Laboratory Waste Treatment Hazardous and Toxic Materials (B3) the Rest of PCB Etching Using the Electrolysis Method

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***Abstract*— Wastewater from the PCB etching process from laboratory activities is included in hazardous materials B3 because it contains heavy metals that can pollute the environment and have a negative impact on the human body. So far, the wastewater has only been discharged into the environment diluted approximately 20x to 30x using water. Meanwhile, the standard value limit for wastewater quality has been set by the Government as a reference in determining the limit of heavy metal levels in wastewater. One of the processing methods that can be applied to reduce the content (reduction) of heavy metals in wastewater is the electrolysis method. The tool used is an electrolysis reactor using an electrolysis tank. In this study, the electrode material used was an iron plate, with dimensions of 15 x 4 cm, the distance between the two was 2 cm. With a duration of 60 minutes, and a supply voltage of 12V DC and a waste concentration of 271 ppm. The solution consists of a mixture of HCl + H2O2 + H2O with a ratio of 1:2:7. The results of data analysis between water dilution and electrolysis processing showed a reduction in copper (Cu) content of 57.9% from 0.495mg/L to 0.2869mg/L, lead (Pb) 21.5% from 0.020mg/L to 0.0043mg/L, zinc (Zn) 42.6% from 0.080mg/L to 0.0341mg/L. Based on the analysis of this research data, it can be concluded that the electrolysis waste treatment method is better than just dilution, and that wastewater with the two treatment methods is safe to be discharged into the environment, because the heavy metal content in wastewater is still below the wastewater quality standards set by the Government.**

Keywords: Electrode, Electrolysis, Iron, Liquid Waste, PCB Etching, Processing, Waste Water.

I. INTRODUCTION

One of waste which comes from practical activities in laboratories, especially in the Department of Electrical Engineering, is process waste water etching or dissolving copper boards in manufacturing Printed Circuit Board (PCB) [1]-[4]. This waste water is included in Hazardous and Toxic Materials (B3) because it contains heavy metals [5]. Disposing of this waste into the environment without certain processing will result in increased environmental pollution and ecosystem damage if the concentration level of heavy metals in the waste exceeds the limit waste water quality standards which has been set by the Government [6]-[8]. So a form of processing effort is needed to reduce the levels of heavy metals in the wastewater before it is discharged into the environment [9]. So far, waste water that will be discharged into the environment is only diluted approximately 20x to 30x dilution using water [10]-[13]. Residual solution *etching* PCBs are made from a mixture of HCl (Hydrochloric Acid) + H_2O_2 (Hydrogen Peroxide) is categorized as hazardous waste water for several reasons, namely Corrosive Properties, Toxicity, Potential for Dangerous Chemical Reactions, Environmental Pollution [14]. To overcome environmental pollution, waste processing efforts are needed to reduce heavy metal levels. As an Education Laboratory Officer (PLP) who has the scope of duties, responsibilities and authority to manage educational laboratories, I carried out this research in an effort to process this waste. One processing method that can be applied is the electrolysis method. The electrolysis method is a wastewater treatment method that uses electric current to reduce heavy metal levels [15]. In this method, heavy metals will be deposited at the cathode, while the anions will be oxidized at the anode. Processing PCB etching wastewater using the electrolysis method has several advantages, including being very effective and relatively cheap. Therefore, the electrolysis method is one of the PCB etching wastewater treatment methods that is feasible to apply. Previous research in 2014 was carried out by Handaru Bowo Cahyono and Nurul Mahmida Ariani from Baristand Industri Surabaya, Ministry of Industry. In the results of their research, they concluded that the process of reducing heavy metals in PCB etching wastewater using the electrolysis method effectively provided the highest removal using electrodes. iron plate by 66.21%, on 12V DC supply voltage, at an electrode distance of 2cm with a processing time of 80 minutes.

