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Assessment of metal concentrations in *Polymesoda expansa* from Sungai Geting, Tumpat, Kelantan and associated health risk

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Abstract. The spatial distribution of lead, zinc, cadmium, copper, and arsenic in *Polymesoda expansa* from Sungai Geting, Tumpat Kelantan were determined with inductively coupled plasma – mass spectrometer, in comparison to the levels in their surrounding water body. The objectives of this research was to determine the possible health risks associated with heavy metal accumulation via consumption of *Polymesoda expansa* by using Target Hazard Quotient (THQ). The data indicate have associations between the concentrations of metal measured in study sampled and the levels observed at the sites. The results suggested that the concentration of arsenic in *Polymesoda expansa* was relatively higher than those studied elements. The concentration of arsenic in studied sample demonstrate the sources of the antropogenic inputs. In terms of risk assessment, concentrations of metals in *Polymesoda expansa* were significantly below the Malaysian Food Regulation 1985.

1. Introduction

The rapid development of industrialization process, economic evolution and population growth has caused significantly on metal pollution issues [1]. Metals can cause the potential threat to ecosystem because these metals are considered to be conservative pollutants and non-biodegradable. At certain level of exposure, the existence of metals are dangerous to aquatic organisms, plants and human health [2]. Due to the biomagnification and bioaccumulation ability, monitoring only the total of metals concentrations in the water column does not provide adequate information to address the actual effects on biota and consumers in the food web, human especially [3]. In this situation, combined measurement of biological samples and water samples are more efficient for environmental assessment activities.

Consumption of seafood has been identified as the main pathway of metal exposure to humans, thus consuming the mud clams could also have been indicated have potentially threat human health [4,5]. Mud clams (*Polymesoda erosa*) or known as lokan by local people is an edible bivalve and non-seasonal species that can be found buried in the stiff mud and mangroves, widely distributed throughout the west Indo-pacific region, as well as in Peninsular Malaysia and Sarawak [6,7]. This clam species is widely consumed and known rich in protein due to its taste and nutritional value. It has been suggested that these species are ingest metals enriched particles directly, thereby have an ability as an indicator of the metal bioaccumulation [8,9]. Therefore, it is importance to measure the concentrations of contaminants in mud clams and determine their potential health risks in human.

Hence, to evaluate the potential risks in human health associated with consumption of contaminated mud clam, a screening-level risk assessment are usually conducted by using the target hazard quotient (THQ) [10]. The THQ were calculated to indicate the health risks of non-carcinogenic effects due to dietary intake [11].The USEPA [12], proposed THQ values as a reasonable parameters for the heavy metals assessment associated with the consumption of contaminated mud clams. The THQ value above 1 (THQ >1), indicated the metal exposure due to consumption of contaminated foods is likely can cause deleterious effects [13]. Therefore, the aim of this study is to analyze the possible health risks associated with metal (Pb, Zn, Cd, Cu, As) accumulation via consumption of mud clam by using THQ.

2. Materials and method

2.1. Sample collection and prepossessing of mud clam sample

The slaughtered mud clam was purchased in April –June 2018 by a local fisherman. The samples originated from the Sungai Geting, Tumpat, Kelantan (Figure 1). The samples were stored in 20 ºC freezer and the length and weight were recorded before dissection. The tissues samples were dried in an oven at 65 ºC to get constant dry weight, and the homogenized with a mortar and pestle. Before wet digestion is started, dried samples were kept in amber jars in a desiccator.

2.2. Sample collection and prepossessing of water sample

The basic physical and chemical water quality parameters include temperature, conductivity, turbidity, salinity, total dissolved solid (TDS), chemical dissolved oxygen (DO) and pH were measured in-situ using YSI 556 MPS multiparameter unit. For the water sampling, the sampling bottles were rinsed twice with the water sample before collection of surface water. The closed-sampler was submersed and the bottle was opened to fill-in the sample and recapped in the sub-surface [14]. The samples then were stored under 8 ºC for further analysis.

