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Heavy Metals in Seawater, Sediments, and Snail Biota Collected From Coastal Waters of Indragiri Hilir Regency, Riau Province, Indonesia

Kamaruddin Eddiwan*, Budijono and Muhammad Hasbi

Department of Fisheries and Marine Sciences, University of Riau, Tampan, Pekanbaru, Indonesia

Research Article

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***For Correspondence**

Eddiwan K, Department of Fisheries and Marine Sciences, University of Riau, Tampan, Pekanbaru, Indonesia, Tel: +6276163274.

E-mail: kamaruddineddiwan@gmail.com

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ABSTRACT

Sea snails with the type of *Ceritihidea obtusa* are commonly found in muddy coastal areas in the mangrove ecosystem and as a popular seafood in Riau Province, but these coastal areas also receive household waste, agricultural activities, industrial and marine sailing traffic. Information on coastal pollution in this region is minimal, especially heavy metals in water, sediment and bioconcentration factors in this snail. In this study, 3 locations in Tanjung Pasir Village were selected as the main collection and source of the largest *C. obtusa* supply for consumption inside or outside the region. Aspects evaluated were concentrations of heavy metals (Pb and Zn) in seawater, sediment and snail meat. The results found that there was heavy metal in the water with levels above the limit of sea water, including snail meat especially Pb above the national and international legal limits for human consumption, except in sediments. A positive relationship was found between concentrations of Pb and Zn in water or sediments with higher snail meat compared to the relationship between concentrations of both heavy metals in water and sediment. The bioconcentration factor for Pb was found to be higher than that of Zn especially accumulated from the water column with the accumulated level of the two metals being moderate. The results indicate that pollutants from local coastal community activities become the source of these heavy metals and pretreatment of these snails needs to be given in order to achieve legal limits for consumption.

INTRODUCTION

The coastal waters of Indragiri Hilir is a fishing ground for traditional fishermen, residential areas, industrial estates, shipping lanes, port areas, refuelling sites for ships operating in the Nyiur and Enok Rivers, in particular, the coast of Tanjung Pasir Village. In this area, there is an area of 11,863.63 hectares of mangrove forest and is a habitat of various sea snails. *Cerithidea obtusa* is one species of the gastropod group, from the Potamididae tribe known locally as a suction snail. These animals are commonly found on mud substrate, roots and branches and mangrove leaves, or in mud bank areas in tidal areas. In Indonesia, *C. obtusa* is an economically valuable fishery resource, with the market price of USD 2, and is a consumable ingredient for local people. Due to the increasing market demand and mangrove habitat destruction, the current production of *C. obtusa* is declining in nature. In addition, *C. obtusa* also plays a role in the food chain and actively accelerates the decomposition process in mangrove habitat. This organism is a nutrient producer that is needed by plants and as a prey from another biota in the mangrove habitat [1]. On the other hand, these animals also act as decomposers because they are involved in the decomposition process of waste and mineralization of organic matter [2]. Various local anthropogenic activities and water quality research results in both rivers (S. Nyiur and S. Enok) showed that the heavy metal content of Pb and Zn was quite high. The heavy metals of Pb and Zn in the Nyiur River reach 0.038 - 0.115 mg/L and Zn 0.119 - 0.139 mg/L [3]. Human activities that occur throughout the region have helped to increase the heavy metal content in seawater [4]. Waste disposal from domestic, industrial, agricultural, fuel and refuelling activities is a major source of heavy metal pollution that has a detrimental effect on water quality. Heavy metal pollution in coastal waters is recognized as a serious environmental problem. In many cases, heavy metals often occur in water bodies with relatively low toxic levels, but because the properties of these heavy metals cannot be degraded, these low concentrations can cause damage to organisms of organisms, as they result in collection and bioaccumulation in the body of organisms, and cannot be metabolized effectively or extracted. Soegianto and Irawan and Colechovska et al. state heavy metals accumulate bioactive on one or several compartments in the food web [5,6]. Then Schwartz mentions that harmful pollutants are heavy metals because they are able to bind cell membranes that affect the intracellular transport process in the form of life in the body [7]. This heavy metal also acts as a potential phase ATP inhibitor [8]. These heavy metals enter the animal organ network and reach the target organ in the body by passing through the membrane layer, affecting permeability and decreasing normal enzyme transport. The heavy metals reported by Mwachiro and Durve can affect the liver and kidneys [9]. The observation of the dynamics of the development of pollution in the waters becomes a world issue and very interesting as the industry in the coastal region [10]. Bioaccumulation of metals is important from a public health standpoint, especially when humans consume their accumulators. This phenomenon is now being exploited in the assessment of environmental quality, in addition to the chemical aspects of water and sediment. Given its limited report on heavy metal pollution in waters and sediments against *C. obtusa*, this study was conducted in the coastal waters of Tanjung Pasir Village, Indragiri Hilir District, Riau.

MATERIALS AND METHODS

The study was conducted in March - July 2017 on the coast of Tanjung Pasir Village, Tanah Merah Sub-district, Indragiri Hilir Regency **(Figure 1)**. The three locations of water collection, sediment and snail biota are determined by purposive random sampling method with distance between stations 1000 m, i.e., Station 1 is located in the northern part of the community settlement, mangrove forest is still natural and as the vessel traffic passage between villages or regions (00°26'19,12" south latitude and 103°20'6,0" east longitude); Station 2 is located in community settlements, fishing ports, on the front there are coconut processing industries (00 26'0.98" south latitude and 103°21'32,4" east longitude) and Station 3 in the southern part of the fishing area, snails, shells and mangrove crabs (00°26'50,49" south latitude and 103°22'55,2" east longitude), including also researched for various parameters such as temperature, velocity, salinity, pH and heavy metals (Pb and Zn) in water, sediment and *C. obtusa* meat.