A. Description of Position Duties Activities and Work Results of Educational Laboratory Staff (PLP)

In PermenpanRB No.7 of 2019 in CHAPTER V concerning Description of PLP job duties and work results, and on page Appendix-1 concerning Details of PLP position duties activities in the Elements of Laboratory Management column, sub-element Design of laboratory activities and sub-elements Operation of equipment and use of materials, several The

following important things related to this research have been defined and stipulated in the articles, including:

1. Processing waste resulting from the process of using special and general materials.
2. Develop SOPs for the use of materials in educational, research and community service activities.

Based on several things above, in this research, as a PLP, I conducted research in the field of wastewater treatment remaining from the use of special materials, namely HCl solution and H_2O_2. Meanwhile, the output of this research is in the form of SOPs and Work Instructions (IK) for processing PCB etching wastewater using the Electrolysis method as carried out in this research.

B. Previous Research

Several previous studies have been conducted to study the influence of the electrolysis method on the reduction of heavy metal levels in PCB etching wastewater. In 2014 previous research was done by Handaru Bowo Cahyono and Nurul Mahmida Ariani from Baristand Industri Surabaya, Ministry of Industry. In the results of their research they concluded that the process of decline or *reduction* heavy metals in residual wastewater *etching* PCB using the electrolysis method effectively provides the highest removal using iron plate electrodes, namely producing a value of 66.21% with a supply voltage of 12V DC, and at an electrode distance of 2cm with a processing time of 80 minutes. Based on previous research conducted by Handaru Bowo Cahyono and Nurul Mahmida Ariani, this research was carried out as a form of applying the method to *reduce* or reduce the concentration levels of heavy metals in residual wastewater *etching* PCB, by Electromechanical Workshop, Telecommunication Engineering Study Program, Department of Electrical Engineering, Malang State Polytechnic.

C. Wastewater Quality Standards for Hazardous and Toxic Materials (B3)

The following are government regulations and laws that contain and regulate hazardous and toxic materials and their management. Among other things, Law of the Republic of Indonesia number 32 of 2009 concerning Environmental Protection and Management. Furthermore, Government Regulation number 101 of 2014 concerning the management of hazardous and toxic waste. Furthermore, Minister of Environment Regulation number 5 of 2014 concerning Waste Water Quality Standards. Furthermore, Minister of Environment and Forestry Regulation number 6 of 2021 concerning Procedures and Requirements for Management of Hazardous and Toxic Waste. The following important things related to B3 waste have been defined and stipulated in the articles, including:

1. Liquid waste is residue resulting from an activity and/or activity in liquid form which is disposed of into the environment and is thought to reduce the quality of the environment.
2. Hazardous and toxic materials, hereinafter abbreviated as B3, are substances, energy and/or other components which, due to their nature, concentration and/or amount, either directly or indirectly, can pollute and/or damage the environment, and/or endanger the environment, health, and survival of humans and other living creatures.
3. Hazardous and toxic waste, hereinafter referred to as B3 waste, is the remainder of a business and/or activity that contains B3.
4. What is meant by "waste water quality standards" are the limits or maximum levels of pollutants that are tolerated or permitted to be introduced into water media or discharged into the environment.
5. Environmental pollution is the entry or entry of living creatures, substances, energy and/or other components into the environment by human activities so that it exceeds established environmental quality standards.
6. B3 waste management is an activity that includes reducing, storing, collecting, transporting, utilizing, processing and/or landfilling which aims to prevent and/or reduce the risk of B3 impacts on the environment, human health and other living creatures.

Furthermore, in Appendix XXIV to the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014, the value is determined *waste water quality standards* for electronics industry businesses and/or activities, are as follows:

NO	PARAMETER	UNIT	CONCENTRATION
	Physical Parameters		
1	TSS	mg/L	60
2	COD	mg/L	110
3	pH		6.0 to 9.0
	Chemical Parameters		
4	Tembaga (With)	mg/L	0,6
5	Lead (Pb)	mg/L	0,1
6	Seng (Zn)	mg/L	5

D. Considerations or Reasons for Selection of Research Parameters for PCB Etching Waste

TSS, COD, and pH are key parameters in assessing the quality of liquid waste. By understanding the meaning and implications of each parameter, we can take appropriate action to maintain the quality of the water environment.

