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Heavy Metal (Pb, Cu, and Zn) Content in *Geloina erosa* and *Cerithidea obtusa* from the Western Coast of Dumai, Riau Province

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ABSTRACT

Industrial and shipping activities in coastal areas have the potential to increase heavy metal pollution, which can accumulate in marine organisms and impact food safety. On the west coast of Dumai, *Geloina erosa* and *Cerithidea obtusa* are widely consumed by the local community, making it important to study their heavy metal content. This study aims to analyse the levels of Pb, Cu, and Zn in the soft tissues of these two species and compare the differences between species and sampling locations. The study was conducted in February 2025 at two stations: Station 1 (Purnama) and Station 2 (Pangkalan Sesai). Samples were collected using purposive sampling and analysed using Atomic Absorption Spectroscopy (AAS). The results showed that the average Pb, Cu, and Zn content in *G. erosa* were 6.79 µg/g, 6.13 µg/g, and 8.36 µg/g, respectively, while in *C. obtusa* they were 7.09 µg/g, 6.27 µg/g, and 7.41 µg/g. Significant differences ($p < 0.05$) were detected in the Cu and Zn content in *G. erosa*, as well as Zn in *C. obtusa,* between stations. Pb and Cu were generally higher in both species at Station 2, while the highest Zn levels were found in *G. erosa* at Station 1 (9.12 µg/g) and *C. obtusa* at Station 2 (8.50 µg/g). The highest PTWI value was found in *G. erosa* at Station 1; however, all results remained within safe consumption limits. Therefore, both species are deemed safe for consumption, despite variations in heavy metal content between species and research locations.

Keywords: *Cerithidea obtusa, Geloina erosa*, Heavy metal**,** Western Dumai

1. INTRODUCTION

Population growth and industrial development in coastal areas have intensified pressure on marine ecosystems, particularly through the accumulation of heavy metals. Dumai City, located in Riau Province, Indonesia, is experiencing rapid industrialization and urban expansion. Activities such as land reclamation, mangrove deforestation, and the discharge of industrial and domestic waste are significant contributors to the decline in the quality of coastal waters (Nurhayati & Putri, 2019). These anthropogenic disturbances pose ecological threats to the region, as evidenced by recent findings that reported the presence of heavy metals in Dumai's coastal waters at levels exceeding environmental quality standards (KLHK, 2023).

Heavy metals such as lead (Pb), copper (Cu), and zinc (Zn) are frequently detected in polluted marine environments due to their widespread industrial use and persistent nature (Nurhayati & Putri, 2019). In Dumai, significant sources of such contamination include palm oil processing industries, oil refineries, fertilizer plants, shipping activity, and domestic waste. Once released into the marine environment, these metals tend to settle in sediments and may be taken up by aquatic organisms, potentially accumulating through the food chain and posing health risks to humans.

Benthic mollusks, such as bivalves and gastropods, are widely used as bioindicators of heavy metal contamination because of their sedentary lifestyle and direct contact with sediments. *G. erosa* and *C. obtusa* are two mollusk species commonly found in the coastal waters of West Dumai. These species are frequently harvested and consumed by the local population due to their nutritional value, including high levels of protein, unsaturated fatty acids, and essential minerals. Previous studies have demonstrated that both *G. erosa* and *C. obtusa* are capable of accumulating heavy metals from their surroundings (Wariski et al., 2021), supporting their role as sentinel species for monitoring marine pollution.

This study aims to determine the concentrations of Pb, Cu, and Zn in the soft tissues of *Geloina erosa* and *Cerithidea obtusa* collected from the coastal waters of West Dumai. The objective is to assess the level of contamination in these two species and evaluate the potential environmental and health risks associated with them.

2. RESEARCH METHOD

Time and Place

The research was conducted from January to February 2025 in the coastal waters of Purnama and Pangkalan Sesai, Dumai City, Riau Province (Figure 1).

