GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 13, NO. 3, 2007: 339 - 346
COPYRIGHT (C) BACHUDO SCIENCES CO. LTD. PRINTED IN NIGERIA. ISSN 1118 - 0579

BIOACCUMULATION OF NICKEL, LEAD, COPPER, MERCURY AND CADMIUM IN TISSUES AND ORGANS OF *ETHMALOSA FIMBRIATA* FROM THE FORCADOS RIVER, NIGER-DELTA, NIGERIA.

D. OKORO, V. F. OLALEYE, AND J. O. DJERESA

(Received 18 July 2006; Revision Accepted 12 January 2007)

ABSTRACT

Increase in concentrations of heavy metals notably nickel, lead, copper, mercury and cadmium from the surface water to organs and tissues of *Ethmalosa fimbriata* (Bonga fish) sampled from three locations of the Forcados River has been observed. The seasonal survey showed that increments in metal accumulations were higher in the dry season compared to the rainy season. Increased temperature in the dry season could have led to increase in metabolic rate, which eventually increase uptake of metal from the surrounding water. There were notable significant differences in metal levels among the five organs and tissues (gills, liver, gonads, muscle and gut) investigated ($P < 0.05$). This difference may be attributed to differences in physiological activities of the different organs, and proximity of the tissue to the toxicant medium. The results of the present study has given the background concentrations of these metals in the fish specie and their distributions in the different organs.

KEYWORDS: bioaccumulation, bongafish, metals, organs, tissues.

INTRODUCTION

The Niger-Delta region of Nigeria has one of the highest plant and animal species biodiversity in the world (Moffat and Linden, 1995). The area encompasses over 20,100 square kilometers of vast flood plain and extensive swamps built up by silt accumulation washed down the Niger and Benue Rivers (Moffat and Linden, 1995). The Niger Delta region is composed of four main ecological zones namely the coastal barrier islands, mangroves, freshwater swamp forest, and lowland rainforest whose boundaries vary according to the patterns of seasonal flooding inundating the areas. The mangrove forest of the Niger–Delta is the third largest in the world and the largest in Africa (Moffat and Linden, 1995). Along the shores of the Forcados rivers, are flow stations, oil well heads, loading terminals, oil tank farms, agro-allied and thermal power generating industries each with its own characteristics pollutant (Egborge *et al.*, 1986; Fufeyin, 1988; Onwudinjo, 1990).

Contamination of the marine environment by heavy metals has risen in recent years due to the increase in global population and industrial development. The estuarine and littoral zones are more exposed to this problem than the oceans because of their proximity to pollution sources. Metals, which are natural constituents of the environment, are found in varying levels in all underground and surface waters (Martin and Coughtrey, 1982). Some of these metals are essential elements required for the normal metabolism of organisms while others are non-essential (Batley, 1983). The existence of heavy metals in aquatic environment has led to much concern over their influence on plant and animal life in these environments and indeed on man's need for wholesome water (Stephen, 1988). Metals are bioaccumulated by fish, either directly from the water or by ingestion of food, since these heavy metals are non-biodegradable (Patrick and Loutit, 1978). Fish exposed to high levels of trace metals in the water can take up substantial quantities of these metals (Hampson, 1986; Nightingale, 1987). Studies have shown that mercury, cadmium, lead, and copper are metals of concern in aquatic toxicity and human health effects (Walker *et al.*, 1997; GESAMP, 1985). These heavy metals are considered hazardous to aquatic life because of their extreme persistence, high toxicity, tendency to bioaccumulate, and because they are available through many and diverse anthropogenic sources (Atchison *et al.*, 1987).

Baseline surveys of the concentration of heavy metals in selected fish species have been conducted on several coasts around the world (Essink, 1989; Rainbow and Philips, 1993) including rivers and some creeks of Nigerian River (Okoro and Osakwe, 2005). Owing to the deleterious effects of heavy metals on aquatic systems, it is imperative to monitor the bioaccumulation of metals in aquatic systems to probably give an indication of the temporal and spatial extent of heavy metal accumulation, as well as an assessment of the potential impact on human health and organism health. Furthermore, extensive work had been carried out on the concentration of heavy metals in fish organs and tissues, very little information is available on heavy metal concentration in fish organs and tissues from Nigeria coastal environments such as those of Forcados River, hence the need for this study. The objective is therefore to assess the different organs and tissues essentially the gills, liver, gonads, muscle and guts in Bonga (*Ethmalosa fimbriata*) to ascertain the extent of heavy metal contamination of the fish specie. Bonga is the most important clupeid fish specie in the coastal inshore waters of Nigeria, widely consumed and it dominates the pelagic fishery in the Forcados River (Ajayi *et al*, 1986). It rarely goes below 20m and it is limited to estuaries and the adjacent coastal areas (Longhurst, 1960). The study shall also produce baseline data on the levels of these metals in the organs and tissues of the fish.

