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Absorption of Heavy Metal Lead Using Floating Aquatic Plants (Duckweed, *Lemna Minor*)

Ishan Yashikharan Baskaran[1], Nuramidah Hamidon[1*]

[1]Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, Higher Education Hub, Pagoh, 84600, MALAYSIA

*Corresponding Author Designation

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Abstract: Heavy metal contamination of surface water is a serious problem that affects the livelihood of the people, flora and fauna around the globe. The main objective of this research is to determine the chemical properties of Sungai Panchor and investigate the effectiveness of duckweed (*Lemna Minor*) in absorbing lead (Pb) from the surface water of Sungai Panchor by using the process of phytoremediation. Turbidity, pH, dissolved oxygen (DO) and heavy metal lead were the parameters for this experiment. Duckweed was left in the water sample for nine days and the results of the four parameters were taken before and after the experiment. After nine days, the water quality improved, which can be proven by the increase of dissolved oxygen and the decrease of concentration of lead. Turbidity and pH also decreased. The duckweed shows a removal percentage of lead of 35.88%. To improve the effectiveness of duckweed in absorbing lead from Sungai Panchor, a fence or border can be built so that the plants are not disturbed by waves from boats and the flow of the river.

Keywords: Duckweed , Concentration Of Lead, Surface Water, Water Quality

1. Introduction

Our most valuable natural resource is water. In many crowded places of the globe, clean water is becoming scarce. The demand for water is rising every day owing to population and industrial expansion. We read and hear about the lack of clean water supply in printed or social media. Even though Malaysia is a growing country that will eventually become a developed country, it faces this issue in both urban and rural areas. Water that is safe for fishing is scarce in many parts of the world due to pollution and other human activities. Pollution from industrial discharges, agricultural runoff, and urban stormwater runoff can introduce harmful chemicals and heavy metals into surface water, making it unsafe for fishing and other recreational activities. Climate change is also a factor that affects water quality, leading to changes in temperature, water levels, and other factors that can make it difficult for fish to survive.

*Corresponding author: nuramidah@uthm.edu.my

Heavy metal contamination in surface water refers to the presence of excess levels of metals such as lead, mercury, cadmium, and others in streams, rivers, lakes, and other bodies of surface water. Since they may enter the human body by a variety of routes, including ingestion, retention, and other means, they are toxic to all living things [4]. Some of the impacts of heavy metal contamination in surface water include toxicity to aquatic life, damage to the food web and ecosystem, and reduction of water quality. Heavy metals can also accumulate in fish and other aquatic organisms, leading to health risks for humans who consume them. In addition, heavy metal contamination can also cause aesthetic problems, such as discoloration of water and the formation of metallic precipitates.

Phytoremediation is the use of plants to clean up or remove pollutants from the environment. Duckweed (*Lemna minor*) is a type of aquatic plant that has been studied for its potential use in phytoremediation. Duckweed has been shown to be effective in removing heavy metals, such as lead and cadmium, from water [2]. The plant's ability to absorb these pollutants is due to its high surface area-to-volume ratio, which allows it to take up large amounts of contaminants. In addition, duckweed is also able to remove other types of pollutants such as nutrients, organic compounds and pathogenic microorganisms [5]. The use of duckweed in phytoremediation has several advantages. It is a fast-growing plant that can be easily propagated, it can be grown in a wide range of environmental conditions, and it does not require extensive inputs of water, fertilizer or pesticides. Furthermore, duckweed has a high biomass yield and can be used as a source of biofuel or animal feed. Phytoremediation using duckweed is a promising strategy for the treatment of contaminated water, especially in small-scale and low-cost applications. Further research is needed to optimize the use of duckweed in phytoremediation, including the study of the mechanisms of metal uptake and the identification of the most suitable species and strains.

2. Materials and Methods

This section describes the materials, methods and equations that are required to obtain the results of the study, also known as methodology.

2.1 Materials

Duckweed (*Lemna minor*) was used in this experiment to absorb heavy metal lead from Sungai Panchor surface water. It is a small, aquatic plant that belongs to the Lemnaceae family. It is a fast-growing, floating plant that is commonly found in freshwater environments such as ponds, lakes, and slow-moving streams. Duckweed has been used in a variety of applications, including wastewater treatment, biofuel production, and phytoremediation. Because of its fast growth rate and ability to absorb pollutants, it is considered as a potential tool for the remediation of contaminated water bodies [6].