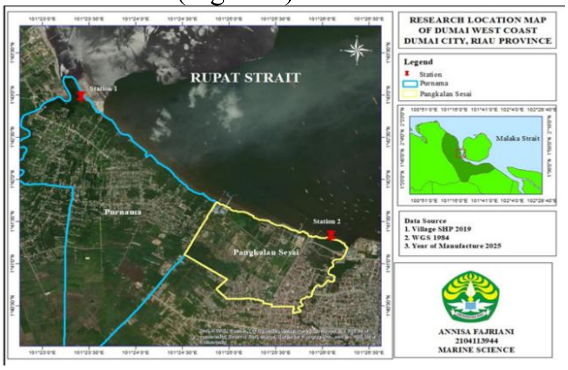

Figure 1. Research location

Method

Sampling was conducted using purposive sampling, which involves selecting locations based on local environmental conditions. Location 1 is located in the waters of Purnama Subdistrict, West Dumai Regency, which is relatively far from the city centre and has a lower level of anthropogenic activity. This location was chosen because it is considered to represent coastal environmental conditions that are less affected by industrial activities. In contrast, Location 2 is located in the waters of Pangkalan Sesai, Dumai Barat District, which is closer to the city centre and is influenced by higher levels of anthropogenic activity. These activities include the disposal of domestic and industrial waste, as well as pollution from maritime traffic. The differences in conditions between the two locations are expected to show variations in the accumulation of heavy metals in organisms living in these waters.

Procedures

Water Quality Measurement

Water quality measurements were conducted in situ at high tide using temperature, pH, and salinity parameters at each research location. Temperature was measured using a digital thermometer by immersing the sensor in water. pH values were obtained using a pH meter after calibration, while salinity was measured using a handheld refractometer calibrated with distilled water. The sample was then dripped onto the lens and read on the salinity scale.

Sample Collection and Handling

Samples of *G. erosa* (30–60 mm) and *C. obtusa* (20–40 mm) were collected directly from two research sites, with three individuals of each species obtained from each site. The collected samples were stored in ice boxes and placed in a freezer upon arrival at the laboratory to prevent tissue degradation.

Before analysing the heavy metal content, the flesh was separated from the shell using non-metallic tools such as plastic spatulas and tweezers, then washed with pure water and placed in sterile plastic containers. Non-metallic tools were used to prevent metal from the tools from entering the samples, ensuring that the analysis results would not be contaminated (Yap et al., 2002).

Subsequently, the concentrations of heavy metals Pb, Cu, and Zn in both organisms were analyzed. Before analysis, the soft tissues were dissolved in concentrated acid to break down organic matter and release the heavy metals into solution for subsequent determination using AAS. The analysis method followed the procedure described by Yap et al. (2002). Heavy metal concentrations were measured using an Atomic Absorption Spectrophotometer (AAS), model Shimadzu AA7000G with an Autosampler. The concentration of each metal in the samples was calculated using the formula proposed by Supriatno & Lelifajri (2009), as follows:

$$K\ (\mu g/g) = \frac{a\ (\mu g/mL) \times b(mL)}{c(g)}$$

Description:

K = Actual concentration of the sample (µg/g)
a = Concentration calculated based on AAS absorbance value (µg/ml)
b = Volume of the digested sample (ml)
c = Weight of the sample (g)

Data Analysis

To determine differences in heavy metal content between species and locations, statistical analysis was performed using a T-test, which is commonly used to compare two groups of data and determine whether the observed differences are statistically significant. This analysis aims to identify potential variations in the levels of heavy metal contamination accumulated in the soft tissues of both organisms. Additionally, to assess the overall level of heavy metal contamination in the tissues of the organisms, the Metal Pollution Index (MPI) was calculated using the formula proposed by Usero in Giusti et al. (1999) as follows:

$$MPI = \sqrt[n]{C1xC2xC3x \ldots Cn}$$

Description:

MPI	:	Metal Pollution Index
n	:	Number of metals
Cn	:	Concentration of the nth heavy in the sample (mg/kg)

To determine the safe weekly intake limit of heavy metals, the Provisional Tolerable Weekly Intake (PTWI) approach is used. PTWI refers to the maximum amount of heavy metals that can be ingested weekly without posing health risks. This value is calculated based on FAO/WHO standards and adjusted to an average human body weight. The formula is presented as follows:

$$PTWI = Bm \times Bb \times 1000$$

Description:

PTWI	=	Provisional Tolerable Weekly Intake (µg/kg/week)
Bm	=	Maximum permissible limit of metal as recommended by FAO/WHO (mg/kg/week)
Bb	=	Average body weight (70 kg)
1000	=	Conversion factor from milligrams (mg) to micrograms (µg).

