

Phytoremediation relationship of lead (Pb) by Eichhornia crassipes on pH, BOD and COD in groundwater *by*

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Phytoremediation relationship of lead (Pb) by *Eichhornia crassipes* on pH, BOD and COD in groundwater

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Abstract. *Eichhornia crassipes* is an effective plant to overcome the issues of lead (Pb) contamination in groundwater. This study aims to analyze the relationship between the effectiveness of using *E. crassipes* to absorb Pb and the changing of pH, BOD, and COD. The treatment was applied by adding one *E. crassipes* plant to a container containing groundwater and Pb with concentration of 2 ppm and 4 ppm. The results showed that *E. crassipes* reduced Pb concentrations by 95.95% at 2 ppm Pb treatment and 89.90% at 4 ppm Pb treatment. The study was conducted for 12 days at both treatments, the pH fluctuated and changed to optimal on the 4th day while BOD increased and COD decreased. At the 2 ppm Pb treatment, the optimum pH was 6.79, the highest BOD was 2.09 ppm and the lowest COD was 76 ppm. Whereas at the 4 ppm Pb treatment, the optimum pH was 6.80, the highest BOD was 2.28 ppm and the lowest COD was 79 ppm. *E. crassipes* that absorbed Pb at lower concentrations had higher absorption efficiency and its relationship with pH, BOD and COD was better.

1. Introduction

The rapid development of industry in various sectors often produces waste which can affect organisms and disturb the human health [1, 2]. Lead (Pb) is one of the heavy metals which is toxic even in small concentration [3]. The main sources of Pb pollution in the environment are mining, electronic industrial waste, paint, fertilizer, pesticide, and municipal sewage sludge [4, 5].

Pb pollution which gets in water will have a negative effect on the aquatic biota because it can be accumulated. According to WHO, the maximum limit of Pb in water is 0.01 ppm [6]. Meanwhile, based on the Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning the Management of Water Quality and Water Pollution Control, Pb quality standards based on class, among others: 0.03 ppm (class I, II and III) and 1 ppm (class IV) [7].

All this time, heavy metal pollution has been overcome by physical-chemical technology such as chemical reductions, ion exchanges, membrane filtration, and electrodialysis [8]. However, such technology needs a large amount of chemicals, large area, and expert operators. These methods are also not cost-efficient and are not suitable to be applied for small-scale industrial waste treatment [9]. Therefore, one of the more effective and efficient method that can be used as an alternative is phytoremediation by using a water hyacinth (*Eichhornia crassipes*). *E. crassipes* can accumulate heavy metals of Pb, Fe and Zn found in water and sediment even in small concentration [10].



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The presence of aquatic plants can change the physical-chemical properties of water [11]. *E. crassipes* grown in water which is contaminated by crude oil improve the physical-chemical properties of the water, such as decreasing the pH, temperature, salinity and turbidity [12]. In addition, *E. crassipes* that absorbs cadmium (Cd) at a concentration of 25 ppm, 50 ppm and 75 ppm can cause exudates both in roots and other plant tissues [13]. Exudates has a function as nutrients for microorganisms and can affect the water quality [13]. Therefore, a study of the ability of *E. crassipes* in absorbing Pb needs to be conducted in order to see its relationship to water quality parameters which include pH, Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

2. Materials and methods

2.1. *Eichhornia crassipes* and groundwater sampling

The *E. crassipes* sample was taken from the lake of Hasanuddin University, Makassar. All parts of the this plant including the roots, stems and leaves were cleaned using water and acclimatized in the acclimatization pool for 12 days [13]. *E. crassipes* used had a relatively uniform size and weight [14]. The groundwater samples were taken at Experimental Farm, Faculty of Agriculture, Hasanddin University, Makassar.

2.2. Preliminary test

Pb analysis on water hyacinth was performed to determine the presence of Pb content before phytoremediation was performed. In addition, the analysis of carbon (C), nitrogen (N), phosphorus (P) and potassium (K) was carried out on groundwater.

2.3. Phytoremediation experiment

The phytoremediation method used in this study is a batch system or water which is phytoremediated in a stationary state [15]. The treatment was made using a container with a volume of 10 liters. All treatments were made by mixing groundwater with Pb(NO₃)₂ and adding one *E. crassipes* to each treatment. There were two types treatment, namely 2 ppm Pb and 4 ppm Pb. Each treatment was repeated twice. The water sampling for the observation of Pb, pH, BOD and COD was conducted every 4 days for 12 days, which was on the 0th, 4th, 8th and 12th day [13].

