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STUDY OF BOD, COD AND TSS REMOVAL IN BATIK INDUSTRY WASTEWATER USING ELECTROCOAGULATION METHOD

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ABSTRACT

Central Java, especially Pekalongan, is one of the largest batik centres with a high amount of batik waste and has the potential to pollute the environment. Wastewater treatment using the electrocoagulation method as an alternative to environmental pollution prevention in Pekalongan Regency. This study determined the effect of stress and resistance time on decreasing COD, BOD and TSS levels in batik wastewater. The analysis performed on the samples included BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), TSS (total suspended solids), and pH. Voltage variations of 12, 24, and 30 volts and holding times of 90, 120, 150, and 180 minutes were applied. A pair of aluminium metals (Al-Al) was used with a thickness of 0.1 cm, an area of 12x14 cm, and a volume of 2500 ml. The results showed that the voltage and contact time decreased the amount of COD, BOD and TSS. In addition, the results showed that the electrocoagulation method at a voltage of 30 volts and a contact time of 180 minutes could reduce COD levels by 75.78%, TSS levels by 93.9%, and BOD levels by 83.75%.

Keywords: *electrocoagulation, COD, BOD, TSS*

INTRODUCTION

Central Java, especially Pekalongan, is one of the largest batik industrial centres in Indonesia, with a very high amount of batik liquid waste and has the potential to pollute the environment[1]. A river is a favourite place for wastewater disposal, which impacts the high pollution level due to batik industry waste, especially from dyes. The production of batik industry produces concentrated colored wastewater with high Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), and Total Suspended Solid (TSS) [2,3,4]. The content is produced from several types of mixtures of dyes and chemicals used in industry [5]. Batik water waste contains chemical compounds in the coloring process, including acid, alkaline, direct, reactive and naphthol colors that pollute the environment [6].

Various methods have been used for wastewater treatment, biologically, physically-biologically, chemically, physically-biologically and physically [7,8,9,10]. However, the physical method that is effective, efficient, and easy to apply in the community for batik wastewater treatment is the electro-coagulation method [11,12,13]. The Electrocoagulation method is an electrochemical technique used to remove suspended solids, chemicals, pollutants, harmful microorganisms, and other contaminants in wastewater by applying direct current (DC) to a pair of electrodes [14,15,16]. The basic principle of electro-coagulation is a reduction and oxidation (redox) reaction. The working system of the electrocoagulation method uses two different/same electrode plates, each acting as an anode and a cathode. Then a direct electric current causes an electrochemical process in which anions (negative ions) move towards the anode to release oxidized electrons and cations (positive ions) move towards the cathode to accept electrons from reduction, which eventually forms flocs that bind contaminants. For electrocoagulation, aluminium (Al) electrodes are used because this metal has good coagulant properties. The electrocoagulation method has several advantages over other methods, such as equipment that is easy to obtain, lower costs, and does not require additional chemicals [17,18]. However, this method also has a weakness, namely the periodic replacement of electrodes because one of the electrodes is burned [19].

Previous studies used electro-coagulation with PbO_2/Cu electrodes for wastewater treatment [20]. The results showed a decrease in COD levels by 80.7% and BOD by 81.44%. as well as other studies [21] have used electrocoagulation methods with variations in potential difference (10, 12.5, and 15) volts and time (10, 20, 30, 40, 50, and 60) minutes with aluminium (Al) electrodes in his research. Decreased contaminants by 99.6% in the thorium treatment of 12.5 V/30 minutes. The Electrocoagulation method has been carried out using aluminium-iron (Al-Fe) electrodes with potential variations (3, 6, 9, and 12) volts and time (90, 150, and 210) minutes [22]. The results showed a decrease in TSS by 76.08% (150 minutes/12 volts), COD by 94.01% (90 minutes/6 volts), and BOD by 97.30% (90 minutes/6 volts). The effect of the electrocoagulation method with variations in potential difference and contact time on the reduction of COD and TSS in laundry wastewater also showed a decrease in COD and TSS of 88.69% and 81.82% at 30 volts/60 minutes [23]. Research related to the management of batik liquid waste using the electrocoagulation method is still limited, and there is no proper treatment for maximum results in reducing COD, BOD and TSS content. The electric potential applied in previous studies is still relatively low, so the contaminant reduction is low. In addition, the condition of the batik wastewater samples used was clear enough to facilitate researchers in the purification process. This prompted researchers to examine batik wastewater treatment using the electrocoagulation method by applying a high electric potential and a relatively long variation of holding time with the condition of concentrated wastewater samples produced from the first washing. The study results are expected to be an alternative to environmental pollution prevention in

Pekalongan Regency. The effectiveness of the electrocoagulation process in this study was seen based on the percentage decrease in COD, BOD, TSS, and PH levels in wastewater.

