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JUDUL ARTIKEL : THE TREATMENT OPTIMIZATION OF ELECTROCOAGULATION (EC) PROCESS IN PURIFYING THE PALM OIL MILL EFFLUENTS (POMES)

PENULIS : RUSDIANASARI, AHMAD TAQWA, JAKSEN, ADI SYAKDANI

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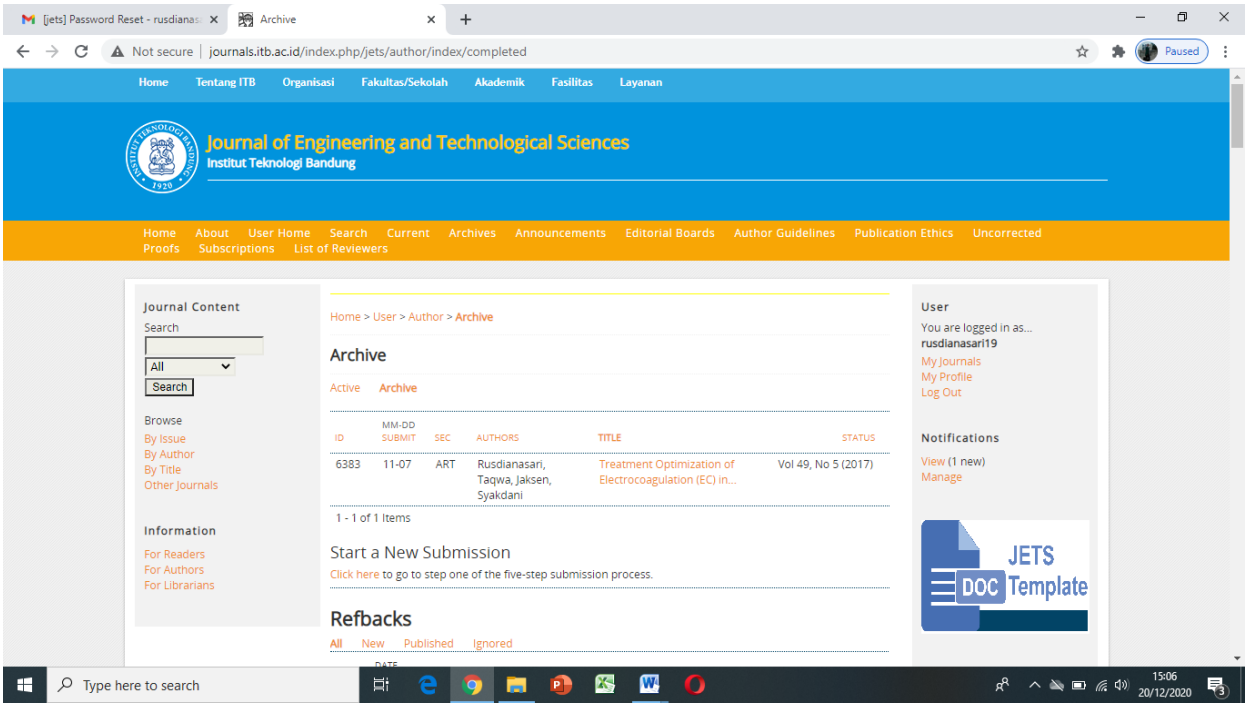

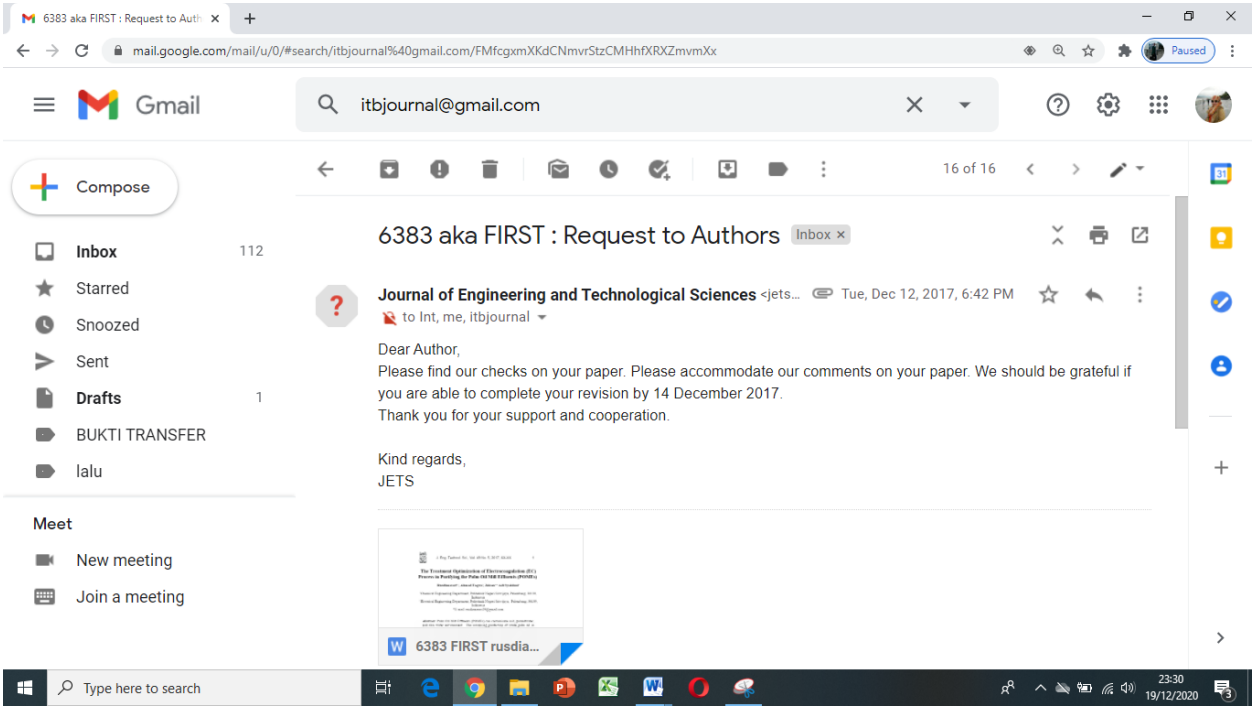

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The Treatment Optimization of Electrocoagulation (EC) Process in Purifying the Palm Oil Mill Effluents (POMEs)

Rusdiansari[1,*], Ahmad Taqwa[1], Jakrea[1] & Adi Syakdani[2]

[1]Chemical Engineering Department, Politeknik Negeri Sriwijaya, Palembang, 30139, Indonesia
[2] Electrical Engineering Department, Politeknik Negeri Sriwijaya, Palembang, 30139, Indonesia
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Abstract. Palm Oil Mill Effluents (POMEs) can contaminate soil, groundwater, and also water environment. The increasing production of crude palm oil in Indonesia produces enormous amount of POMEs waste. Therefore, it is needed a method that can be used in processing POMEs. One of them is using electrocoagulation (EC) method. In this paper, EC method for purification of the wastewater and design the optimization of this method are presented. The optimization was performed by varying the voltage and processing time. The applied voltages were 6V, 9V, and 12V and the processing time were between 30 and 150 minutes. The measured parameters included COD, BOD35, pH, TSS, lipid and NH3-N. The result showed that the optimum condition was got at voltage of 12 V and a processing time of 150 minutes, with a COD value of 8000 mg/L; BOD35 of 12000 mg/L; pH of 7.46; TSS of 324 mg/L; lipid of 17.8 mg/L; NH3-N concentration of 0.65 mg/L. The results are in accordance with environmental quality standards. This study shows that the EC method is an effective method in purifying POMEs from any pollutants.

Keywords: *wastewater treatment, electrocoagulation (EC), POMEs, aluminum electrode*

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1 Introduction

Palm oil mill effluents (POMEs) that are disposed to the environment without any treatment can be one of dangerous pollutants, especially to the water such as rivers, swamps and lakes. POMEs production in Indonesia is estimated around 28.7 million ton each year. They become potential environmental pollutants due to their smell, COD, BOD contamination and the high total suspended solid. In most cases, POMEs consists of floating, dissolved solids and oil in its water emulsion. Besides that, it usually also contains inorganic and organic compounds which some of them cannot be decomposed by microorganisms. In general, waste that contains organic compounds can be decomposed by bacteria using biological methods, i.e., biological wastewater treatment. This treatment can be applied to the POMEs using aerobic and

anaerobic processes [1,2]. Besides biological methods, there are various methods that can be applied to the POMEs treatment, i.e., anaerobic bioreactor hybrid [3,4], coagulation and flocculation method using a coagulant [5,7], methane emission from anaerobic ponds [8], synthetic polyelectrolytes [9,10] and electrocoagulation (EC) method [11].

Electrocoagulation (EC) is one of the most effective methods in wastewater treatment. This method is popular since this method can process the effluent into the wastewater that can be reused. The main issue arises nowadays is that how to process industrial and domestic wastewater into pure water before disposing it to waste inland. This issue leads to the increasing of researches looking for new and effective method for purifying the wastewater. Although many researches already discussed the effectiveness of EC, however there is always a desire to find a better technique for EC in order to increase its effectiveness [12].

EC method is based on the electrolysis cell that consist of device that can make electrical energy DC (direct current) to produce an electrolysis reaction. The basic principle of EC is a reaction of reduction and oxidation (redox). In addition to the electrode EC reaction, a treated water that serves as an electrolyte solution was also involved [13].

POMEs can be treated effectively using EC method due to it is economical, environmentally-friendly and the result of wastewaters that are processed using EC can fulfill the standard of pure water. EC is a process of coagulation using a direct current through electrochemical processes that acts as electrolyte decomposition. The aim of this study is to determine the effects of voltage on the performance of the EC method and determine the best time for POMEs treatment.

2 Experimental

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The EC method in this study used aluminum as its anode and cathode. The process of EC was done in batches. It is intended to decrease the concentration of COD, BOD, TSS, lipid, NH-N and to increase the acidity value in the POMEs so that they will not pollute the environment when they are disposed to the environment.

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2.1 POMEs Sample

The POMEs samples came from some industries located in South Sumatra, Indonesia. The compositions of the POMEs samples in this study are characterized in order to assess the COD, BOD, TSS, NH-N and lipid.

2.2 Experimental Device

The experiment was conducted in batches as shown in Figure 1. The electrochemical unit consists of an EC cell, a DC power supply and the aluminum as its electrode. In this experiments, two mono polar electrodes with the same dimension act as the anode and the cathode. These electrodes were separated each other with distance of 10 mm. The composition was kept the same by turning the speed of stirrer up to 300 rpm. This speed is also intended to avoid the association of the flocs in the solution. After one batch was completed, all of the electrodes were cleaned up using HCl dilution. All of the experiment was conducted in room temperature [14].

