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THE EFFECT OF QUARRYING ON SOIL AND VEGETATION IN AKAMKPA LOCAL GOVERNMET AREA OF CROSS RIVER STATE, NIGERIA

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ABSTRACT

The impact of tailing waste from quarry operations on the soil and vegetation in Akamkpa Local Government Area, Cross River State were investigated. The selected sampling areas (0 km, 0.75 km and 2 km or control) were delineated based on the intensity of exposure to tailings and distance from the quarry Samples of the extracted material (chippings) was analyzed to ascertain the chemical composition. Samples of the soil (0-5cm), fodder species *Alchornea cordifolia* and *Aspilia africana*, edible fruit *Carica papaya* and *Mangifera indica* as well as root and tuber species *Manihot esculenta* and *Colocasia esculenta* were collected separately from each of the sampling area and analyzed for chemical characteristics. From the rock material, the concentrations of Cu, Pb, Zn, Fe, Cd, Ni, Cr and Mn in quarried materials (Chippings) were 9.28, 1.88, 10.64, 349.50, 2.06, 3.22, 1.12, and 2.44 (mg/kg) respectively. Quarry activities in Akamkpa affected the levels of Pb, Cu, Zn, Fe, Mn, Ni and Cd in the soil as these element had significantly higher concentrations in the soils collected from the immediate vicinity of the quarry (0 km). Also the concentrations of the metals in the plants leaves within the quarrying site were significantly higher ($P<0.01$) than that of the control (2 km). The concentrations of Zn, Cu and Ni in leaves of *Mangifera indica* collected from the farthest sampling position from the quarry were lower by 81%, 63.04% and 51.93% respectively than that collected from immediate vicinity of the quarry site. Quarry operation is causing increasing building of trace metals in the soils and vegetation in Akamkpa Local Government Area of Cross river State. Thus, the operations of the quarry industry need to be regulated to reduce the health risk the practice poses to the local populace.

KEYWORDS: Quarry, Soil and vegetation

INTRODUCTION

Quarrying as a land use method is concerned with the extraction of non-fuel minerals from rocks (Okere *et al* 2001). Gravels for building houses and other civil construction are obtained from quarrying of rocks of the earths crust. There is now a great demand for rocks especially limestone as an essential constituent of many building and construction processes. A variety of products from mining and crushed rocks form primary raw materials in many industrial applications (Ellen, 2000). Crushed rocks are used as aggregate in high ways or concretes construction, in bituminous mixture and rail road ballast (Wills, 1995). However, several wastes are generated during the processes of extraction and crushing of rocks. Environmental disturbance and contamination as a result of mining and mineral processing activities constitute the major threats to public health and environmental quality (Adepoju, 2002).

The severity of the environmental problem depends on the characteristics of the mineral being extracted, the method of mining, waste materials generated and site characteristics. The effects of such problems are manifest in the air, land, plants, and water around with mining activity. Tailing, a finishing ground particle of rock, are the most environmentally important component of the quarrying waste, released into the environment. Tailing generated from mining operations and weathering of rocks is among the major sources of trace metals introduced into the environment. The pollution of soils and water with trace metals through atmospheric deposition is well known (Kakulu 2003, Nriagu, 1990). Trace metals such as lead, Zinc, Cadmium, Copper, Manganese and iron from mining activities can also occur as natural biochemical cycles (Mattigod *et al*, 1983, Brown, 1979). Although some trace metals are essential in plants nutrition, plants growing in an environment with excessive accumulation of trace metals suffer toxicity effect and pose serious risk to human health when such plant based foodstuffs are consumed (Vausta *et al*, 1996, Alloway, 1990). Unfortunately extensive research aimed at understanding the effect of these heavy metals and their possible impacts on the environment in Akamkpa Local Government Area have not been done; also the important regulatory policies to minimize their environmental effects are not yet formulated.

