Bioaccumulation of Lead (Pb) on The Dog Conch (*Strombus canarium*) in Madong Waters, Tanjung Pinang

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Abstract

The waters of Madong in Tanjung Pinang city are located in a strategic area that has a significant impact on the livelihoods of fishermen, post-bauxite mining areas, ship traffic, and population activities. These factors have contributed to the contamination of heavy metal Pb in the waters, sediments, and dog conch. The purpose of this study is to analyze the levels of heavy metal Pb in the waters, sediment, and dog conch, and to assess the bioaccumulation factors of heavy metal Pb in dog conch in Madong waters. Samples of waters, sediment, and dog conch were collected from three stations and analyzed using AAS at the Marine Chemistry Laboratory of Raja Ali Haji Maritime University. The concentration of Pb in the waters ranged from 0.0204 mg/L to 0.0636 mg/L, while the concentration of Pb in sediment ranged from 0.5947 mg/Kg to 0.9402 mg/Kg. The Pb metal concentration in juvenile dog conch ranged from 0.0745 mg/Kg to 0.3437 mg/Kg. The highest BAF and BSAF values for Pb metal in adult dog conch were observed at station 1, with values of 27.241 and 0.6991, respectively. The categorization of Pb metal in *Strombus canarium* dog conch as low is based on the BAF and BSAF value categories.

Keywords: *Strombus canarium*, Bioacumulation factor, Madong waters, Heavy Metal Lead.

INTRODUCTION

The Madong water area in Tanjung Pinang city is known to harbor a diverse range of marine invertebrates, including the Gastropoda class mollusk, *Strombus canarium*, which has been observed in the waters surrounding Tanjung Pinang city (Anam *et al*., 2019). *Strombus canarium* is a member of the phylum Mollusca and the family Strombidae. It is an economically important species in the Indo-West Pacific (Oo, 2018). This snail plays a crucial role in coastal ecosystems (Cob *et al*., 2012). According to Maharani *et al*. (2019), *Strombus canarium* is classified as a herbivore that forages in the sediment by scraping the substrate attached by flora or microfauna (grazers). Due to its presence, it can serve as a suitable bioindicator of water quality. It is worth noting that this snail has been the subject of extensive research by scientists in Riau Islands Province, as highlighted by Irawan (2015). The *Strombus canarium* snail is a valuable resource for the local fishing community, as it is used for both trade and personal consumption (Putra *et al*, 2021). The snail meat is enjoyed by both the local community and migrants, which is reflected in the growing number of restaurants run by local fishermen. The high consumer demand has resulted in the overexploitation of this species (Supratman and Syamsudin, 2016).

The Madong waters are of great strategic importance for the development of economic and industrial areas. Madong Waters is an area traversed by a multitude of maritime traffic, including freight ships, fishing boats, and also encompasses residential areas, fish ponds, fishermen's restaurants, and a former bauxite mining area (Ismail, 2013). It is worth noting that the area has former bauxite mining sites, which, although not using chemicals, can cause contamination and have negative environmental impacts during the exploitation and exploration process (Kurniawan and Mustikasari, 2019). Waste disposal or residual mining activities will settle or be carried by currents at sea level (Santosa, 2013). The continuous activities in the Madong water area will inevitably result in the production of an ever-increasing quantity of organic and inorganic waste, with the potential for a concomitant increase in the pollution of the water areas (Ginting *et al*., 2019). One of the byproducts of this process is the generation of heavy metals. Heavy metals that enter the waterways

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will be contaminated and will settle in the sediment (Amin *et al*., 2013). According to Ika *et al*. (2012), heavy metals are difficult to decompose and easily accumulate in waters, which can have harmful effects on the quality of water and the life of organisms.

Heavy metals are generally toxic and can induce oxidative stress, DNA damage, cancer, and cell death (Kim *et al*. 2015). One of the most dangerous and toxic metals is lead (Pb). As stated by Suryono and Djunaedi (2017), lead metal (Pb) is a contaminant that is frequently encountered in aquatic environments. Heavy metal of Pb is considered to be a toxic metal that has the potential to pollute water and negatively impact the physiology, morphology, and genetics of organisms (Nasution, 2011). Waste sources that may contain Pb metal include fishing boat fuel, household waste disposal, particles eroded by bauxite mining activities, and ship paint made from lead that has been eroded by water currents (Rahayu, 2017). The accumulation of heavy metal contaminants in sediments and marine organisms has a negative impact on organisms, both directly and indirectly (Wariski *et al*., 2021). The process of lead (Pb) accumulation in tissues occurs subsequent to metal absorption from water or through foodstuffs contaminated with lead (Pb) and is transported by the circulatory system, subsequently distributed to the tissue system (Prianto and Husnah, 2017).

