

**EFFECT OF URBAN FLOOD WATERS AND SEDIMENTS ON THE
PRESENCE AND LEVELS OF HEAVY METALS IN VALLEY BOTTOM
SOILS OF EKPOMA METROPOLITAN, SOUTHERN NIGERIA.**

ABSTRACT

An experiment was conducted on some selected valley bottom soils in Ekpoma metropolitan, to investigate the presence and levels of heavy metals as affected by urban flood waters and sediments. Three sites were chosen for the investigation: Ambrose Alli University Teaching and research farm, Ekpoma (AAU), Emaudo (EM) and Uhiele (UH) quarters. AAU was used as control since it received no flood waters and sediments. At each site, a plot (25m x 25m) was demarcated for soil sample collection. Within each plot five spots were randomly chosen and soil samples were augered at two depths (0-15cm and 15-30cm), making ten samples per site. Samples were bagged, labelled and taken to the laboratory for analysis. The following metals were investigated – Mn, Pb, Co, Ni, Fe, Cd, Cu, Zn. Some chemical and physical properties were also investigated. Results were analysed statistically using (ANOVA) to determine significant differences between treatment means ($p=0.05$) and LSD was used to separate the means. Results revealed soils of Uhiele to be sandy clay loam, while Emaudo and A.A.U were sandy loamy. p^H values for all the sites and depths showed that the soils were acidic. Values for organic matter for the two sites were significantly higher ($p=0.05$) when compared to the control AAU. For heavy metals, the levels were below risk level for all the sites. All the metals showed increased values except Cobalt and Nickel, compared to the control (A.A.U). This experiment confirmed increase levels of heavy metals in valley bottom soils of Ekpoma metropolitan that regularly receive flood waters and sediments. Since anthropogenic activities will always be there, and with uncontrolled waste disposal systems, it is recommended that levels of heavy metals in these cultivated valley bottom soils be periodically monitored, so as to detect when the levels will pose health risk for those who may consume harvested products from these soils.

Key word: metropolitan, valley bottom soils, heavy metals and health risk.

1 INTRODUCTION

The immerging concern for actual or possible pollution of our environment is as a result of many anthropogenic activities which attempt to alter the environment in order to satisfy the many insatiable desires of man. One of such concern is the detection of health threatening levels of heavy metals in some major components of our environment, which include, air, water and the soil.

Heavy metals are toxic to plants and animals if absorbed in excessive amount and some of the metals are essential nutrients needed by plant such as copper (cu), manganese (Mn) and Zinc (Zn). Also most heavy metals,

act as enzyme inhibitors and disrupts the metabolic process of plants and organisms [1].

Activities such as mining, manufacturing, industries and the use of synthetic products such as pesticides, paints, batteries, industrial wastes and land application of industrial or domestic sludge can result in heavy metal contamination of urban agricultural soils [2].

Soils are major sink for heavy metals released into the environment by the aforementioned activities. Unlike organic contaminants which are allowed to oxidize to carbon (iv) oxides by microbial activities, most metals do not undergo microbial or chemical degradation [3] and their total concentration in soils persists for a long time after their introduction [4]. Municipal waste containing these heavy metals most and up at the valley bottom. Valley bottom soils are those at the bottom of the toposequences. These soils are hydromorphic in nature [5]. Water which is the major component of valley bottom soils flows into it from surface run-offs from upper slope, ground water seepage, and direct precipitation. In most cases, valley bottom soils are close to over flow and thus receive water from river when it over flows its bank especially during the rainy season [6].

Studies of the forms and distribution of heavy metals in valley bottom soils of urban cities are rare. This is despite the fact that the physico-chemical properties of these soils are different from the urban upland soils. The use of valley bottom land to grow vegetables during the dry season is wide spread in urban cities of Sub-sahara Africa. There is scarcity of information on heavy metals distribution in valley bottom city soils. Studies on metal enrichment in Nigeria, have concentrated on dump sites automobile garages, roadside drainage, channels of industrial areas [7,8,9].

Ekpoma is in fast growing semi urban settlement in Esan West Local Government Area, Edo State, Nigeria as well as a university town. As a result, it has quite considerable number of middle class citizens. This in turn has attracted small to medium size industries, artisans, markets, hospitality industries, health centres, network of roads with asphalt surfaces. On the other end are farmers, who cultivated various crops, to supply the needs of these urban dwellers.