MATERIALS AND METHODS

THE STUDY AREA:

The study area was at Akamkpa Local Government Area of Cross River State, Nigeria. The area lies between Latitude 6° 50N and 07° 30S. The maximum annual mean daily temperature of the area is between 29°C and 34°C. Akamkpa is characterized by the high rainforest vegetation. The two major seasons that prevail in the area are dry season (October-February) and rainy season with bimodal pattern (March- September). Short dry and windy periods of harmattan usually occur in the dry season. The mean annual rainfall is 2050mm. The soil in this area is clayey loam. Akamkpa has a population of about 95,000 people (NPC, 1991); and their main occupation is farming. The farmlands are owned by individuals according to the traditional tenure system and the major crops grown include cassava, maize, yam, okra and cocoyam.

Quarrying activities started in 1982 in Obot Netim Village in Akamkpa Local Government Area of Cross River State. Presently the companies that are carrying out quarrying in the area are: Crush Rock company, PRODECO (Property Development company) and HITECH company.

METHOD OF STUDY

During the dry season and prior to sample collections, 3 steel coated pans were kept for 48 hours at the 3 different distances in order to ascertain the amount of dust produced during the quarrying process that could settle in the pans to delineate the positions where the samples were to be collected,. The pans were kept at 0km, 0.75km and 2km away from the quarry site. This was done to determine the extent of spread of dust arising from the quarry operation and to establish the point of control. The contents of the pans were checked after the 48 hours and point without settlement of dust particles was used as the control.

Six different plant species of economic value were

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identified to be occurring commonly in the 3 sampling positions and were therefore selected as screening materials for he level of heavy metals. Leaf samples were collected from the 6 plant species (Table 1) in the 3 sampling locations using secautuer. The leaf samples were oven dried at 60°C to a constant weight, milled, sieved and digested.

At each of the three sampling positions (0 km, 0.75 km, and 2 km), a 50g soil samples were collected randomly from a depth of 0-5cm using soil auger. The soil samples were collected on 4 replicate points at each sampling location. The soil samples were air dried for 4 days, screened, sieved and digested. The different types of samples were digested and extracted using 0.1% perchloric acid. The extracts were analyzed for Mn, Cu, Fe, Pb, Ni, Cr, Zn, and Cd using the Atomic Absorption Spectrophotometer (Unicam 919 model) at central research Laboratory, University of Uyo, Nigeria. Analysis of the crushed stones (Chippings) was done to support any inference that could be drawn on the accumulation of heavy metals in the area. Data collected were analyzed using the Analysis of variance (ANOVA) procedure (Steel and Torrie, 1980).

The least significant Difference (LSD) was used to compare means along rows

Table 1: Plant sample collected at the three different location of the quarrying site and their economic uses

Plant Species	Class of Species	Economic importance
Manihot esculenta (cassava)	Arable Crop	- tubers used for making garri, foo-foo, starch, tapioca
Abelmochus esculentus (okra)	Arable Crop	- fruit used as soup condiment
Colocasia esculenta	Arable Crop	- corm used as food
Carica papaya (paw paw)	Cash crop	- fruits used as food, leaves as medicine, etc
Psidium guajava (guava)	Cash crop	- fruits used as food, leaves as medicine, etc
Mangifera indica (mango)	Cash crop	- fruits used as food, leaves as medicine, etc
Alchornea cordifolia	Fodder crop	- Feedstuff for livestock
Centrosema pubscens	Fodder crop	- Feedstuff for livestock
Pennisetum purperum	Fodder crop	- Feedstuff for livestock
Pteridium acquilinum	Fodder crop	- Feedstuff for livestock

