AES BIOFLUX

Advances in Environmental Sciences -
International Journal of the Bioflux Society

Heavy metal concentrations in the bank root sediments of the Calabar River, adjacent to the Marina resort, Calabar, Nigeria

Christopher B. Ndome, Dominic A. Mowang, Kalu A. Okorafor, Faith G. Ikpabi

Department of Zoology and Environmental Biology, University of Calabar, Calabar, Nigeria. Corresponding author: C. B. Ndome, cndome@yahoo.com

Abstract. The concentration of heavy metals in the bank root sediments of Calabar River which is adjacent to the Marina resort was analyzed from the months of July to September using the AAS technique (Atomic Absorption Spectrophotometer). Samples were collected in two locations (bank root proximal to the resort and opposite to the resort) from 3 sampling points (upstream, adjacent and downstream). Heavy metals concentration in location 1 ranged between 0.43–345.07 mg/kg for Fe; 0.46–3.85 mg/kg for Cd; 0.02–4.07 for Cr and 0.22–0.30 mg/kg for Al while in location 2 values ranged between 0.56–328.39 mg/kg for Fe; 1.29–3.22 mg/kg for Cd; 0.02–2.56 mg/kg for Cr and 0.33–0.77 mg/kg for Al, with iron found to be in the highest concentration and chromium in the lower concentration in the wet season. Some of the heavy metals analyzed were discovered to have exceeded the set limit of FEPA and WHO standard level except for chromium (0.02 mg/kg) for the month of September at both sampling locations. Analysis of variance did not differ significantly for all metals. This is an indication that there is utmost need to control industrial, domestic waste and sewage disposal into the Calabar River.
Key Words: cadmium (Cd), chromium (Cr), Aluminum (Al), iron (Fe).

Introduction. Metals and in particular trace metals are a major class of contaminants in our world arising principally from natural and anthropogenic source (Adriano 2001). Nasiri (2002) defined sediments as mild sand and solid particles that settle at the bottom of the water body (USEPA 2002). The term heavy metal refers to any metallic element that has a relatively high density and is toxic or poisonous at low concentrations examples mercury, lead and arsenic (Garbarino et al 1995; Duruibe et al 2007). The most often polluted phases of the environment are the aquatic system, especially the surface water. This is because contaminants in air, soil or on land ultimately ends up in the aquatic system via local precipitation, water surface run off and leaching of rocks and soil wastes (Forstner & Wiltmann 1979). Sewage, industrial wastes and agricultural chemicals such as fertilizer and pesticides, mineral and petroleum exploration and exploitation are however the main causes of surface water pollution (Yong 1999). Due to sediment particles, reactivity, metals tend to accumulate in sediments and as a result may persist in the environment long after their primary source has been removed.

Smolders et al (2002) in their studies of the effects of heavy metal concentrations in sediment in the Pilcomayo river in South America recorded that the extent of the contamination differs greatly among the various regions sampled during the survey, heavy metal concentration in water and sediment were lowest in the Poituco region and in the Cache Mayu river can be considered as natural background concentration. Forster & Wittmann (1983) in his studies of distribution of heavy metals in vegetation surrounding the Blackstone river in U.S.A, he recorded that the maximum concentration based on the dry analysis are 248 $mgKg^{-1}$ for Cr and 6 $mgKg^{-1}$ for Cd. In Egypt heavy metals in sediment was recorded that sediment concentration poses one of the worst environmental problems in ecosystems, acting as sinks and sources of contaminating in aquatic systems (Lin et al 2008). Sediment analysis plays an important role in accessing the pollution status of the environment (Mucha et al 2003). Edem et al (2008) reported the distribution of heavy metals in Bones, Gills, Liver and Muscles of *Oreochromis niloticus* (Tilapia) from Henshaw Town Beach market in Calabar Nigeria.

This research was aimed at determining the concentrations of some selected heavy metals (Cadmium, Chromium, Aluminum and Iron) present in each of the sediment collected from various sampling points in the study area.

Material and Method

Study location. This study was carried out in Calabar River adjacent to the Marina Resort.

