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Some trace elements in the fadama soils and spinach (*Amarantus* sp.) along River Jakara near the abattoir in Kano, Nigeria

N.I. Dike*, S.J. Oniye, A.U. Ezealor and V.O. Ajibola[1]
Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria
[1]*Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria*

ABSTRACT

The concentrations of lead, copper, iron and cadmium in the soils and spinach (*Amarantus* sp.) along the microtopographical features of the River Jakara (Levee, levee backslope, cover plain and backswamp) near the abattoir in Kano, were determined in some dry and wet season months of 2003 by Atomic Absorption Spectrophotometry (AAS). The spinach were irrigated with waste water from the river, especially during the dry season. The soil samples were taken at two depths, 0–15.0cm and 15.0 – 30.0cm at the four microtopographical zones while the spinach were from two slopes, the levee and backswamp. Results showed positive correlation between Pb and Cu in each of the slopes and in all slopes in the two depths with r-values of 0.50, 0.10, 0.93, 0.79 and 0.67 for the levee, levee backslope, coverplain, backswamp and combined slopes respectively between 0 – 15.0cm depth. Between 15.0 – 30.0cm depth, the r-values for the slopes were 0.76, 0.93, 0.98, 0.86 and 0.80. There was also a positive correlation between Fe and Cd in each of the slopes and in all slopes (except the backswamp with negative correlation) with r-values of 0.97, 0.83, 0.52, -0.82 and 0.69 for the levee, levee backslope, coverplain, backswamp and combined slopes respectively between 0 – 15.0 depth. Between 15.0 – 30.0cm depth, the r-values for the slopes were 0.17, 0.66, 0.63, -0.95 and 0.32. Concentrations of Pb and Cu increased at the same time and so were the concentrations of Fe and Cd. The accumulations of these trace elements in the two depths of the soils were in the magnitude of Fe > Pb > Cu> Cd while it was Pb> Fe> Cu> Cd in the spinach. The concentrations of the metals in the soils and vegetables in the two depths of most of the slopes exceeded the international maximum permissible limits.

*Author for correspondence

INTRODUCTION

Flood-plain, "fadamas" are hydromorphic soils of the valley bottoms along stream and river courses [1]. Right angle away from the riverbank, micro-topographical features such as levee (lower slope nearest to the river), levee backslope (middle slope), coverplain (upper slope) and backswamp (crest slope) are exhibited [1,2]. The physical and chemical component of these features vary [3].

Floodplain "fadama" soils are used for agriculture and allows the production of crops throughout the year and are therefore of economic benefits to the local communities and environs. Fadama cultivation commences as soon as the dry season sets in and the inland valleys are sufficiently drained. The usual cereal-based farming system is replaced with vegetables such as carrots, cabbage, lettuce, spinach, tomatoes and onions. River Jakara in Kano metropolis which is used for the irrigation of these crops also transport urban waste and domestic sewage in addition to other wastes that assist accumulation of some trace elements in the river [4,5], fadama soils and subsequently in the vegetables planted in them. For instance, a large proportion of soil around the city of Lahore, Pakistan, has been contaminated with Cd, Ni, Pb and Cu due to the application of sewage water for many years [6]. Most croplands in the vicinity of rivers fed with industrial sewage have been contaminated by toxic micrometals [7], and plants growing on industrial effluent-contaminated soil accumulate potentially toxic elements from the soil [8].

Therefore, this study was designed to determine the concentrations of some trace elements in the River Jakara floodplain and spinach cultivated in them near the abattoir in Kano, Nigeria.

EXPERIMENTAL

Sample Collection

Composite soil samples were collected in February and April (dry season) and in June and September (rainy season) of 2003. Samples were collected from each of the four microtopographcial features i.e. levee (lower), levee backslope (middle), coverplain (upper) and backswamp (crest) slopes of the

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River Jakara, near the abattoir. Samples were taken at two depths, 0 – 15.0cm and 15.0 – 30.0cm for each month using an auger. Samples were collected in triplicates from each microtopographical zone. The soil samples were then stored in polythene bags, taken to the laboratory and air-dried. The samples were later ground using a mortar and a pestle and sieved using a 2mm sieve.

