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PERFORMANCE OF OXIDATION DITCH ALGAE REACTOR (ODAR) FOR ORGANIC COMPOUND REMOVAL OF GREY WATER

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ABSTRACT

An excessive amount of organic compound has disturbed the balance of water ecosystem. A treatment using Oxidation Ditch Algae Reactor (ODAR) benefits algae that live in water and their symbiosis with bacteria. The purpose of this study is to determine the removal efficiency of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) in the wastewater used for the reactor. This study's first step was done using grey water, while the second step was done using artificial wastewater. The main parameter to be tested was BOD for once every 7 days, COD for once every 3 days, and chlorophyll a as the parameter for algae growth. The dominant algae species was identified as *Chlorella sp.* There were also parameters of water quality to be tested, namely dissolved oxygen, acidity, temperature, light intensity, and Mixed Liquor Suspended Solids (MLSS). The results of this study showed that the capability of ODAR to reduce BOD and COD in grey water was 25.52 % and 50 % and in artificial water was 29.45% and 40%. The results also showed that the parameter of water quality improved the capability of ODAR.

Keywords: Algae; BOD; COD; Chlorophyll a; ODAR; Removal efficiency

1. INTRODUCTION

One of the problems of wastewaters is the excessive amount of organic compound that can disrupt water ecosystem. Various treatments that have been done are mostly not sustainable and unable to optimize the benefit of wastewater. Treatment using algae not only reduces the content of substances, but also benefits wastewaters as the media. Algae would take the nutrient in the wastewaters for its growth, thus producing biomass. This biomass can be harvested and utilized as a new resource.

The application of microalgae to the treatment of municipal wastewater for pollutant remediation was proposed almost 70 years ago (Caldwell, 1946). Wastewater treatment and microalgae have been linked to each other since ancient times. This connection has been extensively researched in wastewater stabilization ponds, which have been used for more than 3000 years in the world (EPA, 1983). Since then, commercial wastewater treatment systems have been developed in which microalgae contribute significantly to the overall treatment process with respect to biological and chemical oxygen demand (BOD and COD) and pathogen reduction, nutrient removal, and water disinfection (Oswald, 1988).

A research conducted by Abdel-Raouf et.al.(2012) found that the domestic wastewater being released to the environment has a high concentration of organic and inorganic substances. To remove the easily suspended substances and oxidize the organic

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substances in wastewater, a gradual treatment is needed. A research from Malla & Khan, et.al. (2015) showed that the removal efficiency of BOD and COD in sewage drain wastewaters using *Chlorella minutissima* is 31% and 27% respectively. Another research conducted by Chandra & Usha, et.al. (2016) showed the results for the removal of BOD and COD are 82% and 75%.

2. METHODOLOGY/ EXPERIMENTAL

2.1. EXPERIMENTAL METHODS

In this research, the domestic wastewaters treatment was done using oxidation ditch algae reactor (ODAR) with biological treatment using non selective algae. The main purpose was to know the capability of ODAR in the removal of organic compound.

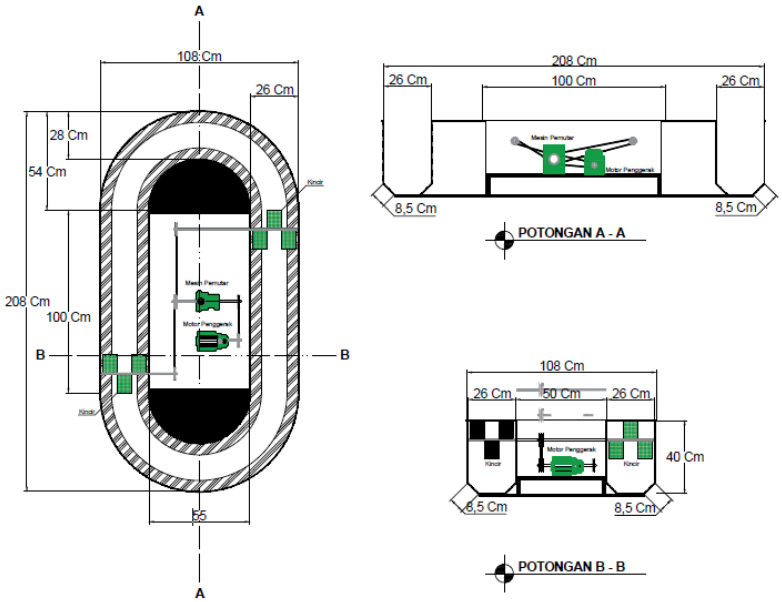

Figure 1 The dimension of ODAR

Figure 2 Running Oxidation Ditch Algae Reactor (ODAR)