It lie between longitude 08^o 25´ E and latitude 4^o N and 8^o N. Two sampling locations in the Marina resort which is adjacent to Calabar River were selected for sampling. These locations were the bank root close to the Marina resort and the bank root across the Marina resort with 3 sampling points each i.e. the upstream, adjacent and the downstream on the river bank for each locations.

Collection of samples. Sampling was conducted fortnightly for 3 months i.e. from July to September 2013 (During the wet season). Sediment samples were collected with the help of core sampler in accordance with Mwashote method (2003) which was improvised using a PVC corer pipe into tagged plastic containers to show the locations from where each sample was obtained and transported to the laboratory for analysis. In the laboratory samples were allowed to dry thoroughly at room temperature for a couple of days to remove moisture content after which samples were grounded manually to a fine powder in an alumina mortar and passed through a 2 mm mesh screen and preserved in polythene bags for further analysis for heavy metals.

Metal analysis. The analysis of heavy metals like Aluminum (Al), Cadmium (Cd) Chromium (Cr), Iron (Fe) was done using flame atomic absorption spectrophotometer. An atomizer was used with an air acetylene burner to determine the four elements present in each sample collected. For the determination of each element 10 ml of aliquot from the stock sample were taken with its volume adjusted to 100 cm^3 using distilled water. The treated samples were then analyzed for trace metals, using the atomic absorption spectrophotometer with the instrument calibrated using standard solution for the four heavy metals (Al, Cd, Cr, Fe).

Results

Variation in heavy metal concentration in the month of July. The variation in the mean heavy metals (Fe, Cd, Cr and Al) concentration in the 2 analyzed locations (close to the resort and across the resort) in the month of July are presented in Table 1.

Table 1

Heavy metal concentration (mg/kg) in 2 sampling locations on the bank root Sediments of Calabar River in the month of July

Parameter	*Heavy metal concentration*	*Mg/kg (mean±S. E.)*
	Location 1 (Close to resort)	*Location 2 (Across the resort)*
Fe	132.67±10.99	147.62±5.42
Cd	3.55±0.60	3.22±0.63
Cr	4.07±0.43	2.56±0.78
Al	0.29±0.22	0.77±0.07

Fe - Iron, Cd – Cadmium, Cr - Chromium, Al – Aluminum.

Location close to the resort recorded a mean Fe concentration of 132.67 mg/kg while across the resort recorded a mean of 147.62 mg/kg. Cd recorded a mean concentration of 3.55 mg/kg (close to the resort) and 3.22 mg/kg (across the resort). The mean concentrations of Cr close to the resort and across the resort were 4.07 mg/kg and 2.56 mg/kg respectively. While the concentrations of Al close to the resort and across the resort were 0.29 mg/kg and 0.77 mg/kg respectively (Table 1). The mean concentrations of these metals (Fe, Cd, Cr, and Al) did not differ significantly ($p>0.05$) in locations 1 and 2.

Variation in heavy metal concentration in the month of August. The variation in the mean heavy metal (Fe, Cd, Cr and Al) concentration in the 2 locations (close to the resort and across the resort) in the month of August are presented in Table 2.

Table 2

Heavy metal concentration (mg/kg) in 2 sampling locations on the bank root Sediments of Calabar River in the month of August

Parameter	*Heavy metal concentration*	*Mg/kg (mean±S. E.)*
	Location 1 (Close to resort)	*Location 2 (Across the resort)*
Fe	0.43±0.14	0.56±0.32
Cd	3.85±1.12	2.39±0.63
Cr	1.78±0.54	1.76±0.24
Al	0.30±0.15	0.33±0.19

Fe - Iron, Cd – Cadmium, Cr - Chromium, Al – Aluminum.

Location close to the resort recorded a mean Fe concentration of 0.43 mg/kg while across the resort recorded a mean of 0.56 mg/kg. Cd recorded a mean concentration of 3.85 mg/kg (close to the resort) and 2.39 mg/kg (across the resort). The mean concentrations of Cr close to the resort and across the resort were 1.78 mg/kg and 1.76 mg/kg respectively. While the concentrations of Al close to the resort and across the resort were 0.30 mg/kg and 0.33 mg/kg respectively (Table 2). The mean concentrations of these metals (Fe, Cd, Cr, and Al) did not differ significantly ($p>0.05$) in locations 1 and 2.

