HEAVY METAL CONCENTRATIONS IN THE RAZOR CLAMS (*SOLEN* SPP) FROM MUARA TEBAS, SARAWAK

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Abstract

The razor clams (*Solen* spp) or locally known as 'ambal' in Sarawak collected from Muara Tebas were studied for their heavy metals contents in tissues and shells. Sediment samples were also tested for their metal contents. Concentrations of Pb, Fe, Zn, Cu, Cd and Mn were determined by using Flame Atomic Absorption Spectrophotometer (FAAS). Tissues of razor clams showed highest concentrations of Fe and Zn, while shells accumulated highest concentrations of Pb and Mn. The lowest metal concentrations found were Cu and Cd. In general, the levels of metals in 'ambal' were within the permissible limit recommended by international standard, the Food and Agricultural Organization (FAO). However, the study revealed that the sediments at Muara Tebas fall under the category of slightly polluted (for Pb) when compared to the guidelines suggested by United States Environment Protection Agency (USEPA).

Abstrak

Razor clam **(***Solen* spp) atau lebih dikenali sebagai ambal di Sarawak telah dipungut dari Muara Tebas untuk kajian kandungan logam berat dalam bahagian tisu dan cengkerangnya. Sampel sedimen juga telah dikaji kandungan logam beratnya. Kepekatan logam Pb, Fe, Zn, Cu, Cd dan Mn telah ditentukan dengan menggunakan Spektroskopi Serapan Atom Nyala (FAAS). Bahagian tisu ambal mengandungi kepekatan Fe dan Zn yang tertinggi manakala cengkerang pula menunjukkan kepekatan Pb dan Mn yang paling tinggi. Kepekatan logam yang paling rendah ialah Cu dan Cd. Secara keseluruhannya, tahap kepekatan logam dalam ambal berada dalam had yang disyorkan oleh piawai *Food and Agricultural Organization* (FAO). Walau bagaimanpun, kajian ini menunjukkan bahawa sedimen di Muara Tebas berada dalam kategori sedikit tercemar (untuk Pb) apabila perbandingan dibuat dengan piawai yang disyorkan oleh *United States Environment Protection Agency* (USEPA).

Introduction

Various species of edible bivalve mollusks such as clams, oyster and cockles are found on the mangrove mudflats and intertidal sandy beaches in Peninsula Malaysia as well as Sarawak. Razor clam (*Solen* spp) or locally known as "ambal" is found abundantly in the intertidal sandy beaches in Kuching and Samarahan Division of Sarawak. There are three different species of Ambal in the genus *Solen* that commonly found in Sarawak [1]. The three species are Solen corneus, Solen species and Solen vagina and they are locally known as "Ambal Biasa', 'Ambal Jernang', and 'Ambal Riong' respectively.

Heavy metals pollution has been a hot issue in environmental studies for many years. Even though, metals occurs naturally in the environment but due to the anthropogenic inputs which originate from various human activities the concentrations have been rising. Heavy metals tend to accumulate in the food chain and eventually will be consumed by organisms. Bivalve mollusks are well-known to accumulate heavy metals and have been widely used as bioindicator for monitoring heavy metal pollution in aquatic environment [2-4]. There is very little documented information available about the metal contents in 'ambal' despite the popularity as a source of seafood item in Sarawak. Owing to limited studies on 'ambal', various aspects on 'ambal' are still unexplored such as the feeding behavior, biology and population dynamics. A study was conducted on the stock assessment and some biology perspective of 'ambal' [5]. Some work was also done on the bacterial density and quality of water in 'ambal' from Asajaya Laut and Kampung Buntal, Sarawak [6].

Thus, this study was undertaken to determine the amounts of heavy metals (Pb, Fe, Zn, Cu, Cd and Mn) in tissues and shells of razor clam and sediments at Muara Tebas. The suitability of 'ambal' as a seafood item was evaluated by comparing with an international standard (FAO).

