African Scientist Vol. 9, No. 1 March 31, 2008
Printed in Nigeria

1595-6881/2008 $12.00 + 0.00

http://www.klobex.org/afs

AFS 2007082/9104

A Comparative Assessment of the Heavy Metal Loads in the Tissues of a Common Catfish (*Clarias Gariepinus*) From Ikpoba and Ogba Rivers in Benin City, Nigeria

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(Received September 18, 2007)

ABSTRACT: This investigation determined and monitored the concentrations of Cu, Zn, Mn, Cd, Cr, Ni and Pb in the tissues (Offal, Gills, Liver and Muscle) of the Catfish, *Clarias gariepinus* from Ikpoba and Ogba Rivers in Benin City, Nigeria between January and June, 2006. The same metals were also determined in the water of the two rivers. The results showed that the water and tissues of the fish from both rivers were contaminated to varying levels. The levels of the metals (except Ni and Pb) in the water of both rivers were not different at the sample stations of each river and between the rivers. The levels of Mn, Cd, Ni and Pb in water of the rivers exceeded WHO and FEPA maximum acceptable limits for drinking water and the mean natural background levels for African inland waters. It was also showed that most metals levels in fish tissues varied between stations and also between rivers. Tissues metal levels exhibited no particular trends, but seemed to be higher in offal and gills. Metal levels in all tissues were all greater than the maximum acceptable limits in food fish and thus indicated contamination to levels that could pose potential hazards when consumed. It was therefore inferred that the fishes of the rivers were unfit for human consumption. Based on the above findings, close monitoring involving human health risks assessment in relation to environmental pollution of Ikpoba and Ogba Rivers were strongly recommended.

Key Words: Heavy metals; Water pollution; Catfish (*Clarias Gariepinus*); Ikpoba River; Ogba River.

Introduction

Water pollution has become a global problem. Heavy metals have long been recognized as serious pollutants of the aquatic environment. Heavy metals are natural trace components of the aquatic environment, but background levels in the environment have increased especially in areas where industrial, agricultural and mining activities are widespread (Bryan and Langston, 1992). Heavy metals released into the environment find their way into aquatic systems as a result of direct input, atmospheric deposition and surface runoffs. Consequently, aquatic organisms may be exposed to elevated levels of heavy metals due to their wide use for anthropogenic purposes (Kalay and Canli, 2000).

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In the aquatic environment, heavy metals in dissolved form are easily taken up by aquatic organisms and accumulate in their tissues and may become toxic when accumulation reaches a substantially high level. Heavy metals may affect organisms directly by accumulating in their body or indirectly by transferring to the next trophic level of the food chain.

The concentration of a metal in an organism is the product of an equilibrium, between the concentration of the metal in an organism's environment and its rate of ingestion and excretion (Idodo-Umeh, 2002). Toxic effects occur when excretory, metabolic, storage and detoxification mechanisms are no longer able to counter uptake.

Fish absorb dissolved or available metals and can therefore serve as a reliable indication of metal pollution in the aquatic ecosystem. The common Catfish (*Clarias gariepinus*) is considered a good test organism for heavy metal contamination because of its feeding behavior and bottom feeding habits. The fish is a regular food item on the table of most population of the Benin City area. Regular fish supply to the markets, come mostly from the Ikpoba and Ogba Rivers in Benin City. These rivers have become increasingly polluted by sewage, industrial effluents and runoffs from surrounding agricultural fields. Earlier investigations showed that the fish of the rivers are contaminated by heavy metals (Fufeyin, 1998, Oguzie, 2003, Wangboje and Oronsaye, 2001).

This investigation is a comparative assessment of the levels of heavy metal contamination of the common catfish (*Clarias gariepinus*) from Ikpoba and Ogba Rivers, with a view to determining the suitability of the fishes of the rivers for human consumption. The specific objectives were to determine the levels of Cu, Mn, Zn, Cr, Ni and Pb in water and fish tissues (Offal, Gills, Liver and Muscle) of *Clarias gariepinus*, a dominant species in the fisheries of the rivers.

Material and Methods

Study Area

The Ikpoba and Ogba Rivers are two major rivers in Benin City, Nigeria. The city lies within Latitude 6.5^{o}N and Longitude 5.8^{o}E in the area described generally as the Benin lowlands. The soil is underlain by the Benin formation composed of unconsolidated coarse sand, interspersed with lignite and laterite sandy clay. Rainfall in the area is bimodal in pattern, peaking usually in July and again in September, with a brief drop in August. Minimal rainfall is in March and February, followed by the onset of heavy rain in March. Mean temperature is 26.7^{o}C, while the mean daily relative humidity is 70% (Obanor, 1992).

Urban Benin City has a generally flat terrain, drained in the north by the Ikpoba River (Fig.1) and in the south by the Ogba River (Fig.2). The Ikpoba River flows from the north, south-eastwards across north western part of the city and joins the Ossiomon River, which empties into the Benin River and finally into the Atlantic ocean. On the river is established a 107.5 hectares Reservoir for potable water supply. The Ogba River on the other hand, takes its source from a spring in the south
west part of the city and flows in a north-south direction before meandering eastwards to join the Benin River.

