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Characterization of Effluent Organic Matter (EfOM) in Domestic Wastewater Using Oxidation Ditch Algae Reactor (ODAR) with Microalgae *Spirulina platensis*

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ABSTRACT

Oxidation ditch (OD) is a tub used to treat wastewater by utilizing oxygen and microorganisms contained in it to determine its ability to reduce the release of organic substances. Oxidation Ditch Algae Reactor (ODAR) is a biological wastewater treatment that utilizes the symbiosis between algae and bacteria in water. The results of biological processes contain organic material called effluent organic matter (EfOM). This research aims to investigate the characterization of effluent organic matter (EfOM) produced from the Oxidation ditch (OD) process with and without algae both in continuous aeration (oxic) and intermittent aeration (oxic-anoxic) conditions in domestic household wastewater and microalgae *Spirulina platensis*. Characterizing effluent organic matter (EfOM) is a crucial thing to understand its ability to treat wastewater. Based on the analysis results, the characterization of effluent organic matter (EfOM) in the oxidation ditch process using an algae ratio of 1:1 in continuous aeration (oxic) conditions through the UV_{254} test was identified as containing the highest aromatic organic matter up to 59.68%. Meanwhile, without using algae with a 1:0 ratio of intermittent aeration (oxic-anoxic) conditions, the lowest decrease in aromatic organic matter content reached 34.79%.

Keywords: Oxidation Ditch Algae Reactor (ODAR), effluent organic matter (EfOM), aromatic compund

Introduction

Oxidation Ditch Algae Reactor (ODAR) includes biological treatment. According to Michael-Kordatou et al. (2015), it is shown that the results of biological processes contain organic matter called effluent organic matter (EfOM). EfOM consists of particulate and dissolved organic compounds. Based on the standard procedure, to separate the particulate and dissolved compounds, filtration with a membrane filter size of 0.45 m was used. If the particles pass through the 0.45 m filters, they are classified as dissolved organic matter effluent. While the particles left in the filter membrane are classified as colloidal or particulate organic matter effluent (Michael-Kordatou et al., 2015). Characterization of effluent organic matter (EfOM) consisting of humic-like and hydrophobic compounds (HPO), as well as refractory compounds, residual substrates that can be decomposed, intermediates, end products, complex organic compounds, and soluble microbial products (SMP) (Barker & Stuckey 1999).

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The main components of EfOM are carbohydrates, proteins, amino acids, lipids, phenols, alcohols, organic acids, and sterols (Mostofa et al., 2013). EfOM generally comes from 3 main sources, namely (i) allochthonous originating from the soil, (ii) autochthonous originating from algae or phytoplankton activities, and (iii) synthetic organic substances made by humans or derived from marine activities and industry. EfOM in natural waters consists of a heterogeneous mixture of organic compounds with molecular weights ranging from less than 100 to more than 300,000 Daltons (Fewson, 1986). On the other hand, particulate EfOM consists of plant remains, algae, phytoplankton, cells, bacteria, and so on (Mostofa et al., 2013). The characterization and content of EfOM is highly dependent on the wastewater source, wastewater treatment process, and operating conditions (Fang et al., 2010). In this study, it is helpful to determine the characteristics of EfOM in ODAR processing of microalgae *Spirulina platensis* and without algae in continuous aeration (oxic) and intermittent aeration (oxic-anoxic) variations using the UV_{254} test to determine the content of aromatic compounds in water.

Material and Methods

This study uses an oxidation ditch reactor (ODAR) with a batch system at a brush aerator speed of 60 rpm combined with *Spirulina platensis* on a pilot scale with continuous (oxic) and intermittent (oxic-anoxic) aeration variations. The wastewater used in this study is domestic wastewater from the Penjaringan Sari II flats, Pandugo, Surabaya City. In this study, 2 ODAR with a capacity of 250 liters were used with the ratio between wastewater and microalgae being 1:1 and 1:0 in two aeration conditions, namely continuous aeration (on for 5 x 24 hours) and intermittent aeration (on every 7 hours and off for 3 hours x 5 days).

