Analysis of heavy metal content (Pb, Cu, Cd, and Fe) in the seagrass *Thalassia hemprichii* as a bioindicator of marine pollution in Tihi-Tihi Village, Bontang City, East Kalimantan

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ABSTRACT

The waters of Bontang City have relatively productive anthropogenic activities that trigger changes in the quality of surrounding waters that have the potential for pollution in the waters of the Bontang City area and there is a seagrass ecosystem that can be used as a natural indicator because it is sensitive to the presence of pollutants. To answer the problems found, this final project aims to determine the concentration levels of heavy metals (Pb, Cu, Cd, and Fe) contained in seagrass Thalassia hemprichii species in the waters of Tihi-Tihi Village. This study uses descriptive methods and location determination using the purposive sampling method and heavy metal analysis in water samples, sediments, and seagrass T. hemprichii analyzed using the AAS (Atomic Absorption Spectrophotometry) tool. The results showed that the waters of Tihi-Tihi Village had been contaminated with the heavy metal content of Pb, Cu, Cd, and Fe with different concentration levels, the metal content in water ranged from <0.001-0.098 mg/L, in sediment ranged from 2.64-1063.53 mg/kg and in seagrass ranged from 0.02-3468.08 mg/kg.

INTRODUCTION

Bontang City is an administratively recognized city in East Kalimantan Province. Geographically, it is located between 117°23'–117°38' E and 0°01' N, bordered to the north and west by East Kutai Regency, to the south by Kutai Kartanegara Regency, and to the east by the Makassar Strait. Bontang City covers an area of 158.2276 km², with only 29% of its total area consisting of land, while 71% is dominated by aquatic ecosystems (BPS, 2019). As a coastal region rich in natural resources, particularly in Tihi-Tihi Village, seagrass species are highly diverse, with *Thalassia hemprichii* being the most commonly found species (Fadilah et al., 2022). The waters of Bontang City are exposed to relatively high anthropogenic activities, which contribute to changes in water quality and pose a risk of pollution in the marine environment (Fitrian et al., 2021).

Marine pollution is a highly complex issue that is difficult to manage. It negatively impacts the environment and disrupts ecosystem sustainability on a broad scale. One of the major sources of pollution in marine waters is the presence of heavy metals, which originate from both anthropogenic activities and natural sources. According to Listiawati (2018), seagrass is an effective bioindicator in coastal waters due to its high sensitivity to pollutants entering the marine environment. Seagrass has the ability to efficiently absorb heavy metals from both seawater and sediments. Due to the limited research on heavy metal accumulation in seagrass, this study is essential. Specifically, the study aims to determine the concentration of heavy metals in seagrass, which can serve as an environmental indicator in one of the aquatic areas of Bontang City, East Kalimantan.

METHODOLOGY

This research was conducted from October to December 2023, with water, seagrass, and sediment samples collected from the waters of Tihi-Tihi Village, Bontang City, East Kalimantan. Water sample analysis was performed at the Water Quality Laboratory, Faculty of Fisheries and Marine Science, Mulawarman University, while sediment and seagrass analysis was conducted at the Soil Science Laboratory, Faculty of Agriculture, Mulawarman University.

