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# Public Health Significance of Metals' Concentration in Soils, Water and Staple Foods in Abakaliki South Eastern Nigeria

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**Abstract:** Concentrations of trace elements were quantitatively estimated in foods, water and soil samples in South-eastern Nigeria using atomic absorption spectrophotometric technique. The mean concentrations in ppm of iron (Fe): 3.25±0.00, zinc (Zn): 115.70±0.28 and copper (Cu): 3.25±0.11 in the surface soil were found to be higher than those of the sub-surface soil: 2.08±0.14, 107.50±0.03 and 22.40±0.50, respectively. Water samples from wells had the highest mean concentrations of all the trace elements. Leafy vegetables contained the highest mean concentrations in ppm of Fe: 127.80±0.66, Cu: 5.77±0.11, Cd: 0.47±0.06 and Pb: 159.55±0.4), followed by the legumes: 48.45±0.25, 44.46±0.12, 0.13±0.00 and 50.75±0.13, respectively. The tubers and the cereals had comparatively much lower concentrations of the elements.

**Key words:** Trace elements, concentration, soil, water, foods, Nigeria

## INTRODUCTION

Among the essential nutrients in the foods are trace metals such as iron (Fe), zinc (Zn), copper (Cu), lead (Pb) andcadmium (Cd). Some of these elements including Fe, Zn and Cu are vital components of many human body enzymes and other protein structures (Berg, 1990; Taylor, 1996). However, the intake of these elements in excess of natural loads constitutes human health hazards of increasing concern.

Heavy metals such as mercury, arsenic, lead, cadmium, vanadium, chromium, as well as essential trace metals such as iron, zinc and copper are present in the soil, water and air in various forms and these may become contaminants of foods and feeding stuff (Ezeonu *et al*., 2002). Researches have shown that some common vegetables and root crops are capable of accumulating high levels of metals from the soil (Gracia *et al*., 1981; Khan and Frankland, 1993; Xiong, 1998; Cobb *et al*., 2000). Certain *Brassica* species (Cabbage) are high accumulators of trace metals into edible tissues of the plant (Xiong, 1998). Incidents of metal poisoning arising from contamination of foods are well documented (Watanabe *et al*., 1985, 1989; Tabaku and Panariti, 1996; Taylor, 1996; Olivieri *et al*., 2000).

Evaluating the levels of these metals in the soils, water and staple foods is an important aspect of environmental pollution assessment and management. However available data on trace metal status of the environment in some parts of sub Saharan Africa, including Abakaliki southeastern Nigeria is grossly insufficient. This dearth of information has negatively affected effective environmental pollution management in this part of the globe. The objective of this study therefore is to investigate

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the levels of trace metals (Fe, Cu, Zn, Pb, Ni and Cd) in the immediate environment of a rural area in the South-eastern Nigeria as part of efforts to contribute scientific information for effective management of environmental pollution in a resource scarce setting.

## MATERIALS AND METHOD

### Study Area

The study was conducted at Abakaliki, South-eastern Nigeria from December 2003 to February 2004. Mining of lead-zinc ore is reported to exist in the area well before the 19th century (Orazulike, 1994). A comprehensive review of the geology of the Benue trough of the study area is well documented (Ofoegbu, 1985). The geological formation is a basement complex with more than 20 ore bodies that are symmetrically bound with gneissic galena coated with cerusite ($PbCO_3$), anglesite ($PbSO_4$), well formed quartz, crystals of siderite ($FeCO_3$), chalcopyrite ($CuFeS_2$) and marcasite ($FeS_2$) (Orazuilike, 1994). The area has two distinct seasons, the rainy season (April to October) and the dry season (November to March), with annual rainfall of 15,000-20, 000 mm, average temperature of 32°C and relative humidity between 45- 65%. Subsistence farming and mining of lead-zinc ore are the main stay of the economy of the area.

