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CONCENTRATION OF HEAVY METALS ON ROOTS, STEM AND LEAVES OF *Enhalus acoroides*, IN TUNDA ISLAND, BANTEN BAY

KONSENTRASI LOGAM BERAT PADA AKAR, BATANG DAN DAUN Enhalus acoroides, DI PERAIRAN PULAU TUNDA, BANTEN

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ABSTRACT

Heavy metal pollution is one of serious problem for tropical mangrove ecosystem. Heavy metals can decrease the quality of a waters. The decreasing in water quality can caused by pollutants such as heavy metals with high concentrations greatly affects the aquatic environment, especially living organisms. The aimed of study is to determine the accumulation level of heavy metals such as Al, Cu, Pb, As, Ni, Cr, Ti, Mn, dan Fe, in root, leaves and stem of *E. acoroides*. The sampling was carried out in the northern and southern parts of Tunda Island, in March 2015. The method used for seagrass destruction is 6 mL 65% HNO_3 and mL H_2O_2 30%, sediment destruction using Milestone Start D microwave labstation. and using ICP-OES (Inductive Coupled Plasma-Optical Emission Spectrometry) Thermo Scientific iCAP 700 Series. The result show that, the Al, was the dominant heavy metals observed both in sea water and sediment surrounding the observed sea grass areas. Similar result was also observed for seagrass. The dominant sediment grain size absorbing heavy metals is silt-clay because it has more organic matter to control the binding of heavy metals. Heavy metal bioaccumulation is predominant in seagrass leaves and stems due to heavy metal entry into seagrass, substance storage tissue, and seagrass characteristics that are completely submerged in water. Seagrass meadow ecosystem in Tunda Island has been contaminated by several heavy metals.

Keywords: pollution, tropical ecosystem, mangrove, seagrass

ABSTRAK

Pencemaran logam berat adalah salah satu masalah serius bagi ekosistem bakau tropis. Logam berat dapat menurunkan kualitas perairan. Penurunan kualitas perairan yang diakibatkan oleh zat pencemaran seperti logam berat dengan konsentrasi yang sangat tinggi mempengaruhi lingkungan akuatik, terutama organisme hidup. Tujuan penelitian adalah untuk menentukan tingkat akumulasi logam berat seperti Al, Cu, Pb, As, Ni, Cr, Ti, Mn, dan Fe, di akar, daun dan batang E. acoroides. Pengambilan sampel dilakukan di bagian utara dan selatan Pulau Tunda Banten pada Maret 2015. Metode yang digunakan untuk destruksi lamun yaitu 6 mL HNO_3 *65% dan mL* H_2O_2 *30%, destruksi sedimen menggunakan* Milestone Start D microwave labstation, dan ICP-OES (Inductive Coupled Plasma-Optical Emission Spectrometry). *Hasil menunjukkan bahwa, Al adalah logam berat dominan yang diamati baik di air laut maupun sedimen di sekitar rumput laut. Hasil serupa juga ditemukan untuk lamun. Ukuran butiran sedimen dominan yang menyerap logam berat adalah lanau lempung karena memiliki lebih banyak bahan organik untuk mengontrol pengikatan logam berat. Bioakumulasi logam berat dominan pada daun dan batang lamun, karena masuknya logam berat ke lamun, jaringan penyimpanan zat, dan karakteristik lamun yang terendam sepenuhnya dalam air. Ekosistem padang lamun di Pulau Tunda telah terkontaminasi oleh beberapa logam berat yang melewati tingkat tercemar.*

Kata kunci: *polutan, ekosistem tropis, mangrove, lamun, logam berat*

I. INTRODUCTION

Heavy metal pollution is a serious problem that occurs in sea waters. Heavy metal pollution caused disorder in humans, ecosystems and organisms as well as a decrease in the quality of sea waters. Declining in sea water quality can be caused by contaminants such as heavy metals with a high concentration of highly impact to the aquatic environment, especially living organisms (Siaka, 2008). Heavy metal is a metal element with a density greater than 5 g / cm^3 (Wang *et al.,* 2009). Heavy metals can be absorbed by living organisms through biological processes and eventually accumulate in their body.

One indicator of environmental disturbance at sea water is the content of heavy metals in coastal waters derived from natural or industrial activities. The coastal area relatively close to the anthropogenic activity such as industrial activities in the Banten Bay Region. It becomes a potential contribution of contamination hence, they may alter the quality of water each year in Pulau Tunda (Riska *et al.,* 2015). Tunda Island is the outermost area of Serang Regency located at 106050 '00 '- 105051’51 "BT and 5056'15" -5059'00 "LS in Banten Bay. Tunda Island is surrounded by edge reefs that grow in depths of 1 to 25 meters. The eastern part of Tunda Island is calm moving water with visibility reaching 10 meters. This area is very suitable for diving and snorkeling activities. This area has high diversity of coral reef organism. Coral growth is relatively good. Zamani *et al.* (2016), showed the average growth rate of corals *P. lutea* at southern part of Tunda Island was 1.11 cm/year, while in the north part was 1.20 cm/year. Riska *et al.* (2015) found the presence of heavy metal deposits in the *P. lutea* coral skeleton in the northern and southern part of Tunda Island with an average concentration of 9.69 mg kg-1 / year and an average of 13.33 mg kg-1 / year. The results of this study indicate the presence of heavy metal content in the Tunda Island waters.

