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Concentration of Zn, Cu and Pb in Some Selected Marine Fishes of the Pahang Coastal Waters, Malaysia

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Abstract: Problem statement: Heavy metals constitute one of the most hazardous substances that could be accumulated in biota. Fish populations exploited by man often live in coastal area environments that contain high levels of heavy metals, coming from human activities such as industrial and agricultural wastes. A problem to deal when using fishes as biomonitors of heavy metals is the relationship existing between metal concentration and several intrinsic factors of the fish such as organism size, genetic composition and age of fish. **Approach:** Concentration of Zn, Cu and Pb were determined in eight commercially valuable fish species, *Selaroides leptolepis*, *Euthynnus affinis*, *Parastromateus niger*, *Lutjanius malabaricus*, *Epinephelus sexfasciatus*, *Rastrelliger kanagurta*, *Nemipterus japonicus* and *Megalaspis cordyla* from Pahang coastal water. The concentration was measured by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The study focuses on the level of Zn, Cu and Pb in order to assess the environmental pollution by using fishes as an indicator. **Results:** Concentrations of the heavy metals in examined fish species ranged as follow: Zn 19.27 $\mu g\ g^{-1}$ dry weight; Cu 2.88 $\mu g\ g^{-1}$ dry weight and Pb 0.26 $\mu g\ g^{-1}$ dry weight, respectively. The concentrations of Zn, Cu and Pb were found to follow the order: stomach > muscle > gills. Significant correlations were found between fish weight and heavy metals concentration in the fish organs. **Conclusion:** The estimated values of all metals in muscles of fish in this study were below the established values. Therefore, it can be concluded that the fish from Pahang coastal water are comparatively clean and do not constitute a risk for human health.

Key words: Pahang coastal water, Zn, Cu, Pb, ICP-MS

INTRODUCTION

Fish are the major part of human diet and it is not surprising that numerous studies have been carried out on metal accumulation in different species (Kucuksezgin *et al*., 2001; Lewis *et al*., 2002). Fish also have been popular targets of heavy metal monitoring programs in marine environments because sampling, sample preparation and chemical analysis are usually simpler, more rapid and less expensive than alternative choices such as water and sediment (Rayment and Barry, 2000). In recent years, much attention has been directed to the concentrations of some inorganic elements in marine fish and other aquatic organisms (Farkas *et al*., 2003; Mansour and Sidky, 2002). The commercial and edible species have been investigated in order to check for those hazardous to human health.

Metals can be taken up bay fish from water, food, sediment and suspended particulate material (Agusa *et al*., 2005). However, the presence heavy metal at high concentrations in water or sediment does not involved direct toxicological risk to fish, especially in the absence of significant bioaccumulation. It is known that bioaccumulation is to a large extent mediated by abiotic and biotic factors that influence metal uptake. Due to the deleterious effects of metals on aquatic ecosystems, it is necessary to monitor their bioaccumulation in key species, because this will give an indication of the temporal and spatial extent of the process, as well as an assessment of the potential impact on organism health (Fernandes *et al*., 2006).

Marine organisms, in general, accumulate contaminants from the environment and therefore have been extensively used in marine pollution monitoring

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programmes (Linde *et al*., 1998; Mora *et al*., 2004). In many countries, industrial wastes, geochemical structure and mining of metals create a potential source of heavy metals pollution in the aquatic environment, due to their toxicity and accumulation behavior. Under certain environmental conditions, heavy metals might accumulate up to a toxic concentration and cause ecological damage (Sivaperumal *et al*., 2007). Metal such as Zn and Cu are essential metals since they play an important role in biological systems, whereas Pb is non-essential metals, as they are toxic, even in traces. The essential metals can also produce toxic effects when the metal intake is excessively elevated (Turkmen *et al*., 2005).

