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Difference of Electrocoagulation Contact Time on Sulfide Decrease and Color in Waste Water in Sipatex Putri Lesari Company, Bandung, West Java, Indonesia

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Abstract. PT Sipatex Putri Lestari is an industry engaged in the textile sector. In the production process, this industry produces alkaline wastewater and there are several parameters that exceed threshold value including sulfides and colors. From the results of laboratory tests it was found that sulfide levels were 1.3 mg / l, the sulfide content of this wastewater exceeded the predetermined quality standard, which was 0.3 mg / l.

The high levels of sulfide in waste water cause an unpleasant odor and can disrupt the concentration of employees in work and the color of the waste water after processing is still a little thick. The purpose of this study was to determine the differences in the electrocoagulation contact time of 30 minutes, 60 minutes and 90 minutes against the reduction of sulfides and colors in wastewater. The type of research used in this study was an experiment with the design of pre and post control.

From the results of the ANOVA test it was found that the electrocoagulation process can reduce sulfide and color in wastewater (p-value <0.05). Electrocoagulation contact time 30 minutes, 60 minutes, 90 minutes respectively can reduce sulfide 35.29%, 60.33%, 76.28%. And the color decrease was 42.28%, 52.28%, 80.62%.

The most effective reduction in sulfide and color is at 90 minutes of contact time, with 12 volt electricity voltage, 3 A electric current and 3 cm between electrodes. This electrocoagulation method can be a simple alternative to processing liquid waste with several other considerations. The electricity tariff used in the electrocoagulation process with a voltage of 12 volts, a current of 3 amperes and a time of 90 minutes is: 0.054 kWh x Rp.1,420.12/kWh = Rp.76,14648.

Key words : *Contact Time, Electrocoagualation, Sulfide, Color, Economic valuation*

1. INTRODUCTION

Waste water management is not well implemented by most industries, so what happens is pollution of water bodies by waste. Various kinds of waste parameters produced from an industrial activity such as, pH, color, Biological Oxygen Demand (BOD), Chemical Oxygen Demand, Total suspended Solid (TSS) and Sulfide.

PT Sipatex Putri Lestari is an industry engaged in the textile sector. PT SipatexPutri Lestari itself has also been processing for waste water produced from the production process. From the secondary data from the results of laboratory wastewater tests, data were obtained that the sulfide content of PT Sipatex Putri Lestari wastewater was about 1.3 mg / l, the sulfide content of this wastewater exceeded the predetermined quality standard of 0.3 mg / l (Candy-LH No 5 of 2014).

According to Margaret (2009), sulfide in waste water comes from the decay of organic matter in the form of hydrogen sulfide (H_2S) produced by decomposing microorganisms from organic substances that are toxic to algae and other microorganisms. The results of decay of organic substances cause air pollution and odor. In addition, sulfide is corrosive in the form of hydrogen sulfide which causes problems in the environment (Vaiopoulou in Septiyani, 2017).

Not only sulfides, but the color content is also one of the problems for the environment, especially for the textile industry which uses coloring agents as one of the additives used for its production. Color waste produced from the textile industry is generally a non-biodegradable organic compound that can cause environmental pollution especially waters.

Electrocoagulation is a separation technique that uses electrochemical cells commonly used to handle water (Gameissa in Yolanda 2015). The electrocoagulation process is a combination of electrochemical processes and the process of flocculation-coagulation (Susetyaningsih et al. 2008). These three basic processes interact and are related to carrying out electrocoagulation.

The working principle of this electrocoagulation method is to use two electrode plates which are inserted into a vessel filled with water to be clarified. Then the two electrodes are flowed in a direct direction so that an electrochemical process occurs that causes the cation to move towards the cathode and the anion moves towards the anode. And finally flocculants are formed which will bind contaminants and particles from the raw water. In electrocoagulation there is an anode and cathode. At the anode there is the release of active coagulant in the form of metal ions into the solution, whereas at the cathode an electrolysis reaction takes place in the form of hydrogen gas release (Kashefi in Gunawan 2016).

2. MATERIAL AND METHODS

The type of research used in this study is experimental research with the design of pre and post test without control. The purpose of this study was to determine the differences in the length of electrocoagulant contact time for sulfide and color reduction in wastewater at PT Sipatex Putri Lestari. The variation of contact time used in this study was 30 minutes, 60 minutes, 90 minutes. This research was carried out in PT Sipatex Putri Lestari's during the internship and the results were examined in the Accredited Laboratory of the Environmental Management Agency of Cimahi City.

