Proceedings of the 1st International Conference on Natural Resources Engineering & Technology 2006
24-25th July 2006; Putrajaya, Malaysia, 54-59

Analysis of Heavy Metals in Soft Tissues of *Thais Aculeata*, a Gastropod Taken from Chendering Beach, Terengganu as an Attempt to Search for Indicator of Heavy Metal Pollution in the Aquatic Environment

[1]Nakisah Mat Amin*, [1]Jamilah Mamat and [2]Noor Azhar Mohd Shazili

[1]*Department of Biological Sciences, Faculty of Science and Technology*
[2] *Institute of Oceanography,*
Kolej Universiti Sains dan Teknologi Malaysia [KUSTEM]
Mengabang Telipot 21030 Kuala Terengganu

Abstract

In this study, *Thais aculeata*, a gastropod that commonly found on rocky beach was used to analyse the accumulation of heavy metals, viz Cu, Zn, Fe, Pb and Cd in its tissues as indication of these metal pollution in seawater around that area. The gastropods were collected from rocky shores, at Chendering, Terengganu and their soft tissues were digested as described by Agemian et al. (1980) for heavy metal contents analysis by a Atomic Absorption Spectrometry (AAS). Seawater samples were also collected from the same area and its heavy metal contents were analysed by APDC-MIBK solvent extraction method of Sturgeon et al. (1979). The results obtained in this study indicated that the concentrations of Cu, Zn, Fe, Cd and Pb in dry weight soft tissues of *T. aculeata* were 150.3 ± 58.0 μg.g-^{1}dw, 158.4 ± 27.9 μg.g-^{1}dw, 316.7 ± 125.3 μg.g-^{1}dw, 11.3 ± 5.9 μg.g-^{1}dw and 0.6 ± 0.3 μg.g-^{1}dw respectively. The concentrations of these heavy metals in seawater measured in this study were Cu (0.10 ± 0.01 μg.L^{-1}), Zn (0.25 ± 0.06 μg. L^{-1}), Fe (2.79 ± 1.60 μg L^{-1}), Cd (0.48 ± 0.03 μg L^{-1}) and Pb (2.11 ± 2.01 μg L^{-1}) which were relatively low compared with their concentrations in the animal tissues except for Pb, to indicate the animal's capability to accumulate at much higher concentration of heavy metals from the environment in its tissues. The suitability of this gastropod as indicator for heavy metal contamination in seawater especially at Chendering Beach area is discussed.

Keywords: thais aculeata, soft tissues, indicator, heavy metals, aquatic environment.

1.0 Introduction

Research for heavy metals in the environmental samples have become widely established because of concerns over their accumulation and toxic effects particularly in aquatic organisms. Majority of aquatic organisms can accumulate pollutants, but only few can be used as indicator species due to their physiological and ecological suitability. The importance of indicator organisms is that they are able to reflect the environmental changes or disturbances. Attempts to use bivalve molluscs as bioindicators in marine and estuarine ecosystems have been reported by many researchers [3,4]. Many mollusks are filter feeders, grazers and carnivorous, so they tend to accumulate the pollutants from the environment by many ways into their tissues. The concentration of these metals in their tissues can be used to predict the status of heavy metal contamination in the environment. Since molluscs such as

* *Corresponding author: Tel: 609-6683245; Fax: 609-6694660; Email: nakisah@kustem.edu.my*

bivalves have a very low level of activity of enzyme systems to metabolize persistent organic pollutants, contaminants concentrations in their tissues are more accurately reflect the magnitude of the contaminants in the environment [5]. Most bio-indicator studies are on bivalves such as on *Anadara senilis* and *Perna viridis* [4,6], reports on other shelled-molluscs such as *Thais* spp are not yet widely documented. Therefore, in this study, *Thais aculeata*, a carnivorous gastropod that is commonly found on rocky shores were collected at Chendering Beach, Terengganu to analyse for heavy metal contents in their soft tissues to estimate the metal contamination in that environment.