Experimental

Sample Collection

This study was carried out along the beach at Muara Tebas during low tide in the month of September and November 2004, the harvesting periods of 'ambal' (Figure 1). The sampling stations was divided into 3 positions namely low tide station (S1), middle tide station (S2 and S3) and high tide station (S4, S5).

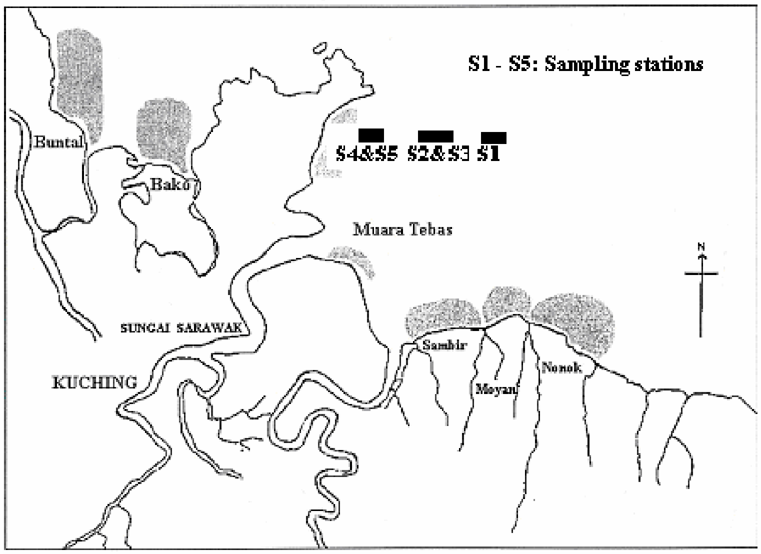

Figure 1 : Map showing the sampling stations at Muara Tebas

The razor clams were collected using long, elongated, slender stick of four feet in length a mixture of limestone powder, ashes and salt. Razor clam samples ranging between 3.0 and 10.0 cm in length were collected. About 10-15 individuals were collected at each station to prepare a pooled sample. Immediately after collection, the samples were washed with seawater to remove sediment before being kept in the labeled glass jar. The samples were kept in a cool box. Sediment samples were collected from each sampling stations around the area inhabited by the razor clam using the PVC tubes. Three to four random surface sediment samples were collected from each station were divided into two sub-ranges, 0 - 5 cm and 5 - 10 cm.

Chemical analysis

Razor clam samples were thawed and carefully washed with tap water and deionized water to remove any extraneous material. Tissues and shell samples were freeze-dried. Subsequent to the drying process, the samples were ground to fine powder using pestle and mortar and stored in polyethylene bottles. The composite homogenates were divided into three sub-samples for replicate analyses.

Acid wet digestion method modified from [2] was employed to the razor clam samples. One gram of tissue sample was weighed and digested with 6 ml of concentrated nitric acid (63 %) and 1 ml of 30 % hydrogen peroxide using hot plate digester. While for the shell samples, one gram of shell samples was digested with the mixture of 2 ml of concentrated nitric acid (63 %), 5 ml of concentrated hydrochloric acid (37 %) and 1 ml of 30 % hydrogen peroxide. The samples were dissolved for one hour and then digested for another one hour. The digested samples were filtered and diluted to 50 ml with deionized water.

Oven-dried sediment samples were ground to the size of 50 mesh. One gram of sediment samples was digested for three hours with freshly prepared mixture 1:3 of 20 ml of nitric acid and hydrochloric acid using hot plate digester. The levels of heavy metals in the filtrate were determined with Flame Atomic Absorption Spectrophotometer (Perkin – Elmer Model 3110). The quantitative measurement was made using calibration curves obtained with five standard solutions of each elements analyzed in this study. Fresh working standard solutions were prepared using AAS stock solution (1000 ppm). Acid blank for every batch was analyzed to evaluate any contamination. All results reported in this study are expressed in dry weight.

Statistical Analysis

One-way analysis of Variance (ANOVA) is used to study differences in metal concentrations at different sampling period and at two different depths for sediments. Correlation coefficient (r) was used to test the relations between the concentrations of metals in sediments with tissues and shells of razor clam.

