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Research Paper

Evaluating the Distribution of Some Selected Heavy Metals In The Soils of a University Community Farm Land In Mid-Western Nigeria.

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ABSTRACT:- This study was carried out to evaluate the distribution of some selected heavy metals (Fe, Mn, Pb, Cu, Zn, Cd, Ni, Cr) of a University Community farm land with the aim of identifying the extent of either the defficiency or toxicity of these elements in soils. The main objectives of this study were to determine the levels of concentration of the heavy metals, examine the pattern of distribution and to predict the risk of toxicity or deficiency of the metals in soils using the guidelines provide by Alloway(1995) for heavy metal concentration. The study site is located at the proposed University of Benin farm project area, Benin City, Edo State and the size is about 62ha. The methodology employed involved soil survey by rigid grid method that produced seven mapping units, each mapping units was represented by a pedon which was described and sampled for laboratory analysis.

The result showed that Cd concentration in areas of pedons 1,2, 3 and 4 which occupied 39.52 ha exceeded the standard limit values in soil, while Cd concentration in areas of pedons 5, 6 and 7 were within permissible limits. The other heavy metals (Fe, Zn, Pb, Cu, Cr, Mn, Ni) were within permissible limits in all seven pedons. However, 2 ha of the total land area was inaccessible all through the period of survey.

Keywords:- Heavy metals, Distribution, Pedon

I. INTRODUCTION

Heavy metal is a member of loosely defined subsets of element that exhibit metallic properties. It may include the transition elements, some metalloids, anthanides and actinides. Heavy metals are often used as a group name for metals and metalloids that have been associated with contamination and potential toxicity (Duffus, 2002). Some heavy metals are pollutants with harmful influences on the natural ecosystem and human health (Hg, Pb) while others are essential elements or micronutrients (Fe,Zn,Cu) and they become harmful if present in excessive amounts, hence these micronutrients have a range of intake over which their supply is adequate to the body (Harmanescu et al, 2011). However, beyond these ranges, toxicity and deficiency effects are observed. Thus this project is aimed at not only identifying the type of heavy metals present but also the extent of either its deficiency or toxicity in the soils of the University farm land.

Heavy metal pollution in terrestrial ecosystem is of concern for a number of reasons-, Pollutants in the soil maybe absorbed through the roots together with soil water in which they are dissolved and may either cause injury to the plants or pass through the food chain when the plants are consumed. Metals are natural components of the earth crust-, they can neither be degraded nor destroyed and will remain in the soil permanently until they are leached out . Long term exposure and extensive use of agricultural land with frequent application of pesticides (Nicholson et al, 2003) could result in heavy metals such as copper, nickel, zinc and cadmium accumulating in the top soil. Contamination of soil by heavy metals is one of the most serious environmental problems that is implicated in human health process (Dang et al 2002, Obiajuwa et al, 2002). Sources of heavy metals that constitute major anthropogenic inputs include atmospheric deposition, waste disposal, fertilizer application and waste from agricultural lands. Generally, the distribution and relative mobility of heavy metals can be influenced by the nature of parent materials, and climatic conditions depending on such soil parameters as mineralogy, texture and classification of soil (Krishna and Govil, 2007). Some physico-chemical properties of soil such as pH and organic carbon are important parameters that control the accumulation availability of heavy metals in the soil environment.

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From the above observations, it has become obvious that heavy metals can become a source of worry in agricultural lands especially as was found in the University community land during the course of soil mapping where evidence of abandoned refuse dumb sites from both the University of Benin Teaching Hospital (UBTH) and the University seem to abound.

Various environmental agencies, including the Canadian council of ministers of the environment (CCME), 1999 have published soil quality guidelines to help protect environmental and human health, the New York state department of environmental conservation (NYSDEC)(1999), guidelines for assessing metal concentration in sediments and the USEPA-(2004) guidelines. For this project the guidelines by Alloway (1995) is used for the assessment of heavy metal concentration in soil.

Therefore, the main objectives of this study include were to determine the levels of heavy metals(Fe, Zn, Cd, Pb, Mn, Cu Ni, Cr) in the various soils of University of Benin community land; examine the pattern of distribution of the heavy metals; and predict the possible risk of either toxicity or deficiency of the heavy metals in the soils of the study area.

II. MATERIALS AND METHOD

STUDY AREA

This study was carried out at the University of Benin Community land, Benin City. The site is defined by points PC1 to PC8, appropriately geo-referenced as in the attached Location map1, divided into parcels A (29.1ha) and B(33.1ha) – situated between latitude 06.395890N and longitude005.63235$^{0^{\circ}}$E. Location Map2 also defines an aerial view generated from Google maps of the same area. The area is characterized by a tropical climate with an annual average rainfall amount of 1900mm, mean annual temperatures ranging from 23^{0}C to 37^{0}C and mean annual relative humidity ranging from 89% in the morning (10.00am) to 75% in the evening (4pm), recorded over a period of 18years (NIFOR, 2013). The site is situated at the Rainforest belt of the humid tropics (Illoba and Ekrakene, 2008) and southern ecological zone of Nigeria, with distinct dry and wet seasons (Molindo and Nwanchokor, 2010). The seasons correspond to the periods of dominance of the wet tropical continental air masses with seasonal distribution of rainfall following the direction of the Inter-Tropical Divergence (ITD) and vary almost proportionally with distance from the coast. The dry season begins early November and ends by March. The rainfall pattern is bimodal with peaks in July and August. However, there is a short spell in mid August which is accompanied by few thunder storms.

The soils are derived from recent coastal plain sands known as Benin formation (unconsolidated sands and sandy clay) and alluvial deposits (Umweni, 2007). Physiographic position is a terrace which descends down the slope and ends in a river. The vegetation includes primary forest along the river course; scattered trees of Rubber, Oil palm, Bamboo and Raffia palms; and some old and new farms cultivated to yam, cassava, fluted pumpkin, plantain, banana, pineapple, and so on.

Moreover, it is probable that abandoned construction site and burrowed pit may have predisposed some parts of the terrain to serious soil degradation expressed in deep aggressive gulley erosion and moat site converging to produce some dominant Entisols at the lower slope positions of the land scape. Construction contractors may have also abandoned some reasonable quantities of trips of granite observed at some portions of the land scape.

