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Characterization of the Effluent Organic Matter (EfOM) from the Domestic Wastewater Treated using Oxidation ditch and Microalgae *Chlorella sp.*

Emira Aulia Rachma, Euis Nurul Hidayah*, Yuliatin Ali Syamsiah, Hirsandy Rachmadhany Alamsyah

Department of Environmental Engineering, Universitas Pembangunan Nasional"Veteran" Jawa Timur, Surabaya 60294, Indonesia

*Corresponding author:
E-mail: euisnh.tl@upnjatim.ac.id

ABSTRACT

Many advantages are obtained in treatment using microalgae. Microalgae treatment using an oxidation ditch can remove organic matter in wastewater. On the other side, the wastewater treatment using microalgae with oxidation ditch algae reactor (ODAR) to reduce organic matter also produces by-products that are harmful if dissolved in water. Processing in ODAR has Effluent Organic Matter (EfOM) and Algae Organic Matter (AOM) which are by-products of the microalgae process. The content of these compounds can lead to the formation of DBPs in water. This research was conducted on control variation (without microalgae) and variation of the volume of waste and microalgae 1:3, with oxic and oxic-anoxic conditions. Spectroscopy FTIR test is used to determine the organic matter contained through its functional groups. In the oxic-anoxic control variation, the FTIR percentage increased to 46.63% on the fifth day. In control oxic variation, it decreased to 46.12%. Meanwhile, in the oxic-anoxic 1:3 variation, the percentage decreased on the fifth day to 46.39%, and in oxic conditions, the rate was 46.8%. From the results obtained, the addition of microalgae can increase the content of organic matter in processing due to the by-products produced by microalgae and bacteria in processing.

Keywords: Oxidation Ditch Alga Reactor (ODAR), characterization, Chlorella sp., FTIR

Introduction

Biological treatment using microalgae is still rarely used in Indonesia. According to Sosa (2020), the use of algae in sewage treatment can be beneficial because algae have many advantages. Some of them are high growth rate, fast efficiency, and high biomass productivity. Wastewater processing using microalgae includes the Oxidation Ditch Algae Reactor. One of the studies regarding the treatment of gray water waste was carried out using Oxidation Ditch biological treatment by Ardhina (2018). She found that the algae used were able to remove 25.52% BOD.

Several studies state that the effluent from the biological treatment process of wastewater contains organic material called Effluent Organic Matter (EfOM). EfOM consists of refractory compounds, biodegradable residual substrates, intermediate substrates, organic compounds, and soluble microbial products (SMP). SMP is an organic compound produced in the substrate metabolism process (Jarusutthirak & Amy, 2007). Aside from that Oxidation Ditch using algae or Oxidation Ditch Algae Reactor (ODAR), the wastewater contains EfOM and Algae Organic Matter

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(AOM). Villacorte (2015) reported that AOM consists of the main ingredients of biopolymers (>50%), such as polysaccharides and proteins, while the remaining fraction consists of organic refractory substances such as humic-like substances and low molecules of heavy acids and neutral compounds. Leloup et al. (2013) stated that AOM is mainly composed of polysaccharides, proteins (30-55% dry algae biomass), peptides, amino acids, and organic materials such as fatty acids, which give it a highly hydrophilic character. It is known that AOM contains Extracellular Organic Matter (EOM) and Intracellular Organic Matter (IOM), which includes organic compounds such as proteins, peptides, amino sugars, and polysaccharides (Li et al., 2012). Extracellular Organic Matter is produced by living cells, and Intracellular Organic Matter is produced by autolysis of cells which is generated during population growth and decline. The production of AOM and the evolution of its characteristics depend on the species of microalgae, growth phase, the age of the culture, and environmental conditions (Leloup et al., 2013). AOM can cause operational problems in water treatment, such as an increase in Total Organic Carbon (TOC), a precursor to the formation of DBP, and others. Characterization of Effluent Organic Matter (EfOM) in wastewater needs to be done to determine the amount of content and ability to treat wastewater. The FTIR test method is used to identify organic compounds in EfOM and AOM in wastewater. This research will identify and compare the characteristics of Effluent Organic Matter (EfOM) on Oxidation Ditch with and without microalgae *Chlorella sp*. in terms of functional groups using the Fourier-Transform Infrared Spectroscopy (FTIR).

Research Method

Before the research started, microalgae seeding and acclimatization were carried out. During the seeding process, nutrients containing N, P, and K are given to help the growth of microalgae. The seedings process is carried out until the number of microalgae is as much as required. The following step is microalgae acclimatization that was carried out for five days to see the maximum acceptable limit for microalgae in the new environment.

Microalgae seeding is carried out by mixing mineral water and *Chlorella sp.* microalgae seeds in a container, with the ratio of microalgae and wastewater being 1:1. The time for seeding depends on the number of microalgae needed. The microalgae seeding will be completed when the required amount has been fulfilled. The growth of microalgae can be visually seen from the color change to the dark green. The growth of microalgae in the seeding process could be affected by various factors, such as light and the given nutrients.