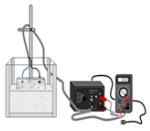

Figure 1 Scheme of EC Process

2.3 Experiment Procedure

The experiments in this study were conducted in batches using 500 mL POMEs sample for each test. The samples were treated with EC cells by dipping two electrodes as mentioned before. The setting voltages were 6, 9, and 12 V. The processing time was set to be 30, 60, 90, 120, and 150 minutes. The voltage was set up to 12 V due the significant results can be achieved in this voltage.

After each EC process, the samples were conditioned in room temperature for 15 minutes to let the flocs settle down. The next treatment was collecting the supernatant sample to perform the determination of COD, BOD, pH, TSS, NH-N, and lipid.

2.4 COD, BOD_5 and TSS Determination

COD and BOD_5 of the POMEs before and after EC were determined based on the standard methods of water and wastewater examination [15]. COD was analyzed using the closed reflux titrimetric method. This method involves refluxing the known volume of samples with an oxidizing agent in a closed ampule at 150°C for two hours and titrating the excess oxidizing agent with standard ferrous ammonium sulphate using ferroin as indicator. BOD_5 determination involves overflowing the sample into a BOD bottle of the specified size and incubating it at 20°C temperature for 5 days. TSS determination was using gravimetric method

2.5 Lipid Determination

Lipid content was determined using extraction method, i.e., by separating layers of water with its solvent. 10 gram Na_2SO_4 anhydrate filter was used to clean the solvents. The extraction centrifuged in 5 minutes with 2400 rpm of angular velocity. This method was conducted several times until no emulsion detected.

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3 Results and Discussion

The result that shows the comparison of unprocessed and processed POMEs using EC method is shown in Table 1.

Table 1 Unprocessed and processed POMEs using EC method

Properties/test	Unprocessed	Processed
BOD_5 mg/L	23700	12000
COD mg/L	45000	8000
TSS mg/L	12000	324
Lipid mg/L	100.4	17.8
NH3-N mg/L	3.73	0.65
pH	4.48	7.46

3.1 Effect of Voltage to Processing Time for COD

COD was the quantity of oxidant that reacted with the samples in a certain condition. The amount of oxidant used was proportional to the oxygen needs. Both organic and inorganic compounds in the sample were oxidized subjects,

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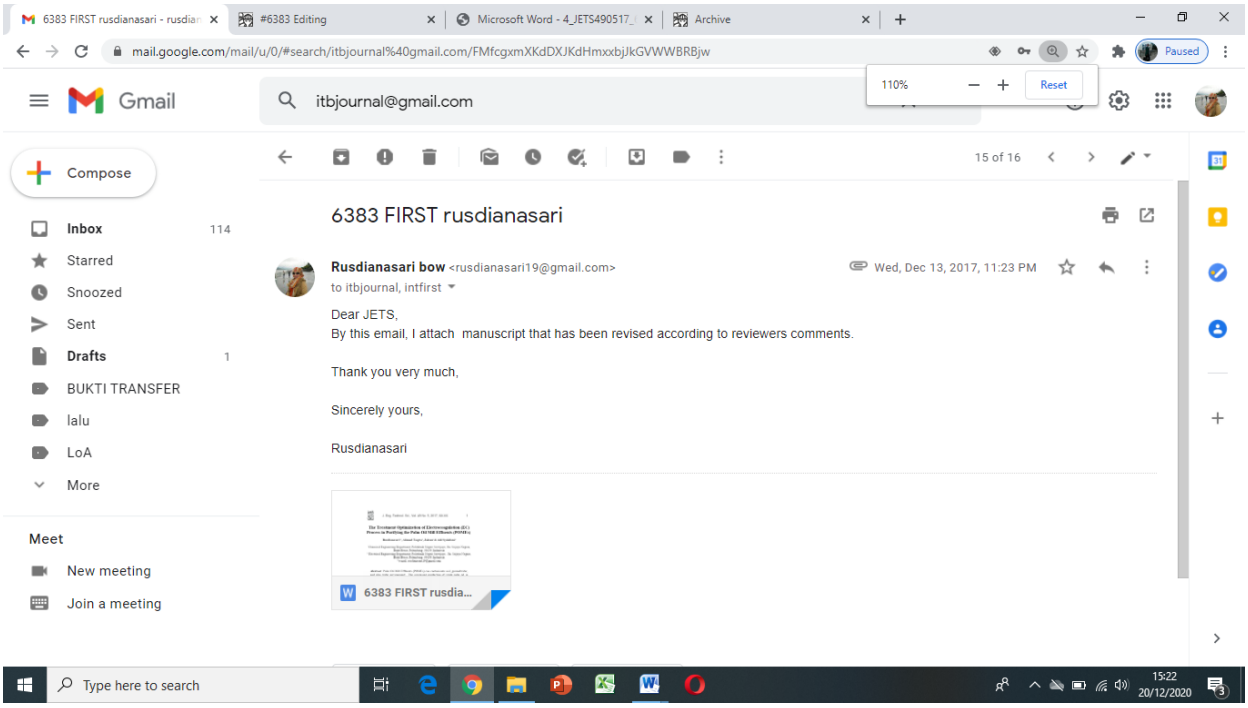
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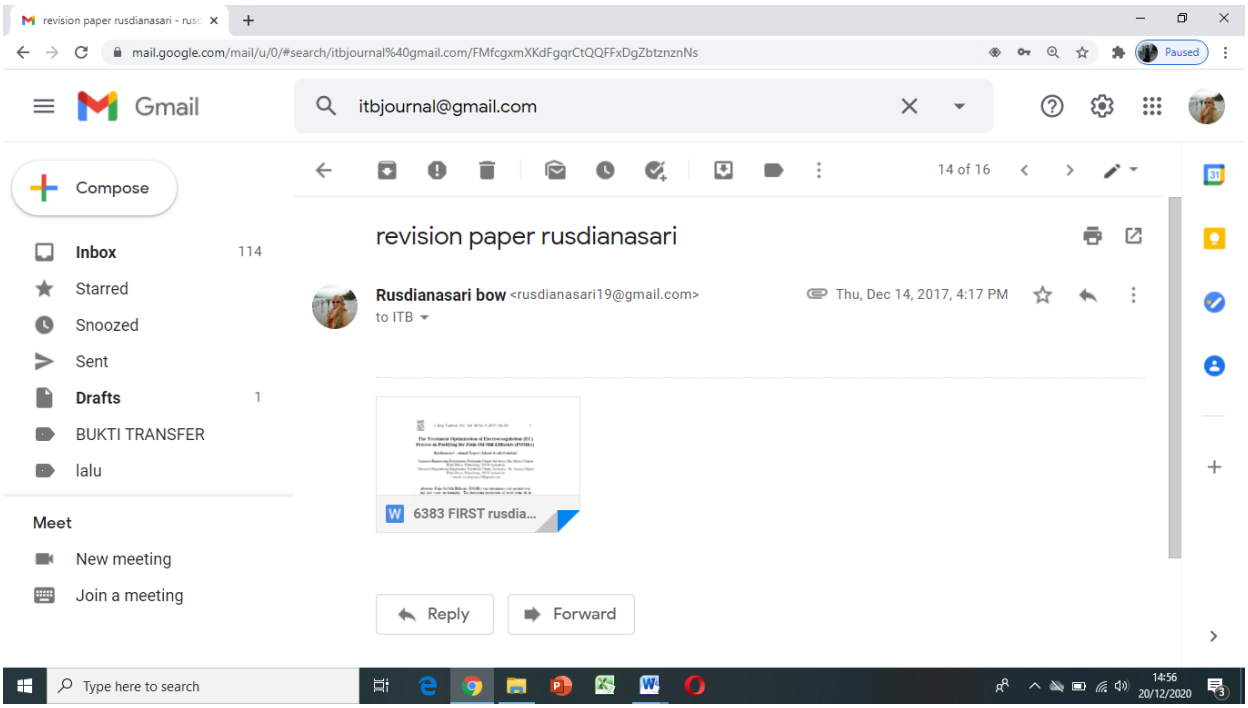
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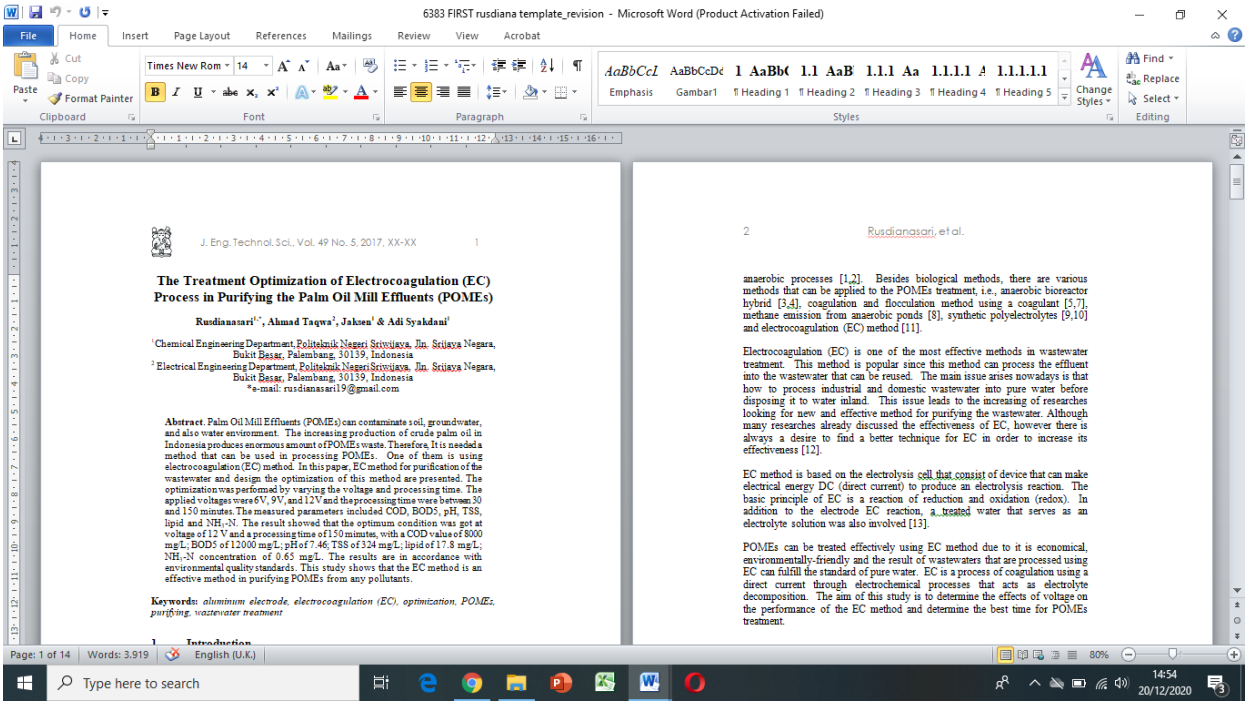

J. Eng. Technol. Sci., Vol. 49 No. 5, 2017, XX-XX 1

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[1]Chemical Engineering Department, Politeknik Negeri Sriwijaya, Jln. Srijaya Negara, Bukit Besar, Palembang, 30139, Indonesia
[2] Electrical Engineering Department, Politeknik Negeri Sriwijaya, Jln. Srijaya Negara, Bukit Besar, Palembang, 30139, Indonesia
*e-mail: rusdianasari19@gmail.com

Abstract. Palm Oil Mill Effluents (POMEs) can contaminate soil, groundwater, and also water environment. The increasing production of crude palm oil in Indonesia produces enormous amount of POMEs waste. Therefore, It is needed a method that can be used in processing POMEs. One of them is using electrocoagulation (EC) method. In this paper, EC method for purification of the wastewater and design the optimization of this method are presented. The optimization was performed by varying the voltage and processing time. The applied voltages were 6V, 9V, and 12V and the processing time were between 30 and 150 minutes. The measured parameters included COD, BOD5, pH, TSS, lipid and NH_3-N. The result showed that the optimum condition was got at voltage of 12 V and a processing time of 150 minutes, with a COD value of 8000 mg/L; BOD5 of 12000 mg/L; pH of 7.46; TSS of 324 mg/L; lipid of 17.8 mg/L; NH_3-N concentration of 0.65 mg/L. The results are in accordance with environmental quality standards. This study shows that the EC method is an effective method in purifying POMEs from any pollutants.

