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Processing of Liquid Confectionery Wastewater Using Combination of Electrocoagulation with UV Lights Method

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ABSTRACT

Liquid confectionery wastewater treatment is carried out using a combination of batch system electrocoagulation methods and irradiation by UV light. The variations of contact time applied were 30, 45, 60, and 75 minutes, the electrode distance was 2 cm and voltage variation were 20 and 30 volts. In addition to reducing pollutant levels, UV lamps are also used to remove odors. The result showed that the electrocoagulation process and UV irradiation could reduce pollutant levels maximally at 30 volts 73 minutes. COD level decreased from 6958.99 mg/L to 1646.40 mg/L (efficiency 76.34%) and TSS from 459.50 to 50 mg/L (efficiency 88.68%). UV irradiation is also effective in removing the odor of soft confectionery wastewater. This result meets the wastewater quality standard according to PERMENLH No. 5 of 2015 Appendix XXVI, it's just that COD does not meet the quality standards, therefore further research is needed.

Keywords: Electrocoagulation, Sugar Confectionery Waste, COD, TSS, UV Light

1. INTRODUCTION

The development of industry and technology in various fields of life, apart from improving the quality of human life, also has other impacts on the sustainability of the environment, namely in the form of pollution. To prevent unwanted environmental pollution, the government issued a quality standard for waste disposal. Liquid waste disposal is quite strict, thus encouraging industrial players to look for and use waste processing technology that is economical and highly efficient. Wastewater is a combination of liquid and liquid waste originating from residential, office and industrial areas together with ground water, surface water and rainwater [1]. Industrial wastewater is water resulting from processing an industrial process. This type of water is classified as having poor quality because of the contaminants contained in the water. One industry that is closely related to environmental problems is the soft confectionery industry (jelly candy) with various flavors, using sugar and glucose as the main raw materials. Because the main raw material is sugar, the organic material content of the waste is very high with an average COD content of 10,000-30,000 mg/liter [2] When making soft candy, liquid sugar is used instead of water, therefore there is not much waste produced. Waste in the confectionery industry usually or mostly comes from equipment leaks, spills during pouring, or sugar spills. The most common source of liquid waste comes from washing. All liquid waste originating from the factory will enter the drainage channel inside the factory and flow by gravity to the Wastewater Treatment Plant (IPAL). This research uses a combination of the batch system electrocoagulation method with UV light irradiation which aims to determine the effectiveness of the electrocoagulation method in reducing COD and TSS levels as well as eliminating odors using UV light in liquid waste from the soft confectionery industry.

2. METHODS

2.1. Tools and Materials

The materials used are UV lamps, confectionery industry waste water, digestion solution ($K_2Cr_2O_7$), DHL standard solution (0.01 M KCl standard solution), buffer solution 4, buffer solution 10, buffer solution 7, sulfamic acid (NH_2SO_3H), standard solution of Potassium Hydrogen Phthalate ($C_8H_5KO_4$) = COD 500 mg O2/L, reagent solution of sulfuric acid,

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concentrated hydrochloric acid (HCl), mineral-free water (aquademin), concentrated nitric acid (HNO_3), NO_2 gas, acetylene gas (C_2H_2), 0.05 M HNO_3 dilution solution, 5% (v/v) HNO_3 washing solution, ethanol p.a. (Merck, Germany), ethyl acetate p.a. (Merck, Germany), 2-butanol (Merck, Germany), and nitrogen gas. The tools used are a series of electrocoagulation tools, membrane filters with a size of 0.45 µm, electric heaters, desiccators, DO meters, pH meters, conductometers, watch glasses, beakers, 5 ml volumetric pipettes; 10 ml; 15 ml; 25 ml; 50 ml, measuring flask 50 ml; 100 ml; 250 ml; 500 ml; 1000 ml, Erlenmeyer, analytical balance, thermometer, 25 ml burette, glass funnel, filter paper, DC power supply, stopwatch, set of vacuum filter tools, atomic absorption spectrophotometer (SSA), 10 µL Hamilton syringe, 1.0 volume pipette; 2.0; 5.0 ml, syringe, Shimadzu GC-14 BPF gas chromatograph.

