DOI: http://dx.doi.org/10.4314/gjass.v11i1.1

GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL 11, NO. 1, 2012: 1-4
 ISSN 1596-2903
www.globaljournalseries.com; Email: info@globaljournalseries.com

A COMPARATIVE STUDY OF THE INFLUENCE OF HEAVY METALS ON SOIL AND CROPS GROWING WITHIN QUARRY ENVIRONMENT AT AKAMKPA, CROSS RIVER STATE, NIGERIA

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(Received 14, July 2011; Revision Accepted 18, October 2011)

ABSTRACT

A comparative study of the influence of heavy metals on soils and crops grown within quarry environment at Akamkpa, Cross River State was conducted in 2009 year. The study area was delineated into3 zones P1, P11, P111 based on the intensity of exposure to tailings, wind speed, wind direction and distance from the quarry. The selected sample distances were (0km, 1km and 3km as control). Soil sample with the depth of (0-15cm), cassava leaves and, fluted pumpkin leaves were collected separately from each of the sampling area and analyzed for chemical characteristics. The concentration of heavy metals Pb, Cr, Ni, Cd, Mn, Fe and Cu in the leaves samples of fluted pumpkin and cassava in sample position (P1) were (25.26± 0.58, 15.54± 0.75, 14.28± 1.23, 18.05±0.20, 42.25±0.10, 87.22±0.40 and 28.14±0.71)mg/kg for fluted pumpkin and (23.41±0.50, 11.25±0.11, 10.78±0.23, 12.25±0.60, 38.25±0.05, 75.28±0.40 and 26.51±0.15)mg/kg for cassava leaves respectively. The values of these heavy metals Pb, Cr, Ni, Cd, Mn, Fe and Cu of soils in zone (P1) were (12.26±0.86, 5.75±0.50, 3.25±1.84, 8.25±1.24,14.29±0.25,125.0.85±0.05 and 5.67±0,98)mg/kg respectively. The values of heavy metals in plant species were significant (P<0.05) higher than values of the soils in sample position. Similar trend was recorded in zones P11 and P111. The high concentrations of trace metals recorded in the leaves of the plant species may be due to bioaccumulation and biomagnifications of those metals in plant. The decrease in concentration of these metals in the soil may be as a result of losses due to leaching, harvest of agricultural products, volatilization and soil pH.. The correlation between heavy metals in the soil and the relationship with the soil factors showed that some metals correlate significantly and positively with other metals while some do not. It is concluded that quarry activities in Old Netim in Akamkpa Local Government Area of Cross River State has a significant impact on the level of heavy metals on crops around the area. This is a matter of great concern in view of the environmental and health implication, since man and livestock depend on these plant species for food.

KEY WORDS: Biomagnification, heavy metals, soils, economic crops.

INTRODUCTION

Quarrying is a major land used activity in Akamkpa Local Government Area of Cross River State, Nigeria. Due to the availability of mineral deposits in commercial quantity in the area, the mining activity provides large tones of chippings of various sizes as well as accompanying toxic waste affect both environment and human.

The social and environmental disturbances as a result of mining and mineral processing activities include destruction of wildlife and biodiversity, loss of fertile soil, pollution of drinking water and air, degradation of farm land, impairment of human health, forced pollution migration, destruction or reduction of agricultural and related activities and damage to aquatic ecosystems (Adepoju, 2002). The effect of mining is manifest in air, land, crops and water.

Tailings generated from mining operations and weathering of rocks is important source of heavy metals introduced into the environment (Kakulu, 2003; Nriagu, 1990). Inputs of heavy metals into the soils have gradually increased over the past decades as a consequence of agricultural practices (e.g. the use of fertilizers and pesticides), disposal of sewage sludge, and mining operations (Adriano, 1999; Berrow, 1986). Although some heavy metals are essential in plants nutrition, plants growing in an environment of heavy metals pose serious risk to human health when such plant based food stuffs are consumed (Vousta *et al*., 1996). Unlike energy which tend ton deplete and becomes more dispersed at each step in the trophic level, heavy metals become more concentrated with each trophic level in the food chain “bioaccumulation and biomagnifications” (Egunjobi and Nkwoko, 2002).

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The concentration of these chemicals become enhanced with progression along the trophic levels in the ecosystem rather than dissipate, a process referred to bioaccumulation (Dara, 1993). The concentration of heavy metals and other minerals in the soil are decreased due to harvests of agricultural crops, losses by leaching and volatilization (Jones, 1999). Therefore, the concentration of heavy metals in crops increases because of bioaccumulation and biomagnifications of these metals in plants. Bioaccumulation is expressed as the ratio of concentration of the chemical in the organism to that in the medium. Unfortunately, extensive research work aimed at understanding the correlation of heavy metals between the soils and plants within the quarry site and the possible effects in the food chain have no yet been done, also the important regulatory policies to minimize the environmental health hazards are not yet in place. This research was carried out to assess the relationship of heavy metals in the soils and plants within the quarry site, since the area is an agricultural zone.