TSS (Total Suspended Solids) is a Turbidity Indicator. TSS measures the total amount of solids suspended in water. These solids can be soil particles, mud, organic material, or even microorganisms. The impact on the environment is that high levels of turbidity can inhibit the penetration of sunlight. Influences the photosynthesis process in aquatic plants and aquatic ecosystems. Blocks fish gills, causing death of aquatic biota. Calms the sediment at the bottom of the water, changing the basic water ecosystem.

COD (Chemical Oxygen Demand) is an Organic Substance Indicator. COD measures the amount of oxygen required to oxidize all organic substances in a water sample, both those that are easily and difficult to biodegrade. The impact on the environment is that high COD levels indicate organic pollution. Can come from domestic, industrial or agricultural waste.

Decreased water quality reduces dissolved oxygen (DO) levels in water, thereby threatening aquatic life. Potential for sludge formation. Decomposing organic substances can produce sludge which can pollute water bodies.

PH is an Acidity Indicator. pH measures the level of acidity or alkalinity of a solution. The pH scale ranges from 0 to 14, where pH 7 is neutral. Environmental Impact, namely a pH value that is too low (acidic) or too high (alkaline) can affect aquatic life. Many aquatic organisms have narrow pH tolerance ranges. Dissolves heavy metals, low pH can dissolve heavy metals which are harmful to the environment and health. Affecting biological processes, extreme pH can inhibit the biological waste processing process.

Why is this parameter important to measure? By measuring TSS, COD and pH, we can find out the quality of waste water, comparing it with predetermined quality standards. Determining the right type of processing, choosing the appropriate processing technology to reduce pollutant levels. Prevent negative impacts on the environment, protect aquatic ecosystems and human health. Monitoring the effectiveness of processing, evaluating the performance of waste processing systems.

Furthermore, PCB etching waste is the residual liquid resulting from the process of dissolving the copper layer on the PCB board (*Printed Circuit Board*) using a mixture of chemical solutions, among others HCl (Chloric Acid) + H_2O_2 (Hydrogen Peroxide) + H_2Oh (water). HCl mixture, H_2O_2, and H_2O in making PCBs produces several compounds, and the reactions are complex with several stages. Here's the explanation:

Level 1: Decomposition of Hydrogen Peroxide (H_2O_2)

- H_2O_2 decomposes spontaneously in water to produce oxygen gas (O_2) and water (H_2O). This reaction is catalyzed by chloride ions (Cl-) from HCl.
- Reaction: $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

Level 2: Reaction of Hydrochloric Acid (HCl) with Copper (Cu)

- HCl reacts with copper (Cu) on the PCB surface, producing copper chloride ($CuCl_2$) and hydrogen gas (H_2).
- Reaction: $Cu(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2(g)$

Level 3: Copper Chloride Reaction ($CuCl_2$) with Hydrogen Peroxide (H_2O_2)

- $CuCl_2$ react with H_2O_2 produces copper chloride peroxide ($CuCl_2(H_2O_2)_2$) and water.
- Reaction: $CuCl_2(aq) + H_2O_2(aq) \rightarrow CuCl_2(H_2O_2)_2(aq)$

Level 4: Deposition of Copper Peroxide (CuO_2)

- $CuCl_2(H_2O_2)_2$ thermally decomposes to produce copper peroxide (CuO_2) and chlorine gas (Cl_2).
- Reaction: $CuCl_2(H_2O_2)_2(aq) \rightarrow CuO_2(s) + Cl_2(g)$

The remaining compounds from PCB etching found in this waste are: Copper chloride ($CuCl_2$), Copper chloride peroxide ($CuCl_2(H_2O_2)_2$), Copper peroxide (CuO_2)

This waste is characterized by:

- High Acidity (Low pH): Etchant is usually strongly acidic (pH < 2) to dissolve copper, so the waste also has a low pH.
- Heavy Metal Content: The etching process involves a solution of copper (Cu) along with other metal contaminants such as zinc (Zn), nickel (Ni), and lead (Pb).

