Video-Based Teaching on Electrolysis Using Simple Copper Media to Vocational School Students

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Abstract: The purpose of this study was to present learning the concept of electrolysis using simple copper media to vocational high school students in grade 3. This research was conducted by making a sample of well water with $CuCl_2$ solution which has a concentration of 1g / L and voltage variation (1.5; 3; 4.5; 6,0; 7.5; and 9,0 V). The test was carried out by electrolysis and water quality tests consisting of solute level testing, water pH test, and water temperature test. This research was also conducted by providing pre-test questions, learning videos, and post-tests. The results showed that the most effective electrolysis method occurred in variations with a voltage of 9V. This is indicated by the value of the decrease in concentration and the increase in mass of solutes after electrolysis. Meanwhile, the test results of vocational high school students show that video-based teaching can improve students 'understanding, as indicated by the students' post-test scores that are higher than the pre-test scores. This research is expected to assist in the selection of instructional media for students and to find out which electrolysis method is effective for reducing Cu levels.

Keywords: $CuCl_2$, electrolysis, learning media, simple copper.

1. Introduction

The very rapid development of science and technology causes almost all human activities to be controlled by the application of science and technology. The more development in science and technology, an effort is needed that can make it easier to find out about these sciences (Li et al., 2017). One of the most appropriate ways is to take advantage of technology in learning in such a way that students are facilitated. Currently, technology as a means of communication has become a separate trend in social life. One of them is the use of video as a means of communication as well as learning media.

Video is one of the information media that is very important in teaching and learning because it is also more communicative and has its attractiveness because the information in video format can give a true impression of the facts on the ground (Hernawati & Nandiyanto, 2021; Winarni & Rasiban, 2021). One example of the use of video-based teaching media is the Development of Video-Based Learning Media on Milling Machine Theory (Vokasi, 2019) and Optimizing the quality of endoscopy in inflammatory bowel disease: focus on surveillance and management of colorectal dysplasia using interactive image-and video-based teaching (Kaltenbach et al., 2017). and Learning Video-based on the Effect of Various Types of Flour on the Characteristics of Sagon Crackers for High School Students (Anggraeni et al., 2020).

Along with the times, it is also very difficult to get good water quality. People still use wells as a source of clean water supply as an activity in their daily life and as a source of drinking water. However, much well water is now contaminated, both organic and inorganic (Adimall et al., 2018). The decline in water quality is the result of human activities that do not care about the environment and do not heed the principles of sustainable development. The source of water pollution is caused by human activities, the food industry, the drug industry, household waste, tin smelting, oil disposal, the oil industry, and the batik industry, most of which contain the heavy metal (such as Cu) (Paul et al., 2019). Heavy metals can be associated with the biota's food chain system in the waters so that they can reach the human

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body that consumes them. Thus, it is necessary to process water to meet daily water needs.

Electrolysis is a chemical change or decomposition reaction in an electrolyte by an electric current (Chai et al., 2019). The electrolysis method is a chemical process that converts electrical energy into chemical energy (Held et al., 2019). The most important components of electrolysis are electrodes and electrolyte solutions (Huang, 2018). Laboratory-scale processing of copper elemental liquid waste utilizes an electrolysis process that provides effective results, the percentage of removal ranges from 96.88 to 99% (Li et al., 2020). However, in its application, this process requires very expensive operational costs. Therefore, this study was carried out using simple copper. Understanding some practicum is important for vocational school (Ana, 2020; Handayani et al., 2020).

Based on our previous studies for applying experiment for vocational school (Nandiyanto et al., 2020a; Nandiyanto et al., 2020b; Nandiyanto et al., 2020c; Nandiyanto et al., 2020d; Nandiyanto et al., 2020), here, experiments were carried out by making teaching combined with experimental demonstrations. The teaching process is supported by pre-test questions, instructional videos, and post-test results.

2. Materials and Method

2.1. Materials

The materials used in this study were copper (II) chloride ($CuCl_2$), water, and Chironomus larvae. The tools used are batteries, copper electrodes, brass, tin clamp, scales, beaker, TDS meter, thermometer, and universal indicator mark (pH paper).