MATERIALS AND METHODS

Study area

The study was carried out on the Forcados River, which is located on the western side of Niger-Delta area (Figure 1). Presently, along the Forcados River, there is intense oil exploratory and production activities taking place in the river catchment area as well as location of several well-heads and flow stations in close proximity to the river. The river also serves the dual purpose of hosting one of the largest crude oil processing and loading terminals in Nigeria. The major activities of the Forcados oil terminal, which became operational over 30 years ago include: crude oil gathering, dehydration, storage and export. Also within the vicinity of the Forcados terminal and along the northern and southern banks of the Forcados estuary are a number of fishing ports, villages and towns. After the initial recognizance survey of the study area, three villages (locations) contiguous to Forcados River were selected for the study. These are Oguogbene (5^0 24' N and 5^0 19' E), Aboro (5^0 23' N and 5^0 22' E), and Yokri (5^0 26' N and 5^0 16' E) locations.

D. Okoro, Institute of Science Laboratory Technology, Delta State University, Abraka, Delta State, Nigeria.
V. F. Olaleye, Department of Zoology, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.
J. O. Djeresa, Institute of Ecology & Environmental Studies, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

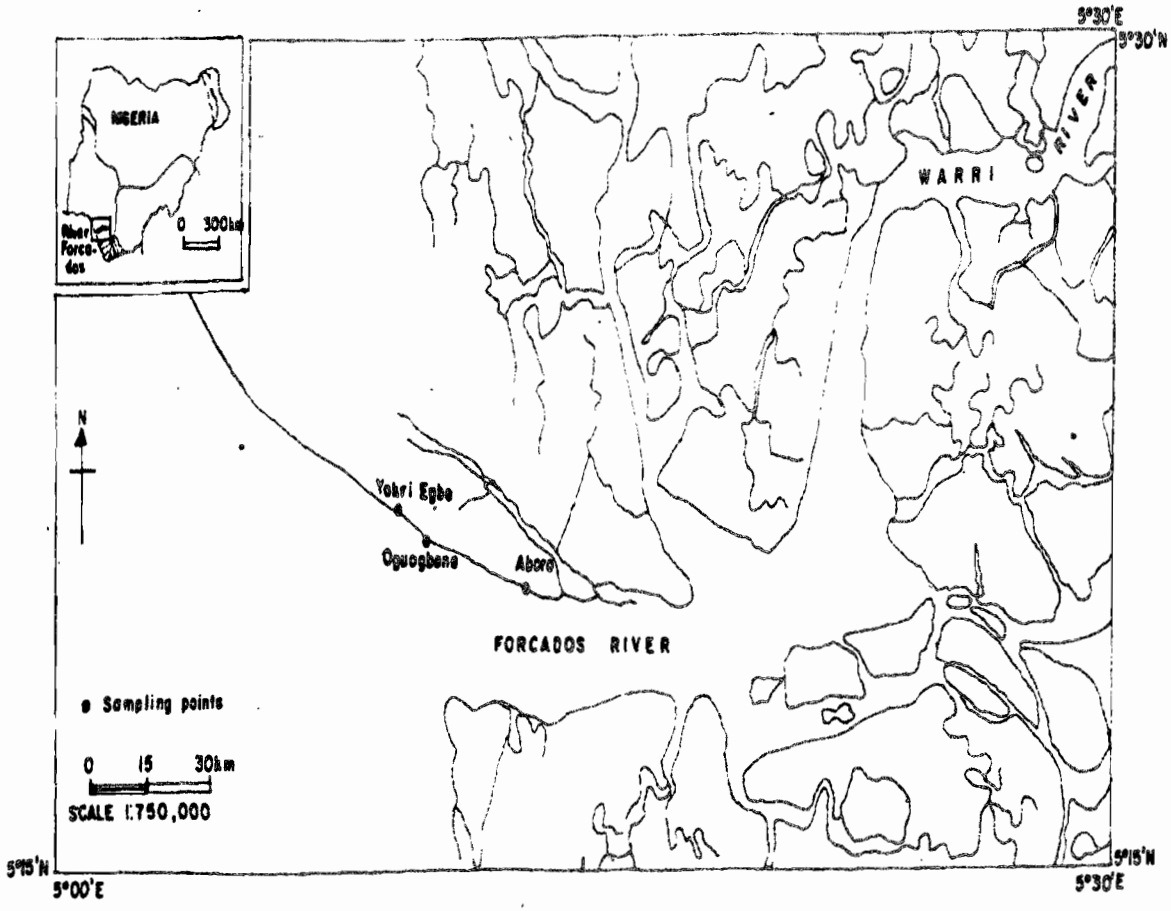

Figure 1: Map of Forcados River showing the Sampling Points (Insert: Map of Nigeria)

Sampling Methods

Sampling of water and fish were carried out between August 2004 and February 2005. Water samples were collected from the designated locations on different sampling days with the aid of a Friendinger water sampler. Each sample collected was properly labelled and preserved by addition of 5ml of concentrated nitric acid. The samples were then transferred to the laboratory. The fish samples were collected from local anglers at the mouth of each Forcados creek (Oguogbene, Aboro and Yokri) same time with water sampling campaigns. The size of the *Ethmalosa fimbriata* ranged between 13.3 – 16.5 cm and the weight is between 12.4 – 15.6g. Pooled samples of five fish (liver, gills, muscle tissue, gonads and stomach content) from each site were prepared for the analysis. The fish were dissected on a polyethylene work-surface using stainless steel tools while taking care to prevent any contamination of the samples (Klusek and Heit, 1982). Liver, gills, muscle tissue, gonads and stomach content were removed from each fish and frozen until heavy metal analyses were performed.

