 h^{-1} using LED Flat Panel lights. In a research on microalgae cultivation with a pilot scale with a volume of 35 L using Chlorella protothecoides and Chlorella variabilis showed values of 0.0022 h^{-1} and 0.003 h^{-1} (Uyar, et al., 2018).

Nutrient Removal

The removal of nutrient ammonia-N and phosphate almost shows the similarity between *Spirulina platensis* and *Nannochloropsis oculate*. It can be seen that the initial Ammonia-N content in each treatment between *Spirulina platensis* and *Nannochloropsis oculate*, namely 12 mg/L and 14 mg/L (Figure 3).

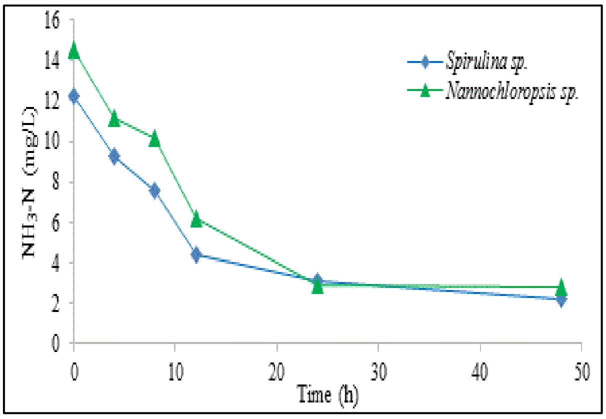

Figure 3. NH3-N degradation oleh *Spirulina platensis* dan *Nannochloropsis oculate*

At the start of processing from 4 hours to 12 hours of processing *Nannochloropsis oculate* was seen to be faster removing NH_3-N, at 24 hours and 48 hours of processing, NH3-N removal was almost the same. The removal efficiency of NH_3-N was 82% and 80%, respectively. Higher yields can be obtained by another study with a residence time of 10 days, NH_3-N removal by *Spirulina platensis* was 97.8% (Kun *et al.*, 2010). The use of microalgae Nannochloropsis sp in treating rubber industry wastewater can reduce the NH_3-N content by 98% (Utomo *et al.*, 2015).

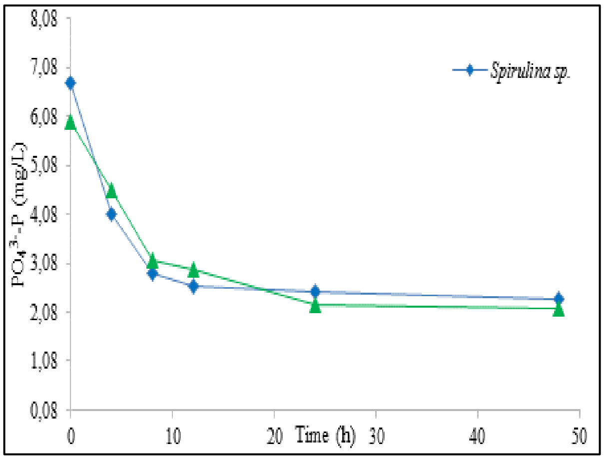

Figure 4. PO_4^{3-}-P degradation oleh *Spirulina platensis* dan *Nannochloropsis*

The removal of phosphate compounds in the form of PO_4^{3-}-P also showed a removal that was almost the same as NH_3-N where the removal of phosphate was seen to be faster than that of NH_3-N (Figure 4). The phosphate removal efficiency for *Spirulina platensis* and *Nannochloropsis oculate* were 65.2% and 63.7%, respectively. *Spirulina platensis* that was cultivated by previous researchers only resulted in a 64.5% reduction (Kun *et al*., 2010). The manufacture of Wastewater Treatment Plant (WWTP) based on microalgae biofilm with the best detention time of 24 hours showed a removal of 80% ammonia and 60.38% Phosphate (Anugroho, et al., 2019). The use of microalgae media is very effective in removing nutrients, especially on NH_3-N compared to activated sludge which only removes 17.9% of NH3-N (Suryawan *et al*., 2019). These results indicate that the efficiency of nutrient removal is highly dependent on environmental conditions and the microalgae cultivation technique. Phosphate compounds as macro compounds are useful for microalgae for cell growth, for energy transformation, for photosynthesis, and for the formation of chlorophyll (Kanibawa, 2001).

Control Parameters

To support the processing of NH3-N and PO_4^{3-}-P, the TDS value was measured (Figure 4). A decrease in the TDS value can be seen to occur drastically at the beginning of processing, namely at 4 hours and 8 hours of processing. Meanwhile, at 12 hours, 24 hours, and 48 hours it has shown a stable value. The pH value in the treatment did not appear to change significantly (Figure 5).

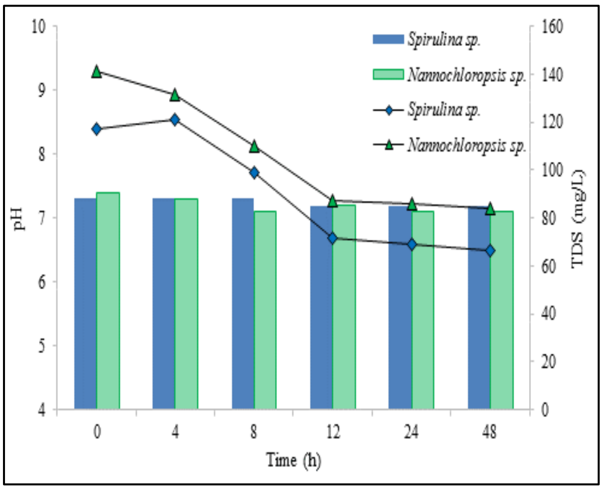

Figure 4. Changes in TDS and pH Values in Domestic Wastewater Treatment by *Spirulina platensis* and *Nannochloropsis oculate*

CONCLUSIONS

The specific growth rates of microalgae cultivated by *Spirulina platensis* and *Nannochloropsis oculate* were 0.0279 h-1 and 0.0282 h-1, respectively. The NH_3-N content can be reduced by 82% and 80%. The PO_4^{3-}-P parameter can be reduced higher, namely 65.2% and 63.7%.

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