Utilization of *Cladophora glomerata* for Organic Substance Removal in Laundry Wastewater with Artificial Light Exposure

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Article Info	ABSTRACT
Key word: *Wastewater* *Cladophora glomerata* *Organic substance* **Article history:** *Received:14/06/2019* *Revised:15/07/2019* *Accepted: 21/08/2019*	*Macroalgae is an alternative technology to reducing organic content in the wastewater. This study amis to determine the performance of Cladophora glomerata as a Macroalgae to remove laundry wastewater pollutants with artificial light. Light exposure (12 and 20 hours exposure) and five nutrient variance concentration conducted . The results of this study showed that macroalgae succeeded in reducing organic matter as COD to ±25.81% and BOD to ±54% within in 5 days. Statistical analysis found that removal efficiency not significantly correlation with biomass growth (P-Value = 0.328 and 0.201 in 12 and 20 hours). Performance of algae to decrease organic substance determine the effect algae-bacteria symbiosis which prevail in the reactor. Furthermore, nutrient content could affect the algae ability to remove the organic substance.*

Introduction

In this recent years, human have more complex demand whether it will be generate wastewater in more complicated. Domestic wastewater in this era will increasing wastewater contaminant in the water, soil or groundwater (Chen, Nam, Westerhoff, Krasner, & Amy, 2009; Whitton, 1970a).This problems will threatening sustainable of the environments. Organic substances is one of the pollutants constituents which interfere of the environment, because will decreasing of the dissolved oxygen in the water. (Cuellar-Bermudez et al., 2017; Putra & Farahdiba, 2018).

Significantly, high organic matter content in domestic wastewater increases pollution in the receiving water body that could reduce public health. Previous studies using microalgae as a bioremediation technology for wastewater treatment (Ardhiani, Farahdiba, & Juliani, 2016; Farahdiba, Budiantoro, & Yulianto, 2019; Sutherland, Turnbull, Broady, & Craggs, 2014)

The development of science shows a tendency that leads to the biotechnology process where one form of scientific reform to help preserve the environment. Green biotechnology utilize algae also can be used as a way out of environmental pollution without chemical addition (Cai et al., 2019; González-Camejo et al., 2018; Neveux et al., 2016)

Macroalgae can be used as wastewater treatment with low operating costs. In this system, Macroalgae, for example,

Cladophora glomerata, require light to carry out photosynthesis. However, the use of biomass macroalgae for the treatment of wastewater certainly needs the intensity of light in a given time (Cole et al., 2016; Whitton, 1970a, 1970b).

The previous studies show that macroalgae growth depends on the availability of inorganic carbon, nitrogen, phosphorus, light intensity and media temperature. Availability of substrate and nutrient will determine the algae biomass production (Derabe-Maobe, 2014). Macroalgae is conditioned in constant light intensity, temperature and homogeneous stirring. Increasing photon fluence densities were accompanied by a strong rise in the growth rates up to the maximum of 0.52 μ/day of green algae *Klebsormidium dissectum* (Karsten & Holzinger, 2012). Therefore, the importance of macroalgae ability study is carried out in decreasing laundry waste which is affected by exposure of light intensity duration.

Research Methodology
Research Time and Location
Laundry sample is taken in the laundry business around Surabaya. This research was conducted at Laboratory, Environmental Engineering, Universitas Pembangunan Nasional "Veteran" East Java. Acclimatization and RFT test developed in February, while main experiment and data analysis conducted in remain months until last April.

Material and Methods
Research conducted with laboratory scale with 300 ml of laundry wastewater sample in glass jar. Each reactor spiked with macroalgae *Cladhopora glomerata* for remove the content of laundry waste containing COD and BOD. This research done during 5 days with additional light using LED lamp 20 watt (or 3600 lux) for 12

hours and 20 hours. BOD and COD parameter were tested based on SNI 06-6989.14-2004 and SNI 06-6989.15-2004.