2.3. Procedure

The process of processing liquid waste from the confectionery industry is carried out using the batch system electrocoagulation method which is a method of agglomerating and settling fine particles in wastewater using direct electric current to a pair of electrodes (two Al plates) which are 2 cm apart with a contact time variation of 30. 45, 60, and 75 minutes with 20 and 30 volts. then continued with UV light irradiation. The parameters analyzed before and after processing are COD, TSS, pH, DHL, Al^{3+} content test as well as odor and color. Then the change data for each parameter is plotted against the contact time and voltage to obtain the optimum contact time. COD measurements were carried out using closed reflux spectrophotometrically, pH measurements were carried out using the potentiometric method, TSS measurements were carried out using the gravimetric method, Electrical Conductivity (DHL) measurements were carried out using the electrochemical method, Al3+ content measurements were carried out using Atomic Absorption Spectrophotometry (SSA), and odor measurements were carried out using organoleptic test.

3. RESULTS AND DISCUSSION

Initial analysis carried out before processing or before electrocoagulation includes analysis of pH, DO, COD, DHL and TSS. The results of the analysis before processing are presented in Table 1 as follows.

Table 1. Average results of liquid waste measurements before processing

Repetition	pH	DO (mg/L)	DHL (µS/cm)	COD (mg/L)	TSS (mg/L)
1	4.04	2.70	198.40	7057.99	466.00
2	4.07	2.50	203.20	6860.00	453.00
Average	4.05	2.60	200.80	6958.99	459.50
Standard	6-9	-	-	150	150

Based on Table 1, it shows that the parameters tested include pH, DO, DHL, COD, TSS. The DO parameter is very low, namely 2.60 mg/L, which shows that the quality of wastewater is very polluted and can harm aquatic biota that need oxygen if it is not treated first. The high COD value is also due to the high level of organic material in the liquid waste of soft confectionery products that has not been oxidized. The higher the COD value in wastewater, it indicates that the degree of pollution is also higher. This initial waste characterization is a sign that waste must be managed first before being discharged into the environment [3]. High TSS values in waters will reduce the use value of waters and affect the organisms that live in them and affect water clarity [4].

3.1. Increasing pH in Soft Sugar Confectionery Waste

In the electrocoagulation process at the anode, an oxidation reaction will occur from the metal that makes up the electrode. In this research, the one that will experience oxidation is aluminum.

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

At the cathode a reduction reaction will occur.

$2 H_2O + 2 e^- \rightarrow H_2 (g) \uparrow + 2 OH^-$

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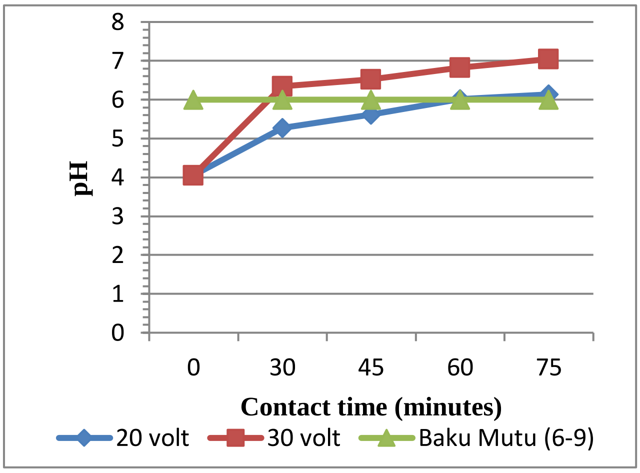

Figure 1. Increase in pH in Soft Confectionery Liquid Waste

Seen that the greater the voltage and contact time applied, the greater the increase in pH. At a voltage density of 30 volts with a time of 75 minutes it can increase the maximum pH by 7.04 and experience a pH increase efficiency of 73.73%. These results have met the quality standards of Minister of Environment Regulation No. 5 of 2014 Appendix XXVI. The effect of voltage and contact time in the electrocoagulation process on pH gives directly proportional [5].