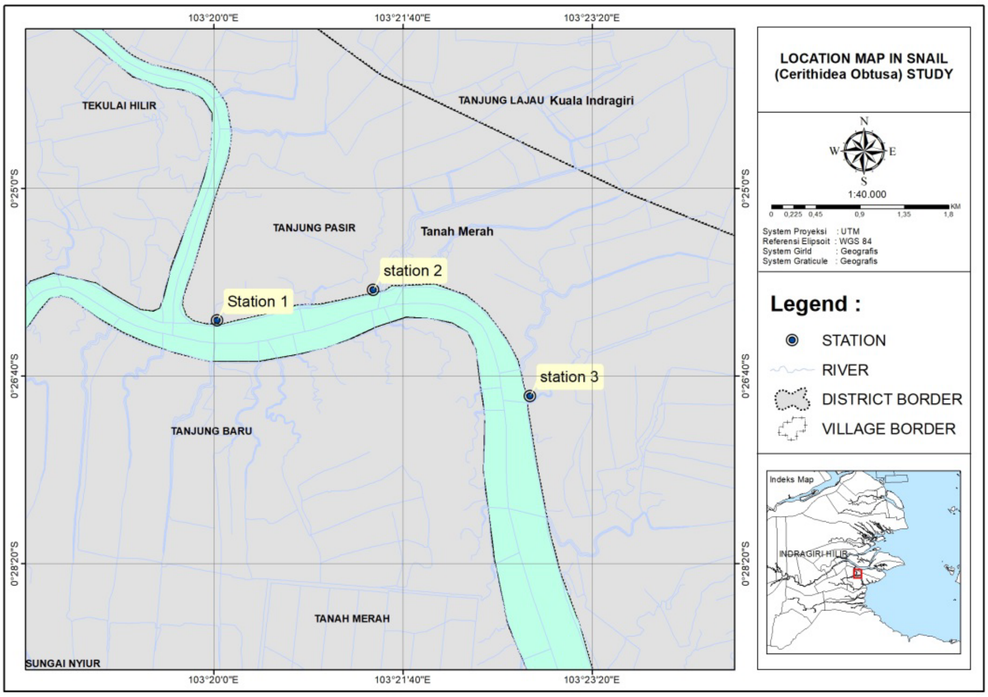

Figure 1. Location map of tanjung pasir village, Tanah merah Sub-district, Indragiri Hilir.

Water samples and sediments are collected as far as one meter from three points at each of the above-mentioned stations at 9 am to 3 pm. Water samples were collected using bottles of BOD (250 ml) and temperature, pH, salinity and current velocity were recorded. Each station is made up of one transect line consisting of 3 plots measuring 1 m × 1m with the distance between the left and right plots is 25 meters. In each plot, *C. obtusa* is found (as on the surface of the substrate or attached to the root, stems and leaves of mangrove plants and dug as deep as 15 cm in the observation plot) taken by hand and sediment (one kg wet weight) taken with Eckman grab. The samples obtained were incorporated in plastic bags and marked from each plot as density and identification data. *C. obtusa* refers to the Mollusca identification key [11]. The collected samples were then frozen at 4°C until analyzed. Water pH was recorded using pH meter ATC, temperature with Hg thermometer, the current velocity with current drought of manual vane type and salinity with hand-refractometer ATAGO. Atomic Absorption Spectrophotometers (Variants. AA-220) were used to analyze the presence of heavy metal concentrations in the water, sediment and *C. obtusa*. Each metal had a characteristic wavelength, lead (217.0 nm) and zinc (213.9 nm). The analysis of heavy metal began with the preparation of the blank solution, then the standard solution and the analysis of the sample. Heavy metal content analysis of Pb and Zn in seawater was conducted based on SNI Method 6989: 8: 2009 and SNI 6989: 7: 2009. 50 ml of water sample put into 100 ml cup glass and added 5 ml of concentrated HNO_3 [12-14]. cover with a watch glass. Then heated slowly until the remaining volume of 15 ml - 20 ml. If the destruction is not perfect (not clear), then added another 5 ml of concentrated HNO_3 and covered with a watch glass then heated again (not boiling). This process is carried out repeatedly until all the dissolved metal which are visible from the colour of the water sample sediment become clearly white or the water sample becomes clear. After that, the glass of the watch is rinsed and rinse water is inserted into the cut glass. Then the water sample was transferred to a 50 ml measuring flask and water washed up until the last mark was homogenized. Water samples are readily measured with AAS.

The analysis of the heavy metal content of Pb and Zn on sediment and snail meat is done based on SNI 06-6992.3-2004 and SNI 06-6992.8-2004 method with the following steps:

- Sediment starts from drying sediment samples and then removing foreign objects such as plastics, leaves and other materials that do not test materials, then crushed by crushed and homogenized. Considering a homogenized sediment sample of 1.0 g, then incorporated into a 250 ml Erlenmeyer and added 25 ml of aquades water then stirred with a stir bar. Added 5 ml of 10 ml of concentrated NHO_3 and stirred until well mixed. Add 3 grains to 5 rounds of boiling stone and covered with a glass of watch and then heated over an electric bath with temperature 105°C to 120°C until the sample volume becomes 10 ml. then in lift and cooled. Adding 5 ml of concentrated HNO_3 and 1 ml to 3 ml of concentrated $HClO_4$ dropwise through the Erlenmeyer glass wall is then reheated until white smoke is exposed and the test sample solution becomes clear. After the white smoke warms up for 30 minutes then the sample is cooled and filtered. The sample filtrate was placed in a 100 ml measuring flask and aquades were added to the tera mark. Sediment samples are readily measured with AAS [15].