RESULTS AND DISCUSSION

The rock substance on subjection to analyses contained various concentrations of different trace metals. The mean concentration of Cu, Pb, Zn, Fe, Cd, Ni, Cr and Mn in quarried materials (Chippings) were 9.28, 1.88, 10.64, 349.50, 2.06, 3.22, 1.12, and 2.44 (mg/kg) respectively. The concentration of Fe in the quarried materials was highest compared to other metals, while Cr had the least concentration (0.01mg/kg) in the same rock material. A similar study has shown that heavy metals can also occur as natural cycling from rocks but their various concentration depend on the type of parent material, age and formation (Mattigod *et al* 1983). The concentrations of Fe, Cu, Zn, Cd, Cr, Ni, Pb and Mn in the soils of the 3 sampling positions are shown in Table 2. The highest concentrations of almost all the heavy metals determined were recorded from the sampling position in the immediate vicinity of the quarry (0 km) except in the case of Cu. The concentrations of these heavy metals declined as distance from the quarry increases Apart from the levels of Cu and Cr, other heavy metals had significantly higher level of their concentration in the immediate quarry vicinity than that occurring at the 0.75 km and 2 km sampling locations. The higher concentrations of heavy metals recorded in sampling position within the vicinity of the quarry could be a contribution from the tailing waste generated from the quarry which in itself contained high level of these metals. The soils from the other 2 locations farther away from the quarry had reduced heavy metal contents because the dispersal of the tailing wastes diminished in the area with increasing distance.

Table 2: The mean concentrations (mg/kg) of some heavy metals in the crushed rock (chippings)

Elements	Mean Concentration (mg/kg)
Copper	9.28±0.25
Lead	1.88±0.18
Zinc	10.34±1.27
Iron	349.50±2.34
Cadmium	2.02±0.05
Nickel	3.22±1.55
Chromium	1.12±0.02
Manganese	2.44±0.01

Also in all the economic plant species examined, higher concentrations of the metals (Mn Fe, Cu, Zn, Cd, Cr, Pb, Ni) were recorded from those growing within the immediate vicinity of the quarry (0 km) than those growing at 0.75 km or at 2 km away from the quarry. The enhanced concentrations of these trace metals is an indication that they were more available for absorption by the plants at the quarry site than other areas farther away. Among the 6 plant species sampled, *Manihot esculenta* and *Colocasia esculenta* which are tuber and root crops respectively had higher concentration of Pb, Mn and Fe in their leaves (Table 3). The mean concentration of Pb, Mn and Fe in *Colocasia esculenta* and *Manihot esculenta* declined significantly in the farthest sampling position from the quarry (2 km) (Table 4). The decline in concentrations of these metals as the distance from the quarry increases further shows that the quarrying operation is strongly associated with the build up of the trace metals in the plants. In most instances the concentration level of these metals in soil is less than that in plants. Many authors have indicated that the concentration of trace metals contained in plants may be higher than that of the soil on which they are growing due to biomagnifications and bioaccumulation (Ponyat and McDonnel, 1991). This also suggests the existence of other possible factors such as type of soil and plant species that affect nutrient absorption process which ultimately contribute in determining the level of heavy metals in plants (Egunjobi and Nwoko, 2002). The concentration of some of these metals reported in this study was well over the recommended level of 0.05mg/kg for vegetable species (FEPA, 1991).

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 related study, high Pb level was found in the blood sample of cattle reared near a lead smelter plant (Neuman and Dollhopt, 1992).

The concentrations of Zn, Cu and Ni were found to be higher among the fruit crops (*Carica papaya* and *Magifera indica*) than in other species sampled. The concentration of Zn, Cu and Ni in *Magifera indica* and *Carica papaya* were 21.36 and 23.25 for Zn, 21.50 and 18.95 for Cu; 26.08 and 24.95 (mg/kg) for Ni respectively. The percentage concentrations of Zn, Cu and Ni in leaves of *Magifera indica* collected from the farthest sampling position from the quarry were lower by 81%, 63.04% and 51.93% respectively than that of plant leaves collected from immediate vicinity the quarry site. Also the leaves of *Carica papaya* occurring in the farthest sampling point had concentrations of Zn, Cu and Ni reduced by 75%, 48.92% and 59.77% when compared with stands of *C. papaya* occurring in the immediate vicinity of the quarry. The concentrations of these metals tend to decline as the distance from the quarry increases. Table 4 shows the concentrations of Cd and Cr in *Centrosema pubescens* and *Aspilia africana* as being higher than those other plant species evaluated in the immediate vicinity of the quarry (0 km). The values of Cd and Cr in these 2 plants decreased away from the immediate vicinity quarrying site. *Aspilia africana* consistently had higher concentrations of both Cd and Cr than other plant species in all the sampling position even at 2km distance from the immediate vicinity of the quarry. This shows that the capacity to absorb Cd and Cr is enhanced in this fodder species than the other type of plants. The significant concentration of these heavy metals in plant leaves at sampling position within the quarrying site indicates that the waste generated from the quarry is a major contributor of these metals to the vegetation and soil systems. The values obtained in this study were above the recommended range of 0.1-24mg/kg regarded as the maximum acceptable level for Cd in plant (Bowen, 1979). Cd levels greater than 5mg/kg had been reported as toxic to plants (Alloway 1995).

