

# Analysis of heavy metal content (Pb, Cu, Mn, and Zn) in water and sediment of seagrass beds in Tihi-Tihi waters, Bontang City, East Kalimantan, Indonesia

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## ABSTRACT

Seagrass has clear economic benefits in supporting the availability of various commercial fish species and also serves multiple ecological functions. The presence of seagrass in marine waters can act as a bioindicator of heavy metal pollution, as it can absorb and accumulate contaminants. Until now, the exact concentration of heavy metals in the water and sediment of seagrass beds in Tihi-Tihi Village, Bontang City, has not been clearly known. This study aims to determine the content of heavy metals (Pb, Cu, Mn, and Zn) in the water and sediment of seagrass beds in Tihi-Tihi Village, Bontang City, East Kalimantan. The results showed that the concentrations of heavy metals (Pb, Cu, Mn, and Zn) in the water were the same across all stations, ranging between  $<0.001$ – $<0.003$  mg/L, which is below the quality standards set by the government. Lead (Pb) is the heavy metal of most concern due to its concentration falling within the Severe Effect Level. Further studies are needed to investigate the potential impacts of the high concentration of Pb in the sediment of this seagrass bed.

## INTRODUCTION

The marine waters of Bontang City are the site of various maritime activities, including the Lok Tuan Port, which serves as a container terminal, and Tanjung Laut Port, which handles local goods, especially from the Sulawesi region. Bontang Kuala Beach also serves as a tourist destination and residential area. In addition, there are major energy industries such as gas and coal operating around the area. These maritime and surrounding activities have the potential to contribute to changes in the environmental quality of marine waters, which can disrupt the ecological functions of aquatic ecosystems and lead to the degradation of seawater quality physically, chemically, and biologically, especially in seagrass ecosystems.

Seagrass has clear economic value (providing habitat for various commercial fish species) and also plays multiple important ecological roles. The presence of seagrass in marine waters can act as a bioindicator of heavy metal pollution, as it is capable of absorbing and accumulating contaminants (Endang et al., 2016). Heavy metals are hazardous wastes that are harmful to health and have toxic properties that pose risks to the human body. In addition to altering water quality, heavy metals that settle in sediment can lead to the transfer of toxic chemicals from the sediment to organisms, dilution and dispersion processes, and eventual absorption by marine organisms such as seagrass (Kenworthy et al., 2006).

Until now, the exact concentrations of heavy metals in the water and sediment of seagrass beds in Tihi-Tihi Village, Bontang City, have not been clearly known. This information is crucial to understanding the relationship between heavy metal content and the seagrass ecosystem. Therefore, this study was

conducted to determine the levels of heavy metals (Pb, Cu, Mn, and Zn) in the water and sediment of seagrass beds in Tihi-Tihi Village, Bontang City, East Kalimantan, Indonesia.

## METHODOLOGY

This research was conducted from October to December 2023, with water and sediment sampling carried out in the waters of Tihi-Tihi, Bontang City, East Kalimantan. Water sample analysis was conducted at the Water Quality Laboratory, Faculty of Fisheries and Marine Science, Mulawarman University, Samarinda, East Kalimantan. Meanwhile, heavy metal content analysis and substrate analysis were performed at the Soil Science Laboratory, Mulawarman University, Samarinda, East Kalimantan.

The research was carried out systematically, beginning with the preparation of tools and materials, determination of sampling locations, measurement of parameters and laboratory analysis, data processing, and final report preparation. The obtained data were analyzed descriptively by comparing the results with the applicable quality standards, namely: Government Regulation of the Republic of Indonesia No. 22 of 2021 on Marine Water Quality Standards, Government Regulation No. 82 of 2001 on Water Quality Management and Water Pollution Control, Decree of the Minister of Environment No. 200 of 2004 on Criteria for Seagrass Bed Damage and Guidelines for Determining Seagrass Bed Status, and sediment quality standards from the *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*.

