Research Article

Evaluation of heavy metal profiles in *Telfairia occidentalis* Hook and soil along Abak-Oruk Anam Ukanafun road in Akwa Ibom state of Nigeria

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Abstract

Evaluation of heavy metal contents in soil and *Telfairia occidentalis* Hook was carried out along Abak- Oruk Anam-Ukanafun road in Akwa Ibom State of Nigeria. Two major sampling locations, road side (RS) and remote area (RA) were choosen and sub-divided into four sampling units each, RS_1 to RS_4 (RS_1- Obio Akpa, RS_2- Ikot Uboh, RS_3- Nkek Abak and RS_4- Ikot Akpa Ntuen) and RA_1 to RA_4 (RA_1- Obio Akpa, RA_2- Ikot Uboh, RA_3- Nkek Abak and RA_4- Ikot Akpa Ntuen). Leaf (*Telfairia occidentalis*) and soil samples were obtained from each sampling units in five replicates. Soil chemical properties (pH, organic matter, available phosphorus, total nitrogen, calcium, magnesium, sodium, and potassium) and heavy metals (zinc, copper, iron, lead, and cadmium) in experimental soil and leaf of the test crop were examined in each sampling unit. The results showed that there were significant differences ($P < 0.05$) in soil chemical properties, heavy metal contents (zinc, copper, iron, lead and cadmium) in soil and leaf of the test crop between the two major sampling locations. The values of the heavy metals of the contaminated sites were within the internationally recommended levels of crop tolerance in agricultural soils. This study suggests that there were significant ($P < 0.05$) variations in levels of heavy metals between the two sampling locations; hence, construction companies should always put in place appropriate measures to handle the contamination around their construction sites, most especially in cultivated lands.

Keywords: Heavy Metals, *Telfairia Occidentalis*, Soil, Abak-Oruk Anam-Ukanafun Road, Nigeria.

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INTRODUCTION

Chemical contamination is a potential risk associated with waste reuse, construction operations and mining activities[5,29]. Chemical contaminants may be transported to cultivated soils through various channels such as leaching, erosion and air movement[4,10]. Agricultural soils are faced with chemical hazards such as heavy metals, nutrients such as nitrogenous compounds, phosphorus compounds, minerals, insecticides, pesticides, fertilizers, fungicides, herbicides and organic wastes[13,18]. This study was conducted in 2013 when Abak - Oruk Anam - Ukanafun road in Akwa Ibom State of, Nigeria was constructed with its attendant's generation of waste from tar, cements, rocks and other components used in road construction. There are cultivated lands, mostly at subsistence scale along the study area. It is important to note that the poorest groups involved in urban and rural agriculture are most likely to utilize high - risk sites with toxic components[17] Thus, this may pose a health risk on local communities growing and consuming food crops and vegetables in contaminated sites. The sequence of contamination involves contamination of soils by chemicals, the potential uptake by crops and the possible chronic and long term toxic effects in humans[12,19]. Although plant uptake of heavy metals depends significantly on the metals as well as the prevailing soil conditions, several studies have indicated that crops grown on heavy metal contaminated soils have higher concentrations of heavy metals than those grown in uncontaminated soil[11,18,29]. Road or high way soils have been reported to become enriched with some heavy metals emanating from vehicle emission, road construction activities and other pollution sources[28,12]. *Telfairia occidentalis* Hook belongs to the family Curcubitaceae. It is a vine which grows in the forest zone of West Africa, and a delicious perennial crop which climbs by means of coiled tendrils. The crop is cultivated for its succulent tender shoot which constitutes an important component in the diet of people[22,26]. Although several studies have been conducted on plant-heavy metal-soil interactions, this present study was conducted to assess the impact of road construction activities on soil and *Telfairia occidentalis* Hook in the study area.

MATERIALS AND METHODS

Study Area

The study was carried out along Abak - Oruk Anam - Ukanafun road in Akwa Ibom State of Nigeria between the months of March and April, 2013. Akwa Ibom State has the following Coordinates; Latitude 4º30´- 5º30´N; Longitude 7º30´- 8º30´E; Altitude- 106m AMSL (Above mean sea level), and is located within the humid tropical rainforest zone of south eastern Nigeria. The mean annual rainfall is about 2,000 mm with a mean annual minimum, and maximum temperature of 23ºC and 31.7ºC, respectively. The dry season is between December to February while the wet season is between March to November[6,31].