METHODS

1. Materials

This research uses batik wastewater from the dyeing, shaving, and rinsing processes in the Pekalongan batik industry. The equipment used in this research is an electrocoagulation reactor consisting of an acrylic bath with a capacity of 3 L as a wastewater container. Electrode plate consisting of a cathode and anode plate, a plate made of aluminium with a size of 12 cm x 14 cm and a thickness of 0.1mm, connection cables for cathode and anode, direct current (DC) power supply, digital multimeter, pH meter. Eight electrode plates are used with a distance between the electrodes of 2 cm, which is connected to the power supply. Figure 1 shows the prototype design of the electrocoagulation device.

2. Preparation

The preparations carried out were designing and installing a reactor consisting of an aluminium plate, electrode cable, power supply, digital multimeter and supporting equipment, as shown in Figure 1.

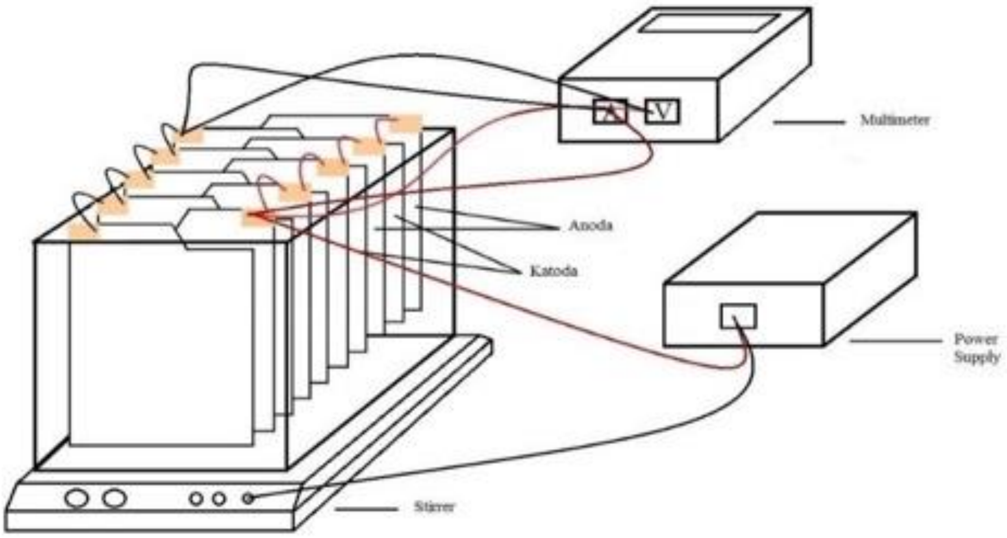

Figure 1. electrocoagulation reactor

The initial characterization of the wastewater sample was carried out before the electrocoagulation method was applied. Then, variations of voltage (12, 24, and 30) volts and time (90, 120, 150, and 180) minutes were done.

3. Analytical method

Sample characterization was measured to determine the content of COD, BOD, TSS, and PH. Analysis of COD content was used to determine the amount of dissolved oxygen with the test standard of SNI 6989.73:2019. TSS content analysis was used to determine the total suspended solids with the test standard of SNI 06-6989.3:2019. Analysis of PH content with test standard SNI 06-6898.11:2019. The calculation of removal efficiency of each parameter is calculated using equation [11]:

$$eff(\%) = \frac{C_0 - C_1}{C_0} x100\%$$

With
C_0: levels before electrocoagulation
C_1: levels after electrocoagulation

RESULTS AND DISCUSSION

The initial characterization of batik wastewater samples was carried out before the electrocoagulation method was applied to the sample. The characterization of batik wastewater samples is shown in Table 1. Table 1 shows that the content of COD, BOD, TSS and pH in the sample is relatively higher than the standard set by the government. COD levels reached 4161.5 mg/L, BOD levels in the samples reached 1528.9 mg/L, TSS levels were 164 mg/L, and pH 8.12. Research has been carried out by applying an increase in electric potential and a relatively long variation of holding time with concentrated wastewater samples. The increase in electrical potential and variations in holding time were carried out to determine the effectiveness of the electrocoagulation method on the percentage reduction in the content of COD, BOD, TSS, and PH in wastewater[24].

Chemical Oxygen Demand (COD) is the amount of dissolved oxygen in mg/L O_2 required to oxidise organic substances [25]. Table 2 shows the decrease in COD levels after treatment with the electrocoagulation method. The COD level, which originally reached 4161.5 mg/L, decreased to 1007.5 mg/L at 30 volts/180 minutes.

