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Cultivation of *Chlorella* sp. and Algae Mix for NH_3-N and PO_4-P Domestic Wastewater Removal

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Abstract. Domestic wastewater provides the largest contribution to pollution both in terms of quantity and quality. Therefore, before being discharged into the environment, wastewater needs to be managed first. This study used the cultivation of microalgae *Chlorella* sp. and algae mix to manage domestic wastewater. The reactor used in the study was a 3L volume of water. The cultivation process was assisted by UV-A and UV-B with the air flow rate as much as 1.2 L/min. Pollutant parameters being focused on were NH_3-N and PO_4-P nutrient parameters. Allowance for NH_3-N by *Chlorella* sp. and algae mix were 54.9% and 49%, respectively. Allowance for PO_4-P by *Chlorella sp.* and algae mix were 70.2% and 57.1% while biomass of *Chlorella sp.* and algae mix increased 85.5% and 98.9%. Specific growth rate of *Chlorella sp.* and algae mix were 0.025 h^{-1} and 0.027 h^{-1}. As a control on biomass growth, turbidity value in the study also increased.

Keywords: Algae Mix, *Chlorella sp.*, NH_3-N removal, PO_4-P removal

1. Introduction

A research conducted in Jakarta by the Japan International Cooperation Agency (JICA) Team reported that the total amount of wastewater in Jakarta was 1,316,113 m^3/day, while the amount of domestic waste was 1,038,205 m^3/day that reached 79% of total wastewater [1]. In addition, there is an increasing concentration of population and industry in urban areas that directly disposing wastewater from activities into rivers or waterways without prior processing [2]. Discharged wastewater with high organic material content will take large amounts of dissolved oxygen for the decomposition process [3]

In addition to organic materials, nutrients such as Ammonia-Nitrogen (NH_3-N) and phosphate (PO_4-P) are important nutrients for growth and metabolism of phytoplankton in waterway. High concentration of these two substances can cause eutrophication in the river, causing death of marine biota. Industrial and domestic wastewater are main sources of NH_3-N and PO_4-P. Excessive presence

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of phosphate accompanied by the presence of nitrogen can stimulate the explosion of algae growth in waters (algae bloom).

Wastewater management usually uses microorganisms to degrade material contained in it. One of microorganism that has the opportunity in wastewater management is microalgae. The multiplication of microalgae biomass coupled with wastewater management is considered as one of the most promising ways to produce bioenergy and bio-based by-products that are economically and environmentally friendly [4]-[5].

Microalgae that is easily obtained is *Chlorella sp.*, a single-celled microalga that lives in the marine environment, grows and flourish hovering on freshwater, seawater, and brackish by utilizing sunlight as an energy source and carbon dioxide as a source of carbon. *Chlorella sp*. is one of the green algae groups that almost 90% of them live in freshwater and 10% live in sea water compared to other green algae. Microalgae has a bioactive composition that can be used as a source of antioxidants, antibacterial, anti-inflammatory and anticancer [6].

The purpose of this study is to determine the effectiveness of cultivation of *Chlorella sp.* in processing nutrients in the form of NH_3-N and PO_4-N in domestic wastewater. A mixture of algae taken naturally to compare NH_3-N and PO_4-N removal. The growth rate of the microalgae was also measured in the form of mix liquor suspended solid (MLSS), thus the specific growth rate of *Chlorella sp.* and algal mixture can be seen.

2. Material and Methods

This study consisted of two stages, namely the acclimatization and running stages. Seeding was done within one week to adjust the microalgae in room conditions. *Chlorella sp.* microalgae culture was obtained from algae farm, while the algal mixture is taken from Cisadane River in Jakarta Selatan. Cisadane river consist of uncontrollable growth of algae [7]. Cisadane River is used because it has an abundance of 19 types of phytoplankton and 10 types of zooplankton [8]. Domestic wastewater used in the experiment obtained from mixed influent domestic wastewater treatment plant.

Acclimatization was carried out to adjust microalgae in domestic wastewater. Acclimatization was done by adding 0,3-gram sugar and wastewater with a ratio of 50:50 (300 mg/L sugar: 300 mg/L COD). The running stage was carried out with 100% domestic wastewater. The volume of water in the reactor used was 5L. The volume of *Chlorella sp.* and algae mix was 20% of total volume reactor. Air was flowed into the reactor using an aerator with an air flow rate of 15 liters/minute. UV lamp used was a combination of UV A and UV B lamps. Pollutant parameter measurements were carried out at 0 4 8 and 24 hours. Measurement of NH_3-N and PO_4-N nutrient parameters were done by phenate method (SNI 06-6989.30-2005) and ascorbate method (SNI 06-6989.31-2005), respectively.