2.2. Method

Figure 1 shows the experimental steps in this study.

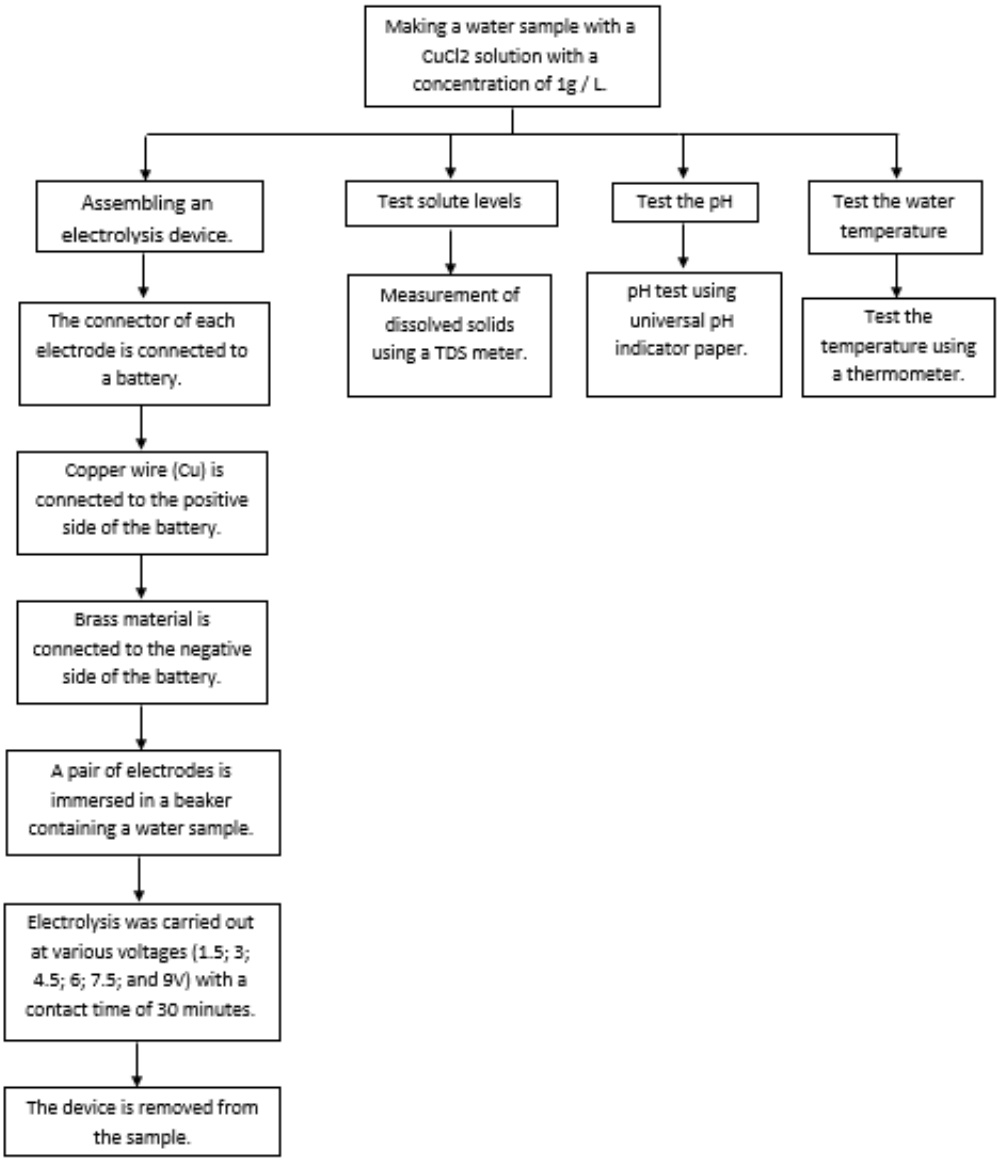

Fig. 1 Experimental steps

2.2.1. Water sample making

The water sample used was obtained by mixing water and copper (II) chloride. The concentration of the sample solution is 1g / L, copper (II) chloride powder is dissolved into the water by stirring until homogeneous with water.