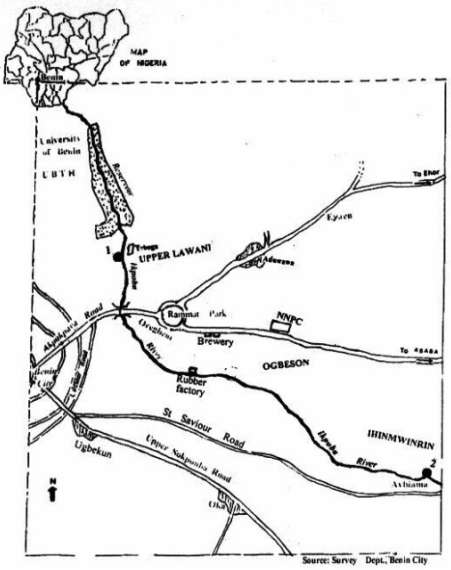

FIG.1: Map of Benin City showing Sample Stations on Ikpoba River

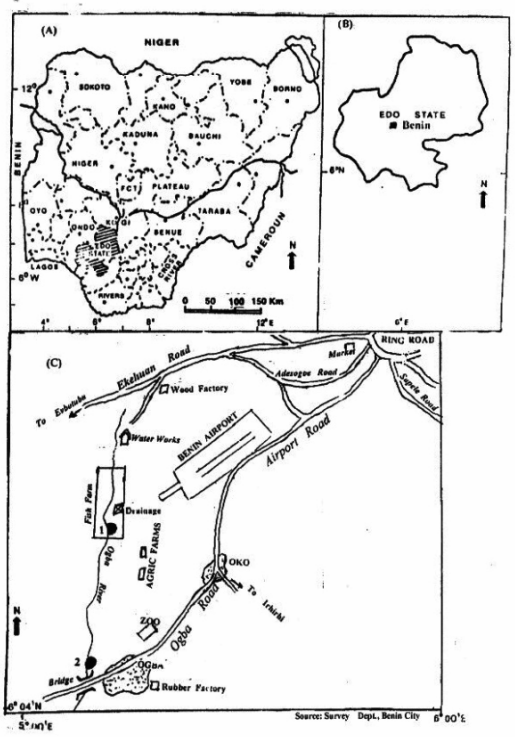

FIG.2: (A) Map of Nigeria showing position of Edo State.
(B) Edo State showing position of Benin City.
(C) Benin City showing Ogba River and Study Stations.

Samples were collected from two sections of each river and were designated as Stations 1and 2. On Ikpoba River (Figs.1), Station 1 was located south of the reservoir and receives drainage effluents (sewage and surface runoffs) from the city. The river at this point was about 5.0 m wide, with fringing vegetation composed of Indian bamboo (*Bambusa sp*.), shrubs and grasses. The soil was composed mainly of sand and silt. Human activities were restricted to bathing, laundering and fishing. Station 2 was about 4.0m from Station 1 and water at this point was about 3.0m wide. The length of the station was also flanked by Indian

bamboo (*Bambusa sp*.), palm trees (*Elaeis guineensis*), shrubs and grasses. The substratum was composed of fine sand, laterite, small gravel and silt. Human activities were fishing, bathing, washing, farming and aquaculture.

On Ogba River (Fig.2), Station 1 was about 700m from the point, where an underground drainage channel introduces municipal wastewaters into the river. The water at the point was 3.0m wide and about 0.7 m deep. The vegetation in the area was composed of palm trees, *Commelina* and *Emilia* species. The soil was composed mainly of silt and coarse sand mixed with clay. Human activities at the station were bathing and fishing. Station 2 was about 2.5 m downstream of Station 1. The water in the area was about 4.0 m wide and 2.0 m deep. The vegetation was mainly shrubs and grasses. The soil was composed mainly of coarse sand. Human activities were bathing, laundering, traditional worshipping and sand excavation.

Sample Collection

Samples (water and fish) were collected fortnightly over a six month period (January-June, 2006). Dugout canoes with paddles were used for sampling from the stations. Water samples were collected in plastic bottles previously cleaned with detergent and soaked overnight in 5% nitric acid. Water samples for heavy metal analysis were fixed, using 5% nitric acid and stored frozen at -10^{o}C. Fish samples were collected using gill nets, baited hook and lines and traps. The fish samples were placed in plastic bags and stored frozen at -10^{o}C after cleaning with distilled water to remove any adhering dirt (Ademoroti, 1996a).

Sample Treatment

Water quality parameters were determined using standard methods (APHA, 1989; Ademoroti, 1996a). All frozen samples were allowed to thaw at room temperature (27±2 ^{0}C). Water samples were not given any other treatment, but were mixed vigorously and then aspirated in a Varian Techtron (Spectra AA-10) Atomic Absorption Spectrophotometer for trace metal determination (APHA, 1989). The fish samples after defrosting were dissected into gills, offal, liver and muscle, using stainless steel dissection instruments, while wearing surgical gloves (Heit and Klusek, 1982). After dissection, all tissue samples were separately oven-dried at 105 ^{0}C to constant weight and were each ground to powder. 1 gram of each powdered sample was digested using a mixture of 1.5.1, 70% perchloric, conc. nitric and conc. sulphuric acid at 80 ± 5 ^{0}C in a fume chamber, until colorless liquid was obtained (Sreedevi *et al*, 1992).

After digestion, each digested sample was made up to 20ml with distilled water and analyzed for heavy metals in a Varian Techtron (Spectra AA-10) Atomic Absorption Spectrophotometer (AAS) for trace metal determination (APHA, 1989). Values were recorded in *mg/kg*. Bioaccumulation factors (Weiner and Giesy, 1979) between the fish tissues and the water (BF) were calculated.

Statistical analysis was performed using the Statistical soft ware package STATISTICA. Tests of significance between pairs of stations were carried out using the t-test, while the Spearman-R test was used to correlate mutual data.

