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THE EFFECTIVENESS OF COMBINED DUCKWEED (Lemna minor), CYANOBACTERIA IN THE DEGRADATION FOR CADMIUM (Cd) AND IRON (Fe) METALS

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ABSTRACT

The high content of cadmium (Cd) and iron (Fe) is one of the causes of environmental and health problems. This study aims to test the combined effectiveness of duckweed (Lemna minor) and Cyanobacteria in the degradation of heavy metals cadmium (Cd) and iron (Fe) in leachate water at the Gampong Jawa landfill. This effectiveness test was carried out with a variation of contact times of 2, 4, and 6 days and the test was carried out using an Atomic Absorption Spectrophotometer (AAS). Physical changes occurred in the water, and Cyanobacteria became blackened and duckweed (Lemna minor) was pale in color. The highest decrease in heavy metal cadmium (Cd) occurred on day 4 with a percentage of 94.55% and in iron (Fe) occurred on day 2 with a percentage of 62.58%. This demonstrates the effectiveness of incorporating duckweed (Lemna minor) and Anabaena in reducing heavy metals like cadmium (Cd) and iron (Fe) in leachate water.

KEYWORDS: heavy metals; cadmium; iron; Lemna minor; anabaena; leachate

INTRODUCTION

The high population growth in Indonesia also causes urban waste generation to continue to increase (Miao et al., 2019). This problem is also experienced in Aceh, especially in Banda Aceh City, which is the capital of Aceh Province, where all activity centers are carried out in this city. The method of landfilling and composting burning can be a solution to the problem, but this method can produce leachate, which will pollute the environment (Fitriawardhani, 2020). The heavy metal content of leachate is not only chemical compounds, but there are also heavy metals that are classified as essential and non-essential (Irhamni et

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al., 2017)

Duckweed (*Lemna minor*) is one of the hyperaccumulator plants that can accumulate heavy metals in water by absorbing them into its tissues after exposure to heavy metals (Ekperusi et al., 2019). In addition to using phytoremediation methods for reducing heavy metals, another method that has proven effective for removing heavy metals in wastewater is biosorption and bioaccumulation techniques using algae and similar organisms that have been studied since 1970 (Abdolali et al., 2017). The use of Cyanobacteria has the potential to reduce heavy metals due to its high photosynthetic efficiency, simple structure, large surface area, and high sorption capacity with a low operational cost, but it is more promising than conventional methods (Safari & Ahmady-Asbchin, 2018; Shen et al., 2021)

Gampong Jawa Landfill is one of the landfills in Banda Aceh City, which plays a role in accommodating waste generated from two cities/districts, namely Banda Aceh City and Aceh Besar Regency. The examination results that have been carried out for heavy metal Cd levels in leachate water at the Gampong Jawa landfill are 0.147 mg/l. For these results that have exceeded the standard quality limit of PermenLH No.59/Menlhk/Setjen/Kum.I/7/2016 concerning leachate quality standards for businesses and/or Waste Final Processing Site Activities, which is 0.1 mg/l. As for the heavy metal iron in the landfill, it is 12.256 mg/L, which has exceeded the standard quality threshold according to PermenLH No.04/2014 concerning Wastewater Quality Standards, which is 5 mg/L.

Based on the above problems, this study was conducted to investigate the potential of combining duckweed (*Lemna minor*) and Cyanobacteria in removing heavy metals cadmium and iron in leachate water by biosorption and bioaccumulation methods that will provide input and develop a natural system for removing heavy metals from leachate water that is relatively cost-effective and technically feasible

RESEARCH METHOD

Instruments

The instruments used in this research are scales, Centrifudge 4500 rpm (WifugTM), Erlenmeyer (PyrexTM), Beaker glass (PyrexTM), Tissue Oil absorb (Paseo), Tissue (Nice), Bunsen, and Reactor.

Materials

The materials used in this study were leachate water, duckweed, and BG-11_0 media

Research Design

This research is experimental. The leachate water used came from pond one at the Gampong Jawa landfill. The duckweed (*Lemna minor*) used has been acclimatized for two days. Cyanobacteria is used in the genus

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Anabaena. The research used time variations of 2, 4, and 6 days. The research was conducted at the Microbiology Laboratory of FMIPA USK and the Environmental Engineering Laboratory of Ar-Raniry State Islamic University in December 2022.