Table 1. Initial characterization of batik wastewater

No	Parameter	Standard	Result	Test Standard
1	COD (mg/L O_2)	150	4161.5	SNI 6989.73:2019
2	BOD (mg/L O_2)	60	1528.9	SNI 6989.72:2009
3	TSS (mg/L)	50	164	SNI 06-6989.3:2019
4	PH	6-9	8.12	SNI 06-6898.11:2019

Note : Wastewater industry standard

Table 2. Amount of COD in wastewater

No	Voltage (Volt)	Time (minutes)	COD (mg/L)
1	12	90	3960.8
		120	3407.5
		150	2950.6
		180	2289.5
2	24	90	3257.8
		120	2570.3
		150	1612.2
		180	1149.1
3	30	90	3163.2
		120	2427.8
		150	1563.9
		180	1007.5

Figure 2 shows that the voltage variation of 12 Volt/180 minutes obtained the highest COD reduction efficiency of 44.94%. While at a voltage of 24 Volts, it can increase the efficiency of decreasing COD by an average of 49.89%. The increase in voltage to 30 Volts indicates a significant increase in COD reduction efficiency to 23.98%, 41.66%, 62.41% and 75.78% for 90, 120, 150, and 180 minutes, respectively. The contact time affects the number of metal ions attached to the electrode. The attached metal ions form flocs that bind the particles [26]. The longer the contact time, the more flocs formed. The increase in potential difference causes an increase in the release of electrons and Al^{3+} into the wastewater. $Al(OH)_3$ is formed from Al^{3+} and OH- ions which act as coagulants. The coagulant binds to the surrounding colloidal particles and forms a floc. The longer the electrocoagulation process, the more $Al(OH)_3$ floc is formed at the anode, and the light particles are flotation so that the floc tends to settle and a decrease in COD concentration occurs [27].

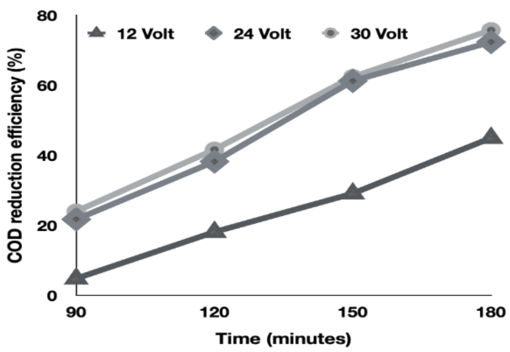

Figure 2. COD Reduction Efficiency (%)

Total Suspended Solid (TSS) indicates the amount of suspended or dissolved solids [28]. Table 1 shows the TSS content before the 164 mg/L electrocoagulation method treatment. These results exceed the threshold permitted by the State Ministry of the Environment in the textile industry, which is 50 mg/L for TSS. Table 3 shows the decrease in TSS content after the electrocoagulation method treatment. The TSS content, which initially reached 164 mg/L, decreased to 10.0 mg/L at a variation of 30 volts/180 minutes. Again, this value is well below the threshold.

Table 3. Amount of TSS in wastewater

No	Voltage (Volt)	Time (minutes)	TSS (mg/L)
1	12	90	128.5
		120	102.3
		150	97.2
		180	74.6
2	24	90	136.5
		120	96.8
		150	78.0
		180	37.4
3	30	90	127.8
		120	83.6
		150	62.7
		180	10.0

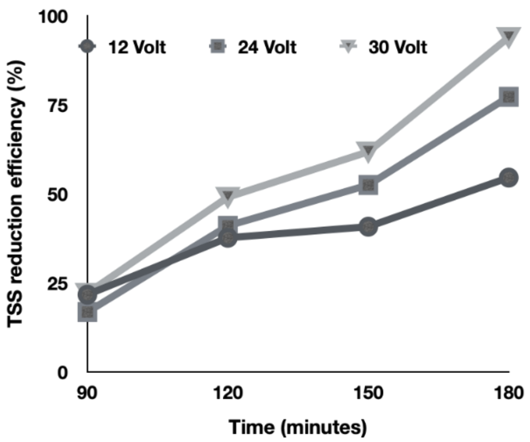

Figure 3. TSS Reduction Efficiency (%)

Figure 3 shows the efficiency of TSS (%) reduction in voltage variation and contact time. Figure 3 shows a significant increase in TSS (%) reduction efficiency of 93.9% with a voltage variation of 30 volts/180 minutes. Both treatments gave the same effect as for COD, that the higher the voltage and the longer the contact time increased the efficiency of TSS reduction. This tendency is also based on the same reason: the effect of coagulant formation and the flotation process. The contact time is directly proportional to the amount of charge flowing during the electrocoagulation process. So that the more metal ions attached to the electrode cause the TSS content to decrease [29].

BOD (Biological Oxygen Demand) is the number of oxygen bacteria needs to decompose organic substances under aerobic conditions [30]. The test results of wastewater samples before being treated with electrocoagulation had a BOD content of 1528.9 mg/L.