The waste resulting from PCB etching includes dangerous and toxic compounds, including:

- Chlorine gas (Cl_2): Very toxic and can cause serious lung damage.
- Copper chloride ($CuCl_2$): Harmful if swallowed or inhaled, may cause irritation to the eyes, skin and respiratory tract.
- Copper chloride peroxide ($CuCl_2(H_2O_2)_2$): Potentially explosive and may cause irritation to the eyes, skin and respiratory tract.
- Copper peroxide (CuO_2): Harmful if swallowed or inhaled, may cause irritation to the eyes, skin and respiratory tract.

Figure 1. Example of PCB etching solution.
Source: https://www.youtube.com/watch?v=5whHnVpSgqI

E. Electrolysis Method for Heavy Metal Reduction

The electrolysis method is a method of processing liquid waste using DC (unidirectional) electric current. Electric current that flows into liquid waste through electrodes will trigger a chemical reaction that can reduce or reduce the levels of heavy metals in liquid waste. So that heavy metals can be precipitated or removed from solution. In the electrolysis method, heavy metals will settle on the cathode, while other heavy metal ions will dissolve in water.

The main components of the Electrolysis method are:

- The anode is the part of the electrolysis system where oxidation occurs. In the context of PCB etching liquid waste processing, the anode can be made of material containing heavy metals that will be reduced.
- The cathode is the part of the electrolysis system where reduction occurs. At the cathode, heavy metal ions dissolved in liquid waste will receive electrons and precipitate as solid metal.
- Electrolytes are solutions that contain ions that allow the flow of electric current and play a role in electrochemical reactions.

The effect of the electrolysis method on reducing heavy metal levels in liquid waste *etching* PCB is influenced by several factors, namely:

- Electrolysis time, the longer the electrolysis time, the greater the opportunity for heavy metals to be deposited on the cathode.
- A higher electric voltage will increase the electrolysis rate, thereby increasing the efficiency of reducing heavy metal levels.
- pH of the solution.
- Electrodes: different electrode materials have different efficiencies in the electrolysis process. A larger electrode surface area increases electrolysis efficiency.

- Electrode Distance: Smaller electrode spacing increases the rate of electrolysis, thus increasing the efficiency of heavy metal removal.

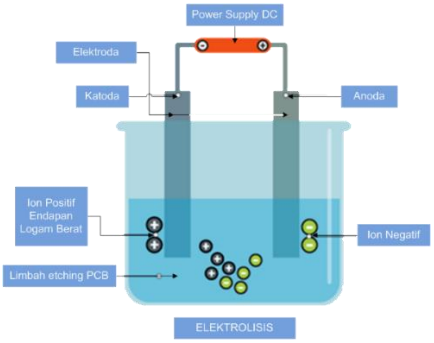

Figure 2. Example relectrolysis reactor or Batch Electrochemical Reactor (REB)
Source : https://air.eng.ui.ac.id/index.php?title=File:Electrolysis.png

Reactions in electrolysis with iron electrodes:
When PCB waste containing $CuCl_2$, $CuCl_2(H_2O_2)_2$, and CuO_2 is introduced into an electrolysis cell with iron electrodes, the following reactions will occur.

