Bull Environ Contam Toxicol (2011) 87:163–165
DOI 10.1007/s00128-011-0314-z

Distribution of Heavy Metal Residues in Fish from the River Nile Tributaries in Egypt

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Received: 24 January 2011 / Accepted: 13 May 2011 / Published online: 25 May 2011

Abstract The distribution patterns of some metals (zinc, iron, copper, cadmium and lead) in fish samples collected from El Menofiya Governorate, Egypt were studied. The samples were collected from El Menofiya, canal water supplies (El Sarsawia, El Bagoria and Bahr Shebin), in addition to El Embaby, El Menofi and Miet Rabiha drainage canals each 2 month during periods of 16 month, June 2007–Septemper 2008. In the present investigation, the high concentrations of metals were found in fish samples collected from the drainage canal. The highest mean concentration of lead (1.864 µg/g), copper (1.495 µg/g) and cadmium (1.840 µg/g) were found in fish samples collected from El-Embaby drain. While the highest mean concentration of iron (108.26 µg/g) and zinc (24.35 µg/g) were present in fish samples collected from Miet-Rabiha drain. Lead and cadmium were found in higher concentration than those recommended by FAO for fish.

Keywords Heavy metal · Fish

Environmental contamination of natural waters by heavy metal residues is of great concern. Inorganic compounds from natural and anthropogenic sources continuously enter the aquatic ecosystem where they pose a serious threat because of their toxicity, long time persistence, bioaccumulation, and biomagnifications in the food chain (Papagiannis et al. 2004). Increased industrialization and agricultural activities contribute to their elevated levels in natural waters (Wahlberg et al. 2001). Inorganic compounds such as trace metal are shown to have a multitude of toxic effects such as acute syndrome and neurotoxic effects (that ultimately cause disease in brain, kidney, skin cancer, etc.). The most frequently found heavy metal contaminants include lead (Pb), chromium (Cr), cadmium (Cd), iron (Fe) and copper (Cu). Trace concentrations of some metals (Cd, Cr, Cu, Ni, Pb, Fe and Zn) are commonly found in many organic wastes, particularly from industrial and municipal sources. Many of these heavy metals are toxic even at trace concentrations. Metal contamination raises environmental concerns, such as influences on the food chain, which can be potentially harmful to humans. Cadmium and Pb are two of the more toxic food chain contaminants. Cadmium damages the lungs and causes the painful Itai-Itai disease. Lead affects the blood, numerous organs, and the nervous system. In spite of heightened concern and pollution programs, very little is currently known about the distribution, behavior, and effects of trace metals in the Nile River. Sources for metals at the Nile River might include airborne particles, dissolved compounds, or those sorbed onto mineral material being transported in the water. Heavy metals are a part from aerosols in the atmosphere and direct effluent discharges into waters. Although heavy metals differ widely in their chemical properties they are used widely in electronics machines and the artifacts of everyday life. Agriculture constitutes one of the very important non-point sources of metals pollutants. The main sources are impurities in fertilizers, pesticides and sewage sludge. River Nile pass through agricultural and industrial fields, since most activities in Egypt are around Nile, thus it is subjected to contamination with different pollutants. Drainage water is pumped into several major drains that finally discharged their waters into the river Nile or lakes. Particularly, this study was designed to evaluate the

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levels of highly toxic heavy metals (Fe, Pb, Cd, Cu and Zn) in aquatic environment (fish) at El Menofiya governorate, Egypt.

Materials and Methods

Nitric acid (HNO_3) (density at 20°C: 1.4 g/mL) (95% purity) was obtained from SDS, Peypin, France. Perchloric acid ($HClO_4$) were obtained from El Naser pharmaceutical chemical Co. Stock Standard solution of zinc (Zn), iron (Fe), Copper (Cu), cadmium (Cd) and lead (Pb) were obtained from Merck in concentration of 1,000 mg/L (Merck, Darmstadt, Germany. Before use all, the glassware had been soaked in detergent, rinsed with water, soaked in 15% nitric acid, rinsed with distill water and kept in the oven at 110°C till need. Fish samples were collected every 2 month, during the period from June 2007 to September 2008 from six sites. The sampled site for the study was selected in El-Menofiya governorate. Samples were taken from El-Sarsawia, El-Bagoria, Bahr Shebin canals, in addition to three drainage canal sites El-Embaby, El-Menofi and Miet-Rabiha drain. Healthy and vigorous fish (*Tilapia nilotica*) were caught by fishermen about 2–2.5 kg from the different sites at the same times as water and sediment sampling. They were transport without sexing to the laboratory. The soft parts of fish samples be removed and a muscle tissue sample (1 g) was taken from the dorsal muscle in aluminum foil and kept in deep freezer until analysis. One gram of tissue samples was transferred to a clean screw capped glass bottle and digested with 10 ml of digestion solution HNO_3–$HClO_4$ (4:1 v/v) (FAO 1983). Initial digestion was conducted for 4 h at room temperature, followed by heating at 40–45°C for 1 h in water bath, then raised to 75°C until the end of digestion. After cooling at room temperature, the digest was dilute to 25 mL with deionized water and filtered through 0.45 μm Whatman filter paper in 25 mL volumetric flask for end determination. The same volume of acid, aqua regia and digestion solution, which used in the digestion of water, sediment and fish samples were subjected to the same digestion, dilution and filtration procedures as previously described in the preparation of water, sediment and fish samples to detect any possible traces of the studies metals in the acids or distilled water. Quantitative determination of lead, cadmium, zinc, copper and iron was conducted by using atomic absorption spectrometer. Thermo atomic absorption spectrometer with hallow cathode lamp and a deuterium background corrector, at respective resonance line using an air-acetylene flame. Recoveries were carried out by the addition of the standards of each element at different levels. All data were corrected according to the recovery percentage values. Blanks were included in each batch of analysis. Calibration standards were regularly performed to evaluate the accuracy of the analytical method. Working calibration standards of zinc (Zn), iron (Fe), copper (Cu), cadmium (Cd) and lead (Pb) were prepared by serial dilution of concentrated stock solution (Merck, Germany) of 1,000 mg/L (Table 1). These and blank solutions were also analyzed in the same way as for the digested samples.