The content of heavy metals accumulated in sea water and sediment will enter into food chain system of organism and affect the life of the organism (Said *et al.,* 2009). Heavy metals enter into the seagrass through two ways. The first way is coming from surrounding seawater around the seagrass, then enter into the tissue of seagrass leaf, and headed to the rhizomes. The second way, heavy metals can be derived from the translocation acropetal water in the sediment into the roots and then headed to the leaves of seagrass (Larkum *et al.,* 2006). *E. acaroidess* is one of seagrases known to have the ability to absorb heavy metals both from sea water and sedimen. *E. acaroides* are highly abundant on Tunda island. These species grow on muddy substrate and in the murky waters, which form a single or dominating seagrass communities (Azkab, 2000). The aims of study is to determine the concentration of heavy metals in sea water, sediment, and seagrass (leaves, stems and roots) *E. acoroides*.

II. MATERIALS AND METHODS

2.1. Time and Place

The samples of sedimen and sea grass *E. acoroides* were taken in the northern (windward) and southern (leeward) part of Tunda Island, Banten Bay (Figure 1) on 20-22 March 2015, while the sample of sea water were taken on 26 June 2015. Sampling was carried out in the north and south of Tunda Island (Figure 1). A 100 gram of Sea grass samples was taken randomly at each of 3 sampling point. A 250 g sediments was also taken at the same location. Analysis of sediment and seagrass were conducted at Laboratory of Natural Resources and Environment, Center for Isotope and Radiation Applications (PAIR), National Nuclear Energy Agency (BATAN), Jakarta.

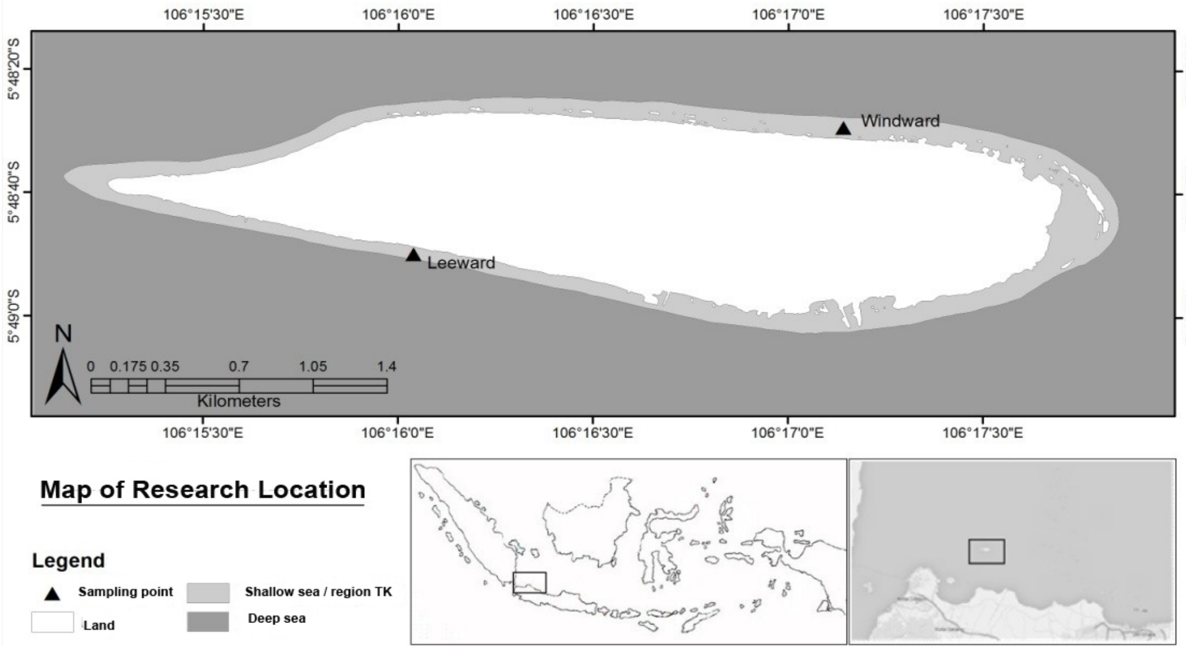

Figure 1. Sampling sites in the waters of Tunda island, Banten province.

As much as 250 mL water samples were taken at each of 5 random points both in the north and south of Tunda Island. This water sample was brought using a cooler box containing ice cubes and analyzed at PT. Intertek Utama Services.