This research used algae from free water ponds; the algae were later cultured in a laboratory. The green color was dominant in the water, thus the first assumption was the dominant species is green algae. One of the most common green algae found was *Chlorella sp.* This species is unicellular in the phylum of Chlorophyta and contains two kinds of chlorophyll namely chlorophyll a and b. Its growth rate is 0.66 day^{-1} at a temperature of 30°C. *Chlorella sp.* often has one to eight flagella. This species is commonly used for reducing CO_2 in water. A research conducted by Singh & Singh (2014) showed that Chlorella vulgaris is capable of reducing CO_2 until 251.64 mg/l/day. The tests conducted in this research were BOD and COD tests. The guidance to these test referred to SNI 06-2412-1991 for the sampling method, SNI 06-6989.14-2004 and SNI 6989.72:2009 for the BOD test, SNI 06-6989.2-2004 for the COD test, and SNI 06-4157-1996 for the chlorophyll-a test. Furthermore, there were parameters of water quality to be tested as additional variables namely chlorophyll a, light intensity, temperature, dissolved oxygen (DO), and pH. Aeration was done using brush aerator installed in the reactor. In the reactor, paddles were also installed, allowing mixing with a rotation of 61 rpm. The COD tests were done once every 3 days for 13 days using grey water and artificial wastewater.

Table 1 The parameter of water quality to be tested and the instruments used

Number	Parameter	Instrument
1	Ph	pH meter
2	DO	Titration
3	Temperature	Thermometer
4	Light intensity	Luxmeter

2.2. Algae Culture

Algae were taken from free water ponds on Kaliurang Street, Yogyakarta. After the taking, seeding and acclimatization were done to prepare the algae for the running of ODAR.

2.3. Wastewater

There were two kinds of wastewater used in this research. The first 13 days of running used grey water taken from the Cafetaria of the Integrated Campus at Islamic University of Indonesia. The next 13 days of running used artificial wastewater made from tap water, with addition of sugar and NPK fertilizer.

2.4. Correlation Analysis

The results of this research were made into correlation as well. This correlation showed the relation between the parameters and other variables. In the correlation analysis, the coefficient was to explain the relation between the independent variable and dependent variable, or to know the relation's strength.

$$R = \frac{n(\Sigma XY) - (\Sigma X)(\Sigma Y)}{\sqrt{\{n(\Sigma X^2) - (\Sigma X)^2\}\{n(\Sigma Y^2) - (\Sigma Y)^2\}}} \quad (1)$$

According to Sugiyono (2012), the interpretation of the coefficient of correlation is guided by Table 2:

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Table 2 Guidance to interprete the coefficient of correlation

Coefficient interval	Relation Level
0.00 – 0.199	Very low
0.20 – 0.399	Low
0.40 – 0.599	Medium
0.60 – 0.799	Strong
0.80 – 1.00	Very Strong

3. RESULTS

The results showed that the dominant algae in the water were coccus-shaped with green color. This could be identified as *Chlorella sp.*which is included in phylum Chlorophyta. *Chlorella sp.* can survive in water with a maximum temperature of 30 until 40°C (Singh & Singh. 2014).

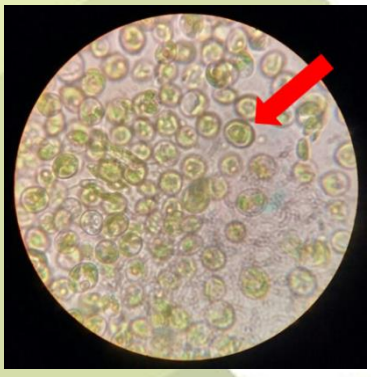

Figure 3 *Chlorella sp.* identified as the dominant species

3.1. Chlorophyll a

Chlorophyll a was tested once every 3 days. Therefore the results showed an increase in chlorophyll a concentration in every test. The increase value is almost 400%, which is a good sign for the algae growth. The results also showed that the algae growth is more fertile in artificial wastewater.

