Teaching Electroflotation Process with Voltage and Electrode Variations in Domestic Wastewater Treatment to Vocational School Students

Sri Anggraeni, Aghisna Nuthfah Anshar, Aldi Maulana, Siti Nurazizah, Zalfa Nurjihan, Silmi Ridwan Putri, Asep Bayu Dani Nandiyanto*

Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229 Bandung, Indonesia
anggraeni_said@upi.edu, aghisnanuthfah@upi.edu, aldimaul@upi.edu, sitinurazizah@upi.edu, zalfanurjihan@upi.edu, silmiridwanppp@upi.edu, nandiyanto@upi.edu

Abstract: This research was conducted to determine the effectiveness of the method of learning the electroflotation process with a variety of stainless steel and copper electrodes and the voltages and voltages used. The experiment was carried out by treating domestic wastewater with the electroflotation method at various voltages of 6; 9; 12; 15; and 18 volts and variations of electrodes A, B, and C. The elements of the dispersed substance in the water medium, the pH level, and temperature in the water sample are measured first, then measured again to find out how much influence electroflotation has in separating pollutants. The application of learning is done by providing pretest questions, learning videos, and posttests. The results showed that sample A was good because it had an average value in the decrease in TDS as well as the temperature of the solution. While the results of the implementation of demonstration videos are effective, the score is not significant because it is likely that students already understand the concept as well as network factors. This research is expected to provide solutions to the problem of domestic oil-tainted water and improve the understanding of vocational school students about the concept of electro flotation to clear water.

Keywords: copper, electro flotation, stainless steel, teaching clears water

Asep Bayu Dani Nandiyanto
Departemen Pendidikan Kimia, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229 Bandung, Indonesia
nandiyanto@upi.edu

1. Introduction

The increasing population increases make the level of water pollution increase due to the results of human activities (Bilad, 2017). Water pollution by domestic waste is proportional to the increase in population. Thus, it requires fast handling, especially waste from waste cooking oil from heating (Bhikuning & Senda, 2020), which is discharged into the sewer system, which can pollute the environment, especially the waters (Singhabhandhu & Tezuka, 2010). Water pollution that occurs includes contamination of groundwater (Hepburn et al., 2019) and river water (Liu et al., 2018). Oil waste in the water can be removed or separated using cotton.

Cotton can be used as an oil absorbent material by coating it with graphene oxide first (Dashairya et al., 2018). In addition, the way to overcome the problem of domestic liquid waste which becomes water pollution is by employing the electroflotation method (Dimoglo et al., 2019). Electroflotation is the process of separating pollutants in a liquid by floating substances or particles scattered in water to the surface through the formation of oxygen and hydrogen gas bubbles at the electrodes (Ahmad et al., 2020).

The application of an electric field produces an electrochemical reaction (Strömberg, 2023), which affects the performance of the electroflotation process (Ghernaout et al., 2015).

At the cathode:

$$2H_2O_{(l)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$$

$$E_0 = -0.83\ V \quad (1)$$

$$2H_3O^+_{(aq)} + 2e^- \rightarrow 2H_2O_{(l)} + H_{2(g)}$$

$$E_0 = 0\ V \quad (2)$$

E_0 is the standard electrode potential at 298 K.

At the anode:

$$2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$$

$E_0 = 1.23$ V (3)

The advantage of this technique is that the electrode grating can be adjusted to provide good coverage of the entire surface area of the flotation tank. Thus, it is well mixed between wastewater and gas bubbles and can also be used on a smaller scale (Kyzas & Matis, 2016). The process performance of this electroflotation can be studied by high school students and is related to chemistry subjects regarding the effect of electricity on dispersed substances. The experimental demonstration method can be used as a method for teaching the electroflotation process.

This experimental demonstration method can attract students' focus and help students to more easily understand the subject matter (Hidayat et al., 2020; Maryanti & Nandiyanto, 2023). This demonstration method will use video media as a medium for delivering performance material from electroflotation. The choice of video as a learning medium is because instructional videos are an effective means and equip students to be more confident in doing a practicum in the laboratory (Stone et al., 2020). The research is focused on learning about dealing with waters polluted by domestic waste because the electroflotation method can treat domestic waste by separating the dispersed oil in the water (Ibrahim et al., 2001).

