The Role of Sedimentation on Waters Edge and Analysis Lead and Zinc Concentration in Water from Sentani Lake, Jayapura-Papua

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ABSTRACT

We have conducted research on the role of sediment on the water edge and content analysis of metal concentrations of lead (Pb), zinc (Zn) in the water of Sentani Lake in Jayapura, Papua Province. The experiment was conducted in April 2013. The study was conducted to determine the role of lake sediments on water quality, sediment characteristics and metal analysis has been analyzed in the laboratory to determine the concentration of Pb and Zn in the sediment. Metal analysis was undertaken using Atomic Absorption Spectrophotometry (AAS). Sediment was characterized as its physical and chemical parameters such as bulk density, density, porosity, water content, texture, pH, DO, colors and others. Sediment sampling locations was taken from Ifale, Estuary, Yahim beach and Yoboy river in depth of 0-5 cm, 5-10 cm and 10-15 cm vertically. The results showed that each sampling sites and sediment depths showed a high significant different of metal content Pb and Zn. The average content of sediment heavy metals (Pb and Zn) each location are Ifale 27.37 mg/Kg and 35.04 mg/Kg, Estuary 28.01 mg/Kg and 15.37 mg/Kg, Yahim beach 3.83 mg/Kg and 33.50 mg/Kg, while in Yoboy found 6.69 mg/Kg and 34.60 mg/Kg, respectively. Lead concentration (3.83 to 27.37 mg/Kg) and zinc (6.69 to 35.04 mg/Kg) in sediments is lower than that regulated the standard quality of heavy metals in sediments (EPA Region V\(^*\)) 40 mg/Kg for Pb and 90 mg/Kg for Zn metals. Therefore, concentrations of Pb and Zn in sediments at four locations in Sentani lake is still following the quality standard levels of Pb and Zn.

Key word: sediment, depth, metals Pb and Zn, Sentani Lake

INTRODUCTION

Sentani Lake is the main source of fresh waters its territory. It is located in Jayapura regency and natural waters that are teeming with activities of daily transport and various kinds of human activities [1]. Function of Sentani Lake is supporting daily water needs, hydropower, and irrigation for agriculture, fisheries and transportation. This brings a wide variety of contaminants including organic and inorganic components. The inorganic contaminant is dangerous heavy metals. Some heavy metals possibly pollute the water such as mercury (Hg), lead (Pb), arsenite (As), copper (Cu), cadmium (Cd), chromium (Cr), zinc (Zn) and nickel (Ni) [2].
There are several issues that arise around Sentani Lake is started silting due to high sedimentation caused by flooding and erosion, increasing the number of settlements, land clearing (shifting cultivation), excavation of sand mining, domestic industry, as well as sewage either directly or indirectly through the river that empties into the lake waters to accumulate in lake sediments that caused decreases of the water quality of the lake [3].

Heavy metal pollution in the Sentani lake, as an example, Pb due to the entry of pollutants originating from urban wastes, agricultural, fishery and water comes from transportation activities in which the means of transportation using a motor boat with a gasoline fuel gases that cause the rest of the fuel combustion process (exhaust) is located below the water surface so that exhaust gases directly interact with the body of water, heavy metals Pb also comes from natural sediments accumulated in a long time, while for heavy metal pollutants due to the inclusion of Zn derived from urban wastes, agricultural, fishery and derived from human activity that is the result of sand mining activity on a rainy day materials will be carried away by flood waters and sedimented in causing sedimentation and increased concentration of Zn metal increases. Heavy metal pollution can come from natural or industrial activities. Water pollution can be salts of heavy metals and heavy metal formed toxic compounds. Heavy metals are often found to water pollution is Hg, Pb, Cd, Cr, Cu, Ni, and Zn in the form of toxic compounds [4]. According Fordtner and Prosi (1978), factors which lead to heavy metals is grouped into the polluted substances are (i) heavy metals cannot be decomposed by biodegradation, and (ii) heavy metals can accumulate in the environment. This is especially in the river sediment as it could be bound by organic compounds and form complex compounds. Because of the heavy metals in the sediment can accumulate then the levels of heavy metals in the water sediments is getting higher and higher [5].