1. **$CuCl_2$**
   - **Cathode (negative electrode):** Cu^{2+} ions will be reduced to copper metal (Cu) which will coat the cathode surface.
   - $Cu^{2+} + 2e^- \rightarrow Cu(s)$
   - **Anode (positive electrode):** The iron (Fe) atoms on the anode will be oxidized to become Fe^{2+} ions and enter the solution.
   - $Fe(s) \rightarrow Fe^{2+} + 2e^-$
   - **Overall reaction:**
   - $Cu^{2+} + Fe(s) \rightarrow Cu(s) + Fe^{2+}$
2. **$CuCl_2(H_2O_2)_2$**
   - **Cathode:** Just like in $CuCl_2$, Cu^{2+} ions will be reduced to copper metal.
   - **He likes:** Apart from Fe^{2+} ions, hydrogen peroxide (H_2O_2) can also be oxidized to oxygen (O_2).
   - $2H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$
   - **Overall reaction:** This reaction is more complex because it involves several possible reactions. However, in general, copper will be deposited at the cathode, while iron and oxygen will be products at the anode.
3. **CuO_2**
   - **Cathode**: Cu^{2+} ions will be reduced to copper metal.
   - **He loves**: Oxide ions (O^{2-}) will be oxidized to become oxygen gas.
   - $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$
   - **Overall reaction**: Copper will be deposited at the cathode, while oxygen will be released at the anode.

The overall reaction that occurs at the electrode or electrolysis cell is quite complex and is influenced by several factors, such as ion concentration, pH of the solution, and electrode potential. However, in general, the dominant reaction is the reduction of Cu^{2+} ions to copper metal at the cathode and the oxidation of iron atoms to Fe^{2+} ions at the anode.

F. Wastewater Coagulation

Wastewater coagulation is a water treatment process that aims to remove small particles, organic substances and microorganisms contained in wastewater. This process is carried out by adding special chemicals called coagulants to waste water.

How does the coagulation process work?

- Particle Destabilization: Small particles in wastewater generally have the same electrical charge, so they repel each other and are difficult to combine. The coagulant will neutralize the electrical charge on the surface of the particles, so that the particles become unstable and easily combine.
- Floc Formation: Particles whose charges have been neutralized will combine with each other to form flocs (clumps). This floc is larger and heavier than the original particles, so it settles easily.
- Sedimentation: The floc formed will settle to the bottom of the settling tank, bringing with it small particles, organic substances and other microorganisms.
- Separation: After the settling process, water that is relatively clean will be separated from the sediment. The sludge formed can then be further processed or safely disposed of.

Purpose of Wastewater Coagulation:

- Eliminates turbidity: Reduces the level of turbidity or darkness of wastewater.
- Reduce levels of organic substances: Reduce levels of organic substances such as oil, fat and protein which can cause pollution.
- Eliminates microorganisms: Kills or inactivates disease-causing microorganisms.
- Preparing waste water for further treatment processes: Coagulation is an important initial step before waste water undergoes further treatment processes, such as filtration or disinfection.

NaOH (sodium hydroxide) and HCl (hydrochloric acid) are not conventional coagulants that are often used in wastewater treatment. Commonly used coagulants are metal compounds such as alum or ferric chloride. However, in special cases such as PCB etching waste, NaOH and HCl may be used for certain purposes.

The purpose of using NaOH as a coagulant:

- Neutralizes Acidity: PCB etching waste is generally acidic because it contains hydrochloric acid which is used to dissolve copper. NaOH is a strong base, so it can neutralize the acidity of waste.
- Metal Precipitation: Under certain pH conditions, NaOH can cause precipitation (precipitation) of several heavy metals contained in waste, such as copper. However, it should be noted that the formation of metal hydroxide precipitates is very dependent on the pH of the solution and the metal concentration.
- Sludge Formation: The process of adding NaOH can produce sludge containing metal hydroxide and other

particles. This sludge needs to be separated from waste water through a sedimentation or filtration process.

The purpose of using HCl as a coagulant:

- Lowering the pH: HCl is a strong acid, so it can lower the pH of the solution. This pH reduction may be necessary in some waste treatment processes, for example to dissolve sediment or optimize the performance of other coagulants.
- Helps Dissolve Metals: In some cases, HCl can help re-dissolve metal deposits that form, especially at low pH.