Results

The results of the investigation have been summarized in Tables 1-3. Water quality parameters are presented in Table 1, while the mean values of heavy metals in water and fish tissues are presented in Tables 2 and 3 respectively. The calculated bio-accumulation factors (BF) for the various metals in the different tissues are also inserted in Table 3.

Water Quality Parameters

Water temperature ranged from a minimum value of 26.60 ^{0}C (Station 2) in Ikpoba River, to a maximum of 27.00 ^{0}C (Station 1) also in Ikpoba River (Table 1). The ranges for the other parameters were TDS (132.90 -146.20 *mg/l*) in Ikpoba River and (120.54-147.08 *mg/l*) in Ogba River; Turbidity (96.85-450.00 *mg/l*) in Ikpoba River and (54.77 -101.32 *mg/l*) in Ogba River; Conductivity (38.00-128.36 *µs/cm*) Ikpoba River and (83.17-111.02 *µs/cm*) Ogba River; pH (5.3-5.8) Ikpoba River and (4.9-5.6) Ogba River; DO (2.41 – 3.84 *mg/l*) Ikpoba River and (2.13-5.21 *mg/l*) Ogba River; BOD (0.98-1.24 *mg/l*) Ikpoba River

and (0.74-2.42 *mg/l*) Ogba River and Alkalinity (10.62- 21.20 *mg/l*) Ikpoba River and (4.87-9.33 *mg/l*) Ogba River. Statistical analysis showed that Water temperature, TDS, pH, DO and BOD were not significantly different ($p>0.05$) between the two rivers, but Conductivity, Turbidity and Alkalinity were different ($p<0.05$) between the stations of each river and also between the rivers (Table 1).

Table 1: Summary of some Physical and Chemical properties of Ikpoba and Ogba Rivers at the study stations during investigation.

Water body	Ikpoba River		Ogba River			
Stations	1	2	1	2	Probability	WHO limit
Temperature, ^{0}C	27.08	26.60	26.76	26.87	$p>0.05$	27
TDS, *mg/l*	146.20	132.90	147.08	120.54	$p>0.05$	500
Turbidity, *FTU*	450.00	96.85	101.32	54.77	$p<0.05$	5 units
Conductivity, *µs/cm*	128.36	38.00	111.02	83.17	$p<0.05$	200-600
pH	5.2	5.8	4.9	5.6	$p>0.05$	7-9.2
DO, *mg/l*	2.41	3.84	2.13	5.21	$p>0.05$	6.2
BOD, *mg/l*	1.24	0.98	0.74	2.42	$p>0.05$	6.0
Alkalinity, *mg/l*	21.20	10.62	4.87	9.33	$p<0.05$	30-150

Heavy metals in water

Heavy metal mean levels in water (Table 2) were varied. Cu mean values ranged between a minimum of 0.011 *mg/l* at Station 2 in Ogba River to a maximum of 0.01 *mg/l* at Station 1 in Ikpoba River. The mean levels for Zn were a minimum of 0.033 *mg/l* at Station 2 in Ikpoba River and a maximum of 0.09*mg/l* at Station 1 in Ogba River. For Mn, the levels ranged from 0.03 *mg/l* at Station 1 (Ogba River) to 0.052 *mg/l* at Station 1 (Ikpoba River). The levels of Mn at Stations 2 of both rivers were similar (0.045 *mg/l*). Cd mean levels were similar (0.038 *mg/l*) at Stations 1 and 2 (Ikpoba River) and Station 2 (Ogba River). Cd level was minimum (0.029 *mg/l*) at Station 1 in Ogba River. Cr levels were similar, being 0.020 *mg/l* at Station 1 (Ikpoba River) and at Station 2 (Ogba River) and 0.01 *mg/l* at Station 2 (Ikpoba River) and at Station 1 (Ogba River). Ni mean levels ranged from 0.029 *mg/l* at Station 2 (Ikpoba River) to 0.679*mg/l* at Station 1 (Ogba River). For Pb, the levels ranged between 0.056 *mg/l* at Stations 1 and 2 (Ogba River) and 0.22 *mg/l* at Station 1 (Ikpoba River). Statistical analysis showed that the levels of the metals (except Ni and Pb) were not significantly different ($p>0.05$) between the rivers.

Heavy metals in fish tissues

In fish, metal mean levels varied between fish tissues and also between stations of both rivers (Table 3). For Ikpoba River, Cu levels ranged between a minimum of 4.34 *mg/kg* in muscle at Station 1, to a maximum of 16.92 *mg/kg* in offal also at Station 1, while in Ogba River, the levels were a minimum of 2.67 *mg/kg* in gills at Station 1 and a maximum of 17.37 *mg/kg* in offal at Station 1. Zn mean levels in Ikpoba River ranged between 8.66 *mg/kg* in liver at Station 2 and 16.78 *mg/kg* in muscle at Station 1, while in Ogba River the levels ranged between 3.03 *mg/kg* in gills at Station 2 and 20.37 *mg/kg* in liver also at Station 2. Zn levels were significantly different ($p<0.05$) among fish tissues in Ogba River, but between the stations, levels in tissue were not different ($p>0.05$). In Ikpoba River, Zn levels though lower at Station 2 than at Station 1, were however not different ($p>0.05$) among tissues and between stations.

