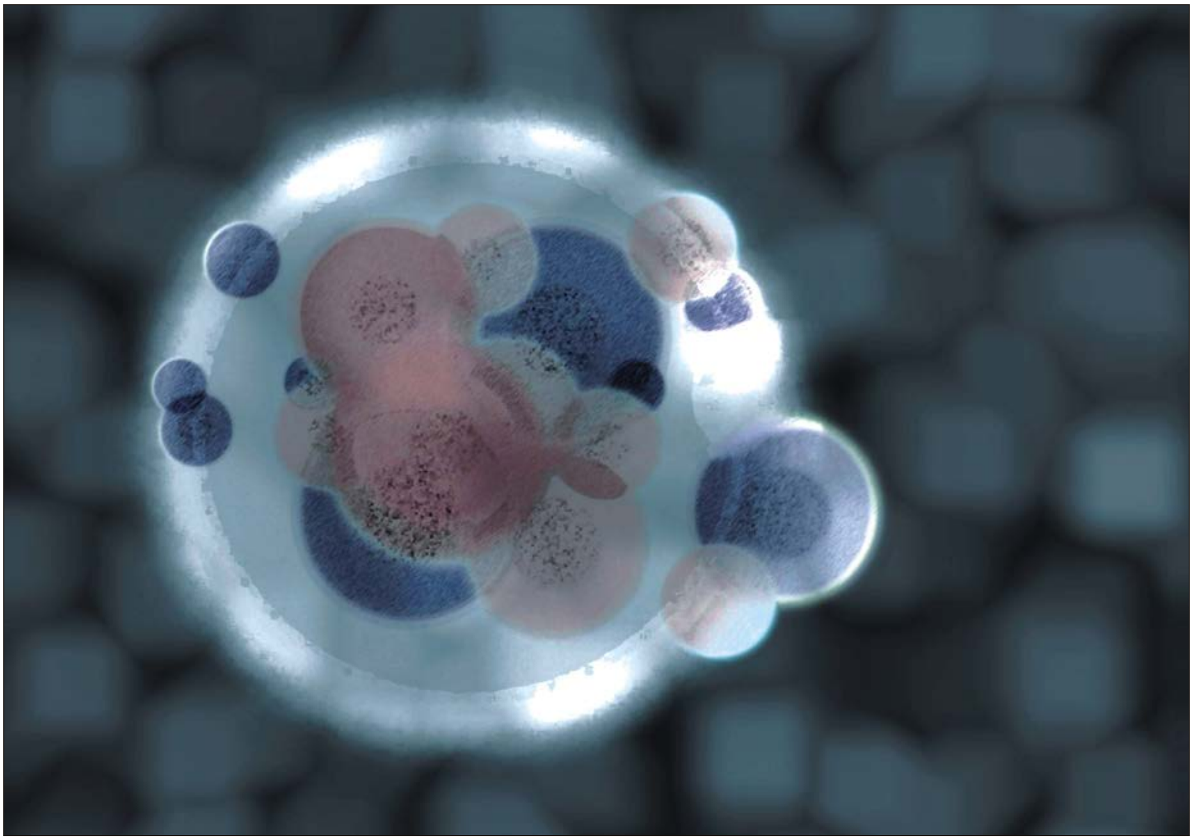

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Levels of Copper, Zinc and Lead in Fishes of Mengabang Telipot River, Terengganu, Malaysia

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Abstract: Heavy metal (Cu, Zn and Pb) concentrations in the muscle, gill and stomach of fish species from Mengabang Telipot River, Terengganu were measured with a fast and sensitive Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The relationships between fish size (length and weight) and metal concentrations in the tissues were also investigated. The average concentration of Cu, Zn and Pb was 13.39, 19.88 and 0.30 mg kg^{-1} dry wt., respectively. A marked relationship between metal contents of the studied species was observed. Generally, the mean concentrations of all the elements were relatively high in stomach, followed by gills and lowest in muscle. The positive relationship of these elements with fish length and weight were observed, suggesting the accumulation of these elements were occurred in the fish. Overall, metal levels found were lower than the international standards of reference and the examined fish were not associated with enhanced metal content in their tissues and were safe within the limits for human consumption.

