Heavy Metal of Lead (Pb) Profile in Water, Sediment and Seagrass (*Thalassia hemprichii*) in Ambon Island

Charlotha I. Tupan¹, E. Y. Herawati², D. Arfiati², Aulanni’am³

¹ Faculty of Fishery and Marine Science, Brawijaya University, Malang, East Java, Indonesia
² Lecturer at the Fishery and Marine Science Faculty, Pattimura University, Maluku
³ Dept. of Chemistry, Faculty of Mathematics and Natural Science, Brawijaya University, Malang 65145, East Java, Indonesia.

Abstract

Differences in the accumulation of lead heavy metal among plant organs (leaves, roots and rhizomes) were examined in the seagrass *Thalassia hemprichii*. Samples were taken from three coastal waters in Ambon Island, with total of nine sampling sites encompassing by seagrass distribution and also based on the land use. Lead heavy metal content was analyzed on the seagrass organs, water and sediment by atomic absoption spectrophotometer. It appeared that leaves, roots and rhizomes of *T. hemprichii* were able to uptake lead from water and sediment. Lead concentration was significantly higher in sediment and roots than water, leave and rhizome. Therefore, roots can be used to determine heavy metal of Pb distribution in coastal waters.

Introduction

Coastal and marine environment pollution has become a global issue, especially in developing countries. Pollution caused by the entry of foreign substances into the environment due to human activities modify the physical characteristic, chemical and biological environment [1]. The impact of these activities on the environment of coastal waters are increasing the amount of waste removed into coastal waters. Heavy metals including hazardous waste is a source of pollution, which are generally toxic. Given their potential adverse effects in the environment, wildlife and human health, they are thus of great concern [2,3].

The ecological risks provoked by metal elements is difficult to assess, due to their complex behavior in marine waters. Metals can be found in colloidal, particulate and dissolved phase, although the concentration of soluble compounds are generally low [4]. Solubility in sea water (including sediment pore waters) the dominant controlled by salinity, pH, sediment type and concentration of the ligand, the oxidation state of the mineral components and the redox potential [5]. Assessment abundance of metals in water and sediment revealed a relatively complete picture of the total burden of contaminants in ecosystems, and numerous attempts have been made to evaluate metal pollution in water and sediments, including interactions [6-10]. However, this approach does not provide enough information about the fraction of available or biologically relevant ecotoxicologically [11]. A suitable alternative for measuring toxic chemical compounds, elements or their metabolites in tissue called biomonitoring, giving the overall appearance and the time-integrated availability of pollutants [2].

Biomonitoring has been widely applied in algae and marine invertebrates, particularly mussels, for the assessment of metal contamination [2,12]. Seagrasses are marine angiosperms that also suitable as metal biomonitoring [13-15]. The fact that they are abundant, widely distributed, long-lived, and easily sampled and identified [16]. In addition, seagrass has a capacity of bioaccumulation of trace metals were high because they interact directly with both the water column (with leaves) and pore water (through the roots), as both the leaves and roots are ion uptake sites [15,17] so that it is becomes a good bioindicator for monitoring heavy metal pollution of a water metal content in plant tissues showed high variability, resulting from the interaction between bioavailability and plant physiology, including the kinetics of uptake and internal translocation between plant parts, either passive or active. Therefore, the metal content can differ substantially between plant organs (usually the leaves, stems or rhizomes and roots). Generally higher metal content in above-ground organs (leaves) than the underground organs (rhizomes and roots), although there are some exceptions [18]. Thus, understanding the accumulation patterns of
different metals in different organs is very important to design the basic biomonitoring programs seagrass and accurate interpretation of the data generated [19].

Seagrass as bioindicator studies have been carried out in the waters outside of Indonesia such as Zostera marina [20], Posidonia Oceanica [17,21,22] and Cymodocea nodosa [23], and in the waters of Indonesia on the species of Cymodocea rotundata [24], while the species of Thalassia hemprichii still rarely investigated while its existence abundant and widespread distribution in the waters of Indonesia especially in the Ambon Island. With respect to the ability of seagrass to absorb and accumulate heavy metals Pb, it is necessary to investigate the heavy metal content of Pb in sea water, sediment and parts of roots, rhizome and leaves of Thalassia hemprichii in the waters of Ambon Island which can be developed as a bioindicator of heavy metal pollution in the sea water.

