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Heavy metal bioaccumulation of selected tuber crops from Ishiagu, Ebonyi State, South East, Nigeria

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Abstract

Heavy metal concentration of soil and selected root crops cassava, yam, cocoyam and potato from three mining areas of Ishiagu, Ebonyi State were Evaluated. Heavy metals were analysed using Atomic absorption spectrophotometer (AAS). Results showed that lead (Pb) concentration of soil samples raged from 1.12 ± 0.01^{a} - 2.05 ± 0.01^{c}, Cadmium 0.46 ± 0.02^{a} – 0.77 ± 0.01^{b}, Chromuim 0.97 ± 0.03^{d} – 1.23 ± 0.02^{b}, Ni 0.83 ± 0.02^{d} - 1.56 ± 0.04^{b}, Mn 1.23 ± 0.04^{d} -1.42 ± 0.03^{c} and Zn 1.95 ± 0.01^{c} – 2.16 ± 0.03^{d}. These values were significantly higher than control ($P<0.05$).Results also indicates that these root crops accumulated all the heavy metals analysed more than the control samples. There is need therefore to have proper remediation in order to reduce heavy metal concentration of these crops.

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Introduction

Quarry mining activities are identified as a major cause of heavy metal contamination of the ecosystem and are largely responsible for growing amount of pollutants in soil. These mining activities are well known for their deleterious effect on the environment due to the deposition of large volumes of wastes on soil (Goyal *et al.*,2008; Nouri *et al.*,2009). Onyedika and Nwosu, (2008) reported that uncontrolled mining activities and illegal mining in developing countries has left a lot of environmental hazards and enormous amount of wastes and different types of pollutants are generated. This is predominant in Ishiagu, Ebonyi State Nigeria as these mining industries discharge waste in an adhoc manner into nearby farmlands.

Soil being an important component of terrestrial ecosystem supports plant growth and biogeochemical cycling of nutrients, these wastes end up interacting with the soil system thereby changing the physical and chemical properties. Akubugwo *et al.*, (2010) reported that soil heavy metal contamination results in the uptake of metals by plants causing accumulation of these metals in plant tissues, hampered crop quality and phytotoxicity. Vousta *et al.*,(1996) demonstrated that high level of heavy metals in soil could indicate similar concentration in plants by accumulation at high concentration causing serious risk to human health when consumed. Fu *et al.*, (2008), reported that accumulation of heavy metals in crops grown in metal-polluted soil may easily cause damage effect on human health through food chain. Excessive concentration of these metals in food is associated with aetiology of a number of diseases (WHO, 1992, 1995). Some heavy metals like As, Cd and Pb have been reported to have no known bio-importance in human biochemistry and physiology and consumption even at very low concentrations can be toxic (EU, 2002; Nolan, 2003).Due to the non-biodegradable and persistent nature, heavy metals are accumulated in vital organs in the human body such as the kidneys, bones and liver and are associated with numerous serious health disorders (Duruibe *et al.*, 2007). Individual metals exhibit specific signs of their toxicity. Lead, As, Hg, Zn, Cu and Al poisoning have been implicated with gastrointestinal (GI) disorders.

Soil is one of the repositories for anthropogenic wastes. Mining activities generate soils and effluents with extremely high metal concentrations of heavy metals that might have adverse effects on ecosystems and human health. Therefore, information on soil and heavy metal concentrations of these root crops is needed to assess the severity of the pollution in relation to bioaccumulation. Cassava (*Manihot esculenta*), yam (*Dioscorea rotundata*), cocoyam (*Colocosia esculenta*) and Potato (*Ipomea botatas*) are staple foods in Ishiagu. These root crops are cultivated by the rural dwellers and consequently, people depend on these crops as source of staple food both within the communities and for sales to other parts of the country. . Keeping in mind the potential toxicity and persistent nature of heavy metals, and the frequent consumption of these root crops it is necessary to analyze these staple foods to ensure the levels of these contaminants does not exceed the acceptable limit. This study is aimed to investigate the concentration of heavy metals in soils around Ishiagu quarry sites in relation to their concentration in these root crops to ascertain the safety of these root crops for consumption.

Materials and methods

Study Area

The study area is Ishiagu, a rural lead/ zinc mining community in Ivo Local Government area of Ebonyi State, South-East Nigeria. It is located between latitudes 7^{o}30 and 7^{o}37E and longitude 5^{o}52 and 6^{o}00N.The area is characterized by tall grasses and a few trees. The people are mainly farmers.

