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Bivalves as Bio-Indicators for Heavy Metals Detection in Kuala Kemaman, Terengganu, Malaysia

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Abstract

Background/Objectives: The objective of this work is to collect representative sample of bivalves, soil and water from Kuala Kemaman. It performs analysis of heavy metal existence and estimate the heavy metals concentration from the collected samples. **Method:** First sampling allocation for bivalves, water and soil after sampling pre–treatment was applied to remove any impurities from bivalve samples. Digestion by acid was done after drying. Then, analysis was carried out by using atomic absorption spectrophotometer (AAS). Estimation was done in triplicate and results were expressed in ppm on average basis with support of standard reference materials that were always with high confidence interval of the certified values. **Findings:** High concentration exceeds the Malaysian Food Regulation (MFR 1985) permissible limits for cadmium (Cd) and lead (Pb) were found in bivalve tissues of Polymesoda Expansa and *Anadara granosa*. However, copper (Cu) and zinc (Zn) levels were below the allowable limit. Heavy metals concentrations in both bivalves (µg/g dry wt) were ranged between 2.3–5.9, 12.8–15.9, 6.8–10.2, 22.9–56.5 and 7–3 for Cd, Cu, Pb, Zn and Fe respectively. Polymesoda Expansa showed a higher tendency to accumulate high concentration of Cu, Zn and Fe. At the same time, *Anadara granosa* showed a higher tendency to accumulate higher concentration of Cd and Pb, even though samples were collected from the same area. For iron, there is no permissible level according to MFR 1985. However, Fe was slightly higher than WHO 1993 (set value; 5 ppm). Analysis of soil and water for the samples collected from the same area showed that heavy metals concentrations were under permissible level set by Malaysian Food Regulation (MFR), World Health Organization (WHO) and USEPA (1993) regulations. **Applications/Improvements:** Results show that *Anadara granosa* have a tendency to accumulate higher concentration of Cd and Pb compared to Polymesoda Expansa where it has a higher tendency to accumulate Cu, Zn and Fe. The concentration of heavy metals in soil and seawater were below the permissible level. In this work, only one time sampling was carried out. Therefore, it is recommended to perform regular monitoring in seasonal basis in order to obtain a clearer picture about the environmental situation in Kuala Kemaman and nearby areas.

Keywords: Anadara granosa, Bio-Monitoring, Bivalves, Heavy Metals, Kemaman, Polymesoda Expansa

1. Introduction

Recently, Kemaman area has witnessed a considerable and increasingly growth especially in the industrial sector. As a result of this rapid growth, significant impact of heavy metals could be occurred since heavy metals represent the major anthropogenic contaminants of estuarine and coastal marine ecosystem. Worsening conditions might lead to the damage of ecosystem balance partially or totally. At the same time, the local population will suffer if no implementation of reliable and immediate countermeasures.

Most of the living organisms need a small amount of essential metals such as Fe, Mn, Cu, and Zn for essential processes such as growth[1–2]. However, all these metals will give harmful effects when exceeding the standard limits[3]. The nonessential metals such as Cd, Pb, Ni and Cr are toxic even at relatively low concentration and not essential for metabolic activities[4]. The abundance of heavy metal may jeopardize human health due to the consumption of contaminated bivalves[5]. For examples, Cd may cause human carcinogen, Pb can damage blood circulation and excessive intake of Zn may cause electrolyte imbalance and lethargy[6–8]. *Many researchers believe that*

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biomonitoring by using bivalve mollusks such as clams, oyster and cockles are found to be very efficient tools. Bivalves are a well known accumulator of heavy metals and have been widely used as bio-indicator for monitoring heavy metal pollution in the aquatic environment in Malaysian coasts and many other countries[9–17].

In order to evaluate the contamination level of heavy metals in Kuala Kemaman, bivalves namely *Polymesoda expansa* and *Anadara granosa* were used as bio-indicators for five heavy metals in bivalves tissue (Cd, Cu, Pb, Zn and Fe). Bivalves were chosen where they are known to concentrate these elements and providing a time integrated indication of environmental contamination.