- The snail meat analyzed derived from uniformly selected snail meat from each station with a length of ± 6 cm of 20 individuals, then dried and mashed. The smoothed sample was weighed 25 g in a porcelain dish, then the sample is dried over the hot plate until it is concocted, then inserted into the kiln. The kiln temperature is adjusted at 250°C then slowly raised to 350°C with each increment of 50°C, then increased again to 500°C with each increase of 750°C, after which the sample is ignored for 16 hours. The furnace is turned off to cool for 30 minutes. Remove the porcelain plate from the furnace and allowed to cool in the desiccator. Dissolved ash in 5 ml of HNO_3, then dried over a hot plate, then the residue was added 5 ml HNO_3 and dissolved then dissolved residue was put into a 50 ml measuring flask. The washing of the residue is repeated 3 times with aquades and made into one of the previous solutions. The flask is diluted to the marked line then the solution is filtered with Whatman No. 41 filter paper. The biota sample is readily measured by AAS.

Data of heavy metals Pb and Zn on seawater were analyzed by comparing with sea water quality standards (State Minister of Environment of Indonesia, and sediment compared with sediment quality referring to ANZECC/ ARMCANZ sediment quality guidelines and meat snails compared to SNI 7387: 2009 and the Decree of the Director General of Drug and Food Control (POM) No.0375/B/SK/VII/89, 1989) regarding the maximum limit of heavy metal pollution in food for bivalves molluscs and sea cucumbers [16-18]. Statistical analysis of differences and relationships between heavy metals in seawater, sediment and crab meat from each station was performed using Statistical Package for Social Science (SPSS) version 16 and the bioconcentration factor (BCF) was used to calculate the distribution of heavy metals between biota and ambient media (sediment and seawater) referring to Mountouris et al. [19,20].

$$BCF = C_{biota} / C_{ambient\ medium}$$

Where C_{biota} is the concentration of heavy metals in the biota and $C_{ambient\ medium}$ is the concentration of heavy metals around.

RESULTS

Population density of *C. obtusa* and water quality parameters, concentrations of heavy metals in water, sediments and *C. obtusa* tissue collected from three different stations are presented in **Table 1**. The population density of *C. obtusa* ranged from 14 - 44 individuals/m^2, and the water temperature ranged from 31 - 32°C, water pH 6.3-6.7, salinity 23-26 o/oo and current velocity of 7.60-9.85 cm/s. The concentrations of heavy metals in seawater, bottom sediment and *C. obtusa* meat are presented in **Table 2**. It is known that the lead content (Pb) in seawater is between 0.0241 - 0.0543 mg/L and Zn 0.0947-0.1767 mg/L. Pb in the sediment is in the range of 0.8142 - 1.7469 mg/kg and Zn 1.9282 – 3.2720 mg/kg, while Pb in *C. obtusa* meat is in the range of 2.3552 – 4.9085 mg/kg and Zn 5.2777 – 8.1990 mg/kg. Significant differences ($P < 0.05$) in each heavy metal in water, sediment and *C. obtusa* meat were observed between stations. The relationship between heavy metals in seawater, sediment and *C. obtusa* biota can be seen in **Table 3**. From the results of linear regression analysis shows clearly the positive correlation (r=0.640 - 0.920) heavy metals Pb and Zn in water, sediment and snail *C. obtusa*.

Cerithidea obtusa's ability to accumulate heavy metals Pb and Zn can be seen from the values of bioconcentration factors (BCFb/w and BCFb/s) in **Table 4**. The value of BCF(b/w) of Pb and Zn metal at all stations was 90.91 - 105.6 and 46.32 - 55.56 respectively and followed by BCF(b/s) for Pb ranged from 2.81 to 3.19 and Zn 2.17 to 2.74.

Table 1. Population density of *C. obtusa* and coastal water quality of tanjung pasir.

Station	Average Density (individual/m²)	Temperature (°C)	pH	Salinity (%)	Water Velocity (cm/sec)
1	28	31	6.6	23	9.85
2	14	32	6.3	24	7.77
3	44	31	6.7	26	7.60

Table 2. Concentration and standard deviation, average, quality standard, P-value oneway ANOVA and least significant difference (LSD) test of heavy metals between stations in seawater, sediment and *C. obtusa*.