Keywords: *aluminum electrode, electrocoagulation (EC), optimization, POMEs, purifying, wastewater treatment*

1 Introduction

2 Rusdianasari, et al.

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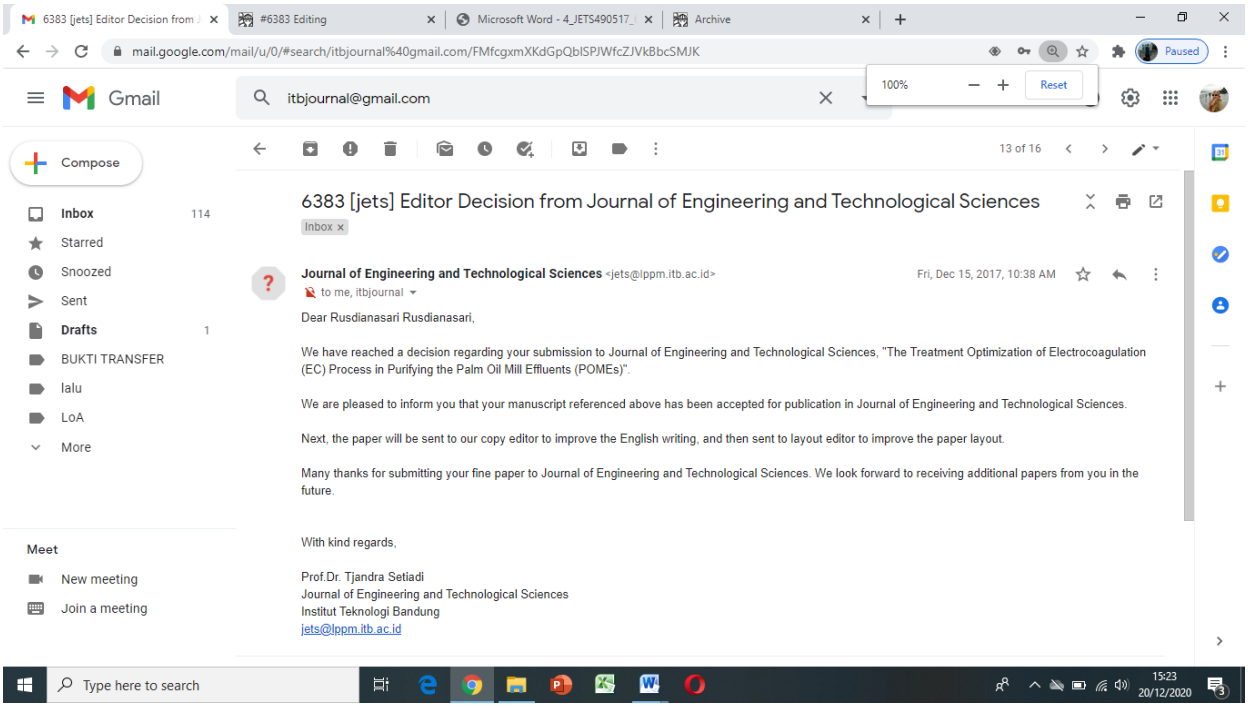

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Dear Rusdianasari Rusdianasari,

We have reached a decision regarding your submission to Journal of Engineering and Technological Sciences, "The Treatment Optimization of Electrocoagulation (EC) Process in Purifying the Palm Oil Mill Effluents (POMEs)".

We are pleased to inform you that your manuscript referenced above has been accepted for publication in Journal of Engineering and Technological Sciences.

Next, the paper will be sent to our copy editor to improve the English writing, and then sent to layout editor to improve the paper layout.

Many thanks for submitting your fine paper to Journal of Engineering and Technological Sciences. We look forward to receiving additional papers from you in the future.

With kind regards,

Prof.Dr. Tjandra Setiadi
Journal of Engineering and Technological Sciences
Institut Teknologi Bandung
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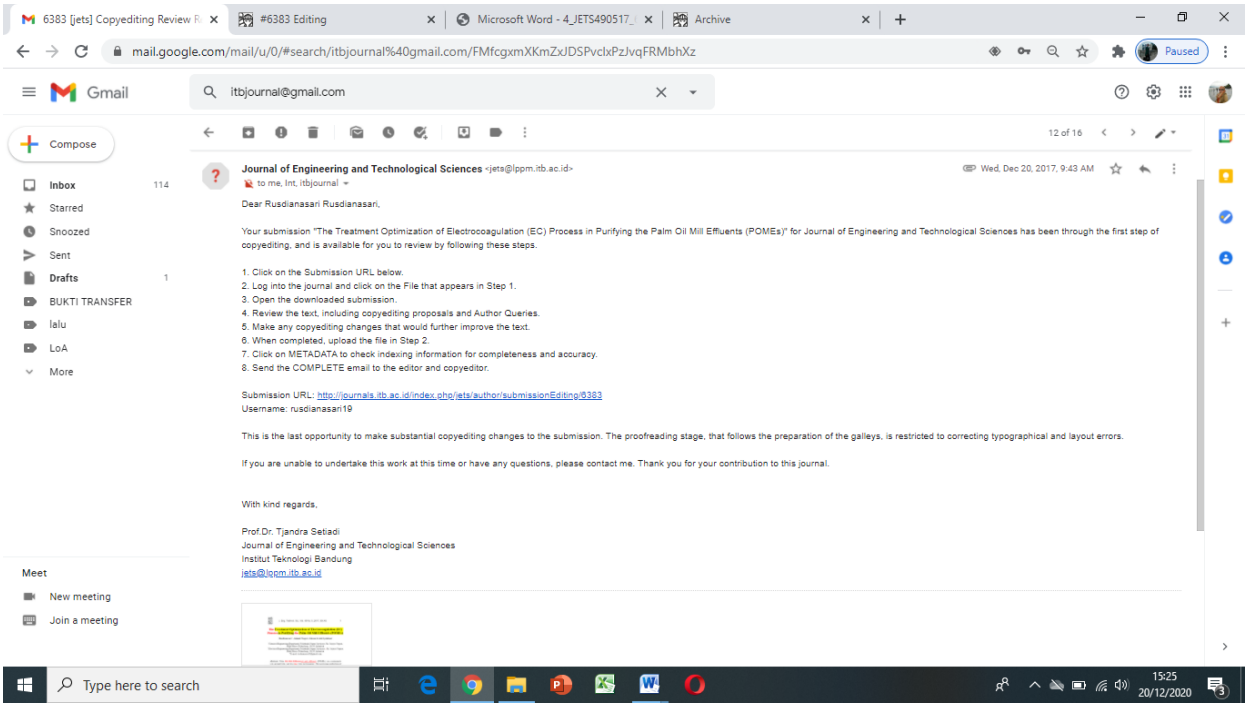
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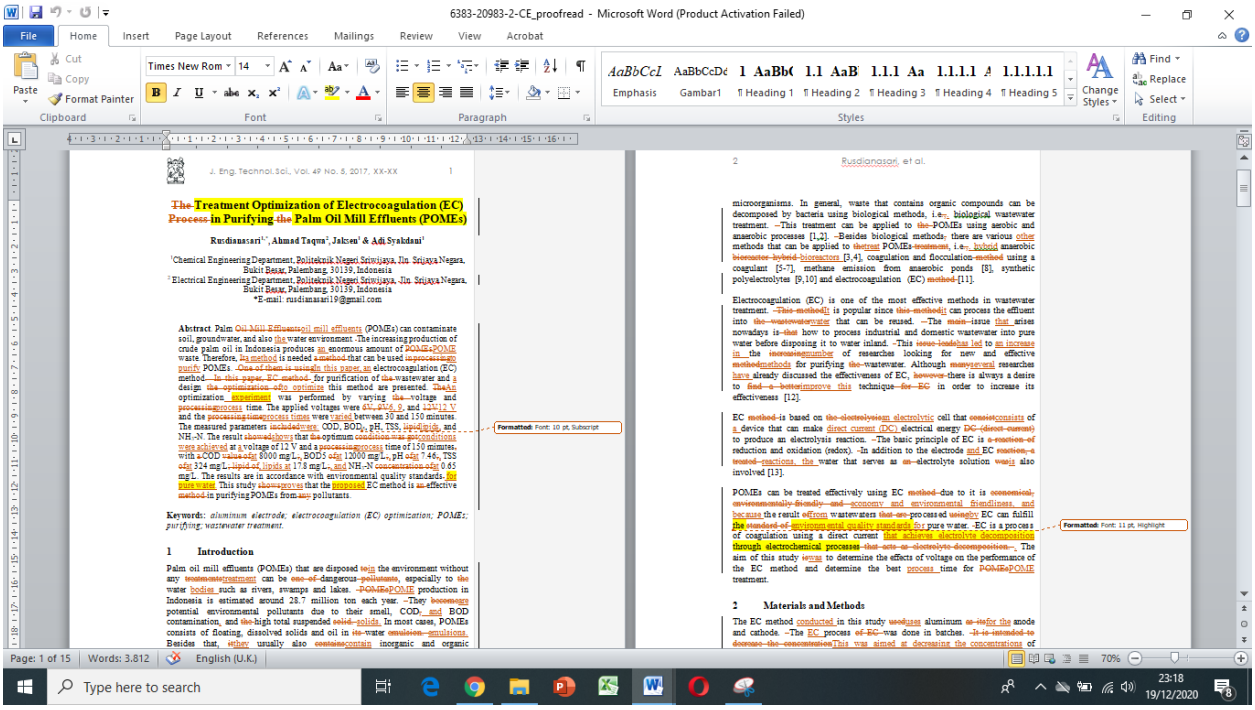
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J. Eng. Technol. Sci., Vol. 49 No. 5, 2017, XX-XX
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Rusdianasari[1,*], Ahmad Taqwa[2], Jakses[1] & Adi Syakdani[1]
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Abstract
Keywords: aluminium electrode; electrocoagulation (EC) optimization; POMEs; purifying; wastewater treatment.
1 Introduction
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2 Materials and Methods
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value ~~of~~ the POMEs, so that they will not pollute the environment when they are disposed ~~in~~ the environment.

