Effectivity Removal of Cadmium Toxic Metals from Leachate Using *Chlorella Vulgaris Non-Living Cell*

Adewirli Putra*[1] Wiya Elsa Fitri[2]

[1] *Department of Medical Laboratory Technology, STIKES Syedza Saintika,*
[2] *Department of Public Health, STIKES Syedza Saintika*
**Corresponding author: adewirliputra@gmail.com*

ABSTRACT

Cadmium (Cd) is a heavy metal group that is toxic, dangerous to health and the environment if its present in large concentrations. Experimental research on the utilization of *Chlorella Vulgaris non-living cells* has been carried out to removing Cd(II) ions from the invention under various conditions and applied to leachate. *Chlorella Vulgaris non-living cells* were isolated from Brackish Water Cultivation Center (BBPBAP) Jepara and then cultured outdoors, in growth media maintaining pH conditions near 7. After cultivation, cells were harvested, dried, sieved, and used. The goal of this research was to find out the absorption efficiency of Cd(II) ions with various parameter surroundings pH, contact duration, and concentration are only a few examples. The greatest amount of at pH 6, the elimination efficiency of Cd(II) ions was achieved, concentration 90 mg/L, contact duration 120 minutes, The *Chlorella Vulgaris non-living cell* optimum conditions were able to remove 94.97% of the Cd(II) ion of the present invention and 95.41% of the leachate. The conclusion from this study is that *Chlorella Vulgaris non-living cell* biosorbent was been a highly effective, efficient, and adsorbent that was good for the environment for eliminating Cd(II) ions solution and leachate, so it was often recommended and applied on an outsized scale.

Keywords: *biosorption, chlorella vulgaris, leachate, non-living cells, toxic metal*

1. INTRODUCTION

Cadmium (Cd) was one of the toxic metals and harmful to health, the environment and may 't be decomposed and can accumulate within the body of living things. The presence of Cd(II) within the environment comes from industrial processes of metallurgy, electroplating, ceramics, pigment work, textile printing industry, tin and zinc mining photo development, alkaline batteries, and metal plating [1]. In addition to industry, the final Disposal Site (TPA) also contributes to being a source of pollution through leachate, generally, leachate contains dissolved organic and inorganic compounds (heavy metals), including cadmium metal. The impact caused by exposure to these metals, Cd(II) ions metal accumulated mainly in the kidneys and liver, these organs are the target organs for acute cadmium toxicity. Acute cadmium poisoning causes several symptoms and damage such as nausea, vomiting, testicular damage, kidney damage, and liver necrosis [2], [3]. Therefore, AWWA and WHO have strictly regulated the maximum concentration of Cd (II) ions beverage and recommended that the concentration of Cd (II) ions shouldn't exceed 0.005 mg/L [4]. Whereas KEPMENKES RI No 907 the amount of Cd (II) ions present should not exceed 0.003 mg/L [5]. It was important to remove these Cd (II) ions from the environment. Several methods are wont to reduce the heavy metal content of aqueous solutions such as precipitation, membrane separation, electrochemistry, coagulation, ion exchange, biological treatment, etc [6]–[9]. However, this method was less effective because of the high cost and generates other wastes such as sediment or by-products.

Chlorella Vulgaris is a group of *Chlorophyta* which was a unicellular green alga that can grow in fresh and marine waters, which can be used as a food source, material for the cosmetic industry, pharmaceutical industry, etc. Because it has health benefits. In addition, *Chlorella Vulgaris* can be used to remove heavy metal ions in water [4], [10]–

[12]. *Chlorella Vulgaris* has a composition of 4-6% nucleic acids, 2-22% fat, 12-26% carbohydrates, and 51-58% protein [13]. With this composition, it is rich in various functional groups so that it can bind Cd(II) metal.

This study aims to study the effectiveness of removing Cd(II) metal from the solution, in terms of the parameters of pH, concentration, and contact duration and applied to leachate at the Final Disposal Site. So that from this research can be a reference to overcome the problem of pollution of Cd(II) metal that endangers the health and the environment.

2. MATERIALS AND METHODS

Chlorella Vulgaris comes from BBPBAP Jepara, Sodium Chloride (NaCl), Walne Fertilizer, Cadmium Nitrate $Cd(NO_3)_2$, Buffer solution pH 2 to 7, Sodium Hydroxide (NaOH), and Nitric Acid (HNO_3), Aquadest, Whatman Filter Paper. Erlenmeyer, Beaker, Measuring Cup, Flask, Funnel, Measuring Pipette, Cylindrical Pipette, Suction Ball, Dropper, Watch Glass, Thermometer, pH meter, Analytical Balance, Shaker, Aerator, LED Light, 120 µm Sieve, Cd (II) ions analysis from solutions using AAS Analyst 700 (Perkin Elmer)

2.1. Preparation of Adsorbents Biomass

Chlorella Vulgaris non-living cell isolated and then cultured, in growth media by maintaining pH conditions near 7. After cultivation, cells were harvested by filtering, then rinsed with clean water, dried in a room that was not exposed to direct sunlight, ground up, and sieved to a size of 120 µm. Ready to use as shown in Fig. 1.