2.2.2 Electrolysis

The first step taken is assembling the electrolysis device with the connector of each electrode connected to the battery. The copper wire (Cu) is the cathode that is connected to the positive side of the battery, while the brass material as the anode is connected to the negative side of the battery. Furthermore, the pair of electrodes are immersed in a beaker containing a water sample. Electrolysis was carried out at various voltages (1.5; 3; 4.5; 6; 7.5; and 9 Voltes) with the duration of the contact for each variation of 30 minutes. Then, the device was removed from the sample, continued by taking water quality test data.

2.2.3 Water quality testing

2.2.3.1. Dissolved substance test

Total dissolved solids, also known as total dissolved solids (TDS), refer to the total amount of inorganic and organic substances dissolved in the water. The basis for measuring TDS is the conductivity or conductivity of the solution. Measurement of dissolved solids can be done using a TDS meter.

2.2.3.2. Water pH test

The pH value is one of the important chemical parameters in determining water quality. The level of acidity or alkalinity of a sample is measured on a pH scale which shows the concentration of hydrogen ions in the solution. High or low pH is influenced by the compounds contained in the solution. The pH scale has a range of 0 - 14, with a value of 7 as a neutral pH, below 7 a solution is called acid, and above 7 a solution is called alkaline. Many chemical reactions are controlled by pH values and so are biological activities which are usually limited by a very narrow pH range (between 6 - 8). The water is expected to be less acidic or alkaline because it is corrosive or might be difficult to treat.

2.2.3.3 Water temperature test

This parameter is very necessary for determining the character of the waste because it relates to the speed of the reaction and its effect on the solubility of a gas, smell, and taste. The population of several types of bacteria is influenced by the temperature of the waste, especially aquatic organisms that are very sensitive to changes in water temperature. Temperature measurements are carried out using a thermometer suitable for each depth variation.

2.3. Teaching Methods

The use of appropriate learning media can become an intermediary for students to understand the material and improve the quality of learning. The use and utilization of learning tools and media are intended to increase the effectiveness and efficiency of learning (Maryanti, 2021; Maryanti & Nandiyanto, 2023). The method used in this research is an experimental demonstration via video. This research was conducted on 20 grade 3 vocational high school students. The learning process was carried out in 3 stages, namely the first stage of the pre-test to determine the students' prior knowledge. The second stage is the provision of instructional videos. And the third stage is the post-test to see the effect of using instructional videos. The material presented in the video is designed in such a way as to have a coherent structure and be able to convey messages that can guide students in understanding the material.

3. Results and Discussion

3.1. Electrolysis

Table 1 is the concentration data of the copper (II) chloride ($CuCl_2$) solution before and after electrolysis which shows a decrease in the concentration of dissolved solids in all variations (1.5; 3; 4.5; 6; 7.5; and 9 Volts). From the results of data analysis, it was found that the highest concentration value decreased with a final concentration of 525ppm from the initial concentration of 615ppm. The decrease in concentration occurs at the variation of 9 Volts, which is the optimum stress strength because there is a significant decrease in concentration at that voltage. The higher the voltage potential, in the electrolysis process, the better the concentration of heavy metals in the sample solution will be decreased (Veronika et al., 2018). This shows that the electrolysis method can reduce the concentration of $CuCl_2$ solution.

Figure 2 shows that the 9v battery voltage can absorb the most copper compared to other battery voltages. This indicates that the amount of electric voltage has a positive effect on the amount of copper absorbed. The higher the voltage resulted the less copper pollutes the water.

