DOI 10.18551/rjoas.2021-12.21

ASSESSMENT OF ZINC CONTAMINATION IN THE SEDIMENT AND MANGROVE (AVICENNIA MARINA) AT WONOREJO MANGROVE, SURABAYA OF INDONESIA

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ABSTRACT

The existence of number industries in Surabaya as the largest industrial cities in Indonesia have affects how much waste they produce and is wasted in the waters. Heavy metal Zn (zinc) is one of the ingredients in the waste. The aim of this study was to analyze the Zn content in the roots and leaves of *Avicennia marina* as well as sediments around it which did in triplicates from 3 stations in Wonorejo Mangrove. The method used in this study was descriptive method. Zn analysis was used the Atomic Absorption Spectrophotometer (AAS) method. Water quality analysis included temperature, pH and salinity was carried out in the field. The results of the Zn analysis obtained the highest value based on the station, namely at station 1 and the lowest at station 2. Based on the samples taken, the highest Zn concentration was found in the sediment and the lowest was in the leaves. The results of the concentration of Zn in the roots, leaves and sediment at each station did not differ much. The calculated values for BCF and TF were less than 1. Analysis of the water quality of the three parameters was still in normal conditions for the growth of mangrove biota. From this research, *A. marina* is included in the type of mangrove that can absorb heavy metals at low concentrations. This is in accordance with the BCF and TF values obtained. Low heavy metal absorption, this type of mangrove is still classified as a phytoremediator.

KEY WORDS

Avicennia marina, phytoremediator, heavy metal, water quality, bioconcentration factor, translocation factor.

The city of Surabaya is one of the big cities in Indonesia with a high number of industrial companies. According to [1] within 5 years the number of industries in the city of Surabaya continues to increase, where the increase is approximately 97%. The number of industries in the city of Surabaya has had a bad impact on the waters. One of the causes of pollution in water areas is exposure to heavy metal concentrations. One type of heavy metal contained in water is zinc (Zn).

Overcoming pollution problems that occur in the waters of Surabaya can be done by phytoremediation through mangrove plants. According to [2] Zn is an essential micro nutrient that is useful for metabolic processes in plants. The Mangrove area in Wonorejo Surabaya is a forest area with an area of 200 hectares, in which there are more than 15 types of mangroves. *A. marina* or *apis* is a type of mangrove that has the ability to weaken toxic effects through a dilution process by storing excess water in its body tissues which is useful for diluting these toxic substances, for example heavy metals. Excessive Zn concentration in plants will have a negative impact, for example inhibiting plant metabolic processes, slowing growth and accelerating aging. Mangrove forest that has been planted on 200 hectares of land has its own role, one of which is maintaining the balance of the aquatic environmental ecosystem. Zn absorbed in the body of mangrove plants has a certain range to support the growth process, if the Zn concentration is very high it will inhibit the growth process. The process of Zn accumulation in mangrove roots and leaves as well as the surrounding sediment needs to be analyzed, to find out how much Zn concentration can be absorbed, whether this value exceeds the threshold or is in the normal range of Zn that accumulates in mangrove plants.

Based on the description above, it is necessary to conduct a research to be used as an environmental evaluation by controlling human activities around Wonorejo Mangrove Area,

Surabaya, East Java, so that the existence of the resource is maintained from heavy metal pollution.

METHODS OF RESEARCH

The method used in this experiment was survey method. The experiment complete with primer or secondary data. Primer data include field observation data. Field observation based on the samples taken from the roots, leaves and sediment surround of mangrove and then checked the number of zinc inside it. Secondary data include science journals and books. The relation between Zn in the environment and the number of Zn in the roots and leaves used BCF and TF formulas.