Variation in heavy metal concentration in the month of September. The variation in the mean heavy metal (Fe, Cd, Cr and Al) concentration in the 2 locations (close to the resort and across the resort) in the month of September are presented in Table 3.

Table 3

Heavy metal concentration (mg/kg) in 2 sampling locations on the bank root Sediments of Calabar River in the month of September

Parameter	*Heavy metal concentration*	*Mg/kg (mean±S. E.)*
	Location 1 (Close to resort)	*Location 2 (Across the resort)*
Fe	0.43±0.14	328.39±3.10
Cd	0.46±0.13	1.26±0.17
Cr	0.02±0. 01	0.02±0.01
Al	0.22±0.30	0.60±0.40

Fe - Iron, Cd – Cadmium, Cr - Chromium, Al – Aluminum.

Location close to the resort recorded a mean Fe concentration of 345.07 mg/kg while across the resort recorded a mean of 328.39 mg/kg. Cd recorded a mean concentration of 0.46 mg/kg (close to the resort) and 1.26 mg/kg (across the resort). The mean concentrations of Cr close to the resort and across the resort were 0.02 mg/kg and 0.02 mg/kg respectively. While the concentrations of Al close to the resort and across the resort were 0.22 mg/kg and 0.60 mg/kg respectively (Table 2). In the same vein, the mean concentrations of these metals (Fe, Cd, Cr, and Al) did not differ significantly ($p>0.05$) in locations 1 and 2 in the month.

Discussion. Heavy metals are among the most common environmental pollutants whose occurrences in water or biota indicates the presence of natural or anthropogenic sources

(Papafilippaki et al 2007). When these metals are deposited in estuaries and they are rapidly incorporated in bottom sediments as particulates (Hanson 1993).

Iron was found to have the highest mean concentration throughout the period of the study with values ranging between 0.43–345.07 mg/kg for two sampling locations which was above WHO/FEPA standard. This is an indication that human activities coupled with corrosion of vessels harbored at the seaport close to the marina resort increased in the month of September which affirms the report by De Gregori (1996) that marine ecosystem gets contaminated with trace metals from numerous and diverse sources. The increase in iron concentration for the various locations followed the sequence L1 > L2 for the month of September, L2 > L1 for July and L2 > L1 for August which was the lowest concentration. The high Fe content in the sediment can be attributed to the absorption of metals from surrounding water.

Cd was also seen to have a high concentration with values ranging from 0.46 to 3.85 mg/kg which was also above FEPA and WHO acceptable limit. Cd was more prevalent in the month of July which can be attributed to the indiscriminate use of commercial fertilizers, fungicides and insecticides for agricultural purposes.

Al and Cr had the lower concentration with values ranging from 0.22 to 0.30 mg/kg and from 0.02 to 2.56 mg/kg. Al was found to be above the acceptance limit of WHO and FEBA and Cd below the acceptance limit of WHO and FEBA making its less harmful to aquatic life and humans.

Conclusions. Heavy metal pollution is an ever – increasing problem of our oceans, lakes and rivers. Incidences of heavy metal accumulation in fish, sediments and other components of aquatic ecosystems have been reported from all over the world. The human activity that affects and arises from our environment depends on economic and social factors. These problems are beyond the limits of physical and institutional bodies and therefore, there is need to set common objectives and implement programmes and policies to eradicate this problem. From this study, the extremely low levels of heavy metals at some period in time would indicate that the river was not absolutely polluted. It has been recognized that long term exposure to metals with low concentration is equally harmful to man though some are essentially in life process. Although there was no significant differences in the concentration of metals in the two sampling stations from the 3 sampling points but the fluctuation in the values gotten from analysis of heavy metals in the sediment samples calls for absolute attention. It also calls for close monitoring to prevent increase in the nearest future.

References

Adriano D. C., 2001 Trace elements in terrestrial environments: Biochemistry, Bioavaliability and risks of metals. 2nd ed, Springer, New York, 860 pp.

Duruibe J. O., Ogwuegbu M. O. C., Egwurugwu J. N., 2007 Heavy metal pollution and human biotoxic effects. Int J of Physl Sci 2(5):112-118.

De Gregori I. H., Pinochet H. C., Arancibia M. J., Vidal A. B., 1996 Grain size effects on trace metals distribution in sediments from two coastal areas of Chile. Bull Environ Contam Toxicol 57:163–170.

