EFFECT OF ADDITION OF CA(OH)2 AND ACTIVATED CHARCOAL ON ELECTROCOAGULATION AS PB (LEAD) REDUCTANT IN WATER USING ALUMINUM ELECTRODES WITH VOLTAGE OF 20 VOLT AND CONTACT TIME OF 60 MINUTES

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Abstract

Electrocoagulation technology using aluminum electrodes spaced 20 cm at a voltage of 20 volts, a current of 10 amperes for 60 minutes was proven to be able to reduce Pb in liquid waste. This electrocoagulation specification was developed with the addition of $Ca(OH)_2$ at pH 10.5 and an activated charcoal filter with a thickness of 20 cm in order to determine the best results for reducing lead (Pb). This study was to analyze the effect of the addition of $Ca(OH)_2$ pH 10.5, activated charcoal thickness of 20 cm and the combination of addition of $Ca(OH)_2$ pH 10.5 and activated charcoal thickness of 20 cm. The research method used *true experimental* which was carried out in the laboratory with a posttest only with control group design, which was a research design consisting of a control group and an experimental group totaling 4 treatments. Data were collected from 5 experiments to obtain a lead reduction rate (Pb) and then analyzed using alpha 5%. The results showed that there was a significant difference in Pb reduction in all treatments. The most optimal reduction in Pb in the treatment of aluminum electrodes was 20 cm with the addition of 60.01% activated charcoal and the addition of $Ca(OH)_2$ and 61.86% combination of activated charcoal. This difference in Pb reduction was shown in accordance with the Post Hoc test for all treatments in the treatment between 20 cm electrode and 20 cm electrode + activated charcoal (p-value = 0.038) and treatment between 20 cm electrode and 20 cm electrode + $Ca(OH)_2$ + activated charcoal (p-value = 0.007). Treatments that were effective in reducing lead (Pb) were treated with 20 cm aluminum electrodes with the addition of 60.01% activated charcoal and 20 cm aluminum electrode treatments followed by the addition of a combined $Ca(OH)_2$ and 61.86% activated charcoal. It is recommended to use electrocoagulation using aluminum electrodes spaced 20 cm at a voltage of 2-volt with a current of 10 ampere for 60 minutes followed by the addition of an activated charcoal filter with a thickness of 20 cm or the addition of a combination of $Ca(OH)_2$ and activated charcoal.

Keywords: water; electrocoagulation; lead reductant; $Ca(OH)_2$, activated charcoal filter; aluminum electrodes

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1. Introduction

The results of the 2015 census of the Central Statistics Agency of Indonesia (BPS) the number of micro and small industries that focus on handling basic metals is 31,122 micro-enterprises and 461 small-scale enterprises in 33 provinces in Indonesia. The by-products (waste) generated from metal processing activities are toxic and dangerous, as is often encountered is lead (Pb) metal waste. BPS East Java Province, 2019, that as many as 142,626 industries consist of Industry: a) Metal, Machinery, Metal, Machinery, and Transportation Equipment as much as 61,167, b) Chemical, Textile, and Chemical, Textile and Miscellaneous 61,352, and c) Electronics and Electronics and Telematics as many as 20,108, among these industries wastewater contains Lead (Pb) [1].

Lead has a high toxicity when in contact with human skin, so it must be treated before being discharged into the environment. The impact that arises is that water bodies will be polluted by lead and a greater carcinogenic risk. Recent examples of heavy metal contamination and health risks include cases Minamata disease, Japan; Bento Rodrigues dam disaster in Brazil, high lead content in drinking water supplies to the population Flint, Michigan, in the northeastern United States. The results of research by Eka & Mukono (2016) in the Journal of Environmental Health Vol. 9, No. January 1, 2017c: 66–74, that acute Pb poisoning affects blood pressure and chronic poisoning causes hypertension and impaired kidney function in adults. Pb levels in workers as a control group who were not exposed to lead showed blood Pb levels 10 g/d [2]. The results of this study are reinforced by the research of Chesaria Candra C. et al (2016) that Pb can affect the nervous system, kidney system, reproductive system, endocrine system, and heart. Therefore, treatment of waste water containing Lead (Pb) must be carried out before being discharged into water bodies [3].