Key words: Muscle, stomach, gill, mengabang telipot river, ICP-MS

INTRODUCTION

Fishes are the important part of the human diet and it is not surprising that numerous studies have been carried out on metal accumulation in different fish species (Turkmen *et al*., 2005; Lewis *et al*., 2002; Kucuksezgin *et al*., 2001). 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 sediment, plant and water (Rayment and Barry, 2000).

The heavy metal pollution of the marine environment has long been recognized as a serious environmental concern (Begum *et al*., 2005). Fish accumulate heavy metals from various sources in the aquatic environment. The possible sources of heavy metals include sediment (Goodwin *et al*., 2003), soil erosion and runoff (Carrasco *et al*., 2003), air deposition of dust and aerosol, discharge of wastewater (Saifullah *et al*., 2002). Under certain environmental conditions, heavy metals might accumulate up to a toxic concentration and cause ecological damage (Defew *et al*., 2005). The accumulation of heavy metals in aquatic organism can pose a long-term burden on biogeochemical cycling in the ecosphere. Once metals enter the food chain, they may accumulate to dangerous levels and be harmful to human health (Manahan, 2000).

Heavy metals in aquatic environment can remain in solution or in suspension and precipitate on the bottom or be taken up by organism. The analysis of metal concentration in biota samples at the same location can indicate the transfer of metals through food chains (Topcuoglu *et al*., 2002; Al-Yousuf *et al*., 2000). The accumulation patterns of contaminants in fish and other aquatic organisms depend on their uptake and elimination rates (Yap *et al*., 2004). Heavy metals are taken up through different organs of the fish and many are concentrated at different levels in different organs of the fish body (Papagiannis *et al*., 2004; Usero *et al*., 2003). Studies from the field and laboratory experiments showed that accumulation of heavy metals in a tissue is mainly dependent upon water concentrations of metals and exposure period; although some other environmental factors such as salinity, pH, hardness and temperature play significant roles in metal accumulation. Ecological needs, sex, size and molt of marine animals were also found to affect metal accumulation in their tissues (Canli and Furness, 1993; Canli and Atli, 2003).

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Fishes are often at the top of the aquatic food chain and may concentrate large amounts of some metals from the water (Mansour and Sidky, 2002). Furthermore, fish is one of the most indicative factors in freshwater systems, for the estimation of trace metals pollution and risk potential of human consumption (Barak and Mason, 1990; Papagiannis *et al*., 2004). Hence, it is important to determine the concentrations of heavy metals in commercial fishes in order to evaluate the possible risk of fish consumption (Cid *et al*., 2001). In the present study, heavy metal (Cu, Zn and Pb) concentrations in the muscle, gill and stomach of fish species were measured with a fast and sensitive Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The relationships between fish size (length and weight) and metal concentrations in the tissues were also investigated

MATERIALS AND METHODS

Description of the study area: The study area is located about 20 km to southern of Kuala Terengganu, the capital state of Terengganu. The study area lies in the wet tropics where high rainfall is recorded in the monsoon season which high rainfall is recorded in the month of November and ends in January. The fish species were sampled in 30th September 2006 by a beam trawl at 5 locations in the Mengabang Telipot river (Fig. 1). The fish were sampled at each station over 24 h until a sufficient number of individuals, at least 5-10 fishes, were caught. The samples were transported to the laboratory and stored at 4°C prior to analysis.