Laboratory Analysis

Concentrations of metals in the water samples were analysed by direct injection into the AAS after filtration. The organs and tissue samples were thereafter mineralized by weighing about 1.00 g of homogenous blend into a Pyrex conical flask and 15 mL of a mixture of three concentrated acids, perchloric, nitric and sulphuric acid in the ratio of 1:2:2, was used to digest the sample for 2 – 3 hours until brown fumes ceased to evolve (Bursell, 1975). The content of the flask after digestion was filtered through a Whatman GFK glass filter and solution made up to 100 mL mark with de-ionized water and kept in a polythene bottle. The filtrate in each case was analysed with Flame atomic absorption spectrophotometer (Perkin-Elmer AAS, 31.000). Mercury was analysed with graphite furnace AAS. The descriptive statistics and ANOVA were performed using Kyplot 2.0 statistical software. All statistical calculations were done within 95 % confidence interval.

RESULTS

Dry Season

The results of heavy metal concentrations in surface water of Aboro, Yokri and Oguogbene locations of Forcados River during the period of study are given in Table 1. During the dry season, it was observed that copper had the highest concentration (0.730 ± 0.159 μg/g) essentially in the Yokri location of the river, while mercury had the lowest concentration (0.001 ± 0.000 μg/g) at the same location of the river. At the Aboro location of the river, the degree of metal concentrations in the surface water was found to be in the following order: Cu > Ni > Pb > Cd > Hg. This trend was also observed in the Yokri and Oguogbene locations of the Forcados River.

TABLE 1: Heavy metals concentrations (µg/g) in surface water of three loactions in Forcados River in the period of study.

December 2004 to February 2005 (Dry Season)					
	Mean ± SD Range				
Location	Ni	Pb	Cu	Hg	Cd
Aboro	0.518 ± 0.242 (0 300 - 0 600)	0.185 ± 0.007 (0.01 – 0 007	0.671 ± 0.138 (0.60 – 0.90)	0.001 ± 0.000 (0 001 – 0.001)	0.006 ± 0.001 (0 004 – 0 00)
Yokri	0.571 ± 0.111 (0.400 - 0.700)	0.018 ± 0.007 (0.01 – 0.030)	0.730 ± 0 159 (0.60 – 1.000)	0.002 ± 0 002 (0 001 – 0.007)	0.006 ± 0.00 (0 005 – 0.00)
Oguogbene	0.600 ± 0.119 (0.400 - 0.700)	0.020 ± 0 007 (0.010 – 0.030)	0.723 ± 0.132 (0.600 – 900)	0.001± 0.002 (0.000 – 0.001)	0.007 ± 0.000 (0.005 – 0.00)
FEPA, 1991	< 1	< 1	1.0 - 1.5	0.001	< 1
WHO, 1998	0.02	NA	2	0.001	0.05
August 2004 to October 2004 (Rainy Season)					
	Mean ± SD Range				
Location	Ni	Pb	Cu	Hg	Cd
Aboro	0.471 ± 0.025 (0.289 - 0.591)	0.074 ± 0.017 (0.009 – 0.082	0.506 ± 0.032 (0.463 - 0.768)	ND ND	0.002 ± 0.001 (0.001 – 0.002)
Yokri	0.324 ± 0.144 (0.273 - 0.452)	0.009 ± 0.002 (0.007 – 0.012)	0.432 ± 0.033 (0.311 – 0.673)	0.001 ± 0 000 (0.000 – 0.001)	0.003 ± 0.000 (0.001 – 0.004)
Oguogbene	0.411 ± 0.102 (0 334 - 0.641)	0.007 ± 0.001 (0 004 – 0.008)	0.512 ± 0.004 (0 432 – 0 573)	ND ND	0.004 ± 0.001 (0.002 – 0.006)
FEPA, 1991	< 1	< 1	1.0 - 1.5	0.001	< 1
WHO, 1998	0.02	NA	2	0.001	0.05

SD = standard deviation; ND = non-detected; NA = not available

The results of the metal concentrations in organs and tissues of *Ethmalosa fimbriata* observed during the dry season survey in the three locations of the Forcados River are given in Table 2.

TABLE 2. Heavy metals concentration (µg/g) in gills, liver, gonads, muscles and guts of *Ethmalosa fimbriata* from Forcados River at Aboro, Oguogbene & Yokri between December, 2004 and February, 2005 (Dry Season).

Aboro						
Heavy metals (µg/g)	Mean ± SD Range					
	Gills	Liver	Gonads	Muscle	Guts	P - value
Ni	0.831 ± 0.076 (0.725 – 0.900)	0.855 ± 0 169 (0.615 – 1.015)	0.829 ± 0.078 (0.720 – 0.900)	0.807 ± 0.080 (0.750 – 0.925)	0.550 ± 0.060 (0 515 – 0.650)	p > 0.05
Pb	0.045 ± 0.003 (0 042 – 0.049)	0.040 ± 0.007 (0.035 – 0.050)	0.044 ± 0.002 (0.042 – 0.051)	0.048 ± 0.002 (0.450 – 0.050)	0 300 ± 0 006 (0 025 – 0.350)	p > 0 05
Cu	1.001 ± 0.138 (0.900 – 1.200	1.361 ± 0.104 (1.205 – 1.420)	1.000 ± 0.200 (0.900 – 1.200)	0.863 ± 0.085 (0.750 – 0.950)	0.850 ± 0.003 (0.825 – 0.875)	p > 0.05
Hg	0.002 ± 0.002 (0.001 – 0.004)	0.001 ± 0.001 (0.001 – 0.002)	0.002 ± 0.001 (0.001 – 0.002)	0.002 ± 0.001 (0.000 – 0.002)	0.001 ± 0.000 (0.000 – 0.001)	p > 0.05
Cd	0.007 ± 0.002	0.007 ± 0.001	0.005 ± 0.001	0.007 ± 0.000	0.006 ± 0.001	p > 0.05