Ekpoma is on a dissected plateau as shown by the physical map of Edo State [10], therefore whenever it rains, flood water easily finds its way from higher ground to the numerous valley bottoms bordering the town. These flood water with uncontrolled waste disposal system and improper drainage, are laden with all sorts of waste from domestic, municipal, to industries sites and latter deposited at these valley bottoms soils. These soils receiving the waste products, may have unacceptable level of heavy metals concentration. Therefore, the objective of this investigation was to assess the presence and level of some heavy metals in selected valley bottom soils in Ekpoma metropolitan.

2 MATERIALS AND METHODS

2.1 Location: The experiment was conducted at various sites in Ekpoma, Edo State. Ekpoma is located at long 6.7°N and Lat. 6.0°E. It is on the dissected Esan plateau. The town is surrounded by many dry valleys, most of which are upper heads of streams that are tributaries to those rivers whose course started from the Esan plateau watershed. The soils are

generally loamy sand. The mean daily temperature is 27.7°C, relative humidity is fairly high and it is above 70% [11]. The vegetation is the humid tropical type, though much of the original forest has been removed by man for one form of use type or the other. [12]

2.2 Three sites chosen for the experiments were:

Emaudo quarters (EM): This is on the north western part of the town. The crest of the slope of the valley is a settlement of several residential buildups, small processing factories, which included palm kernel mills, sawmill, several hairdressing saloons. The valley bottom proper is an orchard of kolanut trees. The size of the orchard was an acre. The trees are matured enough to form close canopies. Artifacts noticed on the soil surface included, plastics, seasoning wraps, rusted metals, pieces of glasses. Prominent weed was guinea grass (*Panicum Maximum*). The settlement was crisscrossed with several tarred roads. The length of the slope was 500m.

(1) **Uhiele quarters: (UH):** This occupies the eastern part of the town. The valley proper is dry and an extension of the head waters of the tributaries of river Orhiowon, whose course started from Esan plateau. The crest proper is a busy settlement with various human activities which included workshops of all types, artisans, vulcanizers, carpenters and welders. It also included several saloons, filling stations, medical centres, markets, and small scale processing factories. Two major highways perpendicular to each other pass through the site. As at the time of the experiment, it was partly cultivated, and partly fallow. Crops included plantain, cocoyam, and a plot been prepared for planting. Several artifacts were on the soil surface. These were plastics, seasoning wraps, rusted metals, pieces of glass, cellophane, and wigs. Stains were noticed on the lower portions of some of the scattered rubber trees that were also in the site. Stains are evidence of flooding [13]. The length of the slope was 1000m.

(2) Ambrose Alli University (AAU), teaching and research farm. (AAU). This site is at the outskirts of the town, in the north westerly direction. The valley proper is dry and extends downward to head waters of streams that flow into the Orley rivers [10]. As at the time of the experiment it was fallow. Predominant weed was *chromolaena Odorata*. The crest proper is occupied with orchard of cashew (*anacardium occidentale*) trees, soursop (*ammanum muncatum*). There were also staff and students experimental plots. No artifact was noticed on the surface of the valley bottom soils. The slope proper was about 500m. The AAU site acted as a control.

2.3 SOIL SAMPLE COLLECTION

At each site plot measuring 25m x 25m was demarcated for soil sample collection. Soil samples were collected randomly with the aid of an auger at two depths. 0-15cm and 15-30cm making ten samples per site. The samples were bagged, labelled and taken to the laboratory for analysis. The samples were air dried sieved and analysed, for the presence and levels of heavy metals. Particle size, pH and soil organic matter (SOM) content were also analyzed. The following metals were investigated: manganese (Mn), Iron

(Fe), copper (Cu), Zinc (Zn), Cadmium (Cd), Cobalt (Co), Lead (Pb) and nickel (Ni).

2.4 Heavy metals presence and levels of metals were determined by atomic absorption spectrophotometer (AAS). Samples were digested with fluoroboric acid. The digests were read by AAS and the absorbance were recovered using hollow cathode iron tube for iron (Fe) concentration. The tube for the other metals were inserted and the aspirate was read from the (AAS) [14]. Particle size distribution was by Bouyoucos's method [15]. Organic matter was Wet Oxidation Method [16]. p^H was determined in a 1:1 soil water suspension, using a pH meter [17].