MATERIALS AND METHODS

Description of the study area

The study area is at Old Netim in Akamkpa Local Government Area of Cross River State, Nigeria. It is located in the southern part of Cross River State, and lies between latitude 06^0C- 50N and longitude 07^0-30S. it has a climate that can be differentiated into two seasons. The wet (rainy) season begins in March and end November, having an average annual rainfall varying between 1500mm to 3000mm. the peak of the rainfall is June/July and in September, with a break in rains in August. The dry season last for four months, which begins in November, and end February. Humidity is high and often above 60% minimum and maximum average temperature is between 25^0C and 36^0C respectively (NIMET, 2008).

Old Netim village in Akamkpa Local Government Area of Cross River State is situated within the lowland rainforest zone of Nigeria. The soil type can be regarded as an acidic soil. The vegetation comprises of trees that are scattered as well as clustered oil palms. The result of large scale exploitation being carried out in the area has destroyed its original vegetation. The population of the people in this area is about 95000(NPC, 2007) and their main occupation is farming . the farmlands are owned by individuals according to the traditional land tenure system and the major crops grown include cassava, yam, maize, fluted pumpkin, cocoyam etc.

Quarrying activities started in 1982, presently there are three (3) companies that are carrying out quarrying in the area; namely: Cross Rock company, PRODECO (Property development company) and HITECH company.

Method of study

The samples were randomly collected at three different positions within the rock mining site. Prior to the collections of samples, three (3) coated pans were kept for 3 days in different distances to delineate the position where the samples were to be collected, in order to ascertain the amount of dust produced during the quarrying process that could settle in the pans. The first zone (P1) was 0km within the quarry site, the second zone (P11) was 1km away from the quarry site and the third zone (P111) used as control was 3km away from the quarry site. At each of the three sampling positions, two different plant species of economic value were identified to be occurring commonly in the 3 sampling positions and were therefore selected as screening materials of heavy metals. Leaves were collected from 2 plant species (Table 1) in the 3 sampling locations, the leaf samples were collected using secautuer. The leaf samples were oven dried at 60^0C to a constant weight, milled, sieved and digested.

At each of the sampling positions (0km, 1km and 3km) a 50g soil samples were collected randomly from a depth of 0-15cm using soil auger. The soil samples were collected on 4 replicate points at each sampling location. The soil samples were air dried, screened, sieved and digested. The different types of samples were digested and extracted using 0.1% perchloric acid. The extracts were analyzed for Ni, Cd, Cr, Pb, Cu and Fe using the Atomic Absorption Spectrophotometer (Unicam 919 model) at the Aluminum Smelter Company Laboratory, Ikot Abasi Akwa Ibom State, Nigeria (ALSCON).

Statistical Analysis

Data collected were analyzed using the Analysis of Variance (ANOVA) procedure (Steel and Torrie, 1980). Experimental means were compared using the least significant different (LSD) $P< 0.05$.

RESULTS AND DISCUSSION

The concentrations of heavy metals Fe, Pb, Cr, and Ni in the three (3) sampling positions P1, P11 and P111 are shown in (Table 1). The highest concentrations of all the heavy metals analyzed from the samples were recorded in the sampling position (0Km) which is the immediate vicinity of the quarry. Plant species samples had a high value of heavy metals than the soil in all the sampling positions, except in the case of Fe that had the highest concentration than the plant species. The high value of Fe may be due to the present of Fe in the rock (Berrow, 1986). The values of the concentrations of Cd, Zn, and Cu (Table 2) were significantly ($P<0.5$) higher in plant species than in soil during the study period. It is observed that concentration of these heavy metals decreased with increase in the distance from quarry. The higher concentrations of heavy metals recorded in sampling positions within the quarry site confirms the relationship between metals concentration and distance from the quarry. The uptake of heavy metals in plants and the translocation were influenced by differences in the mobility of the metals in the plants. Fe and Zn had the highest values of 78.64mg/kg and 27.28mg/kg in pumpkin leaves and 79.24mg/kg and 25.64mg/kg in cassava leaves respectively. The result is in line with the work of (Kabata- Pendias, 1992) who reported that Fe and Zn are essential trace elements, in which plants and animals need in large quantity for their metabolic activities. The concentrations of Fe and Pb in cassava leaves tend to be higher in sampled position two (P11) than the in the leaves of pumpkin.

