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Assessment of heavy metals in Ulasi River sediments, Okija, Anambra State, Nigeria

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Abstract: The concentrations of ten heavy metals (As, B, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn) in surface sediments of Ulasi River, Okija in Anambra state Nigeria were assessed. Data from three sample stations that include; station A. Ubahuabuba, station B. below the bridge along Okija-Nnewi road, and station C. Onitsha – Owerri road were analysed. The result was obtained using ANOVA statistical analysis and there was a significant difference of 0.05%. The results obtained also revealed that the mean concentrations of the metals ranged from Arsenic 0.57 to 0.72mg/l, Boron 1.28 to 1.86mg/l, Cadmium 0.47 to 0.94mg/l, Chromium 0.67 to 0.96mg/l, Lead 0.94 to 1.30mg/l, Manganese 0.78 to 1.18, Fe 1.28 to 2.38mg/l, Cu 0.69 to 1.07mg/l, Zn 1.10 to 2.10mg/l and Nickel 1.10 to 1.36mg/l. When compared with the guidelines of the EPA for sediments, the results of the metals analysed were within the recommended threshold limits.

Keywords: Heavy Metal, Sediment, Ulasi River, Contamination and EPA guidelines

Introduction

Pollution is considered one of the most serious problems that face human societies in the whole world, especially in developing countries. Though sometimes generated by man due to his activities, it has deleterious effects on the environment and resources [Leoni and Satori, 1996; Mendil *et al.*, 2007]. So, pollution and its effects are considered one of man's greatest crimes against himself. Pollutants may cause primary damage, with a direct identifiable impact on the environment, or secondary damage in the form of minor perturbations in the delicate balance of the biological food web that are detectable only over long periods [Sharma, 2012; Ghani, 2015].

Aquatic habitats, especially freshwater ecosystems, are more subjected to pollution than other environments, because of water use in industrial processes as well as the discharge of effluents from industry and urban development [Demirak *et al.*, 2006; Fernandesa *et al.*, 2007]. Most aquatic ecosystems can cope with a certain degree of pollution, but severe pollution is reflected in a change in the fauna and flora of the community, which suffers such pollution. However, the pollution of the aquatic environment with heavy metals has become a worldwide problem and of scientific concern because the metals are indestructible and most of them have toxic effects on organisms (Macfarlane and Burchett, 2000; Censi *et al.*, 2006; Orosanye *et al.*, 2010). Heavy metals refer to any metallic chemical element that has a relatively high density with a specific gravity that is at least five times the specific gravity of water (Lars, 2003). Heavy metals enter rivers and lakes from a variety of sources that include the rocks and soils directly exposed to surface water, in addition to the discharge of various treated and untreated liquid wastes to the water bodies (APHA *et al.*, 2005; Alaa and Osman, 2010). There are over ten (10) heavy metals such as cobalt (Co), lead (Pb), mercury (Hg), arsenic

(As), thallium (Tl), nickel (Ni), manganese (Mn), zinc (Zn), cadmium (Cd), and chromium (Cr) that have a particular significance in ecotoxicology since they are highly persistent (Storelli *et al.*, 2005). The levels of metals such as Mn, Zn, and Cr are toxic beyond a certain limit, whereas Pb, Ni, and Cd are toxic even in trace amounts (Bury *et al.*, 2003; Fernandes *et al.*, 2008). Heavy metals are the most common environmental pollutants and a serious threat due to their toxicity, long persistence, biomagnifications, and bioaccumulation in the food chain [Papagiannis *et* al., 2004]. Toxicity is realized when these heavy metal levels are higher than the recommended limit which is different for individual elements in drinking water. Heavy metals from natural and anthropogenic sources such as industrial effluents, agricultural runoff, transport, burning of fossil fuels, geochemical structure, and mining activities are continually released into aquatic ecosystems [Adnano, 1986; Kalay and Canli, 2000; Papagiannis *et al*., 2004]. Both natural and anthropogenic activities are responsible for the abundance of heavy metals in the environment (Wilson and Pyatt, 2007; Khan *et al*., 2008).

Although essential heavy metals are generally considered to be less toxic than non-essential metals (Batley, 1983), they are toxic when present in elevated concentrations in the environment (Bryan, 1971; Du Preez and Van Vuren, 1994; Sanders, 1997). Various environmental factors like temperature, pH, water hardness, dissolved oxygen, light, salinity and organic matter can influence the toxicity of metals in solution (Bryan, 1976).

Heavy metals enter the aquatic ecosystem from both natural and anthropogenic sources. Entry may be as a result of direct discharges into both fresh and marine ecosystems or through indirect routes such as dry and wet deposition and land run-off [Biney *et al.*, 1994]. Important natural sources are volcanic activity, continental weathering and forest fires. The contribution from volcanoes may occur as large but sporadic emissions due to explosive volcanic activity or as other low continuous emissions, including geothermal activity and magma degassing [FAO, 1992].