Preparation of Cladophora glomerata
Initial algae biomass was measured from the average several samples weighting from fresh algae sample to dry weight of algae biomass. Dry algae biomass was obtained by drying of the algae until no water remain (Ge & Champagne, 2017). This data become the baseline of the algae biomass within sampling on the day.

Range Finding Test (RFT)
In the preliminary research, author couldn't identify the performance of the algae within the pollutants. Therefore, the Range Finding Test (RFT) is carried out to determine the maximum nitrate concentration that can be accepted by macroalgae in certain time. Nitrate was set up to become variant the sample because algae photosynthesis was effect by the nutrient (Bazdar, Roshandel, Yaghmaei, & Mardanpour, 2018).

The RFT test conducted with 300 ml of laundry wastewater sample in glass jar and spiked with macroalgae 3 g dry weight. The results of the RFT test will be used to conduct the main research. Nitrate as an indicator because of the algae will utilize nitrate as an nutrient to photosynthesis. The USEPA Guidelines Part OPPTS 850.4400 states that conducted research with varied concentrations, namely 5 concentrations for 7 days experiment. Figure 1 is the RFT test of the macroalgae.

Nitrate variations in the concentration to be used are 0% (control), 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%. At each concentration, macroalgae growth parameters will be observed. At concentrations that make plants still fresh (not withered and dead) this will be used in the main test.
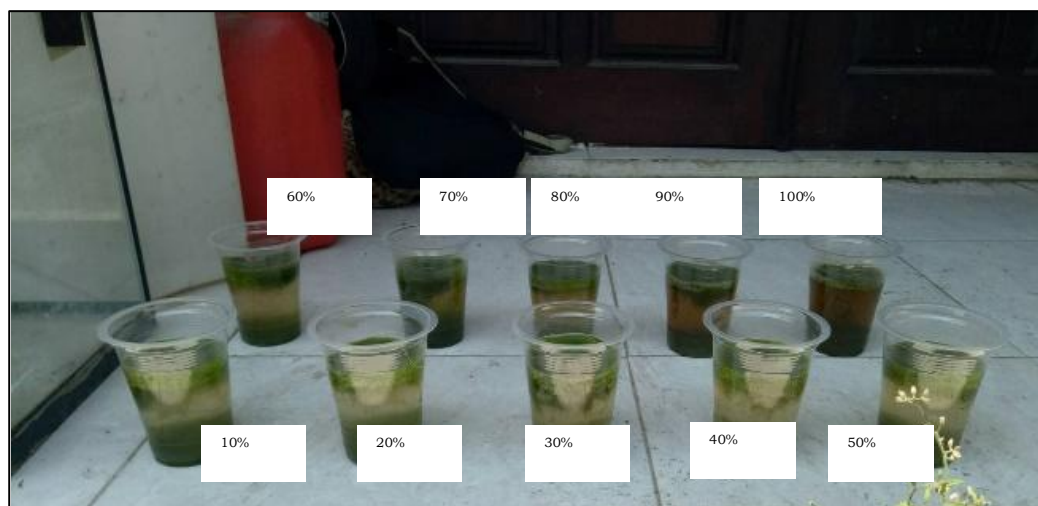
Figure 1. Range Finding Test of the *Cladophora glomerata* Performance

Main Research

This study begins with acclimatization stage as a macroalgae step adapts to the environmental conditions of the study. Acclimatization stage set up algae with mineral water without additional chemical or nutrition.

Experiment conducted within 5 days with 5 samples nitrate concentration variation. This concentration was followed from the RFT results. Five nitrate concentration are: 3.7 mg/L (Sample 1) ; 119.50 mg/L (Sample 2); 202.49 mg/L (Sample 3); 293.66 mg/L (Sample 4); 375.43 mg/L (Sample 5).

Data Analysis

Data analysis used Minitab 2018 Software with correlation significant test with p-value and person correlation. Kaleidagraph 4.0 Software was used to represents data.

