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Reduction of Heavy Metal Levels (Pb and Fe) in Chemical Laboratory Wastewater by the Coagulation - Flocculation Method using Moringa Seeds Bio-coagulants *(Moringa oleifera)*

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ABSTRACT

Chemical laboratory wastewater treatment is important because contains hazardous wastewater substance that pollute the environment if not treated properly. Instead of to Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), and Biological Oxygen Demand (BOD) content, chemical laboratory wastewater also contains several types of heavy metals, such as Pb and Fe, which are infectious, pathological, and cytotoxic. One of the effective methods to treat the chemical laboratory wastewater is the coagulation-flocculation method with the addition of moringa seed powder bio-coagulant. The aim of this study was to determine the effect of coagulant dose and and precipitation time in reducing Pb and Fe metal levels in chemical laboratory wastewater. This study used variations in coagulant dose (1500, 2000, 2500, 3000, and 3500 mg/L) and precipitation time (20, 30, 40, 50, and 60 min). The result showed that the initial level of Pb and Fe in wastewater were 0.519 and 7.849 mg/L, respectively. The dose of 3000 mg/L of Moringa seed bio-coagulants showed the best concentration to reduce Pb level to 0.084 mg/L. On the other hand, at 3500 mg/L for reduction of Fe into 5.555 mg/L. The precipitation at 30 min showed the best time for reducing level both of Pb and Fe into 0.065 mg/L and 4.569 mg/L, respectively. However, the final level of Pb and Fe of wastewater after coagulation resulting in the below quality standard under The Minister of Environment Regulation Number 5 of 2014.

Keywords: chemical laboratory wastewater, heavy metals, coagulation, moringa seed

1. INTRODUCTION

Department of Chemical Engineering has a Chemical Engineering Basic Instruction Laboratory which is a place where students and lecturers usually carry out practicum and research activities. These practicum and research activities produce liquid waste containing toxic and hazardous pollutants [1]. Hazardous substances contained in laboratory wastewater if not adequately treated and directly discharged into the environment within a certain period will cause environmental pollution and poisoning of living things [2].

Based on Government Regulation of the Republic of Indonesia Number 85 of 1999 concerning Hazardous and Toxic Waste Management (B3), laboratory liquid waste is classified as B3 waste [3]. Heavy metals are one of the contributors to the example of hazardous compounds contained in chemical laboratory liquid waste [4]. Therefore, waste treatment is needed so that the concentration of harmful substances contained, such as heavy metals, can be reduced until the levels are within the permitted limits. Therefore, this waste treatment is carried out with the aim of knowing the effect of coagulant dosage in reducing heavy metal levels (Pb and Fe) and knowing the effect of coagulation settling time in reducing heavy metal levels (Pb and Fe) in Chemical Engineering Basic Instrumentation Laboratory waste.

Coagulation is a colloidal particle that clumps due to the combination of charged colloidal particles and forms particles that tend to be larger [5]. The commonly used coagulant is alum in the coagulation process [6]. The natural organic material applied in laboratory wastewater treatment this time is old or dried moringa fruit seeds. The content of moringa seeds (*Moringa oleifera*) in the form of the active substance 4α4-rhamnosyloxy-benzyl-isothiocyanate plays a role in lifting metals contained in liquid waste [7]. In addition, there are proteins that act as cationic polyelectrolytes that are utilized in the process of purifying liquid waste [8]. Therefore, this study aims to determine the effect of coagulant dose and precipitation time in reducing heavy metal levels (Pb and Fe) using Moringa seed powder bio-coagulant.

2. MATERIALS DAN METHODS

2.1 Materials

Chemical laboratory wastewater, moringa seed powder, Pb and Fe metal standard solutions, concentrated nitric acid.

2.2 Research design

The research design used includes dependent and independent variables. The dependent variables were a sample volume of 500 ml, stirring speed of 250 rpm, stirring time of 2 minutes, flocculation time of 15 minutes, and flocculation speed of 25 rpm. The independent variables were coagulant concentrations of 1500, 2000, 2500, 3000, and 3500 mg/L and precipitation times of 20, 30, 40, 50, and 60 minutes. The observed responses were the levels of heavy metals Pb and Fe.

2.3 Preparation of moringa seed powder coagulant

Moringa seeds that have been peeled are dried using sunlight first until dry, then the moringa seeds are crushed using a blender until they become powder. Followed by the drying process again using an oven with a temperature of 105°C for 30 minutes. moringa seed powder is ready to be used as a coagulant.