MATERIALS AND METHODS

Fish samples were collected with the help of LKIM staffs and local fishermen from February to August 2008 from the three LKIM jetties which located in Kuantan, Kuala Pahang and Kuala Rompin of Pahang coastal water (Fig. 1) and transport immediately to the laboratory. Samples were stored in plastic bags at -20°C until dissection. The total length (cm) and weight (g) of each fishes were measured (Table 1). Each sample collected was dissected for its muscle, gill and stomach tissues. Sample preparation and analysis were carried out according to the procedure described by UNEP Reference Methods.

The tissues digested with concentrated nitric acid, hydrochloric acid, sulphuric acid and hydrogen peroxide acid at 60°C until a clear solution emerged and all samples were diluted with 5% nitric acid. Following acid digestion, all samples were analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). All digested samples were analyzed three times for each metal. The standard addition method was used to correct for matrix effects. The instrument was calibrated with standard solutions prepared from commercial materials. Analytical blanks were run in the same way as the samples and determined using standard solutions prepared in the same acid matrix. The quality of data was check by the analysis of standard reference material (DORM-2 National Research Council, Canada).

Statistical analysis of data was carried out using SPSS statistical package program. One-way Analysis Of Variance (ANOVA) and Tukey multiple range tests were used to assess whether metal concentrations varied significantly among tissue. When ANOVA assumptions such as normality and homoscedasticity were not respected, multiple (n>2), sample comparisons were performed by nonparametric Kruskal_Wallis test. An ANOVA paired test was then used for two-sample comparisons. A p-value of 0.05 or less was considered statically significant.

RESULTS

The levels of Zn, Cu and Pb in various tissues of *Selaroides leptolepis*, *Euthynnus affinis*, *Parastromateus niger*, *Lutjanius malabaricus*, *Epinephelus sexfasciatus*, *Rastrelliger kanagurta*, *Nemipterus japonicus* and *Megalaspis cordyla* are given in Fig. 2 for each metals, respectively. The graph show significant differences in the accumulation levels of metals in the tissues throughout the species. We observed higher levels of metal in stomach followed by gills and muscle Several studies shown that various factors such as season (Dural *et al*., 2006), length and weight, physical and chemical status of water (Al-Yousuf *et al*., 1999) can play a role in the tissue accumulation of metals. The high level accumulation of metals in some fish species could be due to heavy rainfall during monsoon season which increase the metal content of water by washing down the agricultural waste. Seasonal changes intrinsic factors such as growth cycle and reproductive cycle and from changes in water temperature. The differences noted in the metal concentrations in different tissues between seasons could have been the result of local pollution.

Table 1: Sample information on marine fish caught

Scientific name	Common name	N	Total length (cm)	Total weight (g)
Selaroides leptolepis	Yellow striped trevally	16	14.00-14.80	31.42-35.68
Euthynnus affinis	Eastern little tuna	12	30.00-32.00	360.87-404.22
Parastromateus niger	False butterfish	22	22.00-26.00	190.75-220.64
Lutjanus malabaricus	Saddle-tailed sea-perch	10	25.20-27.60	115.38-180.41
Epinephelus sexfasciatus	Six-banded rock-cod	16	20.60-23.00	230.22-300.07
Rastrelliger kanagurta	Rake gillat mackerel	28	19.50-21.40	87.30-106.52
Nemipterus japonicus	Japanese threadfin bream	24	19.20-22.00	121.47-131.94
Megalaspis cordyla	Finletted mackerel scad	22	24.50-27.60	156.71-209.93