Table 1. Solution Concentration Data

Variation (Volt)	Before (ppm)	After (ppm)
1.5	526	525
3	526	525
4.5	526	505
6	529	502
7.5	615	542
9	615	525

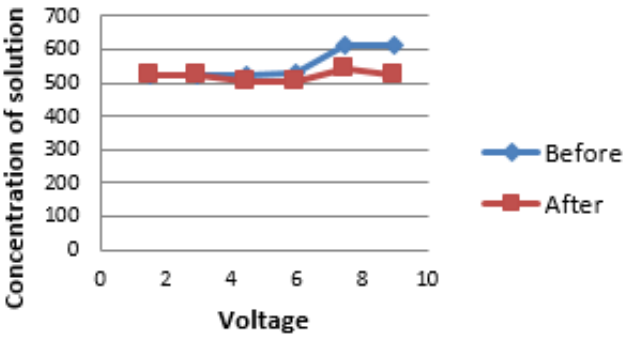

Fig. 2 solution concentration data

Table 2 is the anode mass data before and after electrolysis which shows an increase in mass at variations 3; 4.5; 6; 7.5; and 9 Volts. This increase in mass indicates that

the electrolysis process was successful. From the results of data analysis, the increase in the highest mass value occurred at the voltage variation of 9 Volts with an anode mass of 5.98 g from the initial mass of 5.26 g.

Table 2. Anode Mass Data

Variation (Volt)	Before (g)	After (g)	The mass difference (g)
1.5	5.23	5.23	0
3	5.23	5.27	0.4
4.5	5.23	5.27	0.4
6	5.26	5.32	0.6
7.5	5.26	5.32	0.6
9	5.26	5.98	0.72

Figure 3 shows that the 9-Volt battery voltage produces the largest difference in anode mass compared to other variants. This is because the 9-Volt voltage variant is the highest electric voltage. Thus, it can absorb more copper from the sample. The higher the voltage resulted the higher the mass difference of the anode.

Table 3 is the solution temperature data before and after electrolysis, showing the increase and decrease in temperature at variations of 3; 4.5; 6; 7.5; and 9 Volts. The highest decrease in temperature value is 0.80°C, which occurs in variations of 6 and 7 Volts. The increase in the highest temperature value is 0.90°C which occurs in the 9V variation. This temperature increase indicates that the rate of the electrolysis process is fast as shown in Fig. 4.

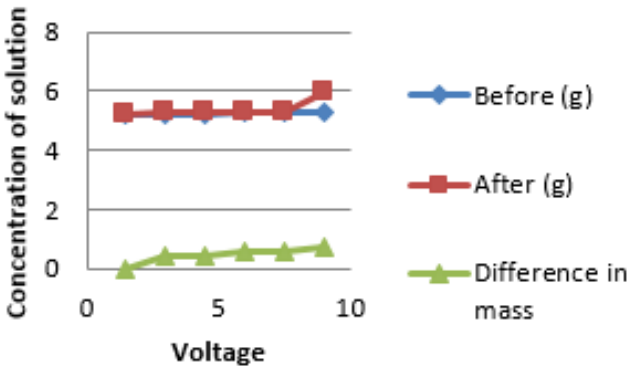

Fig. 3 Anode mass data

Table 3. Solution Temperature Data

Variation (Volt)	Before (°C)	After (°C)
1.5	24.8	24.8
3	24.8	24.7
4.5	24.8	24.3
6	23.3	22.5
7.5	23.6	22.8
9	23.7	24.6

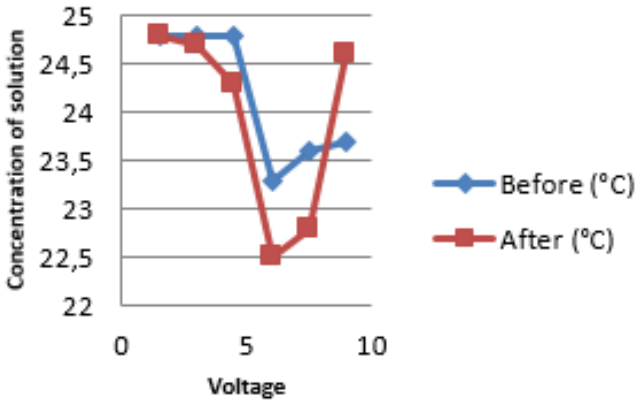

Fig. 4 Solution concentration data

3.2. Teaching media

Video is an audio-visual learning media that combines visual material and auditive material (Hernawati & Nandiyanto, 2021; Winarni & Rasiban, 2021). Visual material makes students able to capture learning messages through visualization (observation) and auditive material makes students able to receive messages through hearing (Anggreini & Dewi, 2020). Table 4 shows the results of student academic learning based on mathematics and Indonesian subjects, showing an average score above 87.50.