10 – 15 matured spinach *Amarantus* sp) were collected from the levee and backswamp slopes at random along with the soil samples for each of the months. The samples were packed lightly in loosely woven bags to the laboratory. The spinach samples were washed with running tap water to clean adhered impurities, then rinsed with distilled water and air-dried thereafter. Dried samples were pulverized using mortar and pestle, and passed through a 2mm sieve. Sieved soil and pulverized vegetable samples were further kept in oven at 65 ± 2^{o}C for 24 hours to obtain a constant weight [8].

All reagents used are of analytical grade and distilled water was used in the work.

Determination of Metal Concentration in Soil and Vegetable Samples

Soil and vegetable samples were digested by a method described by [8]. One gram of each soil and vegetable sample was weighed into a dried 250 cm^3 beaker and was digested with a mixture of (3:1 v/v) of HNO_3 and HCl. Samples were digested on the hot plate until a clear solution was obtained, cooled and a little amount of distilled water added. It was then filtered through a Whatman No. 40 filter paper into a 100cm^3 volumetric flask. The residue was washed with warm distilled water and the solution made to mark with distilled water and transferred into 100cm^3 clean plastic container for the metal analysis using UNICAM 969 Atomic Absorption Spectrophotometer (AAS).

RESULTS AND DISCUSSION

The seasonal variation of Pb and Cu in each of the depths of the soil, 0 – 15.0cm and 15.0 – 30.0cm and in each of the slopes are similar (Fig. 1). In each depth of each slope, the concentrations of Pb and Cu were lower in the dry season months than in the rainy season months (except Pb with higher concentration in April (2.608 mg/l) than in June (0.976 mg/l) between 0–15.0cm depth) with peaks in September. The concentrations of Pb were however higher than that of Cu. Between 0–15.0cm depth, the concentrations of both metals are positively correlated in each of the slopes and in all slopes with r-values of 0.50, 0.10, 0.93, 0.79 and 0.67 for the levee, levee backslope, coverplain, backswamp and combined slopes respectively. Between 15.0–30.0cm depth, the r-values for the slopes were 0.76, 0.93, 0.98, 0.86 and 0.80 respectively. At higher pH values, metals are generally desorbed from organic and clay particles thus becoming more mobile in the soil [9]. The pH values of fadama soils always fall within the acid range [10,11 and 12] and the low pH could have contributed to the low accumulation of Pb and Cu during the dry season months, but may have been made available in the soil during the rainy season due to runoffs from fuel and discharge from excreta and soldering around the vicinity.

Table 1 showed that the concentration of Pb in the spinach increased from 0.769 mg/g in February to 6.084 mg/g in September in the levee. In the backswamp, it was 3.259 mg/g in February, 3.091 mg/g in April and 4.672 mg/g in September. The Cu concentration in the vegetable increased from 0.126

Table 1: Metal concentrations (mg/g) of spinach (*Amarantus sp.*) in the levee and backswamp slopes during the period of study

	Plant	Pb	Cu	Fe	Cd
		FEBRUARY			
Levee	Spinach	0.769	0.126	1.640	0.001
Backswamp	"	3.259	0.018	2.061	0.003
		APRIL			
Levee	Spinach	0.799	0.632	0.944	0.039
Backswamp	"	3.091	0.413	1.224	0.002
		JUNE			
Levee	Spinach	4.757	0.661	2.806	0.012
Backswamp	"	3.116	0.219	2.087	0.002
		SEPTEMBER			
Levee	Spinach	6.084	0.656	1.479	0.004
Backswamp	"	4.672	0.511	1.732	0.003

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mg/g in February to 0.661 mg/g in June with a slight drop (0.656 mg/g) in September in the levee. In the backswamp, it increased from 0.018 mg/g in February to 0.413 mg/g in April and decreased in June (0.219 mg/g) but increased in September (0.511 mg/g). The relatively higher concentrations of Pb and Cu in the vegetable in the rainy season months than in the dry season months could be attributed to the availability of the metals in the soils during the period. Their higher concentrations in the levee than in the backswamp may be associated with washoff of the metals from the latter to the former.

