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Phytoremediation of Lead Using a Combination of Water Hyacinth (*Eichhornia crassipes* (Mart.) Solms) and Mexican Sword Plant (*Echinodorus palifolius*)

Fitoremediasi Logam Pb Menggunakan Kombinasi Water hyacinth (Eichhornia crassipes (Mart.) Solms) dan Mexican sword plant (Echinodorus palifolius)

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Abstract. Phytoremediation using a combination of water hyacinth (*Eichhornia crassipes*) and Mexican sword plant (*Echinodorus palifolius*) can reduce lead pollutants in waters. This research aims to determine the effect of *Echinodorus palifolius* and *Eichhornia crassipes* on reducing Pb levels, pH, temperature, BOD in Pb wastewater of various concentrations (15, 20, 25 ppm). The research was carried out experimentally using a Randomized Block Design (RBD) and one of the treatment factors, namely the Pb concentration in the media (15, 20, 25 ppm). There were 4 repetitions in the research so there were 24 treatment units. The parameters measured in the research include Pb content, pH, temperature, BOD in the planting media. Pb analysis using AAS (Atomic Absorption Spectrophotometer). The Pb content data obtained were analyzed using the T test with an accuracy level of 0.05. pH, temperature and BOD data were analyzed descriptively qualitatively. The results of the research showed that there was an effect of plant combinations on reducing Pb and pH at various Pb concentrations. The combination of plants were able to change the acidic pH to neutral at various concentrations of Pb , reduce temperature and BOD.
Key words: phytoremediators; water pollution; water remediation

Abstrak. *Fitoremediasi menggunakan kombinasi eceng gondok (Eichhornia crassipes) dan melati air (Echinodorus palifolius) dapat mengurangi polutan berupa logam Pb di perairan. Penelitian ini bertujuan untuk mengetahui pengaruh jenis Echinodorus palifolius dan Eichhornia crassipes terhadap penurunan kadar logam Pb, pH, suhu, BOD pada air limbah Pb berbagai konsentrasi (15, 20, 25 ppm). Penelitian dilakukan secara eksperimental menggunakan Rancangan Acak Kelompok (RAK) dan salah satu faktor perlakuannya, yaitu konsentrasi Pb pada media (15, 20, 25 ppm). Terdapat 4 kali pengulangan pada penelitian sehingga terdapat 24 unit perlakuan. Parameter yang diukur dalam penelitian meliputi kadar logam Pb, pH, suhu, BOD pada media tanam. Analisis Pb menggunakan AAS (Atomic Absorption Spectrophotometer). Data kadar logam Pb yang diperoleh dianalisis menggunakan uji T dengan taraf ketelitian 0,05. Data pH, suhu, dan BOD dianalisis secara deskriptif kualitatif. Hasil penelitian menunjukkan bahwa terdapat pengaruh kombinasi tanaman terhadap penurunan logam Pb dan pH pada berbagai konsentrasi logam Pb. Kombinasi tanaman mampu perubahan pH asam menjadi netral pada berbagai konsentrasi logam Pb dan terjadi penurunan suhu, kadar BOD.*
Kata kunci: *fitoremediator; pencemaran air; remediasi air*

INTRODUCTION

Based on the monitoring carried out in 2014 by the Ministry of the Environment of the Republic of Indonesia, the discharge of domestic and industrial wastewater, including detergents and heavy metals, resulted in serious pollution of 75% of river water. The lead Pb pollutes waterways and endangers humans and other living creatures. Heavy metals can enter and contaminate the bodies of living creatures through contamination of food, drink, water or airborne sources (Sankhla et al., 2016). Industries that use lead as a raw or auxiliary material, such as fuel, cables, the foundry and refining industry, the battery industry, and the chemical industry that uses dyes, have the potential to be sources of lead metal contamination. As stated in the East Java Governor's Regulation Number 72 of 2013 concerning Wastewater Quality Standards for Industry and/or Other Business Activities, as long as the Pb metal concentration does not exceed 1 ppm, the Pb metal content in the waters can be considered normal.