It is aimed that the outcome of this research work would guide both the inhabitants or dwellers as well as the policymakers and the law enforcement agencies, on the need and importance of a cleaner environment for both the dwellers and aquatic lives.

Materials and Methods

Description of study area / experimental site

The study area was carried out along the Ulasi River in Okija, Anambra State and the investigation was conducted in three stations.

The Ulasi River proceeds from a source in Dikenafai (latitude 050 45'N, longitude 070 10'E), in Imo State, flowing west through Ezinifite, Anambra State, Osu, Azia, Ukpor, Ihembosi, Ozubulu and Okija. Ubu River, a tributary with its source at Nnewi, passes through Nza-Ozubulu and Ihembosi where it joins. The vegetation is majorly composed of palm trees, bamboo trees, water hyacinths, grasses and shrubs amongst others. It is the only natural surface water for domestic use by the host communities. The study area is characterized by agricultural activities as the major activity in the area. Ulasi River receives effluents from waste dumped by the people of the community, washing Clothes and cars, swimming, and Waste carried out by run-off water from nearby communities. The River transverses the Onitsha-Owerri express road and the Okija-Nnewi road.

Sample stations

Sediment samples were obtained from three areas of activities along the way to Ulasi River at Okija Anambra State. Three sampling sites, Station(A) for drinking water and the other located at Ubahuabuba, Station(B) for bathing Swimming, washing clothes, washing vehicles and fetish activities located near the bridge along the Okija-Nnewi road, Station(C) gutter discharge, refused dumped and fetish activities located near the bridge along Onitsha-Owerri road