~~1. POMEs Sample~~
1. POME samples

The ~~POME~~POME samples came from ~~some~~several industries located in South Sumatra, Indonesia. ~~The~~ compositions of the ~~POME~~POME samples in this study ~~are~~were characterized in order to assess the COD, ~~BOD~~BOD, TSS, NH_3-N, and lipid content.

2. Experimental ~~Device~~device

The experiment was conducted in batches as shown in Figure 1. The electrochemical unit ~~consists~~consisted of an EC cell, a DC power supply and ~~them~~ aluminum ~~as its~~ electrode. ~~In the~~the experiments, two ~~mono polar~~monopolar electrodes with the same ~~dimension set~~dimensions acted as the ~~a~~ anode and ~~the~~ cathode. ~~These~~ electrodes were separated ~~from~~ each other ~~with~~by a distance of 10 mm. ~~The~~ composition was kept the same by turning the speed of ~~the~~ stirrer up to 100 rpm. ~~This~~ speed ~~was~~ also intended to avoid the association of ~~the~~ flocs in the solution. ~~After~~ one batch was completed, all of the electrodes were cleaned ~~up~~ using HCl dilution. ~~All of the~~The whole experiment was conducted ~~in~~at room temperature [14].

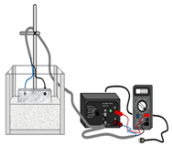

Figure 1 Scheme of ~~EC Process~~the experimental unit

~~3. Experiment Procedure~~
3. Experimental procedure

The experiments in this study were conducted in batches using a 500-mL ~~POME~~POME sample for each test. ~~The~~ samples were treated ~~with~~by EC cells ~~by dipping~~with two electrodes as mentioned before. ~~The setting voltage~~voltage settings were 6, 9, and 12 V. The ~~process~~process time was set to ~~be~~ 30, 60, 90, 120, and 150 minutes. ~~The~~ voltage was set up to 12 V due ~~to~~because significant results can be achieved ~~in~~at this voltage. After each EC process, the samples were conditioned ~~in~~at room temperature for 15 minutes to let the flocs settle down. The next treatment was collecting the supernatant sample to perform the determination of COD, ~~BOD~~BOD, pH, TSS, NH_3-N, and ~~lipid~~lipids.

4. COD, BOD_5 and TSS ~~Determination~~determination

The COD and BOD_5 of the ~~POME~~POME samples before and after EC were determined based on the standard methods ~~for~~ water and wastewater examination [15].~~ COD was analyzed using the closed reflux titrimetric method. This method involves refluxing the known volume of the samples with an oxidizing agent in a closed ampule at ~~150°C~~150 °C for two hours and ~~titrating~~ the excess oxidizing agent with standard ferrous ammonium sulphate using ~~ferroin~~ as indicator. BOD_5 determination involves overflowing the sample into a BOD bottle of ~~the~~a specified size and incubating it at ~~20°C~~20 °C temperature for 5 days. TSS determination was done using the gravimetric method.

5. Lipid ~~Determination~~determination

Lipid content was determined using extraction ~~method~~, i.e., by separating layers of water with ~~the~~a solvent. ~10 gram Na_2SO_4 anhydrate filter was used to clean the ~~solvent~~solvent. The extraction was centrifuged ~~for~~ 5 minutes ~~with 2400 rpm of~~at an angular velocity of 2400 rpm. This method was conducted several times until no ~~more~~ emulsion was detected.

3 Results and Discussion

~~The result that shows the~~ A comparison ~~of~~between the unprocessed POMEs and the POMEs processed ~~POMEs~~ using EC ~~method~~ is shown in Table 1.

Table 1 Unprocessed and processed POMEs ~~using EC method~~

Properties/test	Unprocessed	Processed

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~~BOD~~ BOD_5 ~~mgL^{-1}~~	23700	12000
COD ~~mgL^{-1}~~	45000	8000
TSS ~~mgL^{-1}~~	12000	324
~~Lipid~~Lipids ~~mgL^{-1}~~	100.4	17.8
NH_3-N ~~mgL^{-1}~~	3.73	0.65
pH	4.48	7.46

3.1 Effect of Voltage ~~to Processing Time~~on Process time for COD

The COD ~~was~~is the quantity of oxidant that ~~reacted~~reacts with the samples in a certain condition. The amount of oxidant used ~~was~~is proportional to the oxygen ~~needed~~need. Both organic and inorganic compounds in the sample ~~were~~are oxidized ~~subjects~~, however~~,~~, the organic ~~was~~compounds are more dominant. COD is often used as ~~a measurement of~~ the quantity of pollutants ~~measurement~~ in ~~the~~ water.

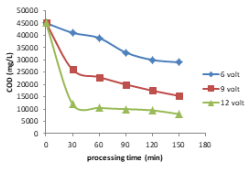

Figure 2 Effect of ~~Voltage to Processing Time~~voltage on process time of COD

Figure 2 shows that the best ~~result~~result in decreasing the COD of the POMEs after being processed using EC ~~method that used with~~ 12 ~~Volts voltage~~V was reached at 150 minutes. The COD in this condition decreased drastically, from 45000 mg/L to 8000 mg/L. ~From Figure 2, it can be concluded that the longer the contact time and the greater the voltage ~~was~~, the greater the reduction of COD ~~would be~~. ~~It was~~. This is due to the reduction and oxidation ~~process~~processes in the EC reactor ~~was~~being faster along with the ~~increasing of~~

They ~~would~~ affect the reduction of COD. ~~The~~ hydrogen gas ~~would~~ being ~~collide~~brings colloid impurities to the surface of the reactor (flotation). ~~It was~~This is characterized by the existence of a ~~lot~~large quantity of bubbles or ~~foam~~foam that ~~brought~~carries the dirt ~~on~~to the surface of the reactor. ~Based on the ~~theory of~~ double layer theory, the reduction of COD ~~was~~is due to the ~~floc~~flocs formed by the organic ~~ion compound~~ ~~ion that was~~ associated with positive coagulant ~~ion~~ ions. The molecules in the effluent ~~merges~~ turned ~~to floc~~into flocs, colloidal particles in the effluent that bind the particles [15].

The reduction of COD ~~occurring~~ during EC ~~occurred~~occurs due to destabilization. Colloidal destabilization ~~was~~ carried ~~out~~occurs by metal cations that ~~form~~form polyvalent polyhydroxide. This complex compound ~~has~~has high adsorption. ~~Thus, it can~~ simplify the process of aggregation with various pollutants ~~in order~~ to form ~~big material~~large flocs that ~~could~~can be easily separated using a flotation technique ~~for~~through which the density of the ~~material become~~ bubbles ~~more~~ smaller.

3.2 Effect of Voltage ~~to Processing Time~~on Process time for BOD_5

Figure 3 shows the decreasing value of ~~BOD~~BOD_5 after the EC process ~~to POMEs~~. From the graph in Figure 3, it can also be seen that the best result of the ~~BOD~~BOD_5 reduction ~~of BOD~~ was at ~~the~~a time of 150 minutes with a voltage of 12 Volts, where the BOD_5 value ~~was~~ changed from 23700 mg/L to 3910 mg/L. ~Based on the graph in Figure 3, it can be concluded that the greater the voltage ~~used~~, the lower the value of ~~BOD~~BOD_5. This ~~happened~~happens because the stability of the colloidal ~~system~~system suspended in the liquid waste samples ~~was~~is disturbed by the addition of aluminum ions ~~that~~coming from the oxidation process ~~at~~ the anode. ~Al^{3+} ions ~~that~~-included in the samples ~~reduced~~reduce the zeta potential. ~~This~~ ~~means it reduced~~It is the charge difference on the surface of the samples~~—~~ is reduced. The ~~reduction~~reduction of this charge difference ~~would reduce~~reduces the thickness of the diffuse layer and ~~disturb~~disturbs the stern layer. ~~This situation would reduce~~reduces or ~~eliminate~~eliminates the repulsive force ~~among~~between adjacent particles~~—~~It ~~load~~, which leads to ~~the happening of~~ coagulation ~~process~~. ~~Compare~~ Compared to 6 ~~volt~~ and 9 ~~volts~~V, drastic BOD reduction occurred ~~at~~ 12 ~~Volts. It was~~V. This is due to the ~~greater~~ voltage ~~was~~increases that is proportional to the ~~increasing of~~ current~~—~~It ~~load~~ increases. This leads to ~~the~~ greater speed of the coagulated particles ~~that would decrease~~, which decreases the amount of suspended particles. ~~The fewer~~smaller the number of particles and the smaller the particles ~~size were~~are, the bigger the currents ~~were~~ needed and the ~~greater~~longer the ~~coagulated~~coagulation time ~~would be~~.

