Macrothink Institute™

Aquatic Science and Technology
ISSN 2168-9148
2015, Vol. 3, No. 1

Analysis of Lead (Pb) Content in the Mangrove Forest Area in Waiheru District, Ambon

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Received: February 23, 2014 Accepted: May 9, 2014 Published: January 1, 2015

doi:10.5296/ast.v3i1.6545 URL: http://dx.doi.org/10.5296/ast.v3i1.6545

Abstract

Mangrove has the ability to absorb waste and pollutants including heavy metals Pb. This study aims to identify sources of metals Pb contamination in mangrove forest area in Waiheru District and to analyze Pb content of in sediment and mangrove roots. The data collection method used was the direct observation (*in situ* measurement) and analysis of laboratory. Sediments and mangrove roots were analyzed by atomic absorption Spectrophotometry (AAS). Findings showed that It was identified three types of activity expected to become the potential of contamination sources of metal Pb in the area around mangrove forests namely; the agriculture activity, settlement and a motorboat. The metal content of Pb in sediment in around *Sonneratia alba* and *Rhizophora apiculata* exhibited the highest concentrations of 1, 9129mg/kg and 1.7965 mg/kg, respectively. Meanwhile, the lowest was in around mangrove from species *Avicennia marina* with the Pb concentration of 0.7259 mg/kg. Among the three species of mangrove, *A. marina* roots indicated highest Pb concentration (0.2857 mg/kg). It means that A. marinawas more effective in reducing of the contaminant material of the metal Pb.

Keywords: Pb, Mangrove roots, Sediment, *A. marina*, Settlement

1. Introduction

The increasing of development rate in all fields in Ambon city resulted in a positive effect on the society living standard improvement. On the other hand, it gave the negative impact namely the presence of waste production (liquid and solid) which continuously increased (Dhokhikah & Trihadiningrum, 2012). The amount of waste produced continues to increase as the population increases. The population of Ambon city in the middle of 2012 amounted 354.464. Compared to the number of people in 2011, the population in Ambon City increased 1.74 % (BPS, 2013). Waste disposal into the environment will cause pollution, disturb public health and give a big impact namely the waste contribution to global warming (Valentine & Sharma, 2013; Koller, 2013; Rarastri, 2008). The estimation of garbage production in Ambon city during 2012 was 1056 m^3/day, almost two times from the garbage production in 2011 namely 560 m^3/day (BPS, 2013). In 2012, the trash volume accumulated in dumpsites was 746 m^3 /day whilst, there was as much as 595 m^3/day transforted to landfills.

One type hazardous waste for human and environment is heavy metal obtained in the waters which is bigger by the increasing of human activity that has the potential to increase the existence of heavy metal. Monitoring of heavy metal in the water and waters sediment in Ambon bay waters showed the concentration of Hg < 0.004 mg/l, Cd < 0.001 mg/l, Cr < 0,001 mg/l, and Cu < 0,008 mg/l, Pb ranged from 0.004 mg/l to 0.005 mg/l and Zn ranged from 0.0078 mg/l to 0.0083 mg/l (BTKLPPM, 2008). Although those values were still below the threshold set, it had the potential for the presence of heavy metal pollution in the waters like the other waters that exceeded the threshold (Tuahatu, 2010).

Pb is a very hazardous heavy metal not only for waters biota that lives in the area but also for human who consume the biota (Rompas, 2010). Waste containing Pb element is commonly comes from industrial waste of paint, battery, car fuel, and pigment (Mukhtasor, 2007). Mangrove is a typical vegetation of tropical and subtropical area, found on the tidal area and sheltered coastal. It has a function as a sediment trap which can absorb the waste or pollution materials including metal elements through its roots (Heriyanto, 2011; Heriyanto & Subiandono, 2011). The heavy metal pollutant materials which are able to be absorbed by mangrove roots are such as mercury (Hg), iron (Fe), manganese (Mn), copper (Cu), lead (Pb), zinc (Zn), chromium (Cr), and nickel (Ni) in sediments and waters(Farlane*dalam*Hamzah & Setiawan, 2010). Therefore, mangrove can be used as the absorber of Pb heavy metal pollutant material.

