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Distribution of heavy metals in sediments of Igbede, Ojo and Ojora rivers of Lagos, Nigeria

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Abstract The distribution of some heavy metals, namely Cd, Pb, Zn, Fe, Cu, Cr and Mn in epipellic sediments of Igbede, Ojo and Ojora rivers of Lagos was studied weekly in the early summer (November) of 2003. The levels of selected trace metals were determined using Atomic Absorption Spectrophotometer (UNICAM 969 AAS SOLAR). Trends in heavy metal burdens in the sediments revealed weekly variations in all the rivers assessed. Statistical analyses also showed different mean levels of trace metals in the aquatic environments, the distribution of which followed the sequence Fe > Zn > Mn > Pb > Cu > Cr > Cd, Fe > Zn > Cu > Mn > Pb > Cr > Cd and Fe > Zn > Mn > Cu > Cr > Pb > Cd in Igbede, Ojo and Ojora rivers respectively. Fe recorded the highest concentration levels (1,582.95 ± 96.57 μg/g–1,910.34 ± 723.19 μg/g) in all the sediments investigated while the Cd levels (0.06 ± 0.10 μg/g–0.47 ± 0.36 μg/g) were the lowest. Expectedly, trace metal concentrations in fine grain muddy sediments of the Igbede and Ojo coastline were much higher than those of Ojora which consist of coarse and sandy deposits covering the near shore area. Generally, the results obtained fell within tolerable limits stipulated by World Health Organization (WHO).

Keywords Epipellic sediments · Heavy metals · Igbede river · Ojo river · Ojora river

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Introduction

Heavy metals are defined as metals having densities greater than 5 gcm^{-3} (Ademoroti, 1996a,b). In aquatic ecosystems, heavy metals are in dynamic equilibrium with pore water and the overlying water column and have pathways that are primarily associated with sediment substrates (Chapman et al., 1982). Aquatic sediments constitute the most important sink of heavy metals and other pollutants (Adams et al., 1992). The quality of sediment is, therefore, essential in assessing the pollution status of ecosystem.

Elevated metal concentrations occur in many aquatic ecosystems due to anthropogenic activities (Udosen, 1992; Forner and Wittman, 1993). The bioavailability and toxicity of sediments-associated metals are influenced by their speciation and transport dynamism which are linked to the textual composition of the sediment. The bioavailability of sediment-bound chemicals is determined by the physical, chemical and biological characteristics of the interstitial water and the sediment. The chemical partitioning between different sediment fractions is very important in determining the available levels of trace metals to benthic organisms

(Bendell et al., 1994). Several benthic organisms are associated with epipellic sediments. They burrow in the upper layer and feed on particulate matter. Trace metals can be taken up by these benthos and accumulated in the food chain (Burton, 1992). However, clear relationships between total trace metal levels in sediments and organisms inhabiting the sediments are seldom found (Van et al., 1991).

Metal contamination is attributed to natural weathering of rocks on land, volcanic activity, atmospheric deposition, industrial mining, agricultural activities, commercial fertilizers, pesticides and sewage sludge application among others. In concentrated amounts, heavy metals are lethal to organisms including humans. Accumulation of lead and cadmium in the body results in brain and kidney damages (Ademoroti, 1996a). Lead contamination leads to metabolic interference, central and nervous system toxicity while cadmium causes skeletal illnesses, high blood pressure and sterility among males. Other heavy metals are also known to have deleterious effects when introduced in undesirable amounts into the environment. In this study, the distribution of selected heavy metals in epipellic sediments of the Igbede, Ojo and Ojora rivers in Nigeria was evaluated.

Materials and methods

Study area

Epipellic sediments were collected from three sites of fresh water swamps namely Igbede, Ojo and Ojora rivers located within Ojo Local Government of Lagos State, Nigeria. These rivers drain areas like Ojo town, Ajangbadi, Sabo-Alaba and Etegbin and link together to join the Lagos creek. The rivers drain predominantly agricultural lands, industrial zones (comprising of haulage, construction and dredging activities), residential and commercial areas. The distance of the sampling sites from Ojo to Igbede is approximately 12 km, and Igbede to Ojora is about 4 km. The Long Point Biosphere Reservoir is an important fishing and fish spawning area. The map showing sampling sites are shown in Fig. 1.