2.4 The coagulation – flocculation process

Biocoagulant in the form of moringa seed powder that is ready for use is weighed using an analytical balance with a concentration variation (mg/L) of 1500, 2000, 2500, 3000, and 3500. Chemical laboratory effluent samples were tested for initial Pb and Fe heavy metal content. Waste samples as much as 500 mL are put into 1000 mL measuring cups, each measuring cup is added with biocoagulant according to the dose variation. In the jar test, the sample was stirred quickly (coagulation) for 2 minutes at a speed of 250 rpm. Then followed by slow stirring (flocculation) for 15 minutes at a speed of 25 rpm. After the stirring process is complete, the sample is allowed to settle according to the time variation (minutes) 20, 30, 40, 50, and 60. The sample is then filtered using filter paper with the help of a vacuum pump. The filtrate obtained was then tested for heavy metal levels using an Atomic Absorption Spectroscopy instrument.

2.5 Analysis of wastewater

a. Analysis of Pb heavy metal content using AAS based on SNI 06-6989.8-2004.

b. Analysis of Fe heavy metal content using AAS based on SNI 06-6989.4-2004.

2.6 Data Analysis

Data were analyzed using the One-Way ANOVA (analysis of variance) statistical test with a P value of 95% for determining the level of metal Pb and Fe from factor of the dosage of bio-coagulants.

3. RESULTS AND DISCUSSION

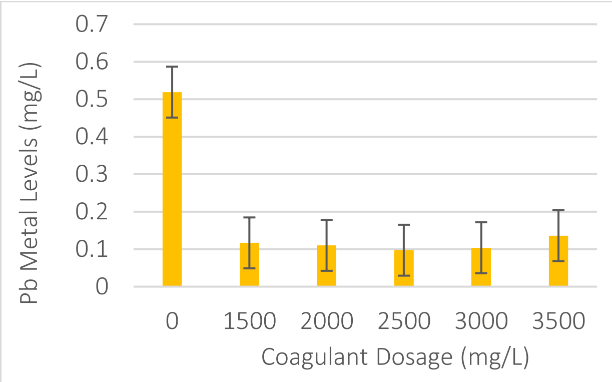
3.1 Effect of coagulant dosage on the reduction of heavy metal levels (Pb and Fe)

The effect of coagulant dose variation on the reduction of Fe heavy metal levels showed a significant effect with a value of $P < 0.05$. The results of the chemical laboratory liquid waste analysis are presented in **Table 1**. Based on the Minister of Environment Regulation Number 5 of 2014 [9], Pb heavy metal levels has reached the permissible limit, while Fe heavy metal levels are still above the quality standard. The decrease in Pb and Fe heavy metal levels, which originally had levels (mg/L) of 0.519 and 7.849, respectively, can be caused by the presence of organic polymers in moringa seeds containing proteins, amino groups, and carboxylates [10]. This content causes moringa seeds to has high reactivity and polyelectrolyte properties that can be used to adsorb dissolved metals in water [11]. Proteins in moringa seeds contain the amino acids glutamate, methionine, and arginine. Glutamic acid is negatively charged on its carboxyl and ionizes when dissolved in water, so dissolved metal cations can be bound to the hydroxyl group [12].

Table 1. Heavy metal levels (pb and fe) with the effect of coagulant dosage

Heavy metal	Code	Concentration (mg/L)	Quality standard (mg/L)*
Lead	Pb	0,084	0,1
Iron	Fe	5,555	5

** Quality Standard according to Minister of Environment Regulation Number 5 of 2014*



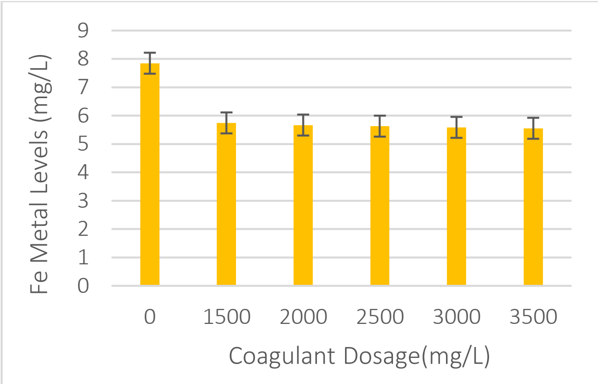


Figure 1. Effect of coagulant dosage on heavy metal levels (Pb and Fe)