3.2. Decreased BOD and COD Levels

COD (Chemical Oxygen Demand) is the need for chemical oxygen to decompose all organic materials contained in water. BOD (Biological Oxygen Demand) is the amount of dissolved oxygen needed by aerobic bacteria to break down organic matter. The results of BOD and COD testing of confectionery liquid waste before and after the electrocoagulation process and irradiation with UV light are presented in Table 2.

Table 2. BOD and COD Test Results

Parameter	Sample	Amount (mg/L)	Average	Efficiency (%)
BOD	Initial	1764.00	1764.00	
	30 V / 75 min (1)	516.00	514.50	70.83
	30 V / 75 min (2)	513.00		
COD	Initial	6958.99	6958.99	
	30 V / 75 min (1)	1685.60	1646.40	76.34
	30 V / 75 min (2)	1607.20		

Based on Table 2, the levels of these two parameters exceed the quality standards set by Minister of Environment Regulation No. 5 of 2014 Appendix XXVI with COD levels higher than BOD levels. The COD value is always higher than BOD, this is because many organic substances are oxidized chemically but cannot be oxidized biologically [6].

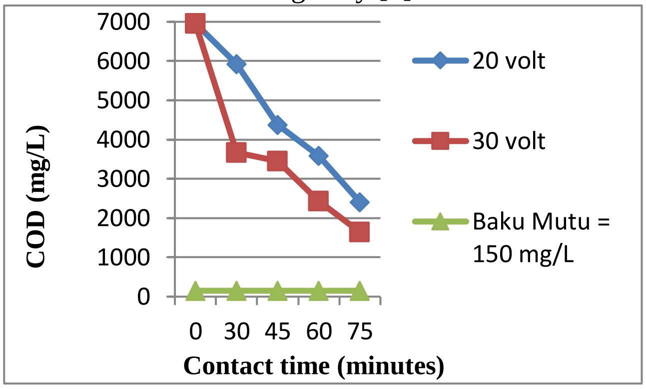

Figure 2. Reduction of COD in Soft Confectionery Liquid Waste

Figure 2 shows that the highest reduction in voltage density of 30 volts with a contact time of 75 minutes was 1646.40 mg/L with an efficiency of 76.34%. The decrease in COD concentration indicates coagulation of organic compounds in wastewater, because basically COD measurements aim to see the amount of oxygen needed to oxidize organic compounds in water [7]. Just like COD, the optimum voltage and contact time to reduce the highest BOD levels is 30 volts 75 minutes. Where the initial BOD level was 1764.00 mg/L to 514.50 mg/L with a reduction efficiency of 70.83%. However, the results of reducing COD and BOD do not meet the permitted quality standards, so further processing needs to be carried out to reduce COD and BOD levels, namely by increasing the voltage and longer contact time to obtain maximum results.

3.3. Reducing TSS in Soft Confectionery Liquid Waste

According to Saputra,[8], TSS is a pollutant that is in suspended form. If a material is suspended, then the material is in solid form with a certain size. This solid material can be easily absorbed into coagulants or absorbed into air bubbles. The results of this adsorption will separate upwards (flotation) resulting in a decrease in TSS concentration.

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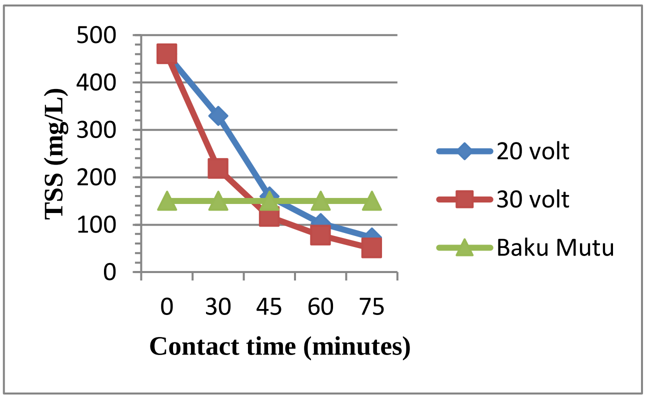