2.0 Materials and Method

Samples of *Thais aculeata* were collected from rocky shores at Chendering, Terengganu during low tide, and were detached from the rock substrates using a hammer. The samples were secured in clean plastic bags, kept on ice while being transported back to the laboratory for heavy metal analysis. Water samples from that area were also collected for heavy metal analysis. Before heavy metal content analyses, the size of molluscs were measured. The soft tissues of the organisms were removed from its shells by a hammer, and were digested as described by Agemian et al., [1]. Heavy metal analysis in seawater samples was carried-out following technique of Sturgeon et al., [2]. Metal contents in the tissues and water samples were obtained by Atomic Absorption Spectrophotometry (AAS) and Graphite Furnace Atomic Absorption Spectrophotometry (GFAAS).

3.0 Results and Discussion

Various metals present in any aquatic environment either by natural geochemical processes or antropogenic activities. Being aquatic organism, a variety of metals present in seawater including those that are essential and non-essential for maintaining biological processes of *Thais aculeata,* will be collected in its tissues. Naturally, the heavy metal content in tissues of aquatic organisms will correlate positively with the heavy metal content in seawater, provided that the organisms do not have special adaptive mechanism to prevent this phenomenon to happen. Results for heavy metal content analyses both in tissues of gastropod and seawater obtained in this study are presented in Table 1. The highest content of heavy metals in *Thais aculeata* observed in this study was Fe, followed by Zn, Cu, and Cd. The concentration of Cd and Pb in tissues of this gastropod was low. The content of these metals in seawater in general was low. The highest concentration observed in seawater was for Fe ($2.79 \pm 1.6\ 0\ \mu g.L\text{-}^{1}$) which is a normal phenomenon since this metal is found in our environment.

According to Lockwood [7], the concentration of metals is higher in tissues of aquatic organisms than in seawater. In average, the concentration of metals in seawater at Chendering beach is below 10 μgL^{-1} and these values are relatively low compared with measurement of seawater obtained for Pulau Pangkor (Zn, 11.60 μgL^{-1}, Cu, 23.00 μgL^{-1} and Cd, 5.31 μgL^{-1})[8].

Table 1 Heavy metals content in tissues of *Thais aculeata* and seawater

	Cu	Zn	Fe	Cd	Pb
Tissues {μg.g-1 dw)	150.3 ±58.00	158.4± 27.90	316.7±125.0	11.3 ± 5.9	0.6 ± 0.30
Seawater samples {μg.L-1)	0.10 ± 0.01	0.25 ± 0.06	2.79±1.6 0	0.48 ±0.03	2.11 ±2.01

Data obtained from 8 replicates

Although being exposed to various kinds of metals that eventually accumulate in their tissues, there is no apparent linear relationship between the concentration of metals in tissues and in seawater observed in this study except for Fe. The concentrations of Cu, Zn, Fe and Cd except for Pb, were 1500, 632, 113, 23 times higher in soft tissues of *Thais* compared with their concentration in seawater. For aquatic organisms, heavy metals enter their bodies either by absorption via their skin/gills or through their consumed food. The ability to accumulate heavy metals by the organisms depend on species, size, location, sex and mode of feeding [9], reproductive cycle, metal bioavailability, season of sampling, hydrodynamics of the environment [6]. Furthermore, the tendency of aquatic organisms to accumulate the metals varies according to the metals. Cu and Zn for example, are essential metals, so they will be accumulated in the animal tissues at higher concentration compared with other metals. In this study, Fe, Zn and Cu were accumulated at higher concentration in *Thais aculeata* compared with other metals. *T. aculeata*, as a carnivorous gastropod accumulates higher amount of Fe, Zn and Cu in its tissues probably from their preys (mostly bivalves that attached to the rocks). Reports on *Thais* spp as algae feeders also support the data obtained in this study. Algae feeders tend to accumulate Zn, Fe and Cu in their tissues compared with other means of feeding [10]. Most alga-eating species of Molluscs such as *Nerita sp., Monodanta sp.* and *Patella sp.* accumulate Zn in their soft tissues [8]. In general, bioaccumulation of the metals in *Thais* is concentrated through food webs in predator-prey relationship a result of bio-magnification.