2.2. Sample Preparation

Sample preparation of seagrass and sediment respectively start from cutting root, stem and leaves of seagrass with scissor and collecting separation sample of sediment grain classification results. Each of these samples, both for seagrass and sediment were weighed 3 grams for seagrass and 0.2 grams for sediment. The destruction of sea grass using 6 mL HNO_3 65%, and 2 mL H_2O_2 30% (Milestone, 2009), while the destruction of sediment using 9 mL $HNO_3$65%, and 3 mL HCl 37% (US-EPA, 2007). The destruction was enhanced and accelerated using a Milestone Start D microwave digester lab station.

Preparation of water samples was carried out at PT. Intertek Utama Services. The five bottles of each water sample of 250 ml were mixed into one. Then 500 ml was taken and submitted to the analyst of PT. Intertek Utama Services for further analysis.

2.3. Measurement of Heavy Metal Concentration

Heavy metals were analysed using ICP-OES (Inductive Coupled Plasma - Optical Emission Spectrometry) 700 Series Thermo Scientific ICAP. The metals which analysed were Cu, Pb, As, Cr, Ni, Ti, Mn, Zn, Fe and Al. The value obtained from ICP-OES then substituted into the formula to calculate the concentrations of heavy metals. The formula for computing the metal concentration levels, namely:

$$\text{Concentration (ppm)}=\frac{C\times V\times D}{S} \quad \ldots\ldots\ldots\ldots (1)$$

Explanation: C : Heavy metal intensity of ICP-OES (mg / l); V : Total volume of solution (mL); D : Dilution factor (sediment = 5 and seagrass = 2); S : Weight of the sample is weighed (g) (US-EPA, 2007).

2.4. Statistic Analysis

Accumulation of heavy metals is calculated by the Bioconcentration Factor (BCF), and translocation factors (TF) in seagrass *E. acoroides* (leaves, stem, root) are carried out using the formulas Ghosh and Singh (2005), as follows:

$$BCF = \frac{\text{Heavy metals Al, Cu, Pb, As, Ni, Cr, Ti, Zn, Fe and Mn, in seagrass E. accoroides}}{}\text{Concentration in sediments}$$

$$TF = \frac{\text{BCF leaves and stems}}{\text{BCF root}} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Calculation of bioconcentration factor (BCF) and translocation factor (TF) is done to assess whether seagrass can be categorized as an accumulator. Data on bioconcentration and translocation factors were tabulated using Microsoft Excel and presented in table format.

MANOVA Analysis and Spearman Correlation using SPSS version 21. The value of the correlation equation according to Sugiyono (2005), with the value of the coefficient interval as follows:

Table 1. Correlation intervals and relationship rate between factors.

No	Interval Koefisien	Relationship Level
1	0.00-0.199	Very low
2	0.20-0.399	Low
3	0.40-0.599	Normal
4	0.60-0.0799	Strong
5	0.80-1.00	Very strong

Sumber: Sugiyono (2005).

III. RESULT AND DISCUSSION

3.1. Heavy Metal in Sea Water

Table 2. showed the result of heavy metal concentration in northern and southern part of Tunda island water. The consentration of Zn, Fe and Al were much higher compared to Cu, Pb, As, Ni, Cr, Ti and Mn.

Based on the concentration of heavy metals Cu, Pb, As, Ni, Cr, Ti, Mn, Zn, Fe and Al (Table 2) in the highest water in the northern and southern waters of Tunda Island are Al 0.210 mg/L and Fe 0.192 mg/L at the northern station, while at the southern station shows that the highest heavy metal concentration values at Fe 1,350 and Al 0.160. The existence of environmental activities in the northern and southern regions of Pulau Tunda affects the high concentration values of the two metals.

The height of the two heavy metals in the two stations is thought to be related to the influence of anthropegenic factors from land to sea, as well as the activities of ship traffic and sand mining around these waters. Sand mining activities in the northern part of the island are one of the activities that might affect higher concentrations of heavy metals Fe and Al on Tunda island (Riska *et al.*, 2015). The concentration of heavy metals can be influenced by the entry of waste containing heavy metals such as industrial waste, domestic waste and agricultural waste (Darmono, 1995). This is because the source of heavy metal pollution comes from two sources (Ridhowati, 2013).

Table 2. Metal content in water at the northern and southern part of Tunda Island.

Heavy Metal	Concentration Heavy Metal in Water	
	North	South
Tembaga (Cu)	0.00200 ± 0.000346	0.001 ± 0.0002
Timbal (Pb)	0.00300 ± 0.000361	0.002 ± 0.000458
Arsenik (As)	0.00180 ± 0.0002	0.0016 ± 0.002081
Nikel (Ni)	0.00100 ± 0.000265	0.001 ± 0.0004
Kromium (Cr)	0.00100 ± 0.000458	0.001 ± 0.000265
Talium (Ti)	0.00500 ± 0.005303	0.005 ± 0.002

Heavy Metal	Concentration Heavy Metal in Water	
	North	South
Mangan (Mn)	0.01500 ± 0.005196	0.009 ± 0.003606
Seng (Zn)	0.07700 ± 0.017521	0.063 ± 0.024637
Besi (Fe)	0.19200 ± 0.05246	0.135 ± 0.039051
Alumunium (Al)	0.21000 ± 0.04	0.16 ± 0.034641

The high iron (Fe) content in the waters is thought to be caused by the Fe content originating from several sources, that is, aside from the soil, it also comes from human activities that occur on land, namely iron-containing household waste, iron water reservoirs, sediment industrial waste deposits and corrosion from water pipes containing iron metal carried by water flow to the waters as well as estuaries (Supriyantini and Endrawati, 2015).