2.4. Analysis of water parameters

The Pb level measurement was carried out using atomic absorption spectrophotometer (AAS) [10], the pH was measured using a pH Meter, BOD measurements were carried out using modified winkler's method and COD measurements were carried out using dichromate reflux method [13, 16].

3. Results and discussion

3.1. Preliminary test

According to the results of the preliminary study, the initial concentration of Pb in water hyacinth before treatment was 0.0004 mg/L. The acclimatized water hyacinth still contains Pb because water hyacinth accumulates heavy metals into its tissues even in small concentrations [9]. Beside to water hyacinth plant, a preliminary test was also carried out on ground water with the aim to determine the nutrient content which includes carbon (C), nitrogen (N), phosphorus (P) and potassium (K) as shown in Table 1.

Table 1. The composition of C, N, P and K on the groundwater.

Nutrient content	Value (ppm)
C	777.03
N	68.85
P	33.53
K	14.17

3.2. Pb concentration

The Pb concentration of 2 ppm Pb treatment on the 0th, 4th, 8th and 12th day were 2.00 ppm, 0.64 ppm, 0.33 ppm and 0.08 ppm respectively, while the Pb concentration of 4 ppm Pb treatment were 4.00 ppm, 0.97 ppm, 0.66 ppm and 0.40 ppm. Both at 2 ppm Pb treatment and 4 ppm Pb treatment, the 4th day is the most effective time for *E. crassipes* in absorbing Pb. Meanwhile, at the 8th and 12th day, the decrease of Pb concentration by *E. crassipes* was not significant. *E. crassipes* is able to absorb heavy metals with high efficiency in a short time and their absorption ability decreases as the contact time increases [17].

The efficiency of *E. crassipes* in absorbing Pb at 2 ppm Pb treatment and 4 ppm Pb treatment for 12 days in a row were 95.95% and 89.90%. The higher the Pb concentration, the more decrease the efficiency of *E. crassipes* in absorbing Pb. This is because heavy metals of As, Cr, Hg, Ni, Pb and Zn absorbed by *E. crassipes* at a concentration of 5 ppm have better absorption efficiency than at concentrations of 10 ppm [18].

The toxicity of Pb on *E. crassipes* affects the absorption efficiency. During the observation, the growth of *E. crassipes* on 2 ppm Pb treatment and 4 ppm Pb treatment did not show any significant physical change. *E. crassipes* plants grow normally: the leaves do not experience any chlorosis, the roots grow well and are blackish brown with 6-18 cm long. This is because *E. crassipes* grows normally at a concentration of 5 ppm and starts to wilt at concentrations greater than 10 ppm [18].

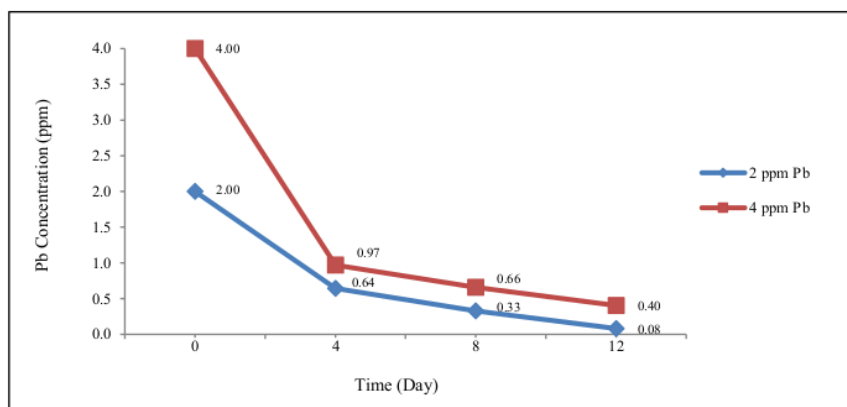


Figure 1. The changes of Pb concentration in groundwater at 2 ppm Pb treatment and 4 ppm Pb treatment.

On the 4th, 8th and 12th day, the concentration of Pb at the two treatments exceeded the threshold set by WHO, which was 0.01 ppm. Meanwhile, based on the Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning the Management of Water Quality and Water Pollution Control, the concentration of Pb at both treatments met the quality standard for class IV, which equals to 1 ppm.