Waiheru District located in Ambon Bay area has an enough wide mangrove forest area in its coastal. However, the presence of various activity of society in Waiheru District was found to be potential of Pb metal source around mangrove forest area. Therefore, this study aims to identify the sources of Pb metal contamination around mangrove forest area of Waiheru District and to analyze Pb metal content in sediments and mangrove roots around mangrove forest of Waiheru District.

2. Methods

This study was carried out on June 2013 located in mangrove forest area in Waiheru District.

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Aquatic Science and Technology
ISSN 2168-9148
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The study was done by the direct observation in the field (*in situ* measurement) and laboratory analysis. On the location, it was selected several stations of data collection which was straightly shoted from the land to the sea based on mangrove forest zone in orther to it could be determined the gradient of Pb metal concentration on each species (Figure 1).

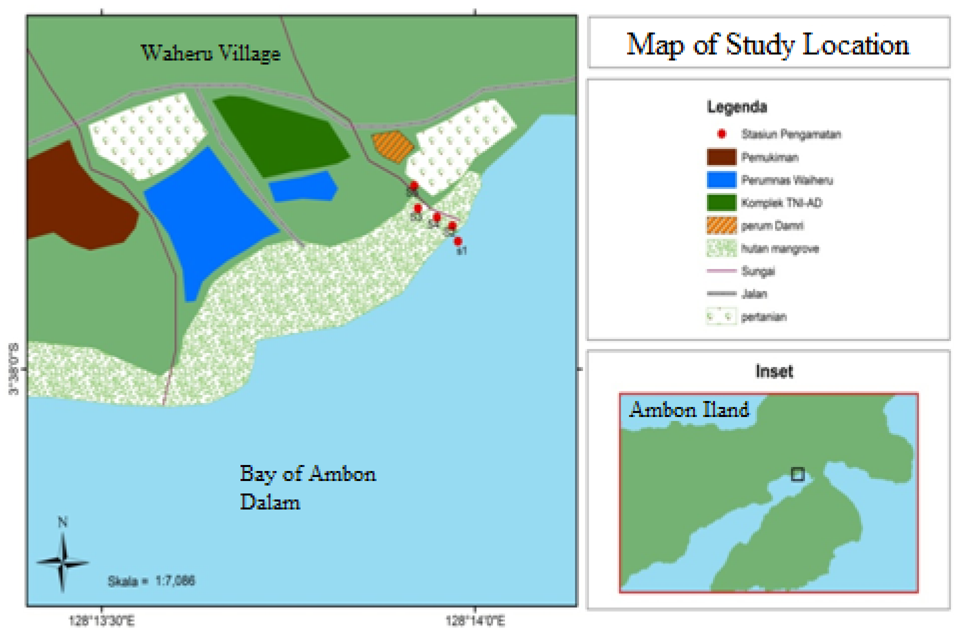

Figure 1. Map of study location

The collection of mangrove roots was only done on mangrove species which were proved their ability of absorbent on Pb metal namely; *A.marina* and *R. apiculata* (Sulistiyati, *et. al*., 2013; Kamaruzzaman, *et. al*., 2009). Meanwhile, sediments were collected using *sediment core*on five stations of observation namely; station 1 (SS_1) located on the outside of mangrove forest area, station 2 on the area of mangrove *S.alba* (SS_2), station 3 on the area of mangrove *R. apiculata* (SS_3), station 4 on the area of mangrove *A. marina* (SS_4) located in mangrove forest area, and station 5 (SS_5) located outside of agricultural area.Pb metal content analysis was carried out Biopharmaca Laboratory of pharmacy faculty of Hasanuddin University using Atomic Absorption Spectrophotometer (AAS). Data was then presented in graph form and further analyzed.