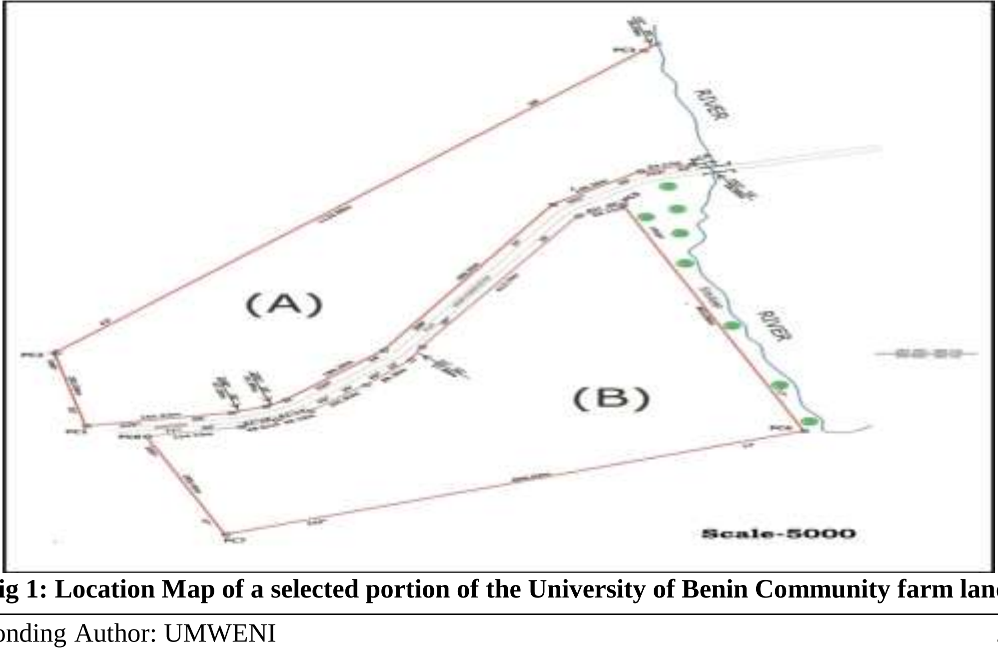


Fig 1: Location Map of a selected portion of the University of Benin Community farm land

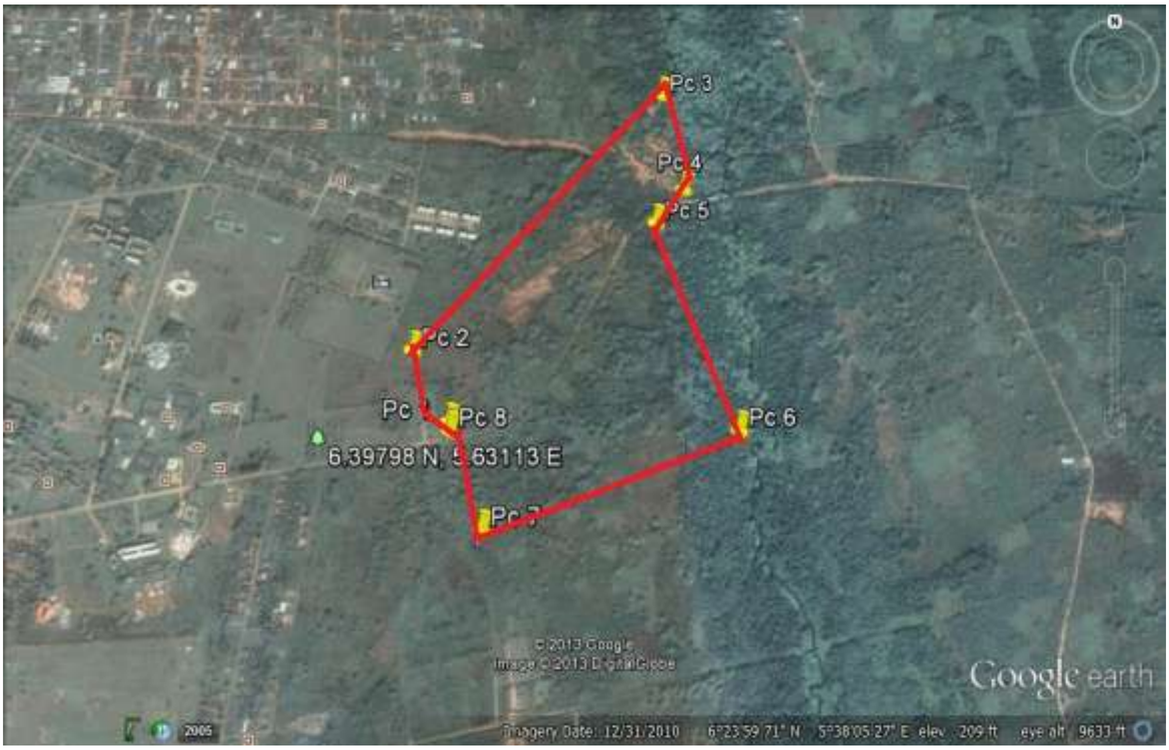
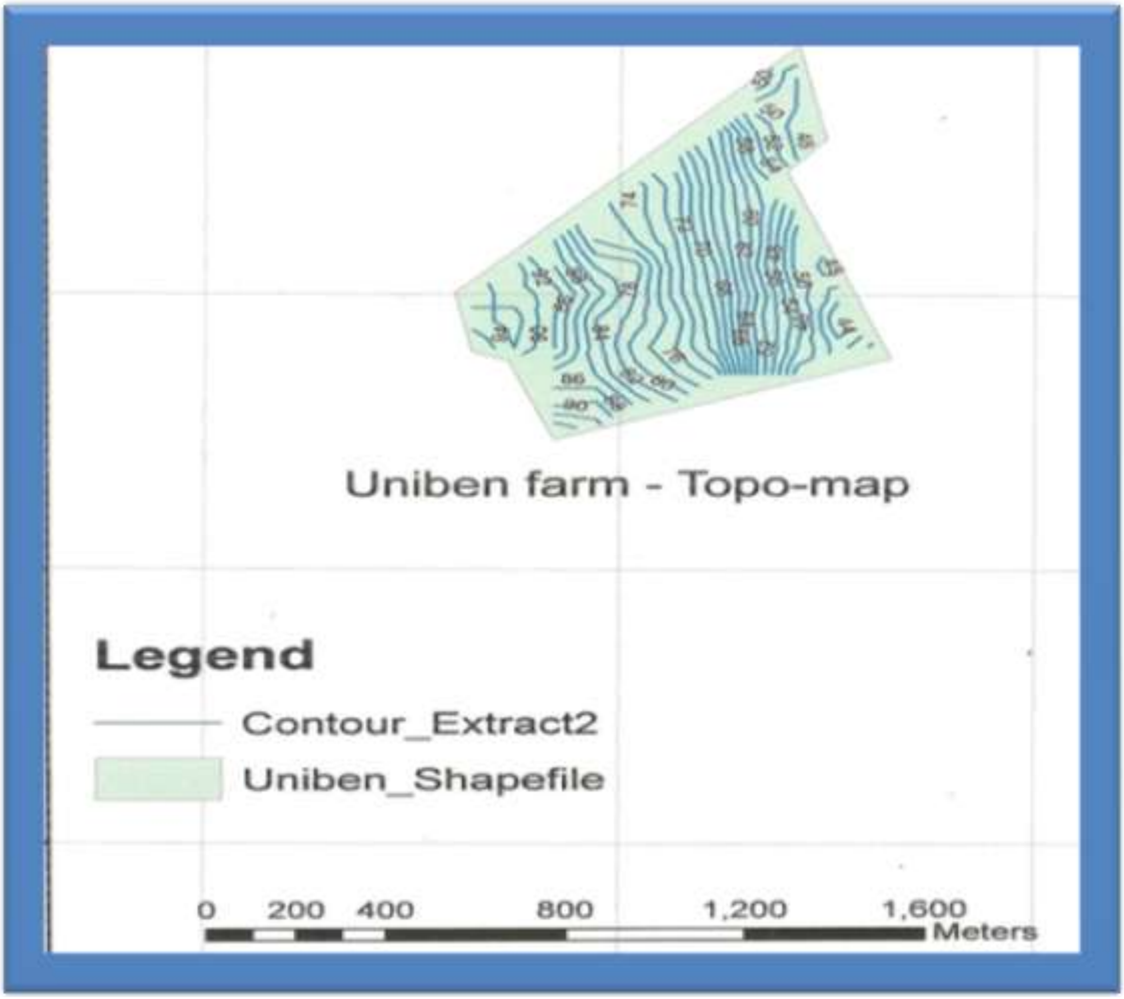