The death of aquatic biota is caused by the increase of lead (Pb) compounds or ions into the water and an increase in lead (Pb) concentrations exceeding the quality standard limits. Aquatic biota can be destroyed in waters that have absorbed Pb compounds or ions, if the Pb concentration in their bodies exceeds the specified threshold. If the Pb metal level reaches 188 mg/l, it can cause marine biota such as fish to die. In water bodies containing biota, *Crustacea* can die because of Pb concentrations of 2.75–49 mg/l for 245 hours, and *Insecta* can die because of Pb concentrations of 3.5–64 mg/l within 168–336 hours. When combined with other elements found in nature, the chemical element lead (Pb) has a negative impact to the environment (Purnomo and Rachmadiarti, 2018). Therefore, to make water contaminated with heavy metals safe for aquatic biota, remediation efforts need to be carried out. Phytoremediation is a remediation technique carried out by aquatic plants. Aquatic plants absorb heavy metals through root absorption mechanisms (Adesuyi *et al*., 2018).

Phytoremediation techniques are technologies for cleaning, eliminating, or reducing contaminants in water or soil with the help of plants. Due to its ability to prevent secondary pollution, phytoremediation is considered more effective than other techniques (Suhartini and Irnia, 2018). Phytoremediation also has benefits because it is able to treat organic and inorganic contaminants. Apart from that, this method is cost-effective so it can be applied in situ or ex situ, because phytoremediation technology does not require additional equipment, people can apply it (Caroline and Guido, 2015). According to Yan *et al.* (2020), the phytoremediation technique is a technology that is visually pleasing, environmentally friendly, and able to reduce pollutant levels significantly.

Plants containing lead (Pb) will also experience changes in chlorophyll physiology. Plants have a green substance called chlorophyll, which is found in abundance in leaves and is an organic antioxidant. Plants will experience a decrease in chlorophyll levels, followed by an increase in lead (Pb) metal accumulation and chloroplast damage (Ulfah *et al*., 2017). Plant roots can absorb heavy metals in the form of metal ions which can dissolve in water, so that metal levels can be reduced through phytoremediation. During the evaporation process, Pb ions can come out of the planting medium and mix with oxygen, producing $Pb(O_3)_2$ ions. Oxygen also binds to Pb ions through reaction with water in the planting medium. When heavy metals are taken up by plants through their ions, the water mass will dissolve the metal followed by the nutrients. After water containing lead diffuses into the roots, root plant cells have higher ion levels than the medium (Rachmadiarti *et al*., 2018).

According to Kasman, *et al* (2019), since 1990, phytoremediation technology has emerged as the newest technology to improve heavy metal pollution. Green plants have the potential to remove a large number of heavy metal pollutants. Some of them are water hyacinth (*Eichhornia crassipes*), water caltrop (*Trapa natans*), water lettuce (*Pistia stratiota*), and Mexican sword plant (*Echinodorus palaefolius*). These plants can be a place to absorb and bioremediate heavy metal pollutants from waste water. Water hyacinth has an adaptive mechanism in tolerance to the toxicity of the heavy metal lead (Pb) at high concentrations (Malar *et al*., 2016). By using a phytoextraction process, the hyperaccumulator plant *Eichhornia crassipes* can remove heavy metals from water bodies. *Eichhornia crassipes* roots will absorb heavy metals from the surrounding water and move them throughout the plant, storing them in specific areas to prevent disruption of the *Eichhornia crassipes*'s important metabolic functions. The metal is first absorbed into the root cells, then moves to the xylem and phloem, and finally to other plant parts. Plants exposed to heavy metal toxicity experience various physiological and biochemical changes, so they require technology to reduce the impact of heavy metal toxicity (Rehman *et al*., 2021; Rahman *et al*., 2022b; Rahman *et al*., 2022c).

Mexican sword plant (*Echinodorus palifolius*) is capable of carrying out the phytoremediation process because it absorbs the heavy metal lead (Pb) through its roots when the planting medium is contaminated with Pb. According to Sari *et al.* (2020), Mexican sword plant is able to absorb oxygen from the leaves, stems and roots which will later be released back into the area around the roots and this is possible because aquatic plant species have spaces between cells or air passage holes as a means of transporting oxygen from the atmosphere. The root system of Mexican sword plant is located at the bottom of the water, its reproductive characteristics are flexible, strong, long and can expand, so it is effective in expanding the area where existing microorganisms attach (Windyanti *et al*., 2020). In addition, because of the large volume of the roots, Pb metal moves from the roots to the leaves through the stems of the Mexican sword plant (*Echinodorus palifolius*). This plant can absorb the heavy metal Pb from its contents through plant roots or what is called rhizofiltration. Rhizofiltration can occur because the roots and stems of the Mexican sword plant (*Echinodorus palifolius*) are in water and have pores or air passage gaps between cells that allow oxygen to reach the roots. Therefore this research aimed to determine the effect of Echinodorus palifolius and Eichhornia crassipes on reducing Pb levels, pH, temperature, BOD in Pb wastewater of various concentrations