3. Results and Discussions

3.1 Source of Pb Metal Pollutant in Mangrove Area of Waiheru

Findings showed that the society activities which had the potential as a Pb metal source in mangrove area were the agriculture activity, settlement and fish motor boat activity. The area of Waiheru District proposed for the agricultural area was very wide namely ± 20 Ha. The agricultural development is inseparable from the utilization of agro-chemicals such as fertilizer and pesticide. The farmer community in Waiheru District used fertilizer from the kind of manure, organic and urea with the highest percentage (53 %) of organic and urea fertilizers (Figure 2). Based on the results of interviews, it could be proved that the majority of farmers in the Waiheru District used organic fertilizer, urea ($NH(CO_2)_2$) and NPK ($NH_4NO_3PO_4$-KCl) for fruit crops. These fertilizers gave the contribution on the input of pollutant material of Pb metal in the land and waters. Heavy metal Pb dissolved in water is very harmful to aquatic organisms because it is a bioaccumulative accumulated and increases in body tissue of organisms (Rompas, 2010). It was due to Pb metal obtained as one of the following elements in the process of agro-chemical making (Setyorini, *et al*, 2003). Organic fertilizer which comes from lime and compost fertilizers can contain heavy metal particularly Pb metal with the concentration of 20-1250 mg/kg and 1.3-2240 mg/kg, respectively (Alloway*in*Setyorini, *et al.*, 2003). Whilst, for NPK fertilizer which is one type of phosphate fertilizers containing Pb substance such as pyromorphite ($Pb_5(PO_4)_3(X)$) (Zhu *et. al.*, 2004). It is very important because Pb metal is one of non-essential heavy metals for the growth and development of plants.

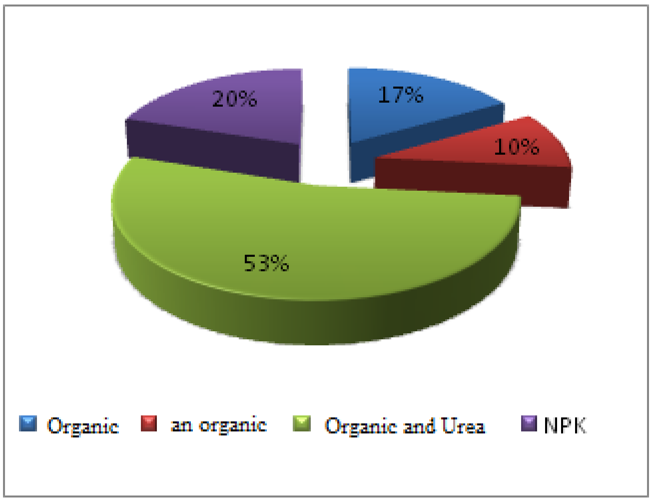

Figure 2. Type of fertilizers used in Waiheru district

Based on estimation count, it was estimated that the dose of urea and organic fertilizers used was ± 200 kg/ha and 1000 kg/ha, respectively for extensive garden area of 1 ha. The giving of this organic fertilizer concentration has exceeded the dose remmended by the Minister of agriculture’s regulation No. 42 in 2008 namely 750 kg/ha for *granule* organic fertilizer and 250 kg/ha for NPK whilst, for urea was still in the range of dosage recommended namely 200-260 kg/ha. As the result, fertilizer residue that is not absorbed by vegetable plants will be accumulated into soil then brought by run-off water to the river through irrigation system and finally gives Pb metal residue as one of fertilizer residues.

