Full Length Research Paper

Determination of post-dredging concentrations of selected trace metals in water, sediment and the freshwater mudfish (*Clarias gariepinus*) from Ikpoba river in Benin City, Edo State, Nigeria

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This investigation monitored the post-dredging concentrations of Cu, Mn, Zn, Cr, Ni and Pb in the water, sediment and the freshwater mudfish, *Clarias gariepinus*, from Ikpoba River in Benin City, Nigeria, over a six-month (February – July, 2005) period. The results showed that the levels of Mn, Ni and Pb in water and Cu, Mn, Cr and Pb in fish were higher than the recommended levels in drinking water and food fish and could pose health hazards. The results also showed that the post-dredging metal contamination levels in water and sediment of the river were lower than available pre-dredging levels, but in fish the differences between the post-dredging and pre-dredging levels were not significant and suggested that dredging could reduce metal contamination levels in the river. Consequently, continued dredging of the river is recommended as it has the potential to substantially improve the quality of the water and reduce hazards posed by heavy metals to the livestock and human population that depend on the river for drinking and other uses.

Key words: Trace metals, pollution, Ikpoba River, Nigeria.

INTRODUCTION

The availability of quality water needed for maintenance of normal biological function is on the decline. Water shortage is one of the most pressing problems facing modern world (United Nations, 1993). Surface water degradation arising from pollution due to introduction of industrial effluents has become of great concern to Environmentalists (Dean et al., 1972, Manahann, 1994). The protection of the aquatic environment and associated resources is one of the programmes of action listed in Agenda 21 of the United Nations for achieving sustainable development (United Nations, 1993). In Africa, the lack of scientific and ecotoxicological data effective for the control and prevention of aquatic pollution has been recognised and highlighted (UNESCO, 1985). According

to Dejoux (1988), existing information on the levels of heavy metal contamination in Africa is scattered and scanty. In Nigeria, the most populous country in Africa and with fairly active agricultural and industrial sectors, over 70% of the manufacturing industries are located close to coastal and inland surface waters (Okoye, 1991; FEPA, 2003).

  The development of meaningful policies and regulatory framework for the protection of the aquatic environment can only be achieved on the availability of reliable and adequate scientific data. Therefore, the need for adequate scientific data on pollutants in all the environmental matrices cannot be overemphasized.

  Ikpoba River in Benin, capital city of Edo State, Nigeria, is important as a source of potable water for drinking by people and livestock in the city, supply of irrigation water to crops and also for fishing and aquaculture. Government, recently (2002) dredged the river, which also receives municipal effluents from the city. There is the fear by

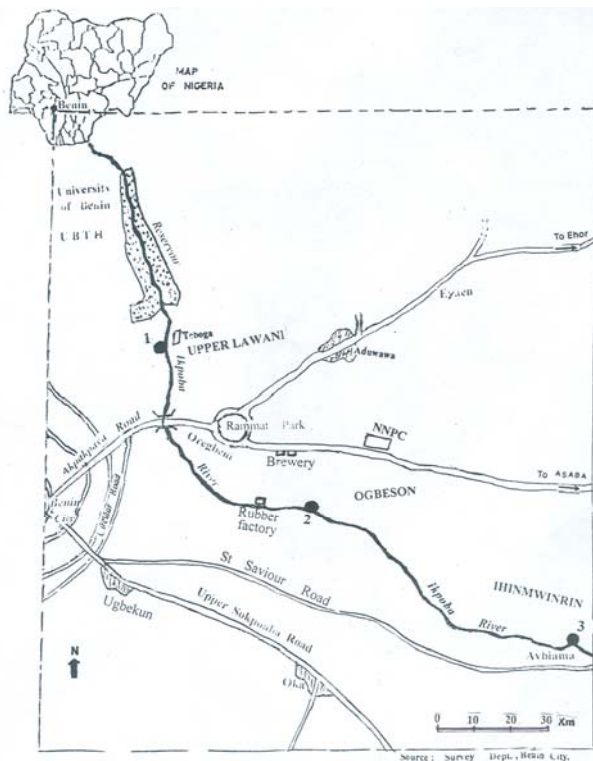*Corresponding author. E-mail: ewaensohan@yahoo.com.

Figure 1. Map of Benin City showing sample stations on Ikpoba River

Table 1. Mean metal concentrations in water of Ikpoba river at the sample stations.