Figure 3. Reduction of TSS in Liquid Confectionary Waste

Figure 3 shows that the greater the voltage and the longer the electrocoagulation time, the greater the decrease in TSS levels. The maximum reduction occurred at an electrocoagulation time of 75 minutes and a voltage of 30 volts with a reduction of 50 mg/L with an initial concentration of 459.5 mg/L (efficiency 88.68%). From the graph it can also be seen that the greater the voltage and contact time, the greater the decrease in the TSS value. This is because the greater the contact time, the greater the potential for breaking down the Al electrode to release Al^{3+} so that the $Al(OH)_3$ floc also becomes greater.

3.4. Reduction of DHL in Soft Confectionery Liquid Waste

The Electrical Conductivity Value (DHL) of a solution shows its ability to conduct electric current which is related to the ionized concentration in the solution. The higher the sample turbidity number, in this case the dissolved solids content contained in the sample, the higher the DHL value [9].

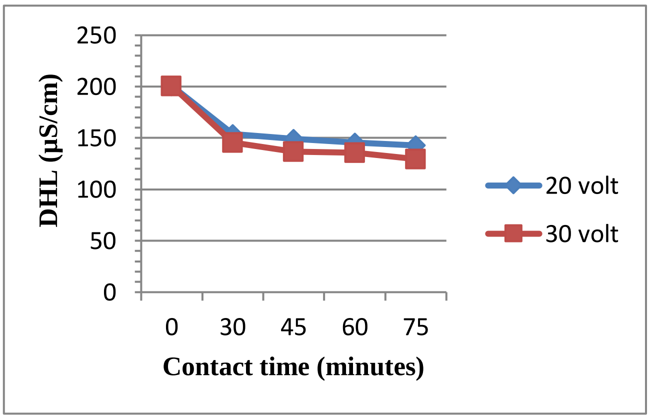

Figure 4. Reduction of DHL in Soft Confectionery Liquid Waste

Figure 4 shows that the longer the electrocoagulation time and the greater the voltage used, the greater the decrease in DHL. The optimum reduction occurred in 75 minutes with a voltage of 30 volts and an efficiency of 35.48%. DHL which continues to decrease can be caused by most of the ions being flocculated so that the electrically conducting ions in solution are decreasing [10].

3.5. Color Reduction in Soft Confectionery Liquid Waste

Dyes are complex aromatic compounds in the form of azo compounds and their derivatives from the benzene group which are difficult to degrade, so their presence in the environment can be a source of disease because they are carcinogenic and mutagenic[11] therefore the color value must be known before the electrocoagulation process, this wastewater had a color value of 2822.3704 Pt-Co, but after the electrocoagulation process with optimum flow rate and voltage, the color value dropped to 69.9629 Pt-Co. The greater the voltage and the longer the contact time, the color value decreases. The decrease in color is caused by the adsorption process, where molecular substances leave the waste solution and combine on the surface of the solid substance (coagulant) in the electrocoagulation process. The adsorption process here functions to remove aromatic compounds and organic compounds .

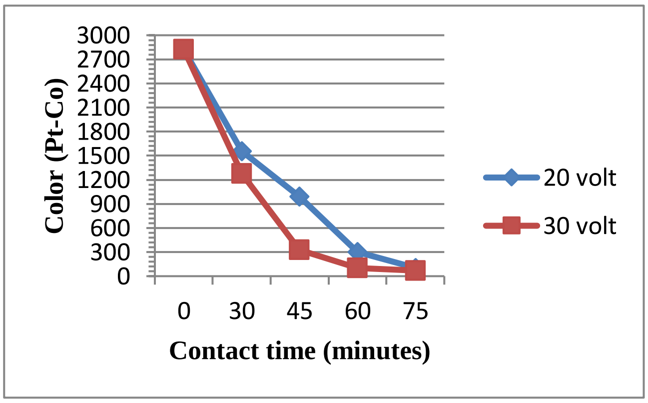

Figure 5. Color reduction in liquid confectionery waste

Before the electrocoagulation process, this wastewater had a color value of 2822.3704 Pt-Co, but after the electrocoagulation process with optimum flow rate and voltage, the color value dropped to 69.9629 Pt-

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Co. The greater the voltage and the longer the contact time, the color value decreases. The decrease in color is caused by the adsorption process, where molecular substances leave the waste solution and combine on the surface of the solid substance (coagulant) in the electrocoagulation process. The adsorption process here functions to remove aromatic compounds and dissolved organic compounds.