Table 3 Chlorophyll a test results

Day	Grey water (mg/l)	Artificial Wastewater (mg/l)
0	0.10	0.48
4	0.21	0.64
7	0.35	0.77
10	0.41	0.96
13	0.59	1.03

Source: Experimental Data, 2016

3.2.Removal of Organic Substances

The results in Fig. 3 (top) show the removal of COD in artificial wastewater and grey water. In artificial wastewater, the removal of COD was gradually done until reaching

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the value of 923.08 mg/l. In the grey water results, COD increases once from day 0 to day 4 before finally decreasing to the value of 1188.03 mg/l.

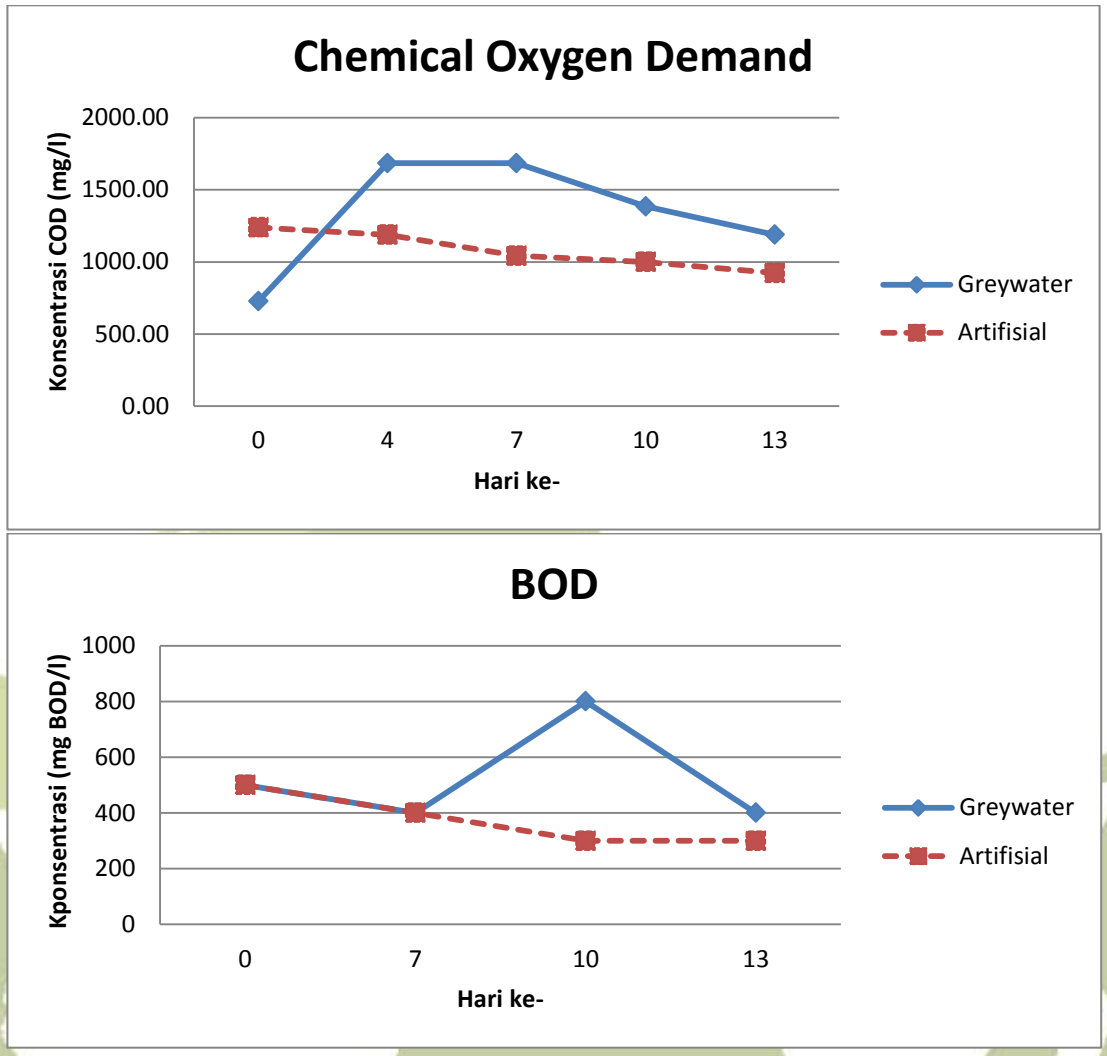

Figure 3 Results of COD (top) and BOD (bottom)

Fig. 3 (bottom) shows the removal of BOD in artificial wastewater and grey water. In artificial wastewater, the removal of COD was gradually done until the value of 300 mg/l. In the grey water results, BOD increases once from day 7 to day 10 before finally decreasing to the value of 400 mg/l. The increase in BOD in the grey water was caused by another addition of grey water on day 7. This was done in order to keep the algae alive. On day 7, the color of the water in ODAR turned into yellow rather than green. Thus the addition of grey water and algae from the algae culture was needed.