Results and Discussions

Metals concentrations in sediments

The pH of the surrounding sediments of Muara Tebas was found to be alkaline (8.13 – 8.36) (Table 1). Temperature and dissolved oxygen (DO) was in the range of 28.5 – 33.7 ^{o}C and 5.2 -7.4 mg/L. Metals contents in sediments at two different depths (0 – 5 cm and 5 – 10 cm) Muara Tebas are shown in Table 2.

Table 1. Mean pH, temperature and DO of sediments at Muara Tebas

Station	pH	Temperature (^{o}C)	DO (mg/L)
Low tide	8.13	28.5	7.4
Mid tide	8.36	30.3	5.2
High tide	8.30	33.7	6.6

Table 2. Metal contents (μg/g dry wt) in sediments from Muara Tebas

	Pb		Cu		Fe		Zn		Cd	
	0-5	5-10	0-5	5-10	0-5	5-10	0-5	5-10	0-5	5-10
S1*	36.67 ± 0.03	35.83 ± 0.03	5.17 ± 0.01	4.67 ± 0.01	529.17 ± 0.05	477.67 ± 0.05	32.50 ± 0.01	34.33 ± 0.01	3.33 ± 0.01	3.33 ± 0.01
S2	35.50 ± 0.04	36.50 ± 0.06	4.33 ± 0.01	4.67 ± 0.01	520.33 ± 0.02	499.00 ± 0.04	32.50 ± 0.01	33.33 ± 0.01	2.83 ± 0.01	1.83 ± 0.01
S3	51.83 ± 0.04	53.17 ± 0.06	5.17 ± 0.01	5.67 ± 0.01	557.00 ± 0.04	523.67 ± 0.01	37.67 ± 0.01	32.83 ± 0.01	1.67 ± 0.01	1.67 ± 0.01
S4	41.83 ± 0.06	44.50 ± 0.08	5.17 ± 0.01	5.67 ± 0.01	546.33 ± 0.03	484.00 ± 0.03	32.67 ± 0.01	35.33 ± 0.01	2.67 ± 0.29	2.67 ± 0.01
S5	38.17 ± 0.05	45.17 ± 0.08	5.17 ± 0.01	4.67 ± 0.01	497.83 ± 0.02	463.67 ± 0.03	29.33 ± 0.01	29.17 ± 0.01	1.67 ± 0.01	1.83 ± 0.01
S1**	49.17 ± 0.07	47.83 ± 0.03	5.17 ± 0.01	4.33 ± 0.01	534.17 ± 0.04	514.83 ± 0.05	30.83 ± 0.02	30.67 ± 0.01	1.50 ± 0.01	2.00 ± 0.01
S2	53.83 ± 0.07	54.17 ± 0.06	4.83 ± 0.01	5.83 ± 0.01	571.50 ± 0.02	571.50 ± 0.05	31.50 ± 0.01	35.17 ± 0.01	1.83 ± 0.01	2.50 ± 0.01
S3	51.83 ± 0.04	53.17 ± 0.06	5.17 ± 0.01	5.67 ± 0.01	546.33 ± 0.04	523.67 ± 0.01	37.67 ± 0.01	32.83 ± 0.01	1.67 ± 0.01	1.67 ± 0.01
S4	54.50 ± 0.03	56.33 ± 0.05	5.67 ± 0.01	5.67 ± 0.01	566.50 ± 0.03	573.33 ± 0.06	34.83 ± 0.01	33.50 ± 0.01	1.83 ± 0.01	2.33 ± 0.01
S5	52.50 ± 0.04	53.67 ± 0.04	4.33 ± 0.01	4.33 ± 0.01	539.33 ± 0.05	527.83 ± 0.05	33.67 ± 0.01	30.33 ± 0.01	1.33 ± 0.01	0.83 ± 0.01

S1* : Data obtained during first sampling
S1**: Data obtained during second sampling