After the microalgae needed have been fulfilled, the next step is microalgae *Chlorella sp* acclimatization. Acclimatization is done by introducing wastewater gradually from small to large concentrations to determine the ability of microalgae to adapt to a new environment and find out how resistant the algae were to pollutants in the wastewater. This process is carried out with a ratio of microalgae and waste of 1:1. In this study, acclimatization was carried out for five days.

The study was conducted using a volume of 250 liters of wastewater on each oxidation ditch. Next, prepare a brush aerator at a speed of 60 rpm. Oxic conditions are made by turning on the brush aerator non-stop. Oxic-anoxic conditions are caused by turning on the brush aerator for 7 hours (oxic prerequisites) and turning it off for 3 hours (anoxic conditions). Variations in the ratio of the volume of waste and microalgae used were control (without microalgae) and 1:3. The research period is five days for each variation. Samples were taken on days 1, 3, and 5. The type of microalgae used is *Chlorella sp*. The parameter used is FTIR spectroscopy to determine the functional groups contained in wastewater in the treatment of control variations and volume variations of 1:3.

Result and Discussion

FTIR spectroscopy was applied to identify functional groups present in organic matter produced by algae. The working principle of FTIR spectroscopy is that the infrared spectrum is generated after passing a beam of infrared (IR) light through a sample of Algae Organic Matter

(AOM). Absorption is noted when the frequency of IR light coincides with the vibrational frequency of covalent bonds in certain molecules present in Algae Organic Matter (AOM) (Villacorte et al., 2015). The results of the FTIR test are analyzed by looking at the specific peaks at certain wavelengths. The results of the FTIR test readings are shown in Figure 1.

Table 1. FTIR percentage ratio control and 1:3 oxic condition

Dominant Functional Group	Bond Diagnosis	Wavelength (cm^{-1})	% Transmittance CONTROL			% Transmittance RATIO 1:3		
			Day 1	Day 3	Day 5	Day 1	Day 3	Day 5
Phenols and Alcohol	H-bond dan O-H strain	3331.804	46,3	46,01	46,12	46,14	46,57	46,8
Amide	C=O strain	1636.025	67,85	67,48	67,39	67,83	67,72	67,40

Table 2. FTIR percentage ratio control and 1:3 oxic-anoxic condition

Dominant Functional Group	Bond Diagnosis	Wavelength (cm^{-1})	% Transmittance CONTROL			% Transmittance RATIO 1:3		
			Day 1	Day 3	Day 5	Day 1	Day 3	Day 5
Phenols and Alcohol	H-bond dan O-H strain	3331.804	46,33	46,48	46,63	47,1	46,82	46,39
Amide	C=O strain	1636.025	67,58	67,73	67,88	68,13	67,97	67,65

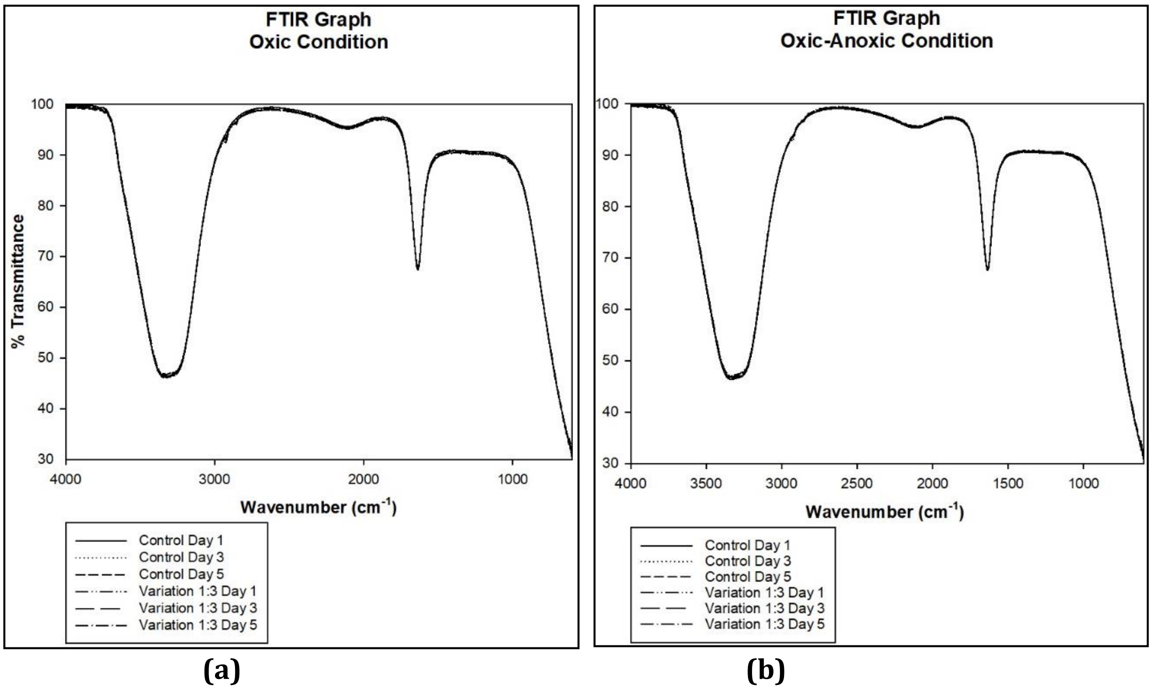

Figure 1. Spectrum Analysis FTIR Ratio Control and 1:3 (a) Oxic ; (b) Oxic-Anoxic Condition