3.2. Heavy Metals in Sediments

Table 3. showed heavy metal concentration in sediment at northern and southern part of Tunda island. The consentration of Zn, Fe and Al were much higher compare to Cu, Pb, As, Ni, Cr, Ti, Mn, Zn, and Al.

Table 3. metal content in sedimen at the northen part of Tunda Island.

Heavy Metal	North Station	
	Sand	Clay
Tembaga (Cu)	0.009 ± 0.001732	0.020 ± 0.005
Timbal (Pb)	0.002 ± 0.001323	0.005 ± 0.001732
Arsenik (As)	0.002 ± 0.000917	0.002 ± 0.001114
Nikel (Ni)	0.002 ± 0.000436	0.004 ± 0.001442
Kromium (Cr)	0.004 ± 0.001803	0.009 ± 0.001732
Talium (Ti)	0.022 ± 0.002646	0.059 ± 0.024637
Mangan (Mn)	0.022 ± 0.004359	0.045 ± 0.010817
Seng (Zn)	0.020 ± 0.004359	0.044 ± 0.016523
Besi (Fe)	1.252 ± 0.347279	3.077 ± 0.233082
Alumunium (Al)	2.535 ± 0.191502	6.793 ± 0.909649

Table 4. metal content in sedimen at the sourthen part of Tunda Island.

Heavy Metal	South Station	
	Sand	Clay
Tembaga (Cu)	0.00837 ± 0.00162	0.031343 ± 0.011837
Timbal (Pb)	0.001723 ± 0.000673	0.002736 ± 0.001555
Arsenik (As)	0.0032 ± 0.001638	0.003682 ± 0.044103
Nikel (Ni)	0.001723 ± 0.000718	0.00199 ± 0.000702
Kromium (Cr)	0.005662 ± 0.000571	0.034826 ± 0.083626
Talium (Ti)	0.008616 ± 0.00825	0.022388 ± 0.013977
Mangan (Mn)	0.034712 ± 0.011268	0.054726 ± 0.012655
Seng (Zn)	0.023403 ± 0.016523	0.072388 ± 0.027895
Besi (Fe)	0.814 ± 0.205672	1.234 ± 0.51643
Alumunium (Al)	0.882 ± 0.334018	2.586 ± 0.877439

There are two classification of sediment in Tunda island i.e sand and silt loam/clay. Overall concentrations of heavy metals in the clay sediment is relatively higher than in sandy sediment for both the southern and northern parts of Tunda island because the relatively former sediment due to their large surface area can bind metals more than in the sand. There were no significant differences of heavy metals concentration of Cu, Pb, As, Ni, Cr, Ti, Mn and Zn in the sandy sediment of northern to southern part of Tunda island. Generally, the heavy metal in clay sediment was higher compared to sandy sediment for both site observation. Al (6.79 mg/) was the highest concentration of heavy metal detected in clay sediment at the northern part of Tunda island. The second highest was Fe (3.077 mg/L) in clay sediment at the northern part of Tunda island (Table 3),while the southern stations the highest heavy metal concentrations were in Fe 1,234 and Al 2,586 (Table 4).

Based on Table 3 and 4, shows that the concentration of heavy metals Fe and Al were higher in the clay sediment compare to sandy sediment both for northern and southern part of Tunda island. The dominant sediment grain size to absorb heavy metals are silt-clay. This is due to the size of the substrate finer silt-clay that has more organic matter content. The organic material is the most important geochemical components in controlling the binding of heavy metals from the substrate (Thomas and Young, 1998). These results were consistent with research conducted by the (Sahara, 2009) in which the higher heavy metal content substrate found in smaller size. Smooth substrate particles have a more stable ion density to bind metal particles compared to larger substrates. That is, the content of heavy metals will be growing with increasing the fine sediment grain size (Sahara, 2009). According to Said *et al.* (2009), increased heavy metal content in sea water and sediment will be entered into the system food chain and affect the life of the organism.

3.3. Heavy Metals in Leaves, Stem and Roots of Seagrass *E. acoroides*

The results of data processing obtained a diagram showing the concentration of ten types of heavy metals in the vegetation structure of *E. acoroides* (roots, stems and leaves) in the waters of Tunda Island.

Table 5. Heavy metal concentration on leaf, steam and root of *E. acoroides* at northern part of Tunda Island.