### Sample Collection and Analysis

### Soil Samples

Soil samples were collected from 30 different randomly selected sites in the area. A distance of about 500 m separated each of the sampling sites. Both surface and sub-surface soils (30 cm below the surface) were collected in labeled polyethylene bags as described previously (Onyeike *et al*., 2002) and subsequently dried in an electric oven at 110°C for 1-2 h. Dried soil samples were ground in a mortar and sieved using 2.0 mm mesh sieve size.

### Water Samples

Water samples were collected from available water sources in the area. These include three boreholes, two springs, five wells and two streams. Water was collected at regular intervals of one week, for two months from these 12 different water sources in stoppered plastic bottles and stored in a freezer.

### Food Crop Samples

The food crops were harvested fresh from farmlands where the soil samples were obtained. The food samples include tubers such as cassava (*Manihot esculenta*) and yam (*Discorea rotundata*). The legumes include peanut (*Ipomea batata*) and cowpea (*Vigna unguiculata*), while the cereals were maize (*Zea mays*) and rice (*Oryza sativa*). Leafy vegetables studied were fruited pumpkin (*Cucurbita pepo*) and okra (*Abelmoscus exulentus*). Five different samples of each food material were randomly collected. The food samples were crushed into slurry and 2.0 g of each sample was weighed into a silica dish and placed in muffle furnace at 500°C for 3 h. The ashing process was not aided because the food samples have relatively bulky ash straight. The muffle furnace was switched off and allowed for 30 min before the samples were brought out and then placed in a desiccator to dry before digestion. Digestion was done by dissolving the ashed samples with 2.0 mL of 6.0 M HCl and the filtrate was then made up to 50.0 mL with distilled water. The filtrate was then used to determine the trace elements spectrophotometrically using the standard official method of the AOAC (1984).

The trace elements in soil and water samples were determined by the same procedure of AOAC (1984) except that the water samples were membrane filtered (membrane diameter of 0.50 μm) before the analysis. The analytical standard used for this research was provided by Sigma-Aldrich Chemical Co. (St Louis, Mo, USA). By comparing the peak of the absorbance of standard with that of the test samples, the concentration of the trace metals in the samples were determined.

**Data Analysis**

The precision, accuracy and sensitivity of the analytical techniques employed in this research were assured by triplicate samples, blanks and the method of standard addition. Results were expressed as the mean plus or minus deviation. Data were also analyzed by one-way analysis of variance (ANOVA) using SPSS package, with special recourse to Duncan's multiple range test (Ducan 1955).

## RESULTS

Results showed that the mean concentration of iron (3.25±0.00 ppm) and zinc (115.70±0.28 ppm), in the surface soil were significantly higher than that of the sub-surface soil (2.08±0.14 ppm and 107.50±0.03 ppm, respectively) ($p<0.05$). There was no significant difference in the mean concentrations of copper (Cu), nickel (Ni) andcadmium (Cd) in the surface and sub-surface soils (Table 1). Water sample from wells had the most significant concentrations of all the trace elements with lead (Pb) recording the highest value (4.42±0.14 ppm), followed by zinc (Zn) (2.01±0.71 ppm) andiron (Fe) (1.05±0.07 ppm). The least concentrations of the trace elements especially Fe, Zn, Cu, Cd and Pb (0.03±0.01, 0.06±0.05, 0.03±0.01, 0.01±0.00 and 1.58±0.12, respectively) were observed in water samples from the streams (Table 1).

Analysis showed that the mean values of Pb (ppm) were 159.55±0.43 (leafy vegetable), 50.75±0.13 (legumes); 49.63±0.01 (tubers) and 45.25±0.07 (cereals). The mean values of Fe were: 127.80±0.66, 48.45±0.25, 47.35±0.33 ppm and 44.80±0.65 ppm for leafy vegetables, legumes, tubers and cereals, respectively (Table 2). While the mean values of Zn (ppm)