From the investigation no single plant species had highest concentrations in the entire heavy metals analyzed. This is attributable to their varying physiological differences and relative selectivity in rate of uptake of minerals. Also the metals are not equally available for absorption by plants, a factor dependent on the ionic form which the metals were occurring in the soil (Nwoboshi, 2000). Occurrence of heavy metals above the acceptable tolerance levels are particularly hazardous because of its uptake by plants, tendency to accumulate in food chain and its persistence once in the environment (Dudka and Adriano, 1997).

Although the present levels of some of these trace metals, for instance, iron and manganese pose no toxicity problem there is need to regulate and control the waste produced from quarrying activities in order to prevent the introduction of further excessive heavy metals into the existing food chain considering that the area is an agricultural zone.

Table 3: The mean concentrations (mg/kg) of some heavy metals in the soils at different sampling distances from the quarry

Sampling positions	Mn	Fe	Cu	Zn	Cd	Cr	Ni	Pb
0 km	28.75±3.85	950.25±2.85	92.24±7.26	21.13±4.26	8.25±1.24	1.45±0.82	3.25±2.84	32.25±2.17
0.75 km	17.92±4.28	520.35±3.75	94.26±3.27	16.25±1.29	3.28±0.29	1.05±2.74	2.98±0.45	14.27±2.08
2 km (control)	12.05±2.28	346.08±2.96	82.28±5.28	12.48±9.68	1.49±1.28	1.08±0.05	2.45±0.55	5.36±0.82

±: Standard error of mean

Table 4: The mean concentration (mg/kg) of heavy metals in plant leaves with respect to sampling distances from the quarry site

Plants	Pb			Mn			Fe		
	0 km	0.75 km	2 km	0 km	0.75 km	2 km	0 km	0.75 km	2 km
Alchomea cordifolia	7.50±3.48	5.50±0.65	2.00±0.47	42.25±1.10	36.07±2.56	12.25±1.16	30.00±0.05	13.28±1.58	12.19±0.40
Centrosema Pubescens	7.25±0.33	6.25±0.54	1.75±0.56	45.29±0.54	46.18±5.42	16.46±2.89	27.25±0.50	15.60±0.56	11.75±0.80
Aspilia Africana	6.25±0.25	5.25±2.87	1.25±0.92	33.25±2.29	28.06±1.19	15.58±3.45	25.09±1.17	14.28±0.65	10.25±0.86
Pterdium aquilium	7.00±2.86	4.75±0.28	27.6±0.08	46.85±6.75	38.0.9±7.85	20.18±4.94	23.48±0.80	18.24±0.50	8.25±0.02
Carica Papaya	8.26±0.38	5.57±0.48	2.75±0 59	60.28±5.50	29.18±4.21	18.16±0.11	42.28±1.45	35.20±1.40	28.29±0.54
Magifera indica	6.35±2.77	4.28±0.44	1.57±0.75	53.19±3.05	31.14±2.42	14.51±2.59	23.75±1.75	16.90±1.75	9.50±0.25
Psidium Guajava	7.60±2.34	3.86±0.95	2.25±0.48	38.71±4.05	26.57±5.55	21.00±0.16	28.17±0.49	20.38±0.84	11.45±0.18
Manihot esculenta	9.25±0.47	4.55±0.89	2.25±0.44	69.07±1.58	32.05±1.89	14.25±1.50	55.28±1.15	29.65±3.90	12.68±0.49
Abelmoscus esculenta	8.57±086	5.68±0.58	2.75±0.46	47.08±1.71	22.50±2.85	10.61±0.19	39.33±3.38	14.75±2.69	10.75±1.05
Colocasia esculenta	9.75±0.84	3.85±0.40	2.75±074	70.25±2.93	36.76±3.70	14.75±2.55	56.50±4.55	19.75±1.15	12.00±3.28

Table 4 (contd): The mean concentrations (mg/kg) of some heavy metals in plant leaves at different sampling distances from the quarry.