Figure 1. Location of sampling sites

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2.3. Laboratory procedure
Nitric acid, sulphuric acid, and hydrogen peroxide were of Suprapur® quality (Merck, Germany). About 0.5 g of dried samples was weighed directly into 50 ml beaker and digested with 5 ml of HNO3 and H2SO4 and heated at 60 ºC for 30 min on a hot plate. After digestion, sample was cooled and 10 ml of HNO3 was added and returned to the hot plate to be heated slowly to 120 ºC for 30 minutes. Then, the temperature was raised to 150 ºC for 30 min, the samples was takeout when the colour changes to black. The sample was cooled down before adding H2O2 until the sample change to clear. The clear sample was filtered through 0.45 µm PTFE membrane before being transferred to volumetric flask and the volume was made up to the mark with distilled water. All the digestate solutions were stored into centrifugal tubes below 8 ºC and were analysed by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) within 5 days [15].

2.4. Calculation and analysis
All calculation and statistical analyses were performed using Microsoft® Excel 2010 and SAS® JMP® version 9 software package. An analysis of variance (ANOVA) was carried out to assess the significant differences between the studied elements. For physico-chemical parameters, Pearson's correlation coefficient were carried out to test the relationship among all the parameters.

In the present study, the methodology of estimation target hazard (TH) will provide indication of human health risk due to contaminant exposure. The equation was used to estimate the risk as follow [16] :

$$\text{THQ} : EDI/RfD$$

As recommended by Agusa [17], EDI estimated daily intake given by equation below :

$$\text{EDI} : C\ x\ IR\ x\ EF\ x\ ED/BW\ x\ AT$$

Where, C is the metal concentration in studied mud clam, IR is ingestion rate (160 g/day/person). EF is the exposure frequency (365 days/year), ED is the exposure duration (70 years), BW is the average body weight; 64 kg (the reference weight were derived from numerous local Malaysia studies [18] and AT is the average time of exposure (365 day/ year) multiple by ED.

3. Result and discussion

3.1. The water quality
Water quality is a reflection of the source environment and degree of anthropogenic inputs which highly influences the usage of the water body. The appraisal of water quality for Sungai Geting, Kelantan is displayed on Table 1. Among the water quality assessment, the measurement of physico-chemical conditions have been indicated as one of the common practices that address the status of water, productivity and sustainability. Each parameters has its own role to play, the aggregate effect is the summation of the interaction of all the parameters.

The variations in water temperature are related to the temporal variability during sampling period (10 am- 1 pm). Water temperature can vary due to the length of a river and anthropogenic activities. The mean water temperature values was within the acceptable condition outlined by World Health Organization [19]. Meanwhile, analysis of Pearson correlation coefficient showed a moderately positive correlation between temperature and TDS (r = 0.52), conductivity (r = 0.55), salinity (r = 0.51) and pH (r = 0.47).

Table 1. The appraisal of water quality

	Sungai Geting, Tumpat
Temperature (ºC)	30.59 ± 0.4
Conductivity (µs/cm)	13030 .83 ± 2051
TDS (g/L)	7.80 ± 1.21
Salinity (ppt)	6.80 ± 1.13
DO (mg/L)	3.51 ± 0.7
pH	7.53 ± 0.02
Cu (mg/L)	< 0.008
Zn (mg/L)	< 0.09
As (mg/L)	< 0.002
Pb (mg/L)	0.0013 ± 0.002
Cd (mg/L)	0.00031 ± 0.001

95 % confidence interval, *n* = 20
Note : Cu, Zn, As : below the LoD

The water conductivity is affected by the water temperature. In this regard, the temperature can alter the viscosity of water and the solubility of salts which affect both the mobility and the concentration of dissolve ions that determine the potential of electrical in measurement of conductivity. Conductivity will highly measure when presence of high dissolved salt content in water [20]. Dissolved oxygen is an important environmental parameter which indicates the ecological health status of the aquatic ecosystem as well as a parameter which is important to monitor and protect aquatic life [21]. Basically, the solubility of oxygen decreases as temperature increases (Table 1). For trace metals (copper and zinc) were found below the detection limits. It is believed that conditions of surrounding (agricultural activities and residential disposal) could well had affected the overall metal inputs, however their contributions input were not clearly revealed by solely water assessment [22].

