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Research Paper

Chemical Oxygen Demand (COD) and Total Suspended Solid (TSS) Removal from Rubber Wastewater Factory Using Electrocoagulation Technique

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Abstract
Rubber industrial wastewater is obtained during washing, shredding, grinding, crumbbing, drying, and pressing bokar. The wastewater produced can be an environmental pollutant because it contains relatively large amounts of organic matter. One alternative to treating rubber wastewater is to use the electrocoagulation process, which is a combination of the coagulation and electrolysis processes. This electrocoagulation process has several advantages in the form of simple equipment, short time, produces odorless wastewater, does not require large areas of land, and can remove various contaminants in water. In this study, rubber wastewater was treated by electrocoagulation using a batch system with variations in the contact time used, namely 20, 40, 60, 80, and 100 minutes. This type of research is experimental research, and descriptive analysis is carried out. Rubber wastewater is physically gray-black before treatment and chemically contains large organic matter. The results of this study showed that the content of chemical oxygen demand (COD) and total suspended solids (TSS) before processing had values of 691 mg/L and 317 mg/L. Optimum conditions for the elimination of COD and TSS contents were achieved within 80 minutes with the percentage of elimination being 89% and 85%.

Keywords
COD, Electrocoagulation, Rubber Wastewater, TSS

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1. INTRODUCTION

Natural rubber is the most important raw material for the rubber industry. The development of the rubber industry has had a positive impact on the country in the form of foreign exchange and economic population growth. In addition to the positive effects, the development of the rubber industry also pollutes the environment in the form of industrial wastewater that does not meet the carrying capacity and pollutant load when discharged into water bodies (Yasin, 2018).

Wastewater rubber is produced in processes of washing, shredding, milling, shredding, drying, and bokar pressing processes (Dewi et al., 2020). The properties of wastewater rubber before treatment show a Chemical Oxygen Demand (COD) value of up to 911 mg/L, and a Total Suspended Solid (TSS) of 618 mg/L (Ariyani and Mulyono, 2015). Compared with the quality standards for liquid rubber effluent according to Minister of the Environment Regulation no. 5 of 2014 the maximum COD content in rubber wastewater is 200 mg/L, and the maximum TSS content is 100 mg/L (Mayasari et al., 2020). The COD and TSS values of the material do not meet quality standards and require further treatment before being discharged into the landfill and body of water.

Wastewater rubber treatment in general consists of anaerobic, facultative, and aerobic ponds with this pond system there are drawbacks, country, long-term residence, potential odor, caution required, and still no contaminants produced meet quality standards (Prawiranti et al.). Several other rubber treatments, namely filtration, actived sludge and adsorption have been used in the treatment of rubber. Among these treatments, they still have drawbacks, namely, they are only able to remove suspended solids and the occurrence of blockages in the pores (Hutagalung, 2018). Therefore, a more effective treatment is needed to reduce the pollutants contained in rubber and can be more efficient in terms of cost and time (Nurhayati et al., 2013).

One alternative for handling rubber processing wastewater is coagulation because coagulation has two methods, namely conventional coagulation and electrocoagulation. Besides that the reduction of total suspended solids in wastewater is dominated by the coagulation method (Teh et al., 2016). Electrocoagulation is a combination of electrolysis and coagulation processes. This electrocoagulation method is very simple and efficient in the wastewater treatment (Rusdianasari et al., 2017). Some of the advantages of this electrocoagulation method are the simple equipment used, the short reaction time, and the odorless product. Wastewater does not require a large area (Ukiwe et al., 2014), and can remove many types of contaminants wastewater (Wiyanto et al., 2014).

Based on the research conducted by Fitri et al. (2020) found that the percentage level of removal of COD and TSS levels in the of fishery activities using the electrocoagulation method that is equal to 82.89% and 31.90% which occurs at a voltage of 12 volts within 60 minutes and 15 minutes (Radityani et al., 2020). Then the research conducted by Ni'am et al. (2017) showed that the optimum conditions for removal of COD and TSS levels in textile wastewater were obtained at a voltage of 12 volts within 45 minutes with a percentage level of removal of COD and TSS levels of 76% and TSS of 85%.