2. Methodology

2.1 Sampling Area

As shown in Figure 1, sampling areas (Kuala Kemaman) lies within latitudes and longitude (4°14"19.08" N 103° 26" 44.60" E). Kuala Kemaman is located south of the industrial location in Teluk Kalong and has the habitat for *Anadara granosa* and *Polymesoda expansa*. Parts of industrial effluents from industries as well as from domestic usage might be deposited into the river, then to the sea either with partial or no pretreatment. Hence, this study helps to know whether the concentrations of selected metals (Cd, Cu, Pb, Zn and Fe) are higher or within the safety limit.

Figure 1. Location of sampling area (Kuala Kemaman, Terengganu, Malaysia).

2.2 Sampling and Preparation Methods

The samples of *Polymesoda expansa*, *Anadara granosa*, sea water and soil were collected from Kuala Kemaman, Terengganu in July 2014. Sampling was carried out by applying standard methods. After collection, bivalve samples were rinsed with seawater to remove encrusted organisms and transported at +4°C in a cold box to the laboratory. In the laboratory, upon arrival, mussels were inspected and dead animals discarded. Then, bivalves were cleaned again with fresh water and whole tissue was removed by cutting the adductor muscle and placed with its ventral edge on filter paper to remove the internal water. A plastic knife was used in order to avoid any metal contamination. The tissues and sediment samples were dried in an oven at 60°C for 48 hours. After drying, crushing was done for bivalve tissues and sediment samples by using agate mortar till fine powder was obtained.

Samples of seawater were collected on the surface by using polyethylene bottles, previously washed and rinsed with distilled water. They were then transported in the cold box for storage at +4°C until analysis. Chemical parameters at the time of sampling were pH = 7.8, Practical Slinity Unitb (PSU) = 32, Dissolved Oxygen (DO) = 8ppm and temperature = 28°C.

The sediment samples were collected by using plastic spoon and kept in polyethylene bottles, which previously washed and rinsed with distilled water. It then be transported to cold box at 4°C and kept in refrigerator until analysis. Before analysis, sediment samples were dried at 105°C for 24 hours to ensure no water contents in the samples.

2.3 Digestion and Heavy Metals Analysis

The concentration of cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn) and iron (Fe) were measured in the whole soft tissues of mussels after hot mineralization. For bivalve's tissue and sediment samples, a known quantity (0.5g) of each dried sample was digested in a Teflon beaker by using 1ml of 1M perchloric acid and 4ml of nitric acid. The digestion will be complete after each of the samples was dissolved in the mixture of the acid at 120°C for 3 hours. After the samples were digested properly, the precipitate was filtered with 45µm Whatman and diluted with distilled water in the 100ml of volumetric flask. After that, the dilution was analyzed by using Atomic Absorption Spectrophotometer AAS (Perkin Elmer AAnalyst 400). For water samples before analysis, the sample was filtered with 45µm Whatman. Estimation was done in triplicate and results were expressed in ppm on average basis. Quality assurance and quality control were assessed by processing blank samples and reference standard materials (Dogfish liver DOLT-4 and Marine sediment HISS-3, National Research Council Canada). Metal concentrations obtained for standard reference materials were always with high confidence interval of certified values (Tables 1 and 2).

3. Results and Discussion

3.1 Assessment of Cadmium (Cd)

As shown in Figure 2, the results show that the range of Cd concentration was in the range of 2.3 and 5.9 ppm for

Table 1. Certified and measured values of metal concentrations obtained for the standard sample (Dogfish liver, DOLT-4)

Element	Cd	Cu	Pb	Zn	Fe
Measured value [PPM dry wt.]	20.1	33.4	0.18	110.3	1918
Certified value [PPM dry wt.]	24.3	31.2	0.16	116	xxx

Table 2. Certified and measured values of metal concentrations obtained for the standard sample (Marine sediment HISS-3)

Element	Cd	Cu	Pb	Zn	Fe
Measured value [PPM dry wt.]	0.2	35.7	18.9	140.5	5.1
Certified value [PPM dry wt.]	0.24	33.9	21.1	159	4.34

