10 Distribution and Bioaccumulation of Zn on Mangrove Coast of Tapak, Semarang, Indonesia: An Approach to Develop Breaking Water Structure from Used Tire

by Sapto Purnomo Putro

RESEARCH ARTICLE

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Distribution and Bioaccumulation of Zn on Mangrove Coast of Tapak, Semarang, Indonesia: An Approach to Develop Breaking Water Structure from Used Tire

Jafron W. Hidayat[1,*], Riche Hariyati[1], and Sapto P. Putro[2]

[1]*Laboratory of Ecology and Biosistematics, Biology Department, Faculty of Science and Mathematics, Diponegoro University, Semarang, Indonesia*
[2]*Center of Marine Ecology and Biomonitoring for Sustainable Aquaculture (Ce-MEBSA) Diponegoro University, Semarang, Indonesia*

Rehabilitation of coastal areas can be done with soft and hard mechanisms. Rehabilitation by hard structure in mangrove areas is usually done by using break water or groin. Used tire can be used as material because it is cheap and easy to applied, but unfortunately still contradictory in pollution potential. The objective of this study was to analyze the environmental quality of coastal area of Tapak mangrove based on the Zn distribution and biomagnification levels in the environment. The study was conducted in the mangrove area of Tapak which already build a break water from used tire in July 2016. The study was observational with the sampling taken from 4 stations and 7 objects, namely in water column, mud substrate, algae, fish, shrimp, oyster and mangrove root. Data analysis was performed by descriptive and statistical analysis to measure the content of Zn in these objects. Besides, it also carried out measurements of physico-chemical factors, i.e., temperature, dissolved oxygen (DO), turbidity and pH. The results showed that the smallest Zn content was found in water column with values between 0.002 to 0.004 mg/lt. This is still lower than the national sea water quality standard of 0.1 mg/l. The greatest value was found in mud substrate of front estuary which reached 167,992 mg/kg. Biomagnification in biota of all objects, including the consumption (fish, shrimp and seaweed) were high over than 1000. The highest bioaccumulation occurred in mangrove plant followed by seaweed; whereas the smallest value was found in oysters. It is advisable to reduce the Zn content in the environment by using a soft rehabilitate mainly mangrove plants. It is also recommended to measure number of mangrove stand of mangrove which is appropriate to reduce such impact in pond water.

Keywords: Zn, Distribution, Accumulation, Mangrove.

1. INTRODUCTION

Destruction of mangrove forests are continuing meanwhile reforestation action is very slow. Mangrove destruction in Java is about 27.072,95 Ha and leaving the undamaged area of 7.645,8 Ha.[1] In Central Java, the destructions are due to construction of extensive pond and some are abrasion that reached 6.566,97 Ha, meanwhile the remaining good condition is only covering 4879,16 Ha. The destruction of mangrove causes abrasion, habitat loss, decline in biodiversity and environmental quality.[2] According to Wibisono[3] to combat the abrasion in mangrove area, it can be done through rehabilitation with soft and hard structures. Soft structure rehabilitation can be implemented through mangrove re-planting, whereas the hard structure rehabilitation is done by using break water or groin. Material to build a proper break water is expensive but it can choose alternative material which relatively inexpensive and easy to apply, i.e., used tire. Tires are very strong to withstand to mechanical forces. Used tires are waste in environmental which will be even greater in the future and potentially cause environmental problems, particularly their dumping sites.[4]

The impact of the used tire application in some countries are different in views. Most researcher stated there is not pollution effect;[4] even to the coral life which is very sensitive.[1] However, some researchers estimate the potential for contamination, especially Zinc, in different environmental conditions.[4,5] Heavy metals are easily accumulated on various objects of organism.[6,7] Zinc is the most prominent heavy metal accumulated within organisms.[8]

In the meantime, Tapak Tugurejo is an area which already apply break water structure of used tire. Here, it is also implementing mangrove conservation since their environment suffer

*Author to whom correspondence should be addressed.

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from industrial pollution of the neighboring industries. Environmental factor at different locations can result in the different zinc content. It is therefore necessary to study the Zn condition at various biota and media as well as their potential bio-magnification on the environment.

The objectives of the research were to identify the distribution and bio-accumulation of Zn on the main biota and media. Besides, it also to analyze the bio-magnification that can build some suggestions to local government in managing the environment. The results are expected to benefit to the government, especially the regulation relate to the use and dumping management of used tires in the mangrove environment.

