International Journal of Fisheries and Aquatic Research
ISSN: 2456-7248; Impact Factor: RJIF 5.44
Received: 28-04-2020; Accepted: 30-05-2020; Published: 11-06-2020
www.fishjournals.com
Volume 5; Issue 2; January 2020; Page No. 49-54

Heavy metal pollutant traps in the estuarine area: the response of *Avicenia Marina* root to lead pollution in the mangrove tourism of Muara Angke, Jakarta, Indonesia

Asep Sahidin[1]*, Ahmad Fadhilah[2], Heti Herawati[3], Herman Hamdani[4], Sunarto[5]
[1-4] Fisheries Department, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Bandung, Indonesia
[5] Marine Department, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Bandung, Indonesia

Abstract
Mangrove have an ecological function which are the ability to absorb, transport, and accumulate toxic materials that come from around the environment where they grow, one of which is lead (Pb) heavy metal. This study aims to determine the ability of water bodies, sediment and response of mangrove root *Avicenia marina* in accumulating heavy metal lead (Pb) in the waters of Mangrove Tourism of Muara Angke, Jakarta, Indonesia. Samples taken in the form of mangrove root *Avicenia marina*, water, and sediment. Then the samples were analyzed in the Laboratory using the Atomic Absorption Spectroscopy (AAS) method. The results showed accumulation of lead in mangrove root is 1.45 ± 1.00 mg/L. Lead accumulation in the sediment have a mighty relationship with lead accumulation in the root of *Avicenia marina* with r=0.87, F= 31.76 and p<0.001, and the response of mangrove root of *Avicenia marina* to the lead contaminant determined by concentration amount of lead, time interaction, sediment type, and water flow. Muddy sediment type is a special sediment lead traps in the coastal.

Keywords: bioaccumulation, mangrove, lead, sediment, root

1. Introduction

Coastal is a common area in the aquatic resource. It is can be used by all human like agricultural, fishing, recreation, settlement, and industrial activities [22]. These activities often produce waste due to pollution to the coastal areas like organic and inorganic matters (Riyadi *et al*. 2012). The rivers carry both domestic and industrial wastes from the upstream to the downstream and releases into the sea. Heavy metal is one of inorganic matter due to coastal pollution. It is widely used as raw materials for catalysts, fungicides, and as additives to industrial activities [10], the industries that are not equipped with a good waste management system will produce metal waste such as Hg, Fe, Mn, Cu, Pb, Zn, Cr, and Ni (Sepetiba *et al*. 2013). Heavy metals are included in macronutrients which are beneficial for aquatic organisms such as Zn, Fe, Cu, Co, but heavy metal wastes such as Hg, Cd, Pb are not classified as essential heavy metals and tend to be toxic to waters [31] will be harmful to the life of aquatic organism [12, 14] that Pb can adversely influence the intelligence development of children, cause excessive lead in blood, and induce hypertension, nephropathy and cardiovascular disease [6, 15].

Fortunately, coastal areas have bordered by mangrove vegetation, the mangrove soil acts as a biological filter and reduces the impact on pollution before reaching to the open waters [27, 3, 28]. Mangroves can absorb organic and non-organic materials so that they can be used as bioindicators of heavy metals in waters [31]. Mangroves grow in intertidal or estuarine areas, most commonly in Africa, Australia, Asia and North and South America [18]. Mangrove has a lot of lateral roots that are fastened to the trees in the slack sediments, where aerial roots are exposed for gas exchange [26]. Pollution caused by heavy metals in normal environments has become an international concern [1].

Mangrove provide diverse ecological advantages including being highly productive, serving as habitat for biodiversity, place to find food, spawning grounds and breeding grounds for various types of fish, shrimp, shellfish and another marine biota and protection against shoreline erosion. Besides, mangrove forests have an important role in biogeochemistry of trace metal contaminants in coastal areas [20]. One of the mangrove species that has the ability to accumulate heavy metals is *Avicenia marina*. According (Napitu 2012; Nasti 2014) *Avicenia marina* can a biological indicator for environments contaminated with heavy metals, especially Cu, Pb, and Zn through periodic monitoring. The most important mangrove types are *Avicennia marina* (white mangrove), *Rhizophora mangle* (Red mangrove) and *Avicennia germinans* (black mangrove) [30, 16].