Body size can influence the accumulation of heavy metals in soft tissues of molluscs [11]. These pollutants can become quite concentrated and sometimes reach the level of toxic in the soft tissues of molluscs. In the present study, in all cases, there was no significant relationship between metal concentration in tissues and body size (shell length) of *Thais* ($P<0.05$)(Table 2; Figures 1, 2). General comments observed in this study on metal accumulation and size distribution are as follows: *Thais aculeata* with size range between 2.1 and 2.5 cm apparently accumulate the highest amount of Fe compared with other size groups (Figure 1). The accumulation of other metals (Cu, Zn, Pb and Cd) in this size group on the other hand, was comparable with other size groups. The accumulation of Cu and Zn apparently similar in all size of molluscs. Metabolic changes of the molluscs with age and season, storage mechanisms as well as temporal variations in metal bioavailability in the surrounding [6] might explain the results obtained in the present study.

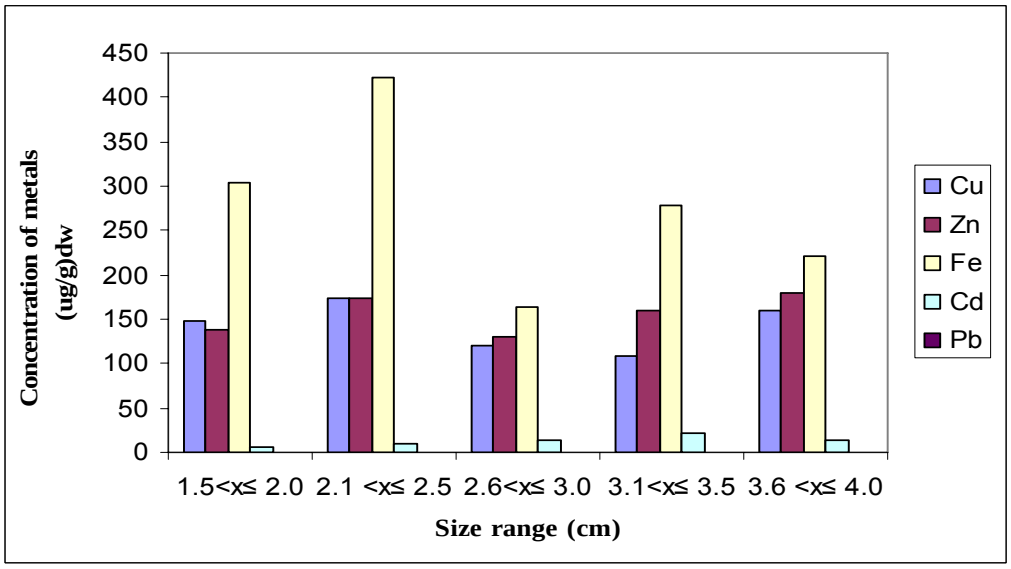
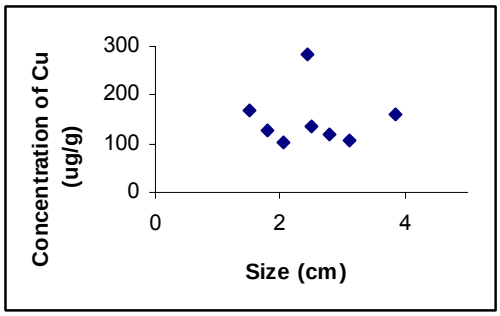
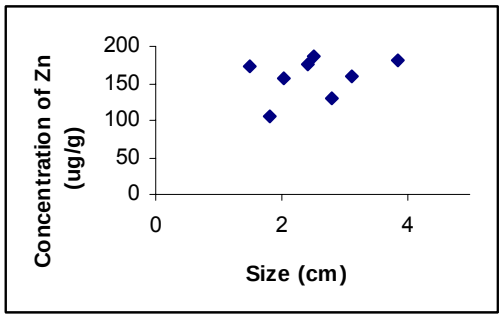


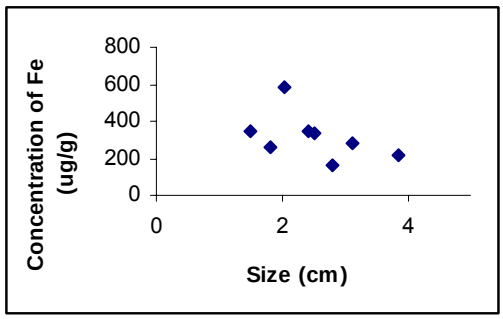
Figure 1 Accumulation of metals in various size range of *Thais aculeata*