## RESULT AND DISCUSSION

### Water quality

Table 1 shows that the water quality parameters in Tihi-Tihi waters comply with the quality standards set by Government Regulation of the Republic of Indonesia No. 22 of 2021. The water temperature in Tihi-Tihi ranges from 29.0°C to 31.3°C, with an average of 30.3°C, indicating ideal conditions for seagrass life. The salinity is recorded at 32.3‰, and the average pH of 8.4 suggests that the pH level is still within the normal range and favorable for seagrass growth. Parameters such as dissolved oxygen (DO), transparency, turbidity, and current speed are all within normal limits in the Tihi-Tihi waters.

Table 1. Water quality parameters in the seagrass bed area of Tihi-Tihi, Bontang City

| Parameter             | Unit | Station 1  | Station 2  | Station 3  | Station 4  | Average    | Quality Standard (*) |
|-----------------------|------|------------|------------|------------|------------|------------|----------------------|
| Temperature           | °C   | 29.0       | 31.3       | 30.3       | 30.7       | 30.3       | 28–30                |
| Salinity              | ‰    | 32.3       | 32.0       | 32.0       | 32.7       | 32.3       | 33–34                |
| pH                    | -    | 8.3        | 8.5        | 8.3        | 8.4        | 8.4        | 7.0–8.5              |
| Dissolved Oxygen (DO) | mg/L | 7.38       | 7.36       | 7.29       | 7.24       | 7.32       | >5                   |
| Transparency          | %    | 100        | 100        | 100        | 100        | 100        | -                    |
| Turbidity             | NTU  | 2.82       | 1.38       | 3.09       | 2.74       | 2.51       | <5                   |
| Current Speed         | m/s  | 0.17       | 0.09       | 0.13       | 0.181      | 0.14       | -                    |
| Substrate             | -    | Sandy Loam | Sandy Loam | Sandy Loam | Sandy Loam | Sandy Loam | -                    |

\*Quality standards referenced from Government Regulation No. 22 of 2021 and relevant environmental guidelines.

There are six types of sediment particles found across the four stations: clay, silt, sand, coarse sand, medium sand, and fine sand. The sediment texture at all four stations falls into the Sandy Loam category. At stations 1, 2, 3, and 4, the measured clay content ranged from 9.30–12.41%, silt from 5.20–13.37%, total sand from 77.33–82.39%, coarse sand from 14.06–23.74%, medium sand from 15.14–19.47%, and fine sand from 7.53–14.61%. Based on field conditions, the loamy sand substrate in this area has a very fine texture. This is likely due to the Tihi-Tihi waters being located near residential areas and far from coral reef zones, resulting in a relatively calm and sheltered environment, protected from strong wave or water turbulence.

### Heavy metal concentration in the waters

Based on the results of heavy metal (Pb, Cu, Mn, and Zn) measurements in the water of Tihi-Tihi waters, the findings are presented in Table 2 below.

Table 2. Heavy metal concentrations in water samples

| Parameter | Unit | Station 1 | Station 2 | Station 3 | Station 4 | Replicate | Water Quality Standard |
|-----------|------|-----------|-----------|-----------|-----------|-----------|------------------------|
| Pb        | mg/L | <0.003    | <0.003    | <0.003    | <0.003    | 1         | 0.05                   |
|           |      | <0.003    | <0.003    | <0.003    | <0.003    | 2         |                        |
|           |      | <0.003    | <0.003    | <0.003    | <0.003    | 3         |                        |
| Cu        | mg/L | <0.002    | <0.002    | <0.002    | <0.002    | 1         | 0.05                   |
|           |      | <0.002    | <0.002    | <0.002    | <0.002    | 2         |                        |
|           |      | <0.002    | <0.002    | <0.002    | <0.002    | 3         |                        |
| Mn        | mg/L | <0.001    | <0.001    | <0.001    | <0.001    | 1         | 0.1                    |
|           |      | <0.001    | <0.001    | <0.001    | <0.001    | 2         |                        |
|           |      | <0.001    | <0.001    | <0.001    | <0.001    | 3         |                        |
| Zn        | mg/L | <0.003    | <0.003    | <0.003    | <0.003    | 1         | 0.05                   |
|           |      | <0.003    | <0.003    | <0.003    | <0.003    | 2         |                        |
|           |      | <0.003    | <0.003    | <0.003    | <0.003    | 3         |                        |