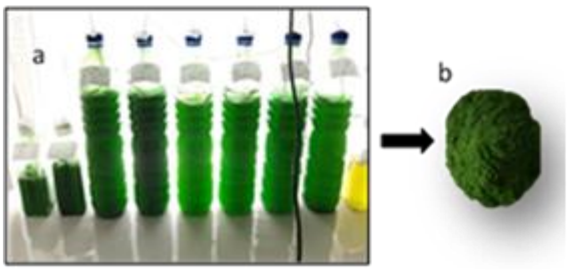

Fig. 1. a) *Chlorella vulgaris* cultivation process, b) *Chlorella vulgaris non living cell*

2.2. Adsorption Process

Changeable pH 2 to 7, early attentiveness of Cd(II) ions 10 to 150 mg/L, contact duration 15 to 120 minutes, room temperature, stirring speed 100 rpm, and particle size of the biosorbent was 120 µm were used in a 10 mL Cd(II) solution. Analyzed by AAS (AA240) to work out following adsorption, the attentiveness of Cd(II) ions.

Determine the quantity of Cd(II) ions that have been adsorbed using the equation [14]:

$$q = (C_i - C_f)\,\frac{V}{W} \qquad (1)$$

Meanwhile, to determined the adsorbed Cd (II) ions removal efficiency using the following equation:

$$R = \frac{(Ci - Cf)}{Ci}\, x\ 100 \qquad (2)$$

Information :

q = Metal Adsorption Quantity (mg/g)

R = Removal of Inefficiency (%)

C_i = The initial concentration (mg/L).

C_f = Balance concentration (mg/L)

V = The volume of solution (L)

W = The adsorbent's. mass (g)

3. RESULTS AND DISCUSSION

3.1. pH on Cd(II) Ions of Effect

Fig. 2. Showed pH's influence on the adsorption process of Cd(II) ions by *non-living cell Chlorella Vulgaris* studied using a starting concentration 10 mg/L. with a pH variety of 2 to 7, from the research data, it was found that 92.01% Cd(II) ion removal efficiency was achieved at pH 6. This was due to the fact that when the pH charge was low, (pH = 2) the concentration of H^+ was high so that there was a competitive exchange of cations on the algae surface. When the pH of the solution increases too pH 6, Cd(II) ions will begin to exchange H^+ ions, this was due to deprotonation of the adsorbent surface, leading to a decrease within the concentration of H^+ ions on the surface of

the adsorbent, this has an impression on increasing the negative charge on the surface of the adsorbent, which supports absorption. Positive charge and reach optimum absorption conditions, this was also explained by other literature [15], at pH > 3 the carboxylic group (-COOH) was deprotonated and negatively charged so that the attraction of positively charged metal ions will increase. Meanwhile, at pH value > 6, it had been possible to precipitate Cd(II) ions within the sort of metal hydroxides because of the reaction of metal ions with OH^- in solution. This was following research conducted by [16].

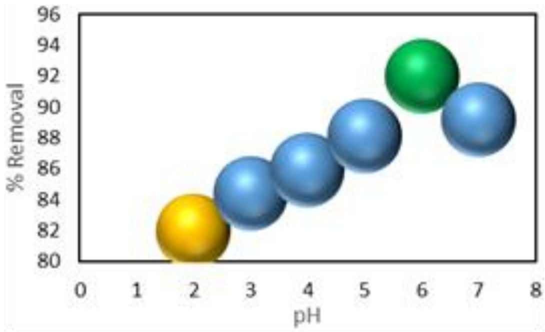

Fig 2. Effect of solution pH on the removal efficiency. of Cd(II) ions.

3.2. *Effect of Concentration Cd(II) Ions*

Fig 3 Showed that at low concentrations the metal ions removal efficiency increases to equilibrium conditions at a concentration of 90 mg/L. With an efficiency value of 94.34%. This condition was because there are still many active spots on the adsorbent's surface that have not been bonded. Then, due to a rise in the initial concentration of Cd (II) ions inside the solution, the removal of metal ions decreased. This was because the surface of the adsorbent has different functional groups with different affinity for each ionic species, the high and low affinity of functional groups in the absorption of metal ions depends on the concentration of metal ions because the saturation of the adsorption site causes most of the decrease in the removal of metal ions in the solution [17]. Meanwhile, according to other literature [18], [19]. This condition was because of the competition between Cd(II) ions to bind to the active spot on the adsorbent's surface.