3. RESULT AND DISCUSSION

Heavy Metal Concentrations (Pb, Cu, Zn) in *Geloina erosa* and *Cerithidea obtusa* from the Coastal Waters of West Dumai

Oceanographic parameter sampling was conducted. Heavy metal content analysis (Pb, Cu, and Zn) was performed on samples of *G. erosa* and *C. obtusa* using flesh samples to determine the level of heavy metal accumulation in these organisms. The analysis results are presented in milligrams per kilogram (mg/kg) of wet weight. The average heavy metal content measurement data for both species are presented in Table 1.

Table 1. Average heavy metal content in *G. erosa* and *C. obtusa*

Station	Species	Pb (µg/g)	Cu (µg/g)	Zn (µg/g)
1 Purnama	*G. erosa*	6.51	5.03	9.12
	C. obtusa	6.89	5.91	6.32
2 Pangkalan Sesai	*G.erosa*	7.08	7.24	7.6
	C.obtusa	7.3	6.63	8.5

Based on the analysis of heavy metal content in the soft tissues of *G. erosa* and *C. obtusa* from two sampling locations, namely Station 1 (Purnama) and Station 2 (Pangkalan Sesai), the concentrations of Pb, Cu, and Zn showed apparent variations between stations and between species. In *G. erosa*, the Pb concentration was higher at Station 2, reaching 7.08 µg/g, compared to 6.51 µg/g at Station 1. The Cu concentration in *G. erosa* was also higher at Station 2, with a value of 7.24 µg/g, while at Station 1 it was 5.03 µg/g. In contrast, the Zn concentration in *G. erosa* was higher at Station 1, with a value of 9.12 µg/g, compared to 7.60 µg/g at Station 2. The results of the analysis indicate differences in the concentrations of Pb, Cu, and Zn in the soft tissues of *G. erosa* and *C. obtusa* from the two sampling stations.

Meanwhile, *C.obtusa* exhibited a similar pattern. The Pb concentration in *C. obtusa* at Station 2 was higher, reaching 7.30 µg/g, compared to 6.89 µg/g at Station 1. Similarly, the Cu concentration was also higher at Station 2, with a value of 6.63 µg/g, while at Station 1 it was 5.91 µg/g. For Zn, *C. obtusa* also showed a higher concentration at Location 2, amounting to 8.50 µg/g, compared to 6.32 µg/g at Station 1. These differences indicate that *C. obtusa* found in stations with higher anthropogenic pressure has a greater potential for heavy metal bioaccumulation, as also reported by Fitria et al. (2023), who highlighted the relationship between proximity to port areas and elevated levels of heavy metals in biotic tissues.

Environmental factors, such as temperature, pH, and salinity, influence the accumulation of heavy metals in organisms. Station 2 exhibited higher temperature and salinity compared to Station 1, which is suspected to increase the solubility and availability of metals in water, thereby facilitating their uptake by benthic organisms (Yam et al., 2020). Additionally, the proximity of Station 2 to industrial areas and ports is also suspected to contribute to high concentrations of Pb and Cu, as reported by Samsi et al. (2017), who stated that benthic organisms in coastal industrial areas tend to accumulate heavy metals at higher concentrations. Furthermore, differences in physiological capacity between species such as *G.erosa* and *C. obtusa* also influence metal bioaccumulation levels, depending on their biological characteristics, feeding habits, and habitat preferences (Surya et al., 2018).

Differences in Heavy Metal (Pb, Cu, and Zn) Content Between *Geloina erosa* and *Cerithidea obtuse*

Heavy metals Pb, Cu, and Zn were analyzed at the Central Laboratory of Andalas University, located on the Limau Manis Campus in Padang, West Sumatra. A detailed comparison of Pb, Cu, and Zn concentrations in each organism is presented in Figure 2.