Analytical procedure: Fish samples were thawed at room temperature and their length and weight were recorded using the callipers and 2 decimal points of measuring weight, respectively. They were dissected using stainless steel scalpels and Teflon forceps using a laminar flow bench. A part of the fish (stomach, gills and muscle) were removed and transferred in polypropylene vials. Before acid digestion, a porcelain mortar was employed to grind and to homogenise the dry tissue samples. Briefly, the digestion method involved the heating of 1.0 g of tissues sample in a teflon beaker with mixed concentrated acids of HNO_3 and H_2SO_4 in the ratio of 1:1. The teflon beakers were kept at 100°C for 2-3 h. After cooling, a H_2O_2 solution was added in order to break down any recalcitrant lipid material in the tissue and a clear solution with no residue should be obtained at this stage. Deionized water was added and allowed to evaporate a few times to dryness and finally the digested tissues were transferred into a 50 mL polypropylene test tube. An inductively coupled plasma mass spectrometer (ICP-MS) was used, for the quick and precise determination of Cu, Zn and Pb in the tissue samples. The precision assessed

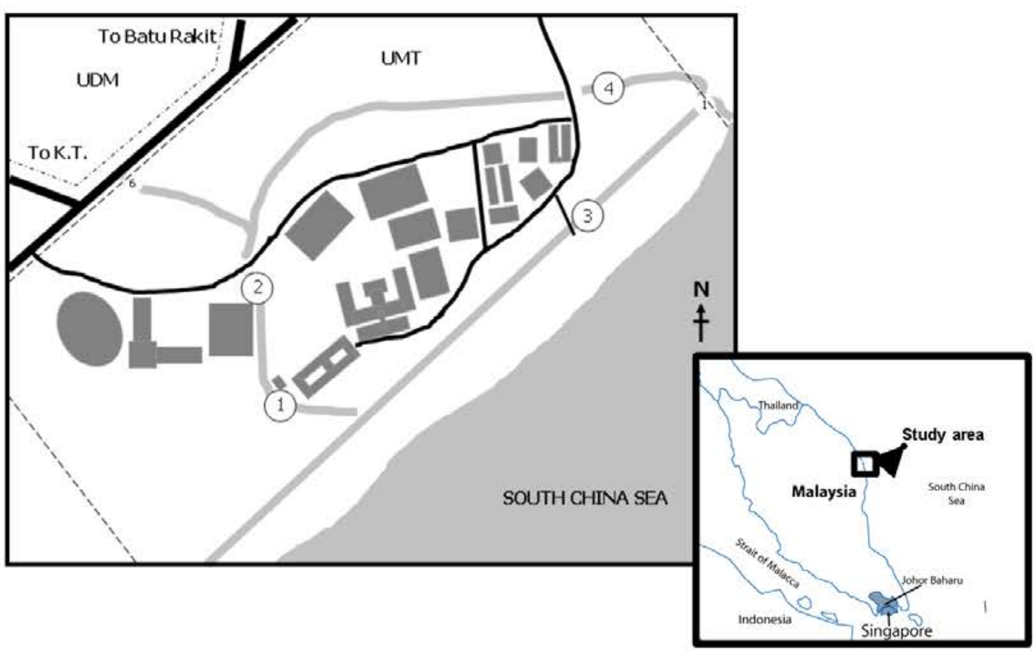

Fig. 1: The study area and sampling locations (1, 2, 3 and 4) at Mengabang Telipot River, Terengganu

by replicate analyses was within 3%. The accuracy was also examined by analyzing a blank and a material standard from the National Research Council of Canada standard (NBS DORM 2) and the results coincided with the certified values within a difference of ±3%.

Statistical analysis: Statistics were performed using a two factor analysis of variance. This method was based on the procedure of general linear models, where samples were examined for potential influence on Cu, Zn and Pb. Differences between level means per factor were treated using Tukey's multiple comparisons of means. When ANOVA assumptions such as sample normality and homoscedasticity were not respected, multiple ($n>2$), sample comparisons were performed by nonparametric Kruskal-Wallis tests. An ANOVA paired tests were then used for two-sample comparisons. A $p \leq 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