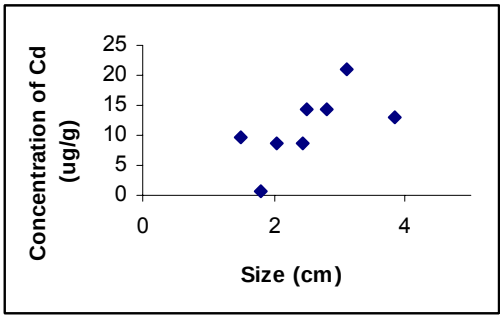
Y=156.675 – 2.526 X;r^2 = 0.001



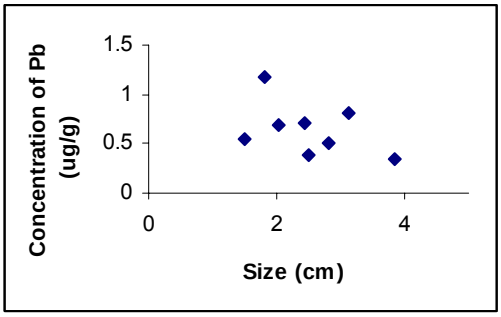
Y=130.295 + 11.206 X;r^2 =0.092



Y=512.802 – 78.29 X;r^2 = 0.223



Y=-0.916+ 4.866 X;r^2 = 0.392



Y= 1.045 – 0.16 X;r^2 = 0.208

Figure 2 Metal concentrations (Cu, Zn, Fe, Cd and Pb) in various sizes of *Thais aculeata.* All data presented based on the animal dry weight

Table 2 Concentration of heavy metals in tissues of *Thais aculeata*

*Size range (cm)	Concentration of metals (μg.g-1dw)				
	Cu	Zn	Fe	Cd	Pb
1.5<x≤ 2.0	147.2	138.62	303.48	5.12	0.86
2.1 <x≤ 2.5	173.33	173.13	421.44	10.63	0.59
2.6<x≤ 3.0	119.93	130.36	162.95	14.34	0.51
3.1<x≤ 3.5	108.41	159.83	277.97	20.85	0.81
3.6 <x≤ 4.0	160.03	180.10	221.26	12.86	0.34

* shell length

There are two types of regression lines available; negative and positive regressions. In negative regression relationship between concentration of metal and body size animals, small size of animals tend to accumulate higher amount of metals faster than the bigger size animals [11]. On the other hand, in case of positive regression, the increase amount of metals in the animal tissues is due to increase in their body size and growth. In this study, this type of relationship between the metal content and the size of gastropod cannot be determined. To understand more the type of association between the content of heavy metal intake, accumulation and depuration in this animal have to be investigated.

Thais chocolatae and *Thais haemastroma* are edible gastropods and in Chile and Spain these gastropods are cultured commercially for food [13]. *Thais aculeata* (siput halia) used in this study collected from rocky shores at Chendering is used by local residents as food. The concentration level of Cu, Zn and Cu in tissues of *Thais* exceeds the metal concentration permitted according to the Food Act, 1983, suggesting that these molluscs taken from rocky shore at Chendering, Terengganu are not safe to be consumed.

Although in this study, detailed mechanisms on how *Thais* accumulates the metals in its tissues was not examined, the results of this study provide us information on the level and sources of metal contamination in its tissues. Since *Thais* is a carnivorous gastropod, this molluscs does not portray the actual metal pollution in the environment, instead the metal contents in its tissues are from its preys (mussels). Mussels are filter feeders, thus these molluscs accumulate the metals directly from seawater [6] hence they are more reliable to be used as indicator species for heavy metal contamination. Therefore, it can be concluded from this study that *Thais aculeata* is not suitable to be used as a primary indicator for heavy metal pollution in aquatic ecosystem.