Results and Discussion

Table 1 shows the particle size distribution and the corresponding textural classes of the three valley bottom soils. In all locations, the value of sand silt and clay varied from 60.0% to 83.2%, 1.4% to 81.2%, and 12.4% to 21.8% respectively. Silt and clay content have an overall mean 7.81.3%, 2.1% and 16.6% in AAU, 62.8%, 16.1% and 21.1% in Uhiele and 80.2%, 4.1% and 15.7% in Emaudo respectively. The silt content was higher in Uhiele site compared to the other sites and this could be due to, excessive, flood water received at the site, compared to others. This is because, it was only at this Uhiele site we noticed evidenced of flooding and induration represented by stained tree trunks [18]. Much more flooding of Uhiele compared to the other site, also implies, more sitting, hence, a different textural class for Uhiele compared to the others. The soils at Uhiele was sandy clay loam, while AAU and Emaudo were sandy loam.

The mean values of the metals investigated, SOM and p^H . (Table 2) At 15cm depth soils from UH and EM was significantly ($p=0.05$) higher in organic matter (OM) when compared to the control (A.A.U). The organic matter content at UH was 4.684% which was significantly ($P=0.05$) when compared to both A.A.U and EM. The range of OM content was 1.587 to 4.684%. [19] established critical level of OM of south western Nigeria at 1.00%. Based on this soils are said to be high in OM. For pH values indicated the soils of all the sites to be acidic. AAU was significantly ($P=0.05$) higher compared to UH and EM. At 15-30cm mean pH value for EM was significantly ($P=0.05$) different from AAU and UH. For heavy metals, (Mn, Fe, Co and Ni) the values recorded for all the sites and at the two depths were not significantly ($p=0.05$) different. On the other hand, three of the metals, Cu, Zn, and Pb, showed significant differences. Values recorded sites were below that which occur naturally as stated by [20,21]. At 0-15cm depth value for UH and EM, for CU were significantly ($P=0.05$) higher when compared to AAU (control). For Zn, value for UH was significantly ($P=0.05$) higher when compared to AAU and EM. For the same metal (Zn) there was no significant difference between EM and control. Values of levels of the metals were generally higher in UH, than EM and AAU. This was due to UH receiving more flood waters and sediments, compared to the other sites as evidenced, by stained tree trunks and more artifacts and stained tree trunk is an evidence of flooding. For the three sites Cd was not present in their soils. In all the metals, values for Fe was highest in each site than other metals. [22] also observed that most soils contain appreciable quantity of Fe. The range was 33.6mgkg^{-1} to 77mgkg^{-1} . UH has the highest value at both depths; and

[23] concluded that continuous application of municipal waste may result in higher metal concentration in agricultural soil. Generally, levels of all the metals investigated were below the maximum allowable limit for soils as recommended by [24] and [25]. [26] also observes low level of heavy metals (Cd, Pb, Zn, Cr, Ni and Co) in river bottom sediment (Table 2).

Table 3 highlighted increase or decrease in levels of the metals in soils at these sites as a results of metropolitan flood waters and sediments received, most of which are products of anthropogenic activities [27]. There was general increase in all the metals except Cd and Ni. At Emuado (EM) only four of the metals showed increase while at Uhiele (UH) all the metals showed increase except Nickel. One of the metals Cd was absent in all the soil, while Nickel alone showed a decrease. The behavior of Nickel (Ni) in the two sites as the only metal that showed a decrease could be due to chelating by clay and organic micelles, or soil reaction as explained by [28].

Table 4 shows the comparism of this work with that of (29) and highlighted the health status of these soils for healthy agricultural land use

SUMMARY

Cultivated valley bottom soils at the two sites Uhiele (UH) and Emaudo (EM) quarters of Ekpoma metropolitan were evaluated for presence and levels of some heavy metals as affected by flood waters and sediments. The following metals were identified, Mn, Fe, Cu, Pb, Zn, Ni. These metals were also in investigated at the valley bottom soils of Ambrose Alli University teaching and research farm. This investigation revealed that there was increase level of metals at the two sites. At Uhiele, which received more flood waters and sediments all the metals recorded increase except Cd and Ni. At Emaudo (EM) only four of the metals showed increase. One of the metals Cd was absent in all the soil, while Nickel alone showed a decrease.

CONCLUSION

Generally levels of all the metals were below maximum allowable health risk level. For now is will be safe to consume harvested farm products from these soils. However we recommend periodic monitoring of these soils since they will continue to act as sink to flood waters and sediments.