Table 4. Average Value of Several Student Subjects in the School

Subject	Average Score
Mathematics	87.65
Indonesian	87.35

Table 5 shows the value of the students' pre-test and post-test results before and after watching the learning video. Pretests and posttests can provide students with cognitive development, improve their understanding of learning content. Learning with video involves students actively so that it provides benefits for students to transfer their knowledge so that a deeper and more complex understanding is obtained. The pre-test results show a lower value than the post-test results.

This shows that video-based learning media has succeeded in increasing student understanding. Learning videos can combine and integrate various learning methods and techniques that effectively help students in the learning process in the classroom and can improve student learning outcomes and motivation. In addition, the limitations of this study need to be considered because this research was conducted when the COVID-19 outbreak occurred online or from home studies that need additional strategies for enhancing students' comprehension (Mulyanti et al., 2020; Hashim et al., 2020; Sangsawang, 2020; Hernawati & Nandiyanto, 2021; Nasution & Nandiyanto, 2021; Huwaidi et al., 2021; Maryanti, 2021; Ganesha et al., 2021; Ramdhani & Nandiyanto, 2021; Albar et al., 2021; Lathifah & Maryanti, 2021; Maulidayani et al., 2022; Anh, 2022; Azzahra et al., 2022; Bermudez et al., 2021; Ledesma et al., 2021; Phanse, 2021).

Table 5. The Percentage of Scores Obtained by Students

No	Question	Score		
		Pre-test	Post-test	Gain
1	Cu in large amounts is a microelement that is needed by organisms.	95	100	1.000
2	Copper particles found in the waters can come from industrial waste, Cu mining, and various port activities.	90	95	0.500
3	Electrocoagulation of copper metal in water is associated with sustainable development goals (SDGs).	70	95	0.833
4	Electrocoagulation is a method of treating raw water or liquid waste by utilizing electrical energy.	80	100	1.000
5	Electrolysis of copper metal in water can be carried out with simple materials.	95	100	1.000
6	Testing temperature, acidity level, and dissolved solids content cannot be used as a method of testing water quality.	90	95	0.500
7	A sample is many CuCl2 powders dissolved with water.	75	90	0.600
8	The amount of electric voltage is directly proportional to the electrolyzed copper content.	80	90	0.500
9	A large amount of metal electrolyzed results in a greater mass of the anode.	75	95	1.250
10	Water contaminated with copper metal can cause health problems.	90	100	1.000
11	Cu is a metal element found in liquid waste.	55	80	0.555
12	Metallic elements in wastewater can be completely removed.	70	85	0.500
13	Different $CuCl_2$ concentrations can result in a decrease in Cu metal content more.	90	95	0.500
14	The effect of battery power can affect the amount of dissolved Cu.	85	90	0.333
5	The size of the $CuCl_2$ concentration can affect the decrease in Cu metal content.	75	90	0.600
16	Chrinomous larvae can survive longer in water containing $CuCl_2$ metal.	45	60	0.272
17	The electrolysis process cannot remove the metal content completely.	45	80	0.636
18	Chrinomous larvae cannot survive in water containing $CuCl_2$ metal.	45	70	0.454
19	The 9-volt variation is the best because it shows the biggest difference.	40	65	0.416
20	The variation of 1.5 volts is the best because it shows the biggest difference.	30	60	0.428
Average				0.643

4. Conclusion

The most effective variation of the electrolysis method used to reduce Cu levels is a variation with a strong voltage of 9 V. These variations indicate a decrease in the concentration of the solution and a very significant increase in mass value. From the test results of 20 grade 3 vocational high school students, the use of video-based learning media can improve student understanding, confirmed by the comparison of the student's scores from the pretest and post-test results which have increased.

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