HEAVY METALS IN EDIBLE INTERTIDAL MOLLUSCS FROM THE MIDDLE EAST COAST OF SUMATERA IN REGARD OF ITS DISTRIBUTION AND SAFE HUMAN CONSUMPTION

by:

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Abstract

Determination of Pb, Cu and Zn concentrations in the soft tissues of edible intertidal molluscs collected from six locations in the midle east coast of Sumatera has been carried out in order to evaluate its concentration, pollution level and safe limit for human consumption. Heavy metals content analysis was carried out by using AAS Perkin Elmer 3110 in Marine Chemistry Laboratory Faculty of Fisheries and Marine Science, University of Riau. The results of the study showed that samples collected from the station with more anthropogenic and industrial activities exhibited higher concentration of metals than those from areas with less anthropogenic activities. The lowest metal concentrations were detected in *Anadara granosa* from Karimun waters whilst the highest concentrations were found in *Strombus canarium* from Batam waters. The PTWI limits would only be reached when people consumed more than 4.893; 4.590 dan 5.071 kg /week of blood cockle from Bagansiapiapi, Asahan and Karimun and 1.302 and 3.092 kg/week for *Strombus canarium* from Batam and *Geloina coaxan* from Selat Panjang waters respectively. Therefore the consumption of blood cockle from those areas was considered to be safe and there would be no risk for human consumption.

Key words: Heavy metal, mollusc, consumption, Sumatera

1. INTRODUCTION

Research on heavy metal concentrations in coastal waters of Sumatra is still very limited and is restricted to the analysis of heavy metal concentrations in the sediments such as in Belawan waters (Alfian, 2005), Rupat waters (Amin and Zulkifli, 1997), Riau Archipelago waters (Amin, 2002a; 2004a), and also in Dumai waters (Amin, 2001; Amin *et al*., 2004b, 2005, 2006, 2007, 2008a, b, 2009a, Nurrachmi and Amin, 2010). The study of heavy metals in aquatic organisms is also limited to a few species of non-commercial and organisms that are not consumed by humans (Amin and Nurrachmi, 1999; Amin, 2004a, b; Amin *et al*., 2005, 2006, 2008b, 2009b, c) making it difficult to evaluate the possible impact on public health. The study showed that there has been an increase in the concentration of heavy metals in sediments and some organisms in certain areas. The increased heavy metal concentrations were allegedly associated with the development of industrial and residential areas around the coastal waters.

Given that heavy metals are toxic and can harm the health of the community, sample of commercial intertidal molluscs such as blood cockle (*Anadara Granosa*), barking snail (*Strombus Canarium*) and Seashell (*Geloina coaxan*) and mangrove snails (*Telescopium*

telescopium) were analyzed for their heavy metal concentrations. This is very important because the waters of the middle East coast of Sumatra was also used as fishing areas. Intertidal molluscs were collected by the surrounding community both for their own consumption as well as commercial purposes. Species of molluscs are popular as seafood favoured by both local and foreign tourists who come to North Sumatra, Riau and Riau Archipelagos. Through the process of biomagnification, molluscs as a filter feeder that has accumulated heavy metals from waters in their body would be very dangerous for the people who consume it. The research was conducted with the aim to analyze and assess the concentration of heavy metal pollution in the waters of the middle East coast of Sumatra which is one of the producer of commercial seafood commodities and to evaluate the feasibility of the organism to be consumed by the public.