3.2. Morphometric and metal distribution of Polymesoda expansa

Polymesoda expansa clam has the morphological characteristic such as hard and thick subrhomboidal and eroded umbo. In order to overcome the potential variability associated with size variation in this study, an effort was taken to sample 100 of mud clams with comparable size and their morphometric are summarize in Table 2. The mean metal concentrations in tissue of mud clams are also summarized in Table 2. Due to regulation, excretion, storage and absorption mechanisms, tissues of mud clams show significant differences ($p < 0.005$) in accumulation rates of metals [15]. The study showed that tissues of mud clam contained significantly higher content ($p < 0.05$) of Pb.

Table 2. Biometry and metal concentrations found in *Polymesoda expansa* samples

Biometric	Type	
	Length (cm)	5. 39 ± 1.15
	Weight (g)	26.50 ± 20.50
Metal concentrations (mg/kg)	Cu	<0.008
	Zn	0.005 ± 0.03
	As	0.047 ± 0.01
	Pb	0.035 ± 0.20
	Cd	0.022 ± 0.02

All reported values are referred to dry base, 95 % confidence interval *n* = 100
Inorganic As (assuming 10 % of the total As are inorganic As)
Note : Cu : below the LoD

The findings are also found consistent with the trends in the Table 1. The concentrations recorded in mud clam were two to three higher than those in water body. However, all metals can cause detrimental effects on mud clam depending on their concentrations. Concentration of studied elements reported were still below the maximum permissible limit set by Malaysia Food Regulation 1985. Overall, metal concentration are generally found to be below the maximum permissible limit (Malaysia Food Regulation, 1985).

The risks of non-carcinogenic health risks associated with mud clam consumption are assessed based on Target Hazard Quotients (THQs). It is unlikely that humans will experience any adverse effects if THQs assume a level of exposure below one (THQ < 1) [23]. Higher values of THQ indicate a higher probability of experiencing long term noncarcinogenic effects. The THQ values in this work are given in Table 3.

Table 3. The Target Hazard Quotient of metal ingestion *Polymesoda expansa*

	Target Hazard Quotient
Zn	9.3×10^{-6}
As	0.46
Pb	0.014
Cd	0.05

Inorganic As (assuming 10 % of the total As are inorganic As)

As can be seen, the THQ values are significantly lower than 1, therefore, it can be concluded that the metals evaluated in the edible parts of *Polymesoda expansa* from studied areas pose no health effects for consumers. Based on Table 3, it is shown that the THQ of As are almost near to one. This indicate that consumption of *Polymesoda expansa* from Sungai Geting over a lifetime is likely to cause deleterious effects for consumers based on the THQ values. It is shown that the sources of As pollution are obtained from anthropogenic activities. The risk to their exposure may be associated to their tolerability efficiency [15]. In addition, exposure to Zn, As, Pb and Cd via mud clam ingestion could be deemed as non-significant since each of studied elements has small THQ values. However, more attention should be given to the consumption of mud clam over a lifetime is likely to cause deleterious effects for Malaysians based on the THQ values.

4. Conclusion

Combined information obtained from water and mud clam samples can describe the pattern of distribution and accumulation of metals. Apart from that, the results obtained illustrated the association between the concentrations measured in the tissues of mud clams and the level of metal contamination in the water column. The distribution of metal concentration followed the order of mud clam > water. The study revealed that there were was a considerable variations in the concentration of studied elements in water and mud clam. This variation might be due to the different sources of metals that are being transferred to the river.

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