Heavy Metal in *E. acoroides*	North Station		
	Leaf	Stem	Root
Tembaga (Cu)	0.001 ± 0.001114	0 ± 0	0 ± 0
Timbal (Pb)	0 ± 0	0 ± 0	0 ± 0
Arsenik (As)	0.002 ± 0.000721	0 ± 0	0 ± 0
Nikel (Ni)	0 ± 0	0 ± 0	0 ± 0
Kromium (Cr)	0 ± 0	0 ± 0	0 ± 0
Talium (Ti)	0 ± 0	0.001 ± 0.001	0.001 ± 0.0004
Mangan (Mn)	0.005 ± 0.001179	0.001 ± 0.0002	0.020 ± 0.015395
Seng (Zn)	0.016 ± 0.009539	0.011 ± 0.001732	0.004 ± 0.001323
Besi (Fe)	0.099 ± 0.087023	0.036 ± 0.014	0.063 ± 0.033867
Alumunium (Al)	0.054 ± 0.038301	0.042 ± 0.018358	0.076 ± 0.023896

Table 6. Heavy metal concentration on leaf, steam and root of *E. acoroides* at southern part of Tunda Island.

Heavy Metal	South Station		
	Leaf	Stem	Root
Tembaga (Cu)	0.001 ± 0.001	0 ± 0	0 ± 0
Timbal (Pb)	0 ± 0	0 ± 0	0 ± 0
Arsenik (As)	0 ± 0	0 ± 0	0 ± 0
Nikel (Ni)	0 ± 0	0 ± 0	0.001 ± 0
Kromium (Cr)	0.001 ± 0	0.001 ± 0.001	0.001 ± 0.001
Talium (Ti)	0.001 ± 0.001	0 ± 0	0.001 ± 0
Mangan (Mn)	0.004 ± 0.001732	0.002 ± 0.001732	0.001 ± 0
Seng (Zn)	0.130 ± 0.067639	0.010 ± 0.006245	0.007 ± 0.002
Besi (Fe)	0.069 ± 0.02358	0.128 ± 0.007	0.088 ± 0.055758
Alumunium (Al)	0.102 ± 0.05246	0.249 ± 0.027495	0.130 ± 0.10018

Based on table 5, it shows that the concentration of heavy metals Cu, Pb, As, Ni, Cr, Ti, Mn, Zn, Fe and Al are mostly found in seagrass organs *E. acoroides* namely Fe and Al, both in roots, stems and leaf. The value of the range of heavy metals Fe 0.099 mg/L and Al 0.054 mg/L in leaves, Fe 0.036 mg/L and Al 0.042 mg/L in the stem and Fe 0.063 mg/L and Al 0.076 mg/L in the roots at the northern station. While the concentration of other metals has a low value. Seagrass leaves are a place for absorption of nutrients through the water column, but in the seagrass leaves there is no stomata but thin cuticles, thus affecting the low metal concentration value. The cuticle serves to absorb nutrients, although in lesser amounts than those absorbed by the roots (Tomasick *et al*., 1997). The concentration of heavy metals found in water and substrate does not affect the size of the concentration of heavy metals in parts of seagrass plants (Nugraha *et al.,* 2017). Although the most dominant heavy metals in sediments and seawater are aluminum, this does not affect the size or concentration of heavy metals in seagrass. For example, seagrass in the southern part has the highest concentration of Zn in the leaf.

Table 6 shows that the highest concentration of heavy metals is found in the leaves and roots of *E. acoroides*, namely Zn 0.130 mg/L and Al 0.130 mg/L at the southern station. Three of the ten types of heavy metals in seagrass southern Tunda Island have a more dominant concentration in seagrass *E. acoroides*. The presence of bioaccumulation of heavy metals in the stem can also occur because in the part of the seagrass stem there is a cortical network consisting of colenchymal and parenchymal tissue. These networks function as the basic network for filling and storing substances such as heavy metals (Nugraha *et al.,* 2017). In addition, according to Ahmad *et al.* (2015), the location of seagrass submerged entirely in water can affect the bio-accumulation location of heavy metals in plant structures.

According to Larkum *et al.* (2006), the bioaccumulation process of heavy metals in seagrass is influenced by several factors, namely sediment and water, types of sediment particles, redox reactions, dissolved organic matter and seasonal patterns. Bioaccumulation of heavy metals in seagrass leaves can occur because the epidermal tissue of seagrass leaves can have the ability to absorb heavy metals from the water column. Hutagalung (1991), that heavy metals that enter the water environment will experience deposition, dilution and dispersion, then absorbed by organisms that live in these waters. Sedimentation in sediments is also absorbed by seagrass roots by taking nutrients by the roots of sediments (Short, 1987).

The condition of seagrass vegetation structure, the most bioaccumulation of heavy metals occurs in leaves (north) and roots (south). This can be caused by the entry of heavy metals into seagrass. According to Larkum *et al.* (2006), heavy metals enter seagrass through two paths, from the surrounding seawater which enters seagrass leaf tissue and then goes to the rhizoma or comes from the translocation of acropetal water in the sediment that enters the root and then into seagrass leaves.