Table 2: Heavy metal mean levels in water of Ikpoba and Ogba Rivers at the sample Stations. (Conc. in *mg/l*)

Water Body	Stations	Cu	Zn	Mn	Cd	Cr	Ni	Pb
Ikpoba River	1	0.013	0.040	*0.052	*0.038	0.020	*0.143	*0.22
	2	0.012	0.033	*0.045	*0.038	0.010	*0.029	*0.14
Ogba River	1	0.012	0.069	*0.030	*0.029	0.010	*0.679	*0.056
	2	0.011	0.046	*0.045	*0.038	0.020	*0.470	*0.056
CIFA,1994 mean background level in Inland water		<1.0	20	0.01	0.02	0.05	0.05	0.03
FEPA, 2003 limit in water		< 1.0	20	< 1.0	<1.0	<1.0	<1.0	<1.0
WHO, 1984 limit in drinking water		1.0	5.0	0.01	0.01	0.05	0.05	0.05

*Levels above CIFA(1994) and WHO(1984) recommended limits

Mn mean levels were a minimum of 0.80 *mg/kg* in gills at Station 2 and a maximum of 2.00mg/kg also in gills at Station 1 in Ikpoba River, while in Ogba River, the levels were a maximum of 0.19 *mg/kg* (gills) at Station 1 and a maximum of 1.58 *mg/kg* (offal) also at Station 1. Mn levels were similar (0.82mg/kg) in offal and liver between stations and among tissues in Ikpoba River, but in Ogba River Mn levels differed significantly ($p<0.05$) among tissues and between the stations.

Cd levels in tissues of fish from Ikpoba River ranged from 0.07 *mg/kg* in gills (Station 1) to 0.13 *mg/kg* also in gills (Station 2). In Ogba River, the corresponding levels ranged from 0.02 *mg/kg* (gills) at Station 1 to 0.22 *mg/kg* (offal) also at Station 1. Cd levels were not different ($p>0.05$) between tissues and stations in Ikpoba River. In Ogba River, Cd in fish tissues were significantly low ($p<0.05$) in gills at Station 1, but at Station 2, Cd levels were not significantly different ($p>0.05$).

Cr levels in tissues of fish from Ikpoba River were a minimum of 0.36 *mg/kg* (muscle) at Station 1 and a maximum of 0.92 *mg/kg* (gills) also at Station 1. In Ogba River, the corresponding levels were 0.52 *mg/kg* (liver) at Station 2 and 3.96 *mg/kg* (liver) at Station 1. Cr levels among tissues were significantly different ($p<0.05$) at Station 1 in Ikpoba River, but at Station 2 of the river, the levels were not different ($p>0.05$). However in Ogba River, the levels were significantly different ($p<0.05$) between the stations as well as among the tissues. Cr levels in fish between the two rivers were different ($p<0.05$).

In Ikpoba River, Ni mean levels in tissues ranged between 0.07 *mg/kg* (muscle) at Station 1 and 0.43 *mg/kg* (gills) at Station 2. In Ogba River, the levels were between 0.07 *mg/kg* (liver) at Station 2 and 0.92 *mg/kg* (offal) at Station 1. Ni levels differed ($p<0.05$) among tissues in each of the rivers. Ni levels in fish tissues among the two rivers were significantly higher ($p<0.05$) in Ogba River (Station 1).

Pb levels among fish tissues and stations of Ikpoba River were not significantly different ($p>0.05$). They range from a minimum of 2.00 *mg/kg* (offal and liver) at Station 2 to a maximum of 2.67 *mg/kg* (gills) also at Station 2. In Ogba River, the corresponding levels ranged from 1.33 *mg/kg* (gills) at Station 1 to 8.00 mg/kg (gills) at Station 2. Among stations of Ogba River, Pb tissue levels were not significantly different ($p>0.05$), but between the rivers, the levels were significantly higher ($p<0.05$) in Ogba River.

Table 3: Heavy metal mean levels in tissues (gills, offal, liver and muscle) of *Clarias gariepinus* and corresponding Bio-accumulation factors (BF) at the sample stations of Ikpoba and Ogba Rivers. (Conc. in *mg/kg*).