Fig 2: Google imagery of a selected portion of the University of Benin community farm land – verged red.



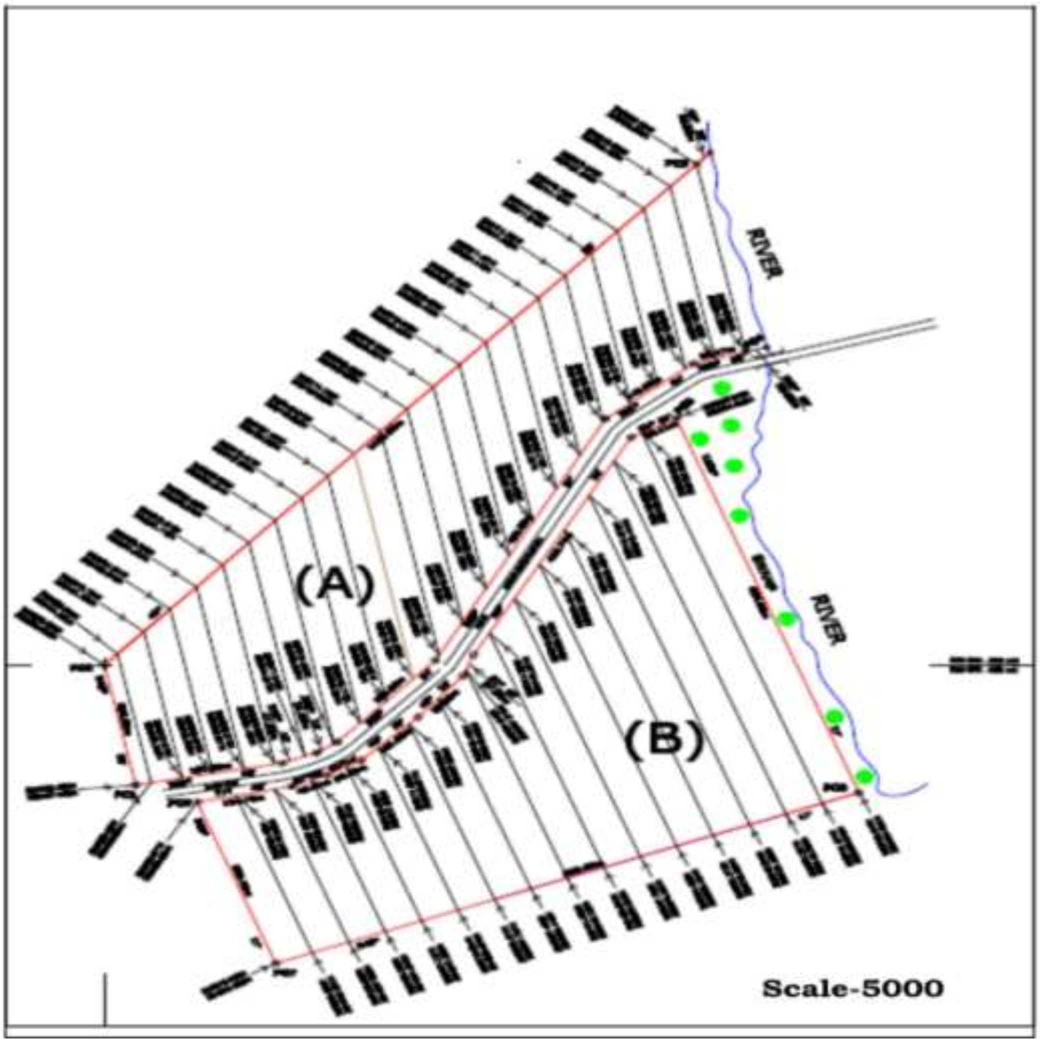


Fig 3: Location Map with grid lines of a selected portion of the University of Benin community farm land.

III. FIELD STUDIES

A land survey map was produced by a team of land surveyors which now serves as a base map.