Results and Discussion
Removal of Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD)

The results of the decreasing COD and BOD can be seen in Table 1. Sampling Chemical Oxygen Demand (COD) analysis was conducted within five day experiment. The initial analysis for COD 676 mg/L. The algae performance of removal COD explain further in Figure 1.

Tabel 1. Concentration of COD and BOD

Light Exposure	Analysis (mg/L)	
	COD	BOD
12 hours	545.44	203.06
	512.71	196.29
	545.44	209.83
	490.9	216.6
	556.35	223.37
20 hours	599.98	179.37
	523.62	155.68
	501.8	202.38
	545.44	208.47
	578.17	211.18

COD removal is achieved by the reactor with nitrate variation 293.66 mg/L (Sample 4) in 12 hours exposure reach 27.42%. The lowest percent COD reduction occurs in 20 hours in sample 5 of 11.29%. Figure 3 shown the removal for BOD parameters in 12 and 20 hours sample 2 have highest BOD efficiency until reach 50%. This is similar results with macroalgae *Oedogonium* could reach of removal efficiency until 50% (Neveux et al., 2016).

Sample 2 is more acceptable while in the range 100mg/L macroalgae still have the ability to survive and develop (Cole et al., 2016; Zhu et al., 2013). This is will have higher performance to reduce contaminant in the water. Macroalgae have lower performance while in the higher nutrient concentration (~200-400 mg/L), Therefore, with higher nutrient concentration removal of organic matter have lower performance because effected by algae-bacteria symbiosis.
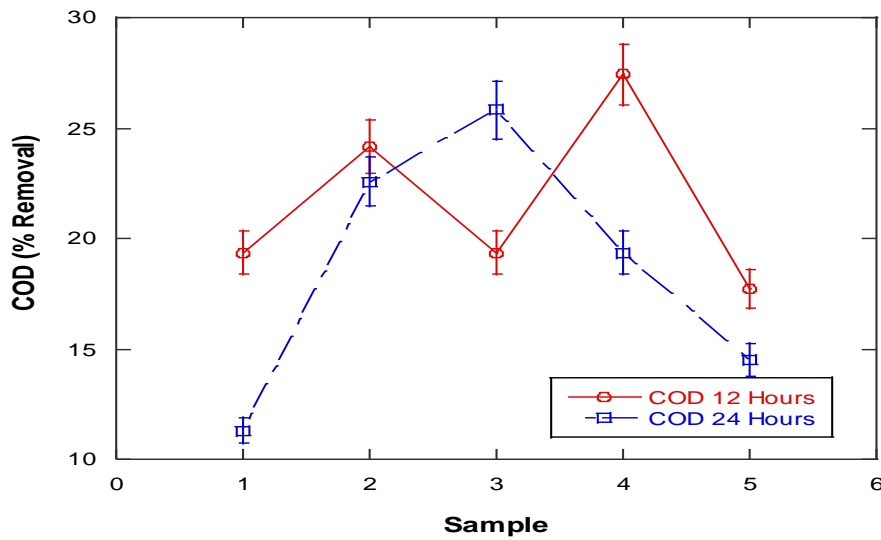
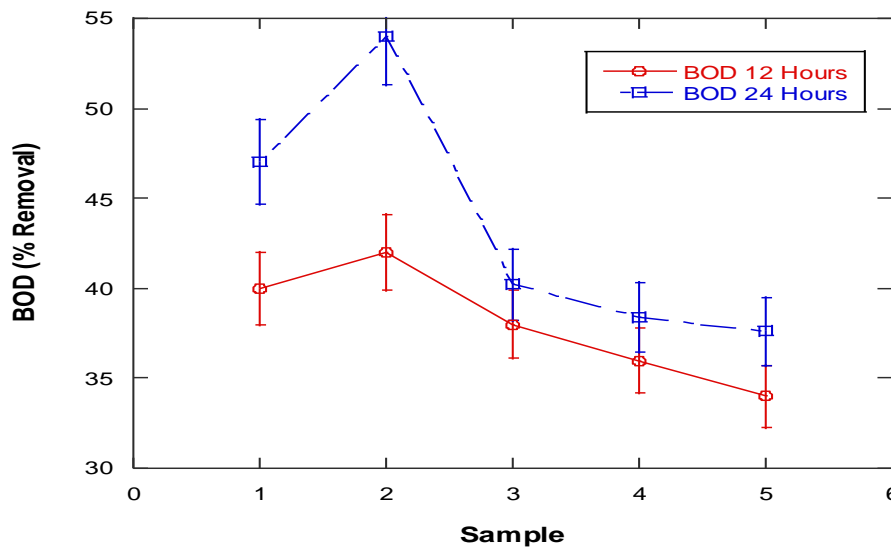**Figure 2. Removal Efficiency of Chemical Oxygen Demand by Macroalgae**