3.6. Increase Al^{3+} in Confectionery Liquid Waste

Dissolution of aluminum occurs at the anode electrode. In the process of dissolving aluminum, different chemical reactions occur on the surface of the two electrodes. The anode process results in the dissolution of aluminum metal into Al^{3+} ion molecules [12].

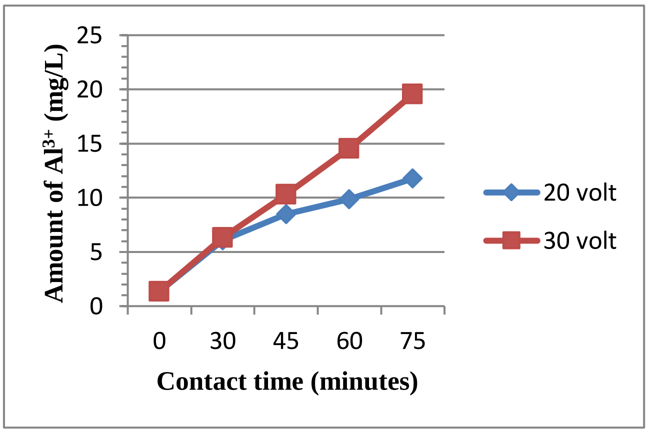

Figure 6. Increase Al^{3+} Metal in Soft Confectionery Liquid Waste

Figure 6 shows that the longer the electrocoagulation time and the greater the voltage, the Al content obtained will increase. The largest increase in Al levels occurred in samples at 30 volts at 75 minutes with levels of 19.55 mg/L. The formation of Al3+ ions as a coagulant can occur due to reactions that occur at the anode and cathode as an electrode pair during the electrocoagulation process.

3.7. Increase DO in Soft Confectionery Liquid Waste

Dissolved oxygen (DO), although not required in wastewater quality standards, is very important to know regarding the number of organic pollutants in wastewater. At a temperature of 27.5 °C the minimum dissolved oxygen requirement is 5.8 mg/L[13].

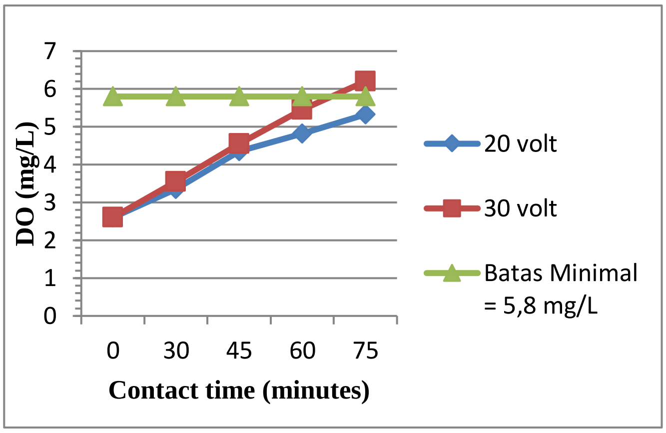

Figure 7. Increase in DO in Soft Confectionery Liquid Waste

Figure 7 shows that the longer the electrocoagulation time and the greater the voltage used, the DO of soft confectionery liquid waste increases. The optimum DO increase at a voltage of 30 volts with a contact time of 75 minutes was 6.2 mg/L.

The greater the number of organic pollutants, the less dissolved oxygen because oxygen is used by microbes to degrade waste. The increase in dissolved oxygen (DO) levels is caused by the oxidation reaction of water to produce O2. The reaction at the anode occurs $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ [14].