Sampling Location

Sampling was carried out using the method of[20]. The study area was divided into 2 major sampling locations, namely road side (Rs) and remote area (RA). Four sampling units (villages) were systematically choosen along the study sites (Obio Akpa, Ikot Uboh, Nkek Abak and Ikot Akpan Ntuen). The sampling units were arranged as follows; RS_1 (Obio Akpa), RS_2 (Ikot Uboh), RS_3 (Nkek Abak), and RS_4 (Ikot Akpa Ntuen) for road side sampling locations while (RA_1 (Obio Akpa), RA_2 (Ikot Uboh), RA_3 (Nkek Abak) and RA_4 (Ikot Akpa Ntuen) were for remote area sampling locations. Soil and leaf (*Telfairia occidentalis)* samples were collected both at the road side (RS) and remote area (RA) sampling locations. Samples were collected at 15m away from the express road for road side (RS) sampling units while collection of samples for remote area (RA) was carried out at 15km from the express road. Leaf samples of the test crop (*Telfairia occidentalis)* were collected two (2) months after planting while soil samples were collected at 0-15cm depth. Each treatment was replicated five (5) times using randomized complete block design.

Analysis of Soil Samples

Top soils (0- 15cm) used for assessment of chemical properties of the experimental soil were obtained at each sampling unit in the study area. Soils samples were air dried to constant weight and the chemical properties were analysed using standard procedures[3,7].

Analysis of Plant Samples

Analysis of plant samples was carried out using the method of[4]. Leaf samples of *Telfairia occidentalis* were thoroughly washed with water, rinsed with distilled water and placed in polybags. They were oven dried to a constant weight at 60^o C, macerated to powder form using pestle and mortar, and stored in sample bottles for analysis. The powdered plant samples were dried in an oven at 105^{o}C for 2 hours, 1.0g weighed into a platinum crucible and placed in a muffle furnace maintained at 400^{o}C. The samples were ashed for 5 hours, dissolved with 10cm^3 of 1M HCL, the resulting solution filtered through Whatman No. 1 filter paper into 50cm^3 volumetric flask and made up to the required mark with distilled deionized water. Standard reagents of analytical grade were used for the analysis, and contents of heavy metals in the solution were determined using Atomic Absorption Spectrophotometer (AAS) of Unicam Model.

Statistical Analysis

Analysis of variance (ANOVA) was used to analyse the data generated from the study. Differences in the means were tested using Least Significant Differences (LSD) at probability level of 5%[21].

RESULTS

The pH of soil in all the sampling locations was acidic with a range of 4.64 to 5.99, although soils at the road side (RS_1, RS_2, RS_3 and RS_4) were more acidic (4.64 to 4.92) than those of the remote area (RA_1, RA_2, RA_3 and RA_4) with a pH range of 5.37 to 5.99 (Table 1). The soil organic matter contents at the road side were between the range of 1.40 to 2.01%, and these were significantly ($P < 0.05$) lower than those of the remote area with soil organic matter ranging from 2.16 to 2.56% (Table 1). The highest and lowest values of 0.95 and 0.62% were recorded in soil at the road side- RS_3 and RS_2, respectively, for soil total nitrogen, while the highest and lowest values of 1.68 (RA_1) and 1.16% (RA_3) soil total nitrogen were recorded for soils in the remote area (RA) (Table 1). The available phosphorus contents in soil at the road side (RS_I- 0.37, RS_2- 0.26, RS_3- 0.73 and RS_4- 0.47%) were significantly ($P < 0.05$) lower than those of the remote area (RA_I- 1.17, RA_2- 1.06, RA_3- 0.83 and RA_4- 0.94%) (Table 1). Similarly, the calcium, magnesium and potassium contents in soil at the road side

(RS) were significantly ($P < 0.05$) lower than those of the remote area (RA) (Table 1). Conversely, the sodium contents in soils at the road side (RS) were relatively ($P < 0.05$) higher than those of the remote area (RA) (Table 1). In all treatments assessed for heavy metal contents of soil, lower values ($P < 0.05$) of heavy metals (zinc, cadmium, copper, iron and lead) were recorded in soil at the remote area (RS) in relation to those of the road side (Table 2). Heavy metal contents in soil for zinc, cadmium, copper, iron and lead ranged from 1.20 to 1.72, 1.34 to 1.62, 1.17 to 1.30, 1.25 to 1.46 and 1.05 to 1.31 mg/100g, respectively, at the road side, while those of the remote area ranged from 0.12 to 0.25, 0.24 to 0.36, 0.30 to 0.40, 0.13 to 0.22 and 0.07 to 0.09 mg/100g, respectively (Table 2). Heavy metal (zinc, cadmium, copper, iron and lead) contents in leaf of *Telfairia occidentalis* were comparatively lower than the heavy metal contents in experimental soils (Table 2 and 3). In addition, the zinc, cadmium, copper, iron and lead contents in leaf of the test crop at the road side were significantly ($P < 0.05$) lower than those of the remote area (Table 3).