Sampling was carried out based on the spread of *A. marina* in the Wonorejo Mangrove Area at 3 stations. Station 1 is near the residential area, station 2 is near the ecotourism area and station 3 is at the estuary. The sampling technique of *A. marina* mangroves is by looking at the age of the mangroves. The sample selection technique for mangrove plants is by looking at the diameter of the mangrove trunk measuring more than 5 cm. The size is related to the root system and the quality of the mangrove plant species. There are 2 parts of mangrove plants that will be analyzed for Zn content, namely the roots and leaves.

Root sampling technique by taking roots submerged in water. Roots were taken with a size of ± 10 -20 cm from the root tip. The selected roots weigh as much as 500 grams each and washed roots are put into a plastic that has been labeled. Leaf sampling technique, by selecting dark green leaves with a size is 8 cm. Take leaves ± 10 leaves in one tree at each station. Each station was repeated 3 times.

In addition to root and leaf samples, sediment samples were also taken using a sickle tool. Sediment samples were taken from each type of mangrove at each mangrove sampling station. Sediment took approximately 1 gram. Sediment samples that have been taken are put into plastic that has been marked.

According to [3], the analysis of heavy metal Zn in root/leaf/sediment samples was carried out with a sample preparation of 1 gram. Mix the sample with 10 ml of HNO_3 , 10 ml of distilled water and 10 ml of H_2SO_4 . The sample was heated at 200 °C for 2-3 hours and left until the smoke in the sample disappeared within 24-28 hours. The sample is filtered and allowed to stand again until the smoke is completely gone. Samples were analyzed using the Atomic Absorption Spectrophotometer at a wavelength of 235.5 nm and the results were recorded in ppm units.

According to [4], temperature measurements in the waters are carried out using an Hg thermometer which is calibrated using distilled water and cleaned using a tissue or cloth. Hg Thermo thermometer put into the water until the entire body of the Hg thermometer goes into the water. Wait for 2-3 minutes and read the temperature value through the numbers on the edge of the Hg thermometer, without the Hg thermometer being lifted from the water.

According to [5], salinity measurement was carried out using a refractometer by means of a refractometer calibrated using distilled water and cleaned using a tissue in the same direction. The water sample is taken using a dropper and counted onto the surface of the refractometer prism. The surface of the refractometer prism is closed and the salinity value on the refractometer is seen by reading the number on the round end of the refractometer.

According to [6], the method of measuring pH is carried out using a pH meter, namely by pressing the on button on the pH meter and then calibrated using distilled water. The pH meter is immersed in the water and wait 1-2 minutes to get the results of the pH of the water. The pH value will appear on the pH meter.

Bioconcentration is the tendency of chemicals present in the waters to enter the bodies of organisms in these waters. According to [7] BCF was calculated to determine the phytoremediation potential. According to [8] the BCF value is classified into 3, namely the value of $\text{BCF} < 1$ is called an excluder, $\text{BCF} = 1$ is classified as an indicator plant and $\text{BCF} > 1$ is an accumulator. The higher the BCF value, the plant is able to accumulate heavy metals higher than the accumulation of heavy metals in the soil. The BCF formula can be calculated as below:

$$BCF = \frac{\text{Heavy metal in roots or leaves}}{\text{Heavy metal in sediment}}$$

According to [9] the TF value was calculated to evaluate the phytoextraction potential of accumulator plants. According to [10] translocation factors can determine the status of plants including phytoextractors or phytostabilizers. Phytoextractor status occurs when the TF value is more than 1, where the plant is able to accumulate heavy metals in the leaves from soil and water. If the TF value is less than 1, the plant is included in the phytostabilizer status. The TF formula can be calculated as below:

$$TF = \frac{\text{Heavy metal concentration in leaves}}{\text{Heavy metal concentration in roots}}$$

RESULTS AND DISCUSSION

Results of Zn concentration from 3 stations have different value. The value concentration based on Figure 1 as below.