Continuous population activities in Madong have been observed to cause a significant amount of waste discharge containing heavy metals, which may lead to pollution of Madong waters and potentially harm the *Strombus canarium* dog conch that inhabit the area. It can be reasonably deduced from the findings of Hasniar *et al*. (2018) that an increase in activity will have a detrimental effect on the quality and pollution status of waters in Madong. Hence, it is imperative to carry out a study on the presence of Pb metal in water, sediment, and dog conch (*Strombus canarium*), along with the bioaccumulation factors of Pb metal in *Strombus canarium* dog conch. The objective of this study was to ascertain the concentration of Pb in waters, sediments, juvenile and adult *Strombus canarium* muscles, and to evaluate the degree of Pb accumulation in juvenile and adult *Strombus canarium* in comparison to Pb concentrations in waters and sediments in Madong waters.

MATERIAL AND METHODS

This research was conducted in September 2022 in Madong coastal waters. Madong waters are located in the Madong village area, Kampung Bugis Village, Tanjung Pinang City, Riau Islands Province with an area of about 2500 Ha and is located at coordinates 0°58'30" North latitude and 104°28'15" East longitude. East Longitude. Determination of the research location is divided into 3 stations. Station 1 is located in the harbor area, pond area, and residential areas. Station 2 is located in the former bauxite mining area, and Station 3 is located in the mangrove ecosystem area as well as a control station in this study (Figure 1). Sample analysis and conducted at the Marine Chemistry Laboratory, Faculty of Marine Science and Fisheries, Maritime University Raja Ali Haji (UMRAH).

The snail samples were collected using a purposive sampling method that met the required sample size at three stations. At each station, the sample data was systematically determined using 1m x 1m transects with 10 plots stretching vertically from the shoreline, at distances of 0-10 meters. The sampling process consisted of collecting water, sediment, and dog conch (*Strombus canarium*). Sample of dog conch were manually collected during low tide in predetermined plots. Polyethylene-based bottles and PVC pipes were used to collect water and sediment, respectively. Additionally, sediment was collected by hand and placed into 500-gram plastic bags. All samples were stored in ice boxes for further laboratory testing. Samples of water, sediment, and *Strombus canarium* dog conch were analyzed for their lead (Pb) metal content using Atomic Absorption Spectrophotometry (AAS).

To determine the content/level of heavy metals in water and sediment, it is necessary to calculate using the formula (Liantira *et al*, 2015).

$$Heavy\ Metal = \left(\frac{mg}{Kg}\right) = \frac{C\ x\ V}{W} \qquad (1)$$

Note: C = Concentration from AAS (mg/L); V = Volume sample (L); W = Weight sample (g).

