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Full Length Research Paper

Trace metals in some benthic fishes of the Ikpoba river dam, Benin City, Nigeria

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The concentration of iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), nickel (Ni), cadmuim (Cd), chromium (Cr) and lead (Pb) in two benthic fish species (*Mormyrops deliciosus* and *Mormyrus macrophthalmus* netted from two locations (Okhoro and Low lift pump sites) on the Ikpoba River Dam, Benin City, Nigeria were determined using atomic absorption spectrometric technique. Sediment and water samples were also analysed for their trace metal concentrations. The range of trace metal concentrations (µg/g) in the fishes which is the focus of the study were as follows: Fe = 39.60 - 41.07 µg/g, Cu = 5.04 - 8.04 µg/g, Mn = 0.38 - 1.34 µg/g, Zn = 17.01 - 23.16µg/g, Ni = 0.24 - 0.48 µg/g, Cd = 0.79 - 0.98 µg/g, Cr = 0.38-0.91 µg/g, and Pb = 2.67-3.53 µg/g. Results show that relatively, higher metal levels were recorded in *M. deliciosus* than *M. macrophthalmus*. No significant differences (P > 0.05) were recorded between the concentrations of Fe, Mn, Zn and Pb in the two fish species. Significant differences (P < 0.05) were however, recorded between the concentrations of Cu, Ni, Cd and Cr in the fishes. The levels of Pb in the fish species exceeded the limit recommended in fish and fishery products by the Food and Agricultural Organization (FAO) of the United Nations. Also, the levels of Fe and Cd in the water exceeded the levels recommended for portable drinking water by the World Health Organization (WHO).

Key words: Trace metals, benthic fishes, Ikpoba dam, Benin City, Nigeria.

INTRODUCTION

In recent years, attention has been drawn to the concentration of trace metals in freshwater and aquatic organisms including fish (Mombeshora et al., 1981). Heavy metals are discharged into inland water bodies mainly through anthropogenic sources (Okoye et al., 1991; Burger et al., 2002). They accumulate in soils, plants and sediments from where they are released into inland water bodies. Trace metals occur in dissolved, particulate and total metal forms and also form complexes in water and become precipitated when they react with oxygen (Forstner, 1985). They also form different compounds and are sorped by organic material fractions of bottom sediments. Sediments act as carriers and possible sources of trace metal pollution because the metals locked up in them are released into the water column due to changes in pH, redox potential or by the presence of organic chelators (Forstner, 1985).

The released metals could then be absorbed by fish either as free metal ions across the gill entire surface or may be sorped onto food and particulates and subsequently ingested by fish (Connell and Miller, 1984).

Uptake and absorption is influenced by chemical speciation of metal forms, ubiquitous nature, food habits and physiological differences that exist among fishes (Connell and Miller, 1984; Odiete, 1999). The mormyrids have become very ubiquitous in rivers of Edo State in Nigeria. According to Reed et al. (1967) and Idodo-Umeh (2003), they feed on a wide variety of food items including detritus and sand in bottom deposits of sediments which was described as “banks” for heavy metals by Wollast and Peters (1976). These groups of fishes are fished extensively by local fishermen and smoked for human consumption. They are well relished because of their protein content and good keeping qualities.

This study was undertaken to ascertain the trace metal profile in fish, sediments and water of the Ikpoba river

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dam in Benin City, Nigeria.

MATERIALS AND METHODS

Study area

The Ikpoba River, flows through Benin city, Edo State, Nigeria and lies within lat. 6.5°N and Long. 5.8°E. The river is dendritic in the upper reaches and its head waters originate from the Ishan Plateau. The river receives domestic, industrial and agricultural wastes through flood run-off water. The river was impounded in 1977 to form the Ikpoba dam. The dam is situated some 3.75 km South-East of the University of Benin. Its storage capacity is 1.5 million M^3. The water supply per day is 150,000 L with a minimum discharge of 9 m^3/s and a maximum discharge of 310 Cu m/s. The dam at full capacity is 3.25 km long and 600 m wide with a crest level of 36.8 m. The study area is surrounded by arable farm land and is about 2.5 km in length within the dam.

Sample collection and preparation

Samples of water, fish and sediments were collected from the Okhoro site and the Low lift pump station sites of the dam in January, March, July and September 2006. Water samples were collected at 30 cm depth in 1 L polythene bottles with screw caps from the two sampling stations. The samples were fixed with 5 ml of concentrated nitric acid and stored frozen at -5°C (Ademoroti, 1996, Oguzie and Izevbigie, 2009). Fish samples were caught using baited hooks, traps and set gill nets. They were washed in flowing water and stored frozen at -5°C in a deep freezer prior to analysis. Sediment samples were collected using an Eckman grab and placed in polythene containers. The containers were previously soaked overnight in 5% nitric acid and rinsed with distilled water (Wangboje and Oronsaye, 2001). Sediment samples were then frozen at -5°C prior to analysis.