We have started to switch to the application of the electroflotation process as an alternative to treating water waste (Dimoglo et al., 2019). Existing research electroflotation is used in laundry waste (Ge et al., 2004), textile waste (Belkacem et al., 2008), metal waste (Khelifa et al., 2005), heavy metal waste (da Mota et al., 2015), and industrial waste (Mostashami & Shang, 2019). The research that has been carried out has not applied the concept to students, so the effectiveness of the electroflotation concept on the types of domestic oil waste that pollutes the waters is unknown. Understanding some practicum is important for vocational school (Ana, 2020; Handayani et al., 2020). Thus, based on our previous studies for applying experiments to vocational schools (Nandiyanto et al., 2020a; Nandiyanto et al., 2020b; Nandiyanto et al., 2020c; Nandiyanto et al., 2020; Nandiyanto et al., 2020), the purpose of this study is to examine the application of the concept of learning to deal with waters contaminated with domestic waste oil through the electroflotation method with variations in electrodes and electric voltage.

2. Method

2.1. Electroflotation process

The main material used was waste oil with modeling. The tools included a multimeter, Total Dissolved Solid (TDS) meter, pH paper, thermometer, 1.5-volt battery stone, battery holder, copper, stainless steel plates, and alligator clip. The variations studied were electric voltage (6, 9, 12, 15, and 18 volts) and the cathode-anode variations of copper (C) and stainless steel (SS) with detailed variations described in Table 1.

Table 1. Anode Cathode Variation

Sample	Cathode	Anode
A	Stainless steel	Copper
B	Copper	Stainless steel
C	Stainless steel	Stainless steel

Figure 1 shows the steps of the sampling and electroflotation process. Briefly, the waste sample was prepared in a glass. We measured the temperature, pH, and TDS. Then, we assembled the electroflotation device with different cathodes and voltages (6, 9, 12, 15, and 18 volts), and observed any changes that occur in temperature, pH, and TDS.

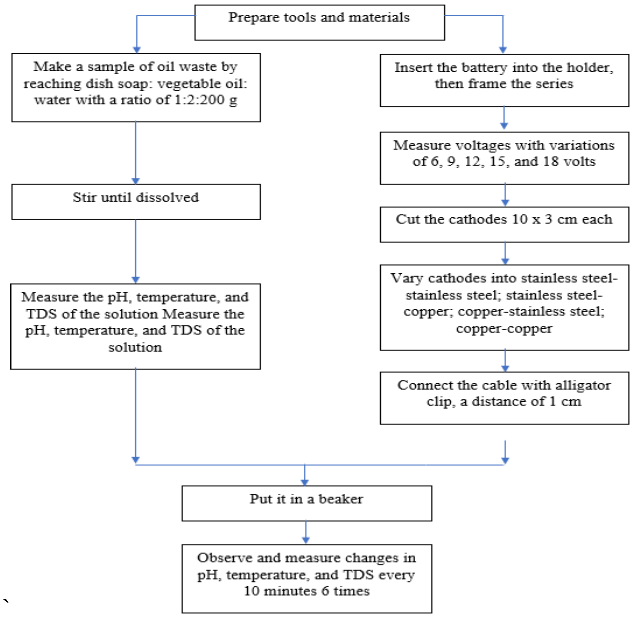

Fig 1. Electroflotation flow chart

2.2. Water quality test

2.2.1 pH test

The level of acidity or alkalinity of a sample is measured based on a pH scale which can indicate the concentration of hydrogen ions in the solution. The pH scale has a range of 0 - 14, with a value of 7 being neutral pH, below 7 a solution is called acid while above 7 a solution is called alkaline. Many chemical reactions are controlled by pH values and so are biological activities that are usually limited by a very narrow pH range (between 6 and 8). To measure the degree of acidity, universal pH paper with color matching is used.

2.2.2 Total dissolved solids

TDS is a measurement of inorganic salts, organic, and other materials dissolved in water. TDS measurements do not differentiate between ions. TDS meters provide water hardness measurement results, measurements can be made with TDS meters (Taylor et al., 2018).