Figure 3. Removal Efficiency of Biochemical Oxygen Demand by *Cladophora glomerata*

This is stated that algae performance effect with algae system. Algae growth and their speciation in cultivation system depend on both abiotic (e.g. pH, temperature, light, salts concentrations) while usually with i.e. photoautotrophic metabolism). The others factor is biotic (e.g. interactions with other microorganisms as bacteria) factors which (i.e. heterotrophic metabolism) (Iasimone et al., 2018). Usually, in this system they use organic carbon. Thus microalgae metabolism can be autotrophic or heterotrophic. Previous research used microalgae (*Chlorella*) to remove organic matter depending on the number of bacteria contained in the reactor (Putra & Farahdiba, 2018; Taziki, Ahmadzadeh, & A. Murry, 2016).

This study clarify from previous study while the removal efficiency reach to 30%-50% within macroalgae and microalge (Ardhiani et al., 2016; Neveux et al., 2016; Putra & Farahdiba, 2018).

Algae performance depend on the light exposure in the light/dark system of photosynthesis (Bazdar et al., 2018). In the highest light intensity in 10000 lux will hindered the microbial activity. Moreover, around ~5000 lux luminescence is still increasing the activity of bacteria.

Variance of 20 hours slightly have higher rate than 12 hours exposure. Furthermore while in the higher nitrate concentration both 12 and 20 hours still have a lower efficiency, response to changes in the environmental variables of temperature and light (Cole et al., 2016).

There is no significant correlation in the variation of COD and BOD removals of the 12 and 20 hours with P-Value = 0.597 and P-Value = 0.018 respectively, while the difference of the error these may be contributed to sudden shocks to the system and augmented concentration of produced oxygen due to changing illumination conditions (Bazdar et al., 2018).

Correlation between Cladophora glomerata (Biomass) and Biochemical Oxygen Demand Removal within 12 and 20 Hours Light Exposure

Table 2 has shown the algae biomass concentration within 12 and 20 light exposure. Figure 4 and 5 shown higher removal efficiency of BOD followed by increasing biomass algae concentration.
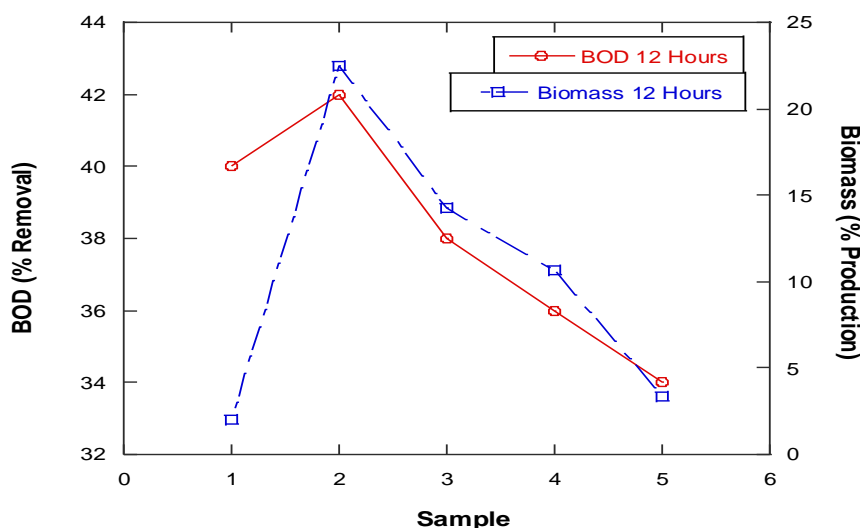
Hereby, within lower nutrient concentrations, resulted in notably higher biomass productivity in the sample 2 (Ge & Champagne, 2017). While in the sample 1, lower nutrient concentration is not progressively increase biomass production.