Environ-mental type	Metals and Unit	Station	Concentration and St.Deviation	Average and St.Deviation	Quality Standard	P value one-way ANOVA	LSD test: comparison between the station	LSD test: Sig.
Seawater	Pb (mg/L)	1	0.036 ± 0.006	0.038 ± 0.006	0.008(1)	0,003	1 and 2	0.012*
		2	0.054 ± 0.005				1 and 3	0.049ns
		3	0.024 ± 0.007				2 and 3	0.001*
	Zn (mg/L)	1	0.129 ± 0.003	0.134 ± 0.014	0.05(1)	0,004	1 and 2	0.017*
		2	0.177 ± 0.011				1 and 3	0.054 ns
		3	0.095 ± 0.029				2 and 3	0.001*
Sediment	Pb (mg/kg)	1	1.191 ± 0.445	1.251 ± 0.288	50-220(2)	0,028	1 and 2	0.070 ns
		2	1.747 ± 0.223				1 and 3	0.186 ns
		3	0.814 ± 0.197				2 and 3	0.010*
	Zn (mg/kg)	1	2.903 ± 0.391	2.701 ± 0.323	200-410(2)	0,007	1 and 2	0.224 ns
		2	3.272 ± 0.373				1 and 3	0.012*
		3	1.928 ± 0.205				2 and 3	0.003*
C. obtusa	Pb (mg/kg)	1	3.802 ± 0.736	3.688 ± 0.399	1.5(3)	0,002	1 and 2	0.028*
		2	4.909 ± 0.132				1 and 3	0.009*
		3	2.355 ± 0.328				2 and 3	0.001*
	Zn (mg/kg)	1	6.299 ± 0.213	6.592± 0.178	100(3)	0,000	1 and 2	0.000*
		2	8.199 ± 0.172				1 and 3	0.000*
		3	5.278 ± 0.148				2 and 3	0.000*

Note: (1)= sea water quality standard; (2) = sediment quality guidelines; (3) = safe limit of consumption; *= significant; ns) = no significant [16,18].

Table 3. The relationship between heavy metals in seawater, sediment and snail *C. obtusa*

Relationships	Regression Equations	R^2	r	Sig.
Metal water – sediment	Y_{Pb} = 0.411 + 21.93x	0.410	0.640	0.063
	Y_{Zn} = 1.075 + 12.16x	0.502	0.708	0.033
Metal water – *snail C. obtusa*	Y_{Pb} = 1.091 + 67.86x	0.665	0.815	0.007
	Y_{Zn} = 2.503 + 30.59x	0.848	0.920	0.000
Metal sediment - *snail C. obtusa*	Y_{Pb} = 1.126 + 2.048x	0.710	0.842	0.004
	Y_{Zn} = 2.521 + 1.506x	0.606	0.778	0.013

Table 4. Value of bioconcentration factor ($BCF_{b/w}$ and $BCF_{b/s}$) heavy metals Pb and Zn on *C. obtusa.*

BCF Value	Station 1	Station 2	Station 3	Average
$Pb_{(b/w)}$	105.6	90.91	98.13	98.21
$Zn_{(b/w)}$	48.83	46.32	55.56	50.24
$Pb_{(b/s)}$	3.19	2.81	2.89	2.96
$Zn_{(b/s)}$	2.17	2.51	2.74	2.47

Note: b = biota (snail); w = seawater; s = sediment

DISCUSSION

Population Density *C. obtusa*

As an illustration, the density of mangrove vegetation in the coastal area of Tanjung Pasir Village is recorded around 1,111 ind/ha consisting of *Avicennia alba* (271 ind/ha), *Rhizophora apiculata*. (300 ind/ha), *Xylocarpus granatum* (271 ind/ha), *Bruguiera gymnorhiza* (157 ind/ha) and Nypa fruticans (157 ind/ha) with a leaf litter production rate of each mangrove species ranged from 1.82 to 4.22 g/tree/day [21]. The existence and structure of uneven mangrove vegetation between different stations and litter production cause the highest population density of *C. obtusa* among stations at Station 3, followed by Stations 1 and 2. It is assumed that the structure of mangrove and litter vegetation produced at Station 3 and 1 is higher compared to Station 2 then this snail behaviour tends to approach mangrove vegetation. *Cerithidea obtusa* as a member of the mangrove gastropod genus that consumes detritus or litter is known to consume substrate and tends to approach mangrove trees so that it can spread horizontally and erect on roots and stems mangrove vegetation to cope with tidal changes [22,23]. The average density of *C. obtusa* at the study sites was higher than in other recorded areas such as 7 ind/m^2 in Pangkal Babu Kuala Tungkal 0.48 ind/m^2 in Matang, Malaysia and 0.05 ind/m^2 in the Mahakam Delta of East Kalimantan [22,24,25].

Water Chemical and Physics

The results of water quality measurements in seawater **(Table 1)** show no major differences from all parameters between stations and almost the same obtained from previous studies at this location with a temperature range of 20.1 - 30.9°C, salinity 21.4-22.9 per mile and a current velocity of 11 - 16 cm/sec, except for a higher pH range of 7.15 - 7.47 [21]. In this study, the temperature was within the range tolerated by *C. obtusa* that is between 25 - 32°C and on the more open beach, substrate temperature slightly higher between 29 - 34°C [24,26]. Nybakken et al. states that water temperature will determine biological activity and its activity in marine biota in water [27]. The range of water pH near normal is thought to have a freshwater effect on the Nyiur River and Enok River and the presence of waste contamination. Similar water pH characteristics were found in Rutnaningsih et al. studies with gastropod pH between 5-9 in the Pangkal Babu Kuala Tungkal mangrove forest, although gastropods are commonly found in areas with a pH greater than 7 [24,28].The salinity found was still within the tolerance of gastropod salinity ranging from 25-40°C [26]. When compared to water quality standards for marine biota (2004), the average environmental parameters in coastal waters of Tanjung Pasir Village are generally still within the tolerance level range of marine organisms.