The Making of Electrocoagulation Reactors

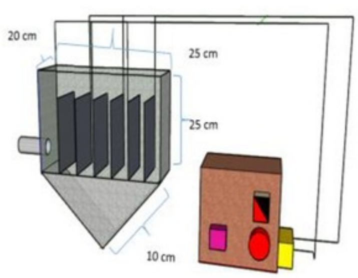


Figure 1. Front Look

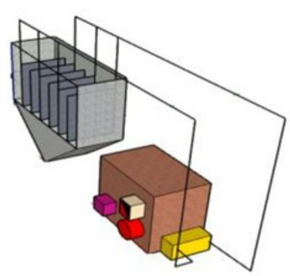


Figure 2. Side View

Figure 3. Electrocoagulation Process

The dimensions of the electrocoagulation tub used are 25 cm × 20 cm × 25 cm with a volume of 12,500 cm^3 and require 12.5 liters of raw water for one treatment.

The use of aluminum plates in this study is adjusted to the volume of the electrocoagulation reactor. The plate size used is 15 × 20 cm as many as 6 pieces for each reactor.

The procedure of this study is that the production of waste water stored in the reservoir will then flow to three electrocoagulation reactors. Samples of wastewater from the three reactors were carried out before electrocoagulation treatment was carried out. Install aluminum electrodes with a distance of 3 cm between electrodes, so that for each reactor requires 3 pairs of aluminum electrodes. Flow the electric current to the electrode with a adjusted contact time of 30 minutes, 60 minutes, 90 minutes. Perform sampling of wastewater from the three reactors after electrocoagulation treatment is carried out.

Data processing is done by calculating the percentage of sulfide and color reduction in wastewater before and after treatment with the following formula:

$$\left(\frac{Initial\ Level - Final\ Level}{Initial\ Level}\right) \times 100\%$$

After calculating the percentage of decline, then analyzed by statistical tests, namely One way ANOVA to determine the significant difference between the time of contact of electrocoagulation to the decrease in sulfide and color in wastewater.

3. RESULTS AND DISCUSSION

Table 1. Results of pH measurement of wastewater before treatment.

Repetition	Average of pH	Final pH 30 mins	60 mins	90 mins
1		7,21	7,22	7,21
2		6,83	6,86	7,12
3		6,69	7,02	7,02
4	6,67	6,78	6,73	6,76
5		6,91	6,97	7,04
6		6,84	7,05	7,13
Average	6,67	6,87	6,97	7,04

Based on Table 1, it can be seen that the initial pH value before being given treatment has an average pH value of 6.67, and after being given treatment the pH of wastewater increases for each treatment. The average for the 30 minute is 6.87, the 60 minute is 6.97 and in the 90 minute is 7.04. Then it can be stated that there is an increase in pH from the electrocoagulation process, namely from acidic pH to neutral pH or almost alkaline.

The increase in pH is caused by the oxidation process that occurs during processing. This increase in pH is the indicator of decreasing pollutant load found in wastewater because the pH value with pollutant load is inversely proportional. If the pH rises, the pollutant load will decrease, whereas if the pH has decreased, the pollutant load will rise.

Table 2. Results of measurements of wastewater temperature before treatment

Repetition	Average temperature	Final Temp. (°C) 30 mins	60 mins	90 mins
1		31,25	31,27	31,28
2		31,22	31,23	31,23
3		31,28	31,31	31,29

4	30,9	31,11	31,12	31,11
5		31,30	31,32	31,27
6		31,06	31	31,12
Average		31,2	31,2	31,2

Based on the table above, it can be seen that the average initial temperature of wastewater before being given treatment is 30.9ºC. While the final temperature of waste water after being given treatment is equal to 31.2ºC.

Changes in the temperature of waste water can be caused by several factors, including due to changes in weather (heat / rain) that can affect the temperature of the wastewater being studied. In addition, other factors, namely from electrocoagulation reactors, are found on the plate used for electrocoagulation processing in the form of aluminum which can stabilize temperature changes and condition with the environment (Retno, 2008).

