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BIOCONCENTRATION OF LEAD AT AVICENNIA MARINA IN MANGUNHARJO, SEMARANG COASTAL AREA

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ABSTRACT

This study aims to determine the bioconcentration of heavy metal Lead Pb in seawater, sediment, and mangrove plants of Avicennia marina and to determine the bioconcentration factor of heavy metal Lead Pb in mangrove which was conducted in January 2022 in Mangunharjo coastal area. The method used in this research was a survey method with quantitative analysis. The samples of A. marina mangroves were divided into three categories of stem diameter, namely small (3 – 8 cm), medium (6 – 15 cm), and large (11 – 23 cm). Measurement of heavy metal concentrations using AAS (Atomic Absroption Spectrophotometry). Heavy metal bioconsentration in Mangunharjo is classified as high exceeding quality standards. The study revealed that the concentration of heavy metal Lead Pb in the seawater ranged from 0.672 - 0.867 mg/L, in sediments it ranged from 56.50 – 65.96 mg/kg, and in the roots and leaves of mangroves A. marina ranged from 6.209 – 24,883 mg/kg. The bioconcentration factor of heavy metal Lead Pb ranges from 0.185 to 0.227, so that the mangrove A. marina in Mangunharjo Water Area can be classified as an excluder species.

Keywords: Avicennia marina, Bioconcentration, Mangrove, Mangunharjo, Lead.

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INTRODUCTION

The Mangunharjo Water Area is a coastal area in the city of Semarang where the Mangunharjo area is close to residential areas, the Mangunharjo area is used by the community for fishing, industrial and residential activities (Jupriyati *et al*., 2013). The Mangunharjo Waters area is an area that is close to the plywood, plastic, and ceramic industries, where the waste products from these industries can be disposed to around the Mangunharjo Waters and cause pollution around it. Heavy metal Lead Lead Pb is a carcinogenic metal. Carcinogenic substances are substances that can grow cancer cells and can cause genetic changes in a cell that are passed on from parents to their offspring (gene mutations). The mangrove ecosystem has the highest productivity when compared to other ecosystems in the estuary area. According to Amin (2001), the mangrove species Avicennia marina can absorb heavy metals found in sediment and water, then these metals are circulated to other body parts by roots. This study aims to determine the concentration of heavy metal Lead Pb in water, sediment, and mangrove plants of A. marina and determine the bioconcentration factor of heavy metal Lead Pb in mangrove plants of A. marina in Mangunharjo waters Figure 1).

METHODOLOGY

Materials

The materials used in this study were water, sediment, roots, and leaves of mangrove species (Avicennia marina) and HNO_3 solution as a preservative for water samples. The tools used in this research include GPS, zipper plastic, plastic bottles, sediment core, cool box, pH soil, refractometer, and DO meter.

Methods

The method used in this research is a survey method. The sampling method is purposive random sampling. The water and sediment sampling technique is the Composite Place Sample at the three research stations as shown in Figure 2.

Seawater samples were taken as much as 100 ml and then put into a sample bottle and then added with HNO_3.Water quality parameters measured in this study are DO, pH soil, salinity, and temperature. Sediment samples were taken on the surface using a sediment core and then put in a zipper plastic. Plant samples were taken using a knife by taking the roots that were in the sediment, and taking the leaves. Then put in a zipper plastic and separated according to size, namely small with a stem diameter of 3-5 cm, medium size 6-15 cm, and large size 11-51 cm.

Heavy metal concentration test of Lead Pb in water, sediment, and mangrove A. marina

Samples of water, sediment, and mangrove plants were then analyzed at the Environmental Engineering Laboratory, Faculty of Engineering, Diponegoro University. Analysis of the concentration of heavy metals in water based on SNI 6989.8:2009 on the Method of Testing Lead (Lead Pb) by Atomic Absorption Spectrophotometry (AAS)-flame. The sediment and mangrove samples were subjected to wet destruction before being tested using AAS. Five

Figure 1. Mangrove Plant Avicennia marina.