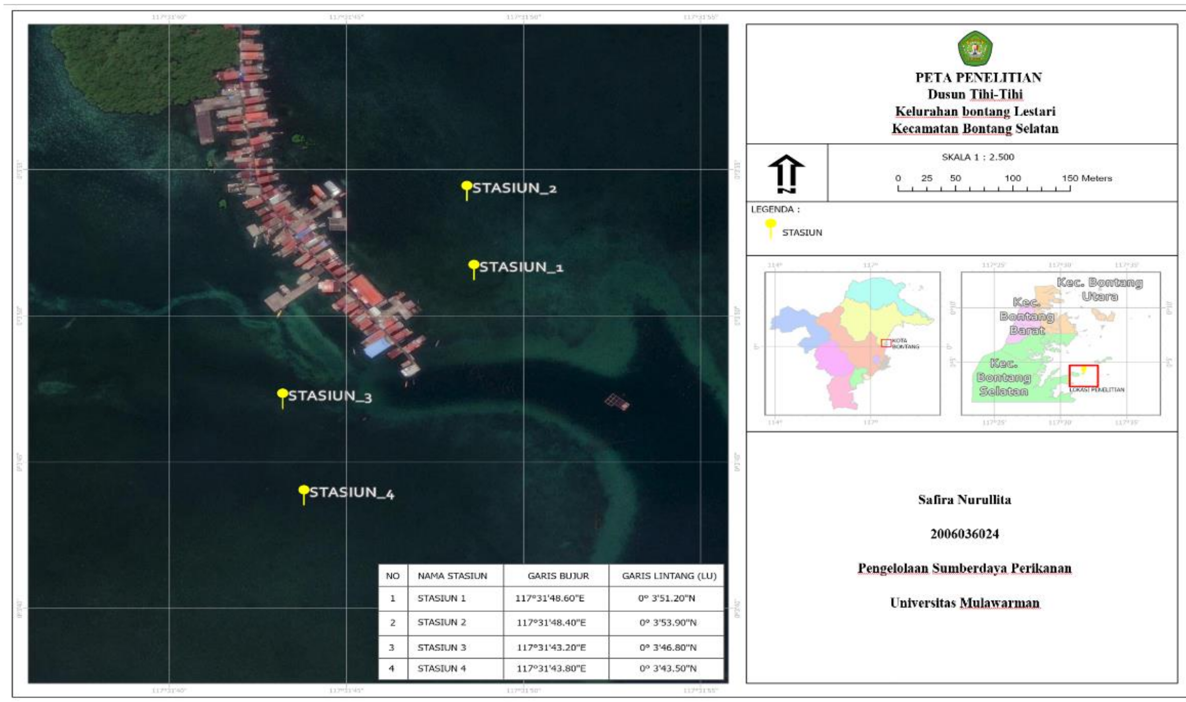

Figure 1. Study location map

This study was conducted at four station points using a purposive sampling method. After sample collection in the field, the samples were analyzed in the laboratory to determine the concentration of heavy metals in water, sediment, and seagrass using the wet digestion method. The results were then compared with environmental quality standards, including Government Regulation of the Republic of Indonesia (PP RI) No. 22 of 2021 on Water Quality Management, PP RI No. 82 of 2001 on Water Quality Management and Water Pollution Control, and the Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario for sediment quality standards. Data analysis was performed using simple linear regression analysis with Microsoft Excel to determine the relationship between heavy metal concentrations in seagrass and its surrounding environment.

Table 1. Sediment Quality Standards

Metal (mg/kg)	No Effect Level	Lowest Effect Level	Severe Effect Level
Lead (Pb)	-	31	250
Copper (Cu)	-	16	110
Cadmium (Cd)	-	0.6	10

Metal (mg/kg)	No Effect Level	Lowest Effect Level	Severe Effect Level
Iron (Fe)	-	20,000	40,000
Manganese (Mn)	-	460	1,100
Zinc (Zn)	-	120	820

Source**:** Hayton (2003)

To determine the relationship between heavy metal concentrations in seagrass and its surrounding environment, simple linear regression analysis was conducted (Kinnear & Gray, 2000) using the following mathematical model:

$$Y=a+bX$$

Where:

X = Heavy metal concentration in sediment (mg/kg)
Y = Heavy metal concentration in seagrass (mg/kg)
a and b = Constants

RESULT AND DISCUSSION

Heavy metal lead (Pb) content

The heavy metal Pb content in water, sediment, and seagrass at each research station can be seen in Table 2.

Table 2. Pb Heavy Metal Content

Station	Pb Content in Water (mg/L)	Sediment (mg/kg)	Leaves (mg/kg)	Roots (mg/kg)	Rhizomes (mg/kg)
I	<0.003	207.85	106.33	100.57	32.68
II	<0.003	215.53	108.56	80.19	33.13
III	<0.003	217.49	122.83	86.15	32.34
IV	<0.003	224.63	123.91	52.87	24.69

The measurement results of pb content in water at each station, with a value of <0.003 mg/L, indicate that based on the quality standards set by government regulation of Indonesia (pp ri) no. 22 of 2021, the pb content in the waters of Tihi-Tihi Village does not exceed the standard quality threshold. pb content in sediment ranges between 207.85-224.63 mg/kg, which, based on the guidelines for the protection and management of aquatic sediment quality in Ontario, falls under the lowest effect level criteria, meaning the contamination level does not significantly affect most organisms living in the sediment. the pb content in seagrass ranges from 24.69-123.91 mg/kg, with the highest concentration found in the leaves at station 4. the high pb concentration in the leaves is because leaves act as accumulators that first respond to pollutants in an ecosystem, especially in seagrass ecosystems (Sugiyanto et al., 2016).