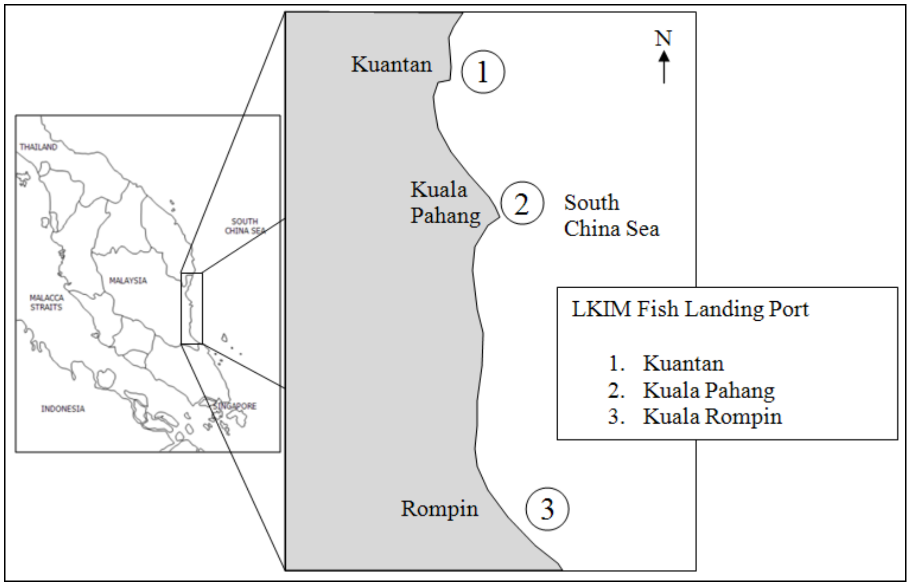

Fig. 1: Map showing the location of the study area

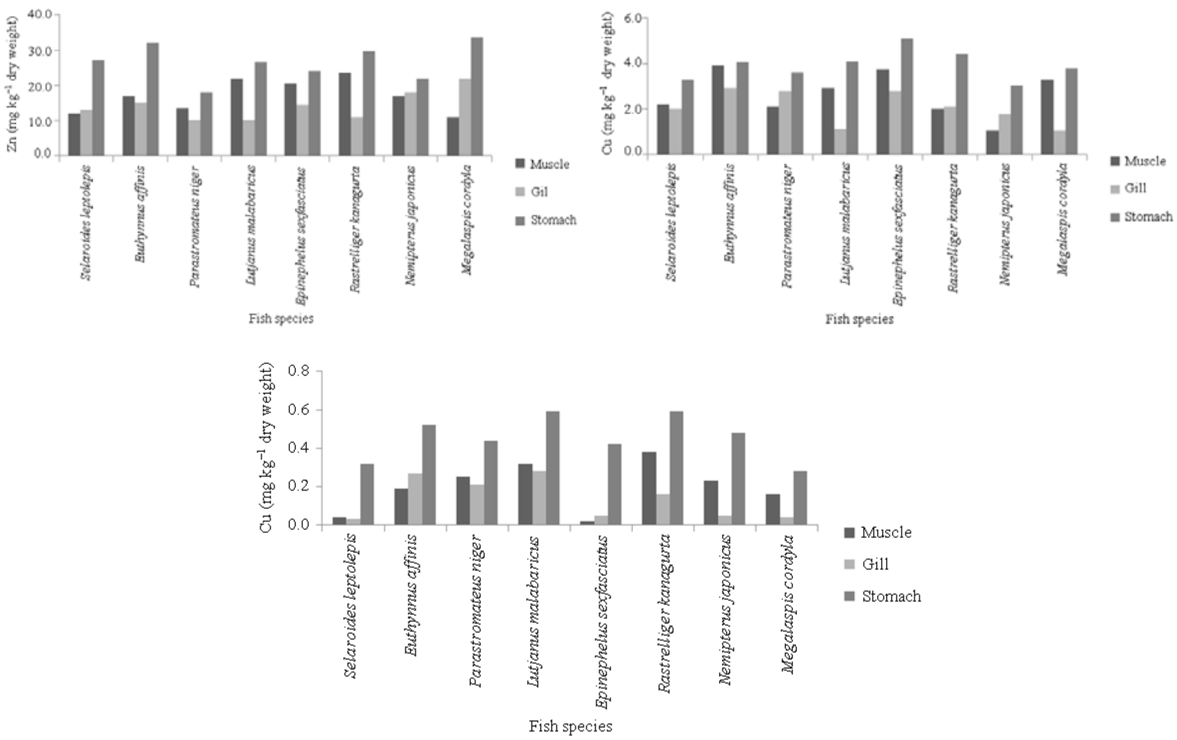

Fig. 2: Mean concentrations of Zn, Cu and Pb in all fish samples

DISCUSSION

Bioaccumulation is species-dependent and therefore feeding habits and life style can be strongly related to the sediment exposure (Chen and Chen, 1999). On the other hand, bioavailability of metals can be influenced by inorganic and organic factors that control metal speciation and thereby bioaccumulation