A total of 25 fishes were analyzed with a weight and mean size varying from 35.95 to 955.01 g and 118 to 300 mm, respectively. The biological information of the specimens and sampling locations are shown in Table 1. As reported by Henry *et al.* (2004), the size of fish could have an influence on contaminant concentrations in different tissues and are independent to the exposure. Concentrations of Cu, Zn and Pb detected in the muscle, gills and stomach samples (expressed as mg kg^{-1} dry wt.) are shown in Fig. 2. From the statistical test, all the metals concentration between fish species and fish tissues were significantly different ($p<0.01$). In this study, significant positive correlations were found between fish weight and concentration of Cu ($p<0.001$), Zn ($p<0.001$) and Pb ($p<0.001$). A bigger fish like *Himantura warnak* and *Channa strictus* and *Liza subrividis* had higher concentrations of heavy metals, compared to smaller fishes such as *Gerres abbreviatus* and *Carangoides fulvoguttatus* (Fig. 3).

Table 1: Sample information on fish sample caught from study area

Scientific name	n	Total length (mm)	Total weight (g)
Chanos chanos	6	240-299	122.64-234.45
Carangoides fulvoguttatus	4	149-190	41.71-108.92
Chelawodon patoca	3	118-133	75.99-103.67
Gerres abbreviatus	3	119-132	35.95-40.59
Megalops cyprinoides	2	249-286	142.09-142.09
Anodontosoma chacunda	1	195	68.88
Lutjanus argentimaculatus	1	204	148.24
Channa strictus	1	298	397.49
Lates calcarifer	1	194	93.63
Himantura warnak	1	300	955.01
Oreochromis niloticus	1	193	145.71
Liza subrividis	1	173	323.76

In this study, it is interesting to note that the mean concentrations of Cu, Pb and Zn behave in a similar way in the examined tissues. As in other studies, we observed higher levels of metal in stomach followed by gills and muscle (Kamaruzzaman *et al*., 2007; Joanna *et al*., 2007). In this study, average Cu concentration in stomach was 12.00 mg kg^{-1} dry wt.: followed by 6.32 mg kg^{-1} dry wt.: in gills and 4.24 mg kg^{-1} dry wt. in muscle. Meanwhile, average Zn concentration in stomach, gills and muscle was 12.74, 9.91 and 5.05 mg kg^{-1} dry wt., respectively. Similar with other metals, the average concentration of Pb in stomach, gills and muscle was 0.24, 0.23 and 0.06 mg kg^{-1} dry wt., respectively. As in other studies,