The seasonal variation of Fe and Cd in the two depths of the soil in most of the slopes is similar (Fig. 1). The concentrations of the metals were higher in the dry season than in the rainy season. The concentrations of Fe were higher than that of Cd. The concentrations of both metals are positively correlated in each of the slopes except for the backswamp (with negative correlation) and in all slopes with r-values of 0.97, 0.83, 0.52, -0.82 and 0.69 for the levee, levee backslope, coverplain, backswamp and combined slopes respectively between 0–15.0cm. Between 15.0–30.0cm depth, the r-values for the above slopes are 0.17, 0.66,

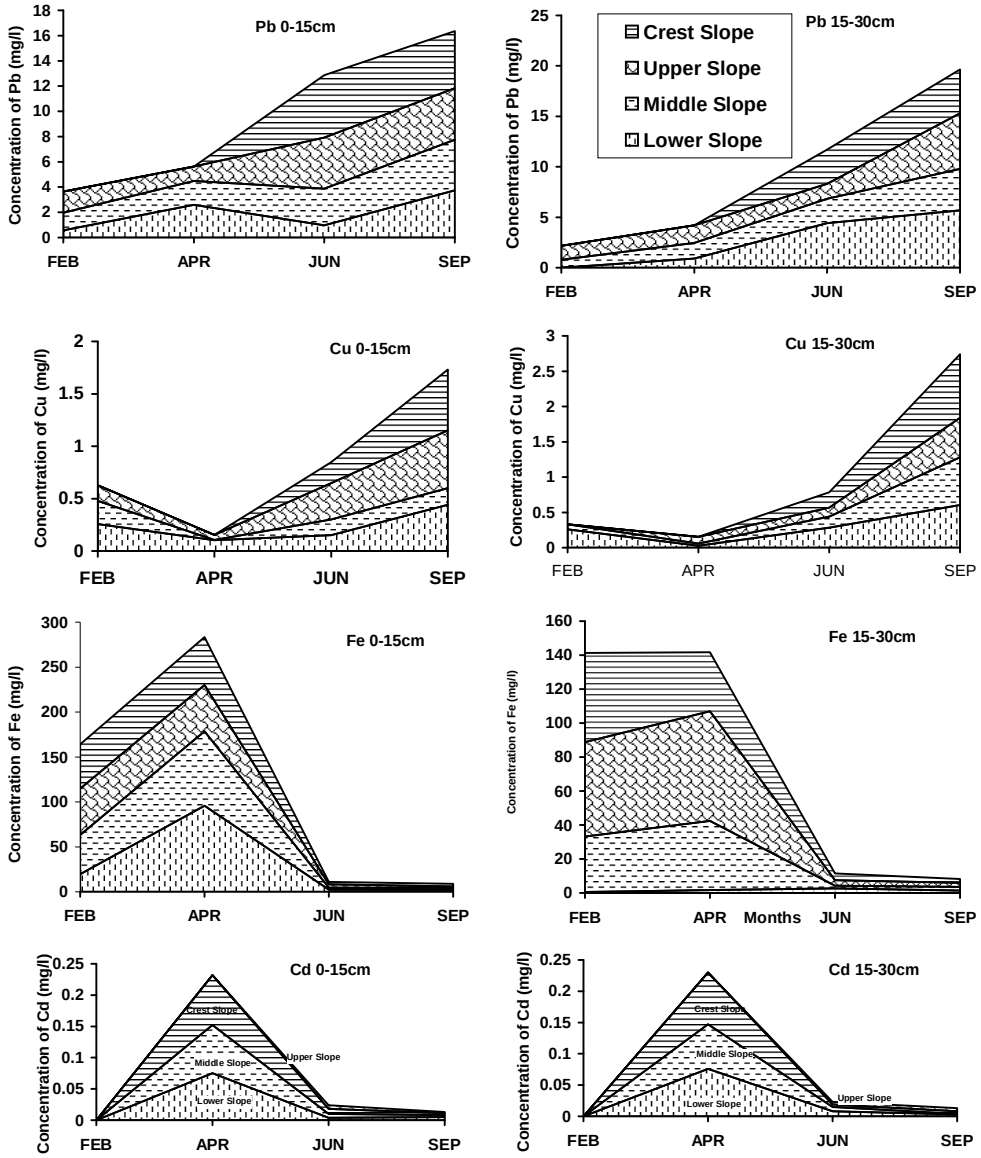


Figure. 1: Area plot of metals (Pb, Cu, Fe and Cd) concentration at 0-15 and 15-30cm depths during the study period.

0.63, -0.95 and 0.32 respectively. The high negative correlation between Fe and Cd in the backswamp in the two depths (r = -0.82 and –0.95) means that both metals did not coexist in the slope. Cadmium coexisted with Pb and Cu as shown by the positive correlation between Cd and Pb (r= 0.85 at 0–15.0cm depth and r = 0.99 at 15.0– 0.0cm depth) and between Cd and Cu (r = 0.35 at 0-15.0 depth and r = 0.85 at 15.0–30.0cm depth). The result showed a combined increase in the concentrations of Pb, Cu and Cd in the backswamp.