Heavy Metals in Seawater

The status of metal pollution in the studied seawater is given in **Table 2** by comparing the concentrations of Pb and Zn as measured by the current seawater quality standard in Indonesia (MENLH, 2004). The result in the decision of seawater quality standards for marine biota establishes Pb 0.008 mg/L and Zn 0.05 mg/L and refers to the standard of seawater quality, our findings obtained both metals have exceeded the limits set so that these studied coastal waters have been polluted by heavy metals Pb and Zn. The content of these two heavy metals at all the high stations is mainly found in station 2 as the location of community settlements, fishing ports and the coconut processing industry. This proves that current coastal activity, directly and indirectly, affects the concentration of these metals in seawater. This plus coastal waters continuously receive river water runoff from the Enok River and Nyiur River which can lower the pH and low pH values cause Pb and Zn to dissolve easily. Heavy metal Zn is higher than Pb in all stations and there is a significant difference ($p<0.05$) of the two metals between stations, except station 1 with station 3. The content of Pb and Zn found in this study is similar to that of the year previously obtained a range Pb 0.031-0.062 mg/L in the same location (Riau Province Research and Development Agency). These findings are also higher than findings in several Indonesian waters locations such as Pb 0.027-0.049 mg/L in the waters of Tanjung Pinang Pb<0.005 mg/L in Natuna waters Sagala et al. Pb 0.006-0.038 mg/L in Natuna waters Rahayu et al. Pb<0.001-0.016 mg/L in Muna Island, Kabaena and Buton and Pb<0.001 - 0.006 mg/L in the waters of the Arafura Rochyatun Sea, 2004), but lower than Pb 1.0 - 26.0 mg/L in the Bay of Klabat waters; Pb 0.02 - 0.07 in the tin mining area of South Bangka district ; Pb 0.0462 - 0.3140 mg/L and Zn 0.0897 - 0.2389 mg/L in coastal waters of Singkep Island; and Pb 1.37 - 1.69 in coastal waters of Dumai City [29-35].

Heavy Metals in the Sediment

Table 3 shows the level of heavy metals in the sediments. The mean concentrations of Pb and Zn in the sediments were higher than in seawater and the concentrations of these two metals were much lower than the reference limits of sediment quality [17,36,37] because the limitation of heavy metal contamination in sediment has not been regulated by Indonesia. The comparison between the mean content of Pb and Zn in the sediment with water obtained by Pb is about 33 fold and Zn is 20-fold in muddy sediments than in seawater, with the highest Pb and Zn found on station 2 similar to the highest Pb and Zn findings in sea water. These findings prove that high metal concentrations in water will increase the accumulation of these metals in the sediments so that the location of community settlements, fishing ports and the coconut processing industry is assumed to be a source of input of both metals in the sediment. Once the heavy metals enter the sea water it will experience precipitation, dilution and dispersion. Heavy metals that settle on the ocean floor will accumulate into the sediments [38]. In aquatic systems, metals are transported either in solution or on the surface of suspended sediments [39]. Due to the strength of particles for particles metals tend to be accumulated by suspended substances or trapped immediately by lower sediments [40,41]. These metals may be in sediment through direct or indirect discharges from local coastal activity or carried by the runoff of river water flowing in these studied coastal waters. As with water, Zn concentrations remained higher than Pb in all stations and there was a significant difference ($p<0.05$) between stations, except at station 1 with station 3. Concentrations of Pb and Zn or one of them in the found sediment in this study is also much lower than other findings in Sumatran waters such as Pb ranging from 20.4900 - 32.8593 µg/g and Zn 130060 - 488890 µg/g at the site of former tin mines in the coastal island of Singkep Kepulauan Riau Amin et al.; Pb 1.55 - 19.58 mg/kg in the tin mining area of South Bangka district Bidayani et al. and Pb 4019 - 4398 mg/kg and Zn 3547 - 6682 mg/kg in coastal waters of Dumai City [33-35]. However, these low concentrations remain to be watched as heavy metals dissolved in water columns at certain concentrations may turn function into a source of toxicity to aquatic life although the toxicity inflicted by a heavy metal type to all aquatic biota is not the same, but the destruction of a group may lead to the breaking down of one chain of life (niche) [42,43].

Heavy Metal in *C. obtusa*

Table 2 shows the mean concentrations of Pb and Zn metal in *C. obtusa* meat and in the 6th column of the table, the legal limit for metals in food, especially Pb is presented. The concentration of this Pb metal in meat (edible part) of *C. obtusa* is higher than the maximum level regulated by Indonesia, i.e., Pb 1.5 mg/kg (National Standard Body of Indonesia) while Zn 100 mg/kg (Decree of the Director General of Drug and Food Control (POM) and the concentration of Pb is also above the limit permitted by some other countries such as Pb 2 mg/kg in Singapore (Agri- food and veterinary Authority of Singapore); Pb 1.5 mg/kg in Europe (Commision Regulation); Pb 2 mg/kg in Spain and according to the report of the Food Standards Committee of England, Zn levels in food should not exceed 50 mg kg [44-48]. Specific Zn, this limit is not exceeded in *Cerithidea obtusa* meat analyzed in this study. Therefore, it is inferred from the presence of Pb concentrations above the safe limits for fixed consumption may pose a health risk to those consuming *C. obtusa* meat because of the heavy metal nature of Pb which is not an essential metal and cannot be biologically described. Pb content in all soft tissues (muscles, limbs and gastrointestinal tract) *C. obtusa* commonly eaten by the public may be hazardous to health, especially Pb content in the gastrointestinal tract because the digestive tract and bowel have the better ability because of the metal. easily attaches to metallothionein in the gastrointestinal tract rather than in other parts of the soft tissues [49]. In addition, the gastrointestinal tract is a central metabolism and heavy metal detoxification [50]. While Zn is an important element and is not considered a significant threat to human health [51]. This condition may serve as a warning to the community and local government to be more vigilant in the future to manage the environment and for the community in the future to provide preliminary treatment to these snails before being processed into foods such as the use of $Na_2CaEDTA$ reviewed [52]. Referring to Prasetyo et al. findings on green shell (Perna viridis L) soaked for 60 minutes with $Na_2CaEDTA$ 1% can decrease Pb by 99.92% and other non-essential essential metals such as Hg and Cd are 99.98% respectively the ability of $Na_2CaEDTA$ as a heavy metal binder so as to form a bond compound with metal ions contained in the body of the shell [43].