Heavy metal copper (Cu) content

The heavy metal Cu content in water, sediment, and seagrass at each research station can be seen in Table 3.

Table 3. Cu Heavy Metal Content

Station	Cu Content in Water (mg/L)	Sediment (mg/kg)	Leaves (mg/kg)	Roots (mg/kg)	Rhizomes (mg/kg)
I	<0.002	2.64	1.01	3.58	1.73
II	<0.002	5.04	3.82	5.51	0.42
III	<0.002	5.12	4.44	5.77	0.97
IV	<0.002	5.82	3.84	7.24	0.95

The measurement results of Cu content in water at all four stations show a value of <0.002 mg/L. Based on the quality standards set by PP RI No. 22 of 2021, the Cu content in the waters of Tihi-Tihi Village does not exceed the standard quality threshold. Cu content in sediment ranges between 2.64-5.82 mg/kg**,** which, based on the Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, falls under the No Effect Level criteria, meaning the chemical levels in the sediment do not affect fish or other organisms living in the sediment. Cu content in seagrass ranges from 0.42-7.24 mg/kg, with the highest concentration found in the roots at Station 4. The high Cu concentration in the roots is due to the roots' direct association with the sediment. The Cu deposited in the sediment is absorbed by the seagrass **roots** through the nutrient uptake process (Bidayani et al., 2017).

Heavy metal cadmium (Cd) content

The heavy metal Cd content in water, sediment, and seagrass at each research station can be seen in Table 4.

Table 4. Cd Heavy Metal Content

Station	Cd Content in Water (mg/L)	Sediment (mg/kg)	Leaves (mg/kg)	Roots (mg/kg)	Rhizomes (mg/kg)
I	<0.001	4.35	0.17	3.19	1.73
II	<0.001	4.19	0.20	2.58	0.42
III	<0.001	3.84	0.24	2.57	0.97
IV	<0.001	3.83	0.24	1.71	0.95

The measurement results of Cd content in water at all four stations show a value of <0.001 mg/L. Based on the quality standards set by PP RI No. 22 of 2021, the Cd content in the waters of Tihi-Tihi Village does not exceed the standard quality threshold. Cd content in sediment ranges between 3.83-4.35 mg/kg, which, based on the Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, falls under the Lowest Effect Level criteria, meaning the contamination level does not significantly affect most organisms living in the sediment. Cd content in seagrass ranges from 0.17-3.19 mg/kg, with the highest concentration found in the roots at Station 1**.** The high Cd concentration in the roots is due to the roots growing together with their substrate. Seagrass readily accumulates metals from its surroundings, as supported by Efendi (2015), who states that the differences in metal concentrations in water, sediment (substrate), and seagrass parts indicate an inter-species relationship, where seagrass accumulates metals from both water and sediment.

Heavy metal iron (Fe) content

The heavy metal Fe content in water, sediment, and seagrass at each research station can be seen in Table 5.

Table 5. Fe Heavy Metal Content

Station	Fe Content in Water (mg/L)	Sediment (mg/kg)	Leaves (mg/kg)	Roots (mg/kg)	Rhizomes (mg/kg)
I	0.098	775.36	472.22	3090.28	1573.16
II	0.077	762.93	725.25	2547.75	1497.91
III	0.048	1063.53	1044.9	3252.56	2678.16
IV	0.038	937.25	589.26	3054.95	2180.66

The measurement results of Fe content in water at all four stations range between 0.038-0.098 mg/L. Based on the quality standards set by PP RI No. 82 of 2001, the Fe content in the waters of Tihi-Tihi Village does not exceed the standard quality threshold. Fe content in sediment ranges between 762.93-1063.53 mg/kg, which, based on the Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, falls under the Lowest Effect Level criteria. Fe content in seagrass ranges from 472.22-3252.56 mg/kg, with the highest concentration found in the roots at Station 3. The high Fe concentration in the roots is due to the roots growing together with their substrate and having a larger surface area, making them the most active site for nutrient absorption (Kiswara, 1990).

Accumulation of heavy metals in seagrass *Thalassia hemprichii*

The presence of heavy metal pollutants Pb, Cu, Cd, and Fe in seagrass organisms at each station is influenced by environmental factors such as water and sediment, which serve as their growing medium. The concentrations of Pb, Cu, Cd, and Fe in the water column are relatively low at each station because water has the ability to self-purify from pollutants entering the system (Haeruddin et al., 2019). In contrast, the concentrations of these heavy metals in sediments are relatively high at all stations since metals can accumulate and settle in sediments over a long period (Palar, 1994).