The addition of NaOH will increase the pH value of the solution because of its basic nature. The more NaOH added, the higher the pH value will be achieved. Meanwhile, adding HCl will lower the pH value of the solution because of its acidic nature. The more HCl added, the lower the pH value will be achieved.

II. METHODS

This research was conducted at the Electromechanical Workshop, Telecommunication Engineering Study Program, Department of Electrical Engineering, Malang State Polytechnic. The variables to be studied are TSS, COD, pH, levels Heavy metals include copper (Cu), zinc (Zn), lead (Pb) on wastewater remaining from the process *etching* (dissolution) of copper boards in manufacturing *Printed Circuit Board* (PCB).

The research method used in this research is an experimental method on a laboratory scale. This research was carried out by comparing two data, namely the first data by diluting waste water 20x to 30x using water, and the second data using an electrolysis reaction process in waste water. So that we know the effect of reducing heavy metal levels, by dilution and by the electrolysis process. Next, several things below need to be defined, including:

1. The object of research is waste water remaining from the PCB etching process. This waste water is the material that will be tested for heavy metal levels before and after the electrolysis process.
2. The equipment used in this research includes:
   a. The DC Power Supply functions to provide a DC or Unidirectional power source (voltage and current) to supply the Anode and Cathode poles.
   b. The multimeter or AVOMeter functions to measure the voltage and current from the Power Supply during the electrolysis process.
   c. Total Dissolved Solids (TDS) meter is a tool for measuring the weight of particles (minerals, salts or metals) in water. In units of milligrams per liter (mg/L) or parts per million (PPM).
   d. A pH meter is an electronic device used to measure the degree or level of acidity or alkalinity (pH) of a solution.
   e. The tray functions as a container in the etching process or dissolving the PCB board metal.
   f. The Electrolysis Tank functions as a container or place to accommodate PCB etching waste water and a place where the electrolysis process takes place.
   g. Glasses or bottles function as containers for holding and storing waste liquid before and after the electrolysis process.
3. The materials that will be used in this research include:
   a. A PCB board is a board where some of the metal will be dissolved to form the desired electronic circuit.
   b. HCl (Hydrochloric Acid) + solution H_2O_2 (Hydrogen Peroxide) + H_2O (water) is a mixture of chemical solutions for etching or dissolving metal on PCB boards.
   c. Copper and stainless steel metal plates as cathode and anode pole electrodes in the electrolysis process.
   d. Connecting cable to conduct electricity from the DC Power Supply to the Cathode and Anode poles.
   e. Laboratory filter paper is semi-permeable paper used to separate fine solid particles from liquids or solutions.

This research stage is shown in the following flow image.

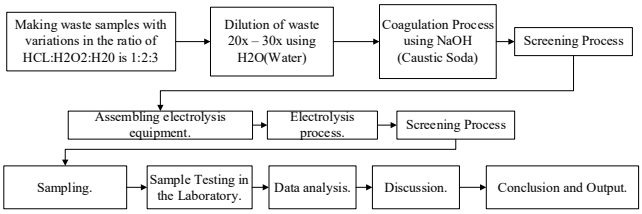

Figure 3. Research Flow and Stages

The following is an explanation of the diagram of the research stages above.

1. First, the preparation stage or making waste water samples.
   a. PCB etching solution is made from a mixture of liquid chemicals HCl, H_2O_2, and H2O with a ratio of 1: 2: 7. The solution is mixed until smooth by stirring in a tray with the volume of each liquid adjusted to the needs or size of the PCB to be used.
   b. Next, prepare the PCB board on which the electronic circuit has been drawn.
   c. If the etching solution and PCB board are ready, the next step is to soak the PCB board in the etching solution. While the PCB is soaking, the tray is shaken so that the PCB copper dissolution process is completed more quickly. If the PCB copper layer has been completely eroded, this is a sign that the PCB dissolution is complete.
   d. When the PCB dissolving process is complete, the PCB copper layer has been mixed into the etching solution, and the etching solution will change to a deeper color.
   e. The remaining solution from the dissolution process (*etching*) These PCBs will be the waste water samples in this research.