	(0 006 – 0.009)	(0 006 – 0 007)	(0 004 – 0.007)	(0 005 – 0.009)	(0.005 – 0.007)	

Oguogbene

Heavy metals (μg/g)	Mean ± SD Range					
	Gills	Liver	Gonads	Muscle	Guts	P - value
Ni	0.802 ± 0 088 (0.710 – 0.900)	0 925 ± 0.050 (0.900 – 1 000)	0 600 ± 0 021 (0.600 – 0.650)	0 766 ± 0.129 (0 650 – 0 950)	ND ND	p < 0 05
Pb	0 037 ± 0.022 (0 004 – 0.050)	0.038 ± 0 020 (0.007 - 0.050)	0.003 ± 0.000 (0 002 – 0.004)	0.045 ± 0.004 (0.040 – 0 050)	ND ND	p < 0 05
Cu	0.963 ± 0 049 (0 900 –1.005)	1.125 ± 0.125 (1 000 – 1 300)	0.800 ± 0.050 (0 800 – 0 900)	0 775 ± 0.155 (0 600 – 0.900)	0 500 ± 0.002 (0 500 – 0 600)	p < 0.05
Hg	0.002 ± 0 001 (0 001 – 0 002)	0.002 ± 0.000 (0.002 – 0.002)	0.001 ± 0.000 (0 001 – 0 001)	0.001 ± 0 001 (0 001 –0 002)	ND ND	p > 0.05
Cd	0 007 ± 0.001 (0.005 – 0.018)	0.007 ± 0.000 (0.006 – 0.008)	ND ND	0 008 ± 0.002 (0 006 – 0.009)	ND ND	p > 0 05

Yokri

Heavy metals (μg/g)	Mean ± SD Range					
	Gills	Liver	Gonads	Muscle	Guts	P - value
Ni	0.851 ± 0.104 (0.715 – 0.950)	0.937 ± 0.048 (0.900 – 1.000)	0.800 ± 0.100 (0.750 – 0.800)	0.763 ± 0.107 (0.700 – 0.925)	ND ND	p < 0.05
Pb	0.027 ± 0.026 (0.004 – 0.050)	0.038 ± 0.021 (0.007 – 0.050)	0.020 ± 0.001 (0.020 – 0 030)	0.043 ± 0 003 (0 040 – 0 045)	ND ND	p < 0.05
Cu	0.978 ± 0.052 (0.900 –1 008)	1.178 ± 0.172 (1.000 – 1 405)	0.900 ± 0.050 (0.850 – 0 900)	0 795 ± 0 086 (0.705 – 0.900)	0.650 ± 0 001 (0 750 – 0 900)	p > 0 05
Hg	0 001 ± 0.001 (0.001 – 0.002)	0 002 ± 0 000 (0.002 – 0.002)	0 001 ± 0.000 (0.001 – 0.001)	0 002 ± 0 001 (0.001 –0.002)	ND ND	p > 0 05
Cd	0 007 ± 0 002 (0 005 – 0 009)	0.007 ± 0 001 (0.006 – 0.008)	0.005 ± 0.002 (0.001 – 0 030)	0.006 ± 0.003 (0.001 – 0.029)	ND ND	p > 0.05

SD = standard deviation; ND = non-detected

At the Aboro location, the highest value observed for nickel was in the liver (0.855 ± 0.169 μg/g) with the lowest value being recorded in the gut of the fish (0.550 ± 0.060 μg/g). The result of the Analysis of variance (ANOVA) showed that there was no significant difference in the levels of nickel observed among the organs and tissues of the fish (P > 0.05). Lead was observed to be highest in the alimentary canal (gut) of fish with mean value of 0.300 ± 0.006μg/g in the Aboro location of the river while it was lowest at the liver with mean value of 0.040 ± 0.007μg/g. There was also no significant difference amongst the organs and tissues of the fish for lead in Aboro during the dry season survey. The liver was observed to contain the highest levels of copper in Aboro with mean value of 1.361 ± 0 104 μg/g. The accumulation order was observed to be in the order liver > gills >gonads > muscle > guts. Levels of mercury and cadmium showed no significant difference (P> 0.05) amongst the organs and tissues of the fish at Aboro in this survey.