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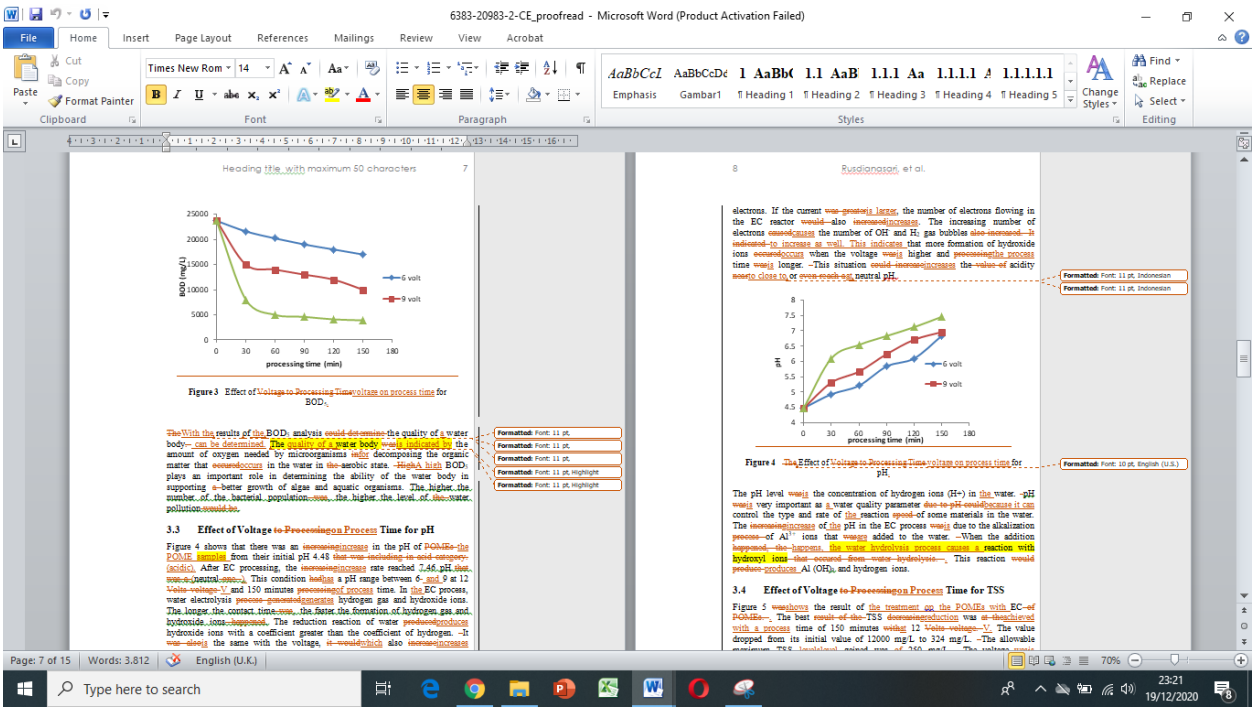
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BOD (mg/L)
processing time (min)
6 volt
9 volt
Figure 3 Effect of Voltage to Processing Time voltage on process time for BOD5
3.3 Effect of Voltage to Processingon Process Time for pH
Figure 4 shows that there was an increasingincrease in the pH of POMEs the POME samples from their initial pH 4.48 that was including in acid category (acidic). After EC processing, the increasingincrease rate reached 7.46 pH, that was is neutral (nor.). This condition hadhas a pH range between 6- and 9 at 12 Volts voltage V and 150 minutes processingof process time. In the EC process, water electrolysis process generatedgenerates hydrogen gas and hydroxide ions. The longer the contact time was, the faster the formation of hydrogen gas and hydroxide ions happened. The reduction reaction of water producedproduces hydroxide ions with a coefficient greater than the coefficient of hydrogen. It was also is the same with the voltage, it wouldwhich also increaseincreases
electrons. If the current was greateris larger, the number of electrons flowing in the EC reactor would also increasedincreases. The increasing number of electrons causedcauses the number of OH and H2 gas bubbles also increased. It indicated to increase as well. This indicates that more formation of hydroxide ions occursoccurs when the voltage wasis higher and processingthe process time wasis longer. This situation could increaseincreases the value of acidity nearto close to or even reach not neutral pH.
pH
processing time (min)
6 volt
9 volt
Figure 4 The Effect of Voltage to Processing Time voltage on process time for pH
The pH level wasis the concentration of hydrogen ions (H+) in the water. pH wasis very important as a water quality parameter due to pH couldbecause it can control the type and rate of the reaction speed of some materials in the water. The increaseincrease of the pH in the EC process wasis due to the alkalization process of Al3+ ions that wasare added to the water. When the addition happened the because the water hydrolysis process causes a reaction with hydroxyl ions that occured from water hydrolysis. This reaction would produce produces Al (OH)3 and hydrogen ions.
3.4 Effect of Voltage to Processingon Process Time for TSS
Figure 5 wasshows the result of the treatment on the POMEs with EC of POMEs. The best result of the TSS decreaseinreduction was at thachieved with a process time of 150 minutes withat 12 Volts voltage V. The value dropped from its initial value of 12000 mg/L to 324 mg/L. The allowable
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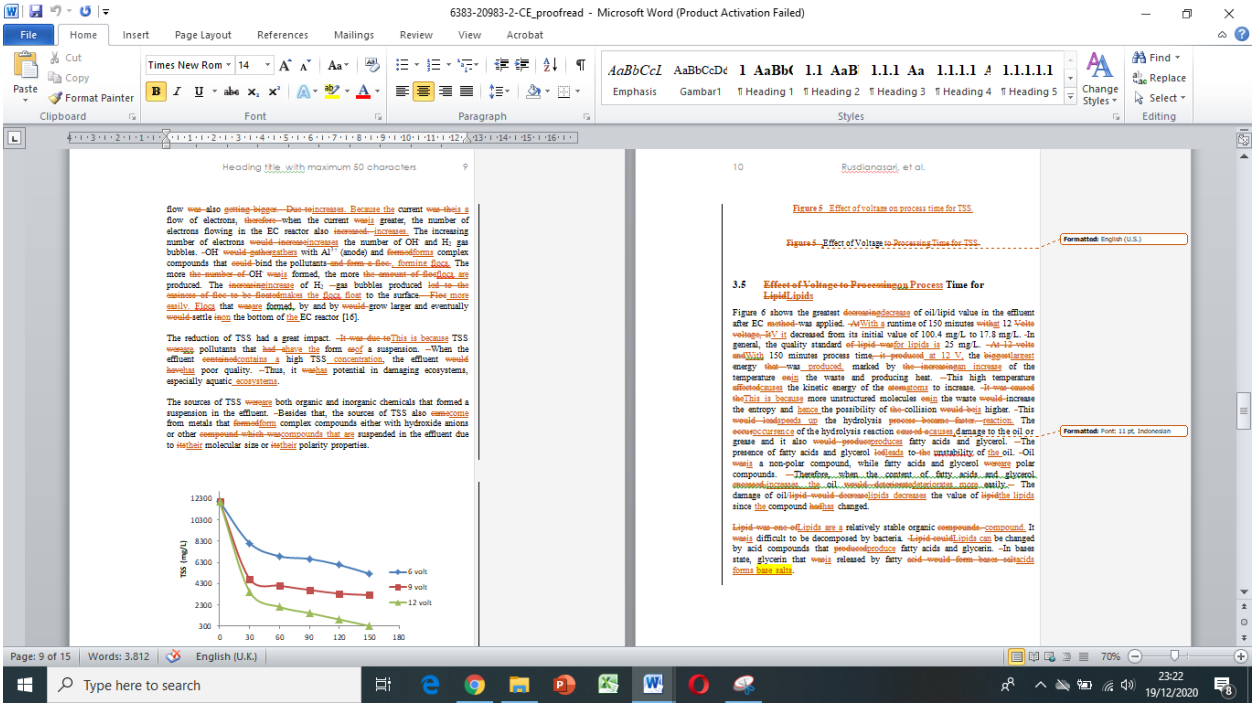
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TSS (mg/L)
6 volt
9 volt
12 volt
Figure 5 Effect of voltage on process time for TSS
Figure 5 Effect of Voltage to Processing Time for TSS
3.5 Effect of Voltage to Processingon Process Time for LipidLipids
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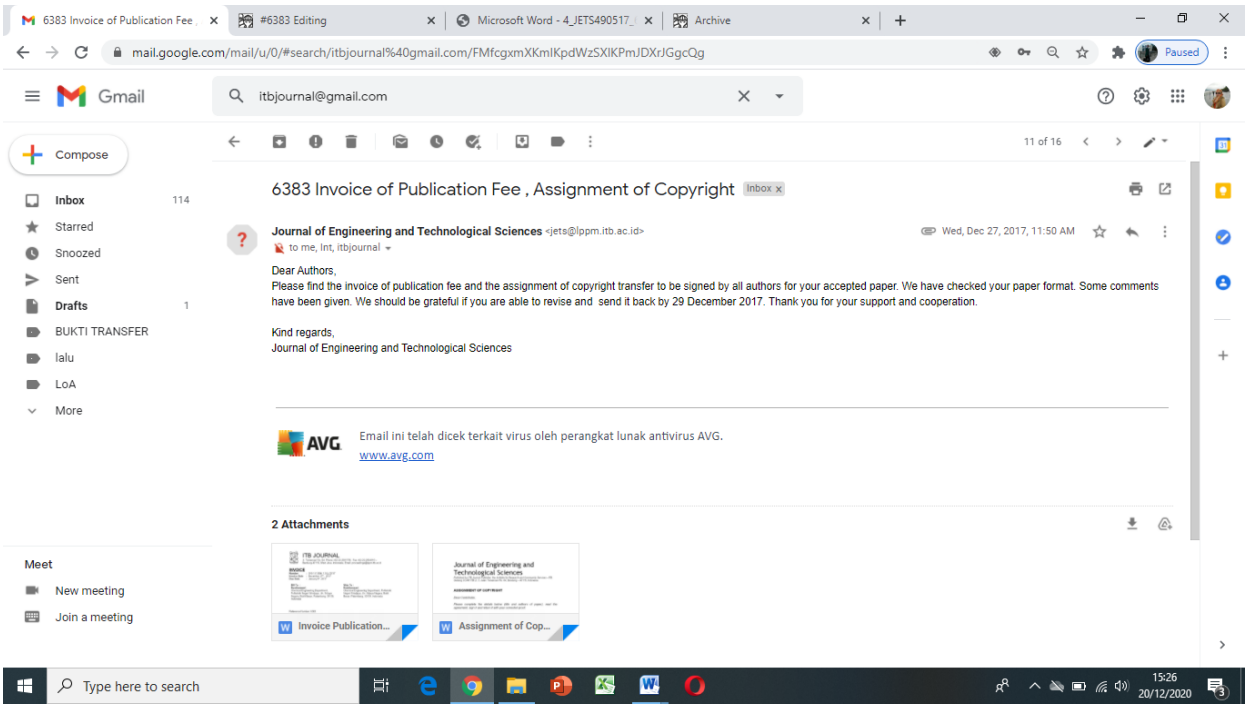
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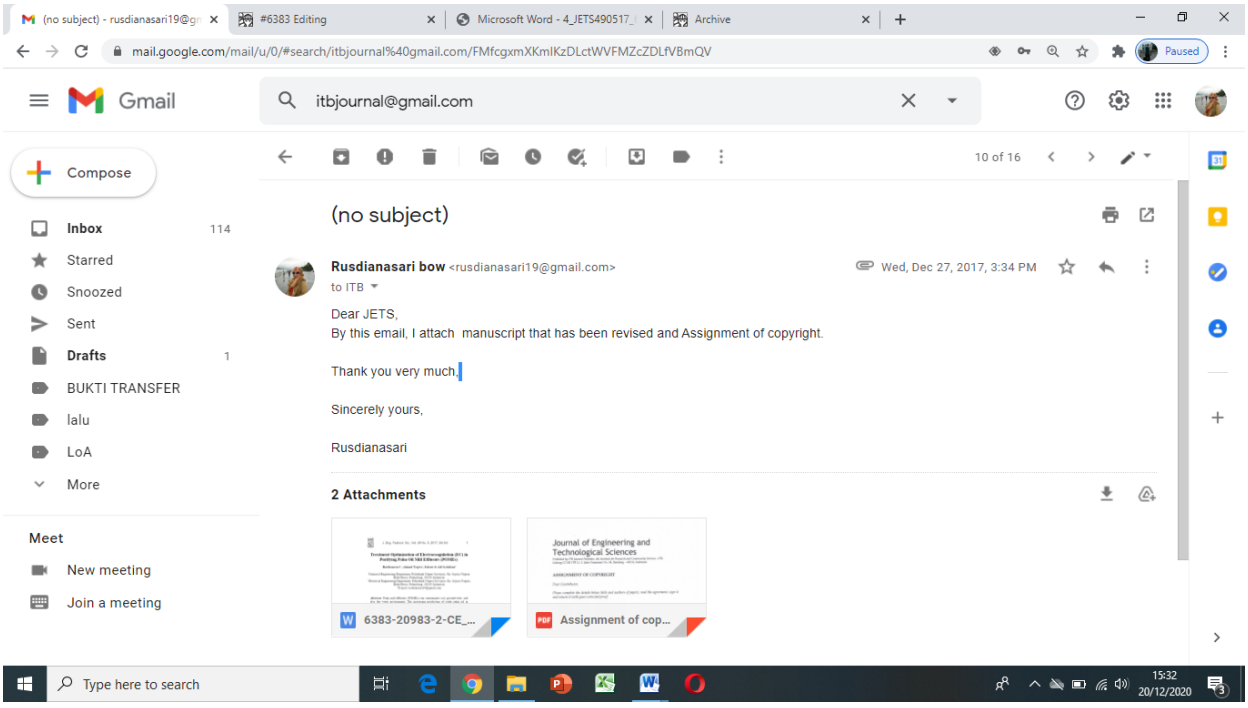
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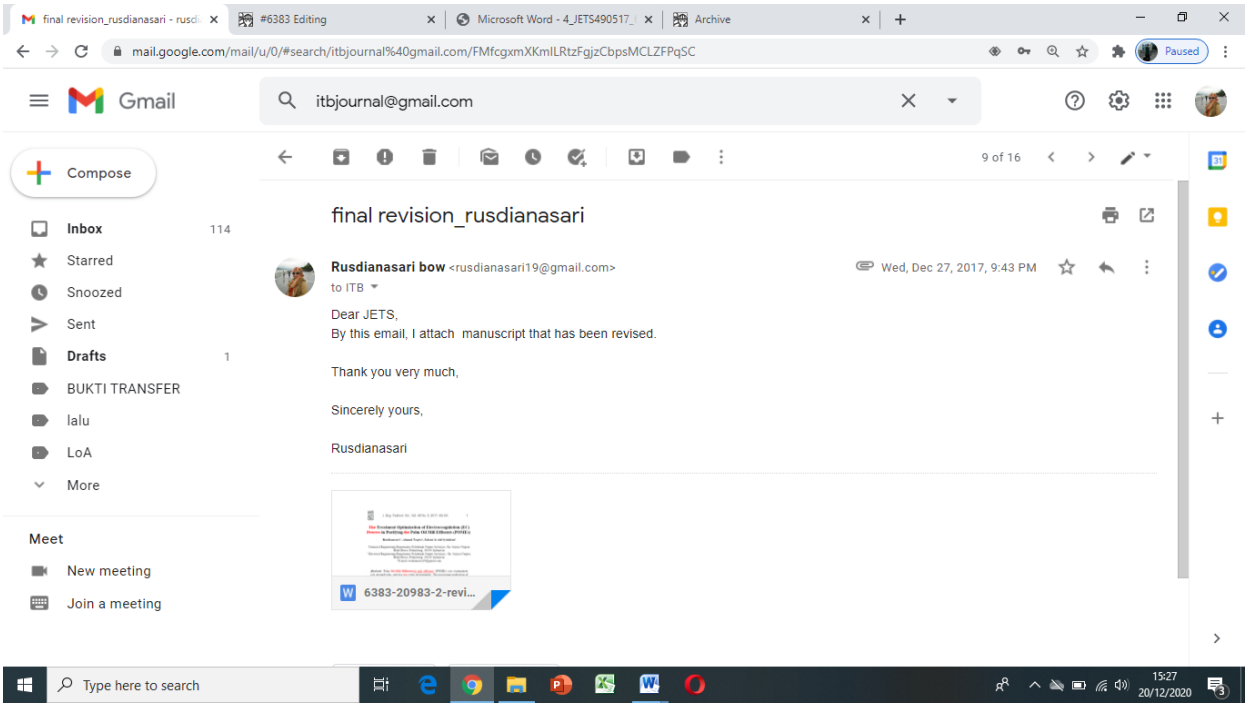
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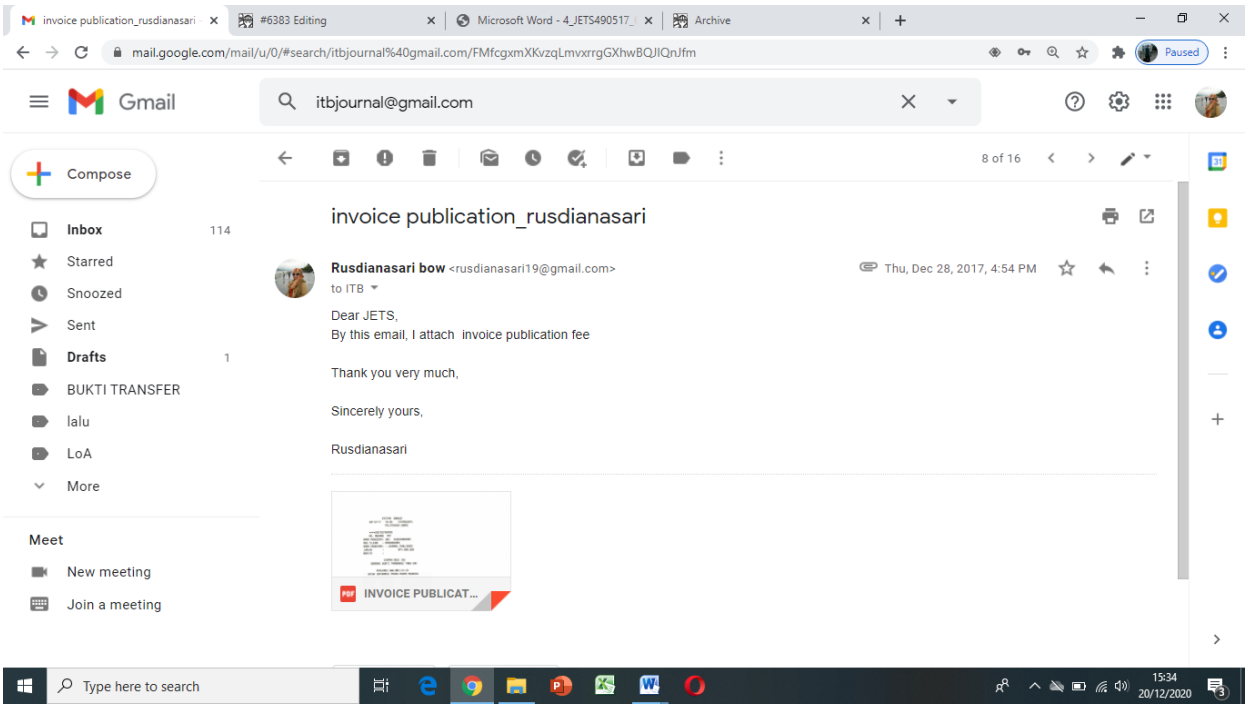
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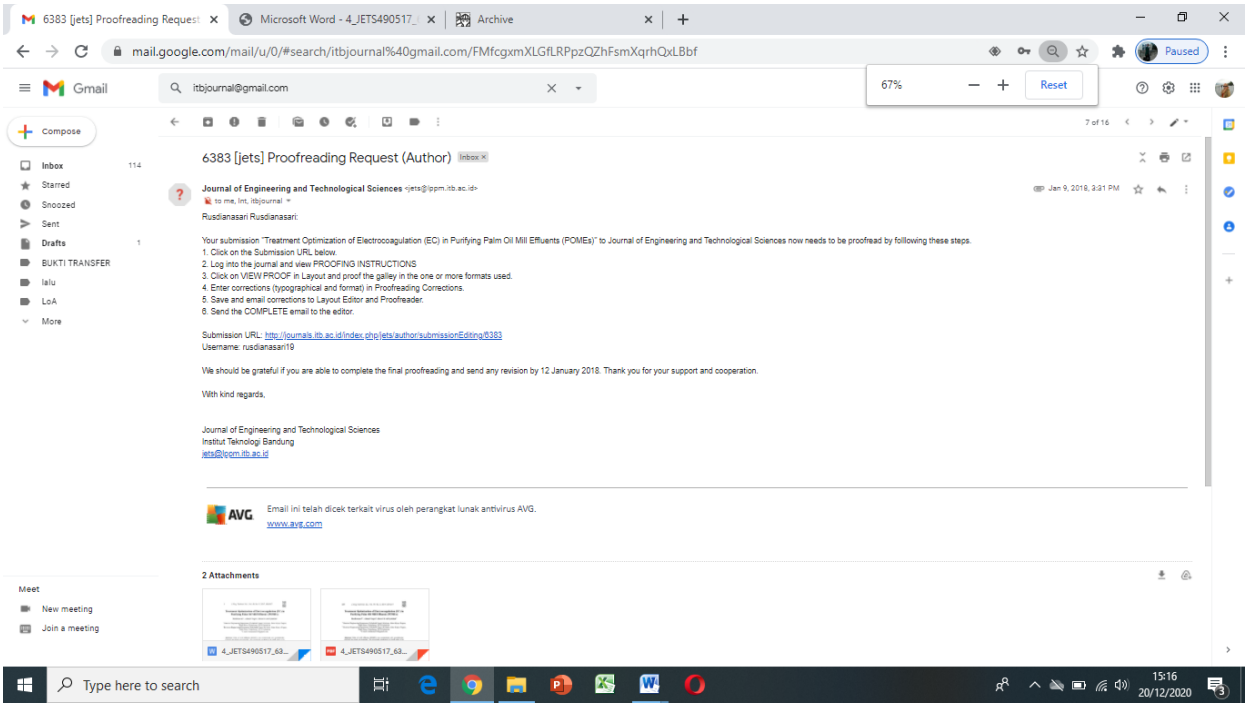
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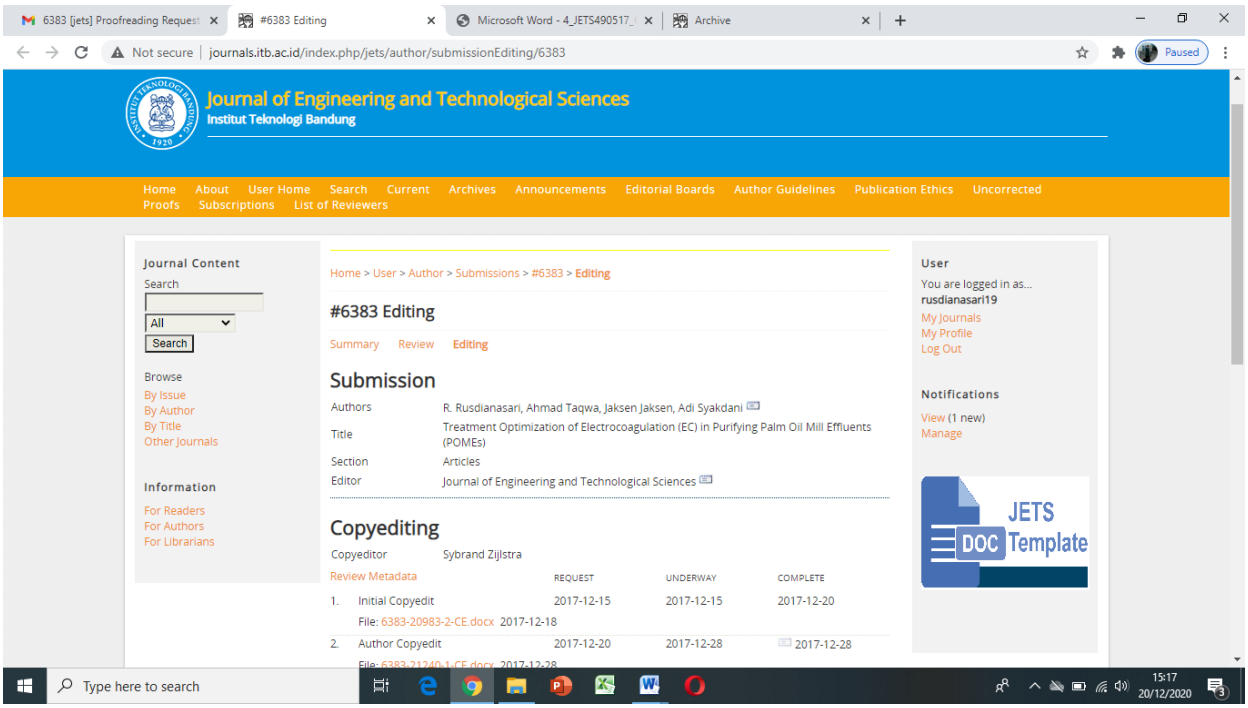
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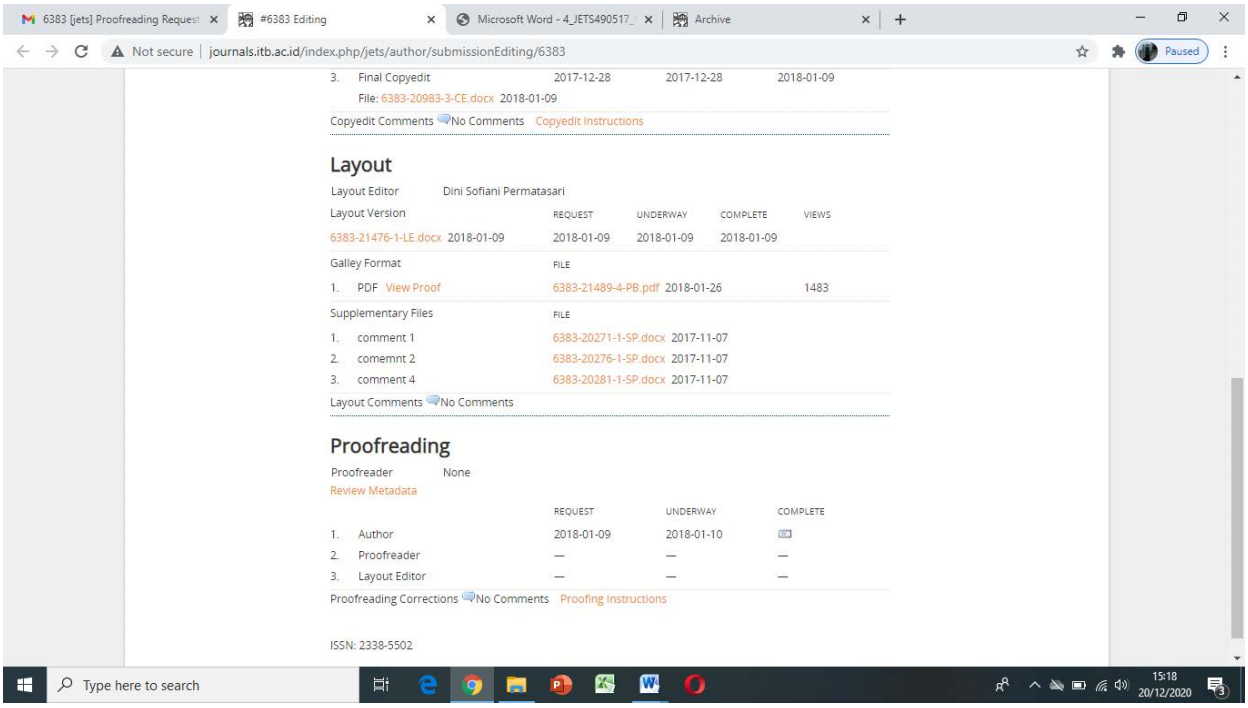