Metals	Station 1	Station 2	Station 3	Probability
Cu	0.032	0.039	0.032	P>0.05
Mn	**0.052	**0.195	0.035	*P<0.05
Zn	0.024	0.023	0.023	P>0.05
Cr	0.004	0.006	0.003	P>0.05
N$_l$	**0.093	**0.141	0.029	*P<0.05
Pb	0.038	**0.070	*0.053	P>0.05

Values are in mg/l.
*Significant at 5% level.
**Concentration higher than WHO and FEPA limits in drinking water.

farms and car wash. Station 2, at Ogbeson about 3.0 km downstream of Station 1, receives larger volumes of effluents from two breweries, a rubber processing factory and a petroleum products depot, while Station 3 was established further downstream at Ihinmwinrin, about 4 km from Station 2. Human activities at Station 3 are mainly sand excavation and bathing.

Water, sediment and fish (*C. gariepinus*) specimens were collected forth-nightly over a six - month (February – July, 2005) period. On each occasion, samples were taken from three replicate spots at each station and the mean values recorded. Water samples were collected at 30 cm below the surface using 1 litre polythene bottles with screw caps. Sediment sample were collected using Eckman grab into plastic bags previously cleaned with detergent and treated with 10% Nitric acid. Fish (*C. gariepinus*) specimens were caught using various mesh sizes of gillnets, local traps and baited hooks and lines set overnight prior to collection. The specimens were taken in polythene bags and stored in a deep freezer at –10°C in the laboratory prior to treatment and analysis.

Treatment and analysis

Water samples were not subjected to further treatment and were aspirated directly into the flames of an Atomic Absorption Spectrophotometer (Varian Techtron Spectra B) for metal determination. Values are expressed in mg/l. Sediment samples were dried at 105±20°C in an oven to constant weight and ground to powder and then sieved through 2 mm mesh screen to remove coarse materials. The fish samples after defrosting were oven-dried to constant weight at 105±20°C and ground to powder. Digestion of all powdered sediment and fish samples were according to Sreedevi et al. (1992) and Oguzie (2003). I g of each sample was digested using 1:5:1 mixture of perchloric acid, concentrated nitric acid and concentrated sulphuric acid in a fume chamber at 80±5°C, until a colourless liquid was obtained. Each digested sediment and fish sample was analysed for trace metals using an Atomic Absorption Spectrophotometer (Varian Techtron Spectra B). Levels of trace metals are expressed in mg/kg.

Tests of significance were carried out using the analysis of variance (ANOVA) of the Statistical Package for Social Sciences (SPSS) computer programme. Means were separated using the Duncan Multiple Range Test.

RESULTS

Trace metals in water

The mean concentrations of the trace metals in water are presented in Table 1. The highest mean value of Cu

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Environmentalists on the effects of the dredging on the ecology of the river. It is against this general framework that this study, which investigated the post-dredging bio-concentrations of trace metals in a commercially important fresh water mudfish (*Clarias gariepinus*) from Ikpoba River was undertaken. The specific objectives were to determine the concentrations of Cu, Mn, Zn, Cr, Ni and Pb in the water, sediment and fish (*C. gariepinus*) of the river. Pre-dredging data were according to Fufeyin (1998), Obasohan and Oronsaye (2000) and Oguzie (1996, 2003).

MATERIALS AND METHOD

Study area

The study was conducted in a stretch of Ikpoba River (Figure 1), a fourth order stream flowing from North to South through Benin City, Edo State, Nigeria (6° 20' N; 5° 31' E). On the northern fringe of the river is located a reservoir (107.5 hectares), built for potable water supply to urban Benin City (Victor and Ogbeibu, 1985; Obasohan and Oronsaye, 2000). Human activities in the area include sand escavation, washing of clothes, car washing, refuse dumps, soap manufacturing, brewery and rubber processing factories.

Sample collection

For the purpose of this study, three sample stations (1, 2 and 3) were established on the river. Station I was established at Upper Lawani close to the reservoir and receive effluents from agricultural

Table 2. Mean metal concentrations in sediment of Ikpoba river at the sample stations (conc. in mg/kg)

Metals	Station 1	Station 2	Station 3	Probability
Cu	0.483	4.755	0.283	*P<0.05
Mn	0.041	1.38	0.031	*P<0.05
Zn	1.475	1.663	1.643	P>0.05
Cr	0.033	0.033	0.024	P>0.05
N$_l$	0.022	0.016	0.018	P>0.05
Pb	0.660	12.98	3.250	*P<0.05

*Significant at 5% level

Table 3. Mean metal concentrations in fish (*Clarias gariepinus*) from Ikpoba river at the sample stations (conc. in mg/kg)

Metals	Station 1	Station 2	Station 3	Probability
Cu	**4.434	**4.932	**4.101	P>0.05
Mn	**0883	**0.504	**0.741	P>0.05
Zn	5.830	6.061	6.224	P>0.05
Cr	**0.724	**0.724	**0.883	P>0.05
N$_l$	0.174	0.162	0.071	*P<0.05
Pb	**2.223	**2.223	1.972	P>0.05