(Henry *et al*., 2004). The metal accumulation in different fish organs depends on their physiological role, behavior and feeding habits, as well as regulatory ability, as reported by Clearwater *et al*. (2002). Other factors, such as sex and size may also influence metal bioaccumulation (Al-Yousuf *et al*., 1999; Canli and Atli, 2003). Some marine organisms have the ability to concentrate heavy metals in their tissues to concentrations which are several orders of magnitude higher than those in water and sediment (Kiorboe *et al*., 1983; Law and Singh, 1991).

This investigation showed that different fish species contained different metal levels in their tissues. Our results show that generally metal accumulation in highest in stomach followed by muscle and gill. This was the case in many fish species, although interspecies differences were shown on the accumulation of various metals in these tissues (Izquierdo *et al*., 2002; Yilmaz, 2002). The levels of Zn, Cu and Pb were determined in the muscle in each species because of its importance for human consumption and also the gill and stomach were analyzed since these organs tend to accumulate metals (Marcovecchio, 2003). These organs are also good indicators of chronic exposure to heavy metals because they are the site of metal metabolism. It is well known that heavy metals accumulate in the tissues of aquatic animals and therefore heavy metals measured in the tissues of aquatic animals can reflect the past exposure. The stomach is often considered a good monitor of water pollution with heavy metals since their concentrations are proportional to those present in the environment. The gills are the uptake site of waterborne ions, where metal concentrations increase especially at the beginning of exposure, before the metal enters other parts of organism.

Gills are the first organs to be exposed to resuspended sediment particles, so they can be significant sites of interaction with metal ions. On the other hand, the stomach has a key role in basic metabolism and is the major site of accumulation, biotransformation and excretion of contaminants in fish (Pawert *et al*., 1998). It is well known that a large amount of metallothionein induction, caused by contamination, occurs in stomach tissues of fish (Olsvik *et al*., 2000). In contrast, the muscle tissues are not considered an active site for metal accumulation (Romeo *et al*., 1999).

Significant positive correlations between total length and weight were found for all fish samples. Significant positive correlations were found between body length and concentration with Zn ($r = 0.713$), Cu ($r = 0.256$) and Pb ($r = 0.079$), where concentration of metals increased with increasing body length of fish.

The accumulation behavior of Zn, Cu and Pb in the stomach, gill and muscle with fish size was examined in term of correlation coefficient, r. In stomach, good correlation coefficient for Zn ($r = 0.810$) while Cu ($r = 0.127$) and Pb ($r = 0.003$) showed poor correlation with fish length, respectively. In gill, Zn ($r = 0.349$) and Pb ($r = 0.180$) concentration increased with increasing fish size while Cu ($r = -0.289$) level decreased. In, muscle, no clear relationship between the Zn and Pb content and fish size was observed except for Cu ($r = 0.613$). Zn and Pb seemed to accumulate up to a certain level and then remains constant in tissue due to several mechanisms (Marcovecchio *et al*., 1991).

CONCLUSION

This study fills a gap by providing information on heavy metal concentrations in different fish species from Pahang coastal water. Based on the sample collected, metal concentrations found in edible muscle are below the proposed limit values set by Malaysian Food Regulation for human consumption. The relatively high content of metals founds in stomach and gill tissues may be due to the metal concentrations in this ecosystem and time of exposure, which is a function of fish age. However, fish stomach and gill are very seldom consumed in this area. Metallothionein induction in fish stomach, coupled with metal determination in this organ, may represent good biomonitors of metals present in the surrounding environment.

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