Figure 1. Sampling location of water and sediment in Sentani lake (reprodominggus)

Aquatic environmental factors such as pH, temperature, hardness, TDS, DHL, salinity and dissolved oxygen (DO) also affects the toxicity of heavy metals. The decreasing of the pH of water causes increasing of heavy metal toxicity. High hardness can influence the toxicity of heavy metals. This is due to easily formation of complex compound by improving of hardness of heavy metals in water, and it will settle in the bottom of water or river. This paper will report the heavy metal contents in the sediments of Sentani Lake, West Papua Indonesia (Figure 1). The reports determining the role of the waterfront or water’s edge sediment on water quality and the content of its heavy metals in sediments. The methods
apply atomic absorption spectroscopy (AAS) for determining of heavy metals quantifications [6].

EXPERIMENT

Sampling locations

The sampling for research was undertaken in four sites, they were Ifale, Estuary, Yahim beach and Yoboy. The location of sampling was determined using global positioning service (GPS) device and sediment samples were taken in 12 location points (Figure 1).

Chemical, materials and equipment

The material used is a white transparent plastic bags, rope, filter paper, label paper, markers, ice cubes, washing powder, universal pH paper, Wathman 42 filter paper, and distilled water. Meanwhile the chemicals used has analytical reagent grade or as mentioned, including nitric acid 65%, nitric acid 1.0 N, potassium chloride 5%, ammonium acetate buffer solution 1.0 M (pH 4.0, 7.0, 10), hydrochloric acid 2.0 M, kalgon solution 5%, acetylene gas, air, lead(II) nitrate, zinc(II) sulfate, sodium phosphate, sodium carbonate, and hydrogen peroxide 30%.

Equipment for research are sediment core, acrylic pipe, atomic absorption spectrophotometer (AAS), analytical scales, ovens, tape measure, ruler, weighing cans, knives, GPS, pH meters, conductometer, DO-meter, pycnometer, hot plate, sieve shakers, desiccator, vacuum pump, thermometer, a set of sieves, electric mixer, spatula, spoon, cool box, hand refractometer, spray bottle, crucible, clamp/pliers, volumetric pipette, measuring pipettes, separating funnel, flask, beaker, erlenmeyer flask, measuring cups, glass bottles, capped tube hone, ball respirators, cup porcelain mortar and funnel glass.

General Procedures

Sediment samples were taken by using sediment cores made of acrylic pipe. The sediment was put in a transparent plastic bag and wrapped in a black plastic bag, put in cool-box. This sample was ready for analysis in laboratory. It was also stored in the refrigerator before analysis. During analysis, sediment samples in the steel container was removed from foreign objects such as pieces of plastic, leaves or other material contained in a sample. Then the sediment was dried in oven at 110 ºC until constant weight. The dry sediments was crushed and screened to 60 mesh of sieve, and stored in a dry jar. For analysis, a carefully weighed 2-3 g of dried sediment was put in to erlenmeyer flask and was added 20 mL of a mixture solution of HNO₃ and H₂O₂ (1:1) and this was further destructed for 3 hours at 120 °C. The result was filtered, and the filtrate was collected in a 50 mL volumetric flask, and diluted with distilled water. The filtrate was then measured by AAS [6-7].

Preparation of curve calibration

A series of lead solution and zinc was prepared. Each solution was measured their lead or zinc absorbance value on AAS instrument [6-7]. Then, a curve calibration was obtained by plotting their absorbance value correlate to their concentrations. Each absorbance was measured at wavelength 283.3 nm for lead (Pb) and 213.9 nm for zinc (Zn).