Based on the description, it can be seen that the electrocoagulation method can reduce the levels of COD and TSS in wastewater. The electrocoagulation method can be used as an alternative treatment for rubber as the object of this research. In this electrocoagulation process, aluminum electrodes are used because it has good electrical conductivity, is corrosion resistant, and has good reducing properties.

2. EXPERIMENTAL SECTION

The wastewater of rubber used in this study was collected at the inlet of a sewage treatment plant and treated using electrocoagulation with contact time variations of 20, 40, 60, 80, and 100 minutes. The electrocoagulation process uses a batch system with a capacity of 500 mL, the type of electrode used is aluminum with a size of 7×10 cm as many as 2 pieces, the distance between the electrodes is 2 cm, and the voltage used is 12 volts. The parameters studied in this study were levels of COD and TSS.

3. RESULTS AND DISCUSSION

3.1 Characteristics of Wastewater Rubber

Characteristics of liquid rubber waste include physical, chemical, and biological characteristics. In this study, the quality of wastewater rubber can be measured physically and chemically. Physical measurements can be seen from the levels of suspended solids contained in rubber, while chemical measurements can be seen from the levels of organic substances in rubber.

The liquid rubber waste taken from the inlet of the Wastewater Treatment process (WWTP) in this study can be physically seen as very cloudy, smells very pungent, is gray-black, and contains high organic compounds. The following is a picture of rubber before it is processed (Figure 1).

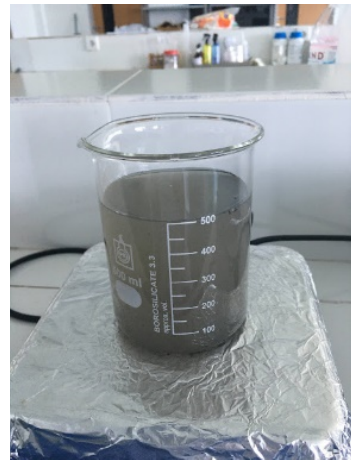

Figure 1. Rubber Before Processing

Characteristics of rubber before processing using the electrocoagulation method must pay attention to the quality standard criteria contained in the Regulation of the Minister of the Environment No. 5 of 2014 concerning Wastewater Quality Standards. The results of the initial characteristics of rubber obtained from the results of laboratory analysis can be seen in the Table 1.

Table 1. The Results of the Initial Test of the COD and TSS Parameters of Liquid Rubber Waste

Parameter	Unit	Quality Standards	Test Results
COD	mg/L	200	691±7.57
TSS	mg/L	100	317±37.745

Based on the table above, it can be seen that the values of COD and TSS levels before processing are still not by the established quality standards. The results of the initial test for COD and TSS levels were respectively obtained for COD of 691 mg/L and TSS of 317 mg/L. The quality standard values for COD and TSS levels in the Minister of Environment Regulation No. 5 of 2014 are 200 and 100 mg/L, respectively. The high levels of COD and TSS are contained in rubber, so it needs to be treated first before being discharged into water bodies.

Based on several previous studies, it was stated that the levels of COD and TSS in rubber still exceeded the quality standard of rubber. In a study conducted by Ariyani and Mulyono (2015), it was stated that the characteristics of rubber before being processed had COD levels reaching 911 mg/L and TSS 618 mg/L. Then the research conducted by Naswir et al. (2020) also stated that the initial content of COD and TSS in rubber before processing was COD of 1415 mg/L and TSS of 340 mg/L. This can prove that the levels of COD and TSS in rubber have high levels and do not meet the quality standards of rubber.