Mangrove Tourism of Muara Angke, Jakarta, Indonesia considering that this area has a fairly large of mangrove ecosystem and the development of waterfront cities in this area is very rapid. The large number of industrial activities around the location is suspected to be the cause of the existence of heavy metals. Water resources from various rivers in Jakarta that pass through the waters of Mangrove Tourism of Muara Angke before ending in Jakarta Bay are also suspected to be the cause of the existence of heavy metals around the area. The contamination on the coast of Jakarta Bay has led to the level of pollution and can cause toxicity to organisms living in the sea. One of which is lead (Pb), cadmium (Cd) and mercury (Hg) [9]. Another place for accumulation of lead (Pb) that is water and sediment. Coastal and marine ecosystems are potentially at risk due to a high concentration of heavy metals in sediments [(Kumar *et al*. 2015). Heavy metals are introduced to the aquatic environment and accumulate in sediments by several pathways via natural and anthropogenic processes (Zarezadeh *et al*. 2017). Mangrove sediments have been shown to have a high capacity to accumulate materials discharged to the nearshore marine environment [7].

This study aims to determine the ability of water bodies, sediment and response of mangrove root *Avicenia marina* in accumulating heavy metal lead (Pb) in the waters of Mangrove Tourism of Muara Angke, Jakarta, Indonesia. The results of this study are expected to provide information about the ability of mangrove bioaccumulation on lead heavy metals in Mangrove Tourism of Muara Angke, Jakarta, Indonesia.

2. Material and Method

2.1 Study site

The research was conducted in February-April 2018 in the Mangrove Tourism of Muara Angke, Jakarta, Indonesia. The research method used purposive sampling with 3 spot site and three replication sampling in the estuary of the Mangrove Tourism of Muara Angke, Jakarta, Indonesia towards land with each distance of 300 meters, and the sample are combined become one sample (Figure 1). Each spot site sampling was repeated for three repetitions with an interval of 14 days. The spot sampling is determined by using the survey method with a composite sampling technique, which is a mixture of several samples taken from certain points with the same volume and time. Water, sediment and mangrove root samples are taken directly at the spot sampling and they are analyzed in Central Laboratory of Universitas Padjadjaran, Bandung, West Java

Fig 1: Map of Research Location

2.2 Heavy metal and statistical analysis

The mangrove samples (roots, stems, and leaves) were cleaned and cut into small pieces. The mangrove samples were dried in the oven at 80 oC, while the sediment samples were dried at 105 oC. Dry samples were ground. Then, 0.5 g of dry mangrove samples was digested by the aqua regia method (HCl: HNO3 = 3:1) and heated until achieving a volume of 1 ml. For the sediment, 0.5 g of dry samples was digested using the aqua regia method, then supplemented with hydroflouric acid (HF) and heated. Aqua Dest distilled water was then added to each sample; samples were filtered until obtaining a volume of 25 ml. The resulting filtrate was submitted to heavy metal analysis using the Shimadzu AAS 6300 atomic absorption spectrophotometer [25]. Data on heavy metal concentrations from both sediments (54 readings) and mangrove trees (90 readings) were used to calculate the bioconcentration and translocation factors.

