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Physicochemical, Major Anions and Heavy Metals in Surface Water and Groundwater at Pb – Zn Mining areas of Ebonyi State, Nigeria

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ABSTRACT: This research is an Appraisal of Physicochemical, major anions and heavy in Surface Water and Groundwater at Pb – Zn Mining areas of Ebonyi state. Heavy metals in borehole samples were analysed using Atomic Absorption Spectrometer (AAS). Physico-chemical parameters determined. Its shows that pH is generally low (3.65) resulting from the dissolution of the sulphide Ore. The heavy metal mean trend indicates that Fe > Zn >Pb> Cr >Cu > Ni > AS > Cd in the water samples. Fe, Zn, Cu, Pb and Cr were observed to be high. The variations for the heavy metals suggest that mining operation is responsible for the distribution and redistribution of chemical elements. The result of the Correlation analysis and principal component analysis (R- Mode and Q-mode) applied to the data analysis show that Zn, Pb, Cd, Cu, and Cr heavy metals originated from similar sources but may have been influenced by mining operation, while Ni, and As are attributed to a geogenic source. Proper sewage disposal practice and water conventional treatment strategies are recommended.

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Water has always and still has a great role in human affairs. Throughout human history, streams have served as a vital source of fresh water and often of fish for food. Before the widespread use of fossil fuels, flowing water pushing paddle wheels powered mills and factories, before the use of gas turbines and wind to generate electricity, water has long been used to generate electricity, for these and other reasons, many towns sprang up and grew along streams and rivers. The determination of elemental status of cultivated lands is necessary to identify yield limiting deficiencies of essential micronutrients and polluted soils (Alloway, 1990). This is especially important in Enyigba, Ameri and Ameka because the inhabitants are essentially farmers, and large quantities of yams, rice and okra are produced both for local consumption and also for food supplies to other parts of the world. Mining has also become important because of the existence of Pb-Zn lodes in the area. The study focuses on the heavy metals Pb, Zn, Cu, Cd, Ni, Cr and As. The potential for these heavy metals to constitute pollutants in the area is high. Availability of these metals and the presence of factors capable of mobilizing, distributing and storing them in pedologic system are critical. These metals are thus components of the existing rocks in the study area. Some may have been absorbed from the ancient depositional environments. Thus, Ni/Zn, Cu/Cd, Cd/Zn and Cu/Zn present a more hazardous effect than the individual metals (Down and Stocks, 1977). The aim of this study is to evaluate some physicochemical, major anions and heavy metals in Surface and Groundwater at Pb-Zn Mining areas of Ebonyi State, Nigeria.

MATERIALS AND METHODOLOGY

Description of the Study Area: The study area falls within Pb-Zn Ore mine area of Enyigba, Ameri and Ameka in Abakaliki district, Ebonyi State, Nigeria (Figure 1). It lies between latitudes 6°8ˡ- 6°24ˡ N and longitude 8°4ˡ-8°16ˡ E. Enyigba, Ameri, Ameka and its surrounding villages is about 14km South East of Abakaliki town. The area is accessible through Ndufu-Alike Ikwo/Federal University Ndufu-Alike Ikwo road. The Enyigba, Ameka and Ameri region is marked by undulating range of shale outcrops, which serve as the host for Pb - Zn mineral deposits.The area forms part of the “Abakaliki antichrionium” and generally underlain by the Abakaliki shales of the Asu River Group. The Abakaliki shale of lower Cretaceous age is exposed in the area. The sedimentary rocks are predominantly black calcareous (calcite-cemented) shale with occasional intercalation of siltstone. The

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Asu River Group which consists of alternating sequence of shale, mudstone and siltstone with some occurrence of sandstone and limestone lenses in some places and attains an estimated thickness of 1500 meters (Agumanu 1989, Farrington, 1952). Kogbe (1989) described the sediments as consisting of rather poorly-bedded sandy limestone lenses. Extensive weathering and ferruginization have generally converted the black shales to a bleached pale grey colour with mottles of red, yellow, pink and blue (Ukpong and Olade, 1979).