The electrocoagulation method is a method of treating liquid waste containing Lead (Pb) by utilizing a chemical reaction from an electric current at the electrode which is thought to be a solution to the problem of managing liquid waste in lead (Pb) industries. Aluminum (Al) is one of the materials that can be used as an electrode in the electrocoagulation process and Aluminum (Al) is a reducing agent. The results of previous research conducted by Kriswandana, et al. [4] used the distance between the electrodes of 20 cm and the distance between the electrodes and the media base of 10 cm. The results showed that Pb in water can be reduced by aluminum electrodes in the electrocoagulation process. The biggest decrease occurred at the voltage of 20 Volts and 10 amperes with a contact time of 60 minutes. The decrease in Pb levels is 85.21% (lead levels from 3 ppm to < 1 ppm) and it is still necessary to increase its effectiveness or ability to reduce Pb so that it does not become a burden on environmental pollution and further research needs to be done to get the best specifications.

The results of the study based on the recommendations for variations in the distance between the electrodes showed the most effective results at the electrodes within 20 cm and each electrode within 10 cm from the left and right edge walls and the ground floor using a voltage of 20 Volts, a current of 10 Ampere with a contact time of 60 minutes. This was developed through further research with the addition of $Ca(OH)_2$, activated charcoal and a combination of $Ca(OH)_2$ and activated charcoal.

According to Sudama [5], that in the range of 200-1000 ml/min flow rate and acidity (pH) 9 and 11 using the chemical $Ca(OH)_2$ as a precipitant, it gives treatment results with concentrations of heavy metal ions in wastewater below the value. Quality standards through the mechanism of heavy metal reactions with hydroxide ions as follows: Lead : Pb+2 + 2 OH Pb $(OH)_2$ solid/precipitate. The addition of alkaline $Ca(OH)_2$ solution at pH 10.5 was able to absorb Lead (Pb) with a removal efficiency of 99.50%. The results of this study indicate that $Ca(OH)_2$ has the ability to reduce Pb (Lead), as well as the addition of activated charcoal to decrease Pb (Lead) content.

According to Puspitaloka, et al [6], the average lead (Pb) level is 0.235 mg/l. after treatment with variations in thickness of coconut shell activated charcoal granules 4 cm decreased to 0.189 mg/l, 8 cm decreased to 0.184 mg/l, 12 cm decreased to 0.171 mg/l, 16 cm decreased to 0.161 mg/l, and 20 cm decreased to 0.140 mg/l. This research shows that activated charcoal has the ability to reduce Pb (Lead) in water.

This study aims to analyze the effect of adding $Ca(OH)_2$ pH 10.5 and activated charcoal with a thickness of 20 cm and the addition of a combination of $Ca(OH)_2$ pH 10.5 and activated charcoal with a thickness of 20 cm on the decrease in Pb after the Aluminum electrode process in electrocoagulation as metal reductant Pb (lead) in the water system batch using a voltage of 20 volts, 10 amperes with a contact time of 60 minutes.

2. Methods

This research used a posttest only with control group design using 1 control group (without treatment) and 4 experimental groups (R1: electrode distance of 20 cm, R2: electrode distance of 20 cm + $Ca(OH)_2$ at pH 10.5, R3: electrode distance 20 cm + activated charcoal with a thickness of 20 cm and R4: electrode distance of 20 cm + $Ca(OH)_2$ at pH 10.5 + activated charcoal with a thickness of 20 cm. The sample size was calculated based on the replication formula according to the number of treatments according to Prihanti [7] using Federer formula: (t-1) x (r-1) $\geq$ 15, the result was 5 times, so that the entire research sample was 25 samples.

Data collection was carried out after 60 minutes. Then R_0 (control group) and R1 (electrode distance 20 cm) was sampled, while the other samples were taken after treatment in group R2 (Electrode distance of 20 cm followed by the addition of $Ca(OH)_2$ at pH 10.5, group R3 (Electrode distance of 20 cm followed by flow into activated charcoal with a thickness of 20 cm and R4 (Electrode distance of 20 cm followed by marker $Ca(OH)_2$ material at pH 10.5, followed by flow into activated charcoal 20 cm thick).

The data that had been collected was processed and analyzed through the One-way Anova with. Prior to the analysis, the normality test was performed and if it was not normally distributed, the hypothesis was tested using the Kruskal Wallis test. The test results show that there was a difference, then a Post-Hoc to determine the difference in the mean decrease in test parameters and effectiveness based on the percentage decrease in lead (Pb) after treatment.