The amounts of Fe, Pb, Zn, Cu and Cd was found in the range from 463.67 μg/g – 573.33 μg/g, 35.50 μg/g – 56.33 μg/g, 29.17 μg/g – 37.67 μg/g, 4.33 μg/g – 5.83 μg/g and 0.83 μg/g – 3.33 μg/g respectively. Fe occurs in the highest level whereas Cd was found in the least amount. Fe is naturally abundant in the earth's crust. There was no much difference observed for the metals concentrations at two different depths. The amounts were quite close for both depths. Even, statistical analysis also showed that there was no significant difference between the depths ($p < 0.05$). The sediments were assessed by doing comparison with United States Environment Protection Agency (USEPA) guidelines [7].

The sediments at Muara Tebas fall under the category slightly polluted with Pb (40-60 µg/g). This could be due to the anthropogenic sources which contribute to Pb contamination. The major source of Pb in the environment is related to the burning of fossil fuels and via atmosphere [8]. Hence, Pb contamination in Muara Tebas may be resulted from burning of fossil fuels from boats used for fishing and also leisure activities at Kuching Bay.

Table 3. USEPA guidelines classification for sediments (µg/g)

Elements	Unpolluted	Slightly polluted	Heavily polluted
Pb	<40	40-60	>60
Cu	<25	25-50	>50
Zn	<90	90-200	>200
Cd	-	-	-

Metal concentrations in razor clam

Table 4 represent the metal concentrations and standard deviation of six elements analyzed in 'ambal' collected from Muara Tebas. The metals contents in tissues and shells of 'ambal' at Muara Tebas revealed major variations. It was further proved by statistical analysis ($p < 0.05$) which showed that there were significant differences of Pb, Fe, Zn, Cu, Cd and Mn in tissues and shells. The most abundant elements in tissues of razor clam were Fe and Zn which ranged from 276.17 µg/g – 1161.00 µg/g and 72.17 – 97.00 µg/g respectively. The shells indicated the highest levels of Pb (52.00 µg/g–58.17 µg/g) followed by Mn (30.83 µg/g – 67.00 µg/g), Cu (12.67 µg/g – 23.83 µg/g) and Cd (7.33 µg/g – 9.00 µg/g).

The wide variations of metals in two different parts of 'ambal' could be expressed by the complex relationship between environmental concentrations and bioaccumulation [9]. There are various factors which influence the metals accumulation in bivalves. Among the factors known include metal bioavailability, season of sampling, size, hydrodynamics of the environment and reproductive cycle [3].

Cd was also found in a very trace amount in tissues and shells likewise in sediments. There was moderate significant negative correlation for Cd in shells with sediments at Muara Tebas ($r = - 0.51.$, $P = 0.00$). This may be attributed to the low bioavailability of Cd in sediments and water environment. Metals concentrations obtained in this study were compared with the international standards for metals in mollusks/shellfish compiled by Food and Agricultural Organization (FAO) of the United Nations [9] (Table 4). All metals were within the regulated limits except for Pb contents in shells. FAO permissible limit for Pb was 5 – 30 µg/g and the results obtained ranged 52.00 µg/g – 58.17 µg/g. The Pb concentration possibly originated from the surrounding sediments as Pb was found in slightly polluted range. However, poor correlation ($r = 0.17$) was attained between Pb concentrations in shells and sediments at Muara Tebas. The results need to be further verified with other techniques as contamination could have occurred during the sample preparation and analysis.

Ambal' collected from Muara Tebas can be classified as safe for human consumption even though the level of Pb in the shells exceeded the permissible limit as 'ambal' are famous for their tissues. The shells are thrown away during the cooking process and only the tissues are consumed.