After the data was obtained from the results of the analysis in the laboratory, then an analysis of the Avicennia marina mangrove root absorption capacity was carried out by using bioconcentration factor calculations which refer (MacFarlane *et al*. 2007) [11] Bioconcentration Factor (BCF) parameter is a comparison between the concentration of a compound in a tissue or body of an organism and in the environment. Following is the BCF formula:

$$BCF = \frac{consentration\ of\ heavy\ metals\ in\ roots}{concentration\ of\ heavy\ metals\ in\ sediment}$$

According Mac-Farlane *et al*. (2007) that if the BCFs> 1 of the concentration in the water column, it means that the organism has the ability to accumulate metals in the body, BCFs $\leq$ 1, means that the organism lacks the ability to accumulate metal in his body. In the calculation of this study the comparison is sediment because of the root *Avicenia marina* interact directly with sediment. The data obtained from the results are presented in tables and graphs and analyzed descriptively. The concentration of heavy metals Pb in water is compared with the Decree of the Minister of Environment No. 51 Year 2004 concerning sea water quality standards for biota. Meanwhile, Pb concentration in sediment refers to sediment quality standards in the Canadian Council of Ministers of the Environment (CCME). Analysis of response of *Avicenia marina* root to lead is combining between lead accumulation in water and sediment with accumulation lead in mangrove root, the analysis by R sources softwere.

3. Results and Discussion

3.1 Water quality parameters

The results of water quality measurements in Mangrove Tourism of Muara Angke, Jakarta, Indonesia can be seen in Figure 2. The research shows pH not a significant difference of each samples taken from every month. pH value is important for detection water quality pressure. According Palar (2004) [17], when waters have a pH value close to normal then lead will experience hydrolysis which makes the lead dissolve in water easily. Meanwhile, if the pH value which is relatively alkaline, lead will easily settle in sediment. The increase pH value in the water body will usually be followed by the smaller solubility of the metal compound, and vice versa, while decreasing pH value causes greater heavy metal toxicity [10].

Temperature measurements shows is ranged between 28˚C - 31˚C. The surface temperature of water is affected by meteorological conditions such as rainfall, evaporation, air temperature, wind speed, and the intensity of sunlight. According Bhateria *et al*. (2016) [2] stated that a rise in water temperature will cause some consequences including, the amount of DO in water decreases, the speed of chemical reactions increases, and the life of aquatic animals is disturbed. The increase of water temperatures tends to increase the accumulation and toxicity of heavy metals, including lead and copper metals (Arsad 2012).

Dissolved oxygen is a response cause the water pollution. It is having relationship with temperature, if the temperature increases, then the dissolved oxygen will decrease. The reality in the field showed that the value of dissolved oxygen is not always inversely proportional to the value of the water temperature. Dissolved oxygen measurements are carried out during the day so that the DO values obtained affect photosynthesis in those waters. According Effendi (2003) [5], stated that if the penetration of light in water is higher it will also cause greater areas that can take photosynthesis, so that dissolved oxygen levels will be relatively high in waters. Oxygen levels also affect the presence of heavy metals in the waters. The concentration of heavy metals in water is lower because the solubility of metals becomes low for waters that are deficient in oxygen causing volatile water so that the concentration of heavy metals will be reduced in waters that lack oxygen. This is in line with Napitu (2012) [12] which stated that in the areas that lack oxygen in water, the solubility of metals becomes lower and easily evaporates so that the concentration of heavy metals will decrease.

The salinity parameters in Mangrove Tourism of Muara Angke, Jakarta, Indonesia show 5.0-18.4 ppm. Salinity is having relationship with growth of mangrove and organism that associated with mangrove ecosystem. Salinitas sangat mempengaruhi produktivitas primer selain cahaya dan suhu dan sering kali menjadi faktor pembatas bagi biota hidup khususnya di ekosistem pesisir termasuk plankton. Secara umum, nilai salinitas dan pH diatas adalah normal bagi ekosistem estuari di daerah tropis