Plants	Zn			Cu			Ni		
	0 km	0.75 km	2 km	0 km	0.75 km	2 km	0 km	0.75 km	2 km
A. cordifolia	8.29±2.55	7.25±0.58	2.80±0.60	16.05±1.05	12.75±2.38	8.45±0.15	12.55±0.56	7.98±0.22	5.05±0.27
C. Pubescens	12.50±1.29	5.29±0.30	1.50±0.56	14.28±2.58	10.28±0.48	5.34±0.08	17.25±0.52	14.28±0.60	12.05±0.92
A. Africana	12.75±1.19	4.75±0.18	3.25±1.28	10.75±1.26	7.14±2.20	6.35±0.57	16.00±0.05	8.88±0.40	4.50±0.22
P. aquilium	10.50±0.85	3.05±0.04	1.27±0.75	11.78±2.31	8.25±0.12	7.28±1.73	13.45±0.99	9.45±0.56	5.68±0.04
C. papaya	23.25±1.11	4.29±1.56	2.25±0.15	18.95±3.21	5.22±0.85	3.50±0.80	24.93±0.56	8.56±0.58	6.28±0.59
M. indica	21.36±1.11	4.29±1.56	2.25±0.15	21.50±3.56	9.25±0.11	4.75±1.06	26.08±0.58	10.50±0.29	8.25±0.75
P. guajava	11.68±1.05	5.28±0.18	1.75±0.06	9.69±1.83	6.75±1.96	5.49±0.57	13.75±0.36	6.85±0.46	2.47±0.56
M. esculenta	12.50±1.21	5.58±1.11	1.25±0.18	10.00±0.02	7.82±0.48	5.00±0.58	10.25±1.06	8.60±1.50	4.28±0.09
A . esculenta	9.27±1.15	3.25±0.05	1.25±0.16	12.08±1.18	7.00±0.03	5.25±2.24	12.55±0.55	7.68±1.85	4.75±0.48
C. esculenta	11.50±0.18	5.65±1.06	3.65±0.25	7.75±0.65	4.25±1.19	4.20±2.20	14.56±1.29	10.25±2.25	6.94±1.53

Table 4 (contd): The mean concentrations (mg/kg) of some heavy metals in plant leaves at different sampling distances from the quarry.

Plants	Cd			Cr		
	0km	0.75km	2km	0km	0.75km	2km
A.. cordifolia	10.50± 1.28	5.28±0.26	2.75±0.56	6.50±1.28	4.00±0.38	2.28±1.18
C. pubescens	12.25±0.60	5.25±0.20	2.10±0.59	12.00± 0.50	3.80±1.84	2.00±1.25
A.. Africana	12.17±0.17	6.26±0.50	3.78±0.59	18.05±1.20	7.50±0.50	5.50±1.70
P. aquilium	8.55±0.48	4.75±1.57	1.57±0.38	9.25±0.85	4.68±0.90	2.28±0.68
C. papaya	10.75±2.34	4.55±1.23	2.26±1.18	8.75±1.33	5.08±1.09	3.05±0.01
M. indica	8.38±1.56	3.25±0.55	1.25±1.14	9.05±0.33	5.52±0.06	3.25±1.14
P. guajava	10.87±1.05	4.55±0.25	1.56±0.25	8.50±0.54	4.95±1.85	2.05±1.56
M. esculenta	11.25±1.05	5.85±1.29	2.25±0.06	9.25±0.80	6.28±0.50	3.75±0.95
A. esculenta	8.25±1.29	3.06±0.90	1.59±0.95	7.50±1.17	3.75±0.65	2.75±1.18
C. esculenta	10.50±1.75	5.36±0.58	2.38±1.58	6.75±1.12	4.28±1.84	3.04±1.10

± Standard error of mean

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