2.2.3 Water temperature test

Temperature parameters are 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. Several types of bacterial populations are affected by the temperature of the waste, and aquatic organisms are very sensitive to changes in water temperature. Measuring temperature can be used as a thermometer that can be used for any depth variation (Ng et al., 2001).

2.3. Teaching methods

This study uses an experimental demonstration learning method. This method was carried out on 18 vocational students in several locations in West Java, Indonesia. The research subjects were vocational high school students consisting of 15 girls and 3 boys with an average age of 17 years. The experimental demonstration was done in 3 stages:

(i) Students were given pretest questions to find out their initial knowledge of electroflotation.
(ii) Students were given a video explaining the electroflotation process with variations in cathode-anode and electric voltage, and how it affects temperature, pH, and TDS. Video accompanied by proof of test results.
(iii) Students were given a posttest to see their understanding of electroflotation which was carried out after being given the video. N-gain is done to determine the difference in the results of the students' pretest and posttest.

The pretest and post-test questions have given are the same questions, consisting of 10 questions with a true or false answer. Students must analyze the statement given and determine whether the question is true or false. The analysis score is 1 if the student answered correctly and 0 if the student answered incorrectly. The maximum score in this analysis is 100. Basic student information, including IQ points and scores for Indonesian, mathematics, and English, were collected to support the research instrument. The IQ point scoring technique was done through an IQ test on tes-iq.com. The questions are:

1. Electroflotation is an electrochemical treatment for wastewater treatment
2. The process of clumping pollutants to reduce metal ions in water by the electrolysis method is called electroflotation
3. The variation of the electric voltage at the electrodes affects the electroflotation process.
4. The difference between electrocoagulation and electroflotation processes is the reaction of dispersed particles in the water
5. One of the indicators that are used as testing material in electroflotation is to test the number of dissolved dispersants in wastewater.
6. The closer the distance between the electrodes, the smaller the number of pollutants that are successfully removed.
7. Oil waste is included in domestic waste and is B3 waste.
8. The best electrode variations that are produced are using copper as the anode and stainless steel as the cathode.
9. Stainless steel is more effective to use as an electrode in the electroflotation process because the removal of dissolved dispersants to the surface using stainless steel electrodes is more effective.
10. The pollutants raised in the waste solution are blue to black, indicating that the amount of large solid lumps that are formed is greater.

2.4. N-Gain score test

Our study of electroflotation was measured using the N-Gain score test, providing results in the form of levels of achievement in equation (1) (Afriana et al., 2016).

$$\langle g\rangle = \frac{\%S_f - \%S_i}{100 - \%S_i} \quad (1)$$

where <g> is normal gain,% Sf is the posttest score, and% Si is the pretest score. with the acquisition of an average score of N-Gain <0.3 in the low category, 0.3 <(<g>) <0.6 in the medium category, and> 0.6 in the high category.

3. Results and Discussion

3.1. pH test

Based on the results of observations of electric voltage to pH is shown in Fig. 2. pH in variation A has an average value of 8.60; variation B has a mean value of 7.33, and variation C has a mean value of 8.18. The results showed that a good pH value is owned by variation B because the pH value is neutral, while the less good pH value is owned by variation A because it has a pH value with a low base indication. A good pH value for water and drinking water is from a threshold of 6 to 8.5 (Sorensen et al., 2018). The pH in this study was only monitored and not controlled, so the pH will change during electroflotation. Figure 2 shows the change in pH of the sample solution along with the length of time for electroflotation. From Figure 2, the pH tends to increase from 12 volts to 18 volts, this happens because of the reduced metal in the solution.