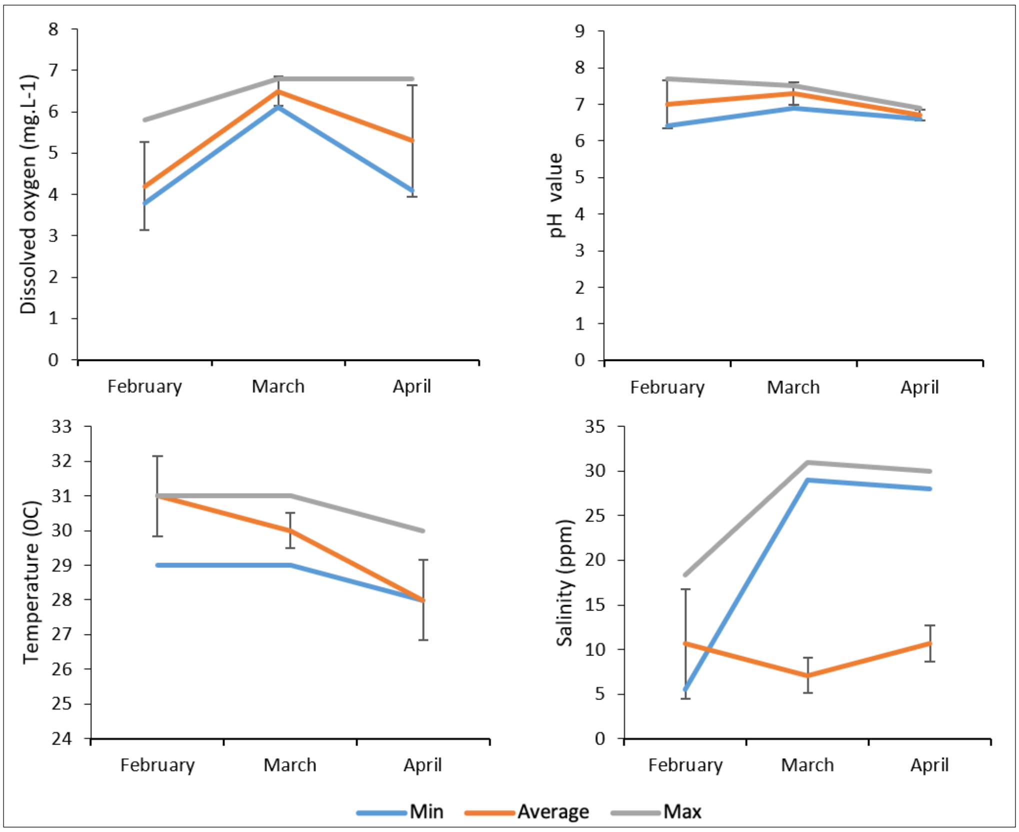

Fig 2: Water quality parameters in Mangrove Tourism of Muara Angke, Jakarta, Indonesia

3.2 Bioconcentration factor (BCF) of Lead in the mangrove root *Avicenia marina*

The results show of the heavy metal bioconcentration factor (BCF) of lead in Mangrove Tourism of Muara Angke, Jakarta, Indonesia is a significant difference between BCF mangrove root with sediment and BCF mangrove root with water bodies (Table 3). Bioconcentration factor of lead between mangrove root and sediment (BCF R-S) is found 0.65 with range 0.56-0.80, while Bioconcentration factor of lead between mangrove root and water bodies (BCF R-W) is found 6.75 with range 4.26-9.65.

Table 1: Bioconcentration factor of lead (Pb) in the Mangrove Tourism of Muara Angke, Jakarta, Indonesia

time sampling	concentration of lead (mg/L)			BCF RS*	BCF RW**
	water bodies	sediment	mangrove root		
February	0.30 ± 0.01	3.42 ± 0.62	1.90 ± 0.60	0.56	6.33
March	0.17 ± 0.14	2.04 ± 0.60	1.64 ± 0.97	0.80	9.65
April	0.57 ± 0.47	3.93 ± 1.91	2.43 ± 1.48	0.61	4.26

*Bioconcentration factor of lead between mangrove root and sediment; ** Bioconcentration factor between mangrove root and water bodies.