Table 4. Metal concentrations in tissues and shells (in µg/g dry weight) at Muara Tebas

	Pb		Cu		Fe		Zn		Cd		Mn	
	Tissue	Shell	Tissue	Shell	Tissue	Shell	Tissue	Shell	Tissue	Shell	Tissue	Shell
S1*	15.00 0.02	56.83 ± 0.04	2.67 ± 0.01	19.50 ± 0.01	289.33 ± 0.02	165.17 ± 0.02	77.83 ± 0.01	11.67 0.01	1.17 ± 0.01	7.33 ± 0.01	16.17 ± 0.01	47.17 ± 0.01
S2	15.33 ± 0.08	52.17 ± 0.01	2.17 ± 0.01	22.17 ± 0.01	298.00 ± 0.01	171.83 ± 0.02	85.50 ± 0.01	7.83 ± 0.01	1.17 ± 0.01	7.33 ± 0.01	19.17 ± 0.01	64.83 ± 0.01
S3	16.17 ± 0.07	56.00 ± 0.02	2.17 ± 0.01	22.00 ± 0.01	276.17 ± 0.01	105.83 ± 0.01	86.17 ± 0.01	7.33 ± 0.01	1.17 ± 0.01	7.33 ± 0.01	15.17 ± 0.01	38.67 ± 0.01
S4	15.33 ± 0.03	58.17 ± 0.01	2.33 ± 0.01	21.17 ± 0.01	312.50 ± 0.03	97.67 ± 0.02	82.17 ± 0.01	6.17 ± 0.01	0.67 ± 0.01	7.83 ± 0.01	18.67 ± 0.01	37.67 ± 0.01
S5	15.50 ± 0.07	55.33 ± 0.06	10.67 ± 0.01	20.67 ± 0.01	377.83 ± 0.04	157.67 ± 0.01	75.67 ± 0.01	4.33 ± 0.01	1.83 ± 0.01	8.67 ± 0.01	16.17 ± 0.01	67.00 ± 0.01
S1**	9.67 ± 0.02	52.17 ± 0.02	4.33 ± 0.01	12.83 ± 0.01	782.50 ± 0.06	95.17 ± 0.01	78.83 ± 0.01	6.33 ± 0.01	2.17 ± 0.01	8.33 ± 0.01	24.17 ± 0.01	30.83 ± 0.01
S2	9.50 ± 0.03	56.33 ± 0.03	4.67 ± 0.01	12.67 ± 0.01	940.33 ± 0.08	143.00 ± 0.02	83.17 ± 0.01	7.83 ± 0.01	1.17 ± 0.01	7.83 ± 0.01	24.67 ± 0.01	35.67 ± 0.01
S3	14.83 ± 0.04	54.83 ± 0.02	4.33 ± 0.01	16.83 ± 0.01	1161.00 ± 0.03	134.17 ± 0.03	72.17 ± 0.01	17.67 ± 0.01	2.00 ± 0.01	8.17 ± 0.01	41.83 ± 0.01	31.33 ± 0.01
S4	9.50 ± 0.04	55.17 ± 0.05	3.83 ± 0.01	23.83 ± 0.01	459.17 ± 0.01	82.67 ± 0.01	97.00 ± 0.04	19.17 ± 0.01	2.83 ± 0.01	8.67 ± 0.01	15.33 ± 0.01	40.33 ± 0.01
S5	13.83 ± 0.03	52.00 ± 0.01	4.17 ± 0.01	19.33 ± 0.01	323.83 ± 0.06	125.83 ± 0.01	89.67 ± 0.01	20.17 ± 0.01	2.17 ± 0.01	9.00 ± 0.01	11.33 ± 0.01	43.33 ± 0.01
FAO limits	**5-30 µg/g**		**50-150 µg/g**		**-**		**200-500 µg/g**		**10 µg/g**		**-**	

S1* : Data obtained during first sampling S1**: Data obtained during second sampling

Conclusions

Accumulation of the selected metals Pb, Fe, Zn, Cu, Cd and Mn in the tissues and shells of razor clam was evaluated. Tissues showed highest accumulation of essential elements like Fe and Zn while shells accumulated highest concentrations of Pb and Mn. The level of Pb in shells exceeded the limit designated by FAO.

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