Figure 2. Map of Research Locations in the Mangunharjo Coastal Area.

grams of mangrove and sediment samples were taken and then 9 ml of HCl and 3 ml of HNO_3 were added. Then heated for 30 minutes and filtered. The filtering results were added with distilled water to a volume of 50 ml and ready to be tested using AAS.

Data analysis

Data analysis used in this research is Friedman test, linear regression, and calculation of bioconcentration. The Friedman test was conducted to determine the difference in the concentration of heavy metal Lead Pb in small, medium, and large mangrove plants. Regression analysis was carried out to determine the relationship between the size of the mangrove A. marina and the concentration of heavy metals in the A. marina plant. The bioconcentration factor was used to determine how much Lead Pb heavy metal content in A. marina mangrove plants relative to the surrounding environment.

Bioconcentration factor is calculated based on the following formula (Potipat *et al*., 2015):

$$BCF = \frac{Cbiota}{Cmedia\ ambien}$$

Note: Cbiota is the concentration of heavy metals in the biota (mangroves) and Cmedia ambien is the concentration of heavy metals in water or sediments.

RESULTS AND DISCUSSION

Results

Water quality parameter measurement

Based on the results of the measurement of water quality parameters in the Mangunharjo waters, the temperature ranged from 29.6-35.1°C; Soil pH ranged from 5.91-6.25 °C; salinity ranged from 5 – 30 ppt; and DO ranged from 0.42 to 6.49 mg/l.

Concentration of heavy metal Lead Pb in water

Based on the results obtained, it is known that the concentration of heavy metal Lead Pb in water in Mangunharjo waters ranges from 0.672 - 0.867 mg/L. The highest concentration of heavy metal Lead Pb was at station III and the lowest was at station II. The concentration of heavy metal Lead Pb in Mangunharjo waters is high. The concentration of heavy metal Lead Pb in the water at each station has passed the water quality standard based on the quality standard set by KEPMEN LH Number 51 of 2004 concerning the Seawater Quality Standard, which is 0.008 mg/L. The results of the measurement of the concentration of heavy metal Lead Pb in water in Mangunharjo waters are presented in Table 1.

Heavy metal concentration of Lead Pb in sediment

Based on the results obtained, the concentration of heavy metal Lead Pb in the sediment ranged from 56.49 - 65.96 mg/kg. The concentration of heavy metal Lead Pb in sediments in Mangunharjo waters was

Table 1. Field observation results

Station	Lead Pb in waters (mg/L)	Quality standards (mg/L)*
I	0.704	0.008
II	0.672	0.008
III	0.867	0.008

Note : *KEPMEN LH Number 51 of 2004

high, where the highest concentration was at station III and the lowest value was at station II. Based on the results of the research on sediment samples, it is known that the concentration of heavy metal Lead Pb in sediment samples has passed the quality standard based on the quality standard set by NOAA (Buchman, 1999) regarding the quality standard of heavy metal in sediment. The concentration of heavy metal Lead Pb compared to the sediment quality standard of 30.24 mg/kg. The results of the measurement of the concentration of heavy metal Lead Pb in sediments in the Mangunharjo waters are presented in Table 2.

Heavy metal concentration of Lead Pb in A. marina

The concentration of heavy metal Lead Pb in mangrove A. marina ranged from 5.34-24.88 mg/kg. In mangroves A. marina, the highest average concentration of heavy metal Lead Pb was found in small mangroves and the lowest average heavy metal Lead Pb was found in mangroves with large sizes. Heavy metal concentrations in A. marina are presented in Table 3.

Bioconcentration of heavy metal Lead Pb in A. marina

The results obtained are the heavy metal bioconcentration factor of Lead Pb in A. marina in Mangunharjo Waters which has a value less than 1 at all stations. This shows that A. marina is classified as an excluder plant for heavy metal Lead Pb. The bioconcentration factor of heavy metal Lead Pb in A. marina is presented in Table 4.