Determination of Pb and Zn concentrations in sample

The filtrate destruction results measured by AAS using a slit width of 1 nm for Pb and 0.5 nm for Zn. Determination of Pb and Zn concentrations in the samples was done by using a calibration curve linear line, so that the concentration of the sample could be determined.
from the measured absorbance. After concentration measurement is known, then the actual concentration of Pb and Zn in the sample can be determined by calculation [8].

\[ M = \frac{C \times V \times F}{B} \]

Where M is metal concentrations (Pb or Zn) in the sample (mg/Kg), C is Pb concentration obtained from the calibration curve (mg/L), V for volume of the sample solution (mL), F is dilution factor, and B is sample weights (g). As note that maximum wavelength for lead is 283.3 nm and 213.9 nm for zinc.

**RESULT AND DISCUSSION**

Physical and chemical parameters of the sediments sample taken from Sentani Lake, Jayapura-Papua were measured toward their bulk density, density, porosity, water content, texture, pH, DO, color and class (Table 1).

<table>
<thead>
<tr>
<th>Location</th>
<th>Weight (g/cm³)</th>
<th>Porosity (%)</th>
<th>Water Levels (%)</th>
<th>DO (mg/L)</th>
<th>pH</th>
<th>Colors</th>
<th>Percentage (%)</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ifale</td>
<td>1.3</td>
<td>2.41</td>
<td>45.7</td>
<td>0.45</td>
<td>50.4</td>
<td>4.61</td>
<td>8.2</td>
<td>10YR31</td>
</tr>
<tr>
<td>River estuary</td>
<td>1.2</td>
<td>2.48</td>
<td>52.7</td>
<td>0.53</td>
<td>58.0</td>
<td>3.37</td>
<td>8.1</td>
<td>10YR55</td>
</tr>
<tr>
<td>Yahim Beach</td>
<td>1.0</td>
<td>2.40</td>
<td>58.9</td>
<td>0.69</td>
<td>61.6</td>
<td>3.36</td>
<td>7.6</td>
<td>10YR31</td>
</tr>
<tr>
<td>Yoboy</td>
<td>0.2</td>
<td>1.84</td>
<td>87.5</td>
<td>3.78</td>
<td>64.5</td>
<td>2.60</td>
<td>8.1</td>
<td>10YR22</td>
</tr>
</tbody>
</table>

**Measurement of Pb concentration**

Measurement of lead concentration from different location indicates that A factor (sediment depth) does not provide a significant difference to the Pb concentration. This means that the depth of the sediment was not significantly give different of Pb concentrations. On the other hand, B factor (location) gives a significant difference to the concentration of Pb. It shows that Pb concentration at each different location were significantly difference. The interaction of sediment depth and location provide a difference results. This shows that the rate of sedimentation at different depth and location were not significantly different to the concentration of lead afforded. Only locations that significantly influence the concentration of Pb. Location in Ifale gives the largest concentration while in Yahim Beach conversely has the lowest Pb concentration (Table 2).

Lead concentration in Ifale gradually increases with lowering sediment depth. The existing of sediment texture is sandy types, the magnitude of the surface area and thickness of the sediment layer probably affect the gravity or metal accumulation, and it tend to result much more metal precipitation. The concentration of Pb (27.37 mg/Kg) is higher than that in other locations. It was predicted that the high lead concentration in Ifale due to the high mobility of water transportation. This activity applies motor gasoline as fuels, and it is common that motor gasoline contains lead which is released during combustion and interact
with the lake water. Moreover, it was also predicted that in Ifale very close to human activity, where Ifale is surrounding by population centers. Slightly different, in Estuary River, Pb concentrations in sediments at the depth of 0-5 cm up to a depth of 5-10 cm showed a rising value. It is decrease in the depth 10-15 cm. However, in this location still the second largest of lead concentration (15.367 mg/Kg) after Ifale.

### Table 2. Lead concentration (mg/Kg) in different depth sediment (cm)

<table>
<thead>
<tr>
<th>Locations</th>
<th>Pb concentration (mg/Kg) in different depth of sediment</th>
<th>Average Pb concentration (mg/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-5 cm</td>
<td>5-10 cm</td>
</tr>
<tr>
<td>Ifale</td>
<td>23.3753</td>
<td>27.4295</td>
</tr>
<tr>
<td>River estuary</td>
<td>14.5418</td>
<td>16.8845</td>
</tr>
<tr>
<td>Yahim beach</td>
<td>3.0307</td>
<td>4.2719</td>
</tr>
<tr>
<td>Yoboy</td>
<td>4.0673</td>
<td>6.8258</td>
</tr>
</tbody>
</table>

Notes: The average value followed by different letters indicate significant differences at DMRT P>0.05.