3.8. Reducing TDS in Soft Confectionery Liquid Waste

Total Dissolved Solids represent the salts in solution, including mineral salts from the water supply. Dissolved solids are important, especially if liquid waste is to be reused after processing. Dissolved solids are a parameter of the amount of material dissolved in water [15].

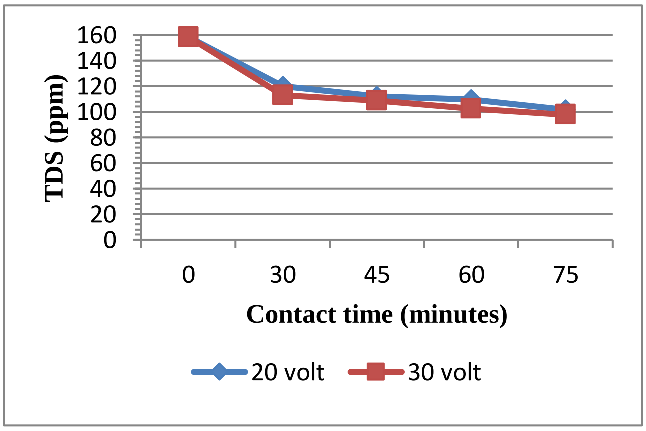

Figure 8. Reduction of TDS in Soft Confectionery Liquid Waste

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The greater the contact time and voltage used, the greater the TDS removal efficiency. A decrease in TDS concentration indicates a decomposition process and a decrease in TDS. The decomposition of TDS is carried out by autotrophic and heterotrophic microorganisms to synthesize cells [16]. At 20 volts (75 minutes contact time) it can reduce TDS levels by 35.89% and at 30 volts (75 minutes contact time) it can reduce TDS levels by 38.35%. The highest reduction in TDS levels in this study was obtained when applying 30 volts 75 minutes, where the initial sample contained TDS of 158.5 mg/L to 97.7 mg/L with a reduction efficiency of 38.35%.

3.9. Analysis of Odor and Color in Soft Confectionery Liquid Waste

Smell is an indication of wastewater spoilage. The cause of the odor in wastewater is due to the presence of volatile materials, dissolved gases, and by-products of decomposing organic materials. Confectionery liquid waste before being treated has a distinctive odor from the process of decomposing organic compounds. After the electrocoagulation process and UV irradiation, the confectionery liquid waste becomes odorless. This shows that the method of treating liquid confectionery waste using electrocoagulation and irradiation with UV light is effective in eliminating odors in liquid confectionery waste.

Figure 9. Wastewater before processing

Figure 9 shows soft confectionery liquid waste before the electrocoagulation process and UV irradiation. The liquid waste produced from this washing process is green and has a distinctive odor.

In research by Sutanto, et al [10], odor reduction was carried out using spectrophotometry. The results of this measurement are still below the quality standards. Therefore, this research was only carried out organoleptically.

Figure 10. Soft Confectionery Wastewater After Processing

Figure 10 shows soft confectionery wastewater after the electrocoagulation process and irradiation by UV light. Where after the electrocoagulation process and UV irradiation, the soft confectionery wastewater which was initially green and smelly became colorless and odorless. The color change after processing is caused by a decrease in the value of dissolved solids and suspended solids. The smaller the flow rate applied also affects the color change results that occur in soft confectionery wastewater, where the wastewater results at 30 volts 75 minutes are clearer.

4. CONCLUSION

The highest reduction in the electrocoagulation process to reduce pollutant parameters in soft confectionery liquid waste was at 30 Volts and a contact time of 75 minutes at an electrode distance of 2 cm with a TSS reduction efficiency of 88.68%, COD of 76.34% and TDS of 38.35% , but it is not effective in reducing the COD value of soft confectionery liquid waste, because the COD value obtained is 1646.40 mg/L and does not meet the quality standards permitted by Minister of Environment Regulation No. 5 of 2014 Appendix XXVI. The reduction results should have met the quality standards within 60 minutes, it's just that the COD and BOD results have not met the permitted quality standards. Therefore, the author analyzes up to 75 minutes.

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