Method

Study Area and Sampling

Determining the location of this study based on distribution of seagrass, obtained two stations at locations in Ambon Bay: Poka Village and Lateri Village, and one station on the southern Ambon Island is Rutong village (Fig. 1). Determination of research stations and sub-stations at each study site, other than by distribution of seagrass is also based on land use: 1. Poka Village (in Ambon Bay), 1.1. The area around the ferry wharves, 1.2. Territory diesel, 1.3. Residential areas: 2. Lateri village (in Ambon Bay), 2.1. The area around the sedimentation, 2.2. Residential areas, 2.3. Mangrove region: 3. Rutong Village (Southern Ambon Island), 3.1. Areas far from residential, 3.2. The area near the settlement, 3.3. The area near the river.

Seagrass was sampled from each sub stations about 200 meters distance from each other and at three points on each sub-station are the back, middle and front with a distance of approximately 50 meters. From each site, 20 shoots of T. hemprichii including leaves, rhizomes and roots, colected haphazzardly over a plot of 1 m². Shoots were rinsed with seawater in situ to eliminate sediment particle and then packed in plastic bag, transport to the laboratory and frozen until processing. Sediment and water sampling was also conducted on seagrass sampling plots.

Analysis of Lead (Pb) Heavy Metal

For the preparation of metal analysis, seagrass tissue was washed again with sea water to remove resiual sediment and other debris. Rinsing seagrass with distilled water causes premature leaching of metals and other cations [25]. Epiphytes were removed by scraping from the leaf by hand. Seagrass tissue were dried to constant weight at room temperature, then dried in the oven at 100°C for 5 h. Sample were ground in an mortar to obtain a homogenous powder, then weighed as much as 1 g and add 5 ml of 5 M
HNO₃, stirred and heated with a hot plate at 85-95°C. The sample were allowed to cool, and filtered into 50 ml volumetric flask using Whatman no 5 filtered paper, then added distilled water to mark the limits. Sample ready to be analyzed using atomic Adsorption Spectrophotometer (AAS) at a wave length of 283.3 nm. Method and instrument for extraction and lead analysis of sediment and sea water similar to those used for seagrass tissues.

Data Analysis

The results were analysed using a parametric statistical tests factorial ANOVA to examine differences in the content of lead at three locations (village) and nine research stations, with three replicates, and differences of Pb content in the water, sediment and three factors of seagrass organs (roots, rhizome and leaves). If there is a difference, then do Duncan comparison test.

Prior to statistical analyses, data from this study first tested the normality using Kolgomorov-Smirnov test and homogeneity test using Levene test. This test is used to test whether the data have a homogeneous distribution of the error or not. In the results of testing normality and homogeneity of error, it is concluded that the observational data do not meet the assumptions of normality, yet meet the homogeneity error. However, it can be noted that the sample size obtained is large enough, ie 135. When the size is very large, there is a tendency data are robust (strong), which means assuming negligible. To measure the robustness of a data can be tested using Skewness and Kurtosis. The test results can be concluded that the observational data held is robust, so that further observational data can be used in the ANOVA analysis.

Results

The results of the analysis of lead heavy metals in water, sediment, roots, rhizome and leaves of Thalassia hemprichii in 3 villages in waters off Ambon Island (Fig. 2). The results of ANOVA test to analyze differences between the content of lead heavy metals Village, station, water, sediment and plants (roots, rhizome, leaves) can be seen in Table 1.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Village</td>
<td>2</td>
<td>13.74</td>
<td>6.87</td>
<td>0.50</td>
<td>0.610</td>
</tr>
<tr>
<td>Station</td>
<td>2</td>
<td>0.03</td>
<td>0.02</td>
<td>0.00</td>
<td>0.999</td>
</tr>
<tr>
<td>Seagrass</td>
<td>4</td>
<td>5512.35</td>
<td>1378.09</td>
<td>99.64</td>
<td>0.000</td>
</tr>
<tr>
<td>Error</td>
<td>126</td>
<td>1742.72</td>
<td>13.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>134</td>
<td>7268.84</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No significant differences in the content of lead heavy metals inter-village and inter-station as well, while there are significant differences in the water, sediment and Thalassia hemprichii (root, rhizome, leaves), at the level of 95% (α = 0.05). Lead heavy metal of the three location on the Ambon Island showed almost the same in water, sediment and seagrass, because utilization in each village there are potentially produce lead. The content of heavy metals Pb differ on water, sediment and seagrass (root, rhizome, leaves).