At the Oguogbene location during the same dry season survey, the liver was also observed to contain the highest levels of nickel (0.925 ± 0.050 μg/g) while the gut was similarly observed to contain the lowest levels of nickel with a non – detectable amount. There was however, a statistically significant difference amongst the organs and tissues of the fish (p < 0.05). The degree of accumulation of nickel was as follows. liver > gills > muscle > gonads > guts. Lead showed more presence in the muscle with a mean value of 0.045 ± 0.004 μg/g while its lowest level was observed in the gut (not detected). There was also a significant difference among the organs and tissue of the fish (P < 0 05). The degree of accumulation of lead was thus muscle > liver > gills > gonads > gut. The levels observed for copper was found to be predominant in the liver with mean value of 1 125 ± 0.125 μg/g and lowest in the gut. There was also a significant difference among the levels of copper in the fish parts. Mercury showed no statistically significant difference among the organs and tissues and its mean value ranging from non – detected (gut) to 0.002 ± 0.001μg/g (gills). There was no significant difference in cadmium levels among the organs and tissues (p > 0 05) with its mean value ranging from non – detected (gonads and gut) to 0.008 ± 0.002 μg/g (muscle).

The survey in the Yokri location during the dry season showed that nickel was observed to have its highest mean levels in the liver with mean value of 0.851 ± 0.104 μg/g while its lowest level was observed to be in the gut with a non – detected amount. There was a significant difference in nickel levels among the organs and tissues of the fish. The ranking of

nickel accumulation was thus: liver > gills > gonads > muscle > gut. The survey also showed that lead had mean values that were statistically significant in differences among the organs and tissue ($p < 0.05$). The degree of lead accumulation was thus: muscle > gonads > liver > gills > gut. There was no significant difference in levels of copper, mercury and cadmium among the organs and tissue of the fish ($p > 0.05$).

Rainy Season

Copper had the highest concentration (0 512 ± 0.004 µg/g) in surface water of the river during the rainy season survey (Table 1). The highest value was observed in the Oguogbene location of the river. The order of degree of metal concentrations was observed to be similar to that of the dry season. The mean concentrations and range of heavy metals in organs and tissues of *Ethmalosa fimbriata* during the rainy season are given in Table 3

Table 3: Heavy metals concentration (µg/g) in gills, liver, gonads, muscles and guts of *Ethmalosa fimbriata* from Forcados River at Aboro, Oguogbene & Yokri between August, 2004 and October, 2004 (Rainy Season).

Aboro						
Heavy metals (µg/g)	Mean ± SD Range					
	Gills	Liver	Gonads	Muscle	Guts	P - value
Ni	0.523 ± 0.128 (0.445 – 0.700)	0.588 ± 0 064 (0.515 – 0.625)	0.800 ± 0.060 (0.700 – 0 850)	0.740 ± 0.031 (0.705 – 0.765)	0 500 ± 0.002 (0 475 – 0 600)	p > 0 05
Pb	0.029 ± 0.023 (0.004 – 0.045)	0.298 ± 0.007 (0.022 - 0.035)	0.040 ± 0.002 (0.035 – 0.080)	0.316 ± 0.008 (0.025 – 0.040)	0 300 ± 0.006 (0.025 – 0.315)	p > 0.05
Cu	0.828 ± 0.003 (0.825 – 0.830)	0.998 ± 0.100 (0.900 – 1.100)	1.000 ± 0.200 (0.900 – 1.100)	0. 576 ± 0.150 (0.480 – 0.750)	0.950 ± 0.200 (0.900 – 1.000)	p > 0.05
Hg	0.001 ± 0.000 (0.000 – 0.001)	0.001 ± 0.000 (0.001 – 0.001)	0.001 ± 0.001 (0.001 – 0.001)	0.001 ± 0.001 (0.001 – 0.002)	0.001 ± 0 001 (0.001 – 0.001)	p > 0.05
Cd	0.006 ± 0.001 (0.005 – 0.006)	0.005 ± 0.001 (0.005 – 0.006)	0.006 ± 0.000 (0.005 – 0.007)	0.004 ± 0.001 (0.004 – 0.005)	0.005 ± 0.001 (0.003 – 0.007)	p > 0.05
Oguogbene						
Heavy metals (µg/g)	Mean ± SD Range					
	Gills	Liver	Gonads	Muscle	Guts	P - value
Ni	0.605 ± 0 107 (0.500 – 0.715)	0.777 ± 0.053 (0.715 – 0.815)	0 700 ± 0.001 (0.700 – 0.750)	0.716 ± 0 102 (0.615 – 0.820)	ND ND	p < 0.05
Pb	0.033 ± 0.003 (0.030 – 0.030)	0.007 ± 0.011 (0.001 – 0.020)	0.030 ± 0.001 (0.025 – 0.035)	0.025 ± 0.000 (0.025 – 0.250)	0.001 ± 0.001 0.000 – 0.002	p < 0.05
Cu	0.907 ± 0.047 (0.855 – 0.945)	0.998 ± 0.006 (0.995 – 1.005)	1.000 ± 0.001 (0.950 – 1.100)	0.583 ± 0.029 (0.550 – 0.600)	0.650 ± 0.001 (0.600 – 0.700)	p > 0.05
Hg	0.001 ± 0.001 (0.000 – 0.001)	0.001 ± 0.000 (0.001 – 0.001)	0.001 ± 0 000 (0.001 – 0 001)	0.001 ± 0.001 (0.001 – 0 001)	ND ND	p > 0.05
Cd	0.005 ± 0.002 (0.004 – 0.008)	0.005 ± 0.001 (0.005 – 0.006)	0.001 ± 0 000 0.000 – 0.002	0 004 ± 0 001 (0.004 – 0.005)	ND ND	p > 0.05
Yokri						
Heavy metals (µg/g)	Mean ± SD Range					
	Gills	Liver	Gonads	Muscle	Guts	P - value
Ni	0.634 ± 0.057	0.748 ± 0.124	0.800 ± 0.110	0.675 ± 0.022	0.800 ± 0.100	p > 0.05