Table 2. Field observation results

Station	Lead Pb in sediment (mg/kg)	Quality standards (mg/kg)*
I	65.51	30.24
II	56.50	30.24
III	65.96	30.24

Note : *NOAA (Buchman, 1999)

Table 3. Concentration of heavy metal Lead Pb in mangrove A. marina

Size	Station	Rod diameter(cm)	Lead Pb in roots and leaves (mg/kg)
Small	I	3-5cm	6.209
	II	4-8cm	11.875
	III	4cm	24.883
Average			14.322
Medium	I	6-10cm	12.488
	II	10-13cm	13.034
	III	13-15cm	11.314
Average			12.279
Large	I	17-51cm	5.344
	II	11-12cm	12.674
	III	18-23cm	16.426
Average			11.481

Station	Heavy Metal Bioconcentration Factor of Lead Pb in A. marina		
	Small	Medium	Large
I	0.095	0.191	0.082
II	0.210	0.231	0.224
III	0.377	0.172	0.249
Average	0.227	0.198	0.185

Differences of heavy metal concentrations in mangrove A. marina plants with different sizes

The Friedman test was conducted to determine the effect of the size of the mangrove A. marina on the concentration of heavy metal Lead Pb in the mangrove plant of A. marina. The results of Friedman's test for heavy metal concentrations in A. marina mangroves with different sizes can be seen in Table 5.

Based on the results of the Friedman test that has been carried out, it is known that there is no effect of the size of the mangrove A. marina on the concentration of heavy metal Lead Pb in the mangrove plant of A. marina (Chi-Square Count is smaller than the Chi-Square Table). The calculated Chi-Square value is 0.667 while the Chi-Square table is 5.991 which is obtained from the distribution table with df; 5%.

The relationship between the size of the mangrove plant A. marina and the concentration of heavy metal Lead Pb in the mangrove plant A. marina

Regression test was carried out to determine the relationship between the difference in the diameter of the stems of A. marina and the concentration of heavy metal Lead Pb in the A. marina plant. The results of the heavy metal Lead Pb regression test in A. marina at each station are presented in Table 6.

Based on the results obtained, it shows that the value of R (Square) is 0.370 which means that 37% of the concentratio of heavy metal Lead Pb in mangrove A. marina is influenced by stem size and 63% is influenced by other factors.

Table 5. Friedman test results for heavy metal Lead Pb in A. marina

Test Statisticsa	
N	3
Chi-Square	.667
Df	2
Asymp. Sig	.717
a. Friedman Test	

The regression equation (y=-0.0121x2 + 0.2447x + 12.648 can be used to estimate the y value or concentration of heavy metal Lead Pb in the roots and leaves of mangrove A. marina at = 0.109. The significance value in the regression test for heavy metal Lead Pb in A. marina with a 95% confidence level (α = 0.05) is 0.109. This value indicates that the relationship between rod size of A. marina and the concentration of heavy metal Lead Pb is not significant at = 0.05 because 0.109>0.05.

Discussion

Concentration of heavy metal Lead Pb in water, sediment, and mangrove A. marina

The concentration of heavy metal Lead Pb in water ranged from 0.672-0.867 mg/L. The lowest concentration was at station II of 0.672 mg/L and the highest concentration at station III was 0.867 mg/L. The high concentration of heavy metal Lead Pb in Magunharjo waters can be caused by various sources of heavy metal contamination including domestic waste, the flow of the Beringin River around the sampling station, waste from industrial activities, and waste from former aquaculture. Some coastal activities that have the potential as sources of heavy metal contamination include those from land and sea such as fishing boat activities, garbage disposal from surrounding communities, tourism activities, wastes from surrounding communities, and industrial pipes around coastal areas (Ramlia *et al*., 2018).

The concentration of heavy metal Lead Pb in sediments in Mangunharjo waters showed different results at each station. Heavy metal concentrations of Lead Pb in sediments in Mangunharjo waters ranged from 56.50 to 65.96 mg/kg. The concentration of heavy metal Lead Pb in sediments in Mangunharjo waters

Table 6. Regression test results for heavy metal Lead Pb in A. marina

R	R square	Adjusted R Square	Std. Error of the Estimate
.608	.370	.265	4.73

has passed the quality standard by NOAA (National Oceanic and Atmospheric Administration). According to NOAA (Buchman, 1999), the limit for Lead Pb content in sediments is 30.24 mg/kg.