The parameters to be studied are the absorbance value of UV_{254} as well as pH and temperature as supporting tests. The UV_{254} test was measured using a UV/vis spectrophotometer at a wavelength of 254 nm. The study took five days for the experiment. It started with a preliminary study which was the process of seeding *Spirulina platensis* microalgae. The purpose of this process is to help increase the number of *Spirulina platensis* cells. The next step is the microalgae acclimatization process. It allows *Spirulina platensis* microalgae to adapt to new environmental conditions.

Result and Discussion

The initial wastewater content characteristic was determined using the preliminary test. The initial condition is shown in table 1.

Table 1 wastewater preliminary result

Parameter	Test Rate	Standard quality
pH	7.4 °C	6-9
Temperature	27	-
UV_{254}	0.4355 cm^{-1}	-

The wastewater quality standard is following the East Java Governor Regulation no. 72 years 2013. UV-VIS spectrophotometer analysis determines the type of chromophore, conjugated double bond, and autochrome of an organic compound based on the maximum wavelength. The quantitative organic compounds are analyzed using Lambert-Beer law (Dachriyanus, 2004). The wavelength between 220 to 280 nm is the most effective wavelength value for investigating organic matter. The wavelength 254 nm is used to determine the aromatic group compounds of organic material (Zhao, 2020).

The initial test result of the absorbance value of UV_{254} in domestic waste is 0.4355 cm^{-1}. After doing the research, here are the results of UV_{254} analysis at variations 1:0 and 1:1 with aeration conditions, namely continuous and intermittent, are shown in table 2.

Table 2. Effect of comparison of variations on the percent increase in UV254 absorbance value

Variation of wastewater: microalgae	Sampling time (day)	Absorbance Value of UV_{254} (cm^{-1})			
		Continous aeration (Oxic)	Percent Increase (%)	Intermitten aeration (Oxic-Anoxic)	Percent Increase (%)
1:0	1	0.495	13.66	0.515	18.25
	2	0.329	-24.45	0.380	-12.74
	3	0.229	-47.42	0.315	-27.67
	4	0.288	-33.87	0.300	-31.11
	5	0.304	-30.20	0.284	-34.79
1 : 1	1	0.498	14.35	0.4105	-5.74
	2	0.512	17.57	0.4575	5.05
	3	0.5876	34.93	0.4985	14.47
	4	0.6356	45.95	0.5245	20.44
	5	0.6954	59.68	0.6135	40.87

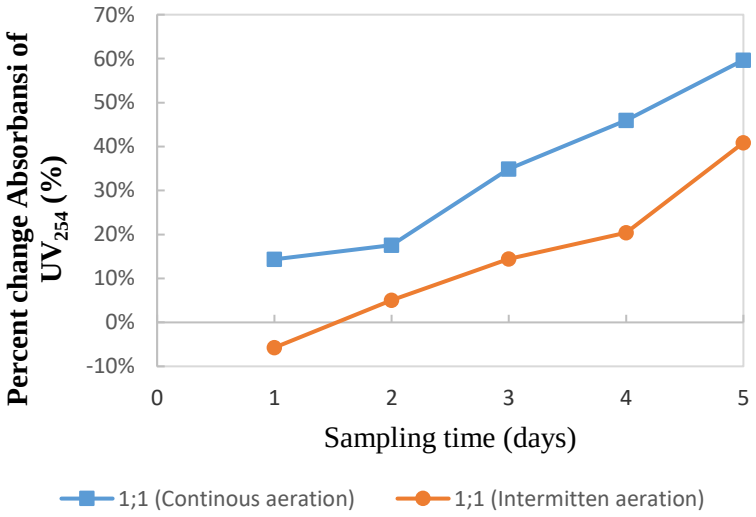

Figure 1. Comparison graph of the change in the percent increase in the absorbance value of UV_{254} under continuous and intermittent aeration conditions with a variation of 1:1