3. Result and Discussion

3.1 NH_3-N Removal

The measurement results of NH_3-N values in Figure 1a, showed that there was a decrease in NH_3-N value during the cultivation of *Chlorella sp.* and algae mix. The NH_3-N content in wastewater was successfully reduced by 54.9% and 49%. The decrease of NH_3-N is caused by ammonia in the waste reacting to form ammonium [9], ammonium formation reaction occurs as equation 1. The removal of ammonia-nitrogen can increase because the form of ammonium.

$$NH_3 + H_2O \leftrightarrow NH_4OH \leftrightarrow NH_4 + OH^- \quad (1)$$

The higher removal was obtained from the cultivation of *Chlorella sp.* reaching 98.7-99.8% with piggery wastewaters media [10] and 80.62% with domestic wastewater media [9]. The same results were produced in swine wastewater treatment with *Chlorella vulgaris* producing 40-90% NH_3-N removal [11]. This study less of NH3-N removal because the COD/NH_3N ratio very high with 678 mg/L/7,81 mg/L. COD/NH3-N ratio or C/N very important to growth of microorganism [12].

Integration of algae in wastewater treatment system can applied to improve the efficiency of the NH_3-N removal in wastewater [13]-14].

3.2 PO_4-P Removal

Orthophosphate (PO_4-P) showed that there was a decrease reaching 70.2% in *Chlorella sp.* and 57.1% in algae mix (Figure 1b). This result contrasted with PO_4-P removal with *Chlorella vulgaris* of previous studies, which reduced only 4.30% of PO_4-P [11]. The results of other studies mentioned the efficiency value of *Chlorella sp.* reached 90% with Mixed domestic-industrial wastewater media [15].

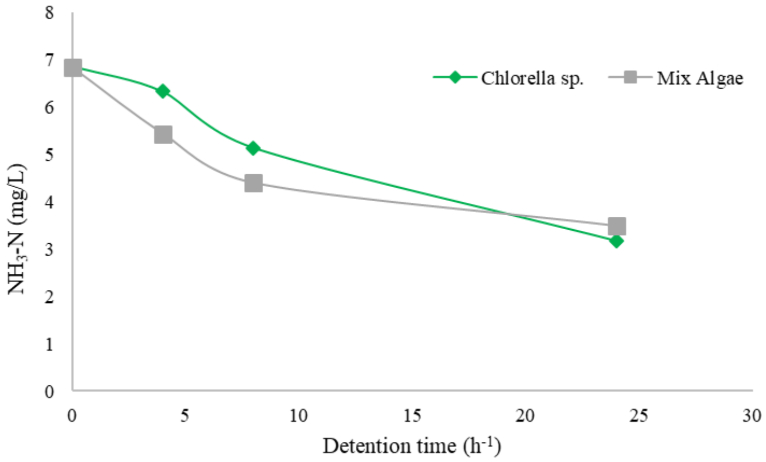

Figure 1a. NH_3-N Removal

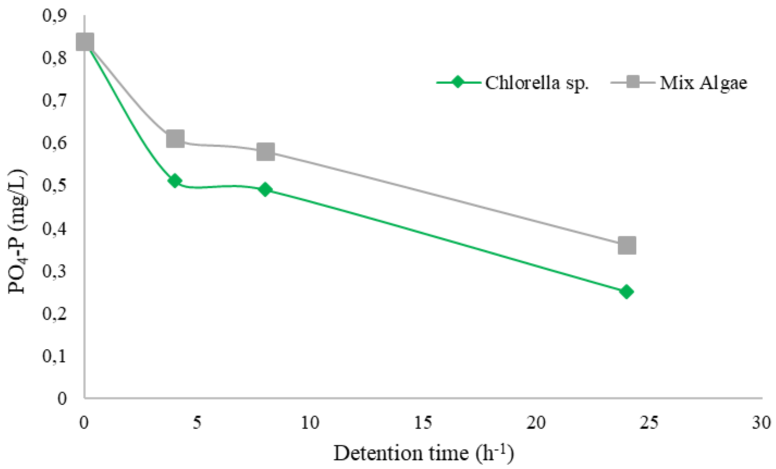

Figure 1b. PO_4-P Removal

Figure 1. Nutrient concentrations of NH_3-N and PO_4-P in the cultivation of microalgae for domestic wastewater treatment