*   Significant at 5% level
**   Concentration higher than WHO and FEPA recommendation limits

(0.039 mg/l) was recorded at Station 2. Stations 1 and 3 recorded equivalent value of 0.032 mg/l each. For Mn, the highest value (0.195 mg/l) was also at Station 2 and the lowest value (0.035 mg/l) was obtained at Station 3. Zn mean value (0.024 mg/l) was highest at Station 1, while an equal value of 0.023 mg/l was recorded at Stations 2 and 3. For Cr, the respective values at Stations 1, 2 and 3 were 0.004, 0.006 and 0.003 mg/l, Ni values were 0.093 mg/l (Station 1), 0.141 mg/l (Station 2) and 0.029 mg/l (Station 3), while for Pb, the respective values at Stations 1, 2 and 3 were 0.038, 0.070 and 0.053 mg/l. Statistical analysis (ANOVA) showed significant differences (P < 0.05) in the values of Mn and Ni at the Stations, but the values for Cu. Zn, Cr and Pb were not significantly different (P>0.05).

Trace metals in sediment

The mean values of the trace metals are shown in Table 2. The highest value for Cu (4.755 mg/kg) was recorded at Station 2, while the lowest value (0.283 mg/kg) was at Station 3. Mn mean value (1.38 mg/kg) was highest at Station 2 and lowest (0.031 mg/kg) at Station 3, Zn highest mean value (1.663 mg/kg) was also recorded at Station 2, while the lowest value (1.47 mg/kg) was recorded at Station 1. For Cr, an equal value of 0.033 mg/kg was recorded at Stations 1 and 2, while Station 3 recorded a low value of 0.024 mg/kg. Ni highest mean value (0.022 mg/kg) was at Station 1, followed by 0.018 mg/kg at Station 3 and 0.016 mg/kg (minimum value) at Station 2. For Pb, the highest value of 12.95 mg/kg was recorded at Station 2, while the minimum value (0.660 mg/kg) was recorded at Station 1. Statistical analysis showed no significant differences (P>0.05) in the levels of Zn, Cr and Ni at the Stations, but the levels of Cu, Mn and Pd were significantly different (P < 0.05).

Trace metals in fish

The mean concentrations of the trace metals in fish at the sample stations are presented in Table 3. Cu highest mean concentration (4.932 mg/kg) was recorded at Station 2, followed by 4.434 mg/kg recorded at Station 1 and the lowest value of 4.101 mg/kg at Station 3. Mn concen-

tration was highest (0.883 mg/kg) at Station 1 and lowest (0.504 mg/kg) at Station 2. The values for Zn were 5.830 mg/kg (lowest) at Station 1, 6.061 mg/kg at Station 2 and 6.224 mg/kg (highest) at Station 3. For Cr, the values were same (0.724 mg/kg) at Stations 1 and 2 and 0.883 (highest) at Station 3. Ni values at the Stations were 0.174 mg/kg (highest) at Station 1, followed by 0.162 mg/kg at Station 2 and 0.071 mg/kg (lowest) at Station 3. For Pb, the values were equal (2.223 mg/kg) at Stations 1 and 2 and lower (1.972 mg/kg) at Station 3. ANOVA showed no significant differences (P>0.05) in the concentrations of Cu, Mn, Zn, Cr and Pb in fish at the Stations, but the concentrations of Ni were significantly different (P<0.05)

DISCUSSION

All the metals (Cu, Mn, Zn, Cr, Ni and Pb) analysed in this study were detected in the water, sediment and fish (*C. gariepinus*) of Ikpoba River. Among the study Stations, the concentrations in water were highest at station 2 for all the metals (except Zn) and lowest at Station 3 (except Pb). The high levels in water at Station 2 could be attributed to the combined effects of the effluents from the breweries, the rubber processing factories and the petroleum products depot, which are discharged into the river close to the station. The low metal levels recorded at Station 3 downstream of the river showed an improvement in water quality in terms of heavy metals pollution and indicated a self-purification ability of the river induced by metal adsorption in sediment. In comparison to recommended limiting standards for drinking water set by WHO (1985) and FEPA (2003), the levels of Mn, Ni and Pb recorded in this study were higher, indicating that the water of Ikpoba River is not safe for drinking.

