Assessment of the Levels of Trace Elements Contamination in Sediments From Ebe And Ora Rivers South Eastern Nigeria

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ABSTRACT:

The top and bottom sediments samples were collected from Ebe and Ora Rivers for the period between November 1999 to September 2000. Metals such as calcium magnesium, sodium, potassium, copper, zinc, iron, lead and cadmium were determined using atomic absorption/emission spectrometer 200 A. The results obtained showed that there were monthly and seasonal variations in the concentrations of the metals in both top and bottoms sediments for Ebe and Ora Rivers. There were no remarkable differences in the metal concentrations in sediments from Ebe and Ora Rivers. The concentrations of calcium, zinc, copper, lead and cadmium were found to be lower when compared to other works reported by researchers. These metals level did not indicate pollution except iron which has the highest values in both top and bottom sediments for both rivers (top sediment 69.303mg/kg dry weight, bottom sediments 67.164mg/kg dry weight for Ebe River top sediment 60.676mg/kg dry weight for Ora River). The spearman rank correlation coefficient indicated that significant relationships ($p < 0.01$) and (p 0.05) existed for the concentrations of sodium potassium, copper, zinc, lead and cadmium between top sediments and bottom sediments

Key Words: Trace elements, sediment contaminations, top and bottom sediment, monthly and seasonal variations, metal concentrations.

INTRODUCTION:

The major sources of pollution in streams and rivers are the effluents from industries and untreated wastes. The movement, accumulation and composition of sediments in aquatic environment were addressed in several publications. Suspended particulate materials of the Krishna River Basin, India, were found to be high in heavy metals (V, Cr, Mn, Fe, Co, Ni, Zn and Pb)(Remesh, 1996). The mean cadmium levels in sediments obtained by Adams et al. (1998) from Newark Bay and Lower Harbour in New York and New Jessey were 2.5mg/kg dry weight and 0.5mg/kg dry weight respectively. Fly ash effluents from the ash ponds significantly increased the concentration of some elements such as Al, Sb, Bi, Cd, Co, Li, Mn, Mo, K and Zn in river water (Walia and Mehra, 1998). Six sediment samples from Kastela Bay studied by Goner et al. (1996) revealed that the elevated concentrations of cadmium found in top sediments were due to anthropogenic activities. According to them, the anthropogenic influence on Pb, Cu and Zn concentrations was identified in all surface sediment samples. Studies on the surface sediments of Elmex region of the Mediterranean in front of Alexandria (Saad et al., 1981) revealed two zones, one of which showed high concentrations of Mn, Cu, Cd, Zn, and Fe as a result of discharges of industrial effluents. Their findings also suggested incorporation of similar proportions of Fe and Mn into the sediments and the co-precipitation of Cu and Zn by iron oxides. Ndiokwere and Guinn (1983) determined As, Cd, Cr, Hg, Mn, Mo, Ni, Se and Sb in two Nigerian rivers and two harbours and attributed high metal concentrations to local pollution sources. In their studies of streams and lakes around Ibadan, Mombeshora et al. (1993) reported much higher levels of lead in sediments than in water. Saad and Fahmy (1985) studied the occurrence of trace metals in surficial sediments from the Damietta estuary of the Nile and concluded that the eastern side of the estuary was exposed to more pollution than the Western side. According to them, areas of maximum averages of Cu, Zn and Cd coincided with the discharge sites of sewage wastes. Many earlier studies have indicated the presence of high levels of trace metals in sediments from estuarine receiving effluent from pig farming (Ishail and Ramli, 1997). The heavy metal contents of the sediments from Paraguay River exhibited seasonal variations (Facetti et al., 1998). The metal contents in the sediments from Elbe River compared to the geochemical background concentrations were highest for Ag, Cd, Cu, Hg, Zn, Pb and As. Most of the contaminants in the bottom sediments appear to be bonded to hydrate of Fe and Mn oxides and to particulate loading (Zdnak, 1996). cadmium levels found in the top sediments of Lagos Lagoon were lower than those of bottom sediments (Nwajei and Gagophine, 2000). Chemical variables related to the retention of heavy metals by sediments were measured by Horsfall et al. (1999) from Okrika River.