	(0.600 – 0.700)	(0.605 – 0.825)	(0.750 – 0.950)	(0.660 – 0.700)	(0.650 – 0.700)	
Pb	0.003 ± 0.001	0.005 ± 0.001	0.025 ± 0.001	0.037 ± 0.003	ND	$p < 0.05$
	(0.003 – 0.004)	(0.004 – 0.006)	(0.025 – 0.030)	(0.035 – 0.003)	ND	
Cu	0.905 ± 0.005	0.967 ± 0.053	0.950 ± 0.050	0.518 ± 0.027	0.650 ± 0.001	$p > 0.05$
	(0.900 – 0.710)	(0.965 – 0.000)	(0.900 – 0.950)	(0.500 – 0.550)	(0.600 – 0.650)	
Hg	0.003 ± 0.000	0.001 ± 0.000	0.001 ± 0.000	0.001 ± 0.000		$p > 0.05$
	(0.000 – 0.001)	(0.001 – 0.001)	(0.001 – 0.001)	(0.001 – 0.001)	ND	
Cd	0.006 ± 0.001	0.003 ± 0.001	0.006 ± 0.002	0.005 ± 0.001		$p > 0.05$
	(0.005 – 0.006)	(0.002 – 0.004)	(0.001 – 0.030)	(0.004 – 0.006)	ND	

SD = standard deviation; ND = non-detected

At the Aboro location, nickel was observed to have its highest value in the gonads (0.800 ± 0.060 μg/g) while its lowest value was observed in the gut (0.500 ± 0.002 μg/g) Lead was more predominant in the muscle (0.316 ± 0.008 μg/g) while it was least dominant in the gills (0.029 ± 0.023 μg/g). Survey also showed that gonads contained the highest levels of copper with a mean value of 1.000 ± 0.200 μg/g. 0.001 ± 0.000 μg/g was found for mercury in the gonads, gills, and gut which was statistically higher than mercury present in gills and liver with a value of 0.001 ± 0.001 μg/g. Cadmium was found to be highest in the gills (0.006 ± 0.001 μg/g) and lowest in the muscle (0.004 ± 0.001 μg/g). The results of the ANOVA showed in all five metals including nickel, lead, copper, mercury, and cadmium that there were no significant difference among their levels in the organs and tissue of *Ethmalosa fimbriata*.

The survey in the Oguogbene location of the Forcados river, showed that the liver contain the highest concentration of nickel, while the gut had the lowest. The level of nickel in the liver was 0.777 ± 0.053 μg/g and that of the gut was non – detected. The ranking of the nickel accumulation was as follows: liver > muscle > gonads > gills > guts. There was significant difference in levels of nickel and lead among the organs and tissues of the fish ($P < 0.05$) Lead accumulation was in the order as follows: gills > gonads > muscle > liver > gut. However, there were no significant difference in the levels of copper, mercury, and cadmium among the organs and tissue of the fish ($P > 0.05$).

At the Yokri location of the river, survey showed that the gonads (0.800 ± 0.100 μg/g) contained the highest levels of nickel with the gills (0.634 ± 0.057 μg/g) containing the least levels. Apart from lead, there was no statistically significant difference in all other metals determined among the organs and tissue of the fish. The degree of lead accumulation was as follows: muscle > gonads >liver > gills > gut.

DISCUSSIONS

The levels observed for nickel in the three locations were within the levels recommended for surface water by FEPA, but were higher than WHO levels of 0.02 μg/g Mercury was within the limits of FEPA and WHO save for its levels in Yokri location during the dry season survey which was slightly above the standard guidelines. Lead, copper and cadmium levels in water as observed from Table 1 were within standard criteria recommended by FEPA 1991 in both dry and rainy season surveys. The interim guidelines for lead, copper and cadmium are respectively < 1, 1.0 -1.5 and < 1 mg/L. The levels were however within the ones reported for the surface water of the Forcados River (Eloke, 2001).

There was an increment in the levels of all five heavy metals determined from the water level to the tissue or organ level which was an indication of bioaccumulation. The bioaccumulation pattern in the organs and tissue agree closely with similar studies carried out in a similar ecosystem (Latif *et al*, 1982). The differences in the levels of these metals among the organs and tissues of *Ethmalosa fimbriata* may be attributed to differences in physiological activities of the different organs (Avenant-Oldewage and Marx, 2000) and proximity of the tissue to the toxicant medium (Panchanathan, 2006). Generally, there was an increase in metal accumulation during the dry season as compared to the rainy season in all matrices.