Field survey was conducted in a selected area measuring 62 hectares using the rigid grid systematic survey method with traverses cut at intervals of 50m from a pre-determined base line with the traverses running in both vertical and horizontal directions at right angles to each other, making a total of 38 traverses. Auger points were placed at 50m interval along the traverses, giving a total of 228 auger/examination points at depth intervals of 0-30cm, 30-60cm, 60-90cm and 90-120cm respectively. Auger samples were described morphologically on the field (soil colour, texture by feel, presence or absence of mottles, mottle colour, presence or absence of concretions, and so on). Areas with similar properties and characteristics such as topographical positions on the land scape and texture were grouped to produce the various soil mapping units. Seven mapping units were thus delineated. Profile pits of 2m x 2m x 2m dimension were dug at representative points in each mapping unit, described according to FAO (1976) and identified horizons and layers were sampled from bottom upward.

IV. LABORATORY ANALYSIS

Soils collected from each horizon were air-dried and passed through a 2mm sieve. The sieved samples were sent to NIFOR and FRANEG (soil science laboratories) for physical and chemical analysis. Particle size distribution was determined by the hydrometer method (Bouyoucos, 1962) after the removal of organic matter content with hydrogen peroxide and dispersion with sodium hexametaphosphate (International Institute for Tropical Agriculture - IITA, 1979). Available P was determined by Bray-1 method (Murphy and Rickey, 1962). The pH was determined with glass electrode pH meter in soil: soil and water: KCl media, each at ratio 1:1 (Maclean, 1982). Exchangeable Bases (Na, K, Ca and Mg) were extracted with neutral normal sodium acetate (NH_4OAC at pH 7.0), Na and K were determined by flame photometer while Ca and Mg were determined by atomic absorption spectro photometer (Thomas, 1982). Total N was determined by Macro Kjedhal method (Bremner and Mulvaney, 1982). Exchangeable Acidity was determined by titration method (Anderson and Ingram, 1993). Organic Carbon was determined by Walkley Black method (Page, 1982). Effective Cation Exchange Capacity (ECEC) was obtained by the summation of Exchangeable Bases and Exchangeable Acidity (Tan, 1996). Base Saturation was calculated by dividing the sum of Exchangeable Bases (Na, K, Ca and Mg) by the ECEC and multiplying the quotient by 100.

Micro nutrients were determined by the Automated (Hydrochloric acid extraction) method and the reagent used was Hydrochloric acid, 0.1M, HCl. (Baker and Amacher, 1982). 5g of soil was weighed into a 100ml plastic bottle (with non rubber stoppers) ; 50ml of 0.1M HCl was added and shaken for 30 minutes; the solution was filtered with Whatman no. 42 filter paper; the micronutrients (Zn, Fe, Ni, Cr, Cd, Cu, Mn) were determined on Atomic Absorption Spectrophotometer.

SOIL CLASSIFICATION

The data generated from both profile description (morphological description) and laboratory analysis of the soil samples were used to classify the soils according to USDA soil taxonomy, FAO-UNESCO soil map of the world and World Reference Base for Soil Resources.

SOIL MAP

Based on the field and laboratory results, a soil map was produced at a scale of 1:5000

CADMIUM toxicity map was produced by merging the affected pedons arising from Alloway (1995) guidelines:

Table 1: Concentration of heavy metals in soils and critical concentrations in soils.

Metal	Normal range in soils (mg/kg)	Critical soil concentration (mg/kg)
As	0.1-40	20-50
Cd	0.01-2.0	3-8
Co	0.5-65	25-50
Cr	5-1500	75-100
Cu	2-250	60-125
Hg	0.01-0.5	0.3-5
Mn	20-10000	1500-3000
Mo	0.1-40	2-10
Ni	2-750	100
Pb	2-300	100-400
V	3-500	50-100
Zn	1-900	70-400

Source: Alloway (1995).

V. RESULTS AND DISCUSSION

Soil classification, vertical and spatial distribution of the heavy metals are discussed and expressed in tables, graphs and maps.

Table 2: Summary of the Soil Classifications for the Pedons.

S/N	Pedon	USDA	FAO/UNESCO	WRB	Areal extent (ha)	Areal coverage (%)
1	1	Fine Loamy Kaolinitic IsohyperthermicRhodicKandiudult	Dystric Nitosols	Nitic Acrisols (Rhodic)	15.183	24.427
2	2	Loamy sand, Kaolinitic, Isohyperthermic, RhodicKandiudult	Dystric Nitosols	Nitic Acrisols (Rhodic)	14.587	23.468
3	3	Sandy Kaolinitic Isohyperthermic Typic Udipsamment	Cambic Arenosols	Protic, HypoluvicArenosols (Eutric)	4.060	6.532
4	4	Sandy, Kaolinitic,	LuvicArenosols	Rubic,	5.696	9.164

		Isohyperthermic, TypicUdipsamment		ProticArenosols (Eutric)		
5	5	Coarse Loamy Kaolinitic IsohyperthermicOxyaquicDystrudept	Dystric Cambisols	Stagnic, Fluvic Cambisols (Oxyaquic, Dystric)	3.116	5.013
6	6	Fine Loamy Kaolinitic IsohyperthermicRhodudult	Dystric Nitosols	Nitic Acrisols (Rhodic)	3.946	6.348
7	7	Fine Loamy Kaolinitic IsohyperthermicRhodudult	Dystric Nitosols	Nitic Acrisols (Rhodic).	12.861	20.691