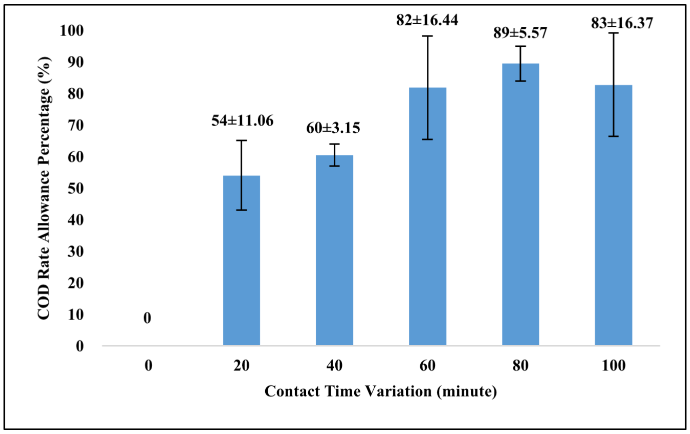

Figure 2. Percentage of COD Removal

3.2 Analysis of Cod Removal in Rubber

COD measurement aims to see the degree of pollution contained in wastewater. In the treatment of rubber using the electrocoagulation process, the COD measurement results are obtained, and then the results from the COD level measurements are calculated as the percentage of removal. Based on the calculation of COD removal, a graph of the COD removal percentage can be obtained, which is shown in Figure 2.

Based on Figure 2, it can be seen that variations in contact time affect the percentage of COD removal in rubber. COD removal percentage starts from 0% to 89%. The percentage value of COD removal at contact time (20, 40, 60, and 80 minutes) increased, while at 100 minutes it decreased. The highest COD removal percentage occurred at 80 minutes, which was 89%. While the lowest COD removal percentage occurred at a contact time of 20 minutes with a removal rate of 54%.

Table 2. Result for Chemical Oxygen Demand

Electrode	Results	References
Al-Al	89%	This research
Al-Al	98.74%	(Fakorede and Adewumi, 2020)
Al-Al	86.82%	(Wiyanto et al., 2014)

Based on Table 2, it can be seen the difference in the results from the use of Al electrodes found on the cathode and anode both from this study with other studies such as fakorede research and wiyanto research which shows a percentage decrease in COD values and produces sludge in the form of $Al(OH)_3$.

The increase in the percentage of COD removal in rubber after processing using the electrocoagulation process is due to a reduction process that occurs at the cathode and oxidation that occurs at the anode. The reactions that occur at the anode and cathode are as follows:

Reaction at the anode:

$Al_{(s)} \rightleftharpoons Al^{3+}_{(aq)} + 3e^-$

Reaction at cathode:

$2H_2O_{(l)} + 2e^- \rightleftharpoons H_{2(g)} + 2OH^-{}_{(aq)}$

Based on the reaction that occurs at the anode and cathode using aluminum electrodes, the results of the reaction are:

$Al_{(s)} + 3H_2O_{(l)} \rightleftharpoons Al(OH)_{3(s)} + 3/2H_{2(g)}$

The electrocoagulation process that occurs at the anode will result in the dissolution of aluminum metal to produce Al^{3+} ions. Al^{3+} ions formed in the reaction at the anode will react with OH^- ions to form solid $Al(OH)_3$, which is insoluble in water. The solid $Al(OH)_3$ formed in the solution can then function as a coagulant in the electrocoagulation process (Hanum et al., 2015). Furthermore, the coagulant formed will make the colloidal particles in the water unstable. Then the unstable colloidal particles will lose their charge, and the particles will form flocs. Meanwhile, the reduction reaction that occurs at the cathode will produce H_2 gas, where the gas functions to lift the floc that binds the contaminants contained in the liquid rubber waste to the surface (Nidheesh et al., 2022). The floc formed over time will get bigger and will settle to the bottom of the beaker glass.