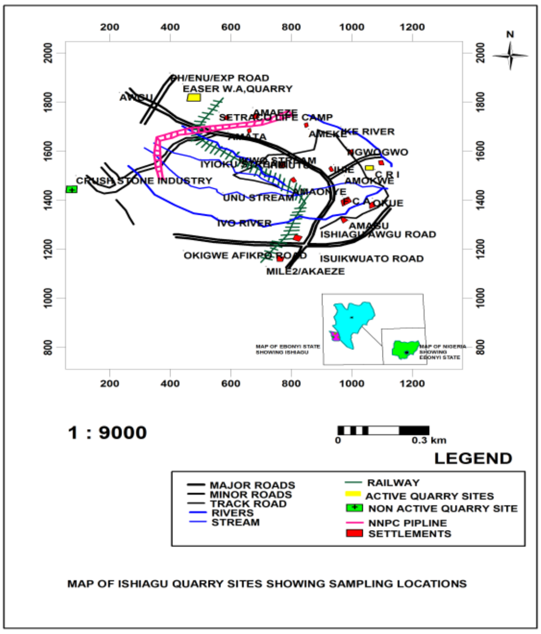

Fig 1. Map of Ishiagu showing sample locations.

Soil and root crop sample collection

Soil samples were collected from three different quarrying points using plastic auger at a depth of 0-45cm and were homogenized before collection. The soil samples were collected from the farms where the root crops were harvested. Both control soil and control root crops were collected from an unimpacted area devoid of mining activities. The root crops used for the study are cocoyam, cassava, yam and potato. These root crops were harvested randomly at peak of the harvest from farms around Ezza quarry mining site in Amaeze, Crush stone quarry mining site in Amita and Crush rock quarry mining site around Okwe region comprising Ngwogwo and Amaokwe all in Ishiagu, Ebonyi State Nigeria.The root crops were washed to remove soil particles before using them for analysis.

Determination soil heavy metals

Heavy metals such as lead (Pb), chromium (Cr), cadmium (Cd), Nikel (Ni), Zinc (Zn) and Manganese (Mn) were analyzed in the soil by the Perchloric acid digestion method described in APHA (1998).

Exactly 1.0g of air dried soil samples were weighed into a digestion tube and 3ml of conc. HNO_3 was added. This was digested on electrically heated block for 1hr at 1450C. Then 4ml of $HClO_4$ was added to whatman #42 filter paper and made to 50ml volume. The filtrate was analyzed for heavy metal using atomic absorption spectrophotometer (AAS).

Determination of heavy metal content of root crops

This was determined using atomic absorption spectrophotometer (AAS) as described by James (1995). Following the ashing of the root crops, the resulting ash was dissolved in 10ml of hydrochloric acid. It was filtered with whatman #42 filter paper. The extract was used for the analysis using Atomic Absorption Spectrophotometer (AAS).

Statistical analysis

Data collected were subjected to statistical analysis using one way analysis of variance (ANOVA) procedure and difference in mean were separated $P<0.05$ using standard students t- Test.

Result and discussion

Table I. Heavy metal concentration of the analysed soil samples.

Heavy Metals	Control	A	B	C
Pd	0.15 ± 0.01^{a}	1.12 ± 0.03^{b}	1.85 ± 0.01^{c}	2.05 ± 0.04^{d}
Cd	0.54 ± 0.04^{a}	0.46 ± 0.02^{a}	0.77 ± 0.01^{b}	0.55 ± 0.04^{a}
Cr	0.19 ± 0.03^{a}	$1.23\pm0.02_{b}$	1.17 ± 0.04c	0.97 ± 0.03^{d}
Mn	0.86 ± 0.02^{a}	1.34 ± 0.04^{b}	1.42 ± 0.03^{c}	1.23 ± 0.04^{d}
Ni	0.46 ± 0.05^{a}	1.56 ± 0.04^{b}	1.82 ± 0.04^{c}	0.83 ± 0.02^{d}
Zn	0.85 ± 0.03^{a}	2.03 ± 0.02^{b}	1.95 ± 0.01^{c}	2.16 ± 0.03^{d}

Values are mean of triplicate determination ± standard deviation.

Mean in the same row, having different alphabet are statistically significant ($p<0.05$).

Key

A= Soil sample from Ezza quarry mining site in Amaeze, B= Soil sample from Crush stone quarry mining site in Amita, C= Sol sample from. Crush rock quarry mining site around Okwe region.