Figure 1 – Results of Zn Concentration in Roots and Leaves of *A. marina* and Sediment

Based on the sampling station, the Zn concentration in the roots and leaves of *A. marina* and the highest sediment was found at station 1 (near residential areas), with a Zn concentration value in leaves of 0.048 ppm, roots of 0.114 ppm and sediment of 0.201 ppm compared to station 2 (near ecotourism area) and station 3 (estuary).

Based on the sampling station, the Zn concentration in roots and leaves of *A. marina* and the highest sediment was found at station 1 (near residential areas), with a Zn concentration value in leaves of 0.048 ppm, roots of 0.114 ppm and sediment of 0.201 ppm compared to station 2 (near the area). ecotourism) and station 3 (estuary). The high value of Zn concentration in areas near settlements is mainly due to the amount of waste generated from household activities that directly enters the waters and accumulates in the mangroves. According to [12], the high concentration of Zn near settlements is also caused by industrial waste, hospitals, hotels and so on and flows into the residential area which is located adjacent to the mangrove area and then towards the estuary.

The lowest Zn concentration value was found at station 2, namely the Wonorejo mangrove ecotourism area. The concentration value on leaves was 0.03 ppm, roots were 0.103 ppm and sediment was 0.188 ppm. According to [13] waste that has entered the mangrove area will be absorbed by mangrove plants. The nature of mangrove plants as absorbents of heavy metals, so as to reduce the concentration of heavy metals contained in the waste. According to [14], mangrove vegetation has the ability to adapt to extreme conditions, one of which is polluted environmental conditions.

The Zn concentration value based on the type of sample taken, the highest was found in the sediments around the mangroves. The sediment concentration values in the three ranged from 0.188-0.201 ppm. According to [15], the high value of Zn concentration in sediments is caused by the density of mangroves. According to [16], the condition of a dense

root system in mangroves will reduce water movement so that very fine particles settle around the mangrove roots and form a collection of sediment layers.

The Zn concentration value in the leaves, where the value is the lowest compared to the mangrove roots and sediments around the mangrove. The Zn concentration value in the leaves ranges from 0.03-0.048 ppm. According to [16] the low concentration of Zn in the leaf organs is due to one of the reasons for the location of the leaves which do not interact directly with sediment, where sediment is the basis for the accumulation of heavy metals.

The mechanism of absorption of heavy metals is through the formation of chelates or phytosiderophores. Phytosiderophores formed will bind metals and carry them to root cells through an active transport process. The water-soluble compounds will be adsorbed on the roots along with the water, while the hydrophobic compounds will be absorbed by the root surface. According to [17], plant root cells generally contain ions with a higher concentration than the surrounding medium which is usually negatively charged. The absorption process in which cations enter the cell passively down an electrochemical gradient, while anions must be actively transported into plant root cells according to the state of the concentration gradient against the electrochemical gradient.

According to [18] the mechanism of plants exposed to toxic concentrations is to minimize the toxic effect (amelioration), localization that occurs in root organs, active excretion through glands in the canopy or passively through accumulation in old leaves followed by leaf shedding, dilution by attenuating the toxic concentration by dilution, chemical inactivation.

Table 1 – Results of BCF Roots and Leaves of *A. marina*

Station	BCF Roots	Leaves
1	0,56	0,24
2	0,53	0,14
3	0,51	0,29

According to [19] a BCF value less than 1 was classified as an excluder. The value of BCF <1 indicates the low capacity of phytoextraction from vegetation so that metals are not transferred from the soil to the roots [20]. Phytoextraction efficiency depends on several factors, including the level of metal contamination, metal bioavailability, metal type, and the ability of vegetation to retain, absorb, and accumulate metals in vegetation tissue [21]. According to [22], the root BCF value was higher than the leaf BCF value, due to the position of the roots that interacted directly with the sediment. According to him, the accumulation of Zn in the part of the mangrove plant can decrease with the amount of water that is absorbed by the roots. The amount of water will dilute the Zn and the dilution takes place in the leaf tissue. The process of dilution of the leaves can cause thickening of the leaves. In addition to going through the dilution process, excretion is also possible to reduce the toxic substances present in mangrove plants. These toxic substances are mostly found in old leaves and stems that will peel off, so that the BCF in the leaves will be less than the BCF in the roots.