Table 3. Results of examination of sulfide levels of wastewater after treatment

Repetition	**Pre (mg/l)**		
	P1	**P2**	**P3**
1	0,73	0,71	0,71
2	0,74	0,79	0,78
3	0,82	0,79	0,81
4	0,69	0,71	0,78
5	0,84	0,83	0,86
6	0,82	0,84	0,83
Average	0,77	0,77	0,79

Based on the table above, it can be seen that the average sulfide content in wastewater before treatment, namely in treatment 1 the average sulfide content of 0.77 mg / l, then treatment 2 of 0.77 mg / l, while treatment 3 amounting to 0.79 mg / l.

Table 4. Results of examination of post-treatment sulfide levels of wastewater

Repetition	Post (mg/l)		
	30 mins	**60 mins**	**90 mins**
1	0,45	0,26	0,13
2	0,47	0,29	0,16
3	0,52	0,31	0,20
4	0,48	0,27	0,18
5	0,56	0,34	0,23
6	0,52	0,39	0,24
Average	0,5	0,31	0,19

Based on the table above, it can be seen that there is a change in sulfide levels after being given treatment for 30 minutes of contact time on average sulfide levels of 0.5 mg / l, 60 minutes 0.31 mg / l, and 90 minutes 0.19 mg / l. So that the longer the contact time given to the treatment of wastewater by electrocoagulation method, the higher the decrease in sulfide in wastewater.

Table 5. Results of wastewater Color checking after treatment

Repetition	Pre (Pt-Co)		
	P1	**P2**	**P3**
1	16,51	16,47	16,49
2	17,26	17,39	17,42
3	16,61	16,47	16,58
4	16,67	16,61	16,73
5	16,54	16,57	16,56
6	16,63	16,66	16,71
Average	16,70	16,69	16,74

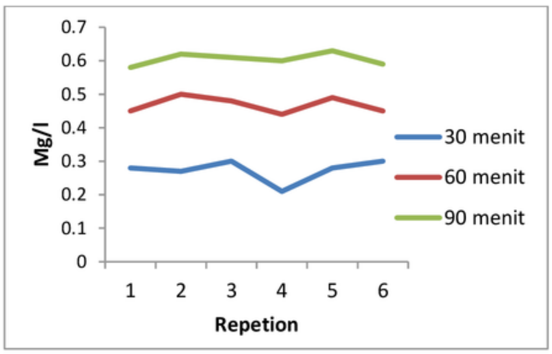
Based on the table above, it can be seen that the average color value in wastewater before treatment, namely in treatment 1 the average color of 16.70 Pt-Co, then treatment 2 is 16.69 Pt-Co, while treatment 3 is equal to 16.74 Pt-Co.

Table 6. Results of wastewater Color checking after treatment

Repetition	Post (Pt-Co)		
	30 mins	**60 mins**	**90 mins**
1	9,23	7,16	2,42
2	9,95	7,96	2,02

3	9,61	7,75	2,91
4	9,44	8,30	2,59
5	9,50	8,32	3,70
6	10,10	9,27	5,75
Average	9,63	8,12	3,23

Based on the table above, it can be seen that there is a change in color After being given the treatment of 30 minutes contact time the average color value is 9.63 Pt-Co, 60 minutes 8.12 Pt-Co, and 90 minutes 3.23 Pt-Co. So that the longer the contact time given to the treatment of wastewater by electrocoagulation method, the higher the color change in wastewater.



Picture 3 Difference in sulfide content of wastewater before and after treatment

Decreasing sulfide levels in textile wastewater, namely at the length of contact time 30 minutes of repetition 1 the highest decline of 38.35% with a difference in number of 0.28 mg / l, for a duration of 60 minutes contact time of 63.38% with a difference in number 0 , 45 mg / l, while the length of contact time of 90 minutes of repetition is 81.69% with a difference of 0.58 mg / l. This reduction in sulfide can be caused by changes in the temperature and pH of wastewater. Because in principle the higher the pH value, the higher the decrease in pollutant load.

The electrical voltage given will affect the amount of pollutants bound, because the higher the voltage, the higher the electric current so that more pollutant waste water is bound to the aluminum plate which can function as a coagulant.

In accordance with what was stated by Michael Faraday, that the longer the time of electrolysis results from a desired chemical reaction will also increase the results that will be desired. So the longer the electrolysis time, the more pollutants will be oxidized.