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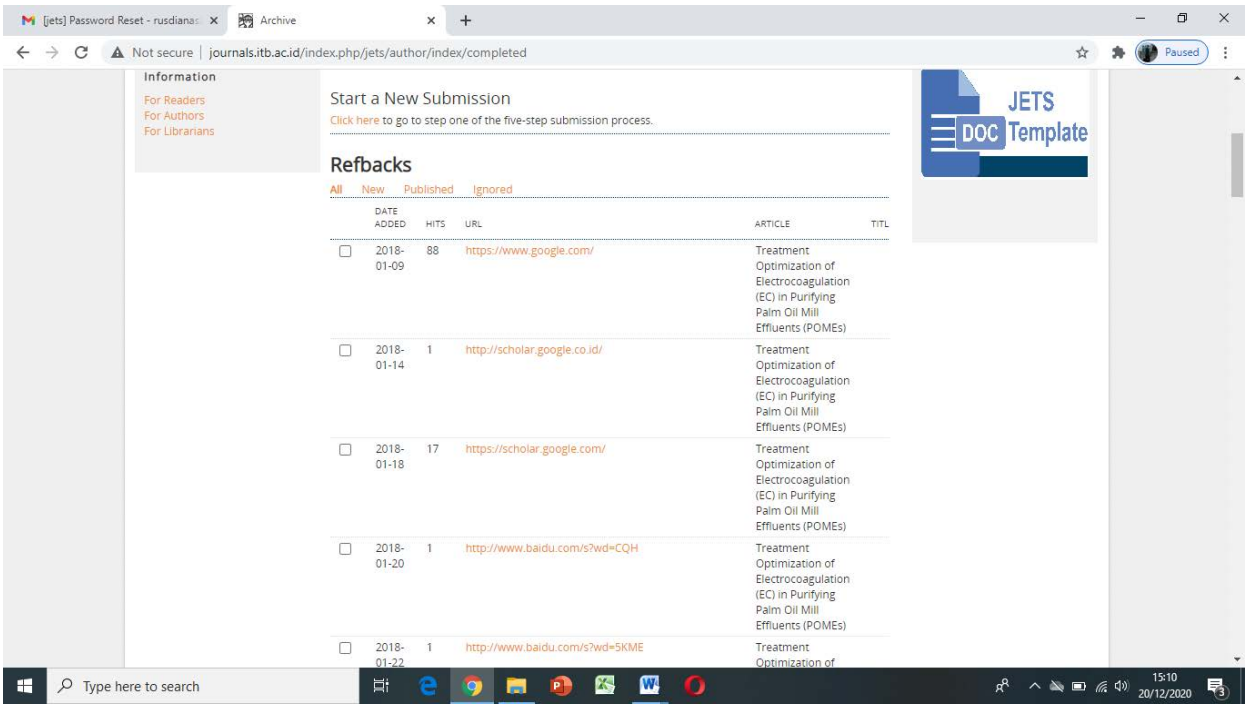