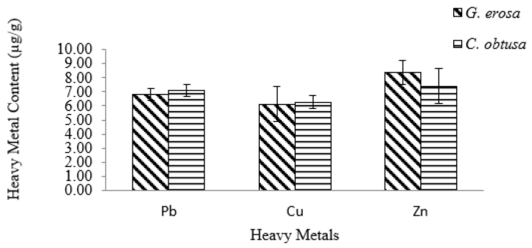

Figure 2. Comparison of Pb, Cu, and Zn Content Between *G. erosa* and *C. obtusa*

Based on the analysis results, higher concentrations of Pb were found in *C. obtusa* (7.09 µg/g), while lower concentrations were observed in *G. erosa* (6.79 µg/g). For Cu, higher values were also recorded in *C. obtusa* (6.27 µg/g), while lower values were observed in *G. erosa* (6.13 µg/g). In contrast, the Zn concentration showed a different pattern, with higher levels found in *G. erosa* (8.36 µg/g) and lower levels in *C. obtusa* (7.41 µg/g).

The differences in Pb, Cu, and Zn concentrations between *G. erosa* and *C. obtusa* reflect variations in the bioaccumulation capacity of the two organisms towards these metals (Silalahi et al., 2014). The differences in heavy metal accumulation between *G. erosa* and *C.obtusa* are influenced by differences in habitat, diet, and ecological behaviour.

Cerithidea obtusa, which is detritivorous and active on the substrate surface and among mangrove roots, tends to accumulate more Pb and Cu due to its diet consisting of detritus, biofilm, and microalgae. In contrast, *G. erosa*, which lives buried in muddy substrate as a filter feeder, primarily filters dissolved particles from the water column, explaining the higher Zn concentrations in its body. Previous studies support these findings, which indicate that *C. obtusa* can absorb and store heavy metals such as Pb and Cu in its body tissues, making it an effective metal accumulator (Krishnan et al., 2022). Meanwhile, Amin (2012) reported that *Geloina* sp. from Muara Sei Jang, Riau, can accumulate Zn in its body tissues at levels more than three times the Zn concentration in the surrounding sediment. Additionally, *G. erosa* has also been shown to accumulate various heavy metals, including Zn, in estuarine environments (Irawati et al., 2018).

In addition to feeding strategies and habitat, physiological capacity also plays a crucial role in the process of metal accumulation. Heavy metals can enter an organism's body through gills, the digestive tract, or direct diffusion through the body surface (Mirsadeghi et al., 2013). As slow-moving or sedentary benthic organisms, both *G. erosa* and *C. obtusa* are susceptible to pollutant accumulation from sediments and water. The filtration activity of both species also increases their exposure to heavy metals bound to food particles. Over time, these metals accumulate in soft tissues, as reflected in the concentrations of Pb, Cu, and Zn found in this study.

The results of the Metal Pollution Index (MPI) calculation showed that the MPI value of *G.erosa* (7.07 µg/g) was slightly higher than that of *C. obtusa* (6.86 µg/g). Although *C. obtusa* accumulated higher amounts of Pb and Cu, the high Zn content in *G. erosa* contributed significantly to the total pollution level. This confirms that the difference in MPI values reflects variations in metal accumulation strategies between species, depending on their physiological capacities and ecological characteristics. Therefore, the simultaneous use of both species in biomonitoring studies will provide more comprehensive information regarding the conditions of heavy metal pollution in mangrove ecosystems.

Based on the results of the T-test analysis, the comparison of Pb, Cu, and Zn concentrations in *G. erosa* (clam) and *C. obtusa (*mud snail*)* showed p-values greater than 0.05, namely Pb (0.23), Cu (0.81), and Zn (0.15). This indicates that there were no significant differences between the two organisms.

Differences in Pb, Cu, and Zn Content in *Geloina erosa* and *Cerithidea obtusa* Collected from Different Locations

After the heavy metal content analysis was conducted, it was found that the soft tissue of *G.erosa* contained Pb, Cu, and Zn with variations in concentration between stations. Higher Pb content was found at Station 2 (7.08 µg/g), while lower Pb content was recorded at Station 1 (6.51 µg/g). For Cu, a higher concentration was observed at Station 2 (7.24 µg/g), while a lower concentration was observed at Station 1 (5.03 µg/g). In contrast, Zn concentration was higher at Station 1 (9.12 µg/g) and lower at Station 2 (7.60 µg/g). In general, the distribution pattern of metal concentrations showed that Location 2 tended to have higher levels of Pb and Cu, while Zn levels were higher at Station 1.