Table 2 – Results of TF Leaves of *A. marina*

Station	TF Leaves
1	0,43
2	0,27
3	0,57

According to [23], a TF value of less than 1 is classified as a phytostabilizer. According to [11] the TF value of 0.1-1 includes a moderate accumulator. This moderate accumulator means that it indicates that the concentration of heavy metals from the roots to the shoots is in sufficient capacity. According to [16] the system of stopping heavy metals from the roots to the leaves occurs accumulation in roots. TF and or BCF values <1 indicate the occurrence of one of the vegetation defense mechanisms in adapting or responding to metal toxicity.

The results of temperature measurements carried out at 3 stations obtained different values. Station 1 has a temperature value of 29 °C, station 2 has a temperature value of 28.8°C. The temperature value at the third station, which is at the estuary, obtained a temperature value of 29°C. The results of temperature measurements at the three stations can be seen in Figure 2 below.

Figure 2 – Temperature Value at 3 Stations

According to [24] a good temperature range for the life of mangrove biota is 27-32 °C. The range value of the temperature measurements carried out at the three stations was 28.8-29°C. This value is classified as normal condition which is in accordance with the quality standard based on the Decree of the Ministry of Environment No. 51 of 2004, where the temperature range is 28-32 °C. According to [25] the temperature value greatly affects the concentration of heavy metals in the waters. The high temperature value can cause high solubility of heavy metals so that the toxicity of these heavy metals is also high.

The results of pH measurements at the three measurement stations tend to be different values. The pH value at station 1 is 7.73, at station 2 the pH value is 7.95 and at the third or last station the result is 8.18. The average value of the three stations is 7.95. The pH values at the three stations can be seen in Figure 3 below.

Figure 3 – Temperature Value at 3 Stations

The results of salinity measurements at 3 stations obtained different results. The salinity value at station 1 is 1 ppt, station 2 is 2 ppt and station 3 is 3 ppt. The results of the salinity at the three stations can be seen in Figure 4 below.

Figure 4 – Salinity Value at 3 Stations

The salinity values tend to be very small, ranging from 1-3 ppt. According to research [26] the salinity value for mangrove life is less than 33 ppt. The salinity value for mangrove biota according to the Ministry of Environment No. 51 of 2004 is up to a maximum limit of 34 ppt. The salinity value at the three stations increased as the station got closer to the ocean area. Station 1 has the smallest value because it is dominantly mixed with fresh water. Station 3 has the highest value where the river mouth is very close to the sea, so that the mixture with seawater is very dominant. The average salinity value of the three stations is 2 ppt. According to [27], one of the factors that influence the level of salinity is rainfall. High rainfall can cause low salinity values. The concentration of salinity also affects the concentration of heavy metals in the waters. High salinity means that the concentration of heavy metals in these waters is also high. Low concentrations of heavy metals and low salinity are caused by increased toxicity and accumulation of heavy metals.

CONCLUSION

The Zn concentration values in the roots and leaves of *A. marina* and the surrounding sediments did not differ significantly for each station. *A. marina* mangroves include mangroves that can absorb relatively low concentrations of Zn in the waters. The accumulated Zn concentration is quite low based on the BCF value of leaves and roots is <1 and the TF value of leaves is < 1. Exposure to heavy metal Zn in *A. marina* can be said that this type of mangrove is classified as a phytoremediation plant, because it indirectly contains heavy metals in the soil and waters. will be reduced by the presence of *A. marina*.

ACKNOWLEDGMENTS

Thank you for the support from various parties in this research.

CONFLICTS OF INTEREST

The authors declare that this research does not have a conflict of interest with any party.

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