MATERIALS AND METHODS

The research design used was a Randomized Block Design. This research was carried out at the Green House and the Physiology Laboratory of the Biology Department, FMIPA UNESA, in October-December 2023. Analysis of Pb levels was carried out at the East Java Environmental Service. The control variable used in this study was the weight of each plant, namely 50 grams and exposure time for 7 days. The manipulation variable used was the concentration of lead metal in the media used, namely 15 ppm, 20 ppm, 25 ppm. The response variables are Pb metal content, pH, temperature and BOD in the planting media at various Pb metal concentrations. This research was conducted for 7 days. Pb levels in the planting media were measured after 7 days of treatment, while pH, temperature, DO, and BOD were measured on the first and seventh days of exposure.

The plants were first acclimatized for seven days using 5 L of distilled water, then the plants were weighed at 50 grams each plants. Exposure to heavy metals on samples was carried out by making planting media in gallons then placing plants in gallons containing planting media contaminated with lead metal at concentrations of 15, 20 and 25 ppm and measuring the pH on the first day of exposure, while on the seventh day the pH was measured. temperature, DO, BOD and Pb metal content in the planting medium. The levels of the heavy metal lead (Pb) in the planting media were analyzed using Atomic Absorption Spectrophotometer (AAS) at the environmental laboratory of the East Java Environmental Service by inserting a 250 ml sample of the planting media into a sample bottle at each concentration and repetition.

The data obtained were data on levels of the heavy metal lead (Pb) in the planting media which were analyzed using the T test. The T test was carried out to see the difference in the reduction of the heavy metal Lead (Pb) with phytoremediation and without phytoremediation using SPSS software and then determining the decision model using statistical tests t, while the Ph, temperature and BOD data were analyzed descriptively qualitatively. These two data are then compared with quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities.

RESULT

Research on the phytoremediation of lead using Mexican sword plant (*Echinodorus palifolius*) and water hyacinth (*Eichhornia crassipes*) was carried out in the Greenhouse of the Biology Study Program, Surabaya State University with the aim of determining the effect of the combination of air jasmine and water hyacinth in reducing levels of lead metal (Pb).) and pH in planting media with various concentrations of Pb metal. So we obtained data on lead metal content (Pb) and pH which are presented in Table 1.

Table 1. Lead (Pb) levels in Mexican sword plant (*Echinodorus palifolius*) and Water hyacinth (*Eichhornia crassipes*) plants

Treatment	Concentration (ppm)	Average Final Pb Content	Quality Standards (ppm)	Sig	T value	T Table	Percentage of Pb Decrease (%)
K0	15	11.93 ± 1.34	1	000	11.035		32%
	20	13.93 ± 0.86	1	000	15.165		29%
	25	18.49 ± 0.96	1	000	18.015		28%
K1	15	2.31 ± 1.10	1	000	11.035	2.44	85%
	20	4.79 ± 0.84	1	000	15.165		79%
	25	6.89 ± 0.85	1	000	18.015		72%

Notes: The quality standards used are based on East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities. K0 means control without plants and K1 means combination between *Echinodorus palifolius* and *Eichhornia crassipes*

Table 1 shows that there is an effect of reducing levels of lead metal (Pb) in each treatment. These results indicate that phytoremediation treatment or treatment without phytoremediation has an influence on reducing levels of lead metal (Pb), because the significance value is <0.05, namely 000; 000; and 000. In the T value column, it can be seen that for both treatments with phytoremediation and without phytoremediation, the t count > t table value is compared with the T table value, which means there is a real difference in the reduction of Pb metal levels in the treatment without phytoremediation and with phytoremediation.

Based on the data in table 1, the average final lead (Pb) metal content in the treatment without phytoremediation was greater than the average final lead (Pb) metal content. The highest average was found in the treatment without phytoremediation with a concentration of 25 ppm, namely 18.49 ppm, while in the treatment with phytoremediation it was 6.89 ppm. The average final concentration of the phytoremediation treatment which was greater than the phytoremediation treatment was also shown at concentrations of 15 ppm (11.93 > 2.31) and 20 ppm (13.93 > 4.79).