3.4. Bioconcentration Factor Value (BCF) and Translocation Factor (TF)

The results of the bioconcentration test (BCF), obtained the highest heavy metal BCF value at the northern station are Zn 36364, As 1.00000 and Mn 0.11111 on the leaves of *E. acoroides*. The highest BCF value in seagrass stem are Zn 0.25000, Mn 0.02222, Ti 0.01695 and the highest BCF value are Mn 0.44444, Zn 0.09091, Ti 0.01695 at the root part. While the metal BCF values of Ni, Pb, Cr, are very low in all three parts of *E. acoroides*. The BCF value can be seen in Table 7.

The highest BCF values of heavy metals in seagrasses at the southern part are Zn 1.79588, Ti 0.04467, Mn 0.07309 and Cr 0.02871 on leaves. Heavy metal BCF in Zn 0.13814, Mn 0.03655 and Cr 0.02871, whereas in the roots, the highest BCF values are Ni 0.50251, Zn 0.09670, Ti 0.04467, Cr 0.02871 and Mn 0.01827. This value can be seen in Table 8.

Table 7 shows that the largest bioconcentration range was found in the leaf part was arsenic (A s) 1.00000 mg/l at the northern station, followed by the Zinc (Zn) 0.36364 and Manganese (Mn) 0.11111 values. This shows that between leaves, stems and roots of *E. acaroides* the highest accumulation of metals observed in leaves (Zn). Seagrass accumulates heavy metals directly from the waters through its body surface so that heavy metals are also concentrated in the leaves and stems. In contrast to land plants, the leaves of aquatic plants such as seagrass have the ability to absorb heavy metals and water soluble substances in the waters through cuticles and stomata (Ahmad *et al.*, 2015).

Table 7. Bioconcentration factor value (BCF) in *E. acoroides* seagrass to north station.

Observation	North Station		
	Leaves (mg/L)	Stems (mg/L)	Root (mg/L)
Tembaga (Cu)	0.05000	0.00000	0.00000
Timbal (Pb)	0.00000	0.00000	0.00000
Arsenik (As)	1.00000	0.00000	0.00000
Nikel (Ni)	0.00000	0.00000	0.00000
Kromium (Cr)	0.00000	0.00000	0.00000
Talium (Ti)	0.00000	0.01695	0.01695
Mangan (Mn)	0.11111	0.02222	0.44444
Seng (Zn)	0.36364	0.25000	0.09091
Besi (Fe)	0.00003	0.00001	0.00002
Alumunium (Al)	0.00001	0.00001	0.00001

Table 8. Bioconcentration factor value (BCF) in *E. acoroides* seagrass to south station.

Observation	South Station		
	Leaves (mg/L)	Stems (mg/L)	Root (mg/L)
Tembaga (Cu)	0.03191	0.00000	0.00000
Timbal (Pb)	0.00000	0.00000	0.00000
Arsenik (As)	0.00000	0.00000	0.00000
Nikel (Ni)	0.00000	0.00000	0.50251
Kromium (Cr)	0.02871	0.02871	0.02871
Talium (Ti)	0.04467	0.00000	0.04467
Mangan (Mn)	0.07309	0.03655	0.01827
Seng (Zn)	1.79588	0.13814	0.09670
Besi (Fe)	0.00006	0.00010	0.00007
Alumunium (Al)	0.00004	0.00010	0.00005

Heavy metals in the water can be absorbed and accumulate in leaf tissue through a passive absorption process (Tupan, 2014). These results are in accordance with Supriyantini *et al*. (2016) states that pollution detection can be done, one of which is by conducting studies on seagrass leaves. The high BCF in the leaves, is estimated the size of the leaf surface of *E. acoroides* which attracts metal deposits in the water column and sediment. In addition, the large translocation factor of rhizoma *E. acoroides* can help transform metals from the substrate (roots) to the leaves.

BCF values of all metals in the stem and root at north station <1. This shows that the stem and root do not accumulate much heavy metals Cu, Pb, As, Ni, Cr, Ti, Mn, Fe, Zn and Al from the sediment, compared to leaf. Seagrass *E. acoroides* is a bioaccumulator category because it lives in complex open waters with anthropegenic influences from land. According to Baker and Brooks (1989) states that, seagrass plants are able to accumulate heavy metals up to > 1000 mg/kg and are known as hyperaccumulators.

On the other hand, the average value of BCF from accumulation of heavy metals in *E. acoroides* and sediments is very low, because the range of weight values obtained has the same magnitude, so that the results of the division with others produce low values. Therefore, the category of conditions of *E. acoroides* and substrate waters in the northern station, cannot be categorized as bioaccumulator because it has a translocation value <1. Plants that have a BCF value> 1 are heavy metal bioaccumulator plants.

The BCF value in table 8 shows that at the southern station not all heavy metals have bioconcentration in the roots, stems and leaves in *E. acoroides* such as Pb and As. While heavy metals Zn and Ni are heavy metals with the largest bioconcentration in leaves and roots, compared to other metals found in *E. acoroides*. The high value of Zn 1.79588 and Ni heavy metals is 0.50251, the southern station is suspected by sand mining and anthropogenic factors that enter from land to sea. According to (Tupan, 2014), seagrass is a marine plant that has a high capacity to absorb heavy metals because it interacts directly with water columns (through leaves) and with sediments (through roots), so that the leaves and roots are good absorbers of metal ions.