Edem C. A., Akpan S. B., Dosunmu M. I., 2008 A comparative assessment of heavy metals and hydrocarbon accumulation in *Sphyrena afra*, *Oreochromis niloticus* and *Elops lacerta* from Anantigha beach market in Calabar – Nigeria. Afr J Environ Pollut Health 6:61-64.

Forstner U., Wittman G. W., 1979 Metal pollution in aquatic environment. Springer Verlag, Berlin, p. 486.

Forstner U., Wittmann G. T., 1983 Metal pollution in aquatic environment. 2nd ed, Springer – Verlag, Berlin, p. 486.

Garbarino J. R. H., Roth D., Antweider R., Brinton T. I., Taylor H., 1995 Contaminations in the Mississippi River, U.S. Geological Survey Circular 1133, Virginia, U.S.A.

Hanson N. W., 1993 Official standardized recommended methods of analysis. Society for analytical chemistry, London, pp. 323–384.

Lin C., He M., Zhou Y., Guo W., Yang Z., 2008 Distribution and contamination assessment of heavy metals in sediment of the second Songhua River, China. Environ Monit Assess 137(1-3):329-342.

Mucha A. P., Vasconcelos M. T. S. D., Bordala A. A., 2003 Macro benthic community in the Deuro Estuary relations with heavy metals and natural sediment characteristics. Environ Pollut 121:169–180.

Mwashote B. M., 2003 Levels of cadmium and lead in water, sediments and selected fish species in mombasa, Kenya. Western Indian Ocean Journal of Marine Science 2(1):25–34.

Nasiri F., Maqsood I., Huang G., Fuller N., 2007 Water quality index: A fuzzy river-pollution decision support expert system. J Water Resour Plann Manage 133(2):95-105.

Papafilippaki A. K., Kotti M. E., Stavroulakis G. G., 2007 Seasonal variations in dissolved heavy metals in the Keritis River, Chana, Greece. Proceedings of the 10th International Conference on Environmental Science and Techology, Kos Island, Greece, pp. 579-585.

USEPA (United States Environmental protection Agency), 2002 Water quality monitoring for coffee Greek (PosterCountry, in Diana). Retrieved in September 28, 2012 from http: www.sepa/research.htm.mode.

USEPA (United States Environmental Protection Agency), 1986 A quality criteria for water. Office of water Regulation and standards, Washington D.C. 20460.

Smolders A. J. P., Vander Velde G., Roelofs J. G. M., Guerrero Hiza M. A., 2002 Dynamics of discharge sediment transport, heavy metal pollution and sabato (*Prochiodus ilneatus*) catches in the lower Pilcomayo River (Bolivia). River Research Application 18:415-427.

Yong T. C., 1999 Water pollution by agriculture, agro industry and mining in metalsia. Proceedings of the regional workshop on water quality management and control of water pollution in Asia and the pacific FAO water reports 21:133-138.

Received: 19 June 2014. Accepted: 22 July 2014 Published online: 09 September 2014.

Authors:
Christopher B. Ndome, University of Calabar, Department of Zoology and Environmental Biology, Nigeria, Calabar, P. M. B. 1115, Etta Agbo Street, e-mail: cndome@yahoo.com
Dominic A. Mowang, University of Calabar, Department of Zoology and Environmental Biology, Nigeria, Calabar, P. M. B. 1115, Etta Agbo Street, e-mail: dominicmowang@yahoo.com
Kalu A. Okorafor, University of Calabar, Department of Zoology and Environmental Biology, Nigeria, Calabar, P. M. B. 1115, Etta Agbo Street, e-mail: okoraforka@yahoo.com
Faith G. Ikpabi, University of Calabar, Department of Zoology and Environmental Biology, Nigeria, Calabar, P. M. B. 1115, Etta Agbo Street, e-mail: ikpabifaith4u@yahoo.com

How to cite this article:
Ndome C. B., Mowang D. A., Okorafor K. A., Ikpabi F. G., 2014 Heavy metal concentrations in the bank root sediments of the Calabar River, adjacent to the Marina resort, Calabar, Nigeria. AES Bioflux 6(3):209-213.