3.3. pH value

The pH value of 2 ppm Pb treatment on the 0th, 4th, 8th and 12th day were 6.50, 6.79, 6.70 and 6.69 respectively, while the pH value of 4 ppm Pb treatment were 6.55, 6.80, 6.71 and 6.71. Both 2 ppm Pb treatment and 4 ppm Pb treatment, the pH fluctuated and changed to optimal on the 4th day.

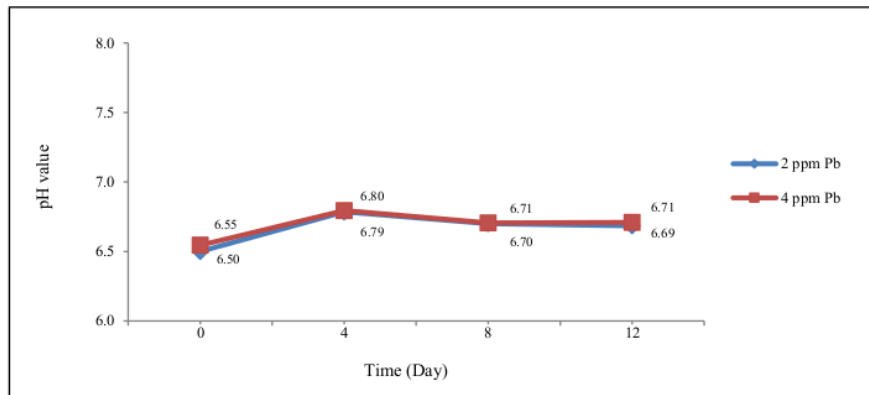


Figure 2. The changes of pH value in groundwater at 2 ppm Pb treatment and 4 ppm Pb treatment.

Photosynthetic activity of aquatic plants can drain the dissolved CO_2 and increase the pH of water because CO_2 is an acidic gas [19]. In plants, lead can inhibit photosynthesis [20]. However, both treatments have no chlorosis disturbance on the leaves because *E. crassipes* grows normally in water containing 5 ppm of lead [18]. Therefore, effective dissolved CO_2 is drained by *E. crassipes* for the photosynthesis. In addition, the increase in pH is also affected by the performance of the *E. crassipes* root which actively absorbs Pb and some cations (H^+) contained in the ground water [21]. Meanwhile, pH decreased on the 8th and 12th day. Changes in pH are related to the release of exudates on *E. crassipes* roots as a result of the accumulation of heavy metals [13].

The addition of $\text{Pb}(\text{NO}_3)_2$ in ground water can affect pH. This can be seen in figure 2 which shows that on day 0th, there is a difference in pH, where 2 ppm Pb treatment has a smaller pH than 4 ppm Pb treatment. In general, differences of pH in both treatments during the 12 days of observation were not significantly different because the added $\text{Pb}(\text{NO}_3)_2$ difference was very small.

3.4. BOD concentration

The BOD concentration of 2 ppm Pb treatment on the 0th, 4th, 8th and 12th day were 0.83 ppm, 1.23 ppm, 1.59 ppm and 2.09 ppm respectively, while the BOD concentration of 4 ppm Pb treatment were 0.81 ppm, 1.22 ppm, 1.69 ppm and 2.28 ppm.

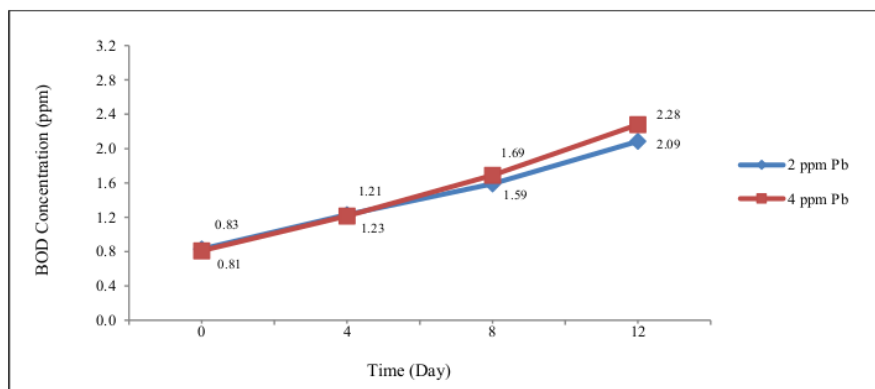


Figure 3. The changes of BOD concentration in groundwater at 2 ppm Pb treatment and 4 ppm Pb treatment.