Figure 2.1: Duckweed (*Lemna Minor*) in a pond

Buckets tied to ropes were used for water sampling of Sunngai Panchor. For the laboratory testing, they were held at the Environmental Lab at Universiti Tun Hussein Onn Pagoh Campus using the following equiupment: HANNA Benchtop pH/mV meter for pH readings, HANNA Portable Galvanic Dissolved Oxygen Meter for dissolved oxygen (DO) readings, HACH Desktop turbidity meter for turbidity readings and DR6000 UV VIS Spectrophotometer for heavy metal lead analysis

2.2 Methods

Water sampling of Sungai Panchor was done using composite sampling, where samples were taken from different spots at the location, as shown in Figure 2.2, and mixed into one sample. A bucket tied to a rope was thrown from a bridge into the river and let to fill with water before pulling it up and pouring it into a container. The container was then kept in a cold place before being tested on. The water sample was then transferred to a rectangular container and duckweed was added. It was kept at a place with continuous sunlight exposure for nine days where it was not moved so that the duckweed is not agitated.

Figure 2.2: Collection point of water sample at Sungai Panchor

Dissolved oxygen and pH testing were done by dipping the rods from the respective equipment into the water sample. For turbidity testing, water sample was poured into a clean sample cell and inserting into the equipment before wiping the sample cell with a wet tissue, followed by a dry one.

The procedure for heavy metal lead analysis is as follows. On the DR6000 UV VIS Spectrophotometer, program 280 Lead, Dithizone was selected. 250 mL of sample was measured and poured into a 500-mL separator funnel. Buffer Powder Pillow, citrate type was added to the contents of the separator funnel. A stopper was used and the sample was shaken to dissolve. Then, DithiVer solution was prepared by adding 50 mL of chloroform to a 50-mL mixing cylinder. The contents of one DithiVer Metal Reagent Powder Pillow was added. The mixing cylinder was inverted several times after putting a stopper. 30 mL of the prepared DithiVer solution was measured with a second graduated cylinder. The measured 30 mL of the DithiVer solution was added into the 500-mL separator funnel. A stopper was used and the separator funnel was inverted to mix. The funnel is then inverted and the stopcock was opened to vent, before being closed. 5 mL of 5.0 N Sodium Hydroxide Solution was added to the funnel. Inverted to mix by putting a stopper. The funnel was vented again by opening and closing the stopcock while being inverted. The funnel is shaken about twice before being vented again. The colour of the mixture inside the funnel became blue-green in colour as seen in Figure 2.3.

Figure 2.3: The colour of the bottom layer (chloroform) becomes blue-green

Another three drops of 5.0 N Standard Sodium Hydroxide Solution was added and shaken into the mixture. Three drops were continuously added and shaken until the solution became orange. Huge quantities of zinc contribute to an indistinct colour shift at the end stage. 5 final drops of 5.0 N Sodium Hydroxide is added. In this step a pink colour in the bottom (chloroform) layer does not necessarily mean that the sample contains lead. Only after the addition of potassium cyanide in the next step does the pink colour indicate the presence of lead. Next, two heaping scoops of potassium cyanide was added to the funnel and shaken vigorously for approximately 15 seconds, until the powder was dissolved. Then, 1 minute was allowed to pass for the separation of the layers. The bottom layer (chloroform) was pink, indicating that the sample contains lead.

For preparing the sample, a cotton ball, the size of a pea, was plugged into the funnel distribution tube. The lower (chloroform) layer was drained gradually into a dry 10 mL sample container. On the other hand, the blank was prepared by filling 10 mL chloroform into a different dry sample cell. Finally, for the testing using DR6000 UV VIS Spectrophotometer, the blank sample cell was cleaned with a wet tissue, followed by a dry one, making sure to handle it only by its neck. It was then inserted into the cell holder. The "ZERO" button was pushed on the device and the display showed "0 mg/L Pb^{2+}". Next, the prepared sample cell was cleaned and handled the same way as the blank and inserted into the sample cell holder. The "READ" button was pushed and result was shown in "mg/L Pb^{2+}". Readings were taken three times for each parameter and the average was calculated to obtain an overall reading.