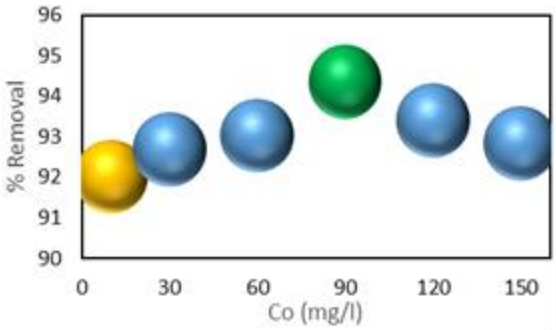

Fig 3. Effect of solution concentration on the elimination efficiency of Cd(II) ions.

3.3. *The effect of Contact duration*

From Fig.4. It showed that from minute 0 to the first 15 minutes the Cd(II) ion's elimination efficiency reaches 93.36%. The adsorption efficiency increased with increasing time until the equilibrium time was reached at 120 minutes, with the Cd(II) ion's elimination efficiency reaching 94.97%. This removal process was related to the supply of a bigger adsorbent area the adsorption of Cd(II) ions, also because of the availability of an internal active site, which was exposed because the cell membrane has been damaged by pretreatment on *Chlorella Vulgaris living cell* [16][20].

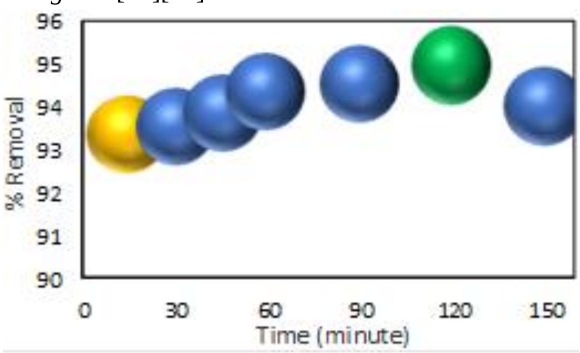

Fig 4. Effect of contact time on the removal efficiency of Cd (II) ions

3.4. *Application on leachate*

This removal application was carried out under conditions of pH 6, contact duration of 120 minutes, stirring speed of 100 rpm. The Cd(II) ion's elimination efficiency in the leachate was reached at 95.41%. This shows that the use of Chlorella Vulgaris non-living cell as an adsorbent is very effective in removing Cd(II) ions in solution and leachate.

4. CONCLUSIONS

This study concluded that *Chlorella Vulgaris non-living cell* has fairly high efficiency of removing Cd(II) ions, both for the experimental solution and leachate from the Final Disposal Site (TPA), where this biosorbent was very effective and efficient in removing Cd(II) ions. However, further studies are still needed to determine the related parameters in the refinement of research to be applied on a large scale in the field.

REFERENCES

[1] K. Kadirvelu, K. Thamaraiselvi, and C. Namasivayam, “Removal of heavy metals from industrial wastewaters by adsorption onto activated carbon prepared from an agricultural solid waste,” *Bioresour. Technol.*, vol. 76, no. 1, pp. 63–65, 2001, DOI: 10.1016/S0960-8524 (00)00072-9.

[2] Adrian, E. Fachrial, Almahdy, Syaifullah, and R. Zein, “The effect of ion Cd(II) in the kidney of experimental rats and utilization of Cassava Leaves (Manihot utilizing) as Antidote.,” *Res. J. Pharm. Biol. Chem. Sci.*, vol. 7, no. 5, pp. 1228–1232, 2016.

[3] Q. Zhai *et al.*, “Protective effects of lactobacillus Plantarum ccfm8610 against acute cadmium toxicity in mice,” *Appl. Environ. Microbiol.*, vol. 79, no. 5, pp. 1508–1515, 2013, DOI: 10.1128/AEM.03417-12.

[4] G. Edris, Y. Alhamed, and A. Alzahrani, “Biosorption of Cadmium and Lead from Aqueous Solutions by Chlorella Vulgaris Biomass: Equilibrium and Kinetic Study,” *Arab. J. Sci. Eng.*, vol. 39, no. 1, pp. 87–93, 2014, DOI: 10.1007/s13369-013-0820-x.

[5] Kepmenkes RI No. 907, “Syarat-Syarat dan Pengawasan Kualitas Air Minum,” *Kemenkes RI*, no. 1, pp. 1–5, 2002.

[6] J. Liu *et al.*, “Synergistic deep removal of As(III) and Cd(II) by a calcined multifunctional MgZnFe-CO3 layered double hydroxide: Photooxidation, precipitation, and adsorption,” *Chemosphere*, vol. 225, no. Iii, pp. 115–125, 2019, DOI: 10.1016/j.chemosphere.2019.03.009.