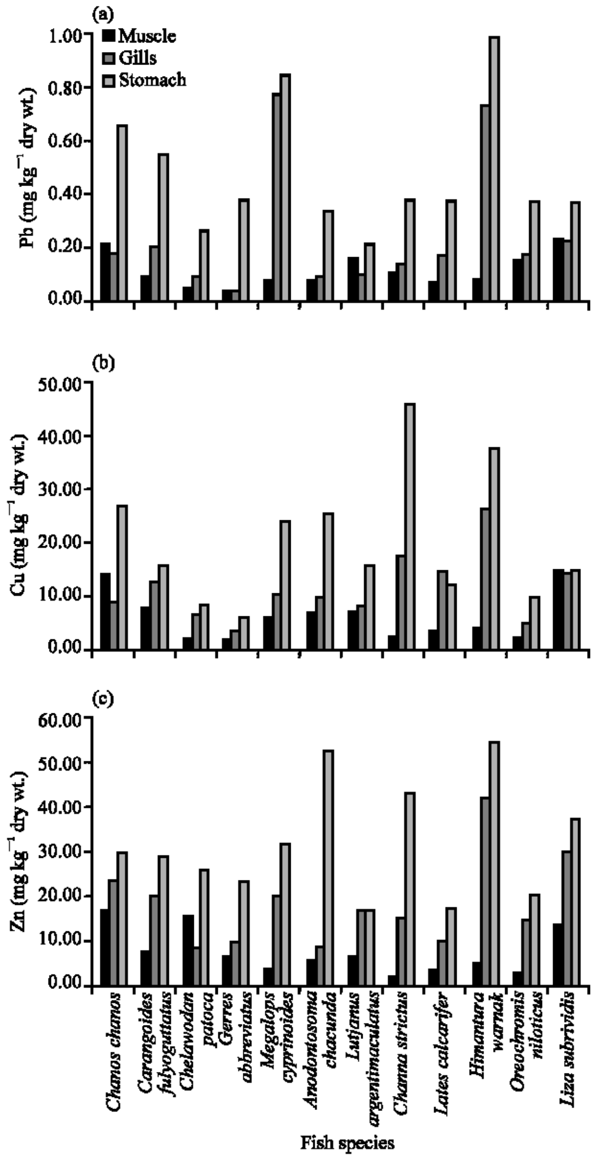

Fig. 2: Mean Cu, Zn and Pb concentrations (mg kg^{-1} dry wt.) in different tissues of sampled fish

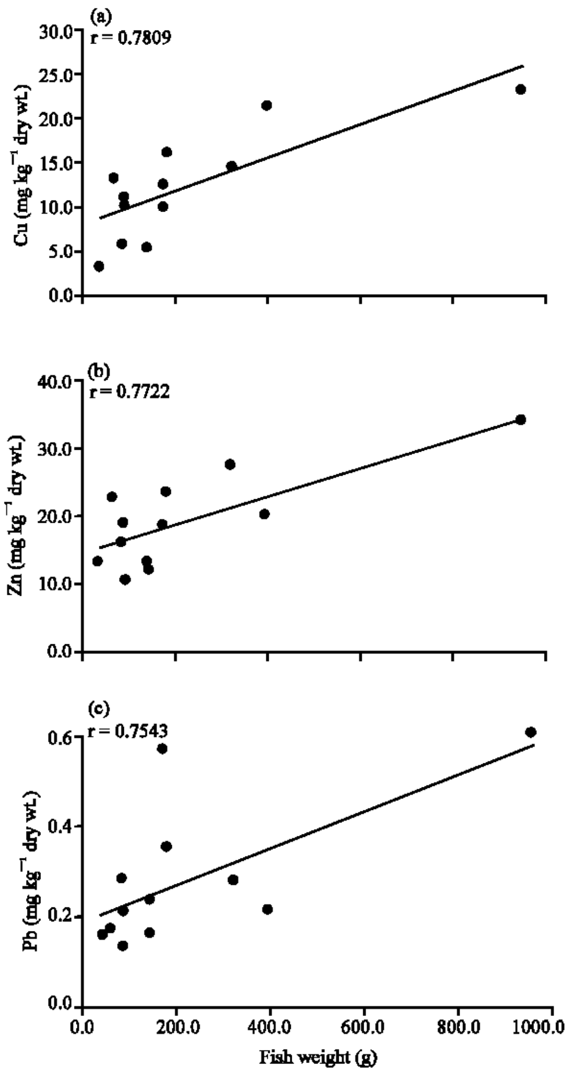

Fig. 3: Relationship of Cu, Zn and Pb concentrations in fish species versus weight

we also observed higher levels of metals in liver than in the muscle or gill tissues. Bioaccumulation in stomach was observed for most metals, since the stomach is a major organ cinvolved in xenobiotic metabolism in fish (Rashed, 2001).

One possible explanation for the higher metal concentrations in fish is due to their dietary habits. Cu and Zn are essential elements and are carefully regulated by physiological mechanisms in most organisms. However, they are regarded as potential hazards that can endanger both animal and human health. Knowledge of their concentrations in fish is therefore important both with respect to nature management and human consumption of fish (Amundsen *et al*., 1994). Even though, there are no clear evidence about Cu dietary transfer; many studies have demonstrated that diet is the most important route of Cu accumulation in aquatic animals (Sindayigaya *et al*., 1994). Pb, like the other metals discussed above, is a natural component of marine ecosystems. It is present at low concentrations in clean seawater, sediments and in the tissues of marine plants and animals. Although fish bioaccumulate Pb from seawater in proportion to its concentration in solution, Pb is not very bioavailable or toxic to marine animals (Dalman *et al*., 2006).