Meanwhile, in *C. obtusa*, higher Pb concentrations were found at Station 2 (7.30 µg/g), while lower concentrations were recorded at Station 1 (6.89 µg/g). For Cu, the higher concentration was also observed at Station 2 (6.63 µg/g), with a lower value at Station 1 (5.91 µg/g). Similarly, for Zn, a higher concentration was found at Station 2 (8.50 µg/g), while the lower concentration was recorded at Station 1 (6.32 µg/g). In general, these results indicate that the heavy metal content in *C. obtusa* tends to be higher at Station 2 compared to Station 1, suggesting the possibility of differences in pollution levels between the two stations. The comparison of average concentrations of Pb, Cu, and Zn in *G. erosa* and *C. obtusa* is shown in Figures 3 and 4.

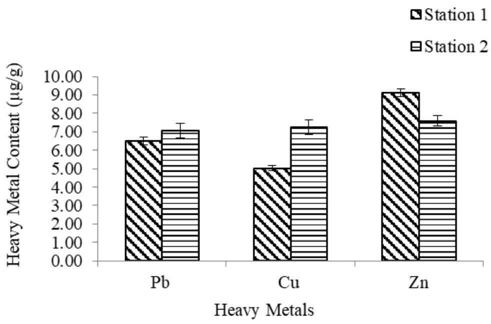

Figure 3. Heavy metal content in *G. erosa*

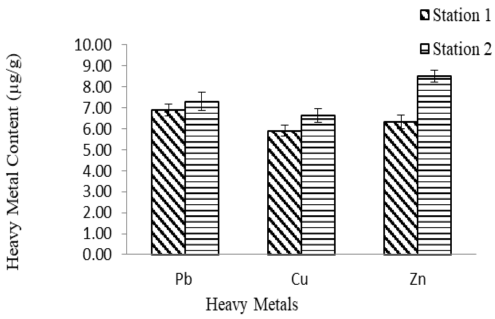

Figure 4. Heavy metal content in *C. obtusa*

The t-test results for heavy metal content in *G. erosa* showed that Pb did not differ significantly between stations ($p = 0.97$; $p > 0.05$), indicating a relatively uniform distribution. In contrast, Cu and Zn exhibited significant differences ($p = 0.01$ and $p = 0.02$; $p < 0.05$), suggesting that station location or anthropogenic activities influenced the accumulation of these metals. In *C. obtusa*, Pb and Cu levels did not show significant differences ($p > 0.05$), whereas Zn differed significantly between stations ($p = 0.01$; $p < 0.05$), indicating that Zn distribution is influenced by local environmental conditions such as sediment type, food sources, or pollution levels at each station.

The Metal Pollution Index (MPI) values indicate that the total accumulation of heavy metals in biota was higher at Station 2 compared to Station 1. At Station 2, the MPI value for *C. obtusa* was 7.43, slightly higher than that of *G.erosa*, which was 7.30. Meanwhile, at Station 1, the MPI values for G. erosa and C. obtusa were recorded at 6.68 and 6.36, respectively. This difference reflects the influence of higher anthropogenic pressure at Station 2, such as industrial and shipping activities, which contribute to increased heavy metal pollution loads in the waters (Amin et al., 2009).

Ecologically, the differences in MPI values between species and stations reflect a combination of biological and environmental factors. *C. obtusa*, which lives on the substrate surface and functions as a detritivore, is more exposed to heavy metals from detritus and biofilm, leading to higher accumulation of Pb and Cu (Krishnan et al., 2022). In contrast, *G. erosa*, as a filter feeder, tends to accumulate Zn from suspended particles in the water column (Amin, 2012). These differences are also influenced by water physicochemical parameters, such as temperature, pH, and salinity, as well as substrate characteristics and organic matter content, which affect metal mobility and availability (Sari et al., 2024).

Although areas with lower anthropogenic pressure tend to have limited pollution, the potential for long-term accumulation remains, particularly in residential and local port areas (Ariani et al., 2020).