Sample collection and preparation

Sediments were collected three times weekly in the early summer (November) of 2003. Samples were collected from each site at four different points with a stainless steel grap sampler and mixed together to give composite samples. They were sieved through a 500 μm mesh and allowed to stand in polyethylene bags. Subsequently, the supernatant was decanted carefully to prevent loss of sediment. After decantation, the sediment was stirred with a plastic spatula and stored in a polyethylene bag prior to determination. 1.0 g of the remaining wet sediment was digested with 20 cm^3 1:1 nitric acid and hydrogen peroxide on a hot plate maintained at 100°C inside a fume hood until white fume was evolved. The resulting digest was cooled, filtered and made up to the mark in a 25 cm^3 standard flask with deionised water.

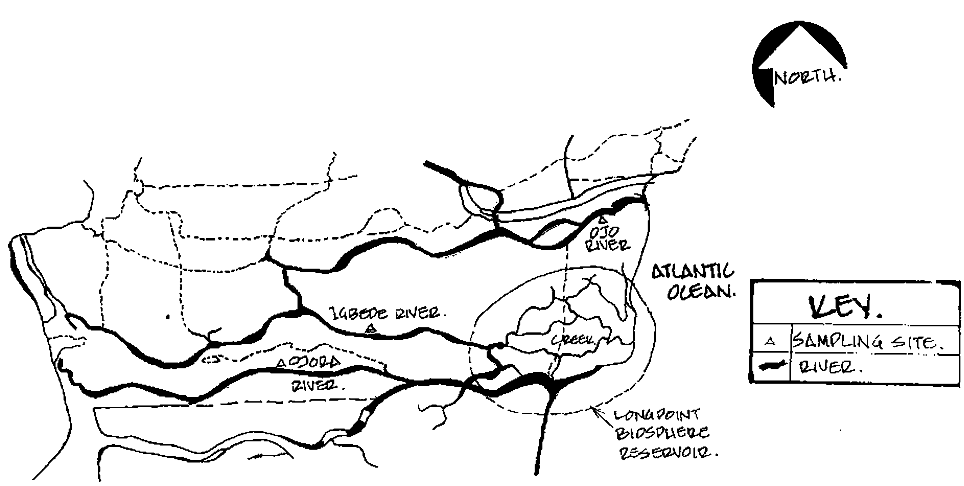

Fig. 1 Map of sampling sites

Preparation of standards

Instrumental calibration was carried out prior to metal determination by using standard solutions of metal ion prepared from their salts. Commercial analar grade 1000 ppm stock solutions of Zn^{2+}, Cd^{2+}, Cr^{2+}, Pb^{2+}, Fe^{2+}, Cu^{2+} and Mn^{2+} were diluted in 25 cm^3 standard flask and made up to the mark with deionised water to obtain working standard solutions of 2.0 ppm, 3.0 ppm and 4.0 ppm of each metal ion.

Heavy metal determination

Copper (Cu), Zinc (Zn), Cadmium (Cd), Lead (Pb), Manganese (Mn), Iron (Fe) and Chromium (Cr) levels in sediments were measured on a UNICAM 969 Atomic Absorption Spectrophotometer Solar with deuterium background corrector.

Results and discussion

The weekly distribution profiles of selected heavy metals in Igbede river (Site A), Ojo river (Site B) and Ojora river (Site C) are presented in Tables 1–4 while their concentrations reported as mean and standard deviations are highlighted in Table 5.

Trends in heavy metal burdens in the sediments revealed weekly variations in all the rivers investigated. Solomons et al. (1984) have reported that heavy metals tend to be concentrated in the finer grain sizes of sediment. This is corroborated in this study as trace metal concentrations in fine grain muddy sediments of Igbede and Ojo coastline were much higher than those of Ojora which consist of coarse and sandy deposits covering the near shore area. Variation in metal concentration in the rivers could be as a result of the cosmopolitan nature of the environment. There is a strong evidence of aerial deposit of heavy metal accumulated and leached into the rivers at various sources by rain water. There is also variation in concentration of heavy metal as a result of geochemical nature of the sediments. Statistical analyses revealed different mean levels of heavy metals in the aquatic environments, the distribution of which followed the sequence Fe > Zn > Mn > Pb > Cu > Cr > Cd, Fe > Zn > Cu > Mn > Pb > Cr > Cd and Fe > Zn > Mn > Cu > Cr > Pb > Cd in Igbede, Ojo and Ojora rivers respectively. Fe recorded