The absorption of these four heavy metals by *T. hemprichii* occurs through two pathways: metals present in the water column are absorbed by the leaves, while those in sediments are taken up through the roots and rhizomes. Once heavy metal pollutants are absorbed by seagrass, the plant translocates these metals from the lower parts to the upper parts of the plant or vice versa (Listiawati, 2018). The presence of heavy metals in both the environment and organisms is closely linked to anthropogenic activities and industrial operations in the surrounding area.

CONCLUSION

1. The heavy metal content (Pb, Cu, Cd, and Fe) in *T. hemprichii* seagrass exhibits variability, with concentrations ranging from 0.17–1044.90 mg/kg in leaves, 1.71–3252.56 mg/kg in roots, and 0.42–2678.16 mg/kg in rhizomes.
2. The concentrations of Pb, Cu, Cd, and Fe in the waters of Tihi-Tihi Village do not exceed the standard quality limits set by Government Regulation of the Republic of Indonesia (PP RI) No. 22 of 2021 and PP RI No. 82 of 2001. Similarly, the metal content in the substrate, based on the Guidelines for the

Protection and Management of Aquatic Sediment Quality in Ontario, does not exceed the Severe Effect Level (SEL) criteria.

3. The high heavy metal content in the substrate (sediment) is attributed to the nutrient trap characteristic of the substrate, where metals become trapped in sediment particles and settle over a relatively long period.

REFERENCES

Ambo-Rappe, R., Lajus, D.L., & Schreider, M.J. (2007). Translational Fluctuating Asymmetry and Leaf Dimension In Seagrass, Zostera Capricorni Aschers in A Gradient Of Heavy Metals. Environ. Bioindic. 2: 99-116.

Badan Pusat Statistik. 2019. Letak Dan Luas Kota Bontang. Bontang: BPS Kota Bontang.

Bidayani, E., Rosalina, D., & Utami, E. (2017). Kandungan Logam Berat Timbal (Pb) pada Lamun Cymodocea serrulata di Daerah Penambangan Timah Kabupaten Bangka Selatan. Maspari Journal, 9(2), 169–176.

Efendi, E. 2015. Akumulasi Logam Cu, Cd Dan Pb Pada Meiofauna Intertitial dan Epifit Di Ekosistem Lamun Monotipic (Enhalus acoroides) Teluk Lampung. Aquasains, 3(2): 279- 288

Fadilah, P., Sari, L. I., & Irawan, A. 2022. Karakteristik Plankton pada Padang Lamun di Perairan Dusun Tihi-Tihi Kota Bontang Kalimantan Timur. Tropical Aquatic Sciences, 1(1), 89–97.

Fitrian, Z., Suharsono, S., & Wahyuningsih, N. 2021. Kajian Kualitas Air Laut di Perairan Kota Bontang Provinsi Kalimantan Timur. Jurnal Riset Pembangunan 4(1): 56-66.

Haeruddin, Purnomo, P. W., & Febrianto, S. (2019). Pollution Load, Assimilation Capacity And Pollution State of West Banjir Kanal Estuary, Semarang City, Central Java. Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan, 9(3), 723–735.

Hayton., D. Persuad., dan R. Jaagumagi. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of Environment and Energy

Kinnear, P.R & Gray, C.D. (2000). SPSS for Windows Made Simple. Psychology Press Ltd. Publishers. East Essex, UK.

Kiswara W. 1990. Kadar Logam Berat (Cd,Cu, Pb dan Zn) dalam Lamun (Zeostera marina L.) di Belanda. Jakarta

Listiawati, V. 2018. Peran Lamun sebagai Bioindikator Kualitas Perairan Pesisir. Proceeding Biology Education Conference, 15(1), 750–754.

Palar, H. 2004. Pencemaran dan Toksikologi Logam Berat. Penerbit Rineka Cipta, Jakarta.

Sugiyanto, R. A. N., Defri, Y., & Rarasrum, D. K. 2016. Analisis Akumulasi Logam Berat Timbal (Pb) Dan Kadmium (Cd) Pada Lamun Enhalus Acoroides Sebagai Agen 37 Fitoremediasi di Pantai Paciran, Lamongan. Seminar Nasional Perikanan Dan Kelautan VI (Pp. 449-455).

Sugiyono. 2017. Metode Penelitian Kuantitatif Kualitatif dan R&D. Alfabeta. Bandung