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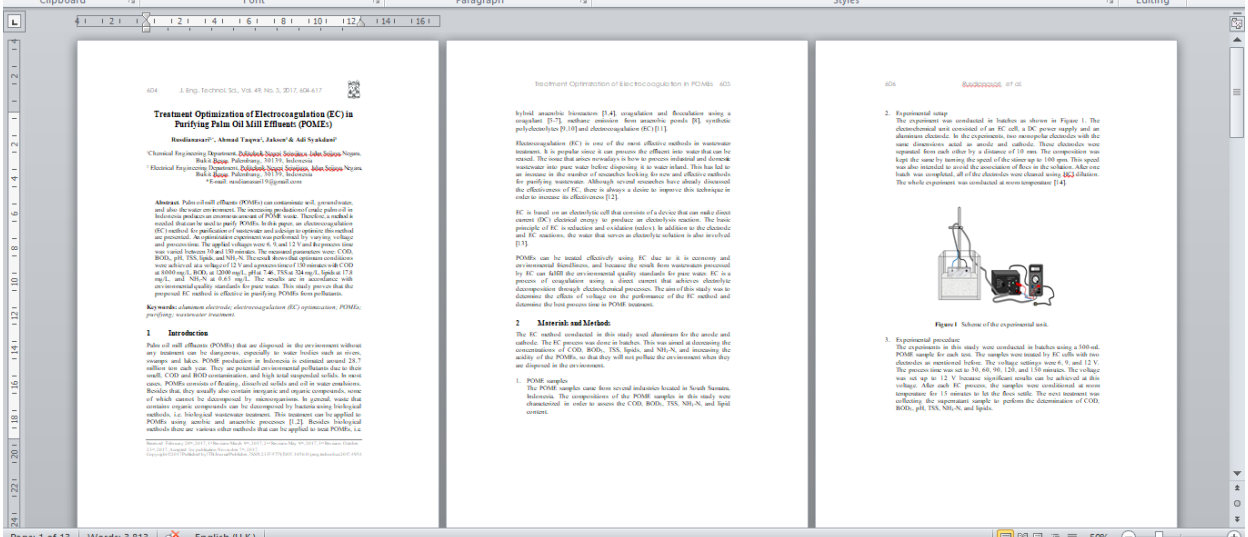

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Treatment Optimization of Electrocoagulation (EC) in Purifying Palm Oil Mill Effluents (POMEs)

Rusdianasari[1]*, Ahmad Taqwa[1], Jaksen[2] & Adi Syakdani[2]

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Abstract. Palm oil mill effluents (POMEs) can contaminate soil, groundwater, and also the water environment. The increasing productions of crude palm oil in Indonesia produces an enormous amount of POME waste. Therefore, a method is needed that can be used to purify POMEs. In this paper, an electrocoagulation (EC) method for purification of wastewater and sidestep to optimize this method are presented. An optimization experiment was performed by varying voltage and processing time. The applied voltages were 6, 9, and 12 V and the process time was varied between 30 and 180 minutes. The measured parameters were: COD, BOD_5, pH, TSS, lipids, and NH_3-N. The result shows that optimum conditions were achieved at a voltage of 12 V and a process time of 150 minutes with COD at 8600 mg/L, BOD_5 at 12000 mg/L, pH at 7.46, TSS at 324 mg/L, lipids at 17.8 mg/L, and NH_3-N at 0.63 mg/L. The results are in accordance with environmental quality standards for pure water. This study proves that the proposed EC method is effective in purifying POMEs from pollutants.