The decrease in lead (Pb) metal levels can be seen through the percentage decrease in lead (Pb) heavy metal levels at each concentration. The percentage reduction in the heavy metal lead (Pb) in the phytoremediation treatment was greater than in the treatment without phytoremediation. The largest decrease was found at a concentration of 15 ppm in the phytoremediation treatment with a percentage of 85%, while the treatment without phytoremediation experienced a decrease of 32%. A greater reduction in phytoremediation compared to no phytoremediation also occurred at concentrations of 20 ppm (79% > 29%) and 25 ppm (72% > 28%). However, the final results of measuring metal levels of lead (Pb) at various concentrations in phytoremediation and without phytoremediation treatment still exceed the quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Wastewater Quality Standards for Industry and/or Other Business Activities, namely 1 ppm.

The following are the pH values for each treatment without a combination of plants (control) and with a combination of plants (phytoremediation) at various concentrations used in the research (Table 2).

Table 2. pH values in planting media at various lead metal concentrations

Treatment	Concentration (ppm)	Average pH	Quality standards
K0	15	5.15 ± 0.50	
	20	5.25 ± 0.57	
	25	5.34 ± 0.27	6-9
K1	15	6.38 ± 0.58	
	20	6.48 ± 0.40	
	25	6.60 ± 0.44	

Notes: The quality standards used are based on East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities. K0 means control without plants and K1 means combination between *Echinodorus palifolius* and *Eichhornia crassipes*

Based on the pH value data in table 2, treatments with and without phytoremediation tend to be acidic. The lowest average pH level after 7 days of treatment was obtained in the treatment without phytoremediation with a lead metal concentration of 15 ppm, namely 5.15. Apart from that, the highest average pH value after 7 days of treatment was obtained in the phytoremediation treatment with a lead metal concentration of 25 ppm, namely 6.60. From the data in table 2 it can be seen that the pH value in the phytoremediation treatment and treatment without phytoremediation still meets the quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities, namely 6-9.

The lowest temperature value is found in the treatment without phytoremediation with a lead metal concentration of 25 ppm, namely 29.7°C, while the highest temperature value is found in the treatment without phytoremediation with a concentration of 20 ppm, namely 30.5°C (Table 3). From these data it can be seen that the temperature value in phytoremediation treatment and treatment without phytoremediation still meets the quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities, at 38°C.

Based on Biological Oxygen Demand (BOD) data in Table 4, from the first to the seventh day it always decreases. BOD measurements were measured using the formula BOD = DO0 – DO5 which was carried out for each phytoremediation treatment and treatment without phytoremediation.

Table 3. Temperature values in planting media at various concentrations of Pb

Treatment	Concentration (ppm)	Average Temperature (°C)	Quality Standard (°C)
K0	15	29.8 ± 0.61	
	20	30.5 ± 0.93	
	25	29.7 ± 0.64	38
K1	15	30.01 ± 0.88	
	20	29.9 ± 0.71	
	25	30.02 ± 0.70	

Notes: The quality standards used are based on East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities. K0 means control without plants and K1 means combination between *Echinodorus palifolius* and *Eichhornia crassipes*

Table 4. Data on BOD reduction in planting media at various concentrations of Pb

Treatment	Consentration (ppm)	Final BOD Content (ppm)	Decreasing Percentage Initial Finale of Lead (Pb) Level (%)	Quality standards (ppm)
K0	15	8 ± 1.38	36%	
	20	8.11 ± 1.47	37%	50
	25	8.73 ± 0.87	35%	
K1	15	1.38 ± 1.02	88%	
	20	4 ± 0.37	71%	
	25	5.03 ± 0.30	58%	

Notes: The quality standards used are based on East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities. K0 means control without plants and K1 means combination between *Echinodorus palifolius* and *Eichhornia crassipes*

The lowest BOD levels were obtained in the phytoremediation treatment at a concentration of 15 ppm, namely with a BOD value of 1.38 ppm (Table 4). The highest final BOD level was obtained in the treatment without phytoremediation at a concentration of 25 ppm, namely with a BOD value of 8.73 ppm. In table 6 it can also be seen that the highest percentage reduction in BOD levels was found in the treatment with phytoremediation at a concentration of 15 ppm, at 88%, while the lowest percentage reduction in BOD levels was found in the treatment without phytoremediation at a concentration of 25 ppm. Based on the average BOD results above, these results did not exceed the quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities, at 50 ppm.