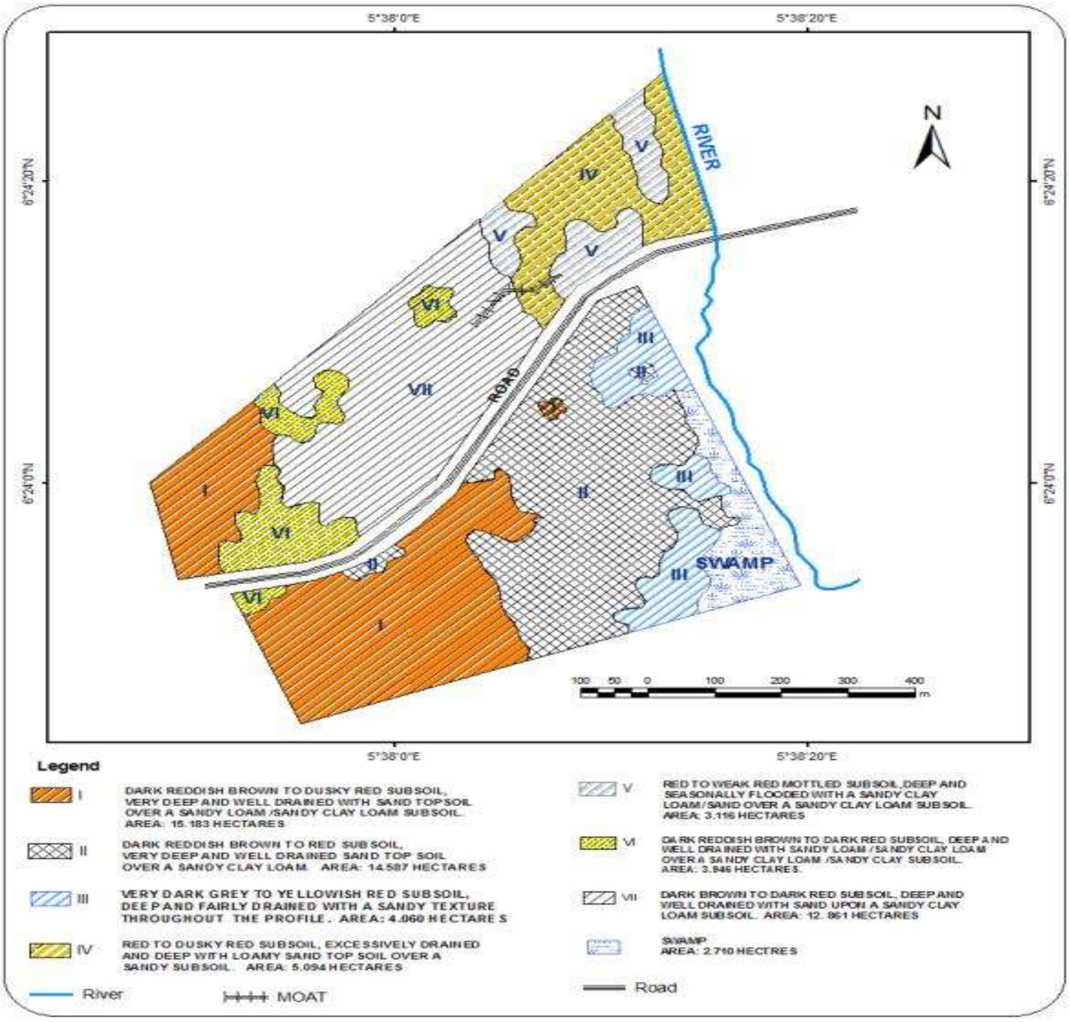


Table 3:

			Micro Nutrients							
S/N	**pedon ID**	**Horizon Depth**	**Fe**	**Cu**	**Mn**	**Pb**	**Cd**	**Zn**	**Ni**	**Cr**
			←			**mgKg^{-1}**			→	
1	**1**	**0-7**	**71.7**	**29.4**	**17.93**	**1.46**	**7.46**	**37.28**	**18.64**	**1.85**
2		**7--27**	**100.357**	**41.35**	**25.84**	**8.5**	**10.54**	**52.72**	**20.67**	**2.57**
3		**27-66**	**71.26**	**29.19**	**18.53**	**0.92**	**0.78**	**37.06**	**14.96**	**0.85**
4		**66-97**	**64.22**	**26.33**	**16.7**	**7.8**	**6.42**	**32.11**	**13.49**	**4.12**
5		**97-143**	**54.411**	**21.64**	**14.07**	**1.68**	**5.91**	**28.13**	**11.9**	**3.89**
6		**143-185**	**59.82**	**24.53**	**12.55**	**6.5**	**6.22**	**31.11**	**12.56**	**2.85**
7	**2**	**0-13**	**86.22**	**35.35**	**22.42**	**1.2**	**8.77**	**44.83**	**17.24**	**5.1**
8		**13-49**	**110.41**	**44.16**	**28.71**	**12.8**	**11.26**	**56.31**	**22.08**	**2.15**
9		**49-80**	**81.82**	**32.73**	**20.46**	**9.8**	**7.93**	**41.73**	**16.36**	**9.01**
10		**80-120**	**58.95**	**23.58**	**14.74**	**4.5**	**5.71**	**30.06**	**11.77**	**4.82**
11		**120-171**	**54.55**	**22.37**	**14.98**	**1.28**	**3.29**	**27.82**	**11.64**	**4.85**
12	**3**	**0-14**	**155.28**	**62.11**	**37.27**	**6.11**	**4.21**	**77.64**	**31.06**	**6.12**
13		**14-31**	**25.98**	**10.91**	**6.75**	**2.1**	**2.78**	**13.25**	**5.45**	**4.82**
14		**31-85**	**124.94**	**49.8**	**29.88**	**5.2**	**3.07**	**62.25**	**24.9**	**5.78**
15		**85-118**	**76.54**	**31.38**	**19.9**	**1.65**	**7.76**	**39.8**	**16.07**	**9.12**
16		**118-156**	**54.11**	**22.181**	**14.07**	**7.1**	**5.63**	**28.13**	**11.36**	**6.12**
17	**4**	**0-27**	**29.47**	**12.38**	**7.66**	**2.61**	**2.41**	**15.32**	**5.89**	**4.9**
18		**27-62**	**138.56**	**55.42**	**34.64**	**8.12**	**4.56**	**69.28**	**27.71**	**5.2**
19		**62-120**	**23.38**	**9.82**	**6.077**	**1.21**	**0.78**	**12.18**	**4.91**	**1.85**
20		**120-142**	**38.27**	**15.69**	**9.95**	**1.82**	**0.31**	**19.7**	**7.65**	**1.1**
21		**142-160**	**61.58**	**25.25**	**16.011**	**7.21**	**6.42**	**31.41**	**12.32**	**8.2**
22	**5**	**0-7**	**54.11**	**22.18**	**14.07**	**1.58**	**0.72**	**28.14**	**10.82**	**3.22**
23		**7--56**	**30.55**	**13.35**	**8.46**	**1.22**	**0.84**	**16.93**	**6.84**	**7.15**
24		**56-99**	**120.97**	**48.39**	**29.03**	**2.81**	**4.86**	**60.49**	**22.98**	**7.15**
25		**99-117**	**43.55**	**17.86**	**11.32**	**2.48**	**1.56**	**22.64**	**8.71**	**5.12**
26	**6**	**0-8**	**6.49**	**2.73**	**1.69**	**0.38**	**0.21**	**3.37**	**1.3**	**1.82**
27		**8--28**	**3.03**	**1.27**	**0.82**	**0.21**	**0.1**	**1.55**	**0.64**	**0.82**
28		**28-61**	**5.63**	**2.36**	**1.46**	**0.23**	**0.21**	**2.73**	**1.18**	**1.25**
29		**61-105**	**62.9**	**26.42**	**16.35**	**4.68**	**6.45**	**32.71**	**12.58**	**0.98**
30		**105-144**	**7.36**	**3.09**	**1.84**	**0.74**	**0.69**	**3.83**	**1.55**	**1.5**
31		**144-170**	**8.23**	**3.46**	**2.14**	**0.41**	**0.35**	**4.28**	**1.73**	**2.09**
32	**7**	**0-13**	**13.42**	**5.46**	**3.48**	**2.18**	**0.64**	**6.84**	**2.68**	**6.98**
33		**13-31**	**8.23**	**3.46**	**2.14**	**0.46**	**0.56**	**4.2**	**1.65**	**2.21**
34		**31-66**	**11.26**	**4.62**	**2.73**	**0.56**	**0.25**	**5.68**	**2.25**	**2.212**
35		**66-100**	**9.96**	**4.18**	**2.68**	**0.61**	**0.32**	**5.18**	**2.09**	**2.29**
36		**100-145**	**5.63**	**2.36**	**1.46**	**0.25**	**0.31**	**2.87**	**1.24**	**2.15**
37		**145-179**	**8.23**	**3.54**	**2.3**	**0.86**	**0.45**	**4.27**	**1.73**	**3.05**