Type of pesticide that are widely used by the farmer community in Waiheru District is antracol $(C_5H_8N_2Zn)_x$ with 70 % of its active material using propineb. This active material will not be toxic if its use is still within the range of normal use (Hidayat, *et al.*, 2010). Based on its composition, this pesticide do not contain Pb metal but it needs to be know that heavy metal including Pb metal if it interacts with the other metals, it can increase or decrease the toxic effect. The reaction between Pb and Zn metal as one of antracol $(C_5H_8N_2Zn)_x$ composition can give antagonistic effect (the decreasing of toxic effect).

The second Pb metal pollution source is come from the settlement around mangrove area. The existence of mangrove area in Waiheru District is located ± 0,5 km from the settlement. The tendency of the near settlement location is based on the presence of resource potency and environment service used by community namely the utilization of mangrove area as landfills (solid/liquid). Type of plastic waste dominated the solid waste dumped into the mangrove area. This kind of waste was produced daily by the community in Ambon City beside the other organic and anorganic waste (Selanno, 2010). In 2012, waste composition per day in Ambon City was dominated by waste from plastic type namely 40 % compared to the other waste types (BPS, 2013). Plastic waste in the manufacturing process is also added a various chemicals such as Pb metal as a colouring agent, stabilizer and filler. Pb substance used was in lead carbonate ($PbCO_3$), lead stearate ($Pb(C_{18}H_{35}O_2)_2$), lead stearate (dibasic) ($2PbO \cdot Pb(C_{17}H_{35}COO)_2$), and lead phthalate ($C_8H_4O_4Pb$) (Kumar & Pastore, 2007). Plastic waste needs a long time to be completely decomposed. At the time of decomposition, Pb element contained in the plastic is also decomposed causing the pollution on soil and aquatic environment. Besdes plastic waste, there was also the presence of various solid waste containing heavy metal such as batteries and tins (Paint tins) waste. Lead (Pb) element and its molecule is used in battery industry as the active material in the streaming of electron current (Arisandy, *et al.*, 2012). Pb metal is also used as the addition material in the coloring paint (Darmono, 2001).

Source potential of the third Pb metal pollution was derived from the use of motor boats by fishermen for fish catching in the sea. Based on the direct observation in the location of study, there were ±10 motor boats belonging to the fishermen moored around mangrove forest area. Motor boat utilization could also be one of the sources of Pb metal contaminant to mangrove forestarea. It was due to the presence of Tetraethyllead – TEL, $(C_2H_5)_4Pb$ obtained in motor fuel (gasoline). This substance is one of organometallic compounds having a low boiling point and has long been used as antiknocking due to its function which can increase octan number of the fuel (petrol) reach 80. TEL substance also gives a pollution effect on aquatic environment, soil and air (Palar, 1994).In addition, the use of paint on motor boats also resulted in the contribution on Pb metal pollution source.

3.2 Lead (Pb) Heavy Metal Content in Mangrove Roots

The analysis of Pb metal content in mangrove roots in two sample collection stations around the river estuary of WaiSalak in Waiheru District showed that Pb metal content was the limit range recommended by WHO for Pb metal content in food namely 0.1-2 ppm (1 ppm = 1 mg/l = 1 mg/kg). Furthermore, Pb metal content in *Avicennia marina* (SA1) and *Rhizophoraapiculata* (SA2) was also still in the normal range for plants namely 0.5-3 mg/kg (Nopriani, 2011). Pb metal content found in *Avicennia marina* roots (SA_1) collected from sample collection station 1 was 0.2857 mg/kg whilst, from *Rhizophoraapiculata*akar (SA_2)

Aquatic Science and Technology
ISSN 2168-9148
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collected from sample collection station 2 was 0.1643 mg/kg (Figure 3). Compared to these two mangroves, the Pb metal uptake in *Sonneratia alba* roots collected from the same location was lower namely 0.098 mg/kg (Hatulesila, 2012). It was cused by the uptake ability difference of these three mangroves (Amin, 2001).

