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Heavy Metals Concentrations in Coal and Sediments from River Ekulu in Enugu, Coal City of Nigeria

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ABSTRACT: The levels of some heavy metals such as; Mn, Cr, Cd, As, Ni, and Pb were analysed in coal and sediment samples from River Ekulu in Enugu, Coal City using Atomic Absorption Spectrophotometer (AAS) model Spectra-AA-10 variant. Mean concentrations of Mn (0.256-0.389mg/kg) and Cr (0.214-0.267 mg/kg) are high relative to concentrations of Cd (0.036-0.043 mg/kg), As (0.016-0.018 mg/kg), Ni, (0.064-0.067 mg/kg) and Pb (0.013-0.017 mg/kg). Except for Mn, there is a steady decrease in the concentration of all metals from November to March corresponding to decreasing run-off. Metal concentrations are generally higher in the coal samples than in the sediments. Selective leaching of these metals is suspected from the trends of their concentration. Seasonal fluctuations are higher in the sediments than the coal samples. Correlation coefficients show that all the metals are positively correlated with each other implying that they are from the same source or origin. The presence of toxic metals in the area is established, calling for the assessment of their impact on the health of human and aquatic lives around the area. @JASEM

Heavy metals can be present in amounts several times higher than their natural background levels and pollute marine sediments in coastal regions near industries and urban areas (Bower, 1979). In Chile and Taiwan, 0.2mg/l arsenic in drinking water and taken for a long time has been calculated as the threshold for skin cancer. Chromium contamination is common in soils and in both ground and surface waters in industrial areas (Katz and Salem,1994). Arsenic concentrations in undistributed soils range from 0.1 to 97mg/kg (Shacklette and Boern, 1984). Hence metals are efficiently bound and accumulated by sediment but are also subject to partial release into the overlying water (Jackson, 1998). Contamination of surface and subsurface environment by heavy metals has established the need to understand metal-soil interactions. Heavy metals may enter soil and aquatic environments via sewage sludge application, mine waste, industrial waste disposal, atmospheric deposition and application of fertilizers and pesticides (Forstner, 1995). For most of the past century, streambed sediment was collected primarily to look for Ore bodies that could be of economic importance. More recently however, the primary interest has shifted to assessing whether trace elements are detrimental to aquatic biota or human health arsenic has been found to have an effect on the liver by causing a disease called cirrhosis (Hutton, 1987). Coal contains diverse amounts of trace elements in their overall composition (Thomas, 1992). The sediments of the sea station of the Indian Ocean showed elevated levels for most of the metals (Stanton et al, 1983). Aerial transport of precursors of acid rain cause leaching of heavy metals to sediments and suspension in the water column. Metals mobilized in soil and sediment as a result of deposition are cadmium, zinc, arsenic and selenium (Maugh, 1984). About 90% of lead is associated with suspended sediments, most of it is a result of runoff from urban areas and from industrial sites (Trefry and Metz, 1985). Coal is a sediment, organoclastic in nature, composed of lithified plant remains, which has the important distinction of being a combustible material (Thomas, 1992). Certain trace elements such as lead, arsenic, cadmium, chromium, and mercury if present in high amount could preclude the coal from being used in environmentally sensitive situations (Ward, 1984). Ekulu River is the largest body of inland waters in Enugu Urban, which is of considerable importance industrially, culturally, and in agriculture. Ekulu coal mine is located by the bank of the Ekulu river. The coal mine station discharges its effluents directly into River Ekulu. Therefore it is suspected that domestic and industrial effluents and waste waters arising from the coal mine and carrying these toxic heavy metals must have contaminated the sediments. The objective of this study therefore is to assess the levels of heavy metals in sediments and coal from Ekulu River.

AREA OF STUDY: Enugu town has been known to be a coal city in Nigeria. It is situated on the western edge of the Cross river plain and is dominated on the west by the Enugu escarpment (Fig 1). The escarpment is highly indented by deep valleys that have been cut by headwaters of the Ekulu, Nyaba and Atafo streams near the sources of some tributaries. Intense gulling has led to the choking of the larger streams with coarse sand up to fifteen kilometres beyond the point where they debouch on the plane. The area is underlain by Enugu Shale and the Lower Coal Measure, both of which crops out at the escarpment. The area of this study includes the source of Ekulu River (Near Ekulu coal mine) and Abakiliki expressway in Enugu town.