3.3 Relationship analysis of Lead accumulation in the water bodies, sediment, and mangrove root.

Based on result show concentration of Pb on water bodies, sediment and root of mangrove (*Avicenia marina*) have difference value (Figure 3; Table 3). The highest accumulation of lead in sediment with 3.47 ±1.51 mg/L, following mangrove root and water bodies with 1.45 ± 1.00 mg/L and 0.43 ± 0.12 mg/L, respectively. Relationship lead accumulation between Avicenia marina root with water bodies and sediment (Figure 3). Lead accumulation in the sediment have a mighty relationship with lead accumulation in the root of mangrove *Avicenia marina*, Theses a relationship is found r=0.87, F= 31.76 and p<0.001 with formulation is Lead-Am=0.069+0.021Sed (Figure 3a). While relationship lead accumulation in the water bodies do not have relationship with lead accumulation in the root of mangrove *Avicenia marina* (Figure 3b). These results show lead in the water bodies dynamically with a sort of time period can be change, while lead accumulation in the sediment remained for a long time.

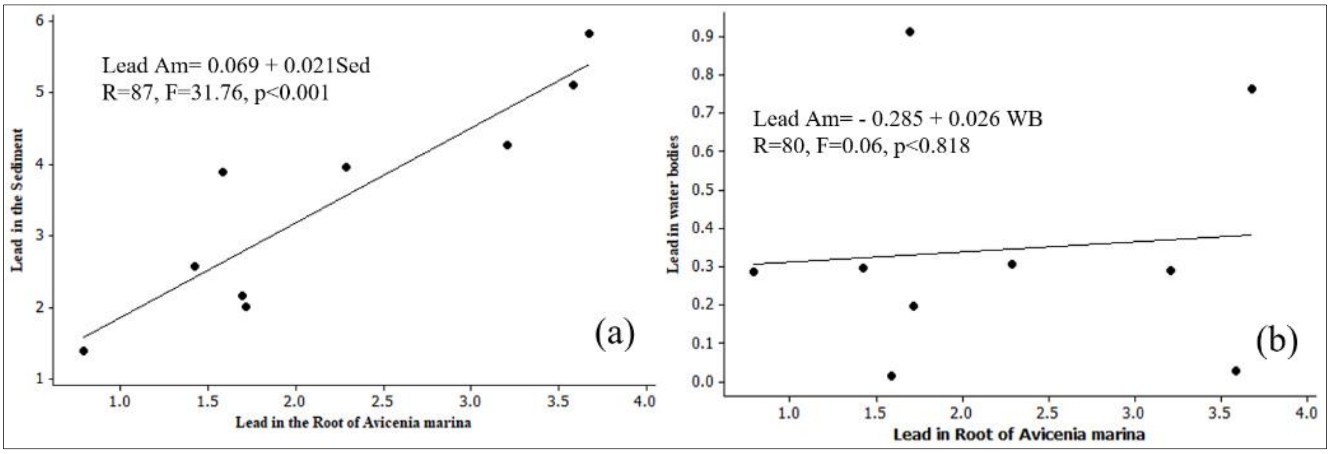

Fig 3: Relationship lead accumulation in root of Avicenia marina (Am). Figure 3a. relationship lead in sediment (Sed) with root of Avicenia marina; Figure 3b. relationship lead in water bodies (WB) with root of Avicenia marina (Am).

4. Discussion

The Bioconcentration Factor (BCF) is the concentration of a compound in an organism divided by the concentration of a compound in a medium of water or sediment. It is calculated to see the ability of *Avicenia marina* in accumulating Pb heavy metal. Based on result of BCF (Table 3) and relationship analysis (Figure 3; Figure 4) show value of bioconcentration factor from *Avicenia marina*, the concentration of Pb heavy metal at the root is divided by the average concentration of Pb heavy metal in the sediment and have a mighty relationship with lead accumulation in the root of *Avicenia marina*. It is due to the roots of *Avicenia marina* to have interact directly with sediment. Lead accumulation in the sediment remained for a long time [24, 29]. The fact showed the concentration of lead in the *Avicenia marina* root not determined by high concentration of lead in the water bodies and sediment for a short time period but determined by long time period interaction between root of *Avicenia marina* with lead contamination.

