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Decrease Levels of Chromium, Copper, and Nickel in Liquid Waste of The Electroplating Laboratory of Medan Polytechnic with Electrocoagulation Method

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Abstract. The liquid waste contained several metals such as Cr, Cu, and Ni in concentrations of 64 mg / L, 252 mg / L, and 125 mg / L, which may cause environmental pollution. The process of coating metal has resulted in heavy metal waste. The electrocoagulation process is a combination between electrochemical processes and coagulation-flocculation processes. This research aims to use the electrocoagulation method as an alternative for treating wastewater containing heavy metals in particular. The results showed a decreasing trend of percentage in metal content with decreased levels of 99.931%, 99.837%, and 99.994% for Cr, Cu, and Ni, respectively.

Keywords: Electroplating, Wastewater, Electrocoagulation, Flocculation, Coagulation, Heavy Metals

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1 Introduction

Land and water pollution occurs due to uncontrolled waste disposal from heavy metals (Darmono, 1994). Electroplating is defined as the transfer of metal ions with the help of an electric current through the electrolyte so that metal ions settle on a conductive solid object to form a metal layer. The basic principle in the metal plating process is the occurrence of reduction and oxidation at two electrodes with the following conditions: the presence of electricity, the presence of a coating metal as an anode, and the presence of a coated metal as a cathode and an electrolyte as an electric current-conducting solution. Heavy metals contained in electroplating waste include zinc (Zn^{2+}), Nickel (Ni^{2+}), silver (Ag^{2+}), cadmium (Cd^{2+}), and chromium (Cr^{6+}) (Ginting, 1992). Heavy metals have toxic properties that are harmful to live organisms in concentrations that exceed the maximum levels allowed by the government (Palar, 1994). The maximum concentration for chromium metal is 0.5 mg/L, copper 3 mg/L, and nickel 0.5 mg/L (KEP-51/MENLH /10/1995). The level of danger and poisoning caused by waste

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depends on its characteristics; pollution due to its toxic nature and non-biological degradation. Types of heavy metals classified as having a high level of toxicity include Hg, Cd, Cu, Ag, Ni, Pb, As, Pb, As, Cr, Sn, Zn, and Mn (Ginting, 1992). So far, various studies have been carried out to reduce heavy metals in wastewater before being discharged into water bodies. The heavy metal removal processes include sedimentation, filtration, adsorption, evaporation, ion exchange, and membrane separation. However, this method cannot be separated from high costs because some of them use chemicals. Most of them require many stages in the implementation process and require a large area of land. Electrocoagulation is a complex process to remove contaminants in water. The working principle of electrocoagulation is the dissolution of the metal anode (M^+) which then reacts with hydroxyl ions (OH^-) to form a coagulant. This coagulant will adsorb pollutants into large insoluble particulate compounds, which will be floated to the surface of the process bath. An electrocoagulation reactor is an electrochemical cell. The anode (usually aluminum or iron) is used as a coagulant producer, producing hydrogen gas at the cathode (Nainggolan, 2011). In 1909 the US obtained a patent for treating sewage by electrolysis using aluminum and iron as anodes (Vik, 1984). At present, electrocoagulation technology is being developed again to improve the quality of wastewater effluent. An electrocoagulation reactor is an electrochemical cell in which the anode (usually aluminum or iron) is used as the coagulant, and hydrogen gas is produced (at the cathode). Several electrode materials can be made of aluminum, iron, stainless steel, and platinum. In this study, the liquid waste studied came from the rest of the metal plating process on a laboratory scale which has the characteristics of metal content above the levels set by the government that the purpose of this research is to remove heavy metals so that they meet the requirements of wastewater and are not dangerous when discharged into water bodies.

2 Materials and Methods

2.1 Equipments

The equipment used includes Pyrex glassware, an adapter as a DC direct current source, two aluminum plates as electrodes, and an Atomic Absorption Spectrophotometer Variant AA 240 FS to analyze wastewater characteristics.

2.2 Materials

The research material consisted of liquid waste from the electroplating laboratory at Polytechnic of Medan, $Na_2S_2O_5$, and NaOH solution.