Table 1 Recovery percentage, relative standard deviation and method detection limits of heavy metals

Name	Recovery	RSD (%)	LOD (ng g^{-1})
Iron (Fe)	88	8	45
Lead (Pb)	86	6	12
Cadmium (Cd)	85	4	9
Copper (Cu)	89	9	36
Zinc (Zn)	84	5	8

Results and Discussion

In Egypt and other developing countries, where environmental protection laws have not been enforced, industrial and domestic wastes are dumped indiscriminately into water bodies. These wastes have been reported to contain toxic and hazardous substances including heavy metals. The contamination of water resources, sediment, soil and fish by heavy metals is of important concern because of their toxicity, persistence and bioaccumulative nature (Ikem et al. 2003). Trace metals could be introduced to aquatic environment as a result of urbanization, industrial and agricultural activities (Heba et al. 2000). Metals in minerals and rocks are generally harmless and only become potentially toxic when they dissolve in water. They enter the environment naturally by weathering of rocks, leaching of soils, vegetation, and volcanic activity (Al-Saad et al. 1997). Human activities also introduce metals to the environment by mining, smelting, combustion of fossil fuel, and industrial wastes disposal. Most of metal loads are transported by water in a dissolved or particulate phase and most of it reaches water via land runoff. In addition, rainwater carries significant Cd, Cu, Zn and especially Pb from the atmosphere to the water (Al-Taee 1999).

Concentrations of five elements in fish samples from the studying area are shown in Table 2. All the metal concentrations were determined on a wet weight basis. Iron concentration was highest in fish samples analyzed in this study. Mean metal content in the fish samples in all location sites followed the profile: iron > zinc > lead > copper > cadmium. The highest mean concentration of lead (1.864 μg/g), copper (1.495 μg/g) and cadmium (1.840 μg/g) were found

Table 2 Concentration ranges (μg/g fresh weight) of heavy metal in fish samples (n = 8 for each sampling site)

Metal	El-Sarsawia canal	El-Bagoria canal	Bahr Shebin canal	El-Embaby drain	El-Menofi drain	Miet Rabiha drain
Lead (Pb)						
Min.	1.454	1.476	1.354	1.390	1.071	1.147
Max.	1.899	2.027	1.778	2.669	1.438	1.566
Mean	1.532	1.507	1.510	1.864	1.283	1.356
Iron (Fe)						
Min.	43.01	34.97	39.67	58.37	44.98	40.80
Max.	51.99	65.49	74.86	83.91	91.61	165.3
Mean	47.67	55.40	58.30	74.89	60.66	108.2
Copper (Cu)						
Min.	0.810	0.540	0.964	1.034	0.804	0.511
Max.	1.190	1.957	1.783	1.964	1.087	0.812
Mean	0.980	1.211	1.278	1.495	0.934	0.735
Cadmium (Cd)						
Min.	0.011	0.032	0.396	0.921	0.614	0.272
Max.	0.039	0.065	1.558	2.690	0.988	1.153
Mean	0.028	0.043	1.107	1.840	0.772	0.752
Zinc (Zn)						
Min.	4.651	5.837	3.350	15.33	10.96	16.87
Max.	5.705	7.323	9.601	21.87	15.84	41.87
Mean	5.195	6.130	5.487	17.56	12.88	24.35

n = number of samples

in fish samples collected from El-Embaby drain. While the highest mean concentration of iron (108.26 μg/g) and zinc (24.35 μg/g) were present in fish samples collected from Miet-Rabiha drain. Also, the highest concentrations of the metals were found in fish samples that collected from the drainage canal. The release of trace metals from sediments into the water body and consequently to fish will depend on the speciation of metals and other factors such as, sediments, the physical and chemical characteristics of aquatic system (Morgan and Stumm 1991).

Accumulation of trace elements in aquatic organisms is one of the most striking effects of pollution in aquatic systems. Since sediments act as sinks for contaminants, which can persist in the aquatic environment for decades, changes in sediment in fauna activity and water chemistry allow these persistent contaminants to enter food chain, and thus into fish tissues (Kirby et al. 2001).

The maximum permissible level recommended by FAO are 0.5 ppm for lead, 30 ppm for copper, 30 ppm for zinc and 0.5 ppm for cadmium in fish (FAO 1983). The concentration of heavy metal for each sample of each site was compared with the MRL. Lead and cadmium were found in higher concentration than those recommended for fish; other heavy metals were almost found at the concentration to those recommended by FAO.

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