The difference in the ability of *Avicenia marina*'s roots in absorbing Pb heavy metal is caused by environmental factors. Mangrove roots will be maximized in absorbing Pb in the sediment for a calm and non-flowing water body because lead will settle and not move to other areas as in sediment where the water body is calm. It can be concluded that the roots of *Avicenia marina* can accumulate heavy metals Pb. This is directly proportional to the results of (Setiawan 2013; Bu-Olayah and Thomas 2017) [23, 3], showing the mangrove root *Avicenia marina*, can accumulate Pb heavy metal in water with a BCF value of 0.619. This refers to the statement (Sahidin *et al*. 2018) [22] which stated that if the BCF value >1 of the concentration in the water column, it means that the organism has the ability to accumulate metal in the body. Meanwhile, if the BCF ≤ 1, it means that the organism lacks the ability to accumulate metal in its body.

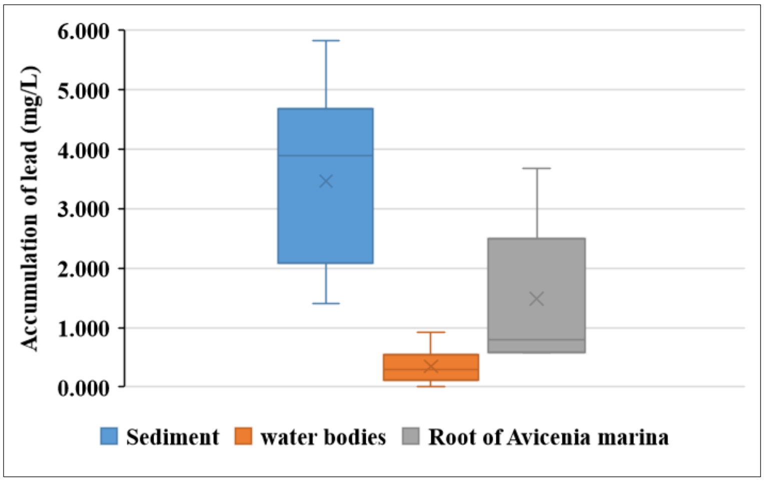

Fig 4: Accumulation of lead (Pb) in difference place on Mangrove Tourism of Muara Angke, Jakarta, Indonesia.

Relationship lead accumulation between Avicenia marina root with water bodies and sediment (Figure 3). Lead accumulation in the sediment have a mighty relationship with lead accumulation in the root of mangrove *Avicenia marina*, Theses relationship is found r=0.87, F= 31.76 and $p<0.001$ with formulation is leadAm=0.069+0.021Sed (Figure 3a). While relationship lead accumulation in the water bodies do not have a relationship with lead accumulation in the root of mangrove *Avicenia marina* (Figure 3b). These results show lead in the water bodies dynamically with a sort of time period can be change, while lead accumulation in the sediment remained for a long time. This is consistent with (Fonseca *et al*. 2013) [7] statement which stated that the amount of metal concentration in root tissue is thought to be due to root tissue having a direct interaction with sediment and water that has been contaminated by metal deposits.

Sediment type is another factor due to difference concentration of lead in the root of *Avicenia marina.* Muddy sediment easily traps of heavy metal pollutant than sand sediment in the coastal. The chunks of heavy metals tend to be sequestered at the bottom [21, 8]. The fluctuation in the spectrum and quantities of heavy metals in bottom sediments is not as rapid as in water and therefore the investigation of heavy metals in a relatively stable state enables the integral specific features of the heavy metal contamination of a water basin to be determined for a specific interval of time [19, 13, 14]. Based on the results of Pb heavy metal concentration on Mangrove Root *Avicenia marina*, it is proven that the roots of *Avicenia marina* can accumulate lead (Pb) heavy metals even with a low amount. This is consistent with [17] statement which stated that the root portion of *Avicenia marina* mangroves can be used as a bioaccumulator in environments contaminated with heavy metals, especially heavy metals such as Pb, Cu, and Zn.