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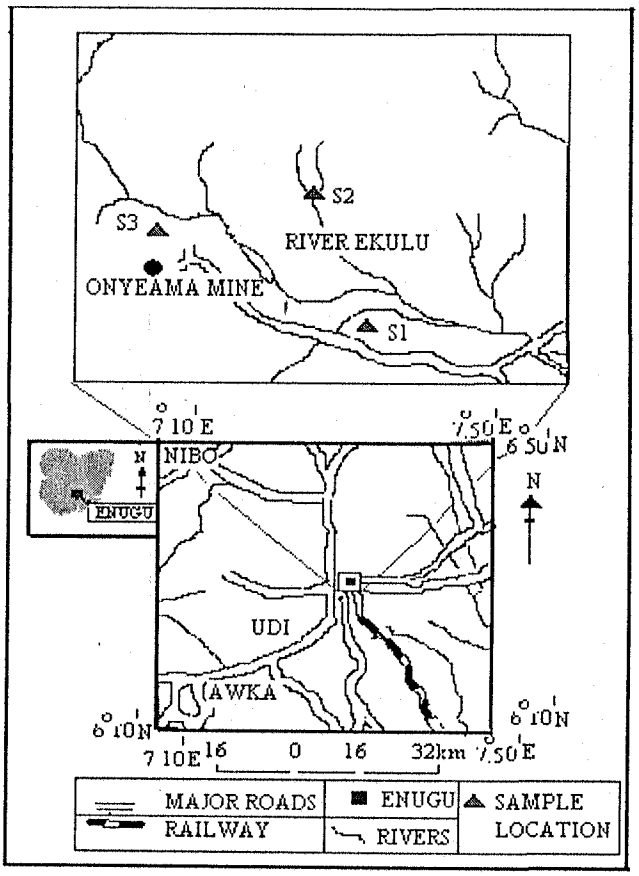

Fig.1. Map of Enugu. inset: Map of Nigeria and Sample Locations.

MATERIALS AND METHODS

Sample collection and preparation: Three sampling stations were chosen in this study (Fig. 1). A total of thirty samples were collected as ten samples per location. Stations 1 (S_1) and station 2 (S_2) were sediment samples while station 3 (S_3) was coal samples. All sediments and coal samples were collected in clean plastics with cock. The samples were dried in the sun and were taken to the Laboratory for storage in the refrigerated prior to digestion.

Sample Analysis: 5.00g of each sample was weighed and kept in a dried clean conical flask. The samples were digested in different ratio of acid mixtures (5ml HNO_3, 3ml $HClO_4$ and 2ml HF). They were placed on hot plates for some minutes and were later transferred to the fume cupboard where they remained for overnight (Jensen, (1992). The cooled solutions were made up to 100ml in volumetric flasks with de-ionized water and were later stored in the refrigerator prior heavy metal analysis using Atomic Absorption Spectrophotometry with a Perkin Elmer 3110 instrument. Absorbances were read in triplicates for reproducibility.

RESULTS AND DISCUSSION

The results obtained in heavy metal analysis from coal and sediment samples are presented in Table 1. Metal concentrations are in mg/kg dry weight and mean values are at 95% confidence level. The metals (Mn, Cr, Cd, As, Ni, and Pb) analysed for, are present throughout the period monitored in both the sediment and coal samples with some variations. Mean concentrations of Mn (0.256-0.389mg/kg) and Cr (0.214-0.267 mg/kg) are high relative to concentrations of Cd (0.036-0.043 mg/kg), As (0.016-0.018 mg/kg), Ni, (0.064-0.067 mg/kg) and Pb0.013-0.017 mg/kg). Sediment samples from station 1 and Station 2 have lower concentrations than those from coal samples from station 3.