Thus, the liver and gill in fish are more often recommended as environmental indicator organs of water pollution than any other fish organs. This is possibly attributed to the tendency of liver and also the gill to accumulate pollutants at different levels from their environment as reported by Canli and Atli(2003). Studies carried out with different fish species have shown that heavy metals accumulate mainly in metabolic organs such as liver that stores metals to detoxicate by producing metallothioneins (Meltem *et al*., 2007; Al-Yousuf *et al*., 2000). However, muscle is commonly analyzed because it is the main fish part consumed by humans and implicated in human health risk. Food and Agricultural Organization limits for Pb was 0.5 mg kg^{-1}, while for Cu and Zn was 30 mg kg^{-1} (Food and Agriculture Organization) (FAO, 1983). The concentrations of these metals measured in the muscles of the fish sample studied were generally lower than the levels issued by FAO.

CONCLUSION

Health-conscious people have repeatedly been told that fish is good for the heart. However, there is growing concern that some seafood lovers are consuming high doses of heavy metals along with their fish dishes and could be suffering from health problems as a result. Results generally showed that metal concentrations were lowest in the muscle and highest in the gills and stomach. This is probably due to their physiological roles in fish metabolism. According to our results, the examined fish were not associated with enhanced metal content in their muscle and were safe within the limits for human consumption. Although, levels of heavy metals are not high, a potential danger may emerge in the future depending on the anthropogenic source from the agriculture and nearby housing area along the river in this region.

REFERENCES

Al-Yousuf, M.H., El-Shahawi and S.M. Al-Ghais, 2000. Trace metals in liver, skin and muscle of *Lethrinus lentjan* fish species in relation to body length and sex. Sci. Total Environ., 256: 87-94.

Amundsen, P.A., F.J. Staldvik, A. Lukin, N. Kashulin and O. Popova *et al*., 1994. Heavy metals contamination in freshwater fish from the border region between Norway and Russia. Sci. Total Environ., 201: 211-224.

Barak, N.A.E. and C.F. Mason, 1990. Mercury, cadmium and lead concentrations in five species of freshwater fish from eastern England. Sci. Total Environ., 92: 257-263.

Begum, A., M.N. Amin, K. Satoshi and O. Kiyohisa, 2005. Selected elemental composition of the muscle tissue of three species of fish, *Tilapia nilotica*, *Cirrhina mrigala* and *Clarius batrachus*, from the fresh water dhanmondi lake in Bangladesh. Food Chem., 93: 439-443.

Canli, M. and R.W. Furness, 1993. Toxicity of heavy metals dissolved in sea water and influences of sex and size on metal accumulation and tissue distribution in the Norway lobster nephrops norvegicus. Mar. Environ. Res., 36: 217-236.

Canli, M. and G. Atli, 2003. The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb, Zn) levels and the size of six Mediterranean fish species. Environ. Poll., 121: 129-136.

Carrasco, M., J.A.L. Ramirez, J. Benavente, F.L. Aguayo and D. Sales, 2003. Assessment of urban and industrial contamination levels in the bay of cádiz, SW Spain. Mar. Poll. Bull., 46: 335-345.

Cid, B.P., C. Boia, L. Pombo and E. Rebelo, 2001. Determination of trace metals in fish species of the ria de aveiro (portugal) by electrothermal atomic absorption spectrometry. Food Chem., 75: 93-100.

Dalman, O., D. Ahmet and B. Ahmet, 2006. Determination of heavy metals (Cd, Pb) and trace elements (Cu, Zn) in sediments and fish of the southeastern aegean sea (Turkey) by atomic absorption spectrometry. Food Chem., 95: 157-162.

Defew, L.H., J.M. Mair and H.M. Guzman, 2005. An assessment of metal contamination in mangrove sediments and leaves from punta mala bay, pacific panama. Mar. Poll. Bull., 50: 547-552.

FAO., (Food and Agriculture Organization), 1983. Compilation of legal limits for hazardous substances in fish and fishery products. FAO Fishery Circular No. 464, pp: 5-100.

Goodwin, T.H., A.R. Young, M.G.R. Holmes, G.H. Old and N. Hewitt *et al*., 2003. The temporal and spatial variability of sediment transport and yields within the bradford beck catchment, west yorkshire. Sci. Total Environ., 314–316: 475-494.