DISCUSSION

Echinodorus palifolius and *Eichhornia crassipes* are aquatic plants that can be used as phytoremediator agents to reduce water pollution in the form of heavy metals, such as iron (Fe), copper (Cu), and lead (Pb). These two plants have proven to be effective in carrying out phytoremediation, as proven by Ramadhania's research (2021) which examined Pb metal levels in aquatic plants, one of which is water hyacinth. Able to reduce the highest levels of lead metal in river water by 0.347±0.005 ppm which has an impact on chlorophyll levels in Water hyacinth leaves. Meanwhile, according to research by Kasman, *et al* (2019), Mexican sword plant is able to remediate Pb(II) from aqueous solutions with adsorbed Pb(II) ranging from 0.231-2.431 mg/L.

In this research, *Echinodorus palifolius* and *Eichhornia crassipes* plants were used as test materials and exposed to planting media given different concentrations of lead metal, namely 15 ppm, 20 ppm and 25 ppm. The treatments in this study were divided into 2, treated without plant combination (without phytoremediation) and with plant combination (phytoremediation).

In Table 1 it can be seen that the average final levels of Pb metal between treatments with phytoremediation and without phytoremediation decreased. The average final level of Pb metal in the treatment without phytoremediation showed higher results than the treatment with phytoremediation, this is because in the phytoremediation treatment there were phytoremediators namely *Echinodorus palifolius* and *Eichhornia crassipes* so that metal absorption was more optimal and the Pb metal content in the planting medium was lower, whereas in the treatment without phytoremediation, the levels of the heavy metal Pb were reduced through the evaporation process so that the absorption of Pb metal in the planting media was less than optimal. This happens because the plant does not fully accumulate metal ions. These ions can move from planting media contaminated with Pb waste during the evaporation process, where they combine with oxygen to form new ions. High temperatures affect the oxygen levels of the planting medium, with increasing temperatures resulting in decreased oxygen levels. Metal ions will bind with oxygen when interacting with water in the planting medium (Rahayuningtyas, *et al*,. 2018).

Based on the results of the analysis, both treatments without combination (without phytoremediation) and with a combination (phytoremediation) of *Echinodorus palifolius* and *Eichhornia crassipes* were able to reduce lead (Pb) metal levels. Judging from the results of the percentage reduction in lead metal levels, treatment with *Echinodorus palifolius* and *Eichhornia crassipes* phytoremediation was able to reduce lead metal (Pb) levels to a greater extent than treatment without phytoremediation which can be seen in table 1, the reduction in lead metal levels which shows the average reduction in metal levels. lead (Pb). Apart from that, the results of the T test analysis in table 1 show that the treatment with phytoremediators was able to carry out better phytoremediation compared to the treatment without phytoremediators. This can be proven by the existence of a significance value <0.05 in each treatment, namely 000; 000; and 000. These data show that treatment with phytoremediation and without phytoremediation both have an effect on reducing levels of lead (Pb). However, the final results of measuring metal levels of lead (Pb) at various concentrations in phytoremediation and without phytoremediation treatment still exceed the quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Wastewater Quality Standards for Industry and/or Other Business Activities, namely 1 ppm , this is due to the exposure time which was only 7 days and the need to increase the weight of the plant as a phytoremediator. Due to the high toxicity of Pb metal, the government has determined that the metal level that is safe for the environment is 1 ppm.

The process of absorbing lead through the roots, causes a decrease in lead metal levels in the planting medium. According to Nasir (2022), *Echinodorus palifolius* and *Eichhornia crassipes* as phytoremediation agents absorb metals in polluted water, forming large amounts of phytochelatin metal complexes, which are then detoxified. With the formation of phytochelatin, plants will accumulate heavy metals in certain areas of their cells, without interfering with metabolic processes. Lead (Pb) accumulation in *Echinodorus palifolius* and *Eichhornia crassipes* begins when plant roots absorb polluted water. Dissolved ions and metals then enter the root cells through the symplast (penetrating the endodermal root cell plasma membrane) or the apoplast through the intercellular space. Metals are carried to leaves and other cell parts through the flow of xylem sap. To improve metal transport, plants use chelates. Histidine is a chelate that can absorb Pb metal (Irhamni, *et al*., 2017).