Table 2. Heavy metal levels (pb and fe) with the effect of precipitation time

Heavy metal	Kode	Concentration (mg/L)	Quality standard (mg/L)*
Lead	Pb	0,065	0,1
Iron	Fe	4,569	5

** Quality Standard according to Minister of Environment Regulation Number 5 of 2014*

In addition to the decrease, **Figure 1** shows an increase in lead metal (Pb) levels which can be caused by excessive doses. This excessive dose of moringa seed coagulant can cause the solution to become saturated, as a result the coagulant can no longer bind Pb metal ions and the coagulant only acts as an impurity. Based on this explanation, it can be concluded that when it reaches the best dose to reduce Pb metal in laboratory wastewater, the addition of coagulant will not produce sediment but instead the coagulant will change the surface of colloidal particles from negative to positive and the colloidal particles will be dispersed again due to the peptization process, where the flocs that form clumps are broken by similar ions into small particles and cause the waste solution to become cloudy.

3.2 Effect of precipitation time on the reduction of heavy metal levels (Pb and Fe)

The effect of variations in precipitation time on the decrease in heavy metal levels of Pb and Fe showed a significant effect with a value of $P < 0.05$. After the waste treatment passes through the fast and slow stirring process, the sample is then allowed to settle for a time according to the predetermined variation. Precipitation time is the time needed to settle the flocs that have formed in the coagulation process [13]. The results of the chemical laboratory liquid waste analysis are presented in **Table 2**. Based on the Minister of Environment Regulation Number 5 of 2014, the levels of heavy metal Pb have reached the permissible limit, while the heavy metal Fe is still above the quality standard.

Based on the research that has been done, the best precipitation time results on both metals are obtained at 30 minutes with a percentage reduction of 41.8% in Fe metal and 87.5% in Pb metal. The graph of Pb and Fe heavy metal levels presented in **Figure 2** increased again as the precipitation time increased due to the weak interaction between metal ions contained in the laboratory wastewater sample solution with moringa seed powder. The increase in metal levels can also be caused by the energy needed to break the Van der Waals force, which is relatively weak or easily broken, so that if the precipitation lasts a long time, the bonds that have been formed will break down again and the Fe heavy metal levels will increase. The interaction between moringa seed powder (*moringa oleifera*) and heavy metal Pb resulted in Van der Waals force. Van der Waals force is the weakest and universal force which can work when the inter-molecular distance is very close.

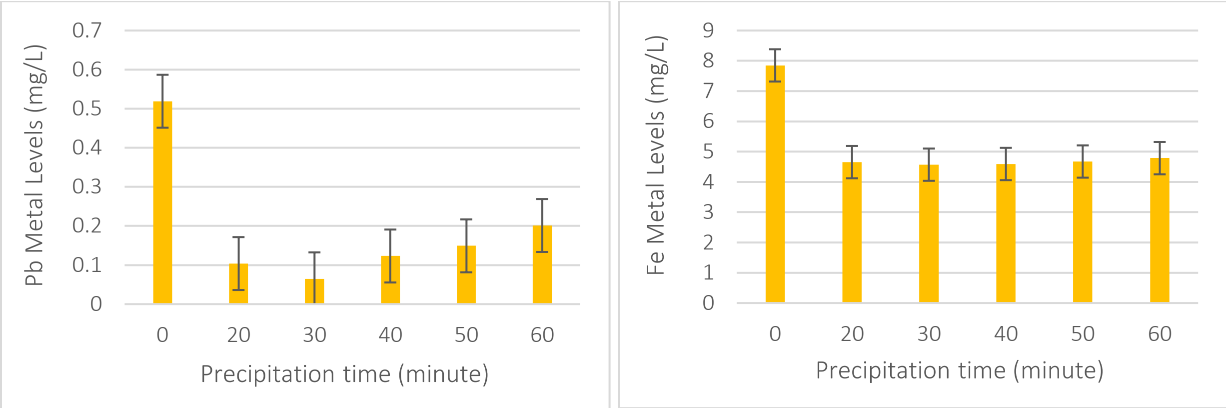


Figure 2. Effect of precipitation time (minutes) on heavy metal content (Pb and Fe)

4. CONCLUSION

Based on the research, the decrease in heavy metal levels in chemical laboratory wastewater on heavy metals (Pb and Fe) has met the quality standards. The Ministry of Environment has set rules through Ministerial Regulation No. 5/2014, where the maximum quality standard of Pb and Fe metal content for wastewater whose quality standard have not been established (Class I) are 0.1 mg/L and 5 mg/L, respectively. Therefore, the using of moringa seed (*Moringa oleifera*) powder coagulant can be considered in chemical laboratory wastewater treatment to decrease the levels of heavy metals Pb and Fe.