		Ikpoba River				Ogba River			
Station	Metal	Gills	offal	liver	muscle	Gills	Offal	Liver	Muscle
	Cu	8.15	16.92	7.48	4.34	2.67	17.37	14.53	11.52
	BF	**626.92**	**1301.54**	**575.38**	**338.46**	**222.50**	**1447.50**	**1210.83**	**960.00**
	Zn	10.43	14.60	10.14	16.78	12.26	15.04	10.98	13.67
1	**BF**	**260.00**	**365.00**	**253.50**	**419.50**	**117.68**	**217.97**	**159.13**	**198.12**
	Mn	2.00	0.82	0.82	1.38	0.19	1.58	1.08	0.98
	BF	**38.46**	**15.77**	**15.77**	**26.54**	**6.33**	52.67	**36.00**	**32.67**
	Cd	0.07	0.10	0.10	0.09	0.02	0.22	0.19	0.14
	BF	**1.84**	**2.63**	**2.63**	**2.37**	**0.53**	**11.58**	**10.00**	**7.37**
	Cr	0.92	0.79	0.74	0.36	0.99	3.30	3.96	2.75
	BF	**46.00**	**39.50**	**37.00**	**18.00**	**99.00**	**330.00**	**396.00**	**275.00**
	Ni	0.26	0.30	0.30	0.07	0.14	0.92	0.64	0.57
	BF	**1.82**	**2.10**	**2.10**	**0.16**	**0.21**	**1.34**	**0.94**	**0.84**
	Pb	2.20	2.10	2.50	2.22	1.33	6.00	4.67	4.00
	BF	**15.71**	**15.00**	**17.86**	**15.86**	**23.75**	**107.14**	**83.39**	**71.43**
	Cu	9.02	14.60	8.68	10.77	9.19	13.36	6.35	9.63
	BF	**751.67**	**1216.67**	**723.33**	**89.50**	**835.45**	**1214.55**	**577.27**	**875.45**
	Zn	9.84	13.15	8.56	10.52	3.03	15.81	20.37	13.07
	BF	**298.18**	**398.48**	**259.39**	**318.79**	**65.87**	**343.70**	**442.83**	**284.13**
2	Mn	0.80	0.82	0.82	0.88	1.13	1.02	0.41	0.85
	BF	**17.78**	**18.22**	**18.22**	**19.56**	**25.11**	**22.67**	**9.11**	**18.89**
	Cd	0.13	0.09	0.11	0.11	0.07	0.11	0.09	0.09
	BF	**3.42**	**2.37**	**2.89**	**2.89**	**1.84**	**2.89**	**2.37**	**2.37**
	Cr	0.66	0.60	0.66	0.64	1.35	0.99	0.53	0.95
	BF	**66.00**	**60.00**	**66.00**	**64.00**	**67.50**	**49.50**	**26.50**	**47.50**
	Ni	0.43	0.38	0.21	0.34	0.14	0.21	0.07	0.14
	BF	**14.83**	**13.10**	**7.24**	**11.72**	**0.30**	**0.47**	**0.15**	**0.30**
	Pb	2.67	2.00	2.00	2.22	8.00	6.00	5.33	6.44
	BF	12.14	**9.10**	**9.10**	**10.10**	**142.86**	**107.14**	**95.18**	**115.00**

Discussion

Water Quality Parameters

Water quality is defined in terms of the physical, chemical and biological content of water. Water quality guidelines (WHO, 1984; CIFA, 1994; FEPA, 2003) provide basic information about water quality parameters and ecologically relevant toxicological threshold values to protect specific water uses. Freshwater quality criteria for fish should not permit accumulation of deleterious substances in fish to such degree that they are potentially harmful when consumed (Alabaster and Lloyd, 1982).

The discharge of drainage (surface runoffs and municipal wastewaters) effluents into the Ikpoba and Ogba Rivers in Benin City, have greatly influenced their physical and chemical characteristics (Oluwande *et al*, 1983; Ogbeibu and Ezeunara, 2002; Eyo, 1999). Surface water temperature values recorded at the sample stations in Ikpoba and Ogba Rivers in this investigation were not significantly different ($p>0.05$) and the range of values (26.60-27.00 ^{0}C) were high and conformed with the high water temperatures typical of water bodies in the tropics. Turbidity levels between the rivers were different ($p<0.05$). In each river, turbidity levels at the stations were also different.The higher level at Station 1, in comparison to Station 2 of both rivers reflected the volume and degree of effluents pollution influence. Station 1 of the rivers, were close to points of effluents intrusion. High turbidities have also been reported at brewery and rubber factory effluents point sources of Ikpoba River (Ogbeibu and Ezenuara, 2002; Oguzie, 2003) and Ogba River (Ezemonye and Kadiri, 1998); Eyo, 1999).

Conductivity levels were different in the rivers. The low level (38.00 *µs/cm*) recorded at Station 2 in comparison to Station 1 of Ikpoba River, could be due to the fact that the station was further away from the effluents discharge point, which was close to Station 1. The mean levels range (38.00-128.36 *µs/cm*) recorded at the stations of the two rivers were low when compared to the WHO (1984) recommended limits of 200-600 *µs/cm* (Table 1). They were also low, in comparison to the 190-196 *µs/cm* reported for Aladja tributary of Warri River in the area (Egborge, 1994).

The levels of pH, DO, BOD and Alkalinity were also low in comparison to the corresponding maximum acceptable limits in inland waters. The mean alkalinity in African Rivers is 43.00 *mg/l* (Wetzel, 1975). Low pH has been reported to cause increase in the solubility and toxicity of heavy metals (Horwarth and Sprague, 1978; Alabaster and Lloyd, 1982; Oronsaye and Ogbebo, 1995; Carvalho *et al*, 2004). Lloyd (1961) reported that low concentrations of DO increased the toxicity of heavy metals, while Oronsaye (1989) and Manahann (1994) reported that low alkalinities are usually associated with low pH and increased toxicity of heavy metals.

Heavy Metals in Water

The mean levels of the heavy metals except Ni and Pb were not significantly different ($p>0.05$) between the rivers. This would suggest uniformity of heavy metal loads in the two rivers and could be linked to municipal wastewaters drained into the rivers. The levels of Ni in Ikpoba River is significantly lower ($p<0.05$) than the corresponding levels in Ogba River. This might not be unconnected with effluents from the wood treatment and rubber processing factories, on Ogba River. Pb mean levels were however significantly higher ($p<0.05$) in Ikpoba River in comparison to Ogba River and could be a reflection of the higher human population and vehicular traffic in the northern part of the city, from which drainage effluents are channeled into Ikpoba River. Mombeshora *et al*, 1981 reported that high levels of Pb in urban areas coincided with high traffic density. Ni and Pb levels were not significantly different ($p>0.05$) among the Stations of Ogba River, but in Ikpoba River, the levels were different ($p<0.05$). The higher Ni and Pb levels at Station 1 of Ikpoba River in comparison to the levels at Station 2 of the river reflected the differential pollution impacts of the drainage effluents. Station 2 of the river, unlike Station 1 was further away from the point of effluents intrusion and consequently received less impact.