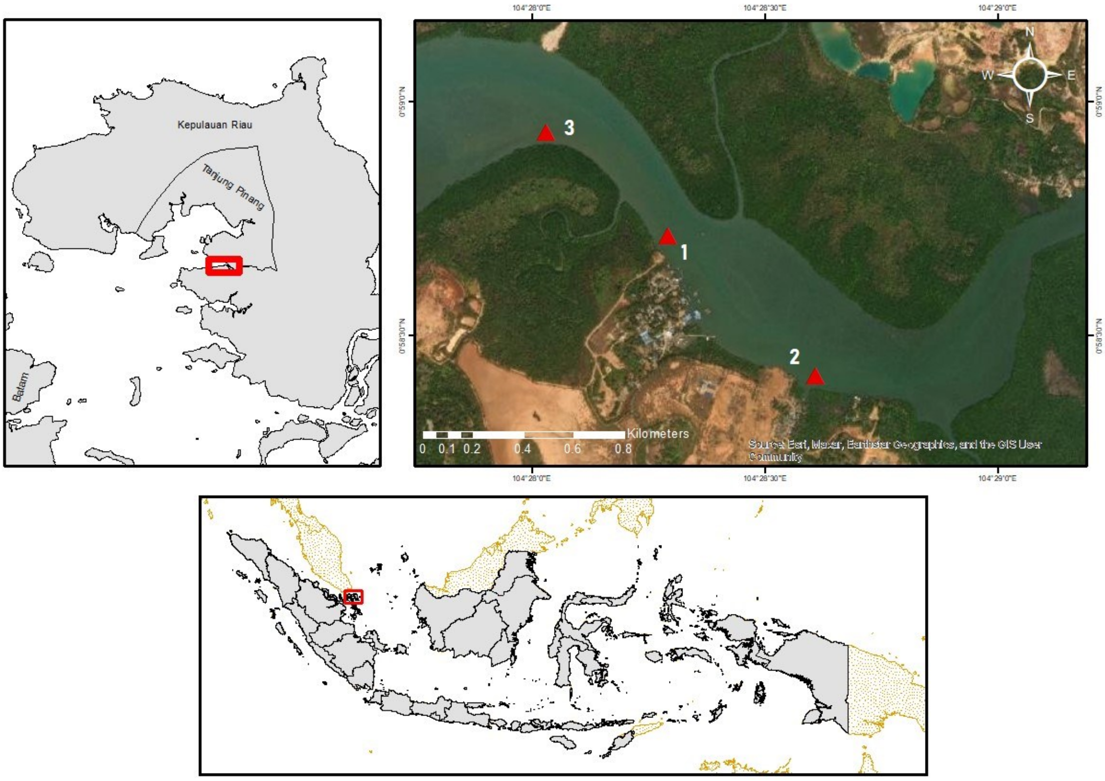

Figure 1. Research Location Map in Madong Water, Tanjung Pinang

The study employed the BAF formula to assess the bioaccumulation factor of Pb metal in dog conch (*Strombus canarium*). Additionally, the BSAF was calculated to determine the ratio of chemical concentrations of the organism (Co) to sediment (CS) (Gobas, 1993). The BAF formula calculates the ratio of chemical concentrations in the organism (Co) to water (CW).

$$BAF = Co / CW \quad (2)$$
$$BSAF = Co / CS \quad (3)$$

Note: BAF = Bioaccumulation Factor; BSAF = Biota Sediment Accumulation Factor; Co = concentration in organism; CW = concentration in water; and CS = concentration in sediment.

RESULTS AND DISCUSSION

The condition of the Madong water area can be said to be good, seen from the water quality parameters calculated in Table 1 such as Temperature, pH, DO, Current, Salinity, and Depth which are still in the normal stage according to the quality standards for the life of marine biota according to KepMen LH No. 51 of 2004. Water quality parameters are used as support for biota life and can trigger an increase in heavy metal concentrations in water areas. Measurement of water quality parameters is one of the first steps in determining the level of heavy metal pollution to be studied.

The water quality parameter calculations indicate that Station 1 had the highest temperature value (30.2 ^{o}C). It is worth noting that high water temperatures have been found to be directly linked to increased accumulation and toxicity of heavy metals. Temperature is one of the factors that contribute to high bioaccumulation values (Suprapti *et al.*, 2016). Furthermore, temperature can accelerate ion formation reactions and increase the solubility of heavy metals (Osei *et al.*, 2021), which can have an impact on the resulting heavy metal concentration values.

The pH measurements in Madong waters ranged from 6,96 to 7,14. According to Riani *et al*., (2017), anthropogenic activities and rainfall tend to increase the pH concentration. It is important to note that high pH levels can cause changes in the solubility of heavy metals in water bodies. As Zhang *et al*., (2018) observed, high pH conditions can alter the level of stability from carbonate to hydroxide and form particle bonds in the waters. At Stations 1 and 2, it is possible that the higher pH concentration may have led to an overestimation of metal concentration in the water. This finding is consistent with Anzori *et al*., (2019) research, which suggests that an increase in pH may lead to an increase in heavy metal concentration in bodies of water.

Salinity refers to the total amount of salt content in a kilogram of water and has a significant impact on the concentration of metals in the water. The distribution of salinity is influenced by various factors such as evaporation, rainfall, and water circulation (Fendjalang *et al*., 2022). The salinity measurements in this study ranged from 26-29. It is important to note that a low salinity value may affect the concentration of metals in the water, resulting in a smaller accumulation rate of heavy metals, while a high salinity value may have the opposite effect (Wardani *et al*., 2014).

The results of the calculation of Pb metal concentration in water and sediment at each station can be seen in Table 2. The concentration of Pb metal in water ranged from 0,0204 to 0,0636 mg/L, with the lowest concentration value found at Station 1 (0,0204 mg/L) and the highest at Station 2 (0,0636 mg/L). The elevated concentration of Pb metal at Station 2 may be attributed to various factors, including the discharge of household waste, deposition of bauxite mining particles, and slow water currents in the Madong water area. As noted by Filipus *et al*., (2018), these currents have the potential to transport organic waste sources into the water. Furthermore, the use of lead-based anti-rust paint on fishing boats is also suspected to contribute to the high concentration of Pb metal at Station 2. Syakti *et al*. (2012) suggest that the concentration of dissolved Pb in the aquatic environment may be attributed to human activities, particularly motor vehicle fumes containing TEL (tetra ethyl lead) used as a fuel octane value enhancer. The presence of several fishing boats anchored around residential areas for refueling supports this evidence.