2.3 Equations

The following equation was used in calculating the percentage removal (R) of lead:

$$\%R = \frac{c_o - c_e}{c_0} \times 100 \qquad Eq.1$$

$\%R$ = Removal percentage

c_o = Initial lead concentration

c_e = Final lead concentration

3. Results and Discussion

The results and discussion section presents data and analysis of the study.

3.1 pH

The pH value shows the condition of water, whether if it is acidic or basic. Acids have a pH value that is less than 6, alkali have values 8 and more while 7 is neutral. The average final pH decreased to 5.31 from an average initial pH of 8.30 as seen in Table 3.1 and Figure 3.1. The result is more acidic than before.

Table 3.1: Initial and Final pH Readings

Initial pH	Average Initial	Final pH	Average Final
8.23		5.36	
8.25	8.30	5.29	5.31
8.33		5.27	

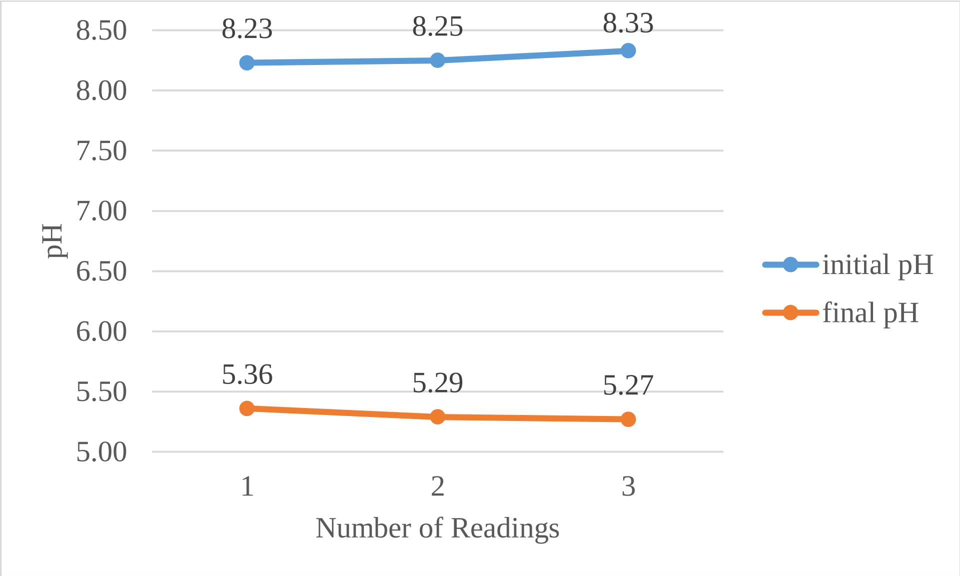

Figure 3.1: Initial and Final pH readings vs Number of Readings

Microbial activities and the increase of CO_2 causes the reduction in pH. Duckweed typically survive in water conditions with a pH value of 5 to 7. The final results indicates that the water has changed from a Class I level to a Class III level [1]. This is ideal as Sungai Panchor is mainly used for fishing activities.

3.2 Dissolved Oxygen (DO)

The DO results in this study increases from an average of 0.96 mg/L to 8.65 mg/L as shown in Table 4.2 and Figure 4.2. The final results classifies the water at Class Level I [1].

Table 4.2: Initial and Final Dissolved Oxygen (DO) Readings

Initial DO (mg/L)	Average Initial (mg/L)	Final DO (mg/L)	Average Final (mg/L)
0.99		8.67	
0.95	0.96	8.66	8.65
0.94		8.63	