The average concentration of Pb and Zn in *C. obtusa* meat is higher than in sediment, even seawater. The concentrations of the two heavy metals in *C. obtusa* have the same concentration distribution and sequence profile with sea water and sediment, i.e., Zn higher than Pb. In *C. obtusa* meat, the highest concentrations of the two heavy metals were also found at station 2 following high concentrations of seawater and sediment and between observed stations, there was also a significant difference ($p<0.05$). Differences in the accumulation of the two metals observed in *C. obtusa* meat were influenced by eating habits, ecological needs, metabolism, age, size and habitat. The Pb content found in this study was higher than other gastropod species such as *C. quadratic* and *Nerita lineata* from the primary market of Kinabalu with a Pb range of 0.098 - 0.54 mg/kg but still lower than Pb on *C. obtusa* originating from the tin mining area on the coastal island of Singkep ranging from 10.8713 - 19.2163 µg/g [34,53]. This suggests that the same species have the same way of life and eating and the same level of metal absorption even from different regions [54]. Metal concentrations in gastropod habitats should not be excluded at all as they depend on geographical factors, sources of contamination, anthropogenic and weather activity in the area [49,55].

Relationship Between Heavy Metals (Pb And Zn) In Seawater, Sediment and Meat of *C. Obtusa*

Table 3 shows the relationship between heavy metal pairs (Pb and Zn) in seawater, sediments and meat of *C. obtusa* tested statistically. The results of linear regression analysis showed a clear positive correlation ($r=0.640$ - 0.920). The level of correlation between pairs of elements (Pb and Zn) is very high. Pb and Zn were found to have a relatively higher positive coefficient (for Pb, $r=0.815$ and for Zn, $r=0.920$ between water and meat of *C. obtusa* and for Zn, $r=0.920$). Similarly, there was also a correlation between sediment and meat of *C. obtusa* with each level of correlation for Pb ($r=0.842$) and Zn ($r=0.778$). For both elements, the correlation between the water and the meat of *C. obtusa* was higher than the correlation coefficient between the sediment and the meat of *C. obtusa.* Therefore, it can be stated that the concentrations of Pb and Zn in the meat of *C. obtusa* can be used as bioindicators to monitor the levels of metal pollution in these snail collecting regions and the observed elemental pairs are from similar anthropogenic sources. This positive correlation of Pb and Zn (between water or sediment and meat of *C. obtusa*) found in this study is similar to *C. obtusa* collected from the location of tin mining on the coast of Singkep Island by Amin et al. with a correlation level for Pb ($r=0.375$) and Zn ($r=0.641$) between water and meat of *C. obtusa*, while between sediment and meat of *C. obtusa* has a correlation level for Pb ($r=0.738$) and Zn ($r=0.793$) [34]. The results of this study found higher levels of Pb and Zn correlation between water or sediment and meat of *C. obtusa*, including the correlation the two metals between water and sediment compared to the findings of Amin et al. with low correlation (for Pb, $r=0.214$ and for Zn, $r=0.416$).

Bioaccumulation of *C. obtusa i*n Accumulating Heavy Metals

The *C. obtusa* concentration factor to Pb and Zn from sea water and sediments is given in **Table 4**. The concentration factor of heavy metal on snails *C. obtusa* and sediments in coastal waters studied illustrates how the accumulation of metals occurs according to the time in this snail habitat originating from activities in coastal areas of the mainland and in marine areas. Siregar et al. stated that the value of the metal concentration factor is the resultant of the dynamics and the heavy metal (dilution, adsorption, ingestion, absorption) process in the coastal ecosystem [35]. In this study, the average value of BCFb/w was found to be 98.21 from heavy metal Pb higher than Zn (BCFb/w=50.24) in all stations studied and the BCFb/w values of these metals were in the range of 30 - 100 which according to the BCF classification by Bernd are in the medium category, which indicates the high ability of these snails to collect water-soluble metals [56]. In contrast, the low BCFb/s value (BCF<30) indicates the limited ability of these snails to collect heavy metals from sediments. The BCFb/w and BCFb/s results show the snail's ability (*C. obtusa*) to accumulate heavy metals, especially Pb from the water column. The easier the metal is absorbed and accumulated in the body of the organism, the greater the concentration factor index and the heavy metal can become more toxic. The size of the concentration factor index is influenced by the type of organism, duration of breathing and environmental conditions such as pH, temperature and salinity [57].