The concentration of heavy metal Lead Pb in sediment tends to be higher than the concentration of heavy metal Lead Pb in water. This is because heavy metals have properties that easily bind organic matter and tend to settle at the bottom of the water and then merge with the sediment so that the levels of heavy metals in sediments are higher when compared to water (Hutagalung, 1991). The high concentration of heavy metal Lead Pb in the sediment comes from former aquaculture waste and domestic waste. Cultivation activities are a significant reason for the accumulation of heavy metals in soil or coastal wetland sediments (Wu *et al*., 2020). According to Abidin (2014), human activities, industry, shiLead Pbuilding, and various port activities can accelerate the increase in metal solubility in waters. According to Heriyantoand Endro (2011), the source of heavy metal Lead Pb can come from the erosion of mineral rocks, Lead Pb particles in the air carried by rainwater, and naturally due to human activities such as industrial waste.

The BCF (Bioconcentration Factor) category is categorized into three, namely accumulator plants if BCF is greater than one, Indicator if BCF is equal to one, and Excluder if BCF is less than one. The concentration of heavy metal Lead Pb in the mangrve A. marina in Mangunharjo waters ranged from 5.344 - 24.883 mg/kg. The results of the analysis of all samples of A. marina mangroves showed that there were differences in the concentration of heavy metal Lead Pb. Small (3 - 8 cm) mangrove A. marina had the highest accumulation of heavy metal Lead Pb. This can be seen from the bioconcentration factor of Lead Pb in small A marina which has the highest value compared to other sizes at each station, which is in the range of 0.095 - 0.377 and can be categorized as plant excluder. Excluder is a property of mangrove plants where these plants limit the absorption of heavy metals in their environment, both in sediments and in water, but when these metals enter the body of mangrove plants, heavy metals will be easily translocated to other plant body parts or to the above biomass (Yoon *et al*. al., 2006).

Bioconcentration of heavy metal Lead Pb in mangrove A. marina

The results of the analysis of all samples of A. marina mangroves showed that there were differences in the concentration of heavy metal Lead Pb. The difference is influenced by the sampling location. Based on the Friedman test that has been carried out, it can be seen that the calculated Chi-Square value (0.667) is smaller than the Chi-Square table (5.991). This shows that there is no diference in the concentration of heavy metal Lead Pb in the mangrove A. marina which has small, medium, and large sizes.

The results of the regression analysis showed that the size of the mangrove A. marina did not have a significant effect on the concentration of heavy metal Lead Pb present in the mangroe plant of A. marina in Mangunharjo waters. This could be because the research was conducted directly in the field, so that there are other factors that affect the concentration of heavy metal Lead Pb in the mangrove A. marina. These factors include differences in concentration in sediment and water, density of mangrove plants, and water quality values. According to Palar (2004), an increase in the pH value will reduce the solubility of heavy metals in water because an increase in the pH value can change the stability of the carbonate form to hydroxide which then forms bonds with particles in the waters so that they will settle to the bottom of the water or sediment. The average BCF value of heavy metal Lead Pb in A. marina mangroves is 0.277 in small size, 0.18 in medium size, and 0.185 in large size. Based on the results obtained, the BCF value in mangrove A. marina is less than 1. If the BCF value is less than 1, then the plant is included in the excluder group. The BCF value which is smaller than 1 can also be caused by the sampling and analysis of heavy metals that were only carried out oce, so that the results of the study presented the absorption of heavy metals only when the study was carried out. With increasing time and human activities, heavy metal uptake in mangroves will also be different (Purwiyanto *et al*. 2013). The existence of A. marina mangrove in Mangunharjo waters can provide benefits, namely to absorb heavy metals contained in water and sediment. A. marina has efforts to overcome toxic, including by dilution or weakening the effect of poison through the dilution process.

CONCLUSION

Based on the researc that has been done, it can be concluded that the concentration of heavy metal Lead Pb in the water in Mangunharjo waters was high and has passed the quality standard based on KEPMEN LH Number 51 of 2004 concerning Seawater Quality Standards. The concentration of heavy metal Lead Pb ranged from 0.672 - 0.867 mg/L. The concentration of heavy metal Lead Pb in sediments in Mangunharjo waters was also high and has passed the quality standard based on NOAA (Buchman, 1999). The concentration of heavy metal Lead Pb ranged from 56.50 - 65-96 mg/kg. Meanwhile, the mangrove A. marina ranged from 5,344 - 24,883 mg/kg. Mangrove plants of A. marina in Mangunharjo waters are classified as excluder plants for heavy metal Lead Pb with bioconcentration factors ranging from 0.185 to 0.277.