2. MATERIALSANDMETHODS

Based on the condition and the presence of intertidal molluscs in the middle East coast of Sumatra along the Malacca Strait, six (6) sampling stations were selected for sample collection. Station 1 in coastal waters of Tj. Asahan Balai (North Sumatra), Station 2 in Bagansiapiapi, Station 3 in Selat Panjang (Riau), Station 4 in Karimun waters, Station 5 in Batuaji waters Batam and Station 6 in Monggak waters Batam (Riau Islands Province) all of which are part of the Straits of Malacca in the middle of the east coast of Sumatra (Figure 1). Not all types of mollusc samples could be obtained in the same place. Samples of blood cockle were obtained from Asahan, Bagansiapiapi and Karimun waters while seashell samples obtained from Selat Panjang. While samples of bark and mangrove snails obtained from Batam waters. Mollusc samples were analyzed their heavy metal concentrations by using AAS Perkin Elmer 3110 in Marine Chemistry Laboratory of the Faculty of Fisheries and Marine Science Pekanbaru Riau.

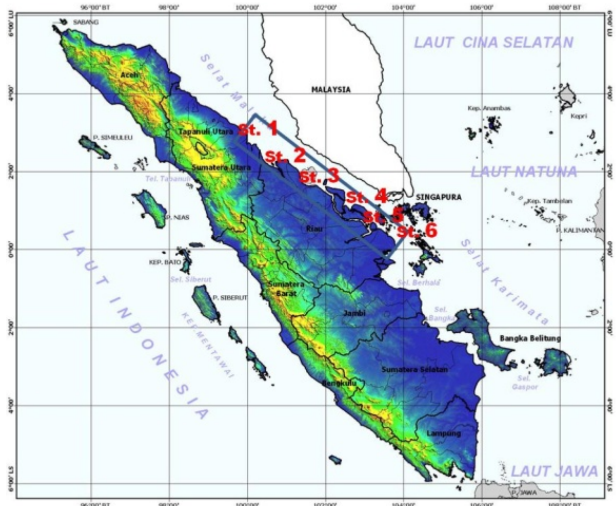

Figure 1. Sampling Locations for Molluscs in the Middle East Coast of Sumatra

The concentrations of heavy metals in the molluscs were analyzed with reference to the procedure proposed by Ismail and Ramli (1997) and Yap *et al*. (2002). Between 0.5 and 1.0 g sample of dried soft tissue were digested in HNO3 solution using a hot plate at low temperature (40 ° C) for 1 hour and then the temperature was raised to 140 ° C for 3 hours. After the samples were completely digested, the solution was cooled and diluted to 40 ml with double distilled water and filtered through whattman filter paper No. 1 and stored in sample bottles. Then sample solution was ready for the heavy metal concentration analysis by AAS.

In order to compare the total concentration of heavy metals in the different sampling stations used Metal Pollution Index (MPI) as suggested by Usero *et al*. (1996, 1997) and Giusti *et al*. (1999). Safety limit for human consumption of molluscs from the sampling locations was calculated by using the Provisional Tolerable Weekly Intake (PTWI) as recommended by WHO/FAO Expert Committee on Food Additives (*in* Turkmen, 2008).

3. RESULTS AND DISCUSSION

Heavy metals concentrations

Concentrations of Pb, Cu and Zn in some species of molluscs are presented in Table 1. Of the six sampling stations, only at three stations (Asahan, Bagansiapiapi and Karimun) that blood cockles were found. While the other two species (seasnails and mangrove snail) were obtained from Batam waters and one species (seashell) from Selat Panjang waters. The lowest concentration of heavy metals was found for Pb (1.380 µg/g) in the blood cockle from Karimun waters and the highest was 10.912 µg/g in mangrove snails from Batuaji, Batam waters. Similarly, the lowest metal concentrations for Cu and Zn, were found in blood cockle samples from Karimun waters (9.992 and 12.020 µg/g) and the highest (173.662 and 224.661 µg/g) was found in samples of mangrove snails from Batuaji, Batam waters.