CONCLUSION

The study found that the amount of concentration of heavy metals identified in seawater and *C. gambiusa* meat has exceeded the legal limits established for marine and food biota, especially high Pb in these meats can be used to evaluate the possible risks of human consumption and the reduction of concentrations before being consumed. The Zn concentration is higher than Pb and the two metals are linearly increasing in the following order: sea water> sediment> snail meat. The concentration factor of metal Pb (b/w) is higher than Zn (b/w), even Pb (b/s) and Zn (b/ s) which indicates accumulation of Pb metal by snails derived from water column compared from sediments with accumulative properties is considered moderate and can be considered as a bioindicator of metal pollution in this coastal region.

REFERENCES

1. Penha-Lopes GP, et al. Population structure, density and food sources of Terebralia polustris (Potamididae: gastopoda) in low intertidal Avicennia marina mangrove stand (Inhaca Island, Mozambique. Estuar Coast Shelf Sci. 2009;20:1-8.
2. Reid DG, et al. Mudwhelks and mangrove: The evolutionary history of an ecological association (*Gastropoda:Potamididae*). Mol Phylogenet Evol. 2008;47:680-699.
3. Report on the water quality of Nyiur and Enok Rivers Tembilaha. Environmental Agency of Indragiri Hilir Regency. 2013.
4. Csuros M, et al. Environmental sampling and analysis for metals. Lewis Publishers, CRC Press. 2002:1-408.
5. Soegianto A, et al. Bioaccumulation of heavy metals in aquatic animals collected from coastal waters of Gecko Indonesia. Asian J Water Environ Pollut. 2009;2:95-100.
6. Celechovska O, et al. Entry of Heavy Metals into Food Chains: a 20-year Comparison Study in Northern Moravia (Czech Republic). Acta Vet Brno. 2008;77:645-652.
7. Schwartz K, et al. Clinical chemistry and chemical toxicology of metals. Elsevier. 1977;17:1-292.
8. Haya K, et al. Adenylate energy charge and AT phase activity. Potential biochemical indicators of sublethal effects caused by pollutants in aquatic animals. Aquat Toxicol. 1985;13:524-525.
9. Mwachiro EC, et al. Heavy metal status of the reservoir Bari near Udaipur (Rajasthan) and the accumulation of the metals in fish organs. Pollut Res. 1997;16:67-74.
10. Zhou Q, et al. Biomonitoring: an appealing tool for assessment of metal pollution in the aquatic ecosystem. Anal Chim Acta. 2008;606:135-150.
11. Jutting WSS, et al. Systematic Studies on the Non-marine Mollusca of the Indo-Australian Archipelago: Critical Revision of the Javanese Freshwater Gastropods V. Treubia. 1956:260-454.
12. Badan Standardisasi Nasional (National Standards Agency of Indonesia). About Test Method Lead (Pb) Destructive Acid with Atomic Absorption Spectrophotometry (SSA) Jakarta. 2004.
13. Badan Standardisasi Nasional (National Standards Agency of Indonesia). About How Zinc Test (Zn) Destructed Acid with Atomic Absorption Spectrophotometer (SSA) Jakarta. 2004.
14. Badan Standardisasi Nasional (National Standards Agency of Indonesia). On the Way of Lead Test (Pb) by Atomic Absorption Spectrophotometer (SSA) Jakarta. 2009.
15. Badan Standardisasi Nasional (National Standards Agency of Indonesia). Maximum limit of heavy metal contamination in food Jakarta. 2009.
16. Decision Letter No.51/2004 Concerning standard quality seawater. Secretariat of State Minister of Environment, Jakarta. Minister of State for the Environment of Indonesia. 2004.
17. Simpson SL, et al. Revision of the ANZECC/ARMCANZ sediment quality guidelines. CSIRO Land and Water, Australia. 2013:1-132.
18. http://www.flevin.com/id/lgso/translations/JICA%20Mirror/english/453.%20BPOM_02592.1991_final.html
19. Kinnear PR, et al. SPSS for Windows Made Simple. Psychology Press. 2000:1-400.

20. Mountouris A, et al. Bioconcentration of heavy metals in aquatic environments: the importance of bioavailability. Marine Poll Bull. 2002;44:1136-1141.

21. Research and Development Agency of Riau Province. The final report of the study of mina mangrove model development as an effort of community empowerment in the coastal area of Riau Province. Cooperation between Research and Development Agency of Riau Province with Riau University, Pekanbaru. 2016.

22. Heryanto, et al. Ecology of mangrove Delta Mahakam, East Kalimantan. Zoo Indonesia. 2008;1:15-20.

23. Vanini M, et al. Vertical migrations of the mangrove snail Cerithidea decollata (L.) (Potamididae) through a synodic month. Estuar Coast Shelf Sci. 2008;78:644-648.

24. Rusningsih, et al. The structure of the gastropod community and the study population of Cerithidea obtusa (lamarck 1822) in the mangrove forest of Pangkal Babu of Jabung Barat Regency. Postgraduate thesis, University of Indonesia, Depok. 2012.

25. Sesekumar A, et al. Faunal diversity in Malaysian Mangrove. Global Ecol Biogeogr Lett. 1998;7:57-60.

26. Hutabarat S, et al. Introduction to Oceanography 2nd edition. Indonesia Press Jakarta. 1985:1-159.

27. Nybakken JW, et al. Marine Biology: An Ecological Approach. 1992:1-459.

28. Ashton EC, et al. A baseline study of the diversity and community ecology of crabs and molluscan macrofauna in the Sematan mangrove forest, Sarawak, Malaysia. J Trop Ecol. 2003;19:127-142.