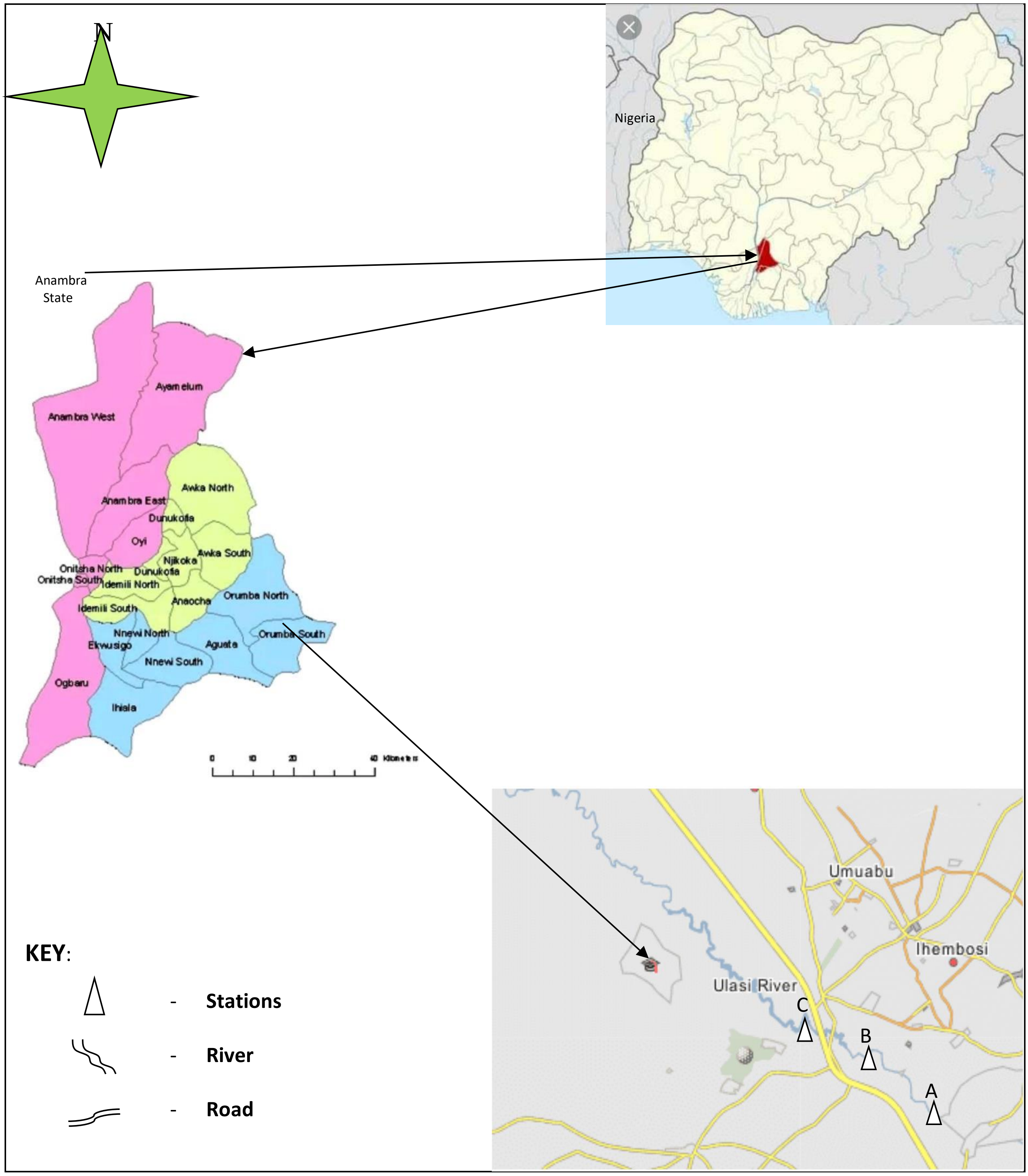

Figure 1: Map of the study site

Sediment sample collection

The sediment samples from each station were collected using PVC of 5cm diameter which was pushed with pressure through the water to obtain the sediment layer at a depth of 15cm. It was pure into a dried well-cleaned polythene bag and was tied up. The samples were properly labelled for identification of sources on the site and immediately transported to the laboratory as soon as after sampling for preservation and analysis. The sediments were air-dried at 150^{o}C until there was no further change in weight.

Statistical analysis data

The heavy metals are statistically analysed using analysis of variance (ANOVA) to detect any significant differences using SPSS (Statistical Package for Social Sciences).

Results and Discussion

Results

Heavy metals in sediment

The results of heavy metal concentrations (As, B, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn) in the water samples from the various sampling sites are presented below

Table 1: Mean concentrations of heavy metals in sediment (mg/Kg)

Heavy Metals	Station A	Station B	Station C
As	$0.67\pm0.03^{e}_{ab}$	$0.72\pm0.01^{f}_{a}$	$0.57\pm0.04^{h}_{b}$
B	$1.28\pm0.02^{a}_{c}$	$1.52\pm0.01^{a}_{b}$	$1.86\pm0.03^{c}_{a}$
Cd	$0.47\pm0.04^{f}_{c}$	$0.59\pm0.03^{g}_{b}$	$0.94\pm0.03^{g}_{a}$
Cr	$0.67\pm0.03^{e}_{c}$	$0.88\pm0.03^{e}_{b}$	$0.96\pm0.02^{g}_{a}$
Cu	$0.69\pm0.03^{e}_{c}$	$0.88\pm0.03^{e}_{b}$	$1.07\pm0.02^{f}_{a}$
Fe	$1.28\pm0.03^{a}_{b}$	$1.37\pm0.04^{b}_{b}$	$2.38\pm0.03^{a}_{a}$
Mn	$0.78\pm0.03^{d}_{c}$	$0.89\pm0.02^{e}_{b}$	$1.18\pm0.03^{e}_{a}$
Ni	$1.10\pm0.02^{b}_{b}$	$1.18\pm0.03^{c}_{b}$	$1.36\pm0.03^{d}_{a}$
Pb	$0.94\pm0.03^{c}_{c}$	$1.10\pm0.02^{d}_{b}$	$1.30\pm0.02^{d}_{a}$
Zn	$1.10\pm0.02^{b}_{c}$	$1.37\pm0.03^{b}_{b}$	$2.10\pm0.02^{b}_{a}$

Notes: Results are means± standard error of means of three replicates. The superscripts show that means that do not share a letter by column are significantly different at 0.05 level of significance, while the subscripts show that means that do not share a letter by row are significantly different at 0.05 level of significance. = significant at alpha = 0.05.

Table 2: Comparison of observed sediment concentration and EPA Guidelines (mg/Kg)

Elements	Not polluted	Moderately polluted	Heavily polluted	Present study
As	ND	ND	ND	0.57-0.7
B	-	-	-	1.28-1.86
Cd	-	-	>6	0.47-0.94
Cr	<25	25-75	>75	0.67-0.96
Cu	<25	25-50	>50	0.69-1.07
Fe	ND	ND	ND	1.28-2.38
Mn	<300	300-500	500	0.78-1.18
NI	<20	20-50	>50	1.10-1.36
Pb	<40	40-60	>60	0.94-1.30
Zn	<90	90-200	>200	1.10-2.10