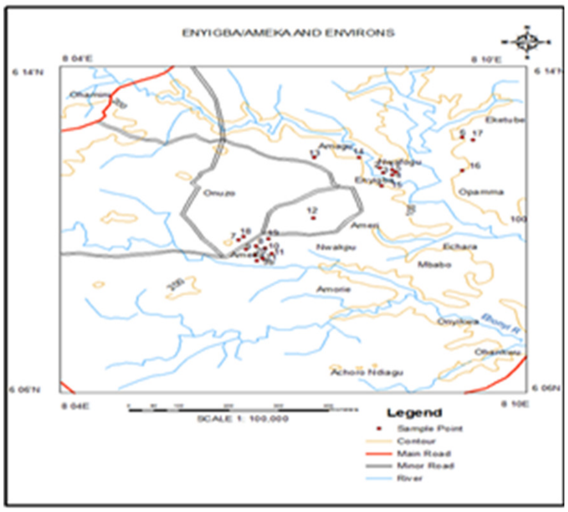

Fig 1. Pb-Zn Ore mine area of Enyigba, Ameri and Ameka in Abakaliki district, Ebonyi State, Nigeria

The rocks are extensively fractured folded and faulted. The lead-zinc Ore is found in the Albian carbonaceous shale of the Asu River Group. The mineralization is structurally controlled and localized in fissures, fault zones and gently dipping veins. The veins are steeply dipping and have been proven to over 150m depth. They vary in width from less than a meter to 20m and in length from 30m to 120m. The dominant Ores in the area are observed from the fissures which contain lodes of sphalerite (ZnS), and /or galena (PbS) in association with smaller quantities of copper. The deposits have been mined on and off for several decades. In the Enyigba, Ameri and Ameka areas near Abakaliki, there is incontrovertible evidence of post-mineralization deformation that the lodes were developed at the end of Santonian folding (Wright, 1968; Nwachukwu, 1972). Pb – Zn Ore mine area of Abakaliki district have been implicated in various disease conditions (Adaikpoh et al., 2005; Onyeobi and Imeokparia, 2011). As, Cd, Co,Cu, Fe, Mn, Ni, Pb, Zn) as well as the pH of soils in the active areas of Enyigba Pb – Zn Mine were determined , and results show that total mean concentrations of the heavy metals decreased with depth in the order of Fe > Pb > Zn > Cu > Cd > Co > Ni > As (Nweke *et al.*, 2008).

Samples Collection: A total of eight (8) and twelve (12) river and borehole water samples respectively were collected from Pb-Zn mine of Enyigba, Ameri and Ameka area in dry and wet seasons, of which ten (4) samples were taken from areas (3 kilometers) away from the Pb-Zn mines as background values. Coordinate and elevation readings were taken with the aid of Global Positioning System (GPS) at the various collection sample points.

Surface Water and Borehole Water Digestion and Analysis: Water samples were acidified to stabilize metals for periods more than four days without the use of refrigeration in the laboratory. Laboratory tests were carried out using deionized water. The pH and Electrical conductivity of the samples was determined using a digital pH meter model GMBH D4040 NEUSIS and a conductivity meter; Radiometer Copen-Hagen CDM83.The turbidity of the water samples was ascertained at a specified wavelength using a HACH DR 2010 datalogging spectrophotometer. The total dissolved solids of the sample were determined using gravimetric procedure as described by Ademoroti, 1996. The total hardness, total alkalinity and sulphate content of the samples were evaluated using titrimetric and turbidimetric methods as stated by Ademoroti, 1996. The nitrate and chloride values of the samples were determined using colorimetric method APHA, 1993 and Mohr' method APHA, 1993 respectively. The phosphate content of the samples was evaluated using the ascorbic acid reduction method described by ASTM, 1990. The acidified water samples were analyzed for total Fe, As, Cu, Pb, Cd, Ni, Cr and Zn concentration of the water samples were determined with the aid of an absorbance spectrophotometer (AAS); BUCK SCIENTIFIC Model 210 VGP USA.