29. Sagala SL, et al. Distribution of heavy metals in Natuna waters. J Trop Mar Sci Technol. 2014;6:297-310.

30. Ahmad F, et al. The level of heavy metal pollution in seawater and sediments in the waters of Muna Island, Kabaena, and Buton Southeast Sulawesi. Makara Sains. 2009;13:117-124.

31. Rochyatun E, et al. The waters of the Digul River and the waters of Arafura waters are seen from the heavy metal content. Oceanogr Limnol. 2004;36:15-31.

32. Arifin Z, et al. Heavy Metals Concentrations In Water, Sediment And Biota In Kelabat Bay, Bangka Island. J Trop Mar Sci Technol. 2011;3:104-114.

33. Bidayani E, et al. The content of heavy metal lead (Pb) in the seagrass (*Cymodocea serrulata*) of tin mining south Bangka regency. Maspari Journal. 2017;9:169-176.

34. Amin B, et al. Concentration, distribution, and correlation of heavy metals in seawater, sediment, and *Cerithidea obtusa* from coastal waters of Singkep Island, Riau Archipelago Province. Indo J Environ Sci Technol. 2014;1:14-21.

35. Siregar YI, et al. The concentration factors of Pb, Cd, Cu, Ni, Zn in coastal waters sediment of Dumai City. Maspari Journal. 2010;1:1-10.

36. Grecco LE, et al. Natural and anthropogenic heavy metals in estuarine cohesive sediments: geochemistry and bioavailability. Ocean Dyn. 2011;61:285-293.

37. Hu B, et al. Heavy metal in surface sediments of the Liaodong Bay, Bohai Sea: distribution, contamination, and sources. Environ Monit Assess. 2013;185:5071-5083.

38. Sany SBT, et al. Heavy metal contamination in water and sediment of the Port Klang coastal area, Selangor, Malaysia. Environ Earth Sci. 2013;69:2013-2025.

39. Dawson EJ, et al. Speciation of heavy metal in floodplain and flood sediments: a reconnaissance survey of the Aire Valley, West Yorkshire, Great Britain. Environ Geochem Health. 1998;20:67-76.

40. Luorna SN, et al. Processes affecting metal concentrations in estuarine and coastal marine sediments. In: Furness RW, Rainbouw, PS (eds.). Heavy Metal in the Marine Environment. CRC Press Inc, Florida. 1990:1-66.

41. Devault VA, et al. Heavy metal in the bottom sediments of the Inari-Pasyik lake-river system. Water Resour. 1998;24:451-457.

42. Palar, et al. Heavy metal pollution and toxicology. Rineka Cipta, Jakarta. 1994:1-152.

43. Prasetyo AD, et al. Determination of metal content (Hg, Pb and Cd) with a time of addition of preservative and different immersion time on the green shell (Perna viridis) in Muara Kamal, Jakarta Bay. Thesis Biology, Syarif Hidayatullah State Islamic University Jakarta, Jakarta. 2009.

44. National Standards Agency of Indonesia. About How To Test Zinc (Zn) By Atomic Absorption Spectrophotometer (SSA), Jakarta. 2009.

45. http://www.ava.gov.sg/docs/default-source/publication/annual-report/corp09-10

46. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32006R1881\

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47. Usero J, et al. Heavy metals in fish (Solea vulgaris, Anguilla anguilla and Liza aurata) from salt marshes on the southern Atlantic coast of Spain. Environ Int. 2003;29:949-956.

48. Cronin M, et al. Trace metal concentrations in deep-sea fish from the North Atlantic. Mar Environ Res. 1998;45:225-228.

49. Berandah FE, et al. Bioaccumulation and distribution of heavy metals (Cd, Cu, Fe, Ni, Pb and Zn) in the different tissues of Chicoreus capucinus Lamarck (Mollusca: Muricidae) collected from Sungai Janggut, Kuala Langat, Malaysia. Environ Asia. 2010;3:65-71.

50. Saha M, et al. Interspecific variation in heavy metal body concentrations in biota of Sunderban mangrove wetland, northeast India. Mar Pollut Ecotoxicol. 2006;32:203-207.

51. Fang ZQ, et al. Heavy metal concentrations in edible bivalves and gastropods available in the major market of Pearl River Delta. J Environ Sci. 2001;13:210-217.

52. Putri WAE, et al. Accumulation of heavy metals (Cu and Pb) in two consumed fishes from Musi River Estuary, South Sumatra. Mar Sci. 2016;21:45-52.

53. Budin K, et al. Concentrations of Cd, Pb, Cu and Zn in gastropods available in major markets of Kota Kinabalu, Sabah. 2nd International Conference on Environment Agriculture and Food Sciences (ICEAFS) Kuala Lumpur, Malaysia. 2013:1-4.

54. Ali RAS, et al. The effect of sewage discharge on the marine gastropod Gibbula sp. collected from the Coast of Al-Hanyaa, Libya. Egpyt Acad J Biology Sci. 2010;2:47-52.

55. Yap CK, et al. Telescopium telescopium as potential biomonitors of Cu, Zn, and Pb for the tropical intertidal area. Ecotoxicol Environ Saf. 2009;72:496-506.

56. Bernd B, et al. Bioaccumulation. Spriger-Verlag, Berlin. 2000.

57. Hutzinger O, et al. Aquatic pollutants: transformation and biological effects - Proceedings of an international symposium. Int Symp on Aquatic Pollutant Amsterdam Pergamon Press, New York. 1977:1-12.