2. EXPERIMENTAL DETAILS

The study was conducted in the coastal mangrove of Tapak Tugurejo Semarang Indonesia, during June to August 2016. The laboratory analysis was conducted in Ecology and Biosistematics Laboratory Universitas Diponegoro, while chemistry data were analyzed in the Wahana Laboratory, Semarang. Observational research was undertaken using parameter of Zn content in organisms including seaweed, fish, shrimp, mangrove oyster and roots of mangrove. While the Zn content in the environment were taken from water and mud. Samples were taken both in ponds and public waters (coastal waters), while the biotic objects were taken out from the pond, estuaries and coastline stations. Pond stations is divided into two stations, namely the intertidal pond (backward of the shoreline) and coastline pond that close to the shoreline. Sampling unit were 28 with three times repetition that represent size and location conditions. Besides, it also carried out measurements of the physical and chemical factors, namely grain size, temperature, pH, salinity and turbidity. Samples of the biota and the media then analyzed of its Zn content by using AAS method (Atomic Absorption Spectrophotometry). Other chemical and physical parameters of the water were measured using water checker (Horiba U10). Data of Zn content as well as other chemical and physical factors were analyzed descriptively, especially the range values and means. Data of Zn content in the substrate were statistically analyzed using ANOVA.[15] Besides, the quality of the environment were also compared to the water quality standards,[10] especially for fish culture status.

Bioaccumulation factor was determined by calculating Bioconcentration factor (BCF) as stated by Refs. [7, 11]. The BCF formula was as follows:

$$\text{BCF}=\frac{\text{Zn metal in biota}}{\text{heavy metal in water}}$$

According Amriani et al.[4] if BCF is greater than 1000 l/kg, the biota is accumulative, if BCF is between 100 up to 1000 l/kg then the biota was moderately accumulative; the non-accumulative is if it is less than 100 l/kg.

3. RESULTS AND DISCUSSION

3.1. Distribution of Zn in Trophic Base

Result shown that Zn content in the mangrove coastal waters of Tapak, Tugurejo very diverse. The smallest Zn value measured in water column was between 0,002 to 0,004 mg/l. The greatest value was found in mud substrate of front estuary which reached 167,992 ppm. Zn content in sequence from large to small values were found respectively in the mud, mangroves, seaweed, fish and shrimp, oyster and water. Zn content on various objects and media were shown in Table I. The small values of Zn content in the water was associated with its dynamic properties of water (dilution and dispersion) especially related to intertidal waves. Compared to the water quality standards of cultivation,[10] it is state to be good since it is less than 0,1 mg/l. Values of this Zn in the water tend to be lower than result reported by Gerhanae and Pernawati[12] ranged from 0,008 to 0,275 on the island of Rote, Indonesia. Potential sources of Zn in Tapak, was likely derived and released from the break water made of used tires that have been built on the beach and also supply through rivers from industrial estates. Tapak area was located alongside the industrial park i.e., Wijaya Kusuma Semarang.[12]

Table I. The range and average of Zn content on various objects.

No	Objects	The range of Zn content (ppm)	Average of Zn content (ppm)
1	Water	0,002–0,004 mg/l	0,003 mg/l
2	Mud	123,56–167,99	145,78
3	Mangrove	23,81–41,34	32,57
4	Seaweed	19,63–26,17	22,9
5	Fish	16,25–17,27	16,76
6	Shrimp	15,56–17,53	16,54
7	Shell	9,34–14,42	11,88

The Zn content at mud were high between 123,56 to 167,99 ppm, especially in the coastline pond. This was associated with the nature and capability of the mud to bind heavy metals compound mechanically.[11] This value was consistent with the measurement by Shete et al.,[6] which reached 158, 16 ppm. The second highest value was found in the mangroves body between 23,81 to 41,34 ppm. Zn content in root *R. mucronata* has a concentration of the highest among the organisms, which amounted to 32,57 ppm. This value was almost the same as measured by Barutu et al.[8] on the coast of Batam, which reached 31–38 ppm. In Muara Angke, Jakarta; this values are even higher, reaching 55,38 ppm.[17] Mangrove has ability to accumulate pollutant, especially heavy metal from the environment.[6,7] The Tapak value tends to be lower than study by Shete et al.[6] that reported the content of Zn in the mangroves around 65,47 ppm at *A marina*. The value is likely due to differences in Zn content in the substrate and the species of the plant. The next largest content was found in seaweeds between 19,63 to 26,17 ppm. Sea weeds were usually cultivated in the coastline (pond and coastal waters), can also enable to accumulate Zn. Therefore, for consumption purposes it should be selected both in area of the culture and pollutant concentration therein. The smaller content of Zn was found in fish and shrimp with a mean value respectively 16,76 and 16,55 ppm. Both were within almost the same values since they were cultivated within the same times length. These Zn content were still low and were feasible for human consumption, since the quality standards of Zn content in fish is 100 ppm.[13,14] The smallest content of the objects was measured from mangrove oysters (*Crassotrea* sp) with an average of 11,88 ppm. This value was unfortunately greater than the content of Zn in Kendari Bay (5,967 to 6,774 ppm).[7] Such a small value of Zn was associated with sessile mode of life in the intertidal zone. During low tide, the body is out the water and thus reduce the inputs including the contaminations.