The agricultural activities which used fertilizer gave the direct and indirect contribution on Pb heavy metal content. Pb metal is a heavy metal that can give synergis or antagonist effect if it binds to other metals in which the intraction to the other metals can ocurre a failure or never occurred (Palar, 1994). If it is bound to its couple and forms a molecule, The synergis heavy metal can be very dangerous toxic or has a highest toxic effect such as the intraction between Pb and Cu metal. In turn, the antagonist heavy metal will have a decreasing toxic effect if it binds to its couple for example the intraction of Pbton Ca, P, S, and Zn.

Pb will result in a toxic effect and be absorbed by plants if it is in a free form. Meanwhile, if Pb is in the form bound it can bind to nutrients, organic and anorganic materials. In this case, Pb will also influence the supplying of plant nutrient and will be absorbed by plant through roots then it will be distributed to the other plant branchs. Pb metal will be absorbed by the plant at the fertile soil condition and low soil organic material content. At this condition, Pb metal will be loose from soil binding and be ion which freely moves in soil solution. If there is no inhibition from the other metals, it will be absorbed by the plant roots (Farlane *et al*., 2003 *in* Hamzah and Setiawan, 2010).

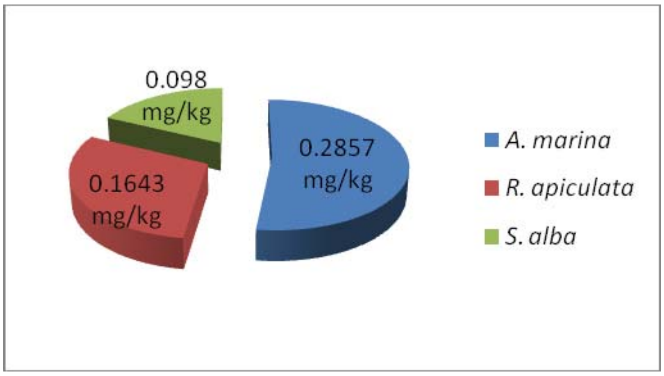

Figure 3. Pbmetal content in mangrove roots

3.3 Lead (Pb) Content in Sediment

Pb metal content in the sediment at the five of observation stations was 1.6020, 1.9129, 1.7965, 0.7259, and 1.4773 ppm, respectively (Figure 4). Pb metal content at SS_4 showed the lower value than that at the other stations because the sediment type at this location was a sandy substrate. Meanwhile, the other four stations were dominated by a muddy substrate. The high Pb metal content in the sediment was commonly influenced by sediment type in which heavy metal content in mud substrate > sandy mud substrate >sandy substrate (Korzeniewski and Neugabieuer *in* Amin, 2002). The bigger of sediment particle size the easier of heavy metal absorption process by sediment layer and in turn (Palar, 1994).

Pb metal content was at SS_2 namely 1.9129 ppm. It was caused by this collection station located at the front part zone of mangrove forest around *S. alba*. Pb metal content at this location was not only influenced by agricultural activity waste from the land area but also affected by Pb metal content from the sea activity such as motor boat use activity and waste brought by the current to the area. Current is one of factors which gives the effect on the spreading of pollutant in marine and coastal environment (EPA *in* Suprapti, 2008).