The levels of Cu, Zn and Cr recorded in the rivers in this investigation were lower than the mean natural background levels in African inland waters (CIFA, 1994) and the maximum acceptable limits in drinking water recommended by FEPA (2003) (Table 2). However, the levels of Mn, Cd, Ni and Pb in the rivers exceeded these limits. Earlier investigations reported similarly high levels of Hg, Fe, Cr, Mn, Cd, Ni and Pb in Ikpoba River (Ogbeibu and Ezeunara, 2002; Oguzie, 2003; Fufeyin,1998) and Ogba River (Wangboje and Oronsaye, 2001; Obasohan, 2003). It could thus be inferred that the waters of Ikpoba and Ogba Rivers might be unfit for drinking purposes.

Heavy metals in Fish tissues

Kalay and Canli (2000) reported that metal accumulation in the tissues of fish varied according to the rates of uptake, storage and elimination. We found that accumulation of each metal varied between stations of the same river as well as between the rivers. For Cu in Ikpoba River, tissue levels were in the order: offal> gills> liver>muscle (Station 1) and offal>muscle>gills>liver (Station 2), whereas in Ogba River, Cu levels order was offal>liver>muscle>gills (Station 1) and was offal>muscle>gills> liver (Station 2). Cu levels were generally different ($p<0.05$) among tissues. This was supported by the calculated bio-

accumulation factor (BF), which were significantly higher in offal and also suggested that Cu uptake was probably via food in gut. Tissues mean levels of Cu seemed to have conformed to the distribution in water. Similar findings were reported on bio-accumulation by fish of Ogba River (Wangboje and Oronsaye, 2001). Cu levels in tissues were not significantly different ($p>0.05$) between the rivers.

Tissues Zn levels profiles in fish from Ikpoba River were muscle>offal>gills>liver (Station 1) and offal>muscle>gills>gills (Station 2), while in Ogba River fish tissues, the profiles were offal>muscle>gills>liver (Station 1) and liver>offal>muscle>gills (Station 2). As in the case of Cu, Zn levels were higher in offal than in gills, indicating uptake probably via gut. This was supported by the calculated BF tissue values of Zn, which were also highest in offals (except liver at Station 2 of Ogba River). Tissues levels of Zn in the rivers were not different ($p>0.05$) except in gills and liver (Ogba River).

Mn levels in tissues of fish of Ikpoba River were in the order: gills>muscle> offal=liver (Station 1) and muscle>offal=liver>gills (Station 2), while in Ogba River, the order were offal>liver>muscle>gills (Station1) and gills>offal>muscle> liver (Station 2). Mn profiles did not show any particular pattern among stations of the same river and between the rivers. Mn tissue levels were not significantly different ($p>0.05$) between stations in Ikpoba River, but between Ogba River stations, the levels were different ($p<0.05$) in gills and liver.

Tissue levels of Cd in fish of Ikpoba River were in the order offal=liver>muscle>gills (Station 1) and gills>liver=muscle>offal (Station 2), while in Ogba River, the order were offal>liver>muscle>gills (Station 1) and offal>liver=muscle>gills (Station 2). Cd profiles followed a particular pattern, showing highest levels in offal and least levels in gills, except at Station 2 in Ikpoba River. The high levels in offals could be explained by the bottom feeding habit of the fish. Idodo-Umeh (2002), reported that bottom feeding fish accumulated higher heavy metal levels in offal, while Biney *et al* (1994) reported that permanent and temporary storage of heavy metals take place in sediments of water bodies.

Cr mean levels in tissues of fish of Ikpoba River were in the order gills > offal > liver < muscle (Station 1) and gills = liver > muscle > offal (Station 2), while in Ogba River the order were liver > offal > muscle > gills (Station 1) and gills>offal > muscle > liver (Station 2). Though there were no particular patterns in Cr levels among tissues, the levels in offal were higher at the stations of the rivers, except at Station 1 of Ogba River. The significant differences ($p<0.05$) in Cr tissue levels in the rivers did not correlate with Cr levels in water. This could be due to differences in water chemistry at the stations of the rivers. High levels in gills suggested Cr uptake via fish gills. The BF values of Cr in all tissues were highest at Station 1 of Ogba River (Station 1) and could explain the significantly high ($p<0.05$) tissue levels at the station.

Tissue Ni levels did not show any pattern in both rivers. However, the levels in offal at the stations of both rivers were higher except at Station 2 of Ikpoba River, where gills level was higher than offal level. Ni levels did not correlate with the levels in water at the stations of the rivers. Ni tissue levels at Station 2 with lower Ni concentration in water, were higher than the tissue levels at Station 1 with higher Ni concentration in water. For Ogba River, though Ni levels in water at the stations were similar, tissue levels were significantly different ($p<0.05$) at the stations (except gills).

The accumulation of Pb in the tissues of fish of both rivers showed no specific trends, but it would seem that the highest levels were predominantly in gills and muscles except in liver at Station 1 of Ikpoba River and in offal at Station 1 of Ogba River. The differences between tissues levels were not significant ($p>0.05$) at the stations of rivers except for gills in Ogba River.