Completely different of lead concentration was found in both Yahime beach and Yoboy. In all different depth level, both locations give lead concentration below 10 mg/Kg. Concentration of Pb in the sediment taken from Yoboy gave a gradual increasing from the depth 0-5 cm, 5-10 cm, and 10-15 cm. The sediment texture in different depth indicates silty clay texture. The size and surface area of the thin layer of sediment affect turbulence of sediment and it results the metal surface tend to be separated in different depth and locations around aquatic plants (water hyacinth). So that the metal is released to the surface and absorbed by existing plants, and the metal concentrations in sediments surface (0-5 cm depth) getting smaller (6.69 mg/Kg).

On the Yahim beach location, Pb concentrations in sediments at a depth of 0-5 cm up to 5-10 cm depth showed a rising. It found the concentration from 3.0307 mg/Kg to 4.2719 mg/Kg, and it relatively constant to 4.2007 mg/Kg in the sediment deep 10-15 cm. Lead accumulation in this location is the lowest compared to the other locations. In average, it was calculated in level 3.8344 mg/Kg Pb contains in the sediment sample. This fact is most probably due to the Yahim beach is located closes to the mouth of the river. Besides that, when the raining season coming, flooding is quiet often occurs. And this will undergo a huge dilution process by rain water affect the decreasing of lead concentration.

**Measurement of Zn concentration**

Analysis of zinc contains in sediment from different sampling location and their sediment depth is summarized in Table 3. In general, it was found that the A factor (sediment depth) does not provide a significant differences toward the concentration of zinc contain in the sediment. It was also shown that the average concentration of Zn taken from sediment in four different locations was not significantly different, even in different sediment depth. On the other side the B factor (location) gives a slight difference.

Concentration of Zn in Ifale locations with increasing of sediment depth give fluctuate result. For sample taken in sediment depth 0-5 cm recorded 39.2238 mg/Kg, and for 5-10 cm depth gave result 31.4344 mg/Kg. It went up to 34.4752 again at the deep 10-15 cm. This fact suggests that the average concentration of Zn metal tends to rise up and down with the level of depth of sediment. The largest zinc concentrations at this location recorded at 39.2238 mg/Kg taken from the upper layer sediment (0-5 cm depth). It was presumably this location is
close to the barren hills for sand mining, and huge material was also taken for road hoarding. As consequent erosion quite often occur during raining season and bring materials contain metal including zinc into the lake. In addition, physical feature of sediment taken from Ifale-sites indicate that surface layer contains mostly sandy textures. This has a lot of metal mixture. Besides that, sediment feature also has a small surface area, but with highest porosity compared to the other locations. This physical properties, especially for high porosity, will easily catch more metals enter and attach into the pores of sediment material including zinc metal (Table 3). Interestingly but it will be more dangerous site more human that both of metals lead and zinc compose sediment in Ifale-site is the highest compared to the other-sites. For lead itself, the average concentration reached to 27.3651 mg/Kg of sediment sample (Table 2).

| Table 3. Zinc concentrations from sediment sample in different depth and location |
|---------------------------------|---------------------------------|---------------------------------|
| Location                      | Zinc concentration (mg/Kg) in different depth of sediment | Average Zn concentration (mg/Kg) |
|                               | 0-5 cm | 5-10 cm | 10-15 cm | 0-5 cm | 5-10 cm | 10-15 cm |
| Ifale                          | 39.2238 | 31.4344 | 34.4752 | 35.0445<sup>a</sup> |
| River estuary                  | 25.5739 | 28.0115 | 30.4491 | 28.0115<sup>b</sup> |
| Yahim beach                    | 34.9329 | 30.4270 | 35.1547 | 33.5048<sup>a</sup> |
| Yoboy                          | 35.9356 | 33.3226 | 34.5533 | 34.6038<sup>a</sup> |

Notes: The average value followed by different letters indicate significant differences at DMRT P>0.05.