The Nkalagu cement factory is located near the Ebe and Ora Rivers. The cement dust, effluent and fossil fuels arising from the factory are discharged into the two rivers. Therefore it became desirable to determine the levels of heavy metals and to identify the source of metal pollutants of both rivers.

AREA OF STUDY

Geographically, the study area cuts across Enugu and Ebonyi States. Ebe River rises from the hills of Umuosigide village of Obollo Eke and flows by the Nigeria cement factory at Nkalagu. It empties into Cross River which rises from Ezimo Hills and also flows by the Nigerian cement factory. The cement factory discharges its industrial emissions and effluents into the rivers. The villagers in Nkalagu and Eha-Amufu depend on both rivers for their water supply.

MATERIALS AND METHODS

Top and bottom sediment samples were taken in the day time for the period covering November 1999 to September 2000. The top sediment samples were collected at the rivers bank in plastic containers with sealed cover. Bottom sediments were collected at the bottom of the rivers. The sediments were air-dried at 60°C. Coarse materials were removed manually, after which they were sieved over 2mm mesh and ground to obtain homogeneity (Ofino and Pederson, 1996; UNEP, 1985). 5g of dried sediment was weighed and transferred into a conical flask. An acid mixture (40ml) prepared by mixing equal volumes of concentrated HNO_3 and $HClO_4$ was used in digesting the sediment sample contained in the conical flasks (Ofino and Pederson, 1996; In-Young et al., 1996). The resultant solution in the conical flask was placed on hot plate with constant stirring before transferring into the fume cupboard to stay overnight. After cooling, the mixture was filtered and the filtrate was made up to 100 ml in a volumetric flask with deionized water. The solutions were stored in the refrigenerator prior to metal determination using atomic absorption spectrometry (Atomic Absorption/Emission Spectrometer 200-A).

RESULTS AND DISCUSSION

The mean and range values (n=11) of metals obtained in top and bottom sediments from Ebe and Ora Rivers are presented in Tables 1 and 2 respectively. This study revealed that metals analysed were detected for both rivers. Monthly and seasonal metals variations were observed. High metal concentration for sodium, potassium, magnesium, calcium and iron were recorded in top and bottom sediments from both rivers. Also high levels of these metals were obtained in top sediments when compared with those for bottom sediments except for iron in sediments from Ora River. Weathering products expected from the underlying geologic units could account for the presence of these metals. Highest iron concentrations obtained in top and bottom sediments are due to the fact that it can complex with other minerals or organic substances. Soil leaching and run off could also account for the elevated concentration of iron.

Table 1: Mean and range concentration of metals in mg/kg dry weight for top and bottom sediments from Ebe River (n=11).

Element	Mean	Range	Mean	Range
Na	6.465	1.55-16.95	5.955	1.54-16.46
K	6.038	0.76-16.08	2.205	0.90-5.46
Mg	4.212	1.639-13.08	4.044	1.41-18.01
Ca	5.111	1.00-18.144	1.865	1.00-3.155
Zn	0.702	0.493-1.159	0.859	0.244-2.17
Fe	69.303	11.20-178.00	67.164	12.504-152.00
Cu	0.112	0.073-0.25	0.160	0.0250-0.67
Pb	0.890	0.00-3.00	1.081	0.00-4.00
Cd	0.026	0.00-0.10	0.032	0.00-0.11

Table 2: Mean and Range concentrations of metals in mg/kg dry weight for top and bottom sediments from Ora River (n=11).