Table 1:Mean concentration values of trace elements in soil and water sources in Abakaliki, Southeastern Nigeria

| | Concentration of trace elements (ppm) | | | | | |
|---|---|---|---|---|---|---|
| Samples | Iron (Fe) | Zinc (Zn) | Copper (Cu) | Nickel (Ni) | Cadmium (Cd) | Lead (Pb) |
| **Soil samples** | | | | | | |
| Surface | 3.25±0.00 | 115.70±0.28 | 3.25±0.11 | 3.58±0.14 | 0.23±0.03 | 44.06±0.02 |
| Sub-surface | 2.08±0.14 | 107.50±0.03 | 2.40±0.50 | 3.10±0.09 | 0.12±0.07 | 48.75±0.06 |
| **Water sources** | | | | | | |
| Bore hole | 0.08±0.02 | 1.02±0.00 | 0.04±0.00 | 0.05±0.00 | 0.03±0.00 | 1.33±0.14 |
| Springs | 0.06±0.03 | 0.80±0.09 | 0.02±0.01 | 0.10±0.02 | 0.02±0.01 | 1.10±0.00 |
| Wells | 1.05±0.07 | 2.01±0.71 | 0.09±0.14 | 0.19±0.00 | 0.07±0.04 | 4.42±0.14 |
| Streams | 0.03±0.01 | 0.06±0.05 | 0.03±0.01 | 0.12±0.01 | 0.01±0.00 | 1.58±0.12 |

Table 2: Mean concentration values of trace elements in various food samples in Abakaliki, Southeastern Nigeria

| | Concentration of trace elements (in parts per million) | | | | | |
|---|---|---|---|---|---|---|
| Food samples | Iron (Fe) | Zinc (Zn) | Copper (Cu) | Nickel (Ni) | Cadmium (Cd) | Lead (Pb) |
| **Tubers** | | | | | | |
| Yam | 45.50±0.30 | 24.38±0.03 | 1.25±0.01 | 3.58±0.14 | 0.24±0.04 | 50.75±0.00 |
| Cassava | 49.20±0.06 | 28.38±0.00 | 1.33±0.04 | 3.00±0.04 | 0.23±0.03 | 48.50±0.01 |
| **Cereals** | | | | | | |
| Maize | 44.00±0.60 | 25.23±0.03 | 2.75±0.00 | 2.08±0.12 | 0.22±0.04 | 49.50±0.00 |
| Rice | 45.60±0.70 | 25.60±0.00 | 1.58±0.14 | 2.50±0.10 | 0.28±0.03 | 41.00±0.14 |
| **Legumes** | | | | | | |
| Beans | 48.00±0.30 | 26.00±0.00 | 4.83±0.12 | 2.92±0.12 | 0.12±0.00 | 52.75±0.00 |
| Cowpea | 48.90±0.20 | 25.50±0.10 | 4.08±0.12 | 3.00±0.00 | 0.13±0.00 | 48.75±0.25 |
| **Leafy vegetables** | | | | | | |
| Okra | 125.40±0.80 | 20.40±0.25 | 5.83±0.10 | 3.50±0.25 | 0.42±0.00 | 158.00±0.72 |
| Fruited pumpkin | 130.20±0.52 | 22.00±0.00 | 5.70±0.12 | 3.00±0.14 | 0.52±0.12 | 161.10±0.13 |
| **Mean concentration values of trace elements** | | | | | | |
| Tubers | 47.35±0.33 | 26.38±0.02 | 1.29±0.03 | 3.29±0.09 | 0.24±0.04 | 49.63±0.01 |
| Cereals | 44.80±0.65 | 25.42±0.02 | 2.17±0.07 | 2.29±0.11 | 0.25±0.04 | 45.25±0.07 |
| Legumes | 48.45±0.25 | 25.75±0.05 | 4.46±0.12 | 2.96±0.06 | 0.13±0.00 | 50.75±0.13 |
| Leafy vegetables | 127.80±0.66 | 21.20±0.13 | 5.77±0.11 | 3.25±0.20 | 0.47±0.06 | 159.55±0.43 |

were: 26.38±0.02, 25.75±0.05, 25.42±0.02 and 21.20±0.13 for tubers, legumes, cereals and leafy vegetables, respectively (Table 2). There was no significant difference in the concentrations of trace elements in the legumes, tubers and cereals ($p<0.05$).