Table 1. Heavy Metal Content of Pb, Cu and Zn (mean ± std. dev.) at each station in intertidal molluscs

Station	Sampel	Heavy Metal Concentration (µg/g)		
		Pb	Cu	Zn
Asahan	*A. granosa*	1,525 ± 0,559	25,391 ± 1,951	25,331 ± 5,502
Bagansiapiapi	*A. granosa*	1,431 ± 0,291	19,183 ± 4,721	21,054 ± 3,856
Karimun	*A. granosa*	1,380 ± 0,272	9,992 ± 1,131	12,020 ± 2,786
Selat Panjang	*G. coaxan*	2,264 ± 1,267	25,131 ± 5,224	26,532 ± 4,452
Monggak, Batam	*S. canarium*	6,786 ± 1,433	56,180 ± 8,310	26,341 ± 7,920
Batuaji, Batam	*T. telescopium*	10,912 ± 3,329	173,662 ± 69,257	224,661 ± 102,512

The concentrations of heavy metals in the molluscs from one station were found to be relatively different to another which was assumed to be related to anthropogenic activities influenced in each region, as well as due to the ability of each species to accumulate heavy metals from the environment. *S. canarium* and *T. telescopium* are gastropods whilst *A. granosa* and *G. coaxan* are bivelve. Generally, the bivalve accumulated metals in larger quantities than gastropods. However, in this study the concentrations of Pb, Cu and Zn were found to be higher in gastropods. This was assumed to be caused by the sampling locations for gastropod *T. telescopium* was around the heavy industrial area of Batuaji, Batam Island.

The coastal waters around Batuaji accept wastes from shipyards and other industries as well as from domestic effluents. According to Daka *et al*. (2007), industrial activities and urban wastes along the coastal areas could be sources of a number of heavy metals into the marine environment which can affect marine ecosystems and caused environmental degradation. Batuaji is known as one of industrial zones in Batam. There are activities of shipbuilding, ports, shipping, residential areas, and also other industries such as PT. Marcopolo II which engaged in shipbuilding certainly produces wastes, including heavy metals. Reddy *et al*. (2004) in their study in shipbuilding industry Sosiya Alang India also showed quite high increase in heavy metal concentrations in its coastal waters.

Darmono (1995) states that heavy metals can cause negative effects to aquatic organisms at certain concentration limits. The effect varies according to the type of metal species, organism, permeability and detoxification mechanisms. Because of the type of organisms that were analyzed are not the same from all stations, only the same species (*A. granosa*) were used for further discussion on the comparison between the stations (Figure 3).

According to Phillips (1980), blood cockle that live in mud as benthic organisms is very good to assess the level of pollution because they are filter feeders and sedentary species.

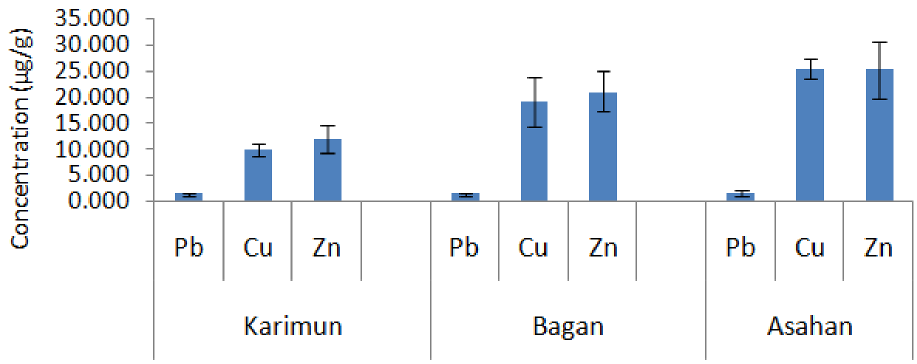

Figure 3. Heavy Metal Concentrations in *A. granosa* from Each Station

The concentrations of metals in the blood cockle from Asahan were higher than Bagansiapiapi and Karimun waters. This was caused by more anthropogenic activities as the source of heavy metals in Asahan waters in comparison with that in Karimun and Bagansiapiapi coastal waters. Zn concentration was relatively higher than Cu and Pb. There was no difference ($p>0.05$) for Pb among the three stations, while for Cu and Zn showed highly significant differences ($p < 0.01$) between the three stations, except for Pb between Bagansiapiapi and Asahan (Table 2).