Digestion and analysis

On the day of analysis, all frozen samples were allowed to thaw at room temperature (27 ± 2°C). The water samples were not given further treatment but were vigorously shaken and aspirated into the flames of a Varian Techtron Spectra B atomic absorption spectrophotometer for trace metal determination. The fish samples were blotted between filter paper and oven dried to constant weight at 105°C. Dried fish samples were ground to powder. One gram of each ground fish tissue was digested using a 1:5:1 mixture of 70% perchloric acid, concentrated nitric acid and concentrated sulphuric acid at 80 ± 5°C in a fume chamber until colourless liquids were obtained (Sreedevi et al., 1992). Sediment samples were oven dried to constant weight at 105°C, ground to powder and sieved through a 200 mm grid mesh to remove unground materials. One gram of each ground sample was digested using a 1:5:1 mixture of 70% perchloric acid, concentrated nitric acid and concentrated sulphuric acid as previously described by Adams et al. (1980). Finally, volumes of digests were made up to 20 ml with distilled water. Digested fish and sediment samples were analysed using a Varian Techtron Spectra B atomic absorption spectrophotometer, using standard techniques. The concentration of trace metals in the water was expressed in mg/l, while the concentration values in fish and sediments were expressed in µg/g. All digested samples were analysed twice. One-way analysis of variance (ANOVA) was used in all cases for mean metals comparison at 5% level of significance. Means were separated using the Duncan multiple range test.

RESULTS

The mean concentration of trace metals in the fish species from the Ikpoba River dam is shown in Table 1. The concentration of Fe was highest in *Mormyrops deliciosus* with a value of 40.66 µg/g. The concentration of Zn was highest in *Mormyrus macrophthalmus* (18.53 µg/g), while the concentration of Pb was highest in *M. deliciosus* with a value of 3.53 µg/g. No significant differences ($P > 0.05$) were recorded in the concentration of Fe, Mn, Zn and Pb between the two fish species sampled at the two stations within the dam. Significant differences ($P < 0.05$) were however recorded in respect of the concentrations of Cu, Ni, Cd and Cr between the two fish species (Table 1).

Table 2 shows the mean concentration of trace metals in water and sediments from Ikpoba river dam. The trace metal profile in descending order is Zn>Cu> Fe>Mn> Pb>Ni>Cd>Cr> for sediments, while the corres-ponding profile for the water is Fe>Ni>Mn>Pb>Zn>Cd>Cr>Cu. Table 3 shows distribu-tion co-efficient (DC) values for trace metals in Ikpoba river dam. These values express the solubility of trace metals in aquatic systems. The highest DC value was recorded for Fe with a value of 0.893, while the least DC value of 0.003 was recorded for Cu.

DISCUSSION

In the present study, the concentration of trace metals recorded in fish and water varied. The concentration of Fe in water from the Ikpoba river dam was higher than all the other elements investigated. This finding is in accord-ance with reports on the Lagos lagoon water by Okoye et al. (1991) and Ogba River (Obasohan, 1997; Oguzie and Igwegbe, 2007). The phenomenon was generally attri-buted to the high degree of solubility of the ferrous and ferric forms of Fe, as reflected in the distribution co-efficient values. In fish, the most prevalent element was Fe. This may be explained by the fact that Fe being the most abundant in the environment could conceivably be bioaccumulated more than the other trace metals. Furthe-rmore, Fe is the major respiratory pigment in the blood and is thus present in abundance in the circulatory system.

The mean range of Fe in the fishes was 36.60 - 40.66 µg/g and is lower than the range 51.32 - 107.54 µg/g of Fe in the fishes of Ogba River previously reported by Obasohan (1997). The range of Cu in the fishes was 5.04 - 9.34 µg/g. This range generally falls below the Food and Agricultural Organization (FAO) upper limits (30 mg/kg) for food and fish (Nauen, 1983). Lower values of Cu in fish were recorded in the Ikpoba reservoir water by Fufeyin (1994), though higher values were recorded in the Ogba river fish (Oguzie and Igwegbe, 2007). The range of Mn in fish was 1.08 - 1.12 µg/g. This range

Table 1. Mean concentrations (µg/g) of trace metals in three replicate fish samples taken from Ikpoba river dam between January to September 2006.

Fish species	Fe	Cu	Mn	Zn	Ni	Cd	Cr	Pb
Mormyrops deliciosus	40.66±10.05 [a]	5.04 ±1.26 [b]	1.12 ±1.02 [ab]	17.01 ±10.31 [a]	0.24 ±0.02 [a]	0.98 ±0.01 [a]	0.91±0.21 [a]	3.53 ±1.08 [a]
Mormyrus macrophthalmus	39.60 ±10.41 [a]	8.00 ±2.33 [a]	1.08±0.02 [b]	18.53 ±10.46 [a]	0.36 ±0.11 [b]	0.81 ±0.23 [b]	0.38 ±0.02 [b]	2.67 ±1.04 [ab]

Data are presented as means ± SD of three (3) determinations. Means in the same vertical row followed by the same superscript are not significantly different at the 5% probability level.