   This study, however, revealed that the levels of Cu, Zn, Cr and Ni detected in water were lower than the predredging levels recorded in water of the river by Fufeyin (1998) and Oguzie (2003) (Table 4). Fufeyin (1998) also

Table 4. Comparison of pre-dredging and post-dredging mean metal levels in water and fish of Ikpoba river (Concentrations in water in mg/l and   fish in mg/kg)

Metal	Cu		Mn		Zn		Cr		Ni		Pb		Remark
Sample	Water	Fish	Water	Fish	Water	Fish	Water	Fish	Water	Fish	Water	Fish	
This study	0.039	*4.93	*0.195	*0.883	0.024	6.224	0.006	*0.883	*0.141	0.174	*0.07	*2.223	Post–Dredging data
Fufeyin (1998)	0.210	2.88	*0.047	2.39	4.41	14.90	*0.20	0.214	*0.25	0.46	0.047	0.183	Pre-dredging data
Oguzie, (1996, 2003)	0.129	1.03	*0.417	0.16	0.127	1.78	*0.059	0.73	*0.244	0.50	0.082	0.16	
WHO (1985)	1.0	3.0	0.01	0.5	5.0	10–75	0.05	0.15	0.05	0.6	0.05	2.0	
FEPA (2003)	<1.0	1–3	0.05	0.5	20	75	<1.0	0.15	<1.0	0.5	<1.0	2.0	

*Concentration above WHO and FEPA recommended limits.

Table 5: Comparison of pre-dredging and post-dredging metal concentrations in sediment of Ikpoba river (conc. in mg/kg)

Metals	Pre-Dredging		Post-Dredging (this Study)		
	Fufeyin (1998)	Obasohan and Oronsaye (2000)	Station 1	Station 2	Station 3
Cu	21.50	10.35	0.483	4.755	0.283
Mn	0.60	1.78	0.041	1.38	0.031
Zn	28.48	7.41	1.475	1.663	1.643
Cr	0.60	1.30	0.033	0.033	0.024
Ni	1.25	0.57	0.022	0.016	0.018
Pb	8.88	6.67	0.660	12.98	3.250

recorded higher Pb level in water, while Oguzie (2003) similarly recorded higher Mn level in water. The possible explanation for the lower post-dredging metal levels could be that the removal of top sediment during dredging enhanced adsorption to exposed lower sediment parti-cles, which resulted in the lower metal levels in water. The implication is that continuous dredging of the river could be beneficial in reducing metal concentrations in the water of the river to tolerable limits.

In sediment, mean metal levels were generally higher than the mean levels in water. This could be as a result of adsorption to sediment particles. It has been reported that in the aquatic environment, permanent and tem-porary storage of metals take place on the sediment (Luoman and Bryan, 1978; Biney et al., 1991). The distri-bution of the metals in sediment at the Stations follow similar pattern as in water; highest at Station 2 with the exception Ni which level was highest at Station 1. Like in water, minimum values of the metals (except Ni and Pb) were at Station 3. Sediment metal levels recorded in this study were low, when compared to available predredging recorded by Fufeyin (1998) and Obasohan and Oronsaye (2000) (Table 5). The levels were also low when compa-

red to levels for unpolluted inland water sediments (GES-AMP, 1982; Salomons and Forstner, 1984).

In fish, metal levels recorded were generally higher than the levels in water indicating bioaccumulation. The most accumulated metal is Zn, while the least accumulated metal is Ni. The concentration profile is Zn > Cu > Pb > Cr > Mn > Ni. The high level of Zn in fish could be linked to higher bio-availability in water and sediment (Tables 1 and 2).

Among the stations, the levels of Cu, Mn, Zn, Cr and Pb were not significantly different (P>0.05) (Table 3). The significantly low (P<0.05) level of Ni in fish at Station 3 in comparison to the levels recorded at Stations 1 and 2, could be due to the low Ni level in water at the station. The observation suggested that Ni uptake was probably via gills rather than through food intake. In comparison to WHO (1985) and FEPA (2003) recommended limits in food, the levels of the metals, except Zn and Ni were higher (Table 4). The mean levels of the metals (except Zn and Ni) recorded in fish in this study were higher than pre-dredging levels in fish of the river (Table 4) and indicated metals retention in fish. Oronsaye (1987) and Oronsaye and Obano (2000) in studies on uptake and

loss of metals in fish reported the retention of heavy me tals in fish tissues.

 However, metal levels recorded in this study, were not significantly different (P>0.05) from pre-dredging levels in fish reported by Fufeyin (1998), Obasohan and Oronsaye (2000) and Oguzie (2003), suggesting that the effect of the dredging on metal concentrations in the fish of the river, if any, was negligible.

Conclusion

The results of this investigation showed that toxic metals (Cu, Mn, Cr and Pb) contamination in the water and fish of Ikpoba River have reached hazardous levels that render the water and fish unsafe for human consumption. The results also showed that the recent dredging of the river resulted in reduced heavy metals concentration in the water and sediment, with no significant adverse effects on the concentrations in fish. Consequently, dredging of the river is recommended as it has the potential to substantially reduce the levels of metal contamination and possible health hazards to livestock and man that depend on the river for drinking water and food fish.

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