According to Duncan's multiple test (Table 2) there was no significant difference between the rhizome and leaves, but there is a difference between the rhizome and water. In addition, there are significant differences between the leaves and sediment, and between roots and sediment. Furthermore, it can be concluded also that the lowest Pb content generated on the water, while the highest are at the root. Furthermore, it appears also that the average content of Pb resulting in sediment and roots relatively large.
Table 2. Duncan test for Pb content

<table>
<thead>
<tr>
<th>Water, sediment and seagrass</th>
<th>N</th>
<th>Mean</th>
<th>Duncan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>27</td>
<td>0.0978</td>
<td>a</td>
</tr>
<tr>
<td>Rhizome</td>
<td>27</td>
<td>6.5667</td>
<td>b</td>
</tr>
<tr>
<td>Leaves</td>
<td>27</td>
<td>7.7185</td>
<td>b</td>
</tr>
<tr>
<td>Sediment</td>
<td>27</td>
<td>15.0441</td>
<td>c</td>
</tr>
<tr>
<td>Roots</td>
<td>27</td>
<td>18.0567</td>
<td>d</td>
</tr>
</tbody>
</table>

Figure 2. Pb content in waters, sediment, roots, rhizomes and leaves in three sampling location in Ambon Island

Discussion

Concentrations of Pb heavy metal in the three village have the same trends relatively in water, sediment and seagrass organs. High concentrations of Pb in sediment and seagrass roots and low on the water. The low concentration of Pb in water is possible because the heavy metals in the water undergoes a process of dilution with the pattern of tidal currents and will settle to the sediment. Heavy metals dissolved in the water will move into the sediment when bonded to organic matter that coats the surface of the sediment, and direct absorption by the surface particle sediment. Further this author remarked that due to the movement of suspended sediment easier time water will dissolve the metal back into the water it contains, so the sediment becomes a potential pollutant sources within a certain time scale. The presence of Pb in the Ambon island waters thought to have come from community activities such as, waste from electricity generation diesel power, pertamina depot, repair and painting from ships and transportation as well as domestic waste and sedimentation carried in the water and settle in the sediment.

Distribution of trace metals in different organ of the seagrass has been reported by several authors. For example, Pergent-Martini [26] and Pergent & Pergent-Martini [13] observed a maximum Hg accumulation in the green blade of *Posidonia oceanica*. This preferential accumulation was interpreted as an indication of high level of contaminants in the water column of the sampling sites. It showed that Cd in
seawater were concentrated in the leaves of *Thalassia testudinum* and transported through a basipetal translocation to the root system. In the present study lead exposition occurred through sediments, and hence that the higher metal accumulation were in the roots.

Pb concentrations were higher in roots than leaves as found also on the seagrass *Zostera capricorni* \(^{(27)}\) and *Cymodocea nodosa* \(^{(19)}\). Marin-Guirao *et al.* \(^{(28)}\) also found higher concentrations of Pb in the roots compared to the leaves of *Cymodocea nodosa*, and explained that the leaves of *C. nodosa* absorb Pb from the water when the availability of Pb in sediments low. Guilizzoni \(^{(5)}\) pointed out that aquatic angiosperms extract nutrients and heavy metals mostly from sediments via root hairs, with subsequent translocation to the upper parts. He has describe that most aquatic species have a well-developed vascular system; in consequence basipetal and acropetal water flow may occur for transport of ions through the xylema.

Heavy metals such as Pb, in a body part of water will be transferred from the body of water through the deposition process, the adsorption and absorption \(^{(1)}\), so that implies the water is relatively small compared to the sediment and seagrass. The content of Pb bound to organic matter and will be deposited in sediments and absorbed by seagrass, led to a high concentration in sediment and seagrass.

**Conclusion**

The results of Pb heavy metal content in the water, sediment and organ parts (roots, rhizome, leaves) of seagrass in the waters of Ambon Island showed that the accumulation of Pb in sediment and seagrass organ. Sediment very representative in describing the status of the water pollution. Additionally, the concentrations of Pb heavy metal and it accumulation pattern in this seagrass may reflect the concentration and the bioavailability of the Pb heavy metal in Ambon Island waters. Thus Thalassia hemprichii may have application as indicator organism of Pb heavy metal contamination and bioavailability in seawater.

**References**