The removal of pollutant load on the electrocoagulation effluent is influenced by the electrode pair used based on the nature of the metal itself. Because the nature of metals used as electrodes will affect the conductivity of electricity and dissolution of metals (Ngatin, 2010). The decrease in sulfide concentration is due to oxidation and reduction reactions that take place at the anode and cathode, following the reaction equation:

Anoda (Oxidation)

$Al \rightarrow Al^{3+} + 3e^-$

$Al^{3+} + 3OH^- \rightarrow Al(OH)_3$

Catoda (Reduction)

$Al^{3+} + 3e^- \rightarrow Al$

$2H_2O + 2e^- \rightarrow 2OH^- + H_2$

Redocs Reactions

$Al \rightarrow Al^{3+} + 3e^-$ | × 2

$2H_2O + 2e^- \rightarrow 2OH^- + H_2$ | × 3

$2Al \rightarrow 2Al^{3+} + 6e^-$

$6H_2O + 6e^- \rightarrow 6OH^- + 6H_2$

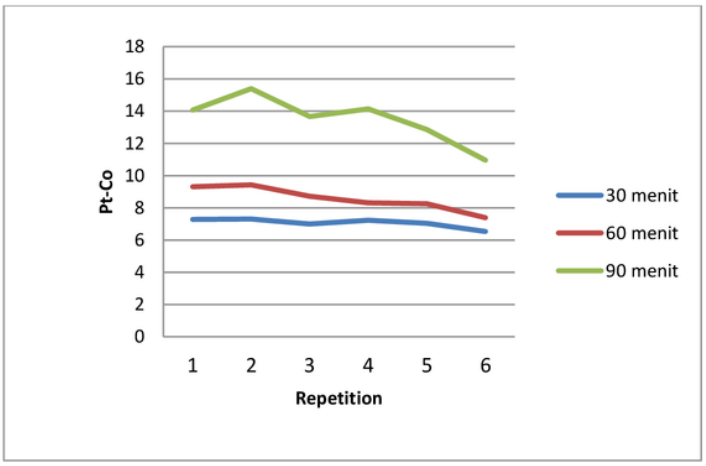
$2Al + 6H_2O \rightarrow 2Al^{3+} + 6OH^- + 3H_2$

From the oxidation reaction, the Al^{3+} ion released at the anode can react with OH- and colloids which are negatively charged to form Al $(OH)_3$ and form flocates with colloidal particles from waste. These flocks will slowly settle to the bottom of the trough.. While the reduction reaction that occurs at the cathode produces hydrogen gas (H_2) which can carry floc and colloid up above the waste water surface. This can be marked with a lot of foam or foam. Because the longer the electrocoagulation process takes place, the more foam produced and the more colloids that are bound to form flocations formed to reduce sulfide.

Chemical reaction if Al $(OH)_3$ reacts with sulfides

$2Al(OH)_3 + S^{2-} \rightarrow Al_2S_3 + 2\ OH^-$

Al_2S_3 is included in ion compounds, because ion compounds are compounds that can receive and release ions. One of the common properties of ion compounds is that they can dissolve in water. Likewise, Al_2S_3 has a low solubility. Because the smaller the solubility of a substance, the more difficult the substance to dissolve and easy to settle.



Picture 4. Color difference of wastewater before and after treatment

Decreasing the color of wastewater at the contact time of 30 minutes of repetition 1 decreased the highest by 44.09% with a difference of 7.28 Pt-Co, for a duration of 60 minutes contact time of 56.48% with a difference of 9.31 Pt-Co , while the length of contact time is 90 minutes of repetition of 2 at 88.39% with a difference in numbers of 15.04 Pt-Co. The small article color declines in industrial waste become larger particles so that the color content in treated water can be reduced due to the electrolysis process in the electrocoagulation method (Holt in Andi, 2012).

In addition to contact time, the color reduction in wastewater is due to the adsorption process. The adsorption process serves to set aside aromatic compounds and dissolved compounds. The greater the electric voltage, the higher the solubility of the anode so that the number of cationic hydroxo complexes will increase and cause the dyestuff to form larger clumps (Mollah in Setianingrum, 2017).