Table 4. Amount of BOD in wastewater

No	Voltage (Volt)	Time (minutes)	BOD (mg/L)
1	12	90	1485.6
		120	1268.1
		150	953.7
		180	832.7
2	24	90	1368.6
		120	1146.3
		150	763.7
		180	482.8
3	30	90	1178.3
		120	1125.0
		150	847.5
		180	248.4

Table 4 shows the BOD content in batik wastewater. The BOD content initially reached 1528.9 mg/L and decreased to 248.4 mg/L at 30 volts/180 minutes.

Figure 4 shows the efficiency of decreasing BOD (%) of voltage variations (12, 24, and 30) volts and time (90, 120, 150, and 180) minutes. The decrease in BOD concentration is proportional to the decrease in COD. For example, Figure 4 shows that the potential voltage of 12 Volt/180 minutes obtained the highest BOD reduction efficiency of 83.75%. The concentrations of BOD and COD are interrelated, so the high values of BOD and COD in the waste indicate that further action is needed to reduce the concentration of the parameters before being discharged into the waters [31].

Table 1 shows the results of the pH content test in batik wastewater before being treated with electrocoagulation of 8.12. Figure 5 shows the electrocoagulation method's pH under voltage and time variations.

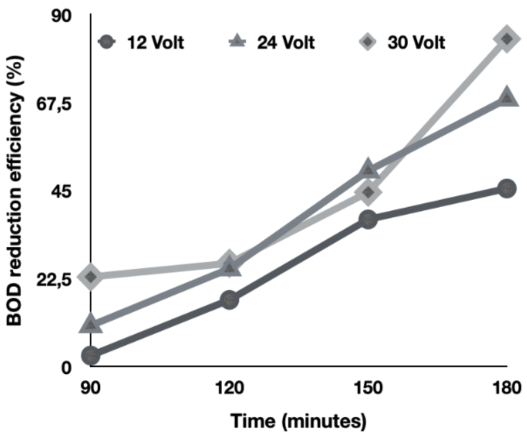

Figure 4. BOD Reduction Efficiency (%)

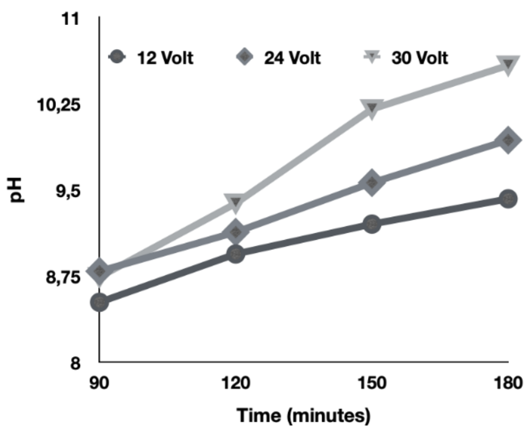

Figure 5. pH at voltage and time variations

Figure 5 shows that during the electrocoagulation process, the pH of the solution will change, which tends to increase over time. Increasing pH results in different distributions of hydroxy monomer complexes and polymers such as $[Al(OH)]^{2+}$, $[Al(OH)_2]^{+}$, $[Al_2(OH)_2]^{4+}$, $[Al_6(OH)_{15}]^{3+}$, $[Al_7(OH)_{17}]^{4+}$,

$[Al_8(OH)_{20}]^{7+}$, $[Al_{13}O_4(OH)_{24}]^{7+}$, $[Al_{13}(OH)_{34}]^{5+}$. causes its reactions to be different according to the pH conditions.

If the aluminium (Al) electrode acts as an anode, the following reaction will occur:

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

Moreover, aluminium cations may produce aluminium oxide, another important specie to remove the pollutants:

$$2Al^{3+}{}_{(aq)} + 3H_2O \rightarrow Al_2O_3 + 6H^+$$

Under acidic conditions, the Al cathode will undergo acid reduction to produce H_2 gas, while the aluminium anode will undergo oxidation to produce Al^{3+} ions according to the above equation. H_2 gas creates hydroxide ions that bind pollutants in wastewater into insoluble compounds that will float to the reactor surface, or electrolytic flotation occurs[32].

CONCLUSION

Wastewater treatment has been carried out using the electrocoagulation method as an alternative to environmental pollution prevention in Pekalongan Regency. The first treatment is the potential difference (12, 24, and 30 volts), and the second factor is the contact time (90, 120, 150, and 180 minutes). A pair of aluminium metals (Al-Al) is used with a thickness of 0.1 cm, an area of 12x14 cm and a waste volume of 2500 ml. electrocoagulation method at a voltage of 30 volts and a contact time of 180 minutes can reduce COD levels by 75.78%, TSS by 93.9%, and BOD levels by 83.75%.

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