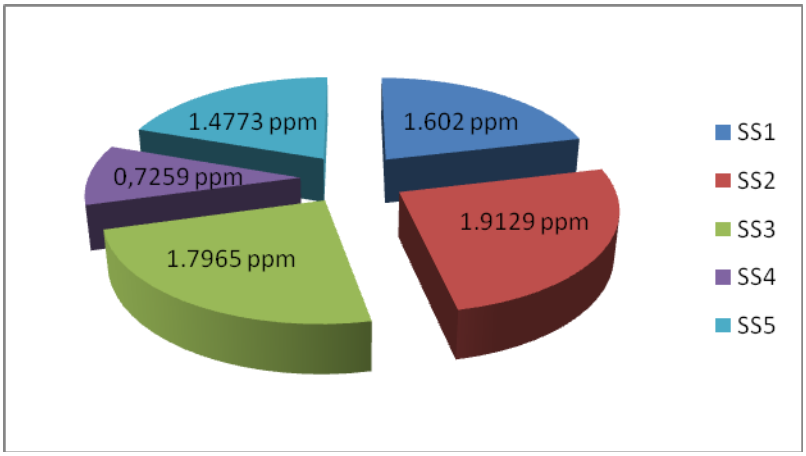

Figure 4. Pb Metal content in sediment

The pH value obtained according to the measurement result was range from 6.1 to 6.4. It could be said that pH at the five of observation stations tended to be acidic. In the acidic sediment, metal cation is very soluble and available for plants so it is easier to move (Alloway, 1995 *in* Amin, 2002). As the result, the transfer of Pb metal from sediment to plants will be easier. In addition, pH deacresing will also cause the higher heavy metal toxic effect. The lowest pH value was observed at two stations namely at SS_2 and SS_4 stations. Compared to Pb metal content in sediment in the four stations, the Pb metal content in sediment at SS_2 station was higher. It was supported by Alloway (1995) *in* Amin (2002) reporting that if pH in sediment is acidic, the solvency of heavy metal will be higher and make the easier deposition process. It also results in the higher heavy metal content in sediment. Whilst, the Pb metal content of *A. marina* sediment at SS_4 station was higher than that in mangrove roots at the other stations. It proved that pH also influences plant in absorbing of Pb metal. The decreasing of sediment pH value will increase the accumulation of heavy metal in roots tissue (Widayati, 2009).

Sample collection process done in June (East season) also very influenced the heavy metal content in the sediment (Deu *et al*. 1994 *in* Khaisar, 2006). It was caused by the higher accumulation of Pb metal in sediment at the dry season (West season) than the rain season (East season). The low relative rate of water flow at the dry season did not support the occurrence of dilution process to decrease the pollutant content by water mass come from rain (Puspitasari & Hindarti, 2009). Pb metal content in sediment in Ambon Bay waters was range from 0.58 to 1.17 ppm in 5 stations whilst, that in the station of Waiheru was 0,74 ppm (Tuahatu & Rahalus, 2008). Further study showed that Pb metal content in sediment Ambon Bay during May and September 2010 was higher than previous study with the highest concentration at Galala, Poka, and Mardika stations whilst, Pb metal content value in Waiheru station was the low enough (Tuahatu, 2010).

Pb metal content in sediment will be observed by the vegetation such as mangrove and accumulated in biota which lives in the sediment. This very worries because there is occurred a biomagnification process on heavy metal. In the biomagnifications process, the top carnivore organisms have the higher Pb metal content than the lower organisms level (Apriadi, 2005). It also gives the dangerous effect on human if they consume the heavy metal befouled biota.

Mangrove actively decreases the absorption of heavy metal throught physiology mechanism if heavy metal content in sediment is high. The absorbtion is still occurred in the limited number and accumulated in the roots. In roots, there is endodermis cell which has a function as filter in the absorption process of heavy metal. Pb metal content in *A. marina* roots was higher that that in *R. apiculata* and *S. alba* roots. There was the decreasing of Pb metal content as the result of *A. marina* roots absorption although its concentration was still in the normal range of Pb metal content in plant. Therefore, it can be recommended that mangrove *A. marina* is more effective in reducing of Pb metal pollution than *R. apiculata*and, *S. alba*.

4. Conclusions

Based on the study results, it can be concluded that there were three potential sources of Pb metal pollution in mangrove forest area in Waiheru District. They were agricultural activities, settlements and fishermen motor boat use. In general, Pb metal content in sediments and mangrove roots was still in the range recommended. The highest Pb metal content was obtained in sediment around S. *alba*and, *R. apiculata*. In addition, *A. marina* roots exhibited highest Pb metal value causing it more effective in reducing of the contaminant material of the Pb metal.

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