Figure 4. PCB etching solution mixture.

Figure 5. Stages of preparing PCB etching wastewater.

2. Waste dilution stage.
Dilution of PCB wastewater is done by mixing or adding H_2O (Water) as much as 15x the waste volume.

Figure 6. PCB etching wastewater dilution stage.

3. Coagulation stage.
   a. This coagulation process uses the chemicals NaOH (Caustic Soda) and/or HCl (Hydrochloric Acid) as the coagulant.
   b. The purpose of the coagulation process in wastewater is to change solid particles in the liquid that cannot settle into ones that settle easily.
   c. Adding NaOH to waste water is carried out if the pH value of the waste water is less than 6, whereas if the pH value of the waste water is more than 9 then the pH value can be lowered by adding HCl solution.
   d. NaOH is added to the PCB waste water little by little, while checking the PH (degree of acidity), using a PH meter. If the PH value has reached 7, then the addition of NaOH can be stopped.

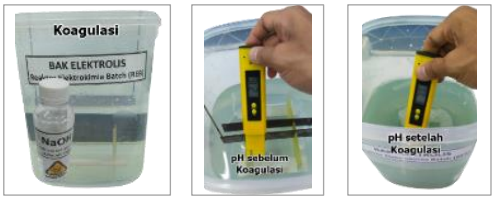

Figure 7. Coagulation Stage.

4. Filtering stage.
   a. The process of filtering liquid waste can use laboratory filter paper. Liquid waste that has gone through the coagulation process is then filtered, requiring at least 2 (two) containers and 1 (one) filter.
   b. Liquid waste is filtered by pouring it into an empty container, by placing the filter on top of the empty container.
   c. With this filtering process, the sediment from the liquid waste will be retained on the filter paper.
   d. Finally, the waste water resulting from the filtering process will be used in the electrolysis process at the next stage.

5. Stage of assembling electrolysis equipment.
The electrolysis equipment is assembled using equipment and materials as shown in Figure 2, namely a picture of an electrolysis reactor.

Figure 8. Preparing the container, electrodes and electrode divider.

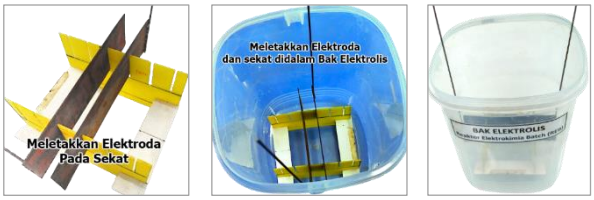

Figure 9. Installing the electrode on the electrode partition and inserting it into the container.

Figure 10. Stages of assembling Electrolysis equipment.

6. Electrolysis process stage.
   a. After the electrolysis equipment is ready, the waste water that has been filtered from the previous stage is poured into the electrolysis reactor container.
   b. Next, the electrolysis process can begin, by turning on the power supply or electrical power source for the electrolysis reactor.
   c. In this electrolysis process, copper compounds that are still present in the waste water will be attracted to the cathode pole

Figure 11. Stages of the electrolysis process.

7. The filtering stage after the electrolysis process.
   a. Repeat step 4.

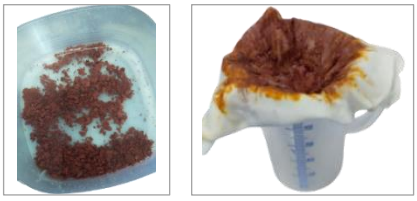

Figure 12. Filtering stage.

8. Stage of taking waste water samples.
Waste water that has gone through the electrolysis process is then stored in several containers.

9. Lastly, laboratory test stage
This waste water sample is then tested in the laboratory using the AAS (Atomic Absobtion Spectrophotometer) and Spectrophotometry (SNI 6989.2:2019) methods to find out the value of the pollutant element levels.