In other locations close to the Ifale-sites, in the estuary river were taken similar number of sediment samples. The patterns of zinc concentration indicate a gradual increasing with lowering position of sediment sample was obtained. At the deep 0-5 cm, 25.5739 mg/Kg of sample contains zinc. It goes up to 28.0115 and 30.4491 mg/Kg when the sample was afforded from sediment in 5-10 and 10-15 cm depth, respectively. However, this increasing value still below the level concentration in average than sample from Ifale-site. In average, total zinc concentration reach to 28.0115 mg/Kg. It was predicted, that the River of Estuary is a high water current-flow river and the location is surrounded by river inlet. Even though its location close to and often utilized for community activity such as sand mining, a high raining often occur in this location. This monsoon, in fact, causing much material is brought down from Estuary River to the lake, and this affect reducing metal accumulation including zinc in the surface and or sediment along the Estuary River.

The different result was obtained for sample taken from Yahim Beach. Zinc concentrations in sediments in the deep between 0-5 cm and 5-10 cm showed decreasing values. Zinc metal was detected in 34.9329 mg/Kg for sediment taken in 0-5 cm depth. It slightly dropped down to 30.4270 mg/Kg for sample taken from sediment in 5-10 cm depth. However, the zinc concentration went up again at sediment obtained in 10-15 cm depth. It was detected 35.1547 mg/KG of dried sediment sample. In average, for sample in Yahim beach, Zn concentration was calculated in the level 33.5048 mg/Kg. This result basically can be understood that Yahim beach location is a transportation area that many people activity is undergoing in this region. However, zinc concentration in Yahim beach still below the level on that reported in Ifale. Even though many activities undergoing but this location is not the central and high rain often occur in this regions.

The similar fluctuation concentration of zinc was obtained from sediment sample taken from Yoboy location. Zinc concentration indicates a slight fluctuation result in different level
sediment depth. At the upper surface (0-5 cm depth), it was found Zn level reached to 35.9356 mg/Kg of dried sediment sample. It went down to 33.3226 mg/Kg at the deep 5-10 cm, and it went up to 34.5533 mg/Kg at the lowest depth of sediment sampling (10-15 cm). This fact, basically still easily to be understood that decreasing zinc concentration due physical properties of sediment texture. A silty clay and small surface are affect zinc metal attach and accumulate into the sediment surface. In addition, heavy stream of water current in this area also affects interaction of metal with material surrounding. The easily released of metal from the sediment surface is also affected by water turbulence, and this phenomena resulting in separation of metal in diverse locations around the surface.

In overall, the levels of Pb and Zn in the sediments surrounded the Sentani Lake is still under the level that regulated as a Quality of Heavy Metals in Sediments by Environmental Protection Agency Region Va [9]. Heavy metals Pb in the mean total is 3.83 to 27.37 mg/Kg and Zn is 6.69 to 35.04 mg Zn/kg. This shows that the presence of sediment in the Sentani Lake acts as a container for heavy metal and not as a source of contaminants to the water quality of the lake.

CONCLUSION

To summarized, it can be concluded that the average content of heavy metals (Pb and Zn) in sediments at each location in Ifale is 27.3651 mg/Kg and 35.0445 mg/Kg, Estuary River 15.3665 mg/Kg and 28.0115 mg/Kg, in Yahim beach 3.8344 mg/Kg and 33.5048 mg/Kg, and in the Yoboy 6.6873 mg/Kg and 34.6038 mg/Kg, respectively. In general, all location sampling having both Pb and Zn concentration in sediment still below from the value for Standard Quality of Heavy Metals in Sediments by Environmental Protection Agency (EPA Region Va) that maximum is 40 mg/Kg for Pb and 90 mg/Kg for Zn contains in sediment. Four locations close to the Sentani Lake still safe for human and environment protections.

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