In all the plants examined, higher concentrations of heavy metals (Pb, Cr, Ni, Cd, and Zn) recorded in sampling positions P1, P11, and p111 were higher values obtained from the soils. Marschner, (1998); Catald *et al*, (2004); Ponyat and McDonnell, (1991) reported that concentration of heavy metals contained in plants may be higher than that of the soil on which they are growing due to the ability of the roots of plant to absorb the elements from the soil and these elements will be stored and accumulate in the plant tissues, process known as bioaccumulation and biomagnification. In the other hand the decrease in the concentration of heavy metals in the soil could be due to harvest of agricultural crops, leaching and volatilization (Jones, 1999). On all the soils examined, a decrease of heavy metals concentration was observed as the distance from the quarry increased, but their concentration in the plant top was consistent. The reversed trend in plant may be linked to the ability of roots to absorb the heavy metals in their rhizosphere. Ruhling, (1968) reported that the dominant factor influencing the rhizosphere is the form in which heavy metals are absorbed. This is attributed to their varying physiological differences and relative selectivity on the uptake of these metals. Dara (1993) reported that the availability of heavy metals for plant absorption depended on the ionic form in which the metals occurred in the soil and their relationship with the soil factors.

Therefore, the concentration of heavy metals recorded in this study was more than the recommended level of 0.05Kg for soils and vegetable species (FEPA, 1991). The influence of heavy metals on soil and crops growing within the quarry environment at Akamkpa Local Government Area of Cross River State, Nigeria is a matter of great concern in view of the environmental and health implication to the people. This raises a lot of environmental concern because both man and livestock depend on these plant species for food. Consequently, they are inadvertently exposed to gradual accumulation of these heavy metals. In a similar study, high Pb level was found in the blood sample of cattle reared near a smelter plant (Neuman and Dollhopt, 1992).

Table 4 shows the correlation coefficient matrix showing the association among concentrations of heavy metals in the soil and their relationships with soil factors. Fe correlate very significantly and positively with Zn (0.585), Ni(0.667), Cr(0.618) and Cd(0.517) but did not correlate with Cu. Copper correlated significantly and positively with Zn (0.575) and Cd(0.567) but did not show any relationship with Fe, and Cr. Zn has a strong relationship with all metals. Other researchers have found Zn to be highly associated with all metals (Kuo *et al*, 1990; Rapin *et al*,. 1982).

Examination of the relationships existing among the heavy metals in the soil and soil factors showed that organic matter and effective cation exchange capacity had no relationship with trace metals. The clay content correlated significantly and positively Cu (0.523) and Zn (0.453). Sand correlated negatively with Fe (-0.165) and Cu (-0.226) where as silt has no relationship with heavy metals. Similar observations were made by (Sedberry *et al.,* 1976, and Ano, 1994), they reported that the factors which largely control the concentrations of these elements in the soil were soil factors and clay minerals.

Table 1: Concentration (mg/kg) of heavy metals in plant leaves and soils at different sampling Distance from the quarry

	Sample position 1 (0km)			Sample position 11 (1km)			Sample position 111 (3km)		
	Soil (0-15cm)	Pumpkin Leaves	Cassava Leaves	Soil (0-15cm)	Pumpkin Leaves	Cassava Leaves	Soil (0-15cm)	Pumpkin Leaves	Cassava Leaves
Iron	125.05	87.22	75.28	85.28	76.28	83.17	35.38	32.68	28.27
Lead	12.26	25.58	23.41	5.36	15.05	17.14	2.56	11.48	9.15
Chromium	5.75	15.54	11.25	2.28	7.85	6.05	0.94	3.50	2.14
Nickel	3.25	14.28	10.78	2.98	11.84	8.25	1.56	6.35	5.28
Cadmium	8.25	18.05	16.25	3.28	14.28	10.05	0.98	8.57	6.28
Zinc	14.75	42.25	38.29	9.92	28.40	27.15	4.14	12.82	11.38
Copper	7.38	20.15	16.78	4.48	19.28	14.28	1.26	4.37	5.38

Table 2: Mean concentration (mg/kg) of heavy metal content in soil and vegetables in the study area

Elements	Soil (0-15cm)	Pumpkin leaves	Cassava leaves	LSD (0.05)
Iron(Fe)(mg/kg)	81.90	78.64	79.24	0.65
Lead(Pb)(mg/kg)	6.72	15.12	16.67	1.53
Chromium (Cr)	2.99	8.18	6.24	1.12
Nickel (Ni)	2.65	10.24	7.18	1.20
Cadmium (Cd)	4.38	13.36	8.14	1.05
Zinc (Zn)	8.93	27.28	25.64	2.47
Copper (Cu)	4.24	14.72	12.05	2.04

CONCLUSION

The higher concentration of these trace elements on the planted vegetables reported in this study, calls for scientific awareness and requires further study as to evaluate the optimum concentration needed for human health. Until that is done, planting of vegetables for human and animal use should be suspended for now based on the toxic levels, which could be hazardous to health.

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