[7] L. Harimu, S. Matsjeh, D. Siswanta, and S. J. Santosa, “Separation Of Fe (III), Cr(III), Cu(II), Ni(II), Co(II), And Pb(II) Metal Ions Using Poly(Eugenyl Oxyacetic Acid) As An Ion Carrier By A Liquid Membrane Transport Method,” *Indones. J. Chem.*, vol. 10, no. 1, pp. 69–74, 2010, DOI: 10.22146/ ijc.21482.

[8] T.-K. Tran, K.-F. Chiu, C.-Y. Lin, and H.-J. Leu, “Electrochemical treatment of wastewater: Selectivity of the heavy metals removal process,” *Int. J. Hydrogen Energy*, vol. 42, no. 45, pp. 27741–27748, Nov. 2017, DOI: 10.1016/j.ijhydene. 2017.05.156.

[9] S. K. Gunatilake, “Methods of Removing Heavy Metals from Industrial Wastewater,” vol. 1, no. 1, pp. 12–18, 2015.

[10] W. E. Fitri, C. Rahmatiqa, and A. Putra, “Bioremediasi Logam Berat Pb (II) Dan Cu (II) Pada Air Lindi Menggunakan Chlorella Vulgaris,” *Dalt. J. Pendidik. Kim. dan Ilmu Kim.*, vol. 4, no. I, pp. 58–69, 2021.

[11] W. E. Fitri and C. Rahmatiqa, “Chlorella Vulgaris dalam penyerapan logam berat,” in *Monograf : Chlorella Vulgaris dalam penyerapan logam berat*, A. Putra, Ed. Padang, Indonesia: Al-fannani Publisher, 2020, pp. 1–71.

[12] F. Manzoor, A. Karbassi, and A. Golzary, “ Removal of Heavy Metal Contaminants from Wastewater by Using Chlorella Vulgaris Beijerinck: A Review,” *Curr. Environ. Manag.*, vol. 6, no. 3, pp. 174–187, 2019, DOI:10.2174/221271780666619071616053 6.

[13] Becker, “Microalgae: Biotechnology and Microbiology - E. W. Becker - Google Buku,” *1994*. https://books. google.co.id/books (accessed Sep. 16, 2021).

[14] A. Fraile, S. Penche, F. González, M. L. Blázquez, J. A. Muñoz, and A. Ballester, “Biosorption of copper, zinc, cadmium and nickel by Chlorella vulgaris,” *Chem. Ecol.*, vol. 21, no. 1, pp. 61–75, 2005, DOI: 10.1080/02757540512331334933.

[15] M. E. Goher, A. M. Hassan, I. A. Abdel-Moniem, A. H. Fahmy, M. H. Abdo, and S. M. El-Sayed, “Removal of aluminum, iron and manganese ions from industrial wastes using granular activated carbon and Amberlite IR-120H,” *Egypt. J. Aquat. Res.*, vol. 41, no. 2, pp. 155–164, 2015, DOI: 10.1016/j.ejar.2015.04.002.

[16] J. Cheng, W. Yin, Z. Chang, N. Lundholm, and Z. Jiang, “Biosorption capacity and

kinetics of cadmium(II) on live and dead Chlorella Vulgaris," *J. Appl. Phycol.*, vol. 29, no. 1, pp. 211–221, 2017, DOI: 10.1007/s10811-016-0916-2.

[17] H. Chen and S. S. Pan, "Bioremediation potential of spirulina: Toxicity and biosorption studies of lead," *J. Zhejiang Univ. Sci.*, vol. 6 B, no. 3, pp. 171–174, 2005, DOI: 10.1631/jzus.2005. B0171.

[18] S. K. Mehta and J. P. Gaur, "Removal of Ni and Cu from single and binary metal solutions by free and immobilized Chlorella Vulgaris," *Eur. J. Protistol.*, vol. 37, no. 3, pp. 261–271, 2001, DOI: 10.1078/0932-4739-00813.

[19] R. Zein, S. Syukri, M. Muhammad, I. Pratiwi, and D. R. Yutaro, "The ability of Pensi (Corbicula moltkiana) shell to adsorb Cd(II) and Cr(VI) ions," *AIP Conf. Proc.*, vol. 2023, no. October 2018, DOI: 10.1063/1.5064096.

[20] M. E. Goher, A. M. A. El-Monem, A. M. Abdel-Satar, M. H. Ali, A. E. M. Hussian, and A. Napiórkowska-Krzebietke, "Biosorption of some toxic metals from aqueous solution using non-living algal cells of Chlorella Vulgaris," *J. Elem.*, vol. 21, no. 3, pp. 703–714, 2016, DOI: 10.5601/jelem.2015.20.4.1037.