The greatest accumulation of copper occurred in the liver in all three locations of the Forcados River. It corroborated the view that the liver in the fish plays a protective role against chronic heavy metal exposure by producing the metallothioneins (McCarter and Roch, 1983) acting as a storage site, and being a vita organ in the regulation of copper (Buckley *et al.*, 1982).These metallothioneins possess high affinities for copper and in doing so, concentrate and regulate it (Klerks and Levinston, 1989). The levels observed in the gills at the three locations are also relatively high (Table 2 & 3). According to Laurent and Dunel (1980), the gills possess an extensive vascular network, which brings the gill tissue into close contact with any blood – borne metal. When fish are exposed to some levels of copper, he gills are the first organs that are affected by this increase. The mucous cells respond by increasing in activity, size and abundance (Noel-Lambot *et al*., 1978) However, the dry season survey showed an increase in the copper accumulation compared to the rainy season. This trend was also observed in the other metals including nickel, lead, mercury and cadmium. A similar study carried out in the Forcados River by Eloke (2001) showed the same trend. It was reported in the study (Eloke, 2001) that temperature was relatively higher in the dry season compared to the rainy season. Higher temperature results in decreasing oxygen levels, leading to increase in metabolic rate. Consequently, the fish take up greater amounts of metal as a result of the increased diffusion or active uptake associated with higher rates of water movement across the gills or other cell membranes (Prosi, 1979). The properties of metals themselves may be directly influenced by temperature, by changing the equilibrium effect between molecular and ionised forms (Cairns *et al.*, 1975). Lower temperature would induce lower metabolism as observed during the rainy season.

In both surveys (dry and rainy season), cadmium was observed to be highest in the gills in all three locations of the River (Table 2 & 3). This difference in cadmium accumulation may be attributed to the proximity of the tissue to the toxicant medium, the physiological state of the tissue, presence of ligands having an affinity to cadmium. The greatly branched structural composition of the gill and the resultant highly increased surface area, along with the large volume of water passing through the gill surface and the highly vascular physiological state (Mayer *et al.*, 1991) make the gill a prime site for cadmium accumulation. According to Paul and

Banerjee (1997), due to the constant and increased ventilatory movements of the operculum under the influence of the xenobiotics, the protective mucous plug inside the opercular chamber is quite often discharged into the medium. These discharges of the mucous plug might make the gills a more vulnerable site for accumulation of cadmium.

Although liver and gonads do not come into direct contact with the toxicant medium, the cadmium accumulation pattern in them followed more or less the same pattern as that of the gills (Tables 2 & 3).These organs have capacity to accumulate cadmium brought by blood from other parts of the body and induce the production of the metal binding protein, metallothionein, which is believed to play a crucial role against the toxic effects of heavy metals by binding them (Bhattacharya *et al.*, 1985).

Nickel and lead, in both surveys exhibited the same accumulation pattern like copper. However, bioavailable mercury in the surface water of the river was generally not sufficient for a significant uptake by the tissues and organs of the fish

CONCLUSION

The increase in the levels of nickel, lead, copper, mercury and cadmium had been observed in Bonga fish (*Ethmalosa fimbriata*) In all metals, except mercury, the levels in the organs and tissues were quite higher compare to that in the surface water. Since *Ethmalosa fimbriata* is pelagic fish, it was possible that the uptake of the metals into its organs was from the surface water. The differences in bioaccumulation patterns in the organs and tissues of the fish may be due to differences in physiological activities of the organs and tissues and proximity of the tissue to the toxicant medium.

REFERENCE

Ajayi, T O., Ukpe, E. T., Ssentongo G. W., 1986. Marine Fishery Resources of Nigeria: A review of exploited Fish stocks. CECAF/ECAF SERIES 86/40 (En). 3pp.

Atchison, G. J., Murphy, B. R., Bishop, W. E., Meintosh, A. W., and Mayes, R. A., 1997. Trace metal contamination of bluegill (*Ponnis macrochirus*) from two Indiana Lakes. *Trans. Am. Fish. Soc.* 106 (6): 637-640.

Avenant-Oldewage, A and Marx H. M 2000 Bioaccumulation of chromium, copper and iron in the organs and tissues of *Clarias gariepinus* in the Olifants River, Kruger National Park. *Water SA* 26 (4). 569 – 582.

Batley, E. E. 1983. The Current Status of trace Element Speciation: In natural waters in trace element Speciation in surface waters (Ed) G. G leppard. Plenum press New- York. H- 36pp.

Buckley, J. T., Roch,M., McCarter, J. A., Rendell, C. A. and Matheson, A. T. 1982. Chronic exposure of coho salmon to sublethal concentrations of copper Effect on growth, on accumulation and distribution of copper, and on copper tolerance. *Comp. Biochem. Physiol.* 72 (1):15 – 19.

Bursell, D. C., 1975. Atomic spectrometric analysis of heavy metal pollutant in water. Ann Arbor Science publishers, Inc., Ann Arbor, Michigan.84pp.

Cairns, J., Heath, A. G. and Parker, B. C., 1975. The effect of temperature upon the toxicity of chemicals to aquatic organisms. *Hydrobiol.* 47 (1): 135 – 171

Egborge, A. B. M., Okoro, J. I., Alawani, O. A. and Uriah, N 1986. Thermal and Chemical Pollution of Benin River and its tributary, the Jamieson river in Nigeria. Nigerian Journal of Applied Science 4 121-149

Eloke, F. O., 2001 Environmental Impact Assesment of Petroleum exploitation on fish and mollusks in the Niger Delta Forcados River as a case study. Msc thesis. University of Benin, Benin City, Nigeria.

Essink, K., 1989. Chemical monitoring in Dutch Wadden Sea by means of benthic invertebrates and fish. *Helgolander Meerseumter* 43: 435 – 446

Fufeyin, P., 1987. Studies on the fish community of Benin river to evaluate the effects of warm water effluents discharged by the NEPA Station at Sapele Bendel State, Msc thesis. University of Benin, Benin city, Nigeria.