Variations in metal bioaccumulation in fish tissues depend on a number of factors such as food habits and foraging behavior of the fish (Ogbeibu and Ezeunara, 2002); trophic status, source of a particular metal, distance of the organism from the contamination source and the presence of other ions in the milieu (Giesy and Wiener, 1977); food availability (Chen and Folt, 2000); bio-magnification and/or bio-diminishing of a particular metal (Barlas, 1999); metallothioneins and other metal detoxifying proteins in the body of the fish (Deb and Fukushima, 1999); temperature, transport of the metals across the membrane and the metabolic rate of the animal (Oguzie, 2003); species, age, size of fish and exposure time (Idodo-Umeh, 2002) and the position and function of the organ in the fish (Nussey *et al*, 2000; Kotze, 1997).

Cu, Mn and Zn are essential elements for the growth and well-being of living organisms. They show toxic effects when organisms are exposed to levels higher than normally required (Biney *et al*, 1994; Ademoroti, 1996_b). However, Cd, Cr Ni and Pb are not essential for metabolic activities and exhibit toxic properties. Metal contamination of the aquatic environment may lead to deleterious effects from localized inputs which may be acutely or chronically toxic. The toxicity effects of heavy metals to fish (Macleod and Pessah, 1973; Howarth and Sprague, 1978; Oronsaye, 1989) and man (Kurland *et al*, 1960; Forstner and Wittmann, 1981; Manahann, 1994; Ademorot, 1996_b) have been well documented. The maximum tolerant

levels for heavy metal concentrations in fish and man have been computed by the World Health Organization (WHO, 1984; CIFA, 1994 and FEPA, 2003).

The levels of all the metals in the tissues of the fish from the two rivers exceeded the WHO (1984) and FEPA (2003) maximum acceptable limits in food fish. The implication of the finding was that the fish from both Ikpoba and Ogba Rivers were contaminated to such levels that could pose potential hazards when consumed. This has serious implications in view of the large population which depend on these rivers as sources of their fish supply.

Conclusion

The results of this investigation showed that the Ikpoba and Ogba Rivers in Benin City, Nigeria have been polluted by drainage effluents. Heavy metals contamination of the water and fishes of the rivers, have reached hazardous levels enough to render the fishes of the rivers unfit for human consumption. However, in view of the short period covered by this study, further studies for a longer period to monitor and assess human health risks in relation to environmental pollution of the rivers are strongly recommended.

References

Ademoroti, C.M.A. (1996a): Standard Methods for Water and Effluent Analysis. Foludex Press Ltd. Ibadan. 182pp.

Ademoroti, C.M.A. (1996_b): Environmental Chemistry and Toxicology. Foludex Press Ltd. Ibadan 215pp.

Alabaster, J. S. and Lloyd, R. (1982): Water Quality Criteria for freshwater fish.. 2 nd Edition, Butterworth. 361pp.

APHA (American Public Health Association) (1989): Standard Methods for examination of Water and Wastewaters. Clesceri, L.S.A., A. Greenberg and R.R. Trussel. 17th Edition. 314pp.

Barlas, N. A. (1999): A pilot study of heavy metal concentrations in varoius environments and fishes in the Upper Sakaryia River Basin, Turkey. *Environ. Toxicol.* **14**: 367-373

Biney, C. A., Calamari, A.T.D; Kaba, N; Naeve, H. and Saad, M. A. H. (1994): Review of Heavy metals in the African Aquatic Environment. *Ecotoxicol. Environ. Saf.* **28**: 134-159

Bryan, G., Langston, W. J. (1992): Bioavailability, accumulation and effects of heavy metals in Sediments with special reference to United Kingdom Estuaries: a review. Environ. Pollut. **76**: 89-131

Carvalho, C. S.; Araujo, H. S S; Fernandez, M. N. (2004): Hepatic metallothionein in a teleost (*Prohilodus scrofa*) exposed to Cu at pH 4.5 and 8.0. *Comp. Biochem. Physiol.* **137** (B): 225-234

Chen, C. Y.; Folt, C. L. (2000): Bioaccumulation of arsenic and lead in a freshwater food web. *Environ. Sci. Technol*. **34**: 3878-3884

CIFA (Committee for Inland Fisheries of Africa) (1994): Review of Pollution in the African aquatic environment, *FAO Tech. Paper*, No **25**. 118pp.

Deb, S. C.; Fukushima, T. (1999): Metals in aquatic ecosystems. Mechanisms for uptake, accumulation and release. *Int. Environ. Stud*. **56**: 385-393

Egboge, A.B.M. (1994): Water Pollution in Nigeria. Biodiversity and Chemistry of Warri River. Ben Miller Books Nigeria Ltd. 331pp.

Eyo, V. (1999): Ecological survey of the macro-benthic invertebrate fauna of Ogba River, Benin City, M Sc. Thesis, University of Benin, Benin City, Nigeria. 120pp.

Ezemonye, L. I. N. and Kadiri, M.O. (1998): Final Report of Studies on Ikpoba and Ogba Rivers in Benin City. Univ. of Benin, Benin City, Nigeria.82pp

FEPA (Federal Environmental Protection Agency. (2003): Guidelines and Standards for Environmental Pollution Control in Nigeria. 238pp.

Forstner, U. and Wittmann, G. T. W. (1981): Metal pollution in the Aquatic Environment, Spring-Verlag, Berlin, Heideberg, New York. 486pp.

Fufeyin, T. P. (1998): Heavy metal levels in some dominant fish of Ikpoba Reservoir in Benin City, Nigeria. *Environmental Review*: **2**: 61-69

Giesy, J. P. and Weiner, J. G. (1977): Frequency distribution of trace metal concentrations in five freshwater fishes. *Trans. Am. Fish. Soc*. **106**: 393-403

Heath, A. G. (1991): Water Pollution and Fish Physiology. Lewis Publishers, Boca Raton, Florida, USA. 359pp.