Referring to the results of the FTIR test, the highest organic matter contained in wastewater was the organic matter in the phenol, alcohol, and amide functional groups. The results of the infrared spectrum in all variations show peaks at wavenumbers 3331,804 cm^{-1} and 1636,025 cm^{-1}. The wavenumber 3331,804 cm^{-1} is the strain of the phenol and alcohol functional groups (H and O-H bonds), while the wavenumber 1636,025 cm^{-1} is the strain of the amide functional group

(C=O). Alcohol is a functional group that belongs to the neutral hydrophobic and hydrophilic neutral fraction, while the phenol functional group is included in the hydrophobic acid fraction, and the amide functional group belongs to the neutral hydrophilic fraction. These functional groups belong to functional groups that can lead to the formation of halo acetic acids (HAAs) (Kanokkantapong et al., 2006). HAAs are a form of Disinfection by-products (DBPs) that can cause cancer if they accumulate in body tissues.

From table 4.3, transmittance values for the control variation (without algae) and the variation in a different volume ratio of the microalgae *Chlorella sp.* and wastes under oxic and oxic-anoxic conditions. The condition of the oxic control variation has a transmittance value that tends to decrease. The transmittance value of FTIR in oxic states at wavenumber 3331,804 cm^{-1}, the first day is 46.3% and the fifth day is 46.12%, and at a wavenumber of 1636,025 cm^{-1} on the oxic conditions on the first day, it was 67.85% and 67.39% on the fifth day. Meanwhile, in oxic-anoxic condition, transmittance value tends to increase, at wavenumber 3331,804 cm^{-1} on the oxic-anoxic conditions on the first day it was 46.33% and 46.63% on the fifth day it and at a wavenumber of 1636,025 cm^{-1} on the first day, it was 67.58% and 67,88% on the fifth day. This indicates that aromatic organic matter in oxic-anoxic conditions decreased more optimally than in oxic conditions. According to Sedyanto (2018), the increase in the percentage of transmittance indicates that the content of functional groups contained in the adsorbent is decreasing. This increase in transmittance percentage indicates that more organic matter is being removed (Rizqa, 2019). Thus it can be said that the control variables of oxic-anoxic conditions is more effective because the adsorbent value in wastewater is less than the other variations.

Meanwhile, in the volume ratio variation with oxic and oxic-anoxic conditions, it was identified that it tended to decrease, except for oxic conditions in the 3331,804 cm^{-1} wavenumbers with the percent transmittance value on the first day of 46.14% to 46.8% on the fifth day. In the 1636,025 cm^{-1} waves, the percent transmittance value decreased by 67.83% on the first day and 67.40% on the fifth day. From the results obtained, it is known that the organic matter in the amide functional group has increased. In the oxic-anoxic variation of 1:3, it was identified that the percent transmittance value of the alcohol, phenol, and amide functional groups decreased. On the first day, the percent transmittance value was 47.1% and then decreased by 46.39% on the fifth day. This is due to the addition of microalgae in wastewater, thereby increasing the value of the adsorbent, which is possible from the by-products of the microalgae processing process in the form of AOM, EfOM, and the microalgae itself.

Conclusion

The characteristics of EfOM in oxidation ditch processing without microalgae (control) under oxic and oxic-anoxic conditions, namely the highest FTIR functional groups, namely phenol, alcohol, and amide functional groups. The highest FTIR functional groups were found, namely phenol, alcohol, and amide functional groups with the highest organic matter reduction effectiveness found in oxic-anoxic conditions as evidenced by the increased transmittance value of 46.63% in alcohol and phenol functional groups and 67.88% in amide. Characteristics of EfOM in ODAR processing using microalgae *Chlorella sp*. was found that the increase in organic matter was indicated by a decrease in the transmittance value until the fifth day in oxic-anoxic conditions with a decrease in the transmittance value in the phenol and alcohol functional groups by 46.39% and in the amide group by 67.65%. In oxic conditions, the amide functional group decreased by 67.40% and increased to 46.8% in the phenol and alcohol functional groups.

Comparison of the characteristics of EfOM content in oxidation ditch treatment without microalgae with ODAR, namely oxidation ditch treatment without microalgae, is quite effective when used to reduce organic content because it is produced in the processing not as much as microalgae treatment. While the treatment with ODAR is effective in reducing organic matter due to the assistance of the microalgae *Chlorella sp*. However, with the addition of microalgae, the content of organic matter in the form of by-products of treatment using microalgae can increase, resulting in the formation of DBPs in the waters. Aeration conditions in the study did not have much effect, because in oxic-anoxic conditions there was still dissolved oxygen content that helped the processing and formation of organic by-products.

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