The concentration of Pb metal in sediments at each station ranged from 0,5947 to 0,9402 mg/Kg. It is believed that the high concentration of Pb metal at Station 2 originates from the continuous discharge of household waste, which accumulates and settles at the bottom of the water. Additionally, the harbor area has higher concentrations due to human activities in the vicinity (Ma'rifah *et al*., 2016). The concentration of Pb metal in water can be influenced by its movement and transportation by the current until it eventually settles. This natural process can result in fluctuations in the concentration of Pb metal due to various dilution processes. The metal can accumulate in biota that settle in the sediment. Based on the SEPA 2002 quality standard of 5 mg/Kg, the concentration of Pb metal in sediments can be considered unpolluted.

Table 1. The Parameter of Water Quality

Stations	Water Quality					
	Temperature	pH	DO	Current	Salinity	Depth
1	30,2	6,96	5,2	0,246	26	1,40
2	29,5	7,14	6,4	0,272	27	1,58
3	29,6	6,86	6,2	0,231	29	1,70

Table 2. Concentration of Heavy Metal Pb in Water and Sediment in Madong Waters

Stations	Concentration of Heavy Metal Pb	
	Water (mg/L)	Sediment (mg/Kg)
1	0,0204	0,7974
2	0,0636	0,9402
3	0,0295	0,5947

According to Table 2, it appears that the concentration of Pb metal in sediments is higher than in water. This observation may indicate that Pb metal tends to accumulate or build up at the bottom of the water, while in seawater, it is mostly transported by the movement of currents until chemical processes take place in the water column. According to Riani (2012), the accumulation of metals at the bottom of bodies of water over time may present a possible risk to the organisms that reside in and consume from those waters.

The concentration of Pb metal in dog conch is presented in Table 3. The calculation results show varied values at each station. The concentration of Pb metal in juvenile dog conch ranged from 0,0745 – 0,3437 mg/Kg. The highest concentration was found in Station 2 while the lowest was in Station 3. The results of the calculation of Pb metal in adult dog conch ranged from 0,0650 – 0,6170 mg/Kg. The cause of the high concentration at Station 2 is thought to be human activities and also the activities of fishermen who use boat paint and fuel containing Lead. Fidiani *et al.* (2015) said there are ship paints made from Lead and function to accelerate the drying process and inhibit the occurrence of rust on the ship. The high concentration at Station 2 is related to the high concentration in the sediment and results in dog conch that live in the substrate will absorb particles or substances that are bioavailable, namely substances or particles that can be absorbed by grazer biota. Particles containing heavy metals will settle to the bottom of the water and are absorbed by biota that tend to settle so that they can affect the lives of organisms (Said *et al*, 2009).

The calculation results suggest that adult dog conch may have higher levels of Pb metal than juvenile dog conch, which could be due to the size of their shells. However, it is important to note that the overall concentration of Pb metal in *Strombus canarium* dog conch remains below the maximum limit for heavy metal contamination in food, as specified by SNI 7387:2009. Therefore, it can be concluded that *Strombus canarium* dog conch in Madong waters are safe for consumption.

Based on the calculation of the Bioaccumulation Factor (BSAF) value, which compares metal concentrations in organisms and water, it has been observed that adult dog conch possess a greater ability to accumulate metals than smaller dog conch. This can be attributed to various factors such as their digestive system, metabolism, and food availability in the substrate. As noted by Agustina (2017), the presence of organic matter as a food source for biota can contribute to the high content of heavy metals in the water. The bioaccumulation factor (BSAF) of heavy metals in *Strombus canarium* snail samples at Stations 1 and 2 (0,6562 – 0,6991) is higher than that of juvenile dog conch (0,3006 – 0,3655), possibly due to differences in size or age. As suggested by Riani (2009), larger or older dog conch of the same species tend to accumulate higher levels of heavy metals than smaller or younger ones. Additionally, the high temperature in Madong waters (29.2 ^{o}C - 30.2 ^{o}C) may also

Table 3. Concentration of Heavy Metal Pb in gonggong dog conch (*Strombus canarium*)

Stasiun	Concentration of Heavy Metal Pb	
	Juveline (<40 mm)	Adult (>40 mm)
1	0,0204	0,5575
2	0,0636	0,6170
3	0,0745	0,0650

Table 4. Bioaccumulation factors of heavy metal Pb in the dog conch (*Strombus canarium*) on sediment