Henry, F., R. Amara, L. Courcot, D. Lacouture and M.L. Bertho, 2004. Heavy metals in four fish species from the french coast of the eastern English channel and southern bight of the north sea. Environ. Inter., 30: 675-683.

Joanna, B., M. Gochfeld, C. Jeitner, S. Burke and T. Stamm, 2007. Metal levels in flathead sole *(Hippoglossoides elassodon)* and great sculpin *(Myoxocephalus polyacanthocephalus)* from adak island, alaska: Potential risk to predators and fishermen. Environ. Res., 103: 62-69.

Kamaruzzaman, B.Y., K. Zaleha, M.C. Ong and K.Y.S. Willison, 2007. Copper and zinc in three dominant brackish water fish species from paka estuary, terengganu, Malaysia. Malaysia. J. Sci., 26: 65-70.

Kucuksezgin, F., O. Altay, E. Uluturhan and A. Kontas, 2001. Trace metals and organochlorine residue levels in red mullet *(Mullus barbatus)* from the eastern aegean, Turkey. Water Res., 35: 2327-2332.

Lewis, M.A., G.I. Scott, D.W. Bearden, R.L. Quarles and J. Moore *et al*., 2002. Fish tissue quality in near-coastal areas of the gulf of Mexico receiving point source discharges. Sci. Total Environ., 284: 249-261.

Manahan, S.E., 2000. Environment Chemistry. 7th Edn., Lewis Publ., Boca Raton.

Mansour, S.A. and M.M. Sidky, 2002. Ecotoxicological studies: 3 heavy metals contaminating water and fish from fayoum Gov. Egypt. Food Chem., 78: 15-22.

Meltem, D.M., Z.L. Goksu and A.A. Ozak, 2007. Investigation of heavy metal levels in economically important fish species captured from the tuzla lagoon. Food Chem., 102: 415-421.

Papagiannis, I., I. Kagalou, J. Leonardos, D. Petridis and V. Kalfakakou, 2004. Copper and zinc in four freshwater fish species from lake pamvotis (greece). Environ. Int., 30: 357-362.

Rashed, M.N., 2001. Monitoring of environmental heavy metals in fish from nasser lake. Environ. Int., 27: 27-33.

Rayment, G.E. and G.A. Barry, 2000. Indicator tissue for heavy metal monitoring – addition attributes. Mar. Poll. Bull., 41: 353-358.

Saifullah, S.M., S.H. Khan and I. Sarwat, 2002. Distribution of nickel in a polluted mangrove habitat of the indus delta. Mar. Poll. Bull., 44: 551-576.

Sindayigaya, E., R.V. Cauwenbergh, H. Robberecht and H. Deelstra, 1994. Copper, zinc, manganese, iron, lead, cadmium, mercury and arsenic in fish from lake tanganyika, burundi. Sci. Total Environ., 144: 103-115.

Topcuoglu, S., C. Kurbasoglu and N. Gungor, 2002. Heavy metals in organisms and sediment from Turkish coast of the black sea. Environ. Int., 1069: 1-8.

Turkmen, A., M. Turkmen, Y. Tepe and I. Akyurt, 2005. Heavy metals in three commercially valuable fish species from iskenderun bay, northern east Mediterranean sea, Turkey. Food Chem., 91: 167-172.

Usero, J., C. Izquierdo, J. Morillo and I. Gracia, 2003. Heavy metals in fish (*Solea vulgaris*, *Anguilla anguilla* and *Liza aurata*) from salt marshes on the Southern Atlantic coast of Spain. Environ. Inter., 29: 949-956.

Yap, C.K., A. Ismail and S.G. Tan, 2004. Heavy metal (Cd, Cu, Pb and Zn) concentrations in the green-lipped mussel *Perna veridis* (linnaeus) collected from some wild and aquacultural sites in the west coast of peninsular Malaysia. Food Chem., 84: 569-575.