Table 2. Statistical Comparison between Heavy Metal Concentrations Pb, Cu and Zn in Blood cockle (*A. granosa*)

Heavy Metal	Station	Karimun	Bagansiapiapi	Asahan
Pb	Karimun	-		
(p=0,713)	Bagansiapiapi	0,957	-	
	Asahan	0,697	0,857	-
Cu	Karimun	-		
(p=0,000)	Bagansiapiapi	0,000	-	
	Asahan	0,000	0,000	-
Zn	Karimun	-		
(p=0,000)	Bagansiapiapi	0,000	-	
	Asahan	0,000	0,076	-

For blood cockles, concentrations of Pb, Cu and Zn were highest in Asahan waters (1.525; 25.391; 25.331 µg/g) and the lowest in Karimun waters (1.380; 9.992; 12.020 µg/g). Higher metal concentrations in Asahan coastal waters and its estuary was related to the more anthropogenic activities such as traffic of both passenger and fishing vessels as well as domestic waste discharges from community around the harbour and along the River Asahan banks. While Karimun waters is an area of mangrove forests that do not receive much waste of various human activities that lead to low concentrations of the analyzed metals in this area.

When compared with the results of studies in other areas, the concentrations of Pb, Cu and Zn in blood cockles in the Karimun, Bagansiapiapi and Asahan coastal waters are not too much different (Table 3). The difference was thought to be caused partly by differences in anthropogenic activities at each station, the time of the sampling, the size of organisms and analytical procedures and methods used in the study.

Table 3. Comparison of Pb, Cu and Zn concentrations in blood cockle (*A. granosa*) with the results of other studies

Location	Concentration (µg/g)			Reference
	Pb	Cu	Zn	
Teluk Pelambung	5,20	2,87	47,28	Saputra (1999)
Pantai Meral	4,30 – 6,20	-	-	Efriyeldi and Amin (2000)
Tanjung Pinang	3,34	5,58	39,58	Amin (2002)
Tanjung Riau	4,84 – 4,16	-	-	Jonsari (2003)
Dumai	20,3	13,2	126,4	Angraini (2007)
Sungai Pakning	0,78-23,47	-	0,75-4,37	Febrizal (1996)
Dumai	3,87-5,20	9,17-9,96	-	Nugrahadi (1998)
Perairan Meral	0,55-1,81	-	-	Sinaga (1999)
Karimun*	1,380	9,992	12,020	Amin *et al* (2012)
Bagansiapiapi*	1,431	19,183	21,054	Amin *et al* (2012)
Asahan*	1,525	25,381	25,331	Amin *et al* (2012)

*Present study

To find out the status of heavy metal pollution in the middle east coast of Sumatra coastal waters, the MPI index (Metal Pollution Index) was used as suggested by Usero *et al*., (1996.1997) and Giusti *et al*., (1999). The MPI values for Asahan, Bagansiapiapi, Selat Panjang, Karimun, Monggak and Batuaji Batam waters were 9.936, 8.33, 6.327, 5.493, 21.575 and 75.228 respectively as can be seen in Table 4. In this study the highest MPI value was found in Batuaji, Batam waters which is dominated by shipbuilding and other industries, while the lowest MPI value was found in Karimun waters that are far from the industrial activity. The MPI value in Batuaji Batam waters was quite high when compared to others and also with the results of other studies by Amin *et al*. (2005) which has MPI value of 7.39 in Lubuk Gaung waters, 8.74 in Sungai Mesjid waters, 8.89 in Tanjung Medang waters and also higher than Dumai River estuary (12.57) in the mangrove snail (*T. telescopium*).