Assessment of Safe Weekly Intake for *G. erosa* and *C.a obtusa* from West Dumai Coastal Waters, Riau Province

The calculated safe consumption limits of *G.erosa* and *C.obtusa* from the coastal waters of West Dumai, Riau Province, are presented in Tables 2 and 3. Heavy metal concentrations in *G. erosa* and *C.obtusa* varied between the two sampling stations. In *G. erosa*, the highest Pb concentration was recorded at Station 2 (7.0885 µg/g), which is in line with the safe weekly consumption limit of 0.24687 kg. The highest Cu concentration (7.2449 µg/g) was also found at Station 2, with a safe consumption limit of 33.8168 kg/week, while the highest Zn concentration was observed at Station 1 (9.1284 µg/g), with a safe weekly consumption limit of 26.8393 kg.

Table 2. PTWI Values and Safe Weekly Intake of *G. erosa*

Station	Metal	Heavy metal content in wet weight	PTWI (µg/kg/week) for 70 kg BW	Estimated safe consumption limit per week (kg/week)
Purnama	Pb	6.8961	1750	0.2537
	Cu	5.9122	245000	41.4397
	Zn	6.3287	245000	38.7125
Pangkalan Sesai	Pb	7.305	1750	0.2395
	Cu	6.6356	245000	36.9220
	Zn	8.5021	245000	28.8164

Table 3. PTWI Values and Safe Weekly Intake of *C.obtusa*

Station	Metal	Heavy metal content in wet weight	PTWI (µg/kg/week) for 70 kg BW	Estimated safe consumption limit per week (kg/week)
Purnama	Pb	6.5112	1750	0.2687
	Cu	5.0364	245000	48.6458
	Zn	9.1284	245000	26.8393
Pangkalan Sesai	Pb	7.0885	1750	0.24687
	Cu	7.2449	245000	33.8168
	Zn	7.6057	245000	32.2126

Meanwhile, in *C. obtusa*, the highest Pb concentration was also recorded at Station 2 (7.305 µg/g), which exceeds the safe weekly consumption limit of 0.2395 kg. The highest Cu concentration (6.6356 µg/g) resulted in a safe weekly consumption limit of 36.9220 kg, while the highest Zn concentration (8.5021 µg/g) corresponded to 28.8164 kg/week.

These findings indicate that although Cu and Zn concentrations are generally higher than Pb, their safe consumption limits are also significantly higher due to Pb's higher toxicity. Therefore, greater attention should be given to Pb concentrations in the context of food safety. Although Cu and Zn concentrations are higher than Pb, their weekly consumption limits remain higher due to Pb's higher toxicity. This indicates that, despite its lower concentrations, lead remains a major concern in terms of consumer safety. However, all measured concentrations of heavy metals were below the limits allowed by JECFA, indicating that consumption of both species remains safe as long as the recommended weekly intake limits are not exceeded.

These findings are consistent with a study by Wariski et al. (2021), which reported that Pb and Cu levels in *C. obtusa* from Panipahan waters remained within safe consumption limits. Similarly, Fauzan et al. (2022) found that the concentrations of Pb and Cu in green mussels from Tanjung Balai Asahan were below the maximum limits set by the Indonesian Food and Drug Monitoring Agency.

4. CONCLUSION

This study reveals that the soft tissue of *G. erosa* and *C. obtusa* from the west coast of Dumai contains high levels of the heavy metals Pb, Cu, and Zn. The average concentrations of

Pb, Cu, and Zn in *G. erosa* were 6.79 µg/g, 6.13 µg/g, and 8.36 µg/g, while in *C. obtusa* they were 7.09 µg/g, 6.27 µg/g, and 7.41 µg/g. Statistical analysis did not reveal significant differences between species ($p > 0.05$), indicating that both species have relatively similar metal accumulation capacities. However, substantial spatial variation was observed in Cu and Zn concentrations in *G. erosa* and Zn in *C. obtusa* ($p < 0.05$), likely due to the influence of environmental factors and human activities. Safety assessment based on PTWI indicates that both species are still safe for consumption, with different weekly safe limits for each metal. Meanwhile, the Metal Pollution Index (MPI) shows slightly higher total metal accumulation in *G. erosa* (7.07 µg/g) compared to *C. obtusa* (6.86 µg/g). Overall, both species can be safely consumed by the public as long as intake does not exceed the established PTWI thresholds.

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