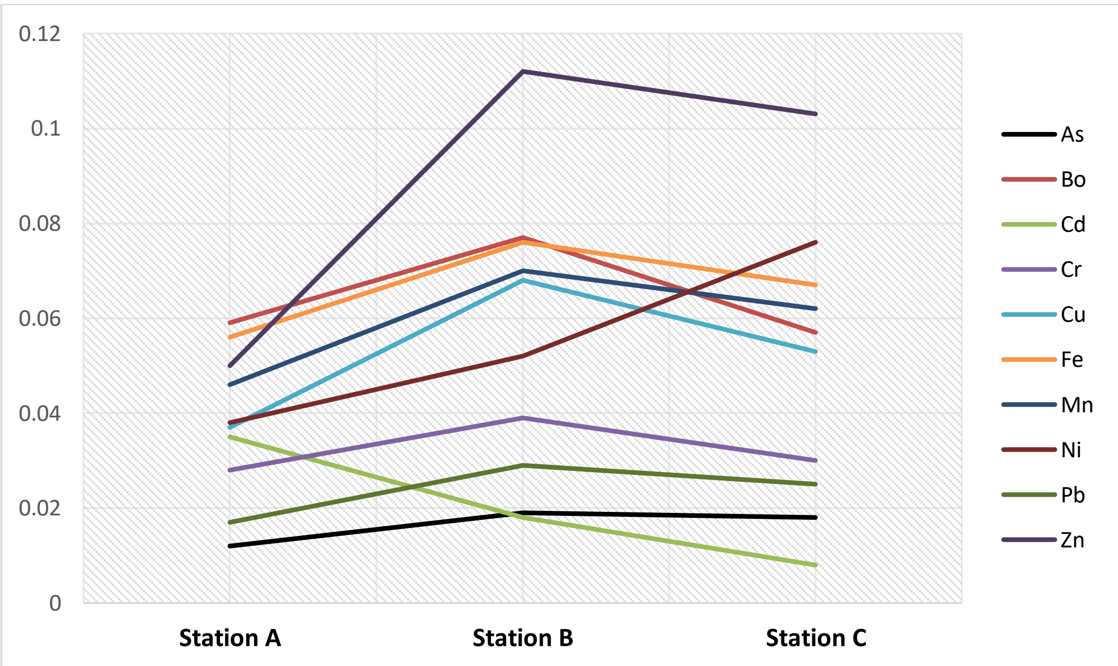

Figure 2: Line graph of Sediment Heavy Metal Concentrations at Stations A, B and C

Discussion

Heavy metal Concentration in Sediments

The accumulation of heavy metals in sediments can be a secondary source of water pollution, once an environmental condition has changed (Chen *et al.*, 1996, Cheung *et al.*, 2003). Therefore, an assessment of heavy metal contamination in sediments is an indispensable tool in assessing the risk of an aquatic environment. To assess metal concentrations in sediments, the EPA guidelines were applied and compared with the results of the analysis. If the metals in the sediments are above the recommended limits, harmful effects are likely to be observed whereas the harmful effects are unlikely if the results of the analyzed metals are below the recommended limits. Heavy metal concentration in bottom sediment is an unbraced and reliable index of water contamination and total anthropogenic load (Penri *et al*., 1997). To effectively assess the metal content in the Ulasi River sediment, the concentration of heavy metals was compared to the EPA recommendation. By comparing the accumulation of heavy metals in sediments, it can be concluded that the heavy metals ranged from Fe, Zn, B, Ni, Pb, Mn, Cr, Cu, Cd and As in increasing order of occurrence.

From the result (table 2), all the metals from different stations, Fe was found to have maximum value in station C followed by Zinc with the range of 2.38±0.03mg/kg and 2.10±0.02mg/kg significantly both in station C, Cd was also found to have the minimum value 0.47±0.04mg/kg in station A. Iron is one of the essential elements in human nutrients; however, its presence at elevated concentrations in aquatic ecosystems possesses serious pollution and health problems. The toxicity of iron in humans has been found to cause vomiting, diarrhea and cardiovascular collapse, while iron deficiency may lead to failure of blood clotting. Statistical analysis using ANOVA showed that there was a significant difference in the levels of Fe from station A to station C according to EPA guidelines, there is a "No Detection", however, some other guidelines reveal that an Iron concentration of above 15kg might lead to pollution of the aquatic environment.

Zinc plays a biochemical role in the life processes of all aquatic plants and animals; therefore, they are essential in the aquatic environment in trace amounts, but at elevated levels, it is toxic to some species of aquatic life (WHO, 2004).

Cadmium in higher concentrations is extremely toxic to the fish population. The highest level of Cd obtained in sediment in this area of study might be due to agricultural run-off, the presence of fertilizers, pesticides and other agrochemicals used. Apart from natural sources, other probable sources of this metal in sediment include agricultural soils where phosphate fertilizers are used. The level of cadmium from three sampling stations was below the recommended EPA guideline standard value for which a value of 6 mg/kg shows heavy pollution.

Conclusion

This study shows that the concentration of heavy metals recorded for the sediment was within the recommended threshold limit as stipulated by the EPA, and the succeeded values indicate that the sediment samples from the three stations were uncontaminated however; more works are periodically recommended as well as suggested on the site to ensure that the results are sustained without interferences of anthropogenic sources.

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