3. Results And Discussion

The results showed a decrease in Pb in the treatment using electrodes 20 cm apart before and after the treatment process for 1 hour ranging from 0.96 to 1.08 mg/liter with an average of 1.02 mg/liter or 52%.

Table 1: Pb Levels Decreased at 20 cm in the Electrocoagulation Process

Replication	Pb levels at an electrode distance of 20 cm (mg/liter)		Decrease	
	Before	After	mg/liter	%
1	1.97	0.90	1.07	54.31
2	1.96	0.88	1.08	55.10
3	1.94	0.96	0.98	50.52
4	1.96	0.97	0.99	50.51
5	1.95	0.99	0.96	49.23
Range	1.94 – 1.97	0.88 - 0.99	0.96 – 1.08	49.23 – 55.1
Average	1.96	1.12	1.02	52

The results showed a decrease in Pb in the treatment using electrodes at a distance of 20 cm with the addition of Ca(OH)2 before and after the treatment process for 1 hour ranging from 0.99 to 1.07 mg / liter with an average of 1.04 mg / liter or by 52.96%.

Table 2: Decrease in Pb Levels at an Electrode Distance of 20 cm with the Addition of Ca (OH)2 pH 10,5 in the Electrocoagulation Process

Replication	Pb levels at an electrode distance of 20 cm (mg/liter)		Decrease	
	Before	After	mg/liter	%
1	1.97	0.94	1.03	52.28
2	1.96	0.87	1.09	55.61
3	1.94	0.94	1.00	51.55
4	1.96	0.97	0.99	50.51
5	1.95	0.88	1.07	54.87
Range	1.94 – 1.97	0.74 – 0.88	0.99 – 1.07	50.51 – 55.61
Average	1.96	0.92	1.04	52.96

The results showed a decrease in Pb in the treatment using electrodes at a distance of 20 cm with the addition of a 20 cm thick activated charcoal filter before and after the treatment process for 1 hour ranging from 1.02 to 1.32 mg / liter with an average of 1.17 mg / liter. or 60.01%.

Table 3: Pb Levels Decreased at 20 cm Electrode Distance with the Addition of 20 cm Thickness of Activated Charcoal

Replicaton	Pb levels at an electrode distance of 20 cm (mg/liter)		Decreased	
	Before	After	mg/liter	%
1	1.97	0.80	1.17	59.40
2	1.96	0.75	1.21	63.68
3	1.94	0.83	1.11	57.22
4	1.96	0.94	1.02	52.04
5	1.95	0.63	1.32	67.69
Range	1.94 – 1.97	0.75 – 97	1.02 – 1.32	52.04 – 67.69
Average	1.96	0.75	1.17	60.01

The results showed that there was a decrease in Pb in the treatment using electrodes at a distance of 20 cm with the addition of Ca(OH)$_2$ and Activated Charcoal gloves before and after the treatment process for 1 hour ranging from 1.12 to 1.34 mg / liter with an average of 1.21 mg. /liter or 61.86%.

Table 4: Decreased Pb Levels at an Electrode Distance of 20 cm with the Addition of Activated Charcoal with a Thickness of 20 cm and Ca (OH)$_2$ pH 10.5, in the Electrocoagulation Process

Replication	Pb levels at an electrode distance of 20 cm (mg/liter)		Decrease	
	Before	After	mg/liter	%
1	1.97	0.74	1.23	62.44
2	1.96	0.74	1.22	62.25
3	1.94	0.82	1.12	57.73
4	1.96	0.82	1.14	58.16
5	1.95	0.61	1.34	68.72
Range	1.94 – 1.97	0.61 – 0.82	1.12 - 1.34	57.73 -68.72
Average	1.96	0.75	1.21	61. 86

The results showed that the decrease in Pb in the control before and after the 1 hour treatment process ranged from 0.01 to 0.02 mg/liter with an average of 0.01 mg/liter or 0.72% <1%. This decrease was as a result of the density of the Pb atom of 14 grams/liter which was greater than that of water (H2O) 0.997 gram/liter so that there was still Pb that precipitated after being left for 1 hour like the length of time in each treatment.