Table 4: Pedon Means of Each Element Using Duncan's Multiple Range Test

ELEMENTS	PEDON1	PEDON2	PEDON3	PEDON4 mg/kg	PEDON5	PEDON6	PEDON7
	A	**B**	**C**	**D**	**E**	**F**	**G**
Fe	**70.3^{b}**	**78.4^{b}**	**87.4^{b}**	**58.3^{b}**	**62.3^{b}**	**15.6^{a}**	**9.5^{a}**
Cu	**28.7^{b}**	**31.6^{b}**	**35.3^{b}**	**23.7^{b}**	**25.4^{b}**	**6.6^{a}**	**3.9^{a}**
Mn	**17.6^{b}**	**20.3^{b}**	**21.6^{b}**	**14.9^{b}**	**15.7^{b}**	**4.1^{a}**	**2.5^{a}**
Pb	**4.48^{a}**	**5.93^{ba}**	**4.43^{a}**	**4.19^{a}**	**2.02^{a}**	**1.11^{a}**	**0.82^{a}**
Cd	**6.22^{bca}**	**7.39^{bca}**	**4.69^{bca}**	**2.90^{a}**	**2.00^{a}**	**1.50^{a}**	**0.42^{a}**
Zn	**36.4^{bc}**	**40.1^{bc}**	**44.2^{bc}**	**29.6^{bc}**	**32.1^{bc}**	**8.1^{a}**	**4.8^{a}**
Ni	**15.4^{bc}**	**15.8^{bc}**	**17.8^{bc}**	**11.7^{bc}**	**12.3^{bc}**	**3.2^{a}**	**1.9^{a}**
Cr	**2.69^{ade}**	**5.19^{ace}**	**6.39^{bc}**	**4.25^{acd}**	**5.66^{ac}**	**1.41^{a}**	**3.15^{a}**

***Means with the same superscript are not significantly ($p>0.05$) different.**

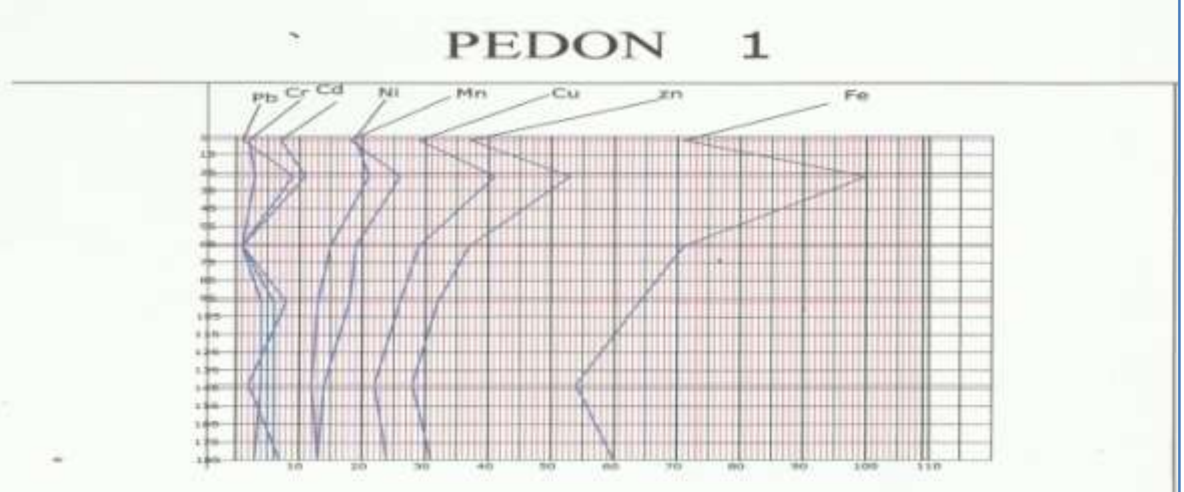


Fig.1:Vertical distribution of heavy metals in pedon 1.