## DISCUSSION

The concentrations of zinc (Zn) and lead (Pb) in the surface and sub-surface soils of Abakaliki, South-eastern Nigeria could be considered very high as these exceeded the normal tolerable environmental levels (UNEP/ILO/WHO, 1995; Liu *et al.*, 2005). The high levels of the Zn and Pb were not unexpected because of the zinc-lead ore mining activities in the area.

The levels of Fe, Zn, Cu, Ni, Cd and Pb in water sources from the area were significantly lower than that of the soil samples from the same locations. The observable difference in the levels of these trace elements could be as a result of hydrogeologic processes such as rainfalls, run-off leaches, seepages, infiltration, percolation, exfiltration which are essential in trace elements distribution kinetics (Egboka *et al.*, 1989). Furthermore since this research was carried out at the peak of dry season (December- February), it is most likely that the absence of these hydrogeologic processes accounted for the low levels of these metals in water. This finding is in accordance with the report of Ezeonu *et al.* (2002).

The levels of iron and lead were significantly higher in the vegetables than in staple foods. This confirmed findings from previous research, which indicated that some edible roots and vegetables were hyperaccumulator of trace elements (Gracia *et al.*, 1981; Khan and Frankland, 1993; Xiong, 1998; Cobb *et al.*, 2000).

The concentrations of Fe, Zn, Pb, Cu, Cd in the staple foods (tubers, cereals, legumes and leafy vegetables) were significantly high in the studied area whereas the Ni concentration was low. The observed high levels of Fe, Zn, Pb, Cu and Cd in the staple foods examined could be the major exogenous contamination sources of these trace elements among the inhabitants of the area. The toxicity problems associated with overloads of these metals are well documented (Macrae *et al.*, 1993; Akubue, 1997; Taylor, 1996; Punnonen *et al.*, 1994; Jung *et al.*, 1993; Sandstead, 1995).

## CONCLUSIONS

The levels of Fe, Zn, Pb and Cu in staple foods, soils, surface and underground water in Ebonyi State exceeded the Recommended Dietary Allowance (RDA) while Ni and Cd are within the accepted limit for soils and water sources. For the staple foods, only Cd is within the permissible limit. The high levels of these metals in the study areas impose health risk to the inhabitants as they feed on these staple foods and drink water from these sources. It also imposes problem to other part of the globe where these foods may be exported. This underscores the urgent need for public health intervention. A major draw back to this study was inability to compare present findings with morbidity and mortality information from the study area. The reason for this was due to the fact that the inhabitants of the area are largely illiterates and subsistence farmers, preferring local herbs to orthodox medicine. Assessing their medical records, which would have been of great help in determining their health status as they feed on these staple foods, was difficult owing to the above reason. Further studies to establish the health implications of the overloads of these trace elements in the immediate environment are advocated.

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## REFERENCES


Akubue, P.I., 1997. Poison in our Environment and Drug Over-dosage. In: A Guide for Health Professionals and the Lay Public. 1st Edn., Nigeria Rex Charles and Patric Ltd., pp: 60-77.

AOAC., 1984. Standard Official method of Association of Analytical Chemists. 14th Edn., Washington DC., pp: 534.

Berg, T.M., 1990. Zinc fingers domains: Hypothesis and current knowledge. Annu. Rev. Biophys. Chem., 19: 45.

Cobb, G.P., S.K. Sand, M. Waters, B.G. Wixson and K.E. Dorwars, 2000. Accumulation of heavy metals by vegetables grown in mine waste. Environ. Toxicol. Chem., 19: 600-607.

Duncan, D.B., 1955. Multiple range and multiplier F-tests. Biometrics, 42: 56-61.