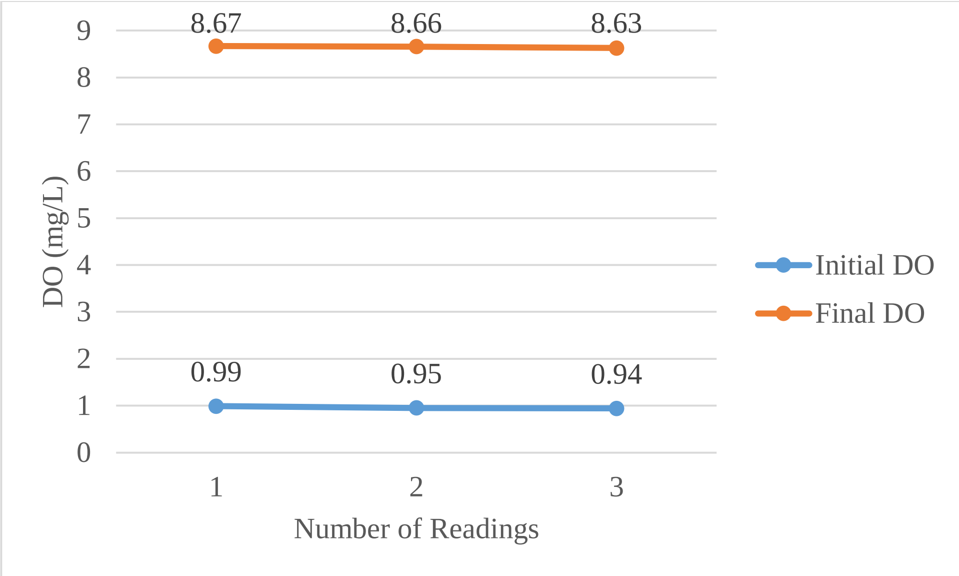

Figure 4.2: Initial and Final Dissolved Oxygen (DO) readings (mg/L) vs Number of Readings

Oxygen dissolves in water through diffusion from the atmosphere and through photosynthesis by aquatic plants. Dissolved oxygen (DO) is an important indicator of the health of a water body because it is required by fish and other aquatic life for survival. If the concentration of DO in the water is too low, it can lead to the death of aquatic life. Conversely, if the concentration of DO is too high, it can lead to the overproduction of algae, which can lead to problems such as eutrophication. During the photosynthesis process, the duckweed excretes oxygen (O_2) and it gets mixed in with the water sample, thus resulting in the increase of DO. This will lead to the increase of aquatic life's livelihood and health in Sungai Panchor, thus increasing the economic state of the fisherman along the river, due to it being one or their main source of money.

3.3 Turbidity

Turbidity is a measure of the clarity of a liquid, typically water. It is expressed in units of turbidity, such as nephelometric turbidity units (NTU), and is used to describe the amount of suspended particles in the water. These particles can include things like clay, silt, algae, and other organic and inorganic matter. The initial turbidity of water from Panchor River was already low, with an average reading of 7.54 NTU. The results still decrease to an average reading of 1.85 NTU, observed from Table 4.3 and Figure 4.3, making the water still stay in Water Class I [1].

Table 4.3: Initial and Final Turbidity Readings

Initial Turbidity (NTU)	Average Initial (NTU)	Final Turbidity (NTU)	Average Final (NTU)
8.35		1.89	
7.52	7.54	1.88	1.85
6.76		1.79	

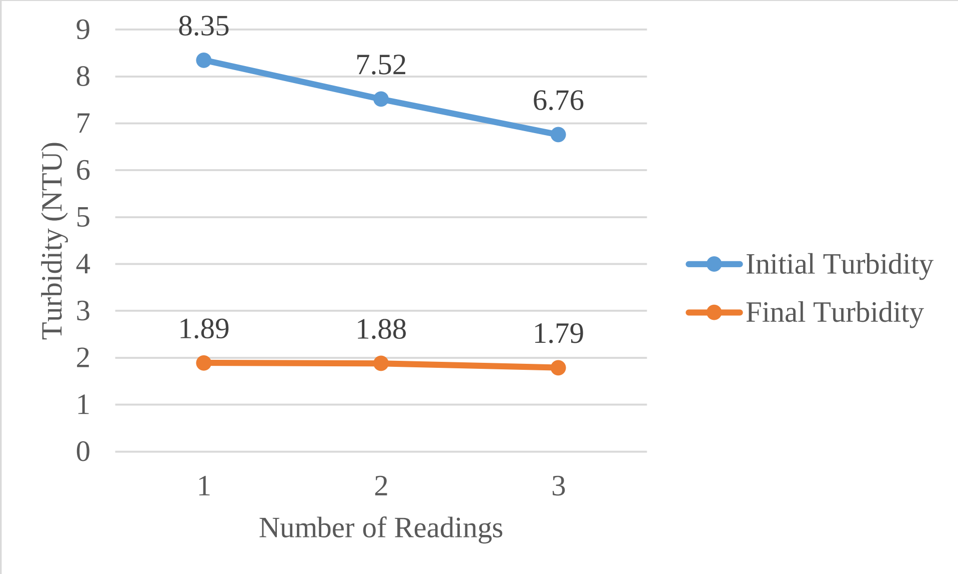

Figure 4.3: Initial and Final Turbidity readings (NTU) vs Number of Readings

This shows that the duckweed is effective in removing physical pollutants that contaminate the water. The roots from the duckweed purify the water through the phytoremediation process, absorbing contaminants and trapping them between the roots. A low turbidity value will prove effective for letting light traverse through the water. In doing so, it will help the process of photosynthesis for aquatic plants that are also food for other aquatic life.