Table 5: Pb Decrease in Control ini the Electrocoagulation Process

Replication	Pb levels at an electrode distance of 20 cm (mg/liter)		Decrease	
	Before	After	mg/liter	%
1	1.97	1.95	0.02	1.02
2	1.96	1.95	0.01	0.51
3	1.94	1.93	0.01	0.52
4	1.96	1.95	0.01	0.51
5	1.95	1.93	0.02	1.03
Range	1.94 – 1.97	1.93 – 1.98	0.01 – 0.02	0.51 -1.02
Average	1.96	1.94	0.01	0.72

The results showed that both the control and all treatments in the electrocoagulation process with an electrode distance of 20 cm using a voltage of 20 Volts and a current of 10 Ampere survived for 1 hour with the addition of Ca(OH)2 or Activated Charcoal and the addition of a combination of Ca(OH)2 and Activated Charcoal experienced a different Pb decrease.

Table 6: Raw Material Pb Research Results, Electrocoagulation Treatment With Electrocoagulation Wheels 20 cm apart at 20 Volt Voltage, 10 Ampere Current Strong Addition of CaOH)2, Activated Charcoal and Combination With the Addition of CaOH)2, And Active Filter in 2022

Replication	Decrease in Pb Levels in Water (mg/Liter)									
	Electrode 20 cm		Electrode 20 cm + Ca(OH)2		Electrode 20 cm + Activated Charcoal		Electrode 20 cm + Ca(OH)2 + ıctivated charcoal		Control	
	n	%	n	%	n	%	n	%	n	%
1	1,07	54,31	1,03	52,28	1,17	59,40	1,23	62,44	0,02	1,02
2	1,08	55,10	1,09	55,61	1,21	63,68	1,22	62,25	0,01	0,51
3	0,98	50.52	1,00	51,55	1,11	57,22	1,12	57,73	0,01	0,52
4	0,99	50,51	0,99	50,51	1,02	52,04	1,14	58,16	0,01	0,51
5	0,96	49,23	1,07	54,87	1,32	67,69	1,34	68.72	0,02	1,03
Average	1.02	52	1,04	52,96	1,17	60,01	1,21	61, 86	0,01	0,72

The results of the one-way ANOVA statistical test for 5 free sample groups with an alpha of 0.05, showed the results that all data were normally distributed and homogeneous, so proceed to the ANOVA test. The results of the statistical test showed a p-value of 0.003, meaning that there was a significant difference in Pb reduction in all treatments. The most optimal decrease in Pb in the treatment of addition of activated charcoal was 60.01% and the combination of $Ca(OH)_2$ with activated charcoal was 61.86%. This difference in Pb reduction was shown in accordance with the Post Hoc test for all treatments contained in:

1) Treatment between 20 cm electrode and 20 cm electrode + activated charcoal (p value = 0.038)
2) Treatment between 20 cm electrode and 20 cm electrode + $Ca(OH)_2$ + activated charcoal (p value = 0.007)

The effectiveness of the results of reducing Pb levels in water through the electrocoagulation process using aluminum electrodes with a distance of 20 cm using a voltage of 20 volts with a current of 10 Ampere for 1 hour occurred in the treatment of adding 60.01% of Activated Charcoal and the addition of a combination of Ca(OH)2 and Activated Charcoal. by 61, 86%.
The results of this research are expected to contribute to the development of science and technology, especially those related to the provision of clean water for life, as well as other scientific findings in terms of water supply, such as the chemical quality of water [8], the quality of groundwater sources [9], river water quality [10, 11] and many more.

4. Conclusion

There was a significant difference in Pb reduction in all treatments. The most optimal decrease in Pb in the treatment of addition of activated charcoal was 60.01% and the combination of $Ca(OH)_2$ with activated charcoal was 61.86%. This difference in Pb reduction was shown according to the Post Hoc test for all treatments in the treatment between 20 cm electrode and 20 cm electrode + activated charcoal and the treatment between 20 cm electrode and 20 cm electrode + Ca(OH))2 + Activated charcoal. The effectiveness of reducing Pb levels in water through the electrocoagulation process using aluminum electrodes at a distance of 20 cm using a voltage of 20 Volts with a current of 10 Ampere for 1 hour occurred in the treatment of the addition of 60.01% activated charcoal and the combined addition of $Ca(OH)_2$ and activated charcoal. by 61, 86%.
It is recommended to use electrocoagulation using 20 cm aluminum electrodes at a voltage of 2-volt with a current of 10 Ampere for 60 minutes followed by the addition of an activated charcoal filter with a thickness of 20 cm or the addition of a combination of $Ca(OH)_2$ and activated charcoal.

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