5. Conclusion

Lead accumulation in the sediment have a mighty relationship with lead accumulation in the root of *Avicenia marina* with r=0.87, F= 31.76 and p<0.001, and the response of mangrove root of *Avicenia marina* to the lead contaminant determined by concentration amount of lead, time interaction, sediment type, and water flow. Muddy sediment type is a special sediment lead traps in the coastal.

6. References

1. Abbas BF, Al-Jubori WMK, Abdullah AM, Sha`aban H, Mohammed MT. Environmental Pollution with the Heavy Metal Compound Research J. Pharm. and Tech. 2018; 11(9):4035-4041. DOI: 10.5958/0974-360X.2018.00743.6
2. Bhateria R, Jain D. water quality assessment of lake water: a review. sustainable water resources management, 2:161-173.
3. Bu-Olayan AH, Thomas BV. Effect of mercury transfer from producer to consumer in a marine environment. Pol. J Environ. Stud. 2017; 26:2487-2494.
4. Canadian Council of Ministers of the Environment. Canadian sediment quality guidelines for the protection of aquatic life: merucy. In: Cana-dian Environmental Quality Guidelines, 1999, 5p.
5. Effendi H. Review of Water Quality for Management of Resources and Aquatic Environment. Fifth Mold. Yogjakarta: Kanisius, 2003.
6. Ekong EB, Jaar BG, Weaver VM. Lead-related nephrotoxicity: A review of the epidemiologic evidence. Kidney Int. 2006; 70(1):2074-2084.
7. Fonseca EF, Neto JAB, Silva CG. Heavy metal accumulation in mangrove sediments surrounding a large waste reservoir of a local metallurgical plant, Sepetiba Bay, SE, Brazil. Environ Earth Sci. 2013; 70:643-650
8. Galkus A, Joksas K, Stakeniene R, Lagunaviciene L. Heavy Metal Contamination of Harbor Bottom Sediments. Pol. J. Environ. Stud. 2012; 21(6):1583-1594
9. Irnidayanti Y. Toxicity and traces of Hg, Pb, and Cd in the hepatopancreas, gills and musceles of perna viridis from Jakarta Bay, Indonesia. Pakistan Journal of Biological Sciences, 2015; 18:94-98.
10. Kadir H. Bioconcentration of Pb heavy metals in soft corals (Synularia Polydactyla) in the waters of Laelae Island, Bone Batang Island and Badi Island. Thesis of FIKP University of Hasanudin, Makassar, 2013.
11. MacFarlane GR, Koller EC, Blomberg SP. Accumula-tion and Patitioning of Heavy Metals in Mangrove: A Synthesis of Fieldbased Studies. Chemosphere, 2007, 1454-1464.
12. Napitu WT. Analysis of concentrations of heavy metals Pb, Cd and Cu in milkfish, mullet and shrimp in the Silvofisheri Blanakan Subang region. Thesis Bogor Agricultural University, Bogor, 2012.
13. Nasr SM, Okbah MA, Kasem SM. Environmental assessment of heavy metal pollution in bottom sediments