Physical and chemical factors such as pH, temperature, DO, and BOD influence water quality. In measuring water quality chemical parameters, pH measurements were carried out which can be seen in table 2. From these data it can be seen that initially the planting medium was acidic due to the presence of a mixture of nitric acid in the preparation of the lead metal contamination solution, after being well treated with phytoremediation or without phytoremediation, there was an increase in pH levels in the planting media. This occurs because of the long period of direct contact between plants and the planting medium (Raissa & Tangahu, 2017).

The average pH value in the treatment without phytoremediation with a lead metal concentration of 15 ppm was 5.15; lead metal concentration of 20 ppm, namely 5.25; concentration of 25 ppm, namely 5.34; while the average pH value in the phytoremediation treatment with a lead metal concentration of 15 ppm was 6.38; lead metal concentration of 20 ppm, namely 6.48; concentration of 25 ppm is 6.60. This shows that the average value of treatment without phytoremediation is still acidic and does not meet quality standards, while the average value of phytoremediation treatment changes to neutral due to plant activity when absorbing heavy metals (Nur *et al*, 2024) and already meets quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities, namely 6-9.

The temperature measurements that can be seen in table 3 state that the lowest temperature value was found in the treatment without phytoremediation with a lead metal concentration of 25 ppm, namely 29.7°C, while the highest temperature value was found in the treatment without phytoremediation with a concentration of 20 ppm, namely 30 .5°C. From these data it can be seen that the temperature values in phytoremediation treatment and treatment without phytoremediation still meet the quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities, namely 38°C. Plant development is influenced indirectly by the surrounding environmental temperature. and its ability to absorb heavy metals. Optimal temperatures will support plant metabolism and photosynthesis. (Rahayuningtyas *et al*., 2018).

The amount of dissolved oxygen needed by living creatures to decompose contaminants in water is indicated by the Biochemical Oxygen Demand (BOD) parameter. Natural dissolved oxygen levels in waters vary depending on temperature, atmospheric pressure and water movement (Zammi *et al*., 2018). If the oxygen intake used is higher, which can be seen from the amount of remaining dissolved oxygen becoming smaller, then the pollutant content in the water needs high oxygen (Tamyiz, 2015).

The BOD measurement results in table 4 show that the final BOD levels in the treatment with phytoremediation were smaller than those in the treatment without phytoremediation. At a metal concentration of 15 ppm, the final BOD value in the growing media with phytoremediation was 1.38 ppm while in the growing media without phytoremediation it was 8 ppm. This also occurs at a concentration of 20 ppm, namely (4 < 8.11) and a concentration of 25 ppm (5.03 < 8.73). In table 6 it can also be seen that the highest percentage reduction in BOD levels was found in the treatment with phytoremediation at a concentration of 15 ppm, namely 88%, while the lowest percentage reduction in BOD levels was found in the treatment without phytoremediation at a concentration of 25 ppm, namely 35%. This shows that *Echinodorus palifolius* and *Eichhornia crassipes* have been proven to be able to reduce BOD levels in planting media contaminated with Pb metal at various concentrations. Water with a higher BOD value is considered more contaminated. High BOD levels can cause oxygen depletion in the water, kill fish and cause an unpleasant odor in the water (Asrori, 2021). The final results of BOD measurements in planting media with various concentrations in phytoremediation and without phytoremediation treatment are still below the quality standards according to East Java Governor Regulation Number 72 of 2013 concerning Waste Water Quality Standards for Industry and/or Other Business Activities, namely 50 ppm.

CONCLUSION

Based on research that has been carried out from the results and discussion, it can be concluded that combination of Mexican sword plant (*Echinodorus palifolius*) and water hyacinth (*Eichhornia crassipes*) had effect on reducing levels of the heavy metal lead (Pb), pH, temperature and BOD in various planting media Pb metal concentration. The combination of Mexican sword plant (*Echinodorus palifolius*) and water hyacinth (*Eichhornia crassipes*) affected quality of lead metal wastewater, characterized by changes in pH from acid to neutral at various lead metal concentrations, a decrease in temperature and BOD levels.

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