Table 1: Chemical properties of experimental soils along Abak-Oruk Anam- Ukanafun road in Akwa Ibom State of Nigeria

Location	Sampling sites	ph	Organic matter (%)	Tota ln (%)	Avail.p (%)	Ca Mg/100g	Mg Mg/100g	Na Mg/100g	K Mg/100g
Road side (rs)	Rs_1 (obio akpa)	4.76 ±0.33	1.82 ±0.53	0.87 ±0.01	0.37 ±0.02	3.21 ±0.63	2.72 ± 0.23	4.26 ±0.53	1.20 ±0.14
	Rs_2 (ikot uboh)	4.64 ±0.23	1.40 ±0.23	0.62 ±0.04	0.26 ±0.04	2.91 ±0.34	2.02 ± 0.41	3.07 ±0.43	1.10 ±0.32
	Rs_3 (nkek abak)	4.92 ±0.52	2.01 ±0.41	0.95 ±0.03	0.73 ±0.06	3.89 ±0.65	2.97 ± 0.35	4.77 ±0.54	1.53 ±0.57
	Rs_4 (ikot akpan ntuen)	4.85 ±0.66	1.96 ±0.64	0.72 ±0.06	0.47 ±0.03	3.70 ±0.23	2.84 ± 0.57	4.60 ±0.88	1.30 ±0.43
Remote Area (ra)	Ra_1 (obio akpa)	5.99 ±0.53	2.56 ±0.54	1.68 ±0.71	1.17 ±0.18	4.60 ±0.56	3.98 ± 0.46	2.39 ±0.35	1.70 ±0.24
	Ra_2 (ikot uboh)	5.83 ±0.42	2.33 ±0.32	1.52 ±0.82	1.06 ±0.21	4.32 ±0.44	3.72 ± 0.71	2.21 ±0.72	1.67 ±0.54
	Ra_3 (nkek abak)	5.37 ±0.36	2.16 ±0.48	1.16 ±0.11	0.83 ±0.04	4.02 ±0.95	3.46 ± 0.45	1.95 ±0.14	1.56 ±0.65
	Ra_4 (ikot akpan ntuen)	5.48 ±0.43	2.42 ±0.63	1.33 ±0.49	0.94 ±0.06	4.20 ±0.32	3.56 ± 0.24	2.07 ±0.19	1.60 ±0.53
Mean		5.22	2.08	1.11	0.73	3.86	3.16	3.17	1.46
Lsd ($p < 0.05$)		1.02	0.91	0.43	0.02	0.83	0.43	0.72	0.54

Mean value ±Standard error from five replicates

Table 2: Heavy metal contents of experimental soils along Abak-Oruk Anam- Ukanafun road in Akwa Ibom State of Nigeria

Location	SAMPLING SITES	ZINC Mg/100g	CADMIU Mg/100g	COPPER Mg/100g	IRON Mg/100g	LEAD Mg/100g
Road Side (rs)	RS_1 (Obio Akpa)	1.65± 0.32	1.58±0.35	1.27±0.04	1.38±0.14	1.16±0.23
	RS_2 (Ikot Uboh)	1.72± 0.46	1.62±0.22	1.30±0.07	1.46±0.12	1.31±0.42
	RS_3 (Nkek Abak)	1.20±0.13	1.34±0.13	1.17±0.05	1.25±0.04	1.05±0.45
	RS_4 (Ikot Akpan Ntuen)	1.61±0.74	1.43±0.43	1.21±0.04	1.42±0.34	1.21±0.37
Remote Area (ra)	RA_1 (Obio Akpa)	0.12±0.03	0.24±0.04	0.37±0.04	0.18±0.01	0.09±0.01
	RA_2 (Ikot Uboh)	0.16±0.01	0.28±0.02	0.30±0.02	0.13±0.04	0.07±0.01
	RA_3 (Nkek Abak)	0.25±0.05	0.36±0.04	0.40±0.01	0.22±0.02	0.11±0.02
	RA_4 (Ikot Akpan Ntuen)	0.18±0.07	0.31±0.06	0.33±0.02	0.16±0.03	0.08±0.01
Mean		0.86	0.90	0.79	0.76	0.74
LSD ($P < 0.05$)		0.05	0.02	0.07	0.06	0.01