Changes in the increase in the value of UV_{254} indicate that the size of the absorbance value of 254 nm reflects the amount of aromatic organic matter in a solution (Eaton, 1995). In Figure 1 above, it can be seen that the variation (1;1) treatment between wastewater and *Spirulina platensis* microalgae, changes in the UV_{254} absorbance value increased from day to day. The highest change in the increase in UV_{254} absorbance value was in the continuous aeration condition, which increased by 59.68%. Meanwhile, in the intermittent condition, the change in the absorbance value of UV_{254} also increased but not as high as in the continuous aeration condition, which increased by 40.87%. The test results show an increase in aromatic carbon organic matter which has a chemical structure in the form of carbon ring bonds in domestic waste. In the ratio of volume ratio (1:1) the highest increase in absorbance is in continuous aeration (oxic) conditions which reached 59.68%. This shows that the ratio of volume ratio (1:1) in continuous aeration conditions has the highest content of aromatic compounds.

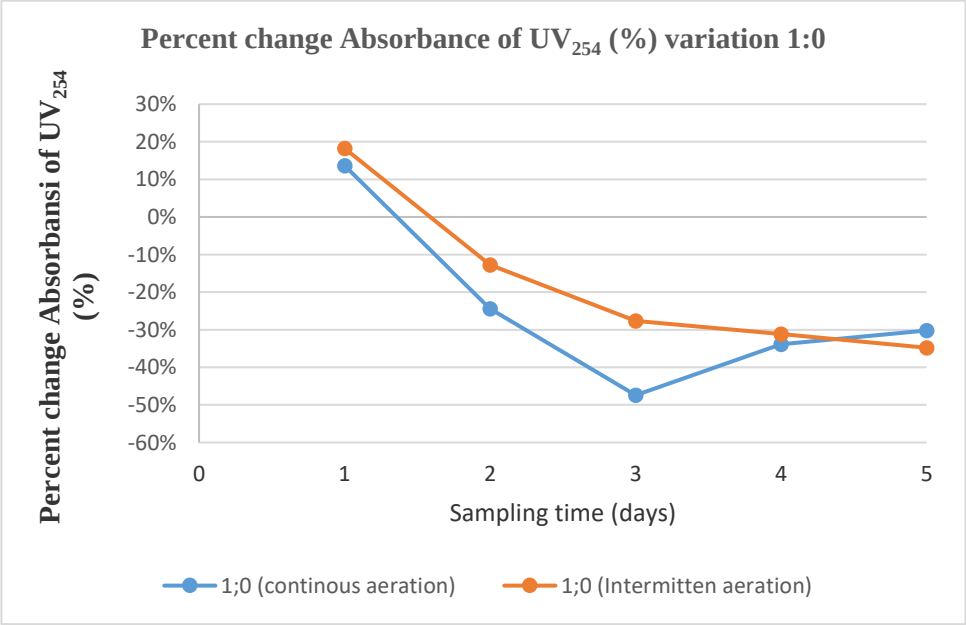

Figure 2. Comparison graph of the change in the percent increase in the absorbance value of UV_{254} under continuous and intermittent aeration conditions with a variation of 1:0

From Figure 2 above, it can be seen in the control variation (1:0) that without the addition of algae, the change in UV_{254} absorbance value decreased, the lowest decrease was in intermittent conditions, which decreased by 34.79%. Meanwhile, in continuous conditions, the change in the absorbance value of UV_{254} also decreased but not as low as in intermittent conditions, which decreased by 30.20%. The test results show a decrease in aromatic carbon organic matter which has a chemical structure in the form of carbon ring bonds in domestic waste. In the control variation, the absorbance decrease was highest and more optimum, namely at intermittent conditions which reached 34.79%. This shows that in the control variation, intermittent conditions contain the least aromatic compounds.