Element	Mean	Range	Mean	Range
Na	7.686	1.914-26.44	5.90	1.643-16.70
K	2.908	0.93-1.764	1.889	0.905-3.58
Mg	6.475	0.59-28.62	4.89	1.385-16.48
Ca	9.292	0.60-76.70	3.328	1.111-17.32
Zn	0.777	0.056-1.658	0.626	0.28-0.94
Fe	60.676	11.635-111.33	66.517	11.704-170.00
Cu	0.195	0.055-0.35	0.122	0.00-0.40
Pb	0.668	0.00-2.20	0.649	0.00-2.40
Cd	0.033	0.00-0.09	0.019	0.00-0.04

There are no remarkable differences in the metal concentrations in the top and bottom sediments from Ebe and Ora Rivers (Tables 1 and 2). Metal levels for Ca, Zn, Cu, Pb, and Cd for both rivers are low when compared with the mean concentrations (18.00mg/kg dry weight for Ca, 88.00 mg/kg dry weight for Zn, 23.20mg/kg dry weight for Cu, 34.50mg/kg dry weight for Pb and 0.086mg/kg dry weight for Cd respectively) reported by Fung and Lo (1997) in Kong city. On the other hand, the mean concentrations of Fe are higher than the mean value (44.30mg/kg dry weight Fe) of Fe from the sediment core of Sai Kung Bay (Fung and Lo, 1997). The metal concentrations for Cu, Zn, Pb and Cd for both rivers are low when compared with the range of trace metal concentrations (4-670 µg/g for Cu; 4-55µg/g for Cu; 4-55µg/g for Zn; 3.4-465µg/g for Pb and 0.1-2.1µg/g for Cd respectively) reported by Ismail and Ramli (1997) for sediments from estuaries receiving effluent from pig farming. Metal levels for Zn, Cd, Pb, Cu and Fe (30mg/kg dry weight for Zn; 8.60 mg/kg dry weight for Cd; 259.80 mg/kg dry weight for Pb; 9.00mg/kg dry weight for Cu; 85548.00 mg/kg dry weight for Fe respectively reported by Nwajei and Gagophien (2000) from Lagos Lagoon were higher than those obtained in this study. The increasing order of magnitude for trace elemental concentrations for top and bottom sediments are arranged as follows: top sediments Cd< Cu< Zn<Pb<Mg<Ca<K< Na< Fe, bottom sediments Cd<Cu<Zn< Pb<Ca< K< Mg<Ca< Na< Fe< for Ebe River; top sediments Cd< Cu< Pb<Zn< K<Mg <Na <Ca <Fe; bottom sediments Cd<Cu< Zn< Pb< K< Ca< Mg< Na< Fe for Oral River.

Table 3: Spearman Rank Correlation Coefficients between top sediments and bottom sediment (TS/BS)

	EBE RIVER	ORA RIVER
Element	TS/BS	TS/BS
Ca	NS	NS
Mg	NS	NS
Na	0.917*	0.799*
K	0.829*	0.792**
Cu	0.998*	0.999*
Zn	0.988*	0.991*
Fe	NS	NS
Pb	0.991*	0.997*
Cd	0.999*	0.999*

Levels of significance
*= $P < 0.01$
** = $P < 0.05$

NS = Not significant

Statistical analysis (Table 3) using spearman rank correlation coefficient indicates that the levels of significance for Na, Cu, Zn, Pb and Cd between top sediments and bottom sediments for both rivers were the same ($P < 0.01$) except for K where TS/BS for Ebe is $P<0.01$ and that of Ora is $P<0.05$. the level of significance were not found for the concentrations of Ca, Mg and Fe for both rivers. This is an indication that the sources of metals such as Na, KI, Cu, Zn, Pb and Cd are not the same with those for Ca, Mg and Fe from both rivers. The statistical analysis also indicated that an increase in metal concentrations in top sediments is associated with an increase in bottom sediments. The sources of these metals in this study are traceable to geochemical processes and emissions from fossil fuels from Nkalagu cement factory.

CONCLUSION

The metals analysed in sediments of Ebe and Ora Rivers were all detected. There were monthly and seasonal variations in metal concentrations due to seasonal changes. There were no significant differences in the metal values between top and bottom sediment for Ebe and Ora Rivers. Significant relationship existed for concentrations of Na, K, Cu, Zn, Pb, and Cd between top sediments and bottom sediments using spearman rank correlation coefficients. Highest iron concentrations were obtained in top and bottom sediments for both rivers. The presence of heavy metals in top and bottom sediments from both rivers is attributed to geochmeical processes and fossil fuels emission from Nkalagu cement factory.

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