The longer the electrocoagulation process, the more coagulants are produced to bind contaminants, resulting in a better decrease in COD levels in wastewater. After the electrocoagulation process is complete, the anode is marked by the eroding of the aluminum plate as a sign of the production of metal ions. While at the cathode, hydroxyl ions and hydrogen gas will be produced. The appearance of hydrogen gas is indicated by the presence of gas bubbles during the electrocoagulation process, resulting in foam on the surface of the glass. In addition, the cathode is marked by the appearance of white spots as a sign that hydrogen gas is produced on the cathode plate (Apriyanto et al., 2018).

Based on the results of the COD measurements obtained, at the 60, 80, and 100 minutes, they have met the quality standards stipulated in the Regulation of the Minister of the Environment No. 5 of 2014 concerning Wastewater Quality Standards, where the quality standard for COD levels in rubber is 200 mg/L.

3.3 Analysis of TSS Allowance in Liquid Rubber Waste

TSS measurement is intended to determine the number of solids that are not dissolved in wastewater. The results of testing the levels of TSS in rubber before being given electrocoagulation treatment obtained a TSS content of 317 mg/L. The amount of TSS levels obtained, so it is necessary to treat rubber first before being discharged into water bodies. After obtaining the TSS content from each time variation used, the percentage of TSS removal in rubber was calculated. The percentage of TSS allowance can be seen in Figure 3.

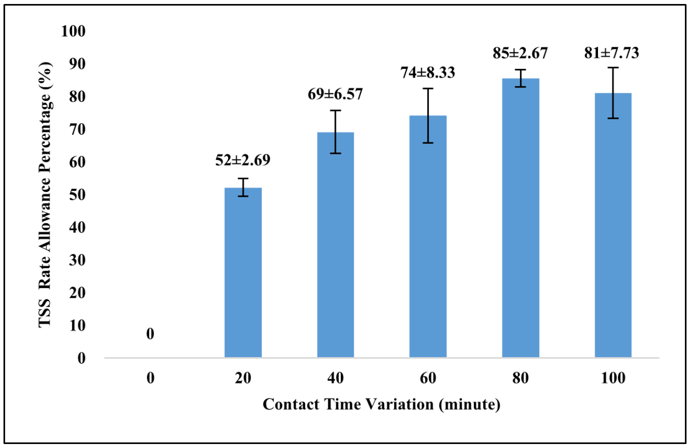

Figure 3. Percentage of TSS removal

Based on Figure 3, it can be seen that variations in contact time can affect the percentage of TSS removal in rubber. The percentage of TSS removal in rubber fluctuates or fluctuates. The percentage value of TSS removal has a range of 0% to 85%. The highest TSS removal percentage occurred at a contact time of 80 minutes with a TSS removal percentage of 85%. While the lowest percentage of TSS removal occurred at a contact time of 20 minutes with a TSS removal percentage of 52%.

Table 3. Results for Total Suspended Solid

Electrode	Results	References
Al-Al	85%	This research
Al-Fe	73%	(Massoudinejad et al., 2015)
Al-Al	89%	(Zailani et al., 2018)

Based on Table 3, it can be seen the difference in the results from the use of Al electrodes or with other electrodes such as Fe found on the cathode and anode both from this study with other studies such as Massoudinejad research and Zailani research which shows a percentage decrease in TSS values and produces sludge in the form of $Al(OH)_3$ and $Fe(OH)_3$.

The increase in the percentage of TSS removal in rubber occurs due to the formation of $Al(OH)_3$. The longer contact time used will be directly proportional to the amount of charge that flows during the electrocoagulation process. This causes more metal ions to stick to the electrodes, resulting in the removal of levels. 5 of 2014 concerning Wastewater Quality Standards, where the quality standard for TSS levels in rubber is 100 mg/L.

4. CONCLUSIONS

From the results of research regarding the treatment of liquid rubber waste for COD and TSS removal using the electrocoagulation method, the conclusions that can be obtained from the results of this study are the initial characteristics of rubber before processing using the electrocoagulation method, namely the COD content of 691 mg/L and the TSS of 317 mg/L. The highest percentages of COD and TSS removal occurred at 80 minutes at 89% and 85%, respectively.

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