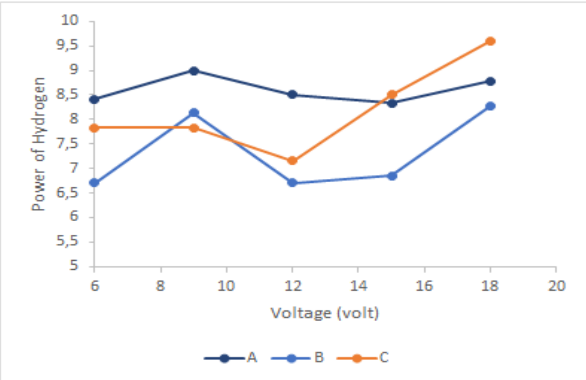

Fig. 2 The effect of electric voltage on pH

3.2. Total dissolved solid test

Figure 3 shows the results of TDS from the variation of the electrode and electric voltage in the electroflotation process. The electroflotation variation A has an average value of 94.75; variation B has an average value of 117.47, and variation C has an average value of 147.76. The results showed that the highest TDS value was owned by variation C, while the lowest TDS value was shown in variation A. A high TDS value indicated the more dissolved metal content in the solution (Sikder et al., 2013). High TDS measurements also integrate all the anions and cations in the sample and some ions or ion combinations are substantially more toxic than other ions or ion combinations, even if TDS toxicity is very sensitive to the life stage of certain species (Weber-Scannell and Duffy, 2007).

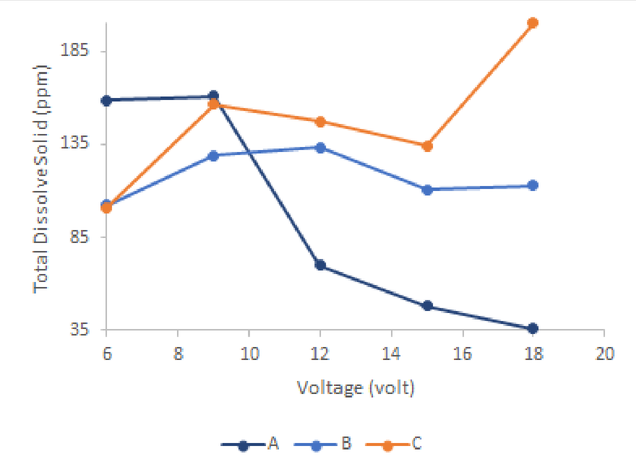

Fig 3. The effect of electric voltage on TDS

3.3. Temperature

Figure 4 shows the results of temperature observations from the variation of the electrode and electric voltage in the electroflotation process. The temperature in variation A has an average value of 28.57; variation B has an average value of 28.91, and variation C has a mean value of 29.73. The results show that the highest temperature value is in the C variation, while the lowest temperature value is shown in the A variation. The temperature of the solution tends to fluctuate during 60 minutes of electrolysis, due to the input of electrical energy. Increasing temperature increases the velocity of the particles in the system so that more collisions between particles can occur (Cleary, 2008).

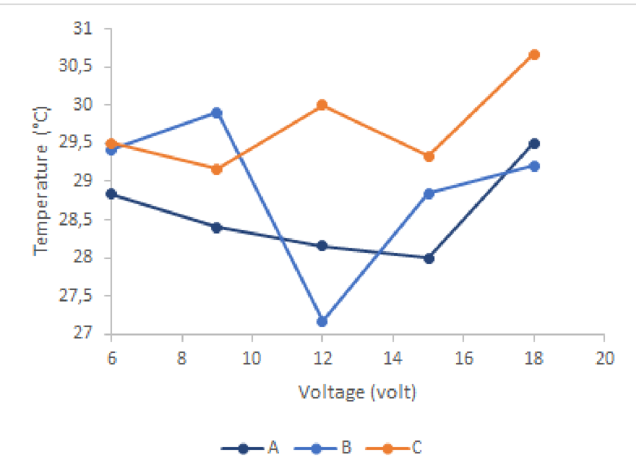

Fig 4. The effect of electric voltage on temperature

3.4 Teaching process to vocational school students

Students who are the research subjects are vocational high school students in several locations in West Java Province, Indonesia. Figure 5 shows the distribution of students' IQ showing different levels of intelligence.

Table 2 shows the students' abilities in general subjects supported by basic grades in Vocational High Schools such as Indonesian, English, Mathematics, and Chemistry which shows an average score of 87.55. In the field of chemistry, the data shows that the student's average score is 87.83, this is because the majority of the sample of vocational students come from majors related to chemistry. This value is sufficient to describe the background of students' learning abilities.