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CONFLICT OF INTEREST

No conflict of interest was reported by the author(s).

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Elia Trisnawati: Data curation, Formal analysis, Investigation, Writing-original draft
Neni Damajanti: Conceptualization, Methodology, Investigation, Formal analysis, Writing-original draft, Supervision

REFERENCES

[1] Ariani, M. D., & Rahayu, D. (2016). Review Artikel: Penyisihan Logam Berat Dari Limbah Cair Laboratorium Kimia. Farmaka, 14(4), 89–97.

[2] Carlsson, B. 1998. An Introduction to Sedimentation Theory in Wastewater Treatment. Sistems and Control Group, Uppsala University.

[3] Peraturan Pemerintah Republik Indonesia Nomor 85 Tahun 1999 tentang Pengolahan Limbah Bahan Berbahaya dan Beracun (B3)

[4] Srivastava, N.K., dan Majumder, C.B. 2008. Novel Biofiltration Methods for the Treatment of Heavy Metals from Industrial Wastewater. Journal of Hazardous Materials, Vol. 151, No. 1.

[5] Riffat. 2012. Fundamentals of Wastewater Treatment and Engineering. London. CRC Press.

[6] Nursyamsi, D., Artanti, R., Kurnia, A., & Hindarwati, Y. (2011). Efektivitas Koagulan Dan Adsorben Alami Dalam Pengolahan Limbah Cair Elektroplating Tercemar Logam Berat Karsinogenik. Teknik Hidraulik, 2(1), 1–96.

[7] Putra, R., Lebu, B., Munthe, M. D., & Rambe, A. M. (2013). Pemanfaatan Biji Kelor Sebagai Koagulan Pada Proses Koagulasi Limbah Cair Industri Tahu Dengan Menggunakan Jar Test. Jurnal Teknik Kimia USU, 2(2), 28–31. Https://Doi.Org/10.32734/Jtk.V2i2.1435

[8] Irmayana, Hadisusantoso, E. P., & Isnaini, S. (2017). Pemanfaatan Biji Kelor (Moringa oleifera) Sebagai Koagulan Alternatif Dalam Proses Penjernihan Limbah Cair Industri Tekstil Kulit. Istek, X(2), 52–67.

[9] Peraturan Menteri Lingkungan Hidup Republik Indonesia Nomor 5 Tahun 2014 Tentang Baku Mutu Air Limbah.

[10] Supriyantini, E., & Endrawati, H. (2015). Kandungan Logam Berat Besi (Fe) Pada Air, Sedimen, Dan Kerang Hijau (Perna Viridis) Di Perairan Tanjung Emas Semarang. Kelautan Tropis, 18(1), 38–45. Https://Doi.Org/10.1111/J.1600-0404.1962.Tb01105.X

[11] Husna, J. 2016. Penurunan Kadar Logam Kadmium Pada Air Dengan Menggunakan Koagulan Serbuk Biji Kelor (*Moringa oleifera,Lamk*) Dan Poly Aluminium Chloride. Laporan Penelitian. Jurusan Kimia. Universitas

Islam Negeri Alauddin Makassar. Makassar.

[12] Dulanlebit, Y. H., -, S., & Male, Y. T. (2020). Efektivitas Biji Kelor (Moringa oleifera Lamk) Pada Pengolahan Air Sumur Dan Penentuan Waktu Optimum Adsorpsi Biji Kelor Terhadap Fe Dan Mg Dalam Air. Molluca Journal Of Chemistry Education (Mjoce), 10(1), 43–52. Https://Doi.Org/10.30598/Mjocevol10iss1pp43-52

[13] Hak, A., Kurniasih, Y., & Hatimah, H. (2018). Efektivitas Penggunaan Biji Kelor (Moringa Oleífera, Lam) Sebagai Koagulan Untuk Menurunkankadar TDS Dan TSS Dalam Limbah Laundry. Kependidikan Kimia, 6(2), 100–113.