3.3 Microalgae Growth

Mixed liquor suspended solids (MLSS) were measured periodically to determine the specific growth rate of *Chlorella sp.* and algae mix. Microalgae biomass were 85.5% and 98.9% with growth rate of 0.025 h^{-1} and 0.027 h^{-1} for *Chlorella sp.* and algae mix, respectively. These results are greater than the results of research using *Chlorella protothecoides* and *Chlorella variabilis* with values of 0.0022 h^{-1} and 0.003 h^{-1} on a field scale [16]. Research on a laboratory scale with *Chlorella vulgaris* produced a specific growth rate of 0.042 h^{-1} [17]. Other results of a larger study with *Chlorella sp.*

were produced 0.064 h^{-1} [18]. This result related with N:P ratio of 15:1, on this study N:P ratio not controlled. The NH_3-N/PO_4-P ratio on this research only 8,75:1, the nutrient ratio very important to microorganism growth [19].

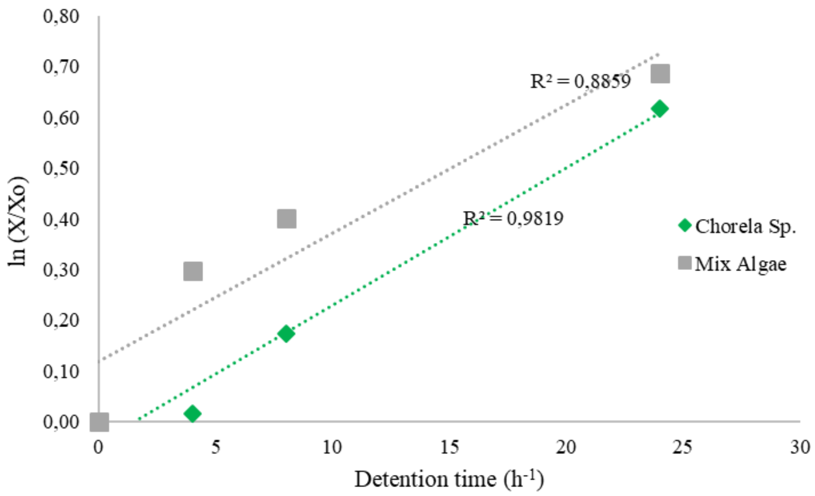

Figure 2. The specific growth rate equation

To control the MLSS values, turbidity values were measured. The value of turbidity continues to increase as seen in Figure 3. This shows that the algae grow well.

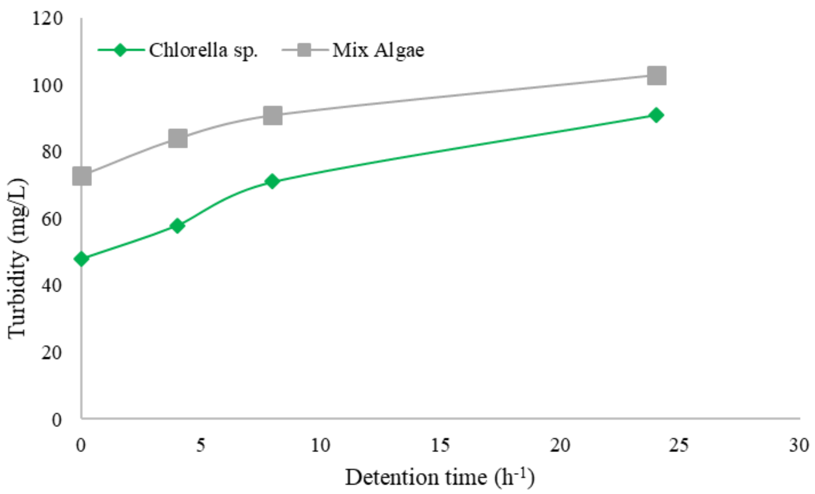

Figure 3. Changes in turbidity values of microalgae cultivation

4. Conclusion

Domestic wastewater treatment using microalgae is effective in removing NH_3-N and PO_4-P nutrients. Microalgae biomass growth also occurs well in the domestic wastewater media. The nutrient was successfully reduced by *Chlorella sp.* and algae mix was 54.9% and 49% for NH_3-N and 70.2% and 57.1% for PO_4-P. *Chlorella sp.* and algae mix growth rate are 0.025 h^{-1} and 0.027 h^{-1}.

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