Table 1. Results of metal concentration (at 95% confidence limit)

Sample Station		Metal concentration in mg/kg dry weight (n=10)					
		Mn	Cr	Cd	As	Ni	Pb
1 (S1)	Oct	0.262	0.228	0.042	0.018	0.070	0.016
	Nov	0.250	0.204	0.040	0.016	0.068	0.015
	Dec	0.246	0.200	0.030	0.021	0.066	0.010
	Jan	0.240	0.204	0.032	0.016	0.060	0.011
	Feb	0.276	0.224	0.036	0.011	0.062	0.012
	Mar	0.272	0.224	0.036	0.014	0.064	0.014
Mean		0.256±	0.214±0.0	0.036±0.0	0.016±0.00	0.065±0.0	0.013±0.0
		0.015	13	05	3	04	02
Standard Deviation							
		0.013	0.011	0.004	0.003	0.003	0.002
2(S2)	Oct	0.275	0.234	0.042	0.016	0.068	0.016
	Nov	0.262	0.242	0.037	0.017	0.070	0.013
	Dec	0.268	0.224	0.033	0.014	0.064	0.013
	Jan	0.270	0.210	0.030	0.014	0.064	0.014
	Feb	0.255	0.202	0.039	0.012	0.058	0.011
	Mar	0.260	0.220	0.035	0.011	0.060	0.010
Mean		0.265±0.0	0.222±0.0	0.036±0.0	0.014±0.00	0.064±0.0	0.013±0.0
		07	15	04	2	05	02
Standard Deviation							
		0.007	0.014	0.004	0.002	0.004	0.002
3 (S3)	Oct	0.380	0.277	0.046	0.020	0.071	0.019
	Nov	0.398	0.272	0.046	0.021	0.070	0.020
	Dec	0.378	0.269	0.040	0.018	0.069	0.020
	Jan	0.400	0.262	0.040	0.018	0.062	0.015
	Feb	0.379	0.257	0.042	0.016	0.063	0.014
	Mar	0.394	0.265	0.044	0.015	0.065	0.014
Mean		0.389	0.267±0.0	0.043±0.0	0.018±0.00	0.067±0.0	0.017±0.0
		0.010	07	03	2	04	03
Standard Deviation							
		0.009	0.007	0.003	0.002	0.003	0.003

Monthly monitoring of the sediments and coal revealed that apart from Mn, there is a steady decrease in concentration of all elements in all locations from November to March (a period of reducing run-off). This implies that these metals are imports from leachates. Calculated standard deviations show that there is a higher monthly fluctuation (except for Pb and As) of heavy metal concentration in sediments than for the coal samples. This implies that heavy metals have a higher residence period in the coal than the sediments around River Ekulu, a possible reason for the higher concentration of heavy metals in the coal. The deviation of concentration of Pb and As from this trend as well as the concentration of Mn which does not follow reducing run-off may be due to selective leaching.

Correlation coefficients show that all the metals are positively correlated implying that they are from the same source or origin. The area under this study shows a lot of gullying processes in progress. It is expected therefore that high rate of leaching will be the norm hence the result of sediment/water interaction will be high leading to a fast accumulation of the metals in water abound.

Table 2. Correlation coefficient for the metals studied.

	Mn	Cr	Cd	As	Ni	Pb
Mn	1.000	0.986	1.000	0.756	1.000	0.996
Cr		1.000	0.986	0.637	0.986	0.997
Cd			1.000	0.756	1.000	0.996
As				1.000	0.756	0.693
Ni					1.000	0.996
Pb						1.000
Hg						

The presence of toxic elements such as As, Cd, Pb, and Cr in the sediments and coal in River Ekulu could be detrimental to human beings and aquatic life. Most trace metals are toxic. When metallic toxicants find their way into the body, they attack the proteins, notably the enzymes. The long-term accumulation of toxic heavy metals in sediments and coal samples should not be taken for granted.

Enugu coal mine occurs in the area where River Ekulu takes its source.

Pollution status of water bearing bodies and environment, especially in mining areas of fast industrial growth like Enugu, should be checked always to avoid danger that may occur in our natural environment.

Conclusion: This work has established the presence of toxic heavy metals in sediments and coal around River Ekulu. These geological setting of the area favours intense gullying and fast accumulation of these toxic metals and hence calls for a follow up study to determine how the human and aquatic lives have been affected.

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