The BOD concentration increased as the contact time increases in both treatments. On day 0th, the BOD concentration of 2 ppm Pb treatment was higher than 4 ppm Pb treatment, but on the 4th, 8th and 12th day, the BOD concentration of 4 ppm Pb treatment was higher than 2 ppm Pb treatment. *E. crassipes* which absorbs cadmium (Cd) at higher concentration produces a greater concentration of BOD because more exudates are released [13].

The increase in BOD value in both treatments was also caused by the presence nutrient content in the groundwater because it can increase the growth of microorganisms. In addition, eutrophication can also increase BOD, because aquatic plants will prevent the entry of oxygen into the water which can change the condition of the waters to be anaerobic [22].

3.5. COD concentration

The COD concentration of 2 ppm Pb treatment on the 0th, 4th, 8th and 12th day were 161.5 ppm, 124 ppm, 105.5 ppm and 76 ppm respectively, while the COD concentration of 4 ppm Pb treatment were 162 ppm, 126.5 ppm, 103 ppm and 79 ppm. The COD concentration decreased as the contact time increases in both treatments. Pb toxicity can interfere the plant physiological activity [4]. This caused the ability of *E. crassipes* to reduce COD concentration at 4 ppm Pb treatment to be smaller than 2 ppm Pb treatment.

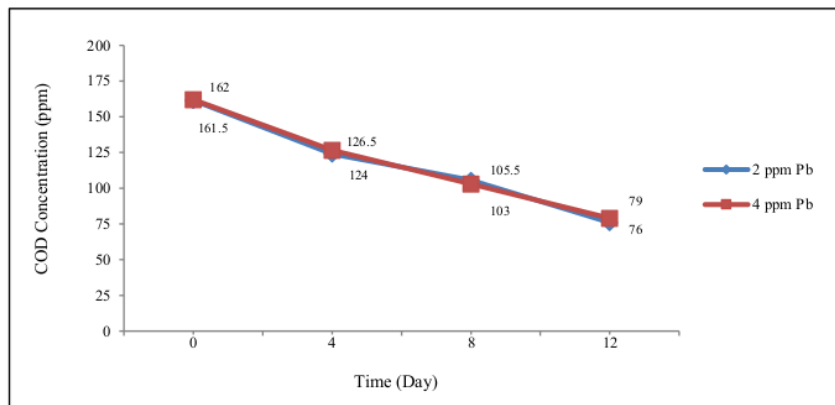


Figure 4. The changes of COD concentration in groundwater at 2 ppm Pb treatment and 4 ppm Pb treatment.

There were several things that cause the COD concentration in wastewater to decrease. The first, the *E. crassipes* was able to reduce nutrients and organic matter. The second, the oxygen that enters waste water was utilized by microorganisms to increase the elimination of organic matter. And the third, nutrients contained in wastewater consumed by microorganisms [22, 23].

From this description, the use of *E. crassipes* at 2 ppm Pb treatment and 4 ppm Pb treatment was effective in absorbing Pb and has a relationship to the quality of water parameters, such as pH, BOD and COD. During 12 days of observation, pH values fluctuated, BOD concentrations increased and COD concentrations decreased. The increase in pH was caused by the ability of *E. crassipes* to absorb dissolved CO₂, Pb and other cations (H⁺) [19, 21]. Meanwhile, the decrease in pH was caused by the accumulation of Pb in *E. crassipes* which can result in the exudate at the root [13]. The Increase in BOD concentration was caused by the presence of nutrients in groundwater and exudates released by *E. crassipes* so that it can increase the microorganism activity [13, 22]. The Decrease in COD concentration was caused by *E. crassipes* and microorganisms that can reduce organic matter [22, 23].

4. Conclusions

The efficiency of *Eichhornia crassipes* in removing lead at 2 ppm Pb treatment and 4 ppm Pb treatment was 95.95% and 89.90% respectively. During 12 days observation, the pH experienced fluctuations but it was optimum on the 4th day which the values of 2 ppm Pb treatment and 4 ppm Pb treatment were 6.79 and 6.80 respectively. On the 12th day, the BOD concentration increased at 2 ppm Pb treatment and 4 ppm Pb treatment which were 2.09 ppm and 2.28 ppm respectively. On the 12th day, the COD concentration decreased at 2 ppm Pb treatment and 4 ppm Pb treatment which were 76 ppm and 79 ppm respectively.

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