Mean value ±Standard error from five replicates

Table 3: Heavy metal contents in leaf of *Telfairia occidentalis* Hook along Abak-Oruk Anam- Ukanafun road in Akwa Ibom State of Nigeria

Location	Sampling sites	Zinc Mg/100g	Cadmiu Mg/100g	Copper Mg/100g	Iron Mg/100g	Lead Mg/100g
Road side (rs)	Rs_1 (obio akpa)	0.88±0.04	0.75±0.12	0.79±0.18	0.53±0.04	0.37±0.02
	Rs_2 (ikot uboh)	0.93±0.05	0.84±0.15	0.88±0.19	0.56±0.12	0.49±0.12
	Rs_3 (nkek abak)	0.72±0.01	0.64±0.10	0.67±0.06	0.42±0.17	0.33±0.04
	Rs_4 (ikot akpan ntuen)	0.86±0.11	0.68±0.09	0.72±0.16	0.48±0.11	0.35±0.05
Remote Area (ra)	Ra_1 (obio akpa)	0.04±0.01	0.08±0.01	0.21±0.03	0.07±0.02	0.03±0.01
	Ra_2 (ikot uboh)	0.06±0.01	0.13±0.03	0.15±0.05	0.04±0.01	0.02±0.00
	Ra_3 (nkek abak)	0.10±0.02	0.18±0.05	0.24±0.02	0.10±0.02	0.06±0.01
	Ra_4 (ikot akpan ntuen)	0.09±0.01	0.15±0.02	0.17±0.02	0.06±0.03	0.02±0.00
Mean		0.46	0.43	0.48	0.28	0.21
Lsd ($p < 0.05$)		0.02	0.08	0.01	0.02	0.01

Mean value ±Standard error from five replicates

DISCUSSION

This study revealed that although, the soil components were negatively affected at the road side than those of the remote area, the overall heavy metal contents in the soil and tissue of the test crop were within the internationally recommended levels for crop tolerance in agricultural soils[14,15]. There were marked variations in chemical properties of soil between the road side and remote area of the study area. These differences may be attributed to the potential source of contamination in the study area, that is, the construction work which was more pronounced at the road side than the remote area. Environmental disturbances as a result of mining and road construction activities have been shown to constitute a major threat to environmental quality[1]. Therefore, the disparity in soil chemical composition between the two sampling sites may be due to the negative impacts of soil contaminants around the construction sites. Thus, contaminants such as dust and heavy metals may reduce biological processes in soils such as litter decomposition, soil respiration and nitrogen mineralization as well as the activity of key soil bacteria[16]. Similarly, the pH range of soil at the remote area which was acidic could have enhanced the nutrient base than those at road side with a relatively low pH value. pH values above or below the slightly acidic range (pH 5.8 to 6.5) have been shown to result in less vigorous growth of plants and nutrient deficiencies[13,30]. The differences in contents of zinc, copper, cadmium, iron and lead in soil between the road side and remote area may be due to variations in the physical, chemical and biological properties which affected bioavailability of metallic ions in soil as reported by[8]. This shows that the soil structure and other components of soil at the road side were negatively affected than those of the remote area. This implies that the movement of solute, salt solubility, chemical reactions and microbial activities, and ultimately the bioavailability of the metal ions depend on the soil structure, texture and moisture[9,25]. The differences in contents of heavy metals in tissue of the test crop between the two locations may be as a result of relationship between the total supply and availability of metallic ions, which depend on the soil conditions [24]. Although, the innate capacity of the plant species to absorb metals plays an important role in the contents of metals in plant tissue, vegetables have been reported to accumulate higher levels of trace metals in leaves than in fruits[19]. Thus, availability of metallic ions in soil may depend on the pH, binding or ion exchange with the soil medium[2,23]. This suggests that the extent of binding of the ions with the soil particles and the rate of diffusion of ions through soil medium to the plant soil interface affect mineral availability[2,27].

CONCLUSION

This study suggests that although the extent of contamination around the construction sites was within the recommended levels for crop tolerance in agricultural soils, there were variations in heavy metal contents between the two major sampling locations in the study area. Therefore, appropriate measures should be put in place for effective handling of contaminants around any construction sites, most especially in agricultural areas.

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