Egboka, B.C.E., G.I. Nwankwo, I.P. Orajaka and A.O. Ejiofor, 1989. Principles and problems of environmental pollution of groundwater resources with case examples from developing countries. Environ. Health Persp., 83: 39-68.

Ezeonu, F.C., M. Amanebo, S.C. Udedi and O.C. Edeogu, 2002. Iron and zinc status in soils, water and staple food cultivars in Itakpe, Kogi State of Nigeria. Environment, 22: 237-240.

Gracia, W.J., C.I.N. Blessin, G.E. Inglett and W.F. Kwolek, 1981. Metal accumulation and cropyield for a variety of edible crops grown in diverse soil media amended with sewage sludge. Environ. Sci. Technol., 15: 793-804.

Jung, K., M. Pergande, H.J. Graubaum, L.M. Fels, U. Endl and H. Stolte, 1993. Urinary proteins and enzymes as early indicators of renal dysfunction in chronic exposure to cadmium. Clin. Chem., 39: 707-765.

Khan, D.H. and B. Frankland, 1993. Effects of cadmium and lead on radish plants with particular reference to movements of metal through soil profile. Plant Soil, 70: 335-345.

Liu, H., A. Probst and B. Liao, 2005. Metal contamination of soils and crops affected by the Chenzhou lead/zinc mine spill (Hunan China). Sci. Total Environ., 339: 153-66.

Macrae, R., R.K. Robinson and M.J. Saddler, 1993. Encyclopedia of Food Science. Food Technology and Nutrition. New York Academic Press, pp: 2667.

Ofoegbu, C.O., 1985. A Review of the geology of the benue trough of Nigeria. J. Afr. Earth Sci., 3: 283-291.

Olivieri, G., C.H. Brack, F. Muller-Spahn, H.B. Stahelin, M. Herrmann, P. Renard, M. Brockhaus and C. Hock, 2000. Mercury induces cell cytotoxicity and oxidative stress and increase β-amyloid secretion and Tau phosphorylation in SHSY5Y, Neuroblastoma cells. J. Neurochem., 74: 230-231.

Onyeike, E.N., S.I. Ogbuja and N.M. Nwinuka, 2002. Inorganic ion levels of soils and streams in some areas of ogoni land, Nigeria as affected by crude oil Spillage. Environ. Monitoring Assess., 77: 151-205.

Orazulike, D.M., 1994. The mineralogy and textures of lead-zinc-copper ores of enyigba lode, Abakaliki-Nigeria. J. Min. Geol., 30: 25-32.

Punnonen, K., K. Irajala and A. Rajamaki, 1994. Iron-deficiency anemia is associated with high concentrations of transferin receptor in serum. Clin. Chem., 40: 774-776.

Sandstead, H.H., 1995. Requirements and toxicity of essential trace elements, illustrated by zinc and copper. Am. J. Clin. Nutr., 61: 6215-6245.

Tabaku, A. and E. Panariti, 1996. Lead intoxication in rural albania. Vet. Hum. Toxicol., 38: 434-435.

Taylor, A., 1996. Detection and monitoring for disorders of essential elements. Ann. Clin. Biochem., 33: 486-510.

UNEP/ILO/WHO, 1995. International programme on chemical safety, environmental health criteria 165 inorganic lead. WHO, Geneva.

Watanabe, T., H. Fuijita, A. Koizumi, K. Chiba, M. Miyasaka and M. Ikeda, 1985. Dietary cadmium intakes of farmers in non-polluted areas in japan and the relation with blood cadmium levels. Environ. Res., 37: 33-43.

Watanabe, T., H. Nakatauka and M. Ikeda, 1989. Cadmium and lead contents in rice available in various areas of Asia. Sci. Total Environ., 80: 175-184.

Xiong, Z.T., 1998. Lead uptake and effects on seed germination and plant growth in a lead hyper accumulator, *Brassica* Pekinesis. Rupr. Bull. Environ. Contam Toxicol., 60: 286-291.