Rejuvenation of Cyanobacteria

Cyanobacteria in this study were Anabaena isolates. Rejuvenation of Cyanobacteria was carried out on BG-11_0 liquid media by taking Cyanobacteria isolates and adding BG-110 50 ml media with an incubation period of 7 days at a temperature of 20-30℃ (Keshari et al., 2021)

Preparation of biomass from Anabaena culture

Preparation of biomass from Anabaena culture using a 4500 rpm centrifuge for 30 minutes. The plate from the centrifugation was taken and weighed 0.8 g.

Test the Ability of Duckweed (*Lemna minor*) and Cyanobacteria in Degrading Cd and Fe

The ability of duckweed (*Lemna minor*) and Cyanobacteria to degrade heavy metal levels of Cd and Fe can be achieved by combining duckweed (*Lemna minor*) 0.58 g and Cyanobacteria genus Anabaena 0.8 g into 100 ml leachate water. For the examination of heavy metal residues using AAS.

Data Analysis

Calculation of effectiveness using the equation:

$$H = C_0 - C_s \text{.....} (1)$$
$$F = (H/C_0) - 100\% \text{ .....} (2)$$

With H being the concentration of cadmium (Cd) and iron (Fe) remediated by duckweed (*Lemna minor*) and Cyanobacteria, CO being the initial concentration of cadmium (Cd) and iron (Fe), CS being the final concentration of Cd and Fe in the medium that has been separated from duckweed (*Lemna minor*) and Cyanobacteria and F being the efficiency of the plant medium and isolates that have been separated.

RESULT

Characteristics of Duckweed (*Lemna minor*)—Cyanobacteria and Leachate Water in Cd and Fe Reduction Tests

Research using duckweed (*Lemna minor*) and Anabaena in leachate water to reduce cadmium (Cd) and iron (Fe) heavy metal levels was conducted for 6 days at the Environmental Engineering Laboratory. In 6 days, there were significant changes in duckweed (*Lemna minor*), Anabaena and leachate water, as presented in Table 1

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Table 1. Physical changes that occurred during the study

Time (days)	Leachate	Duckweed (*Lemna minor*)	*Anabaena*
First	Dark black and has an unpleasant odor.	Bright green in color	Green in color
2th	Light brown with no odor	Green-white in color	Transparent black
4th	Dark brown and odorless	White in color	Dark black and attached to the roots of duckweed (*Lemna minor*)
6th	Dark black and has a bad smell.	White in color	Dark black and attached to the roots of duckweed (*Lemna minor*)

Effectiveness of Duckweed (Lemna minor)-Cyanobacteria on Cd and Fe Reduction Testing in Gampong Jawa Landfill Leachate Water

For the test results of the combination of duckweed (Lemna minor) and Cyanobacteria genus Anabaena in leachate water against heavy metal cadmium (Cd), there was a decrease, with the highest percentage reaching 94.55% on day 4. For the sixth day, there was only a decrease of 84.35%. While the heavy metal iron (Fe) decreased with the highest percentage on day 2 (62.58%), on day six, there was only a decrease in heavy metals of 50.55%. The effectiveness test results can be seen in Table 2, and the percentage reduction is presented in Figure 3.

Table 2. Effectiveness test value of Cd and Fe heavy metal reduction in leachate

Time (days)	Heavy Metal	Initial (ppm)	End (ppm)	Total decrease (ppm)	Decrease in metal content (%)
2	*Cd*	0.147	0.0117	0.135	91.83%
	Fe	12.256	4.585	7.671	62.58%
4	*Cd*	0.147	0.008	0.139	94.55%
	Fe	12.256	5.755	6.501	53.04%
6	*Cd*	0.147	0.023	0.124	84.35%
	Fe	12.256	6.060	6.196	50.55%