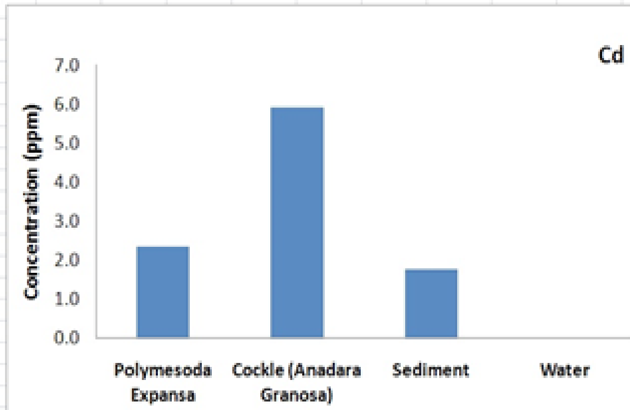

Figure 2. Concentration of Cd in bivalve tissues, soil and water.

Polymesoda expansa and *Anadara granosa* respectively. These values exceed the maximum permissible level set by Malaysian Food Regulation (MFR 1985)[18].

The concentration of Cd in sediment and water were below the permissible level (14.2 and 0.24 ppm) respectively. According to USEPA (1993)[19], the allowable limit for sediment is 420 ppm and therefore 14.2 ppm is below the allowable limit. Cadmium is one of the environmental contaminants which can promote serious damage to human health even at relatively low concentration and non essential for metabolic activities. Cadmium may cause possible toxicological risk and heavy metal related disease such as Parkinson's disease due to long term consumption[20].

3.2 Assessment of Copper (Cu)

The range of copper (Cu) concentration was between 15.9 and 12.8 ppm for *Polymesoda expansa* and *Anadara granosa* respectively as shown in Figure 3. These values below the maximum permissible level, which set by MFR 1985 Regulations. The permissible amount in MFR 1985 is 30 ppm.

The concentration of Cu in sediment and water is below the permissible level (5.2 and 0.032 ppm) respectively. According to WHO (1982)[21], this value is still safe value where it is still less than 1.0 ppm in water and 4300 ppm of soil which set by USAEPA (1993).

3.3 Assessment of Lead (Pb)

As illustrated in Figure 4, the range of Pb concentration was in the range of 6.9 and 10.2 ppm for *Polymesoda expansa* and *Anadara granosa* respectively. These values

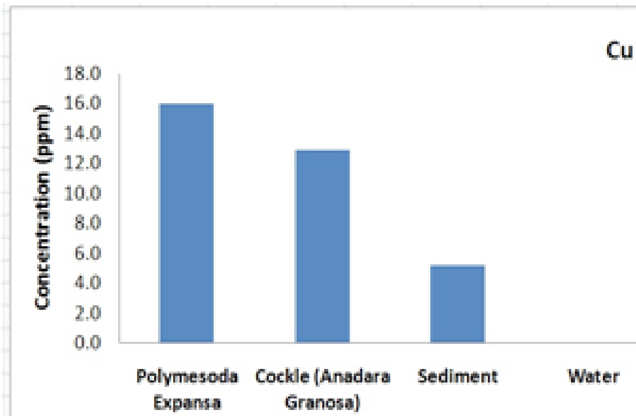

Figure 3. Concentration of Cu in bivalve tissues, soil and water.

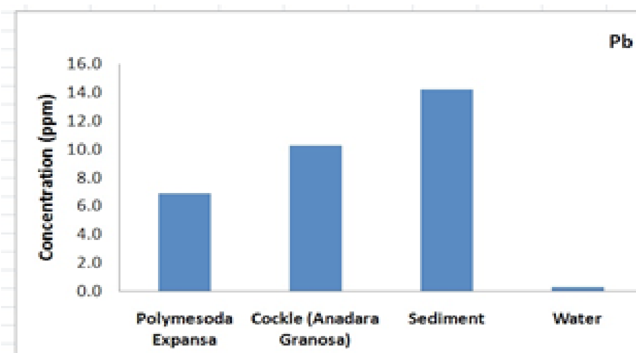

Figure 4. Concentration of Pb in bivalve tissues, soil and water.