Table 2. Mean concentrations of trace metals in water (mg/l) and sediments (µg/g) taken from Ikpoba river dam from January to September, 2006.

Month	Sample type	Fe	Cu	Mn	Zn	Ni	Cd	Cr	Pb
January 2006	Water (mg/l)	3.06	0.02	0.05	0.94	0.10	0.05	0.02	0.06
	Sediment (µg/g)	3.81	8.34	2.11	10.98	0.81	0.48	0.43	1.92
March 2006	Water (mg/l)	3.15	0.01	0.10	0.07	0.09	0.02	0.01	0.05
	Sediment (µg/g)	3.02	7.98	3.48	10.18	0.68	0.36	0.56	1.73
July 2006	Water (mg/l)	3.16	0.03	0.07	0.51	0.05	0.04	0.06	0.06
	Sediment (µg/g)	3.85	8.00	1.46	13.13	0.98	0.67	0.33	2.62
September 2006	Water (mg/l)	2.97	0.04	0.09	0.45	0.11	0.03	0.03	0.07
	Sediment (µg/g)	3.12	7.52	2.52	14.52	0.76	0.59	0.33	2.00
Mean	Water (mg/l)	3.085	0.025	0.078	0.49	0.0875	0.035	0.030	0.060
	sediment (µg/g)	3.45	7.96	2.39	12.20	0.807	0.530	0.413	2.07

Table 3. Distribution co-efficient (DC) values for trace metals in Ikpoba river dam.

Trace metal	Mean level(mg/l) water (A)	Mean level (µg/g) Sediment (B)	DC value (A/B)
Fe	3.085	3.45	0.893
Cu	0.025	7.96	0.003
Mn	0.078	2.39	0.033
Zn	0.490	12.20	0.040
Ni	0.0875	0.807	0.108
Cd	0.035	0.53	0.066
Cr	0.030	0.41	0.073
Pb	0.060	2.07	0.029

showed lower values of Mn in fish recorded for the Ikpoba reservoir water (Fufeyin, 1994). Lower values of the metal were recorded for fish in the Warri river by Ezemonye (1992). The range of Ni in fish was 0.24 - 0.36 µg/g. This value was lower than the FAO standard. Ni values in fish were lower than those recorded for the Ogba River by Obasohan (1997). The mean range of Cr in fish was 0.38 - 0.91 µg/g. Lower values of Cr in fish were recorded for the Warri river (Ezemonye, 1992). The mean range of Pb in fish was 2.67 - 3.53 µg/g. This range is higher than the FAO standard (2 mg/kg). Lower values of Pb were recorded for fish in the Ogba River (Oguzie and Igwegbe, 2007). The mean concentration of Fe recorded in the water was 3.08 mg/l. A higher value was recorded for water from the Ogba River by Wangboje and Oronsaye (2001), while a lower value (0.38 mg/l) was recorded in water, upstream of Ikpoba river (Oguzie and Izevbigie, 2009).

The mean values of Cu, Mn, Zn, Cr and Pb in water from Ikpoba river dam were lower than the World Health Organization (WHO) maximum allowable limit (WHO, 1994). The exceptions were Fe and Cd. In previous studies, higher values of Fe in water were recorded for the Lagos lagoon water (Okoye et al., 1991) and Warri River (Kakulu and Osibanjo, 1991). Lower values of Cd in water were however, recorded for the Ikpoba river (Oguzie, 2003) and Ikpoba reservoir (Fufeyin, 1994; Oguzie and Izevbigie, 2009).

Sediments are sink of pollutants of both organic and inorganic origin and are thus potential source of toxicity to aquatic flora and fauna (Fernandes, 1997, Long et al., 1998). The mean concentration of Fe in the sediment was 3.45 µg/g. A lower value (0.51 mg/kg) for Fe was recorded for sediments of the Ikpoba reservoir by Oguzie and Izevbigie (2009). However, a higher value of Fe was reported for the sediments of the Lagos lagoon water by Okoye et al. (1991). Of all the elements investigated, Zn had the highest mean concentration (12.20 µg/g) in the sediments of the Ikpoba river dam. This value was lower than values for Zn from the sediments of the Lagos lagoon water (Okoye et al., 1991), Warri river (Ezemonye, 1992) and Ikpoba reservoir (Oguzie and Izevbigie, 2009). The lowest value recorded for any element in the sediments in the present study was for Cr (0.413 µg/g). This value is higher than Cr value (0.021 µg/g) reported for the Ikpoba reservoir sediment by Oguzie and Izevbigie (2009). The concentrations of Pb in the fish species were higher than the FAO maximum allowable limit (2.0 mg/kg) for food and fish. The concentrations of these metals in fish, along with those of Fe and Cd in water, call for caution as cumulative effects might constitute health hazards to aquatic life including man who feeds on fish. This is because at higher concentrations, they cause delayed embryo development, tissue damage, reduced growth and death of fish (Odiete, 1999). There is therefore, the need for regulatory agencies and other concerned parties to further monitor the Ikpoba river dam water which is a source of drinking water for the inhabitants of Benin metropolis and beyond.

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