Tabel 2. Algae Biomass Concentration

Light Exposure	Biomass (mg/L)	
	1st day	5th Day
12 hours	1366.67	1394.33
	1367.33	1764.33
	1365.67	1592.67
	1365.33	1527.67
	1363.33	1410.67
20 hours	1382.00	1429.67
	1388.33	1937.67
	1368.33	1519.67
	1365.67	1518.33
	1365.33	1520.67

In further nutrient concentration algae biomass is decline. It is possible that a nutrient suppressed algae growth and biomass production. Moreover, organic matter (measured as COD or BOD) could use as a carbon source resulting with biomass production.

Figure 4. Correlation between BOD Removal and Biomass Production in 12 Hours Light Exposure

Statistical analysis with MINITAB, Pearson correlation of BOD 12 Hours with Biomass 12 hours = 0.559 and P-Value = 0.328. Pearson correlation of BOD 20 hours with Biomass 20 hours = 0.64 and P-Value = 0.201. This is stated that the removal efficiency of organic content not significantly correlation with biomass production.
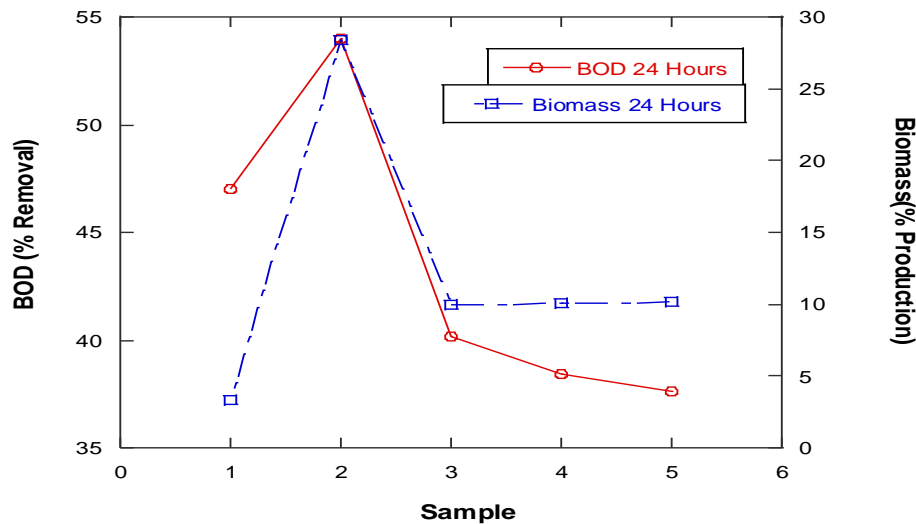
Figure 5. Correlation between BOD Removal and Biomass Production in 20 Hours Light Exposure

Light intensity was a major factor affecting the photosynthetic carbon. While the high light chlorophyll degraded, protein and carbo- hydrate content decreased (He, Yang, Wu, & Hu, 2015). In this research effect of light exposure is not significantly difference while the difference variance of nitrate concentration is more dominant.

Conclusion
Research show the performance of maximamum *Cladophora glomerata* reduce levels of COD and BOD in grey water by ~30% and ~50% removal efficiency in nitrate concentration around ~100mg/L. Light not significantly effect to biomass production, while nitrate concentration have higher capability induce algae capability.

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