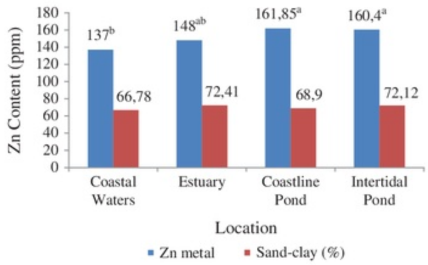

Fig. 1. Distribution of Zn and fine sand-clay composition on the mud substrate at various stations.
Note: Number followed by the same superscript letters mean no significant difference.

3.2. Spatial Distribution of Zn

In term of location, the highest Zn content was found in the coastline pond, followed by the intertidal pond on the backside of the mangrove area, estuary and the smallest value measured in coastal waters. Coastline pond located aside to the groin structure of the tire, so the most potentially receive Zn supply. This was also enlarged by the higher fine sand-clay content of pond (68,9‰). In the intertidal pond, the Zn content was the highest and significantly different to the one in coastal water. This, however is more associated (un-directly) with high content of fine sand-clay (72,12‰). As mentioned before, muds are able to bind heavy metals mechanically. The lower value was found in the coastal waters (137 ppm), although it is exposed to a tire structure. This low value was associated with a lower component of fine sand-clay (66,78‰) and of course affected by the dispersion as well as dilutions action by water. It is means that the Zn of the tire contributed direct and un-directly through mud accumulation to environment. Nevertheless, it needs to be entrapped with soft mechanism, i.e., bio-accumulator. Values of Zn and sand-clay percentage of the substrate shown in Figure 1.

The high Zn value associated with a values in the pond mud (68,90%) above were supplied by loose component used tires scrap. Coastline pond is bordered by break water of used tire that is already installed some years before. These areas is least in overgrown mangrove because some ditch are being aberrated and causing many mangrove plants to be cut off. On the intertidal pond, there were higher mud content (72,12%) and therefore higher in Zn, even though it is away from tire structure. Zn here was not supplied merely from the tire structure through intertidal action, since its Zn of coastal water were small. The ditch of the pond, luckily, is densely bordered with mangrove stand and Zn compound was absorbed and converted into plant body and was

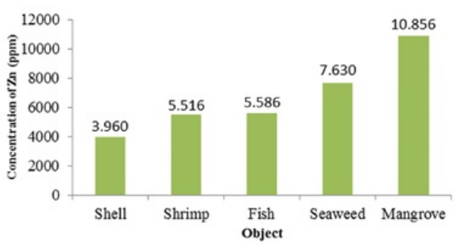

Fig. 2. Bio-concentration factor of Zn in various stations (spatial).

Table II. Physic-chemical parameters of different stations in Tapak mangrove, Tugurejo, Semarang.

No	Parameter	Coastal water	Estuary	Coastline pond	Intertidal pond	The range of values
1	pH	6,8	5,8	6,2	6,8	5,8–6,8
2	Salinity (‰)	30	26,8	26,5	21,5	21,5–32
3	Temperature (°C)	32	34,5	34,3	33,9	32–34,5
4	Turbidity (NTU)	24	54	23	16	16–54
5	DO (ppm)	6,6	6,7	5,7	5,8	5,7–6,7

not dispersed significantly to the fish therein. Mangrove plants are enable to absorb zinc or other heavy metals metabolically become part of the plant body.[2,6]

3.3. Bioaccumulation of Zn in the Environment

Bio-concentrations of Zn in biota were high between 3.960–10.856; more than 1.000.[7] The high accumulation value (shown in Fig. 2) is due to the availability of large reserves of Zn in the mud. Mud is usually entrapped within isolated pond and will be re-suspended during high tide. Mangroves and seaweed have the greatest BCF values and thus can be used as an absorbent agent of heavy metals in the coastal water. Cultivated seaweed is not only can be grown for commodity but also useful for bioremediation purpose. Consumption purpose can be done and is only taken when the remediation action has been done to avoid further magnification to human. The potential contamination of other heavy metals through fishery commodities can be reduced by purification mechanism as explained by Suprapti.[16]

Based on the chemical and physical factor show that salinity range between 21,5 to 32‰. Water tends to have lower in pH value between 5,8 to 6,8. The low value is associated with the degradation process, including mangrove litter. This will generate anoxic and acid condition and at the end, promote to increase toxicity of heavy metals to lives.[4] Therefore, fluctuations in pH should be managed, so that the potential fluctuation of the acidity can be smoothered. Physical and chemical conditions of the environment as shown in Table II.

4. CONCLUSION

The content of Zn in the water column tend to be low between 0,002–0,004 mg/l, while in the mud substrate was already high at 161,85 ppm. The Zn content of the biota was not high, mainly in fisheries commodities (fish and shrimp) and still below the Indonesian government quality standard. Bioaccumulation Zn on plants (mangrove and seaweed) were high, which in this case can be used for bio-accumulator purposes especially Zn.

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