Referring to Government Regulation of the Republic of Indonesia No. 22 of 2021, the concentration of lead (Pb) in water was found to be below the quality standard of 0.008 mg/L. The concentration of copper (Cu) in water was <0.002 mg/L, which is also below the quality standard of 0.008 mg/L as stipulated in the same regulation. The concentration of manganese (Mn) in water was <0.001 mg/L. According to Government Regulation No. 82 of 2001 on water quality management and water pollution control, this value is below the quality standard of 0.1 mg/L. Meanwhile, the concentration of zinc (Zn) at all stations was <0.003 mg/L, which is below the quality standard of 0.05 mg/L as specified in Government Regulation No. 22 of 2021. Based on the analysis results presented in the table, it can be concluded that the concentrations of heavy metals (Pb, Cu, Mn, and Zn) in the water of Tihi-Tihi waters are still within good condition and remain below the quality standards set by the government.

### Heavy metal concentration in the sediments

Based on the results of heavy metal (Pb, Cu, Mn, and Zn) analysis in the sediment of Tihi-Tihi waters, the findings are presented in Table 3.

Table 3. Heavy Metal Content in Sediment Samples

| Parameter      | Unit  | Station 1 | Station 2 | Station 3 | Station 4 |
|----------------|-------|-----------|-----------|-----------|-----------|
| Lead (Pb)      | mg/kg | 207.85    | 215.53    | 217.49    | 224.63    |
| Copper (Cu)    | mg/kg | 2.64      | 5.043     | 5.122     | 5.824     |
| Manganese (Mn) | mg/kg | 6.244     | 6.045     | 7.236     | 6.37      |
| Zinc (Zn)      | mg/kg | 32.100    | 38.641    | 32.526    | 36.56     |

The concentrations of heavy metals (Pb, Cu, Mn, and Zn) in the sediment of Tihi-Tihi waters were as follows: lead (Pb) ranged from 207.85 to 224.63 mg/kg; copper (Cu) from 2.64 to 5.824 mg/kg; manganese (Mn) from 6.045 to 7.236 mg/kg; and zinc (Zn) from 32.100 to 38.641 mg/kg.

According to the Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, the concentration of lead (Pb) at all stations falls under the Severe Effect Level category. This level indicates a high risk of adverse effects on sediment-dwelling organisms and may be linked to industrial waste in the vicinity of the study area, particularly from industries that use Pb in their production processes, such as fertilizer and coal industries.

On the other hand, the concentrations of Cu, Mn, and Zn at all stations fall under the Lowest Effect Level, indicating a low level of contamination that is unlikely to affect organisms living in the sediment (Moore and Ramamoorthy, 1984). These metals (Cu, Mn, Zn) are also classified as essential trace elements, which, in low concentrations, are required by organisms as enzyme cofactors for metabolic processes. However, in high concentrations, they can become toxic (Fitriyah et al., 2013).

Heavy metals in the water column can accumulate in sediments through bonding with free organic matter or organic matter coating the sediment surface, as well as through direct adsorption onto sediment particles (Bangun, 2005).

### CONCLUSION

The concentrations of heavy metals (Pb, Cu, Mn, and Zn) in the water were consistent across all stations, ranging from <0.001 to <0.003 mg/L, which is below the quality standards set by the government. Lead (Pb) is the heavy metal of greatest concern, given that its concentration in sediment falls within the Severe Effect Level category. Further studies are needed to assess the potential impacts of elevated Pb levels in the seagrass bed sediments.

Moreover, additional research on the concentration of heavy metals in various seagrass species is urgently required, considering that seagrass is an important primary producer in seagrass ecosystems and provides essential habitat for a wide range of marine organisms.

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