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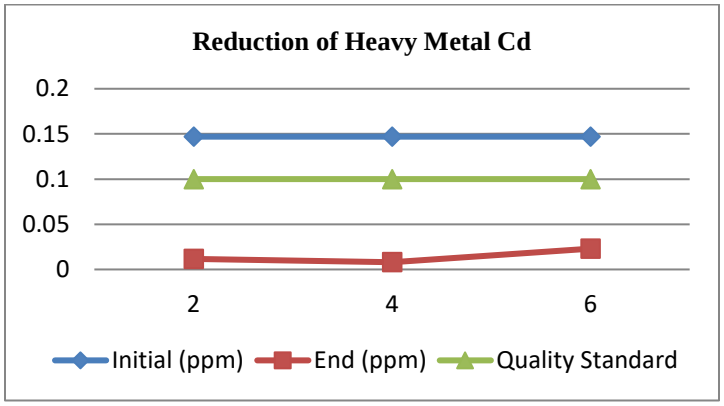

Figure 1. Graph of Cd heavy metal reduction with combined Duckweed (Lemna minor) and Anabaena

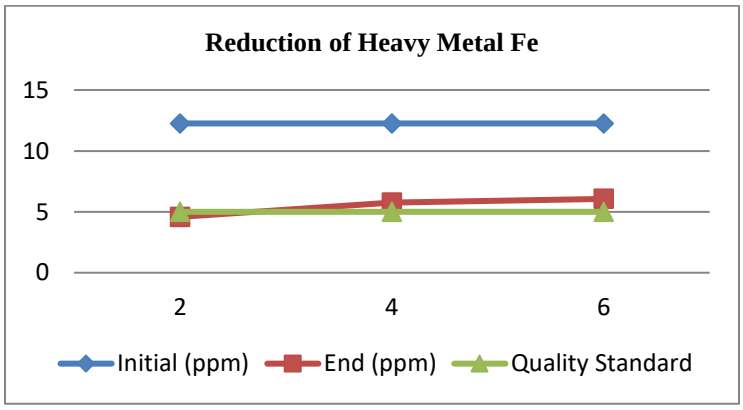

Figure 2. Graph of Fe heavy metal reduction with combined Duckweed (Lemna minor) and Anabaena

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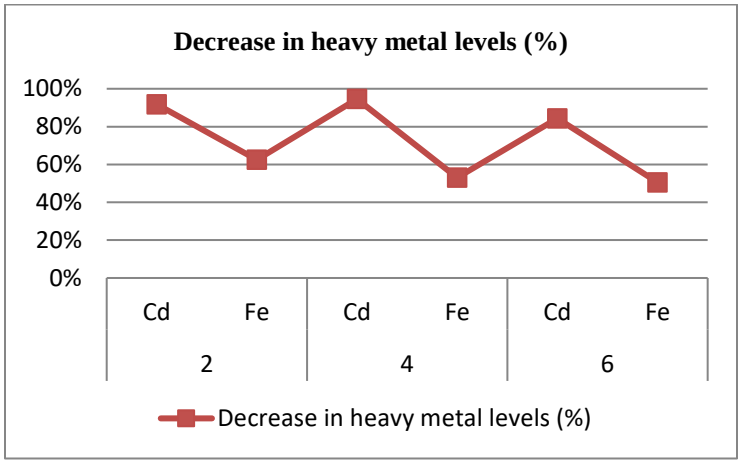

Figure 3. Graph of percentage reduction of heavy metals Cd and Fe with combined Duckweed (Lemna minor) and Anabaena

DISCUSSION

Duckweed (*Lemna minor*) and Anabaena combined in leachate water undergo physical changes, as presented in Table 4.1. The changes that occur, namely in duckweed (*Lemna minor*), are color changes that occur on day 2, namely the color of the leaves, which initially had a bright green color, began to turn white green on 1-2 leaves, and on days 4 and 6, the duckweed (*Lemna minor*) experienced a color change to white on all of its leaves. While the Cyanobacteria of the genus Anabaena experienced physical changes at the beginning of the study, the color they possessed was transparent green. However, on day two, it became transparent black, and on day 4, Anabaena turned dark black but transparent, and its position was attached to the roots of duckweed (*Lemna minor*). On the sixth day, Anabaena's color changed to dark black.