Another study using the MPI has been reported from several coastal waters such as Amin (2009b) who reported a value of MPI from 12.97 to 19.94 in Dumai waters using *Nerita lineata* as biomonitor, Yap *et al*. (2003) reported a value of MPI 4.35 to 11.70 from the west coast of Peninsular Malaysia and Chiu *et al*. (2000) reported MPI in Hong Kong coastal waters ranged from 5.00 to 9.23 with *Verna viridis* as biomonitor. Giusti *et al*. (1999) also reported MPI value of 10.50 to 25.10 in the UK waters by using *Mytilus edulis*.

Safety limit for Human Consumption

The safety limits in consuming molluscs from the middle east coast of Sumatra was estimated by calculating PTWI (Provisional Tolerable Weekly Intake). In this study the PTWI for mangrove snails *T. telescopium* was not calculated because these species are not commonly consumed by the public. The maximum level of heavy metals concentrations that can be consumed by humans were Pb 0.5 mg/kg and 30 mg/kg for Cu and Zn (FAO, 1983). Based on the Decree of the Director General of Drug and Food Control, Ministry of Health of the

Republic of Indonesia Number: 03725/B/SK/1989 stated that standard for heavy metals in biota is 2 ppm for Pb, 20 ppm for Cuand 100 ppm for Zn. Therefore, as the present study was based on the dry weight method, the concentrations were converted to wet weight basis (1:4) for the calculation of PTWI (Thomson, 1990). With reference to the standards of the Director General of the Republic of Indonesia (POM, 1989), concentrations of Pb, Cu and Zn in molluscs from all stations are still suitable for human consumption because it is still below the standard value.

PTWI value for Pb, Cu and Zn of 0.025; 3.5 and 7.0 mg/kg body weight/week respectively is equivalent to 1750; 245,000; 490,000 µg/kg per week for a 70 kg adult body weight (WHO, 1989). The mean metal concentrations of Pb, Cu and Zn in the blood cockles from Karimun waters 1.380; 9.992; 12.020 µ/g dry weight and equivalent to 0.345; 2.498; 3.005 µg/g wet weight. So, based on Pb, Cu and Zn concentrations, people with 70 kg body weight would reach the PTWI value when consumed blood cockles from Karimun waters more 5.071; 24.521; 163.059 kg/week. Thus, it can be said that the PTWI value set by WHO would only be achieved when people with 70 kg body weight consumed blood cockles from Karimun waters exceeded 5.071 kg/week. By the same calculation, and refers to the average metal concentrations of Pb, Cu and Zn, for each station, as indicated in Table 2, it can be seen that the PTWI value set by WHO would be achieved when people with 70 kg body weight consumes blood clocjles from Bagansiapiapi, Asahan and Karimun waters exceeded 4.893; 4.590 and 5.071 kg (Pb), 12.772; 9.649 and 24.521 kg (Cu) and 93.094; 77.376 and 163.059 kg (Zn) per week. As for the *S. canarium* from Batam and *G. Coaxan* from Selat Panjang waters 1.032 and 3.092; 4.361 and 9.749 and 74.410 and 73.874 kg/week in a row for the metals Pb, Cu and Zn respectively.

4. CONCLUSION AND RECOMMENDATION

The lowest Pb concentration in intertidal mollusc was detected in blood cockle from Karimun waters and the highest was in mangrove snails from Batuaji of Batam waters. The highest contamination levels indicated by calculated MPI value was Batam waters which was known as a crowded residential area, ship buildings and other industries. PTWI values set by WHO will be achieved when people with 70 kg bodyweight consumed blood cockle from Bagansiapiapi, Asahan and Karimun exceeded 4.893; 4.590 and 5.071 kg/week. For *G. coaxan* and *S. canarium* were not to exceed 1.302 and 3.902 kg/week. Therefore the consumption of blood cockle from those areas was considered to be safe and there would be no risk for human consumption. However, further research is needed on the environmental parameters that may affect the accumulation of heavy metals by organisms such as temperature, salinity and pH of seawater and dissolved particles so that it can be seen more clearly the factors that influence the distribution of heavy metals in those locations and the rate of accumulation by organisms that inhabit the area.

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