Fadama soils exhibit reducing conditions brought about by the absence of oxygen [2]. In the reducing conditions and in the presence of organic matter, iron compounds are chemically reduced from the ferric to the ferous state, which is more soluble. This could account for the high accumulation of Fe in the soils in the dry season months and may have been in the ferric state in the rainy season months. Leaching may have also contributed to its low accumulation in the rainy season. The concentrations of the trace elements in all the slopes and in the two depths occurred in the magnitude of Fe> Pb> Cu> Cd. Cadmium is soluble in soil under oxidized condition and under reducing conditions, it precipitates as cadmium sulphate [13] which may be responsible for its lowest concentrations in the soils. The concentrations of Fe, though high in the soils were lower than the maximum acceptable limits. On the other hand, the concentrations of Cd (though low) and that of Pb and Cu in most of the slopes, irrespective of season, were higher than the recommended permissible limits. The standard guidelines for Pb, Cu, Fe and Cd in soils are 0.002–0.02 mg/g, 0.005–0.1 mg/g, 7.0–550 mg/g and 0.00025–0.004 mg/g respectively [13, 16]. A large proportion of soil around the city of Lahore, Pakistan has also been contaminated with Cd, Ni, Pb and Cu due to the application of sewage water for many years [6].

Table 1 showed also that the Fe concentrations in the vegetable decreased from 1.640 mg/g in February to 0.944 mg/g in April and decreased to 1.479 mg/g in September from 2.806 mg/g in June in the levee. In the backswamp, the pattern is similar. It decreased from 2.061 mg/g in February to 1.224 mg/g in April, and increased to 2.087 mg/g in June and decreased to 1.732 mg/g in September. Cadmium also accumulated in the vegetable in both the levee and in the backswamp slopes. The Cd concentrations in the levee increased from 0.001 mg/g in February to 0.039 mg/g in April and decreased steadily to 0.004 mg/g in September. In the backswamp, it decreased from 0.003 mg/g in February to 0.002 mg/g in June and increased slightly to 0.003 mg/g in September.

Though the accumulation of Fe in the spinach is little when compared to its higher concentrations in the soils especially during the dry season, its concentrations and that of Pb in both slopes irrespective of season, exceeded the international recommended desirable limits. While the concentrations of Cu in the backswamp (0.018 mg/g) and Cd in the levee (0.001 mg/g) in February were within the range of recommended levels, their concentrations in both slopes in the other months of study were higher than the recommended desirable limits. The standard guidelines for Pb, Cu, Fe and Cd in plants are 0.00005 – 0.003 mg/g, 0.0025 – 0.025 mg/g, 0.04 – 0.5 mg/g and 0.0024 mg/g respectively [13, 16]. High concentrations of Cu, Pb, Cd, Fe and Cr in spinach grown along the banks of River Kaduna in Kaduna have been reported [9]. Leafy vegetables contaminated with Cu, Pb, Zn, Ni, Co and Cd have also been reported in Poland, India, Russia, Taiwan and China and concerns over the concentration of Cd uptake in plants is a serious health concern because of the suspected carcinogenic and mutagenic effects in humans with long-term cumulative exposure [14]. It is therefore imperative that consumers of spinach obtained from the abattoir zone of Kano may be liable to the carcinogenic effect of Cd after cumulative consumption. Cadmium has nephrotoxic effect, while Pb and Fe (though an essential element), have negative cognitive and behaviour effects in children and a dose of 100 g of Cu have resulted in liver and kidney damage [15].

CONCLUSION

The soils of the microtopographical features (levee, levee backslope, coverplain and backswamp) along the River Jakara, near the abattoir in Kano is polluted. This is due to the fact that untreated urban wastes and domestic sewage are discharged into the river coupled with other wastes which contaminate it with heavy metals – Pb, Cu, Fe and Cd especially during the dry season, with values above the international permissible limits for drinking and irrigation [4]. This has indirectly caused the accumulation of these heavy metals in the agricultural soils through irrigation and subsequently in the spinach planted in them, such that their concentrations in the soils (except Fe) and vegetables exceed the international permissible limits. We therefore call upon the relevant organ of government to find an alternative farmland for the farmers along River Jakara, Kano, where unpolluted waste sources can be utilized for production of vegetables.

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