Heit, M. and Klusek, C. S. (1982): The effects of dissecting tools on the trace metal concentrations of fish and mussel tissues. *Sci. Tot. Environ*. **24**: 129-134

Howarth, R. S. and Sprague, J. B. (1978): Copper, lethality to rainbow trout in water of various hardness and pH. *Wat. Res*. **12**: 455-462

Idodo - Umeh, G. (2002): Pollution assessments of Olomoro water bodies using Physical, Chemical and Biological indices: PhD. Thesis, University of Benin, Benin City, Nigeria. 485pp.

Kalay, M. and M. Canli (2000): Elimination of Essential (Cu, Zn) and Non-Essential (Cd, Pb) Metals from Tissues of a Freshwater Fish *Tilapia zilli. Turk. J. Zool.* **24**. 429-436

Kotze, P. J. (1997): Aspects of Water Quality, Metal contamination of Sediment and Fish in the Olifants River, Mpumalanga. M.Sc. Thesis, Rand Afr. Univ., South Africa

Kurland, L. T., Faro, S. W. and Sledler, H. (1960): Minamata Disease: The outbreak of a neurological Disorder in Minamata, Japan and its Relation to ingestion of sea food containing Mercury compounds. *World Neurol. 1*: 370-395

Lloyd, R. (1961): Effects of Dissolved Oxygen concentrations on the toxicity of several poisons to Rainbow trout (Salmo gairdneri). *J. Exp. Biol.* **38**: 447-455

Macleod, J. C., Pessah, E. (1973): Temperature effects on mercury accumulation, toxicity and metabolic rate in Rainbow trout , *Salmo gairdneri* . *J. Fish. Res. Board Can*. **30**: 485-492

Manahann, S. E. (1994): Environmental Chemistry, 6th Edition, Lewis Publishers Ann. Arbor, London, Tokyo. 812pp.

Mombeshora, C.; Ajayi, S. O. and Osibanjo, O. (1981): Pollution Studies on Nigerian Rivers. Toxic heavy metals status of surface water in Ibadan City. *Environ. Int.* **5**: 49-53

Nussey, G; Van Vuren, J. H. J. and Du Preez, H. H. (2000): Bioaccumulation of Chromium, Manganese, Nickel and Lead in the Tissues of the moggel, *Labeo umbratus* (Cyprinidae), from Witbank Dam, Mpumalanga.S Africa. *Water SA.Vol.* **26** (2): 269-284

Obanor, R. U. (1992): Rimar Consult: Feasibility study on the establishment of a hatchery in Edo State, Nigeria. 62pp

Obasohan, E. E. (2003): Ecological effects of urban waste water on the Clariid fish population of Ogba River in Benin City, Nigeria. *Adv. Nat. Appl. Sci. Res.* Vol. **1** (1): 200-219

Obasohan, E. E. and Oronsaye, J. A. O. (2004): Bioaccumulation of Heavy metals by some Cichlids from Ogba River, Benin City, Nigeria. *Nigerian Annals of Nat. Sciences Vol.* **5**(**2**): 11 – 27

Ogbeibu, A.E. and Ezeunara, P.U. (2002): Ecological impact of brewery effluent on the Ikpoba river using the fish communities as bio-indicators. *Journ. Aquatic Sciences 17* (1): 35-44

Oguzie, F.A (2003): Heavy metals in fish, water and effluents of lower, Ikpoba River in Benin City, Nigeria. *Pak. Journ. Sci.Ind.Res.* Vol. **46** (3) 156-160.

Oluwande, P. A., Sridhar, M. K., Bammeke, A. O. and Okubadejo (1983): Pollution levels in some Nigerian Rivers. *Wat. Res.* **17** (9): 863-957.

Oronsaye, J. A. O. (1989): Histological changes in the kidneys and gills of *Gasterosteus aculeatus*(L) exposed to cadmium. *Ecotoxicol and Environ. Safety* **17***:* 279 - 290

Oronsaye, J. A. O. and Ogbebo, F. E. (1995): Acute toxicity of copper to the African mudfish (*Clarias gariepinus*) in soft water. *Journ. Aqua. Sci.* **5**: 1-9

Sreedevi, P., Suresh, A., Sivaramakrishna, B., Prabharathi, B. and Radha Krishnaiah, K (1992): Bioaccumulation of nickel in the organs of the freshwater fish *Cyrino carpio* and the freshwater mussel *Lamelliolens marginalis*, under lethal and sublethal nickel stress. *Chemisphere.* **24** (1): 29-36

Wangboje, O. M. and Oronsaye, J. A. O. (2001): Bioaccumulation of Iron, Lead, Mercury, Copper, Zinc and Chromium by fish species from Ogba River, Benin City, Nigeria. *Afr. Journ. Appl. Zool. and Environ. Mgt. Vol.* **3***:* 45 – 49

Weiner, J.G. and Gresy, J. G. (1979): Concentrates of Cd, Cu, Mn, Pb and Zn in fishes in a highly organic soft water pond. *J. Fish. Res. Bd. Can.* **36**:270-279

Wetzel, G. W. (1975): Limnology. W. B. Saunders Company, Philadelphia, London, Toronto. 743pp.

W.H.O. (World Health Organization) (1984): Guidelines for Drink Water Quality Vol. I: Recommendations, WHO, Geneva. 193 - 199