Statistical Analysis: A multivariate statistical analysis of the data results was made with the SPSS package1988. Specifically, it involved correlation and factor analysis of Q-Mode and R-Mode.

RESULTS AND DISCUSSION

Comparing borehole water in both dry and wet season and river water in the dry and wet season the mean values of Fe, Pb, Zn and Cu are higher in the river water than the borehole water. It may be attributed to the fact that river water is highly loaded with soils and sediments that are full of heavy metals concentration. Cd, Ni and Cr are low and absent in some area. Also, low mean values of river water pH contributed significantly in the higher concentration of the most selected heavy metals.

Table 1: Comparison between River Water Sample in both Dry and Wet Season and Borehole Water Sample in Dry and Wet Season

	River Water Sample		Borehole Water Sample	
Parameter	Dry Season Range, x ± std dev	Wet Season Range, x ±std dev	Dry Season Range, x ±std dev	Wet Season Range, x ±std dev
Fe	1.01-1.97,1.49±1.05	1.02-0.20,0.1175±0.147	0.01-0.18,0.305±0.081	0.01-0.43,0.1150±0.230
Pb	1.10-1.20,1.15±0.81	0.45-1.11,0.79±0.544	0.05-1.15,1.060±0.989	0.63-1.33,0.9025±0.748
Zn	1.00-1.92,1.46±1.03	0.01-1.10,0.785±0.2298	0.90-2.00,1.358±1.090	0.04-1.44,0.5925±0.628
Cd	0.00-0.01,0.005±0.0035	0.01-0.11,0.0575±0.044	0.01-0.11,0.02±0.071	0.01-0.04,0.0125±0.026
Cu	0.97-1.03,1.000±0.71	0.01-0.02,0.0125±0.0123	0.01-0.26,0.085±0.131	0.03-0.20,0.0775±0.108
As	0.00-0.00,0.00±0.00	0.00-0.02,0.010±0.007	0.02-0.20,0.0583±0.114	0.00-0.01,0.005±0.003
Ni	0.00-0.01,0.005±0.0035	0.01-0.10,0.0375±0.00512	0.01-0.10,0.2117±0.072	0.00-0.02,0.005±0.011
Cr	0.00-0.01,0.010±0.00	0.01-0.02,0.0075±0.0159	0.03-0.11,0.030±0.077	0.1-0.03,0.010±0.021
pH	5.00-6.20,5.60±3.959	4.50-6.43,5.3575±3.728	3.65-7.90,5.725±4.118	5.00-/.8,5.1975±5.382

Comparing borehole water in the wet season and river water in the wet season, the mean values of Fe, Zn, Cd and Ni are higher in the river water sample compared with the mean values of borehole water sample. This could be as a result of river water being highly loaded with soil. Mode statistical analysis of the data excluding mine tailing results was made with the SPSS package, in order to quantify relationships between variables under simultaneous consideration of their interactions (Krzanowski, 1988).

Conclusion: This work has provided verifiable and quantitative scientific evidence for the presence of some toxic heavy metals. It has provided valuable information for policy makers, host communities, companies and academic communities to use as foundation for future references and further studies. It has helped to reveal seasonal variations in concentration of sampled media with respect to physico-chemical, major anions and heavy metals. All these heavy metal can cause serious health disorder ranging from acute to chronic levels depending on the dosage of the contaminant or pollutant. It also shows that the river water samples were higher in heavy metal concentrations than the borehole water samples. Also, the risk of heavy metal leaching and groundwater contamination from the mine wastes is very high with considerable likelihood of heavy metal transport by water percolating through the wastes/soils since the dumping of the mine wastes. Also, modern waste disposal facilities should be acquired by relevant authorities and appropriate waste disposal sites be chosen to avoid the injurious effects of indiscriminate disposal of used mine waste. In addition, continuous monitoring and further studies on the level of these heavy metals should be carried out in the near future to ascertain long-term effects of anthropogenic impact. The water of the study area would in future require proper sewage disposal practice and water conventional treatment strategies. This should also involve larger coverage with studies on ground water around such locations.

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