Seagrass roots are part of morphology which has two main functions to support the establishment of seagrass above the sediment and absorb water and minerals from the substrate (Radulescu *et al*., 2013). In roots, Zn and Ni accumulate especially in endodermic and exodermic tissues. In addition, the network has an important role in protecting plants from stress due to heavy metals (Tupan and Azrianingsih, 2016).

Research on the accumulation of Zn (zinc) heavy metals in Seagrass *E. acoroides* and Thalassia hemprichii in the coastal waters of Jepara Kartini, showed that the highest BCF value in seagrass *E. acoroides* was at the root of 2.1 and in *T. hemprichii* seagrass was 1.21. The results of the study by Ismarti *et al.* (2017) explained that the average BCF values of roots and seagrass leaves of *E. acoroides* for Pb heavy metals were 1.44 and 1.76, while the average BCF Cd in seagrass roots and leaves was 3.77 and 4.48. Supriyantini *et al.* (2016) states that BCF values prove that seagrasses can absorb and accumulate heavy metals.

The translocation value (TF) on leaves and stems shows a range of values > 1 in some heavy metals in the northern stations namely Zn, 4.00000, Fe, 1.57140, and Ti 1.00000, Zn, 2.75000 (table 9).

The TF value in the southern station has a range of values of Cr, 1.00000, Ti, 1.00000, Mn, 4.00000, Zn, 18.5714 in leaves, while in the rod has a range of values of Cr, 1.00000, Mn, 2.00000, Zn, 1.42860, Fe, 1.45450 and Al, 1.91540 (table 8). This is because seagrasses have tissue or morphological parts that can be used as bioaccumulators and bioindicators of pollution of heavy metals from waters and sediments (Ahmad *et al.*, 2015). Plants that have a value of bioconcentration and translocation factors > 1 can be used as bioaccumulators (Usman *et al.*, 2013). Differences in TF values indicate that the translocation of heavy metals Cr, Ti, Mn, Fe and Zn, to roots to leaves and seagrass stems *E. acoroides* is large enough to be categorized as a hyperaccumulator plant because it can accumulate high concentrations of heavy metals. According to (Baker *et al.*, 1989), hyperaccumulators because hyperaccumulator plants can accumulate high concentrations of heavy metals in plant tissues (above ground) when found in natural habitats. TF values in observations at north and south stations can be seen in tables 9 and 10. Passive absorption processes, heavy metal translocation in seagrass bodies also occur through active transport until metals accumulate above the body such as leaves, stems and flowers. The ability to add or retrieve pollutants by living things from the environment through a mechanism or trajectory, as do seagrasses, is a form of bioaccumulation (Supriyantini *et al.*, 2016).

Table 9. Translocation Factor Value (TF) in *E. acoroides* seagrass to north station.

Observation	North Station	
	Root-Leaves (mg/L)	Root-Stems (mg/L)
Tembaga (Cu)	0.00000	0.00000
Timbal (Pb)	0.00000	0.00000
Arsenik (As)	0.00000	0.00000
Nikel (Ni)	0.00000	0.00000
Kromium (Cr)	0.00000	0.00000
Talium (Ti)	0.00000	1.00000
Mangan (Mn)	0.25000	0.05000
Seng (Zn)	4.00000	2.75000
Besi (Fe)	1.57140	0.57140
Alumunium (Al)	0.71050	0.55260

Table 10. Translocation Factor Value (TF) in *E. acoroides* seagrass to south station.

Observation	South Station	
	Root-Leaves (mg/L)	Root-Stems (mg/L)
Tembaga (Cu)	0.00000	0.00000
Timbal (Pb)	0.00000	0.00000
Arsenik (As)	0.00000	0.00000
Nikel (Ni)	0.00000	0.00000
Kromium (Cr)	1.00000	1.00000
Talium (Ti)	1.00000	0.00000
Mangan (Mn)	4.00000	2.00000
Seng (Zn)	18.5714	1.42860
Besi (Fe)	0.78410	1.45450
Alumunium (Al)	0.78460	1.91540

3.5. Correlation Analisis

Correlation analysis or analysis of the relationship between physicochemical parameters and metal concentration values in Enhalus accoroides seagrass using spearman correlation analysis with the help of SPSS Statistics 24 software. The level of relationship in this analysis is expressed in the correlation index value (0-1), while the correlation index value is reference value to interpret the level of correlation between environmental parameters (sediment and water) and seagrass *E. acoroides* (Sugiyono, 2005).

Table 11. Correlation test results for heavy metal content in *E. acoroides* seagrass at north station.

Spearman Correlation Test	Test Pair	Sig (2-tailed)	Correlation
North station	Leaves and Sediments in the North	0.740	Strong
Seagrass *E. acoroides*, and environmental parameters (sediment and water)	Leaves and Water in the North	0.922	Very strong
	Stems and Sediments in the North	0.933	Very strong
	Stems and Water in the North	0.996	Very strong
	Roots and Sediments in the North	0.955	Very strong
	Root and Water in the North	0.970	Very strong

Table 12. Correlation test results for heavy metal content in *E. acoroides* seagrass at south station.