Suggestions

Suggestions that can be given in this study is that it is recommended to measure the concentration of heavy metals on a regular basis in water and sediment in the Mangunharjo Waters to monitor changes in pollution in the area. It is recommended to do a study comparing the concentration of heavy metals in each different species, and when conducting research on analysis of heavy metal bioconcentration in A. marina mangroves, it is advisable to do research on the density of A. marina mangroves in that area.

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REFFERENCE

Abidin, F. (2014, in Indonesian). *Macroalgae Fleshy Bioconcentration of Lead Pb and Cu Metals on Bonebatang Island, Barranglompo, and Lae Lae Caddi Makassar City*. Essay. Makassar: Universitas Hassanudin.

Amin, B. (2001, in Indonesian). Accumulation and Distribution of Lead Pb and Cu Heavy Metals in Avicennia marina Mangrove in Dumai Waters, Riau. *Jurnal Natur Indonesia, 4*(1), 80-86.

Buchman, M. (1999). Ilmu Tanah. Gajah Mada University Press, Yogyakarta.

Heriyanto, N.M., & Subiandono, E. (2011, in Indonesian). *Absorption of Heavy Metal Pollutants (Hg, Lead Pb, and Cu) by Mangrove Types*. Pusat Litbang Konservasi dan Rehabilitasi. Bogor.

Hutagalung, H.P. (1991, in Indonesian). *Pollution of the Sea by Metals. Status of Marine Pollution in Indonesia and Monitoring Techniques in the Research and Development Center for Oceanology (LIPI)*. Jakarta, 45-59 pp.

Jupriyati, R., Soenardjo, N., & Suryono, C.A. (2013, in Indonesian). Heavy Lead (Lead Pb) Accumulation and Its Effect on the Histology of Avicennia marina (Forssk) Mangrove Roots. Vierh in Mangunharjo Waters, Semarang. *Journal of Marine Research. 3*(1), 61-68.

KEPMEN LH. Number 51 of 2004 concerning Seawater Quality Standrds.

Palar, H. (2004, in Indonesian). *Heavy Metal Pollution and Toxicology*. PT. Rineka Cipta. Jakarta, 159 hlm.

Potipat, Jakkapan, Nongnud Tangkrockolan, & Herbert F Helander. 2015. Bioconcentration Factor (BCF) and Depuration of Heavy Metals of Oysters (Saccostrea Cucullata) and Mussels (Perna Viridis) in the River Basins of Coastal Ara of Nagarajan Nagarani, Arumugam Kuppusamy Kumaraguru, Velmurugan Janaki Devi Chanthaburi Provinc." Environment Asia, 8(2), 118–28.

Purwiyanto, A. I. S. (2013). Daya Serap Akar dan Daun Mangrove Terhadap Logam Tembaga (Cu) di Tanjung Api-Api, Sumatera Selatan. Maspari Journal. 5(1), 1-5.

Ramalia, R. Amir, dan A. Djalla. 2018. Uji Kandungan Logam Berat Timbal (Lead Pb) di Perairan Wilayah Pesisir Parepare. Jurnal Ilmiah Manusia dan Kesehatan. 1(3):255-264. pISSN 2614-5073, eISSN 2614-3151.

Wu, T., S. Ding, Z. Chen, J. Lei, X. Chen, dan Y. Li. 2020. Dynamic analysis of mangrove wetlands based on LUCC and landscape pattern change in dongzhai port. For. Res. 33, 154–162 (in Chinese with English abstract).

Yoon, J., Cao, X., Zhou, Q., dan Ma, L. Q. (2006). Accumulation of Lead Pb, Cu, and Zn in native plants growing on a contaminated Florida site. Science of the total environment. 368(2-3), 456-464.