2.3 Methods

A total of 1 L of the sample was put into a beaker, added as much as 2 g of $Na_2S_2O_5$, and adjusted the pH to 7, then the electrode that had been dipped into the solution while stirring using a hotplate stirrer for up to 60 minutes. Every 15 minutes, the filtrate is taken by separating

Journal of Chemical Natural Resources Vol. 03, No. 02, 2021 | 143 – 146

the precipitate that is formed. So that later obtained a clear filtrate from electrocoagulation with variations in contact time of 15, 30, 45, and 60 minutes. The resulting filtrate was then prepared for the examination of chromium, copper, and nickel metals using an Atomic Absorption Spectrophotometer (AAS).

3 RESULT AND DISCUSSION

The liquid waste to be electrocoagulated is first prepared and then its metal content is checked using Atomic Absorption Spectrophotometer (AAS), so that the concentrations of Cr, Cu, and Ni contained in the sample are known, as shown in Table 1.

Table 1. Concentrations of Cr, Cu, and Ni contained in the sample

Metal	Concentration
Chromium (Cr)	64 mg/L
Copper (Cu)	252 mg/L
Nickel (Ni)	125 mg/L

After going through the electrocoagulation process, the metals' levels in the liquid waste decreased, and the most effective results were obtained at 60 minutes. The electrocoagulation process was formed through the dissolution of metal from the anode, which then interacts simultaneously with hydroxyl ions and hydrogen gas produced from the cathode. An electric current given to the anode will dissolve the aluminum into a solution that reacts with hydroxy ions (from the cathode) to form hydroxy aluminum. Aluminum hydroxide will flocculate and coagulate. The suspended particles in the formation of larger aggregates will then be separated from the solution through precipitation.

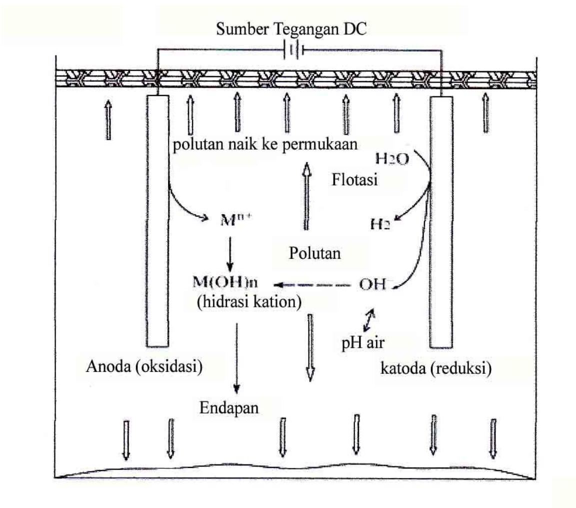

Figure 1. Electrocoagulation Process

Journal of Chemical Natural Resources Vol. 03, No. 02, 2021 | 143 – 146

The aluminum metal anode will be oxidized by following this reaction: $Al^{3+} + 3H_2O \rightarrow Al(OH)_3 + 3H^+ + 3e$. At the cathode, H^+ ions from acid will be reduced to hydrogen gas with a reaction: $2H^+ + 2e \rightarrow H_2$

The floc formed from $Al(OH)_3$ will bind Cu and Ni metals while Cr(VI) is first reduced to Cr (III) using $Na_2S_2O_5$ so that it is adsorbed by $Al(OH)_3$ to form floc. Then the floc formed will separate from the liquid through precipitation.

4 Conclusion

After going through the electrocoagulation process using Al-Al plates, the analysis results showed a decrease in the levels of Cr, Cu, and Ni in wastewater. It was influenced by contact time, where chromium (Cr) decreased to 99.931% with a concentration of 0.0443 mg/L, and copper (Cu) decreased up to 99.837% with a concentration of 0.4101 mg/L. In comparison, nickel (Ni) decreased up to 99.994%, with a grade of 0.007 mg/L. These results were obtained at a contact time of 60 minutes.

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