3.4 Heavy Metal Analysis (Lead)

The initial concentration of lead was an average reading of 69.67 µg/L. After the phytoremediation by duckweed (*Lemna Minor*), the concentration then decreased to 44.67 µg/L, which is shown in Table 4.4 and Figure 4.4.

Table 4.4: Initial and Final Heavy Metal Lead Readings

Initial Lead (μg/L)	Average Initial (μg/L)	Final Lead (μg/L)	Average Final (μg/L)
72.00		46.00	
70.00	69.67	43.00	44.67
67.00		45.00	

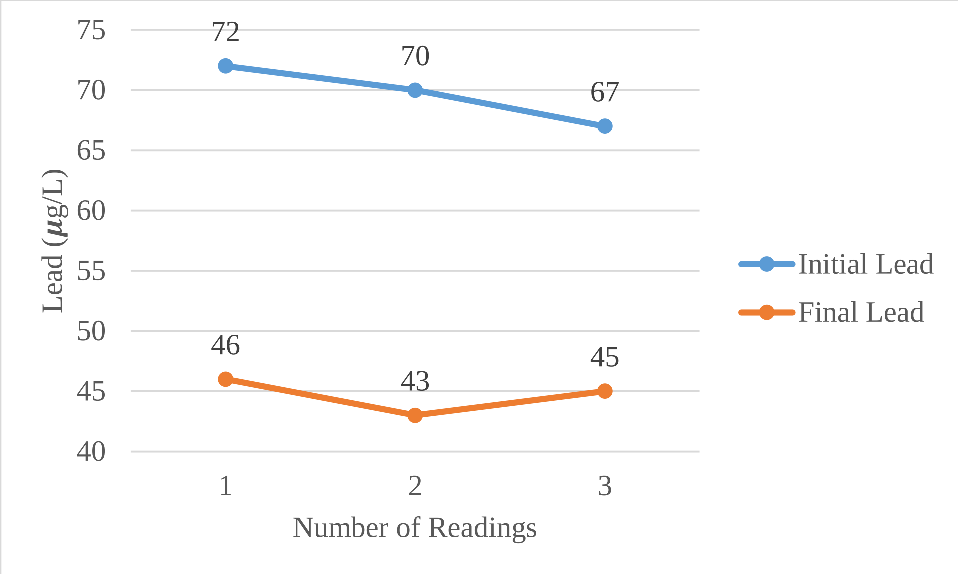

Figure 4.4: Initial and Final Lead readings (µg/L) vs Number of Readings

The percentage of removal (R) of lead is 35.88 %, calculated using $Eq. 1$. The results obtained is comparable with another research that shows a removal efficiency of 88.14 % [2]. The lead in the water of Sungai Panchor may have come from galvanized pipes and iron supports that were present at the collection point of the water sample, which was at a bridge. When plumbing materials containing lead undergo a chemical reaction, lead may end up in the water. Corrosion is the breakdown or wearing away of the metal from the pipes and fittings. When water has a high acidity or low mineral content, this response is more severe [3]. The lead will have then flowed through the river, originating from the said sources, and contaminating it. Lead may be accumulated by duckweed (*Lemna minor*) in order to grow and develop. To sustain growth and development, duckweed has to be able to balance the intake of critical metal ions with the capacity to shield delicate cellular activities and structures from excessive amounts of both essential and non-essential metals. Therefore, the presence of duckweed will result in a reduction in the amount of heavy metal present in the water sample.

4. Conclusion

In this paper, it is concluded that duckweed (*Lemna Minor*), is a suitable option for the absorption of heavy metal lead from surface water with a removal percentage of 35.88 %. The water quality is also improved after the process of phytoremediation, evidently in the reduction of turbidity and the increase of dissolved oxygen (DO). For further research, experiments should be handled in a way where there is no disturbance in the water sample during the phytoremediation process. This will yield more accurate results and at the same time, convince people to use this method for surface water treatment.

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