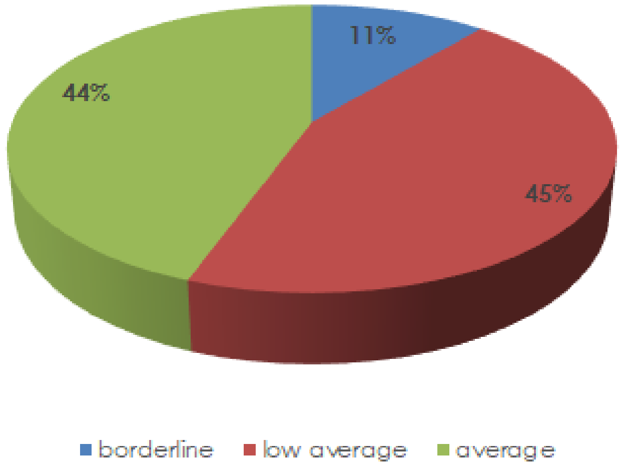

Fig 5. Distribution of student IQ

Figure 6 is the results of the students' pretest and posttest. The figure shows a less significant change between the pretest and posttest of vocational high school students. The mean score of students at the pretest was 67.22 and the mean score at the post-test was 72.22.

Table 2. Students' Mean Scores Based on School Reports

Subject	Average Score
Indonesia language	85.06
English	90.61
Mathematics	86.72
Chemistry	87.83

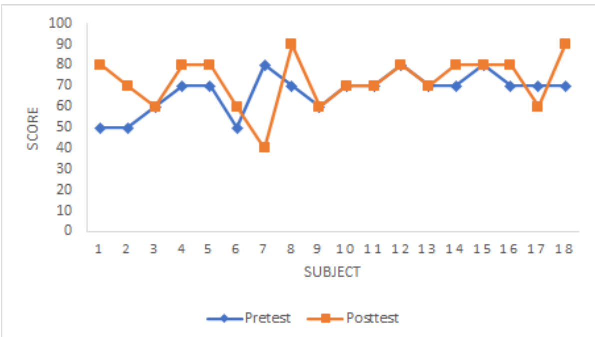

Fig 6. Pretest and posttest results

The two values that do not show significant differences can arise from many factors, one of which is that students are familiar with the concept of electroflotation before applying this concept through video lessons, considering that the majority of the sample of vocational students come from majors related to chemistry.

However, if seen as a whole, this learning video is effective in conveying the handling of water contaminated by domestic oil waste using the electroflotation method because there is an increase even though it is not significant. Providing video demonstrations of learning is very efficient for students because they will imagine the concept and increase focus if abstract material is presented with animation, images, text, and audio (Barak & Dori, 2011).

The t-test results of pretest and posttest scores of vocational school students. The significance value obtained from the relationship test on the t-test shows 0.794, this value is greater than 0.05. This means that posttest data is different from pretest data. Because the data is different, it can be continued to the normalized gain test (N-Gain).

Table 3 shows the results obtained from the use of teaching materials in the form of the delivery of instructional videos to convey learning material regarding the handling of water contaminated with domestic oil waste through the electroflotation method with variations in voltage and electrodes. The table shows the results of an average N-gain of 0.085 which is included in the low category. The acquisition of high N-gain results illustrates the high level of success of the learning method being implemented as well as the low N-gain results indicating the low success of the learning method (Afriana et al., 2016). The acquisition of a small N-gain value is due to other factors that influence this study, including the provision of pretest and posttest conducted online. Less stable network problems become a problem factor when done online.

Table 3. Results of Pretest and Posttest Using N-gain

Subject	Pretest	Posttest	N-gain
1	50	80	0.60
2	50	70	0.40
3	60	60	0
4	70	80	0,33333333
5	70	80	0,33333333
6	50	60	0.20
7	80	40	-2
8	70	90	0,66666667
9	60	60	0
10	70	70	0
11	70	70	0
12	80	80	0
13	70	70	0
14	70	80	0,33333333
15	80	80	0
16	70	80	0,33333333
17	70	60	-0,33333333
18	70	90	0,66666667
Mean			0,08518519

4. Conclusion

From the results of this electroflotation study, it can be seen that the best sample variation is sample A with stainless steel cathode and copper anode because it has a good average value in reducing TDS in the solution. The greater the voltage and the longer the electroflotation process is carried out, the more effective it is in reducing TDS. Student learning outcomes after watching instructional videos show that video learning is an effective medium, while the two scores do not show a significant difference in increasing students' understanding of the concept of electroflotation because students may have understood the concept and network factors.

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