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3.3. Parameter of water quality as variable

The variables tested in this research were pH, temperature, DO, and light intensity. For the temperature, the measurements were done every day at 12.00 a.m. The results showed that the ODAR temperatures were between 27-31°C. for the pH, the measurement showed values ranging from 6.02 until 6.57. As for the dissolved oxygen, the titration was done with the increase in DO in grey water and artificial wastewater in the amount of 37.5% and 23.7%, respectively. The light intensity measurements with lux meter resulted in the amount of 520-8210 lux. For the accession, the parameter of MLSS was added from another research using the same reactor at the same time. The results showed the MLSS value was able to increase from 75 mg/l to 277 mg/l for grey water, and 188 mg/l to 493 mg/l for artificial wastewater.

4. DISCUSSION

The capability of ODAR in reducing organic substances has been proven in some research. Malla & Khan, et.al. (2015) showed that the removal efficiency of BOD and COD in sewage drains wastewater using Chlorella minutissima is 31% and 27% respectively. Another research conducted by Chandra & Usha, et.al. (2016) showed the results for the removal of BOD and COD is 82% and 75%. While in this research, the removal efficiency for BOD and COD in grey water is 50% and 29.45%. As for the artificial wastewater, the removal efficiency for BOD and COD is 40% and 25.52% respectively.

These results depend not only on the existence of algae, but also on the variable which is important in algae growth and ODAR capability. For example, in the special variable chlorophyll a, in which the increase in grey water and artificial wastewater is different. This difference is probably caused by the concentration of ammonia and phosphate in the wastewater. Artificial wastewater has an ammonia concentration of 23.68 mg/l while grey water only has 4.14 mg/l. The phosphate concentrations in grey water and artificial wastewater are 2.43 mg/l and 20.50 mg/l. As for another variable such as temperature, the optimum temperature of the algae especially *Chlorella sp.* is 15-25°C, which means that the algae in ODAR are not in their optimum productivity in reducing organic substances. For light intensity, which is important to photosynthesis, the optimum intensity is in a range of 500-10.000 lux. Therefore, the light intensity in this research is on algae optimum light intensity.

From Table 4, it can be seen that the correlation between BOD and the variables is considered to be very low and low. This is shown in Table 2, in which the range of the relation strength of very low is 0-0.199 and for the low relation strength is 0.20-0.399. The negative symbol indicates that the relation of BOD and the variables is inversely proportional, which means that the higher the variable values, the lower the BOD.

Table 4. Correlation between BOD and variables

Parameter	Variable	Wastewater	Coefficient of correlation
BOD	Chlorophyll-a	Grey water	-0,029
		Artificial	-0,21
	DO	Grey water	0,026
		Artificial	-0,203
	MLSS	Grey water	-0,119
		Artificial	-0,212

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Table 5 Correlation between COD and variables

Parameter	Variable	Wastewater	Coefficient of correlation
COD	Chlorophyll-a	Grey water	0,059
		Artificial	-0,106
	DO	Grey water	0,131
		Artificial	-0,102
	pH	Artificial	-0,08

Source: Experimental Data, 2016

From Table 5, it can be seen that the correlation between COD and the variables is considered to be very low. This is shown in Table 2, in which the range of the relation strength of very low is 0-0.199. The negative symbol shows that the relation of BOD and the variables is inversely proportional, which means that the higher the variable values, the lower the COD.

5. CONCLUSION

The capability of ODAR in reducing BOD and COD is concluded with the removal efficiency for each wastewater. The removal efficiency of COD and BOD for grey water is 25.52% and 50%, and for the artificial wastewater is 29.45% and 40%. Chlorophyll a is used as the parameter of algae growth. It is also found that the variables namely dissolved oxygen, acidity, temperature, light intensity, and Mixed Liquor Suspended Solids (MLSS) are shown to be optimum for the algae productivity and the ODAR capability in order to reduce organic substances.

6. ACKNOWLEDGEMENT

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