Table 1 Distribution of heavy metals in the sediments in week one of November, 2003

Heavy metal	Igbede sediment (μg/g)	Ojo sediment (μg/g)	Ojora sediment (μg/g)
Cu	6.51	9.81	4.79
Cd	ND	ND	ND
Zn	53.35	59.69	38.33
Pb	9.16	7.76	ND
Cr	ND	ND	ND
Mn	21.78	1.33	17.93
Fe	1,536.36	1,410.46	1,664.37

Table 2 Distribution of heavy metals in the sediments in week two of November, 2003

Heavy metal	Igbede sediment (μg/g)	Ojo sediment (μg/g)	Ojora sediment (μg/g)
Cu	7.55	5.00	6.92
Cd	0.25	0.67	ND
Zn	51.95	51.73	35.41
Pb	16.95	2.22	ND
Cr	ND	ND	2.15
Mn	17.96	24.79	23.76
Fe	1,990.57	1,424.46	1,479.39

Table 3 Distribution of heavy metals in the sediments in week three of November, 2003

Heavy metal	Igbede sediment (μg/g)	Ojo sediment (μg/g)	Ojora sediment (μg/g)
Cu	6.16	7.89	4.84
Cd	0.89	0.27	ND
Zn	49.28	48.80	44.06
Pb	0.70	8.84	ND
Cr	11.24	ND	10.08
Mn	20.69	ND	17.82
Fe	1,514.42	1,654.81	1,494.73

Table 4 Distribution of heavy metals in the sediments in week four of November, 2003

Heavy metal	Igbede sediment (μg/g)	Ojo sediment (μg/g)	Ojora sediment (μg/g)
Cu	10.38	11.59	6.43
Cd	0.65	0.95	0.22
Zn	52.83	53.93	36.99
Pb	9.10	ND	2.21
Cr	10.59	9.90	5.67
Mn	ND	1.20	6.19
Fe	1,492.33	3,151.61	1,693.28

Table 5 Metal concentration reported as mean and standard deviation

Heavy metal	Igbede sediment (μg/g)	Ojo sediment (μg/g)	Ojora sediment (μg/g)
Cu	7.65 ± 1.66	8.57 ± 2.44	5.75 ± 0.95
Cd	0.45 ± 0.35	0.47 ± 0.36	0.06 ± 0.10
Zn	51.85 ± 1.57	53.54 ± 3.99	38.70 ± 3.26
Pb	8.98 ± 5.75	4.73 ± 3.73	0.55 ± 0.96
Cr	5.46 ± 5.46	2.48 ± 4.29	4.48 ± 3.82
Mn	15.11 ± 8.83	6.83 ± 10.38	16.43 ± 6.38
Fe	$1,633.42 \pm 206.79$	$1,910.34 \pm 723.19$	$1,582.95 \pm 96.57$

the highest concentration levels in all the sediments assessed, while Cd levels were the lowest. The highest concentration of Fe, 3,151.61 μg/g, was recorded at Ojo river in week 4. This is largely attributed to its geochemistry and speciation in the ecosystem. Studies of the transport of heavy metals by major rivers in the world indicate that substantial quantities of Fe are transported daily and associated with suspended sediments in these rivers (Clark, 1986). Given that all the rivers investigated discharge into Lagos lagoon, they may have been enriched with Fe as a result of transportation. Ojo site, in particular, is part of the extensive commercialized zone where haulage, construction and mining activities take place.

Cr and Cd were not detected in all the sediments during the first week of investigation. Except for week 4, Cd was not detected in Ojora sediment. At 95% confidence interval, the degree of distribution of Cu, Zn, Pb, Fe and Mn in the sediment of Igbede river was significantly different while the distribution of Cd and Cr was not. At Ojo river and at 95% confidence interval, only the degree of distribution of Zn and Fe was significantly different. There was also a significant difference in the distribution of Cu, Mn and Fe at Ojora river at 95% confidence level.

Generally, the metal content profile of the aquatic sediments fell within tolerable limits stipulated by World Health Organization (Clark, 1986).

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