III. RESULTS AND DISCUSSION

A. Data analysis

Wastewater *etching PCB* used in this research were produced from materials as shown in the following table.

NO.	NAME OF MATERIAL	CONCENTRATION	SIZE
1	Hydrochloric Acid (HCl)	32%	100 ml
2	Hydrogen Peroxide (H_2O_2)	50%	200 ml
3	Pure Water (H_2THE)	-	700 ml
4	PCB board	-	20x30cm

The data produced in the analysis in this research was obtained from the results of waste water testing carried out at the Environmental Laboratory of Perum Jasa Tirta I, Jalan Surabaya 2 A Malang, these data include, among others, as shown in the following table.

NO	PARAMETER	UNIT	TEST RESULTS		RAW STOP	CONCLUSION
			Water Dilution 20x (p)	Electrolysis (e)		
A. Physical Parameters						
1	TSS	mg/L	8.00	40.80	60	Filtering improved.
2	COD	mg/L	93.55	68.67	110	Compliant, efficient 26.59%
3	pH	-	7.00	7.21	6 – 9	Compliant.
B. Chemical Parameters						
4	Tembaga (With)	mg/L	0.495	0.2869	0.6	Compliant, efficient 42.04%
5	Lead (Pb)	mg/L	0.020	0.0043	0.1	Compliant, efficient 78.5%
6	Seng (Zn)	mg/L	0.080	0.0341	5	Compliant, efficient 57.37%

The efficiency value in this data analysis is how effective waste processing is *electrolysis* can produce better value for processing by dilution. The formula used is:

$$Efficiency = \frac{(p-e)}{p}\ x\ 100\% \qquad (1)$$

where p is the value of processing by dilution, and e is the value of processing by electrolysis.

Analysis data on waste water *etching PCB* in this research, namely comparing processing data with water dilution and processing *electrolysis* with limits *waste water quality standards* which have been determined by the Government, and calculate efficiency *reduction* levels of pollutant elements from processing *electrolysis* to processing with water dilution only.

From the research data above, it can be analyzed for levels of pollutant elements based on limits *waste water quality standards* that is the level of pollutant elements in waste water does not exceed the limit *waste water quality standards* determined by the Government.

Next is efficiency analysis, namely comparing dilution and processing *electrolysis* namely, the TSS content value with water dilution is 8.00 and with processing *electrolysis* is 40.80 meaning with processing *electrolysis* TSS levels do not produce efficient values because TSS levels actually increase, this can be caused by a lack of performance in the filtering stage or process. And for suggestions for improvements to the TSS value so that it can be better, especially by using the method *electrolysis* like this research, it is best to use a filter with finer or smaller pores at the wastewater filtration process stage. The COD content value, namely by water dilution, is 93.55 and by processing *electrolysis* is 68.67, meaning it is efficient at 26.59%. The pH value, namely by water dilution, is 7.00 and by processing *electrolysis* is 7.21, meaning the pH value corresponds to *waste water quality standards* namely between 6 – 9. For the value of copper (Cu) content, namely by dilution with water is 0.495mg/L and with processing *electrolysis* is 0.2869mg/L meaning it is 42.04% efficient. For the value of lead content (Pb) that is with water dilution is 0.020mg/L and with processing *electrolysis* is 0.0043mg/L meaning it is 78.5% efficient. For zinc (Zn) content values that is with water dilution is 0.080mg/L and with processing *electrolysis* is 0.0341mg/L meaning it is 57.37% efficient.

IV. CONCLUSION

Based on the data analysis above, it can be concluded that waste water is process waste *etching PCB*, either just by dilution using water or by processing *electrolysis* which is in Electromechanical Workshop Laboratory, Telecommunication Engineering Study Program, Department of Electrical Engineering, Malang State Polytechnic, safe to be discharged into the environment, because there is no potential for pollution in the waste water or the levels of pollutant elements in the waste water do not exceed the limit *waste water quality standards* determined by the Government.

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