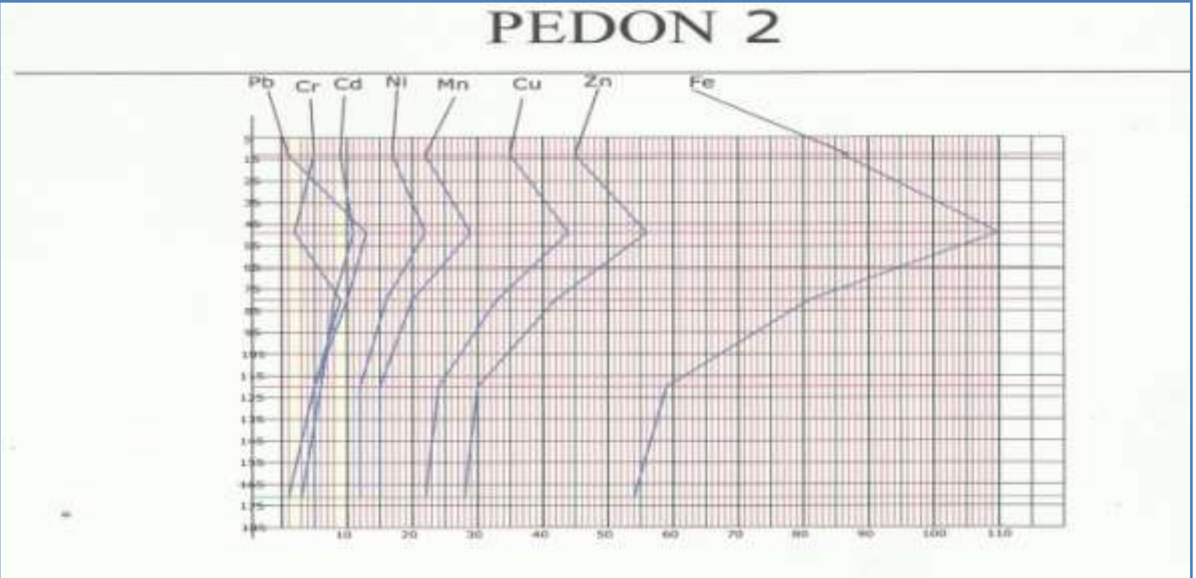


Fig.2:Vertical distribution of heavy metals in pedon 2.

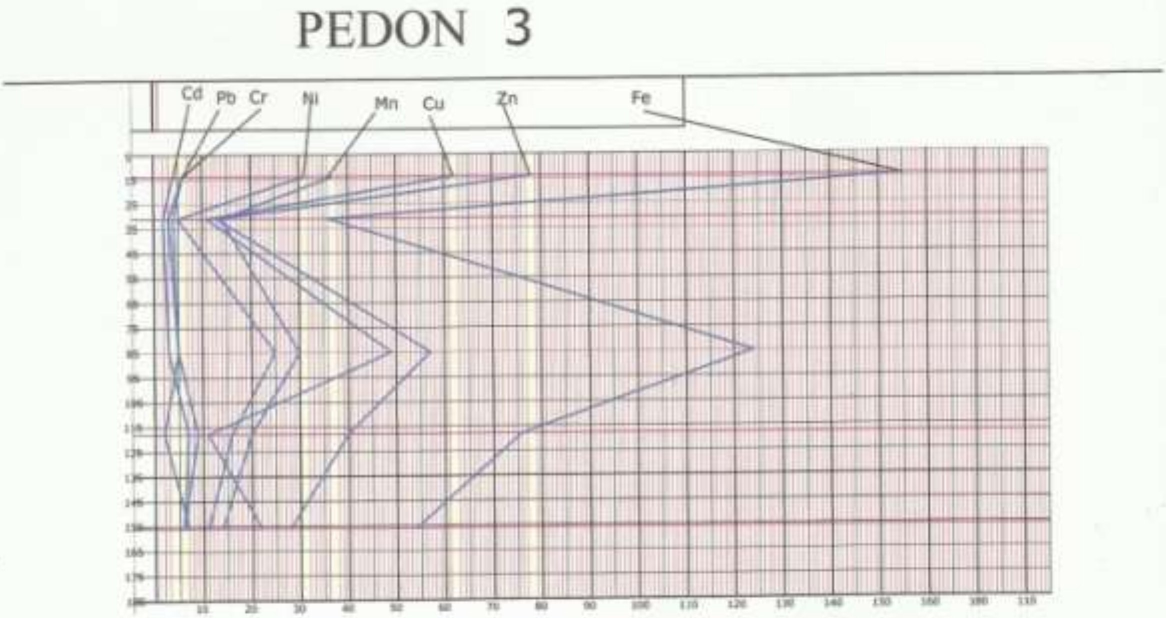


Fig.3:Vertical distribution of heavy metals in pedon 3.

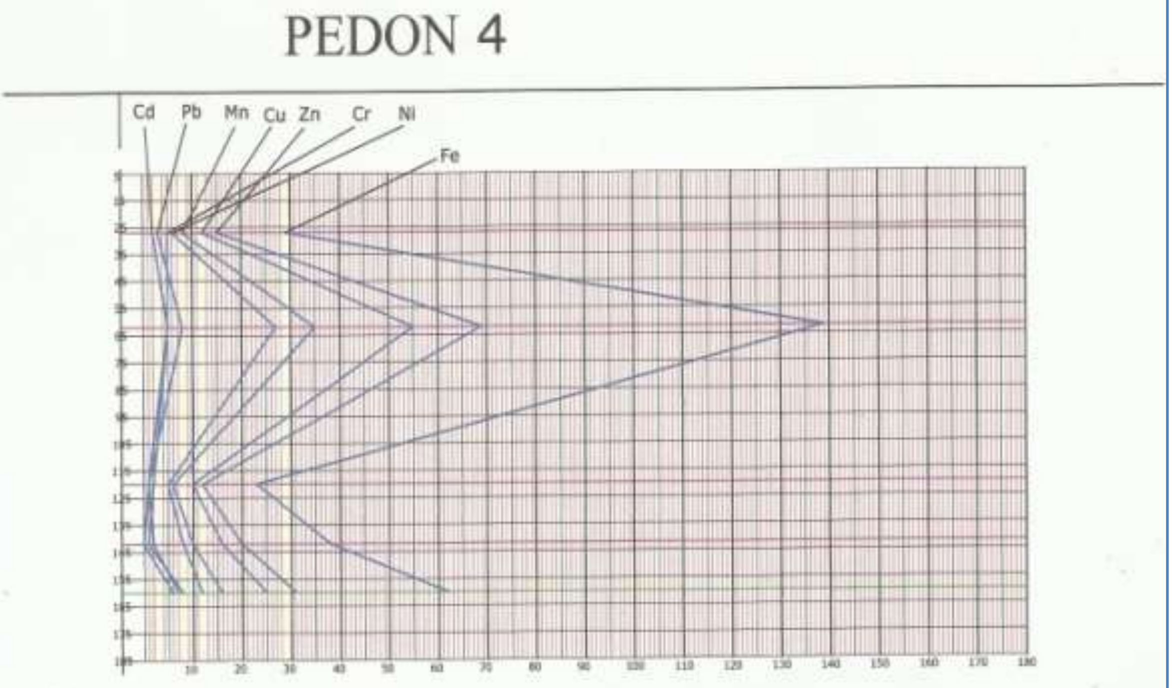


Fig.4:Vertical distribution of heavy metals in pedon 4.