The biological treatment of Oxidation Ditch is combined with various algae in continuous and intermittent aeration conditions. After the treatment of various wastes and algae, it was found that the change in the absorbance value of UV_{254} for 5 days increased in continuous and intermittent aeration conditions. This is because algae can produce by-products, called algae organic matter (AOM). AOM is composed of intracellular organic matter (IOM) from the cell autolysis process and extracellular organic matter (EOM) produced by living cells (Fang et al., 2010). The release of Algae Organic Matter (AOM) into the aquatic environment occurs due to the metabolic excretion process and algae autolysis (Ghernaout et al., 2020). In addition to AOM, there are also Soluble microbial products (SMP) which are organic materials released in biological processing that come from microbial metabolism during the processing (Barker & Stuckey, 1999).

Characteristics of Algae Organic Matter (AOM) consists of various compounds such as polysaccharides, oligosaccharides, proteins, lipids, carbohydrates, peptides, amino acids, organic acid compounds (Zhao, 2020). AOM consists of 57% hydrophilic compounds and hydrophilic polysaccharides which when measured by SUVA, the value is less than 2.0 lm-1 mg-1, then fluorescence such as tryptophan and carbohydrates (Henderson et al., 2008). According to Li et al. (2012), the content in AOM characteristics, such as protein is included in the aromatic tryptophan which is not detected by SUVA. This causes the UV_{254} absorbance value to increase.

Processing using Oxidation Ditch on the control variable (without the addition of algae) in continuous and intermittent aeration conditions decreased the absorbance value of UV_{254}. It

means this process can reduce aromatic compounds. This is because there is no addition of algae in the control variable that can cause the formation of AOM (Algae Organic Matter).

Based on the results of statistical interpretation using One Way ANOVA test analysis, it was found that the aeration conditions (Oxic and Intermittent) to the UV_{254} absorbance value obtained p-value = 0.316, which means p-value > alpha. The Alpha used is 0.05. So with the p-value, H1 is rejected, it can be interpreted that all the means are the same, namely the aeration conditions (oxic and intermittent) do not affect the absorbance of UV_{254}. It is also proven in Tukey's method with a 95% confidence level, two types of conditions, namely oxic and intermittent, are in the same group, namely in group A. Thus, it shows that there is sufficient evidence to say that aeration conditions (oxic and intermittent) are used in the process. Oxidation ditch algae reactor has the same average UV_{254} absorbance value.

Meanwhile, based on the variation of the ratio (waste: microalgae) to the absorbance value of UV_{254} from the statistical interpretation results obtained p-value = 0.000, which means p-value <alpha. So with the p-value, H0 is rejected, it can be interpreted that all the means are not the same, namely the variation of the ratio (waste: microalgae) affects the absorbance of UV_{254}. In the grouping information table from Tuckey's interpretation with a 95% confidence level, three types of ratios exist in groups that are not the same, namely in groups A, B and C. Thus, it shows that there is sufficient evidence to say that the variation in the ratio (waste: microalgae) used in the oxidation ditch algae reactor process has a different average UV_{254} absorbance value.

Conclusion

The results of this study can be concluded that the effluent organic matter (EfOM) from oxidation algae reactor processing using *Spirulina platensis* in domestic wastewater can increase the highest aromatic compound content in water by 59.68% in wastewater variations and 1:1 microalgae in continuous conditions aeration. While the oxidation ditch processing without using microalgae was able to reduce the highest aromatic organic compounds, namely in intermittent aeration conditions, which decreased by 34.79%.

Based on statistical results using the One Way ANOVA test method, it was obtained that in the oxidation ditch algae reactor process using *Spirulina platensis*, what affects the absorbance value of UV_{254} is the variation of the ratio (waste: microalgae). While the aeration conditions (oxic and intermittent) did not affect the absorbance of UV_{254}. This is evidenced in the results of the study that the ratio of volume ratio (1:1) contains the most aromatic compounds where the increase in absorbance value.

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