TABLE 1: PARTICLE SIZE DISTRIBUTION OF THE THREE SITES

LOCATIONS	DEPTH	SAND	SILT	CLAY	TEXTURAL	METHOD
	(CM)	(%)	(%)	(%)	CLASS	
AAU	0-15	81.8	1.4	16.8	SL	Hydrometer method [15]
	15-30	80.8	2.8	16.4	SL	"
MEAN		81.3	2.1	16.6	SL	"
UHIELE	0-15	65.6	14.0	20.4	SCL	"
	15-30	60.0	18.2	21.8	SCL	"
MEAN		62.8	16.1	21.1	SCL	"
EMAUDO	0-15	77.2	4.8	18.0	SL	"
	15-30	83.2	3.4	13.4	SL	"
MEAN		80.2	4.1	15.7	SL	"

KEY:
SL - SANDY LOAM SCL - SANDY CLAY LOAM

234 **Table 2: Mean Values of Heavy Metal Concentrations, Organic**
 235 **Matter and pH of the three sites.**
 236

Metals mgkg ⁻¹ /depth	AAU	UHIELE	EMAUDO	LSD	METHODS
Mn					
0-15cm	0.520	0.529	0.476	NS	Atomic absorption photospectrometry
15-30cm	0.480	0.731	0.605	NS	
Fe					
0-15	41.960	53.100	38.100	NS	“
15-30	33.600	77.600	50.400	NS	
Cu					
0-15	0.033	0.049	0.041	NS	“
15-30	0.017 ^b	0.055 ^a	0.053 ^a	0.033	
Zn					
0-15	0.233	0.461	0.112	NS	“
15-30	0.1209	0.647 ^b	0.109 ^a	0.308	
Cd					
0-15	Nil	Nil	Nil	-	“
15-30	Nil	Nil	Nil	-	
Pb					
0-15	0.047	0.063	0.032	NS	“
15-30	0.020 ^a	0.106 ^b	0.038 ^a	0.043	
Ni					
0-15	0.026	0.017	0.009	NS	“
15-30	0.014	0.020	0.010	NS	
% Om and P ^H					
% OM					
0-15	2.277 ^b	4.684 ^a	3.787 ^a	18.904	Dichromate Wet oxidation
15-30	1.587 ^b	4.280 ^a	2.147 ^b	18.359	
pH					
(1:1,soil:water)	4.5 ^b	5.8 ^a	6.9 ^a	5.28	Glass electrode pH meter
0-15	5.5 ^b	5.6 ^a	6.7 ^a	0.638	
15-30					

Table 3: Mean values of heavy metals in the two sites, compared to the control (AAU) (MgKg⁻¹).

Heavy metals/depth (cm)	A.A.U.	Uhiele	(Differences)	Emaudo	(Difference)
Mn					
0-15	0.520	0.529	+0.009	0.476	-0.044
15-30	0.488	0.731	+0.243	0.605	+0.117
Fe					
0-15	41.96	55.10	+11.140	38.100	-3.860
15-30	33.60	77.60	+44.00	50.40	+16.800
Cu					
0-15	0.33	0.049	+0.016	0.041	+0.008
15-30	0.07	0.085	+0.068	0.053	+0.036
Zn					
0-15	0.233	0.461	+0.228	0.112	-0.121
15-30	0.120	0.647	+0.527	0.109	-0.011
Cd					
0-15	0.00	0.00	oo	0.00	0.00
15-30	0.00	0.00	oo	0.00	0.00
Co					
0-15	0.001	0.002	+0.001	0.001	0.00
15-30	0.00	0.00	+0.00	0.00	0.00
Co					
0-15	0.001	0.002	+0.001	0.001	0.00
15-30	0.00	0.002	+0.002	0.000	0.00
Pb					
0-15	0.047	0.003	+0.016	0.32	-0.015
15-30	0.020	0.106	+0.086	0.038	+0.018
Nil					
0-15	0.026	0.017	-0.009	0.009	-0.017
	0.014	0.020	+0.006	0.010-	-0.004

TABLE 4

Level of heavy metals in soils used to guide clean-up and land use decisions (mgkg⁻¹) (29) and values for this study.

Metals	USEPA	Unrestricted	Restricted	This study mean values of both depths		
	Soil level requiring clean - up	use*		AAU	UH	EM
Manganese (Mn)	—	—	—	0.500	0.670	0.545
Iron(Fe)	—	—	—	37.780	68.350	44.250
Copper (Cu)	—	270	270	0.025	0.052	0.047
Cadmium (Cd)	70	0.43	0.860	Nil	Nil	Nil
Chromium (Cr)	230	11	22	—	—	—
Nickel (Ni)	1600	72	140	0.020	0.019	0.010
Lead (Pb)	400	200	400	0.034	0.085	0.035
Zinc (Zn)	23,600	1100	2200	0.177	0.554	0.116

*Include agricultural land use

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