The chemical reaction between $Al(OH)_3$ which acts as a coagulant reacts with waste water dyes:

$$\text{Dye-H} + \text{(OH)OAl} \Leftrightarrow \text{Dye-OAl} + H_2O$$

The bigger the floc is formed, the more sludge is produced, so that more dyes are lost to waste water.

Data Analysis

Based on the results of the ANOVA test for the effect of electrocoagulation time on sulfide levels that p value (0.00) <alpha (0.05) then H0 is rejected so that there is a difference in the time of contact of electrocoagulation to decrease sulfide in industrial wastewater. And it can be said that there is a significant difference between the differences in the length of time of contact with the decrease in sulfide. So that it continues with the Post Hoc test, to see which groups are different. For a duration of 90 minutes of contact time for a contact time of 30 minutes and 60 minutes has a significant difference in value.

For the test results of anova decreasing the color of wastewater that p value (0,00) <alpha (0,05) then H0 is rejected so that there is a difference in the time of contact of the electrocoagulation to decrease in color in wastewater.

Economic Valuation

Based on the results of the research conducted, the authors provide suggestions as follows:

a. Save costs, because if you use coagulation-flocculation, you need chemicals / chemicals that are quite a lot for one treatment, considering that the waste produced per day is quite a lot.
b. Requires land that is not too large when compared to the coagulation-flocculation process
c. The sludge produced from the electrocoagulation process is less than the coagulation that requires chemicals
    1) Used electricity and aluminum needs:

Calculates dissolved aluminum electrodes

Known :

electrode length: 15 cm

electrode width: 20 cm

electrode distance: 3 cm

initial electrode mass: 130 grams

2) Calculate equivalent mass (e)

The electrode at the anode is reduced to an ion:

$Al \rightarrow Al^{3+} + 3e^-$ (Ar Al = 27)

$$e = \frac{Ar}{n}$$

$$e = \frac{27}{3}$$

3) Number of dissolved aluminum electrodes

Faraday relation and Electric Charge :

1 F = 96500 C

Time = 90 minutes

Then, the formula should be:

$$F = \frac{I.t}{96500}$$

$$F = \frac{3\ A.\ 5400\ s}{96500}$$

$$F = 0{,}167$$

So, the amount of aluminum electrode dissolves:

$$m = e \times F$$

$$m = 9 \times 0{,}167$$

$$m = 1{,}503\ gr$$

2) Power that flows

$$P = V \times I$$

$$P = 12\ V \times 3\ A$$

$$P = 36\ watt$$

$$P = 36\ watt \times \frac{1\ kw}{1000\ watt} \times \frac{90\ minute}{1} \times \frac{1\ hour}{60\ minute}$$

$$P = 0{,}054\ kWh$$

If the electricity rate per kWh is Rp. 1410.12 (Source of PT PLN Persero)

Then the electricity tariff used in the electrocoagulation process with a voltage of 12 volts, a current of 3 amperes and a time of 90 minutes is:

$= 0{,}054\ kWh \times Rp.1420{,}12/kWh$

$= Rp.76{,}14648$

4. CONCLUSIONS

1) There is a difference in the electrocoagulation contact time with a variation of 30 minutes, 60 minutes and 90 minutes on the decrease of sulfide in wastewater, ie at 90 minutes with a decrease of 0.58 mg / l, from the initial sulfide content of 0.71 mg / l to 0.13 mg / l. The results of this inspection have met the wastewater quality standards set by the Government Regulation Environmental Number 5 of 2014 calm Water Quality Standards Sulfide parameter wastes in the textile industry which are 0.3 mg / l.
2) Judging from the p-value, there is a significant difference between 90 minutes of contact time and 30 minutes and 90 minutes and 60 minutes of contact time because of the value of P (0,000) $<\alpha$ (0.05). So the effectiveness of electrocoagulation time in reducing sulfide in electrocoagulation waste is at 90 minutes.
3) Judging from the p-value, there is a significant difference between 90 minutes of contact time and 30 minutes and 90 minutes and 60 minutes of contact time because of the value of P (0,000) $<\alpha$ (0.05). The elecrocoagulation time efficiency in reducing color in electrocoagulation waste was at 90 minutes.
4) The electricity tariff used in the electrocoagulation process with a voltage of 12 volts, a current of 3 amperes and a time of 90 minutes is: 0.054 kWh x Rp.1,420.12/kWh = Rp.76,14648.

Acknowledgements

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