Bioconcentration of Cadmium and Nickel in Mud Clams (*Polymesoda expansa*) at Balok River, Pahang.

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Abstract

Bioaccumulation of heavy metals in mollusc is one of the crucial topics in environmental pollution, toxicology and food safety as it gives great impact on the ecosystem and human health. This study was conducted to identify the level of Cadmium (Cd) and Nickel (Ni) in the soft tissues of mud clams (Polymesoda expansa) andwater samples at Balok River, Pahang. The mud clams and water samples were collected from five sampling stations in Balok River. Sampling was carried out during dry season (May 2018) and wet season (January 2019). The mud clams' tissues were digested and analysed with inductively coupled plasma-mass spectrometry (ICP-MS). The obtained results revealed that the mean level of Cd and Ni in tissues of mud clams during wet season (0.127±0.104 and 0.909±0.482)mg/kg were higher compared to dry season (0.031±0.014 and 0.245±0.106)mg/kg respectively. Both of Cd and Ni concentrations in the mud clams were found below the limits stated by FAO/WHO (1984), MFA (1983) and FSANZ (2002). There was no significance different ($p<0.05$) between Cd and Ni in both seasons. Meanwhile, the concentration of Cd in water samples from Balok River during both seasons were the same, which were (0.0001±0.001)mg/kg respectively, whereas for Ni, the concentration in dry and wet season were slightly different with value of 0.0088±0.001mg/kg and in Jan 2019 is 0.0062±0.001ppm. All the water samples from both seasons had Cd and Ni concentrations within Malaysia's National Water Quality Standard NWQS limits.

Keywords: *Cadmium, Nickel, Mud clams (Polymesoda expansa), Balok River*

1. Introduction

Balok River located near to the Gebeng industrial site, and waste waters from industry always discharge to the Balok River through channels than flows toward to South China Sea. For this reason, environmental monitoring has become recognized as being vitality important in detecting where insidious pollution occurring. A serious health problem in human might cause by contamination of heavy metal in aquatic ecosystem due to discharge of industrial effluents [1]. The water quality of the Balok River is been worsen by anthropogenic impact as a result of the industrial activities in Gebeng Industrial area especially bauxite activities. So, it was possible that Balok River had also been contaminated with heavy metal.

Toxicity of heavy metals, namely nickel (Ni) and cadmium (Cd) resulted in aquatic animal contamination which will lead to health effect in human body. In certain conditions, there are also some metals that are toxic to the body even at low levels such as arsenic (As), copper (Cu), mercuri (Hg), lead

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(Pb) and zinc (Zn) [2,3]. Thus, heavy metal pollution of river will directly affect ecosystem and aquatic resources.

Exposure of Ni to humans can be through inhalation, oral and dermal. The toxicities depend on how exposure occurs. As overall Ni is a potent and also carcinogenic agent [4].

The uses of Cd are limit due to its toxicity. Cd does not break down but changes to the other form into different species and compounds. It is nonessential element to all living organisms because it is most toxic [5]. The exposure of Cd to humans come in two ways which are first through ingestion of cadmium polluted food and water. For specific diseases caused by Cd are renal failure, skeletal damage, cardiovascular disease and probably carcinogen to humans [6].

The mud clams are one of the common species from the family Corbiculidae usually found inhabit mangrove is at Southeast Asia [7]. It also can accumulate chemical elements and compounds in their tissue proportionally to their bioavailability [8]. Mollusc is a filter feeder, so it has the potential to bioconcentrate contaminants, which would normally be present in the water or sediments. Clams like the other bivalves are benthic filter feeders have a tendency biomonitor of toxic metal contamination as they ingest metal-enriched particles directly [9-11]. Trace metals that present in marine environment even in very low concentration can affect mud clams and other bivalves. Therefore, they show insidious tendencies to accumulate certain heavy metals and widely being used as bioindicator organisms where clams are about 70% [12]. This study focuses to analyse the bioconcentration of cadmium and nickel in the tissue of *Polymesoda expansa* collected from Balok River in Kuantan,Pahang.

2. Materials and methods

A total of 20 mud clams and water sample were collected from five sampling points at Balok River. The sampling was done twice during May 2018 (dry season) and Jan 2019 (wet season). In terms of size, the samples ranged between 53 to 60mm in length and 65 to 80 mm in width. For the wet weight, the tissue samples ranged from 0.63 to 5.40g. After drying the mean (dry) weight recorded in a range of 0.15 to 0.63g.