Stasiun	Bioaccumulation factors (BSAF)	
	Juveline (<40 mm)	Adult (>40 mm)
1	0,3006	0,6991
2	0,3655	0,6562
3	0,1252	0,1094

Table 5. Bioaccumulation factors of heavy metal Pb in the dog conch (*Strombus canarium*) on Water

Stasiun	Bioaccumulation factors (BSAF)	
	Juvenile (<40 mm)	Adult (>40 mm)
1	11,714	27,241
2	5,4017	9,6972
3	2,5197	2,2006

be a contributing factor. It has been observed that elevated temperatures may contribute to the accumulation of heavy metals in water, which can have adverse effects on the organisms inhabiting the substrate. Furthermore, it has been noted that high temperatures can increase the metabolism of organisms, potentially resulting in increased levels of bioaccumulation in dog conch. The higher BSAF values observed at Stations 1 and 2 can be attributed to the sediment type present at those locations. The sediments at these stations are classified as muddy sand, and the high mud content contributes to the increased accumulation of metals in the water. Najamuddin (2016) has noted that sediment conditions with high mud fractions have a significant impact on the concentration of metals. It is worth noting that the overall Bioaccumulation Factor (BSAF) value is less than 1, indicating that the ability of dog conch to accumulate Pb metal in the sediment is low.

The Bioaccumulation Factor (BAF) is used to determine the dog conch's ability to accumulate metal concentrations in water. As shown in Table 5, the BAF calculation results vary. The highest BAF values were obtained at Station 1 for both juvenile (11.714) and adult snails (27.241). It is likely that this high BAF value is due to prolonged exposure to metals resulting from human activities in the area. The size of the BAF value is dependent on various factors such as the type of heavy metal produced, the organism, and the length of exposure and environmental conditions (Hutagalung 1996). According to Arnot and Gobas (2006), the BAF value can be categorized as having low accumulation (BAF < 1000), medium accumulation (1000 < BAF < 5000), or high accumulation (BAF > 5000). According to the BAF results presented in Table 5, it can be inferred that the accumulation rate of *Strombus canarium* snails is relatively low.

The highest BAF calculation results were for adult dog conch at Station 1 (Table 5). The accumulation of heavy metals in dog conch can be influenced by various factors, including size and age. These findings are in line with previous research (Riani *et al*., 2017) which suggests that the level of metal accumulation tends to increase with prolonged exposure of the biota to the metal. The study conducted in Madong waters revealed that Station 1 and Station 2 had higher Bioaccumulation Factor (BAF) values (> 5) compared to Station 3. It is worth noting that this difference can be attributed to the general water quality conditions, including temperature, salinity, current speed, pH, and DO. Moreover, it is worth noting that Stations 1 and 2 are situated in close proximity to areas of human activity, such as fishing ports, residential areas, ponds, and former bauxite mining sites. Conversely, Station 3 displays notably lower concentration levels and is deemed the most desirable location due to its location within the mangrove forest area. Mangrove forests play a crucial role in preserving environmental equilibrium. Mangrove forests are known to act as biofilters and pollution traps, while also playing a crucial role in maintaining the balance of the surrounding biota (Bengen, 2004).

CONCLUSION

The concentration of Pb metal in the waters ranged from 0.0204 to 0.0636 mg/L, with no samples exceeding the quality limit of the 2004 KepMen LH regarding the quality standard for sea water quality of 0.1 mg/L. The concentration of Pb metal in sediments ranged from 0.5947 to 0.9402 mg/L, and thus did not reach the standard of 5 mg/kg set forth by SEPA in 2002. The concentration of Pb metal in *Strombus canarium* juveniles ranged from 0.0204 to 0.0745 mg/kg, while in *Strombus canarium* adults it ranged from 0.5575 to 0.6170 mg/kg. These values have not reached the quality standard according to SNI 7387 of 2009 of 1 mg/kg. The concentration of BSAF in *Strombus canarium* juveniles ranged from 0.1252 to 0.3655, while in adult *Strombus canarium* it ranged from 0.1094 to 0.6991. The results indicated that the adult size accumulated more Pb metal. The total BSAF results showed values below 1, indicating that the accumulation rate was low. The concentration of BAF in *Strombus canarium* juveniles ranged from 2.5197 to 11.7140, while in *Strombus canarium* adults ranged from 2.2006 to 27.2410. The results indicated that the adult size accumulated higher levels of BAF. The total BAF results demonstrated a value below 1000, indicating that the BAF value is in the low category. The quality of the Madong waters with regard to Pb metal in the waters, sediments, and *Strombus canarium* remains within safe limits, and the consumption of *Strombus canarium* remains suitable.

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