Al-Nabhan (2022), said that heavy metal accumulation limits chlorophyll production by disrupting the intake of the main components for photosynthetic pigments. According to Iqbal et al (2019), the discoloration of duckweed (*Lemna minor*) leaves is due to nitrogen, which is a substance for chlorophyll formation, being absorbed by Anabaena to survive. Nitrogen assimilation by the leaves and roots of duckweed (*Lemna minor*) is the primary mechanism of nitrogen fixation in plants. However, nitrate and ammonium, the primary forms of nitrogen used by duckweed (*Lemna minor*) as part of the chlorophyll molecule that gives plants their green color, are absorbed by Anabaena through the roots of duckweed (*Lemna minor*). According to El-Hameed et al., (2021), the condition of Anabaena attached to duckweed (*Lemna minor*) occurs because leachate water containing Cd causes reduced chlorophyll levels in Anabaena, so to keep getting chlorophyll, Anabaena uses duckweed (*Lemna minor*) as its host. According to Hu (2021), Cyanobacteria use duckweed (*Lemna minor*) as their host because the color of the leachate,

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which tends to be dark, inhibits the growth of Anabaena. So that the changes that occur in terms of color in duckweed (*Lemna minor*) are caused by the needs of Anabaena, which requires chlorophyll, so it uses duckweed (*Lemna minor*) as its host, and also because of the accumulation process carried out by duckweed (*Lemna minor*)

Based on Figure 4.2, the percentage reduction of heavy metals using a combination of duckweed (*Lemna minor*) and Anabaena in leachate water against the heavy metal cadmium (Cd) decreased, with the highest percentage reaching 94.55% on day 4. For the sixth day, there was only a decrease of 84.35%. While in heavy metal iron (Fe), there was a decrease with the highest percentage on day 2 (62.58%), while on day 6, there was only a decrease in heavy metals of 50.55%. This research is in line with research conducted by Ozyigit et al., (2021), namely that the accumulation of Cd in duckweed (*Lemna minor*) has a high effectiveness on the fourth day of the experiment because duckweed (*Lemna minor*) has the potential to reduce Cd levels in polluted waters due to its high accumulation ability, low polymorphism, and high GTS levels, and shows a high ability to accumulate large amounts of Cd. Sasmaz et al (2019) detected that duckweed (*Lemna minor*) accumulates maximum Cd removal at pH six and temperature 25°C in the treatment system and shows maximum bioconcentration factor at 35°C and is more favorable in tropical areas.

The decrease in iron (Fe) levels carried out by combining duckweed (*Lemna minor*) is said to be effective because, in its lifetime, Cyanobacteria require Fe for the provision of photosynthesis. According to Sadvakasova et al., (2022), iron plays an equally important role in nitrogen fixation. The need for Fe in the nitrogen reduction process is related to the fact that this process requires Fe both in enzymes and to provide healing energy during photosynthesis or respiration mediated by ferredoxin. Iron limitation can reduce nitrate reductase levels in Cyanobacteria.

The effectiveness of the combined duckweed (*Lemna minor*) and Cyanobacteria genus Anabaena concerning the effect of contact time on metals is presented in Table 4.2. The heavy metal Fe takes two days to achieve a high percentage reduction, while for Cd, it takes four days to achieve the highest percentage reduction. This statement is in line with research conducted by Iqbal et al., (2022) that shows the level of metal removal, especially Fe, carried out by Cyanobacteria of the genus Anabaena is higher during the first two days and that most of the removal of heavy metal ions occurs during this period. This event occurred because the removal of metals from the leachate resulted from the biosorption and bioaccumulation processes of the Cyanobacteria. Initially, the biosorption process is dominant in removing most of the metal ions in the first two days of the experiment. Then bioaccumulation is responsible for removing the remaining metal ions until equilibrium conditions are reached. The effect of a longer residence time caused a decrease in effectiveness. This condition is in line with Fanani et al., (2017) research, which says that a long residence time will cause the surface of Cyanobacteria as a

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biosorbent not to be fully exposed in the absorption process due to biomass clumping, thus affecting the absorption capacity.

CONCLUSION

Incorporating duckweed (*Lemna minor*) and Cyanobacteria with the genus Anabaena proved effective in degrading cadmium heavy metals on day four by 94.55% and heavy iron metals by 62.58% on day 2.

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