2.1. Water collection

Water samples in some different sites were collected and preserved in a cleaned polyvinyl plastic bottle and were kept in an ice box to avoid any contamination for further laboratory analysis.

2.2. Mud clams collection

The mud clams were collected randomly about similar sizes and weight to avoid differences in metal content. Immediately after collection, mud clam samples were transferred to the laboratory on ice boxes. Total length and width were measured before brought to the laboratory for analysis.

2.3. Dissection

The mud clams samples were thawed at room temperature. Before dissection, the samples were cleaned several times with ultrapure water to remove foreign particles such as debris and other external adherent. The tissues have been removed by using stainless steel scalpels and knife. The samples were dried in an oven at 80 ˚C for overnight until samples reached constant weight. On the next day, the samples dried weighted prior to analysis [13].

2.4. Digestion

Acid digestion method was used to digest the tissue samples based on the Association of Official Analytical Chemists [14]. Each sample was placed in the digestion tube, and 10 ml of 69 % of nitric acid was added before left overnight at room temperature. On the next day, the samples were digested on the block thermostat at 100 °C for 2 hours before cooling it down for 1 hour. After that, 2 ml of 30 % hydrogen peroxide was added to each sample and heated for 1 hour until it forms a clear solution. Then, it was allowed to cool before solutions were filtered through 0.5 mm filter paper into 25 ml of volumetric flask. Lastly, deionized water was added into volumetric flask until the volume reaches 25 ml. The concentration of heavy metals was determined using the Perkin Elmer ELAN 9000 Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

2.5. Metal calculations

The concentration of tissues was calculated by using the formula below [15]:

$$C=A \times B/M \quad (1)$$

C= Actual concentration (mg/kg)

A= digested concentration (ICP) (mg/L)

B= Volume digested (L)

M= Weight of dried sample digested (kg)

2.6. Statistical analysis

One way analysis of variance (ANOVA) was used to indicate significant differences in metal levels in *Polymesoda expansa* among different sites. All calculations and statistical analyses were performed with Microsoft Excel 2010.

3. Results and discussion

The content level of heavy metals cadmium (Cd) and nickel (Ni) detected in the soft tissues of mud clams were summarized in Table 1.

3.1. Heavy metals concentration in mud clams

The concentration of Cd and Ni in the tissue of *Polymesoda expansa* during dry and wet season were (0.0313±0.0143 0.2445±0.1062 and 0.1271±0.1038 and 0.9085±0.4816)mg/kg respectively. From the results, the highest concentration of Cd and Ni in the tissue of *P.expansa* were from wet season with value of (0.1271±0.1038 and 0.9085±0.4816)mg/kg compared to dry season (0.0313±0.0143 and 0.1271±0.1038)mg/kg. Thus, indicates that *P.expansa* accumulated more metals during monsoon seasons than dry seasons. Mud clams are influenced by the environmental changes such as temperature, pH, changes in salinity, occurrences of obnoxious blooms of phytoplankton and rainfall.

The data obtained in this study were compared with the previous investigations on the same species but from different locations in Malaysia such as Kuala Perlis [16], Pasir Putih [17] and Sarawak [18].

The average Cd concentration found in the present study was lower than that reported from the previous studies as stated in Table 1. These differences are possibly due to the different anthropogenic activities in the sampling areas. However, the pattern of study from Sarawak is the same with present study where Ni element has the highest accumulation rate compared to Cd while the mean concentration of Ni was higher than [19] but lower than [20] and [18].

By referring to the standard stated by FAO/WHO, Malaysia Food Act and FSANZ [21-23], Cd concentration in *P.expansa* are below the permissible limit, whereas Ni concentration was still under the permissible limit of [21] for both seasons. However, this does not indicate that the presence of Cd and Ni in *P.expansa* is not harmful to the mollusc. Bioaccumulation of excessive Cd can lead to severe human health such as kidney and skeletal damage, disturbance in Zn metabolism, reduced haemoglobin concentration, stomach irritation, vomiting and diarrhea.

Moreover, the content level of Ni was higher than concentrations of Cd in both seasons. This is due to the Ni is one of the essential metals in living things [4]. The possible explanation is because the marsh clams might need these essential metals for their living processes while the non-essential metals do not play any role in metabolism of the organism, and thus there is no preferential uptake for these substances [11]. The physiological of mud also clams one of the factor accumulations of heavy metals as there has that ability [12]. It is an essential metal that the body can tolerate in higher concentrations, but of course, within limits [24].