Keywords: *aluminum electrode; electrocoagulation (EC) optimization; POMEs; purifying; wastewater treatment.*

1 Introduction

Palm oil mill effluents (POMEs) that are dispersed in the environment without any treatment can be dangerous, especially to water bodies such as rivers, swamps and lakes. POME production in Indonesia is estimated around 28.7 million ton each year. They are potential environmental pollutants due to their smell, COD and BOD contamination, and high total suspended solids. In most cases, POMEs consists of floating, dissolved solids and oil in water emulsions. Besides that, they usually also contain inorganic and organic compounds, some of which cannot be decomposed by microorganisms. In general, waste that contains organic compounds can be decomposed by bacteria using biological methods, i.e. biological wastewater treatment. This treatment can be applied to POMEs using aerobic and anaerobic processes [1,2]. Besides biological methods there are various other methods that can be applied to treat POMEs, i.e.

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hybrid anaerobic bioreactors [3,4], coagulation and flocculation using a coagulant [5-7], methane emission from anaerobic ponds [8], synthetic polyelectrolytes [9,10] and electrocoagulation (EC) [11].

Electrocoagulation (EC) is one of the most effective methods in wastewater treatment. It is popular since it can process the effluent into water that can be reused. The issue that arises nowadays is how to process industrial and domestic wastewater into pure water before dispersing it to water inland. This has led to an increase in the number of researches looking for new and effective methods for purifying wastewater. Although several researches have already discussed the effectiveness of EC, there is always a desire to improve this technique in order to increase its effectiveness [12].

EC is based on an electrolytic cell that consists of a device that can make direct current (DC) electrical energy to produce an electrolysis reaction. The basic principle of EC is reduction and oxidation (redox). In addition to the electrode and EC reactions, the water that serves as electrolyte solution is also involved [13].

POMEs can be treated effectively using EC due to it is economy and environmental friendliness, and because the result from wastewaters processed by EC can fulfill the environmental quality standards for pure water. EC is a process of coagulation using a direct current that achieves electrolyte decomposition through electrochemical processes. The aim of this study was to determine the effects of voltage on the performance of the EC method and determine the best process time in POME treatment.

2 Material and Method

The EC method conducted in this study used aluminum for the anode and cathode. The EC process was done in batches. This was aimed at decreasing the concentrations of COD, BOD_5, TSS, lipids, and NH_3-N, and increasing the acidity of the POMEs, so that they will not pollute the environment when they are dispersed in the environment.

1. POME samples
   The POME samples came from several industries located in South Sumatra, Indonesia. The compositions of the POME samples in this study were characterized in order to assess the COD, BOD_5, TSS, NH_3-N, and lipid content.

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2. Experimental setup
   The experiment was conducted in batches as shown in Figure 1. The electrochemical unit consisted of an EC cell, a DC power supply and an aluminum electrode. In the experiments, two monopolar electrodes with the same dimensions acted as anode and cathode. These electrodes were separated from each other by a distance of 10 mm. The composition was kept the same by turning the speed of the stirrer up to 100 rpm. This speed was also intended to avoid the association of flocs in the solution. After one batch was completed, all of the electrodes were cleaned using HCl dilution. The whole experiment was conducted at room temperature [14].

Figure 1 Scheme of the experimental unit.

3. Experimental procedure:
   The experiments in this study were conducted in batches using a 500-mL POME sample for each test. The samples were treated by EC cells with two electrodes as mentioned before. The voltage settings were 6, 9, and 12 V. The process time was set to 30, 60, 90, 120, and 150 minutes. The voltage was set up to 12 V because significant results can be achieved at this voltage. After each EC process, the samples were conditioned at room temperature for 1.5 minutes to let the flocs settle. The next treatment was collecting the supernatant sample to perform the determination of COD, BOD_5, pH, TSS, NH_3-N, and lipids.

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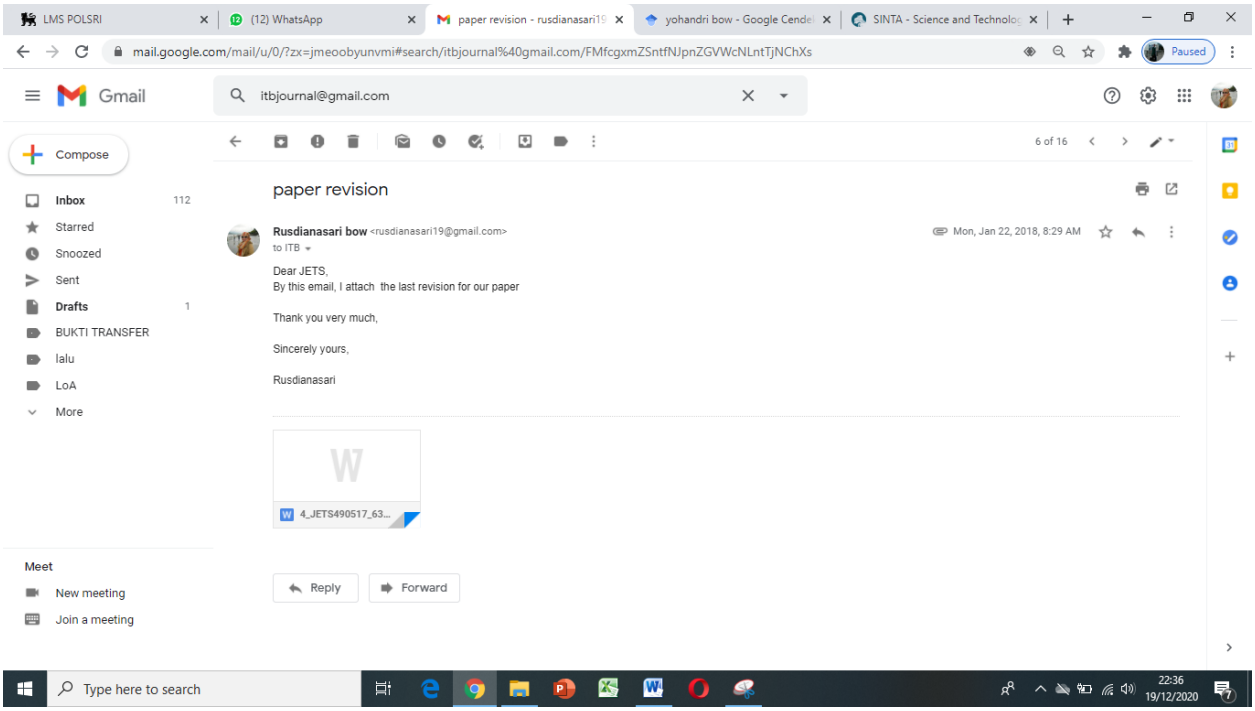
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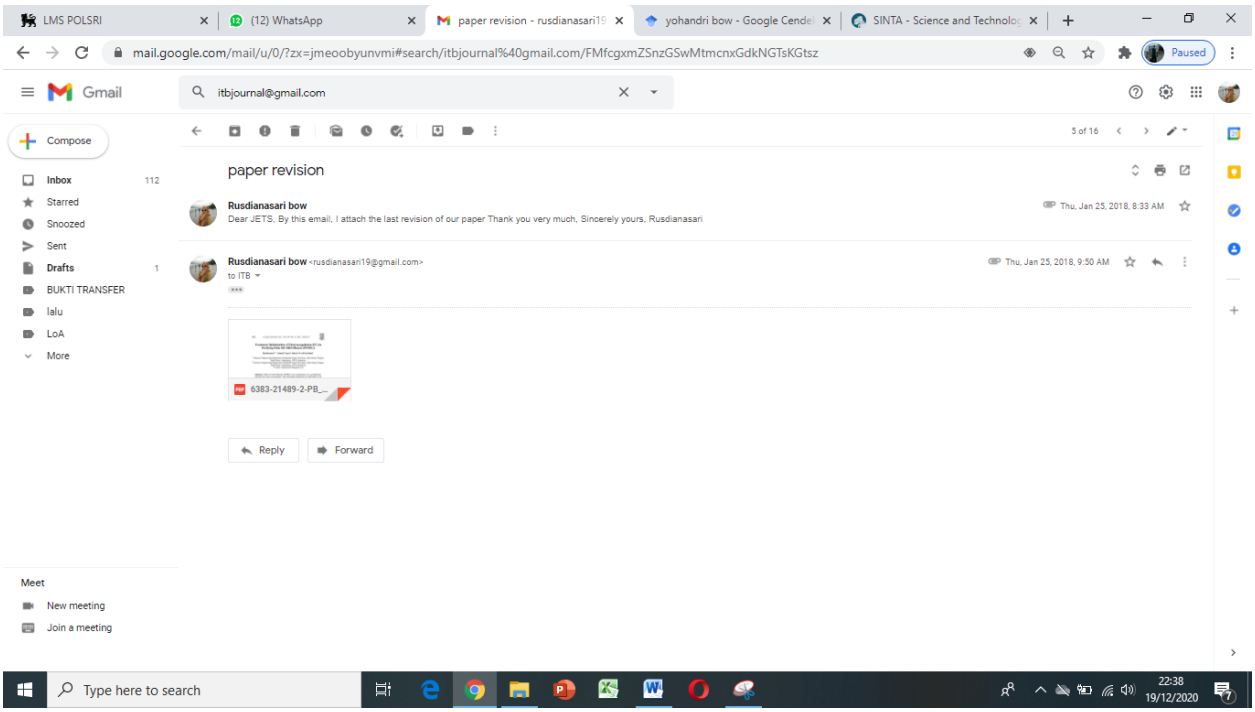
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Dear JETS, By this email, I attach the last revision of our paper Thank you very much, Sincerely yours, Rusdianasari
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Rusdianasari bow <rusdianasari19@gmail.com>
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