Spearman Correlation Test	Test Pair	Sig (2-tailed)	Correlation
Seagrass *E. acoroides*, and environmental parameters (sediment and water)	Leaves and Sediments in the south	0.982	Very strong
	Leaves and Water in the south	0.9718	Very strong
	Stems and Sediments in the south	0.999	Very strong

Spearman Correlation Test	Test Pair	Sig (2-tailed)	Correlation
	Stems and Water in the south	0.933	Very strong
	Roots and Sediments in the south	0.987	Very strong
	Root and Water in the south	0.956	Very strong

The correlation test results in Table 11 show a strong relationship between environmental factors both sediment and water with lamum stem and leaf roots. Seagrass is the only marine plant that lives on the substrate and column of water. The high correlation value in each variable at the northern station is estimated, related to seagrass habitat on the substrate and its presence in the water column that causes seagrass is closely related to heavy metals in certain waters. The amount of heavy metal concentration in each part of the morphology differs depending on the environmental conditions and physiology of seagrass. According to (Llagostera *et al.*, 2011), seagrass physiology determines the ability of a part to store or accumulate heavy metals. In the body of seagrass metal transport takes place actively and passively. Seagrass absorbs and accumulates heavy metals simultaneously because the entire body is submergeed in water so that the metallic cosmetry in each part of the morphology is different (Ahmad *et al.*, 2015).

The high content of heavy metals in parts of seagrass when compared to water and sediments shows that seagrass accumulates metals originating from the surrounding environment. Pratiwi *et al.* (2013) explained that seagrass accumulates more Pb and Cd heavy metals than sea water. This is supported by the statement of Efendi (2015), namely the difference in concentration between metals in water, sediments and parts of seagrass an interspecific relationship that seagrass accumulates metals derived from water and sediment.

Based on Table 12. it can be seen that the value of sig. (2-tailed) test of spearman correlation between lignkungan (sediment and water) parameter and Seagrass *E. acoroides* at north station. Where the correlation between seagrass *E. acoroides* with sediment and water values has a significant correlation sig (2-tailed)> 0.05). This means that, the significance level of the relationship between *E. acoroides* and sediment and water ranges from 0.933 to 0.999. Correlation of heavy metal content in sediments shows an ongoing accumulation. However, heavy metal content in sediments can harm benthos and other biota which are filter feeders or deposit feeders. According to (Tarigan *et al.*, 2003) the process of continuous accumulation in sediments can endanger living biota and forage in sediments. In addition, the occurrence of differences in the level of relationship in each of these variables is indicated because of differences in data obtained from the concentration of heavy metals.

3.6. Analisis Manova

Statistical analysis using MANOVA to distinguish the percentage of heavy metal content in seagrass and sedimentary plant structures in the waters of the northern and southern parts of the island. The results of the MANOVA test showed that *E. acoroides* seagrass with sediment environ-mental parameters were not significantly different ($p> 0.05$). The results of the manova analysis are shown in table 13.

The results of the Multi Variat analysis (Manova) showed that from the sources of plant structure diversity, stem and leaf roots and sediments, it was seen that there were no significant differences. Significant value from the results of the manova analysis is $p <0.05$ so it can be concluded that there are no real differences from all sources of diversity.

Table 13. Analysis of manova in seagrass and sediments.

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Location	Root	367,139	1	367,139	0,239	0,631
	Stem	4485,312	1	4485,312	1,233	0,281
	Leaves	9,005	1	9,005	0,008	0,932
	Clay	1862391,481	1	1862391,481	0,643	0,433
	Sand	218091,613	1	218091,613	0,515	0,482
Error	Root	27666,571	18	1537,032		
	Stem	65455,359	18	3636,409		
	Leaves	21375,780	18	1187,543		
	Clay	52150536,057	18	2897252,003		
	Sand	7621948,377	18	423441,576		

The heavy metal content in all sources of diversity did not have significant or significant differences with a value of 0.05, a confidence level of 95%. There was no significant effect on the manova test because the ratio of the value of heavy metals contained in the structure of seagrass plants and sediments delayed was not significantly different from each parameter. Seagrass ecosystems according to Philips and Menez (1988) are one of the productive marine ecosystems in shallow water which serves to stabilize sediments from sediment traps, providing protection for animals in seagrass beds, helping epiphytic organisms attached to leaves, having high productivity, fixing carbon in the water column partly into the food chain system and partly stored in biomass and sediment.

IV. CONCLUSION

The content of heavy metals Fe and Al in sediments in all stations is known to be higher than in water samples and seagrasses. This is because the water columns and seagrasses are caused by heavy metals entering the water column which will be absorbed by the particles of suspended particles. Correlation tests showed a strong relationship between environmental factors both sediment and water with lamum stem and leaf roots at north and south stations. While the results of the Multi Variat analysis (Manova) showed that from sources of plant structure diversity, stem and leaf roots and sediments it was seen that there were no significant differences.

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