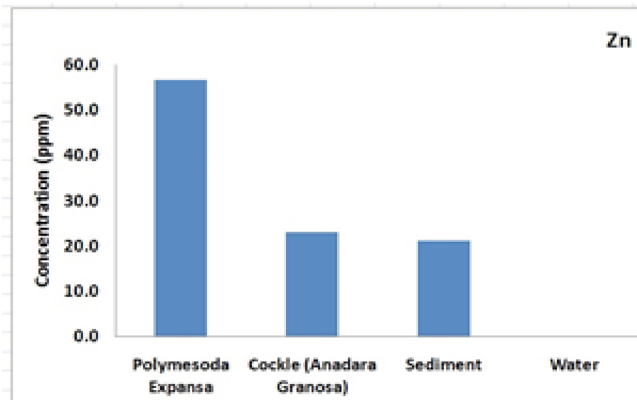

Figure 5. Concentration of Zn in bivalve tissues, soil and water.

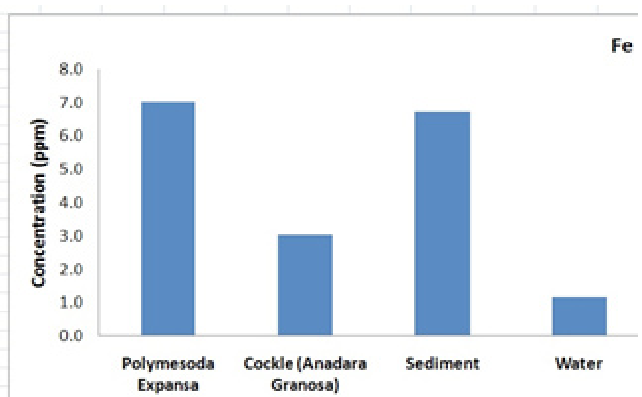

Figure 6. Concentration of Fe in bivalve tissues, soil and water.

exceed the maximum permissible level that set by Malaysian Food Regulation (1985) which is 2.0 ppm.

The concentration of Pb in sediment and water is below the permissible level (14.2 and 0.24 ppm) respectively. According to USEPA (1993), this value is still safe value where it's still less than 420 ppm in soil. Similar to cadmium, lead is also one of the environmental contaminants and possess ability to cause harm to human health even exist in small amount. The high concentration of lead may cause of neurological deficits such as mental retardation in children and kidney disease such as interstitial nephritis to adults. It also contributes to hypertension and cardiovascular disease to the consumers in the coastal areas after long term consumption[22].

3.4 Assessment of Zinc (Zn)

As illustrated in Figure 5, the range of Zn concentration was in the range of 56.5 and 22.9 ppm for *Polymesoda expansa* and *Anadara granosa* respectively. These values are below the maximum permissible level of MFR 1985. The concentration of Zn in sediment and water is below the permissible level (21.0 and 0.064 ppm) respectively. According to USEPA and MFR (1993), this value is still safe where it less than 420 ppm for sediment.

3.5 Assessment of Iron (Fe)

As illustrated in Figure 6, the range of Fe concentration was in the range of 7.0 and 3.0 ppm for *Polymesoda expansa* and *Anadara granosa* respectively. The concentration of Fe in sediment and water is below the permissible level (6.72 and 1.1 ppm) respectively. According to USEPA (1993), this value is still safe value. For MFR, no limit is set for iron.

Iron in particular or dissolves amount state is not toxic to the marine life. However, its reduced or oxidized forms when released may result in mortality of benthic forms[23]. Large amount of Fe can lead to hemocheromatosis that can damage the body organs[24–26].

4. Conclusion

Regular bio-monitoring is a very effective tool to avoid health hazards. Bivalves are recognized as very good monitors of ecosystem changes. Moreover, they have ability to accumulate very high concentration of heavy metals compared to their surrounding environment.

In this study, concentrations of heavy metals were evaluated and analyzed to see the accumulations of heavy metals in bivalve tissues (*Polymesoda expansa* and *Anadara granosa*) as well as in sediments and water that collected from the same area in Kuala Kemaman, Terengganu, Malaysia. Results show concentrations exceeded the permissible levels for Cd and Pb. However, Zn and Cu were below the allowable limits. Iron in particular slightly exceeded the allowable limit that set by WHO 1991.

The usefulness of this work can be further applied to investigate in details the real contamination situation in Kuala Kemaman on seasonal basis as part of coastal healthwatch. It is necessary to recommend suitable treatment methods and effective countermeasures to preserve the health of the marine resources.

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