Table I shows heavy metal result of the soil samples analysed are shown in table 1. Results showed that lead (Pb) concentration of soil samples raged from 1.12 ± 0.01^{a} - 2.05 ± 0.01^{c}, Cadmium 0.46 ± 0.02^{a} – 0.77 ± 0.01^{b}, Cromuim 0.97 ± 0.03^{d} – 1.23 ± 0.02^{b}, Ni 0.83 ± 0.02^{d} -1.56 ± 0.04^{b}, Mn 1.23 ± 0.04^{d} - 1.42 ± 0.03^{c} and Zn 1.95 ± 0.01^{c} – 2.16 ± 0.03^{d}. These values were significantly higher than control ($p<0.05$) except for cadmium at site A and C that are statistically at par with the control. Result showed that soil sample from site C recorded the highest concentration of zinc 2.16 ± 0.03^{d}, and lead 2.05 ± 0.04^{d}.The highest concentration of Cadmium $0.07\pm0.01^{b}$was recorded from site B. The result suggest that mining effluent increased heavy metal concentration of the soil samples analysed when compared with the control ($P<0.05$).The findings is in agreement with Oti *et al.,* (2012) who ….

Table II. Heavy Metal Concentrations of root crops (mg/kg).

Root crops	cassava		Yam		Cocoyam		Potato	
Heavy Metals	**Control**	**Sample**	**Control**	**Sample**	**Control**	**Sample**	**Control**	**Sample**
Pb	0.17 ± 0.03^{a}	1.54 ± 0.02^{b}	0.15 ± 0.02^{a}	0.43 ± 0.03^{b}	0.06 ± 0.02^{a}	0.21 ± 0.02^{b}	0.05 ± 0.01^{a}	0.15 ± 0.02^{b}
Cd	0.02 ± 0.01^{a}	0.55 ± 0.03^{b}	0.03 ± 0.01^{a}	0.09 ± 0.02^{b}	0.02 ± 0.01^{a}	0.05 ± 0.02^{a}	0.03 ± 0.01^{a}	0.24 ± 0.01^{b}
Cr	0.03 ± 0.02^{a}	0.49 ± 0.01^{b}	0.02 ± 0.01^{a}	0.04 ± 0.02^{a}	0.03 ± 0.01^{a}	0.64 ± 0.03^{b}	0.02 ± 0.00^{a}	0.51 ± 0.03^{b}
Mn	0.12 ± 0.02^{a}	1.12 ± 0.03^{b}	0.15 ± 0.01^{a}	1.05 ± 0.02^{b}	0.09 ± 0.03^{a}	0.26 ± 0.01^{b}	0.14 ± 0.01^{a}	1.07 ± 0.03^{b}
Ni	0.13 ± 0.01^{a}	1.75 ± 0.02^{b}	0.14 ± 0.02^{a}	0.21 ± 0.03^{b}	0.11 ± 0.01^{a}	0.64 ± 0.02^{b}	0.04 ± 0.01^{a}	0.32 ± 0.03^{b}
Zn	0.35 ± 0.04^{a}	0.82 ± 0.02^{b}	0.21 ± 0.02^{a}	1.22 ± 0.01^{b}	0.13 ± 0.01^{a}	0.55 ± 0.02^{b}	0.11 ± 0.02^{a}	0.38 ± 0.02^{b}

Values are mean of triplicate determination ± standard deviation

Mean in the same row, having different alphabet are statistically significant ($P<0.05$).

Table II shows heavy metal concentration of root crops analysed. Results showed that crops from the mining areas have higher concentration of heavy metals than the control samples. This is believed to be due to impaction of soils around the mining areas leading to increased concentration of heavy metals in soils. This agreed with Onyedika and Nwosu,(2008) who evaluated lead,zinc and cadmium in root crops from mineralized Galena-sphalente mining area and environment. Various studies have been conducted to evaluate heavy metal uptake by plants in relation to soil pollution with heavy metals (Lee *et al.*, 2002; Osuocha *et al.,* 2013a;Osoucha *et al.*, 2013b., Akubugwo *et al.,*2013) and variable results were reported. Harsen *et al.*,(1992) observed elevated concentration of Cr and As in soil and plant around a wood preservation factory. The result however suggests that these root crops are capable of accumulating these heavy metals to a considerable amount which might pose a health risk to consumers.

Conclusion

Mining effluent impacts negatively on soil and plants around quarry mining sites.Proper remediation should be carried out in order to reduce the health implication of these heavy metals via consumption of these root crops.

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