4.0 Conclusion

Five heavy metals measured in both tisues of *Thais aculeata* collected form a rocky shore at Chendering, Terengganu and in seawater from the same area are Cu, Zn, Fe, Pb and Cd following standard techni dw ques. The concentrations of these metals in tissues of *Thais* were Cu (150.3 ± 58.0 μg.g-1dw), Zn (158.4 ± 27.9 μg.g-1 dw), Fe (316.7 ± 125.3 μg.g-1dw), Cd (11.3 ± 5.9 μg.g-1dw) and Pb (0.6 ± 0.3 μg.g-1dw) and in water were Cu (0.10 ± 0.01 μg.L-1), Zn (0.25 ± 0.06 μg. L-1), Fe (2.79 ± 1.6 μg L-1), Cd (0.48 ± 0.03 μg L-1) and Pb (2.11 ± 2.01 μg L-1). The high content of metals in this gastropod was obtained through food webs

in predator-prey relationship, not from the seawater. The metal content in seawater at Chendering Beach was relatively low. There is no apparent relationship between heavy metal content and the body size of the gastropod observed in this study. The concentration level of Cu, Zn and Cu in *Thais aculeata* exceeds the values permitted by The Food Act, 1983 so this gastropod from Chendering beach is not recommended for consumption. Being a carnivorous gastropod which accumulates metals from its preys, *Thais aculeta* is not suitable to be used as a primary indicator for heavy metal pollution in aquatic ecosystem.

Acknowledgement

The authors wish to thank Ms Faezah Sidek for her technical assistance.

References

[1] Agemian, H., D.P. Sturtevant and K.D. Austen 1980. Simultaneous acid extraction of six trace metals from fish tissue by hot-block digestion and determination by atomic-absorption. *Analyst*. 105. 125-130
[2] Sturgeon, R.E., S.S. Bermn, A. Desaulniers and D.S. Russel 1979. Preconcentration of trace metals from seawater for determination by graphitefurnece atomic absorption spectrometry. *Talanta*. 27: 85-94
[3] Bayne, B.L., D.A. Brown, K. Burns, D.R. Dixon, A. Ivanovici, D.R. Livingstone, D.M. Lowe, M.N. Moore, A.R. Stebbing and J. Winddow 1985. The effect of stress and pollution in marine animals. Preager, New York. Pp 381
[4] Noor Azhar, M.S., M.A. Nakisah, and Tan Yen Li. 2004. *Perna Viridis* as an indicator of cooper and zinc pollution in coastal waters of Johor. In: *Proceedings biomonitoring in tropical coastal ecosystems*, Phang & Brown (*eds*). 151-157
[5] Phillips, D.J.H. 1990. Use of macroalgae and invertebrates as monitors of metal levels in estuaries and coastal waters. Pp 81-99 in : Furness, R.W. and Rainbow, P.S. (eds.). Heavy metals in the marine environment. CRC Press, Boca Raton, Florida. 256p
[6] Otchere, F.A. 2003. Heavy metals concentrations and burden in the bivalves (*Anadara (Senilia) Senilis*, *Crassostrea tulipa* and *Perna perna*) from lagoons in Ghana: Model to describe mechanism of accumulation/excretion. *African journal of biotechnology* Vol. 2 (9), pp. 280-287
[7] Lockwood, A.P.M. 1976. Effect of pollution on aquatic organism. Pergamon Press, Oxford. Pp 388
[8] Tin, C.H. 1999. Kajian akumulasi logam berat dalam moluska marin di persekitaran Pulau Pangkor. Tesis Ijazah Bacelor Sains (Kepujian) Biologi, Fakulti Sains dan Sastera Ikhtisas, Universiti Putra Malaysa, Terengganu.
[9] Brugman, L. 1981. Heavy metals in Baltic Sea. Marine pollution bulletin. 12 : 214-218
[10] Bryan, G.W. 1976. Effects of pollutants on aquatic organisms: Some aspect of heavy metal tolerance in aquatic organisms. Cambridge University Press, Great Britain. 193p
[11] Boyden, C.R. 1977. Effect of size upon metal content of shellfish. Nature. London. 251. 311-314
[12] Fitz Patrik, B.M and H.M. Penrose (eds). 2002. A Preliminary marine ecological survey of Batman Bay, Ningaloo Reef. Oceanwise Environmental Scientist, Perth, western Australia. 74pp
[13] Man and Mollusc's Data Base of Edible Mollusc. http://www.manandmollusc.net/molluscan_food_files/molluscan_food_mp.html