Table 1. The concentration of Cd and Ni in *P.expansa* in the present study, previous studies and permissible limit of heavy metals from organisations.

	Cd (mg/kg)	**Ni (mg/kg)**
Present study		
Dry season, May (2018)	0.0313±0.0143	0.2445±0.1062
Wet season, Jan (2019)	0.1271±0.1038	0.9085±0.4816
Permissible limit by organizations		
FAO/WHO (1984)	0.5	8.0
MFA (1983)	1.0	-
FSANZ (2002)	2.0	-
Previous study		
Alfonso et al., 2008 (Venezuela)	0.26	0.223
Singh et al., 2012 (India)	-	5.76
Lias et al., 2013 (Kuala Perlis)	4.4	-
Edward et al., 2009 (Pasir Puteh)	3.59	6.04
Yusoff, & Long 2011(Sarawak)	1.15	-

3.2. Heavy metals concentration in Balok River water

Water sample collection was collected in five locations started from the river stream that near to the estuary as the first sampling point to the upstream of Balok River. The accumulated concentrations of heavy metals and the results of the analysis from sampling stations in May 2018 and Jan 2019 (wet and dry seasons) are presented in Table 3. The concentration of Cd in both dry and wet seasons have the same level with value of (0.0001±0.0001)mg/kg. However, it was noticed that the concentrations of Ni in dry season (0.0088±0.0002mg/kg) was higher than wet season (0.0062±0.0013mg/kg). This result was in agreement with study from Abasohan and Oronsaye [25] as they stated the low heavy metal concentrations in the wet season were due to the dilution of metal levels associated with heavy rains. According to Andrew [26] heavy rain may enhance the water quality by diluting and washing away pollutants, fertilizers and suspended or dissolved solids. Therefore, conclude that season has significant effect on the concentrations of heavy metals in the river.

The study also showed that the concentration of Ni in both seasons were higher than Cd. Ni is known as an essential metal compared with Cd. Moreover, the surface via runoff from the farms to the river and highly contribute to agricultural pollution, especially chemical fertilisers containing Ni and Pb. Although, Nickel is believed to be one of the most toxic metals found in environment, accumulation of Ni in the food chain result in nickel toxicity. However, the concentration of Cd and Ni in water samples were below the permissible level by NWQS respectively.

Table 2. Concentrations of Cd and Ni in the current and previous study

	Cd (mg/kg)	**Ni (mg/kg)**
Current Study		
May (2018)	0.0001±0.0001	0.0088±0.0002
Jan (2019)	0.0001±0.0008	0.0062±0.0013
Previous Study		
Abdullah et al., 2015	0.5	16.0

Table 3. Classification of rivers water based on Cd and Ni concentration set by NWQS

Heavy Metal	**Class**				
	I	IIA / IIB	III	IV	V
Cd	<0.01	0.01	0.01	0.01	>0.01
Ni	<0.05	0.05	0.90	0.20	>0.20

The average Cu and Ni concentration found in the present study was lower than that reported by Abdullah et al. 2015. The study showed the concentrations for Cd and Ni in the water from the same river were 0.5 and 16.0 respectively. This result showed that the effluent from industries discharged is decreasing from the past few years especially bauxite activities. The effluent from industrial activities may be introduced directly or indirectly [27]. The surface water of the river is confirmed been polluted by some metals at a certain level which are Cd, Co, Cu, As and Pb [27-28]. It was probably due to the dilution by rainwater, which influences concentration and heavy metal mobility. Moreover, heavy metals can be dependant on the total concentrations in the soil and sediments, metal properties and environmental factors.

4. Conclusion

In conclusions, the concentration of heavy metals in mud clams and water samples were identified. The mean level of Cd and Ni in the tissue of mud clams during wet season (0.127±0.104 and 0.909±0.482)mg/kg were higher compared to dry season (0.031±0.014 and 0.245±0.106)mg/kg respectively. However, both Cd and Ni concentrations in the tissue were found to be below the established limits by FAO/WHO (1984), MFA (1983) and FSNZA (2002). There was no significance different ($p<0.05$) between Cd and Ni in both months. Thus, indicates that the mud clams caught from Balok River are safe for human consumption. Besides, the concentration of Cd and Ni in Balok River water in both seasons were also below than the established limit by NWQS. From the analysis, the molluscs may be considered safe for consumption, but they require continuous monitoring to prevent bioconcentration, and Balok River may need extensive water treatment if it is used as water supply.

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