of aden port. Yemen. International journal of oceans and oceanography. 2006; 1(1):99-109.
14. Nastia P. Accumulation of Heavy Metals of Copper (Cu) and Lead (Pb) on Rhizophora mucronata Trees in Mangrove Forests of Fishermen Villages in Medan Labuhan Subdistrict and Jaring Halus Village, Secanggang District. Essay. Forest Cultivation Department. University of North-ern Sumatra. Field, 2014.
15. Navas-Acien A, Guallar E, Silbergeld EK. Rothenberg SJ. Lead exposure and cardiovascular disease: A systematic review. Environ. Health Perspect. 2007; 115(1):472-482.
16. Osorio JA, Wingfield MJ, Roux J. A review of factors associated with decline and death of mangroves, withparticular reference to fungal pathogens.. South African Journal of Botany, 2016; 103:295-301.
17. Palar H. Heavy metal pollution and toxicology. Jakarta: Rineka Cipta, 2004.
18. Panda SS, Chaturvedi N, Dhal NK, Rout NC. Regular Article An assessment of heavy metal accumulation in mangrove species of Bhitarkanika, Odisha, India. Research in Plant Biology. 2013; 3(6):01-05.
19. Pekey H, Karakas D, Ayberk S, Tolun, Bakolu M. 2004. Ecological risk assessment using trace elements from surface sediments of izmit bay (northeastern marmara sea) turkey. Mar. Pollut. Bull, 2004, 48:946.
20. Pumijumnong TN, Danpradit S. Heavy metal accumulation in sediments and mangrove foreststems from surat thani provice. The malaysian forester. 2016; 79(1 & 2):212-228
21. Saad MAH, Beltagy AI, Mahmoud WM. Total dissolved and particulate lead in the western harbour of alexandria, a mediterranean basin under stress. Spec. Issue mar. Pollut. Bull, 2003; 47:52-65.
22. Sahidin A, Zahidah, H Herawati, Y Wardiatno and I Setyobudiandi. Macrozoobenthos as bioindicator of ecological status in Tanjung Pasir Coastal, Tangerang District, Banten Province, Indonesia. Biodiversitas. 2018; 19(3):1123-1129.
23. Setiawan H. Accumulation and distribution of heavy metals in mangrove vegetation in coastal waters of South Sulawesi. Makassar Forestry Research Institute. Journal of Forestry Science, 2013, 7(1).
24. Sharifuzzaman SM, Rahman H, Ashekuzzaman SM, Islam MM, Chowdhury SR, Hossain MS, *et al*. Heavy Metals Accumulation in Coastal Sediments. in the H. Hasegawa *et al*. (eds.). Environmental Remediation Technologies for MetalContaminated Soils. Springer Japan, 2016. DOI 10.1007/978-4-431-55759-3_2
25. Takarina ND, Pin TG. Bioconcentration factor and translocation factor of copper (Cu) in Avicennia sp. at Rawameneng and Blanakan ponds, Subang Regency, West Java, Indonesia. International Journal of Marine Science. 2015; 5(59):1-5. doi:10.54376/ijms.2015.05.0059.
26. Ubong IU, Obunwo C. Heavy metal contents in mangrove leaf, root and sediment from Eagle Island, Port Harcourt. International Journal of Development and Sustainability. 2018; 7(6):1759-1772.
27. Uddin MM, Huang L, Bin X. Spatial and temporal changes of heavy metals in coastal mangrove sediment in China: Review of present status. J Biol. Sci, 2019; 19: 314-322.
28. Uddin MM. Is phytoremediation an ecosystem service? Heavy metal accumulation and partitioning of consumable and non-consumable mangroves of the Kelantan Delta, Peninsular Malaysia. M.Sc. Thesis, Vrije Universiteit Brussel, Brussels, Belgium, 2015.
29. Wei J, Duan M, Li Y, Nwankwegu AS, Ji Y, Zhang J. Concentration and pollution assessment of heavy metals within surface sediments of the Raohe Basin, China. Sci Rep, 2019, 9:13100. https://doi.org/10.1038/s41598-019-49724-7
30. Whigham DF, Verhoeven JTA, Samarkin V. Responses of Avicennia germinans (Black Mangrove) and the Soil Microbial Community to Nitrogen Addition in a Hypersaline Wetland. Estuaries and Coasts, 2009; 32:926-936. https://doi.org/10.1007/s12237-009-9184-6
31. Zhou H, Yang WT, Zhou X, Liu L, Gu JF, Wang WL, *et al*. Accumulation of Heavy Metals in Vegetable Species Planted in Contaminated Soils and the Health Risk Assessment Int. J. Environ. Res. Public Health. 2016; 13(289):1-13; doi:10.3390/ijerph13030289