GESAMP 1995. Impact of oil and related chemicals on the marine environment *GESAMP reports* and studies No 50. p180.

Hampson, P. S., 1986. Effects of detention on water quality of two stormwater detention ponds receiving highway surface runoff in Jacksonville, Florida. U.S. Geol. Sur., Water – Resources Investigations Report 86-4151. pp 44-50

Jayakumar, P. and Paul, V. I. 2006. Patterns of cadmium accumulation in selected tissues of the catfish *Clarias batrachus* (Linn.) exposed to sublethal concentration of cadmium chloride. *Veterinarski Arhiv* 76: 167 – 177.

Klerks, P. L. and Levinton, J. S., 1989. Effects of heavy metals in a polluted aquatic ecosystem. In: Levin S. A., Harwell, M. A., Kelly, J. R. and Kimball, K. D. (eds.) Ecotoxicology: Problems and Approaches. Springer – Verlag, New York, USA 41 – 67

Klusek, C. S. and Heit, M., 1982 The effects of dissecting tools on the trace element of concentrations of fish and mussel tissues. Sci. Total Environ. 24: 129 – 134.

Latif, A., Khalaf, A. N. and Khalid, B. Y., 1982. Bioaccumulation of Cu, Cd, Pb, and Zn in two cyprinid fishes of Iraq. *J. Biol Sci.* 13 (2) 45-64.

Laurent, P. and Dunel. S., 1980.Morphology of gill epithelia in fish. Am. J Physiol 238: 147 – 159.

Longhurst, A., 1960. A Summary of the food of the West African demersal fish. Bull. Inst. Fondam. *Afr. Noire* (A Sci. Nat.), 22: 276 – 282.

Martin, M. H. and Coughtrey P. J., 1982. Biological Monitoring of heavy metals pollution. Applied Science London. 475pp.

Martin, T. D., Brockhoff, C. A., Creed, J. T. and Long, S. E., 1992. Determination of metals and trace elements in water and wastewater by inductively coupled plasma – atomic emission spectrometry. *I.C.P. Nws ltr*, 18(3): 147-169.

Mayer, W., Kretschmer, M., Hoffmann, A and Harish, G., 1991. Biochemical and histochemical observations on effects of low level heavy metal load (Lead, Cadmium) in different organ systems of the fresh water crayfish, *Astacus astacus* L. (Crustacea: Decapoda). *Ecotoxicol. Environ. Safe* 21: 137 – 156.

McCarter J. A. and Roch, M., 1983. Hepatic metallothionein and resistance to copper in juvenile coho salmon Comp. Biochem.Physiol 74: 133 – 137

Moffat, D and Linden, O., 1995. Perception and reality Priorities for sustainable development in the Niger Delta. Journal of the human Environment 24 (7): 528-529.

Nightingale, H. I., 1987. Accumulation of As, Ni, Cu, and Pb in retention and recharge basins soil from urban runoff. Am. Wat. Res. Ass., Wat. Res. Bull. 23(4): 663-672.

Noel-Lambot, F., Gerday, C. H. and Disteche, A., 1978. Distribution of Cd, Zn, and Cu in liver and gills of the eel *Anguilla anguilla* with special reference to metallothioneins. Comp. Biochem. Physiol. 61: 177 – 187.

Okoro, D., and Osakwe, J., 2005. Environmental impact assessment of heavy metals on fishes and crustaceans in Ogunu creek, Warri river in Niger delta area of Nigeria. In: 4th International Symposium on New Technologies for Urban Safety of Mega Cities in Asia (USMCA, October 18 – 19, 2005) Singapore. 457 – 464 pp.

Onwudinjo, C. C., 1990. Hydrology and Plankton of Benin River, Nigerian. Ph.D. Thesis, University of Benin, Nigeria

Panchanathan, J. and Vattapparumbil, I. P., 2006. Patterns of cadmium accumulation in selected tissues of the catfish *Clarius batrachus* (Linn.) exposed to sublethal concentration of cadmium chloride. *Veterinarski Arhive* 76 (2): 167 – 177

Patrick, F. M. and Loutit, M. W., 1978. Passage of Metals to fresh water fish from their food water *Res.* 12: 395-398.

Paul, V. I. and Banerjee, T. K., 1997. Histopathological changes induced by ambient ammonia (ammonium sulphate) on the opercular linings of the live fish *Heteropneustes fossils* (Bloch). *Dis. Aquat. Org.* 28: 150 – 161

Prosi, F., 1979. Heavy metals in aquatic organisms. In: Forstner, U. and Wittmann G. T. W. (eds) Metal Pollution in the aquatic environment. Springer – Verlag, Berlin, Germany. 271 – 323.

Rainbow, P. S. and Philips, D. J. H., 1993. Cosmopolitan biomonitors of trace metals Mar Pollut. Bull. 26: 593 – 601.

Stephen, W. I., 1988. Zinc Cadmium, Mercury and lead: In West TS and Nurberg HW (eds) The determination of trace metals in natural waters. Blackwell scientific Publications Oxford. Pp. 122 – 129.

Walker C. H., Hopkins, S. P., Sibyl, R. M. and Peakall, D. B., 1997 Principle of Ecotoxicology. Taylor and Francis. 112pp.