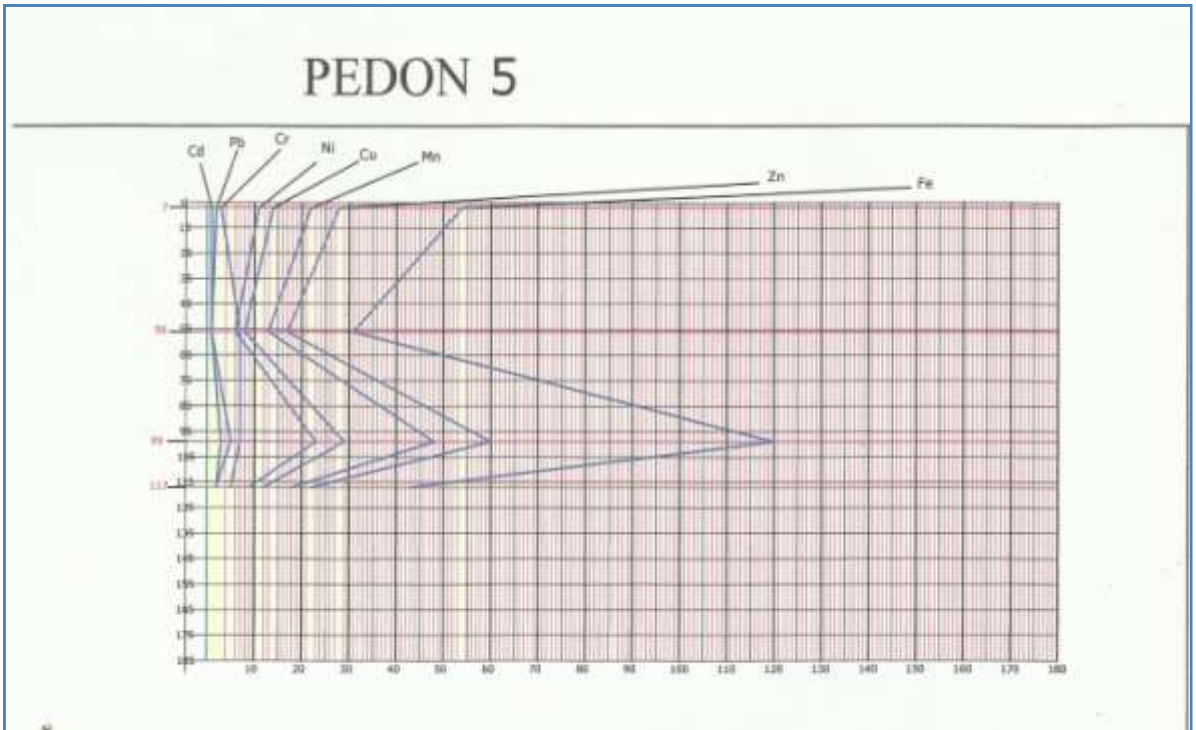


Fig.5:Vertical distribution of heavy metals in pedon 5.

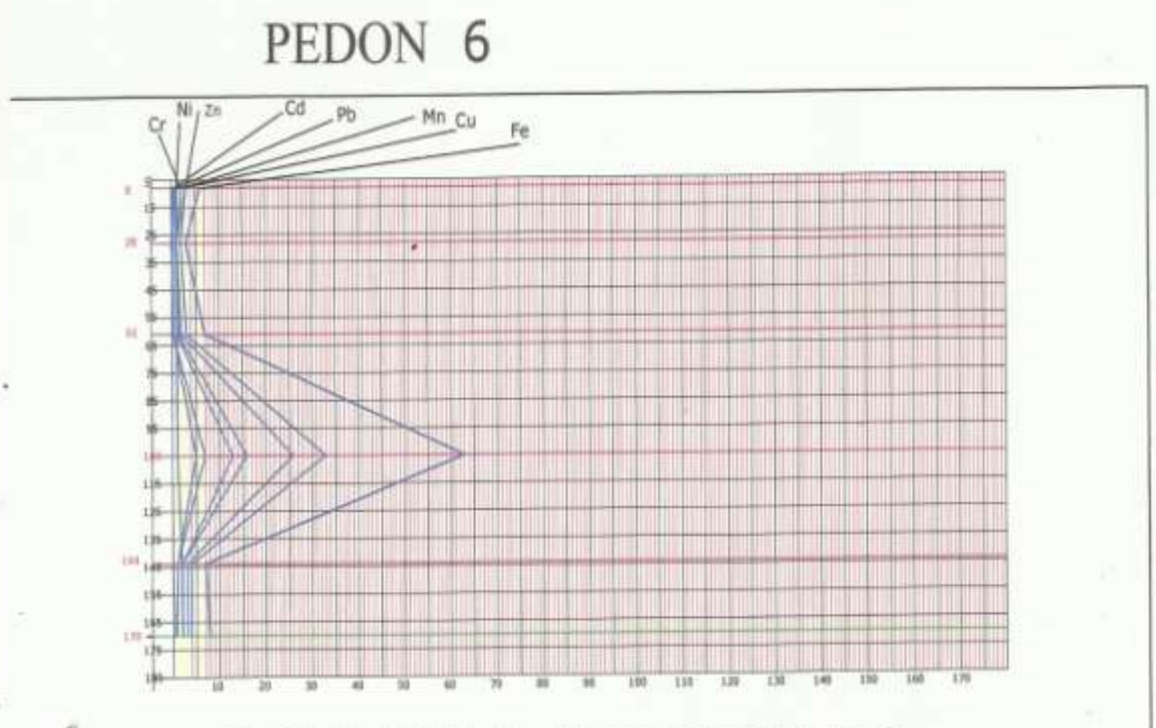


Fig.6:Vertical distribution of heavy metals in pedon 6.

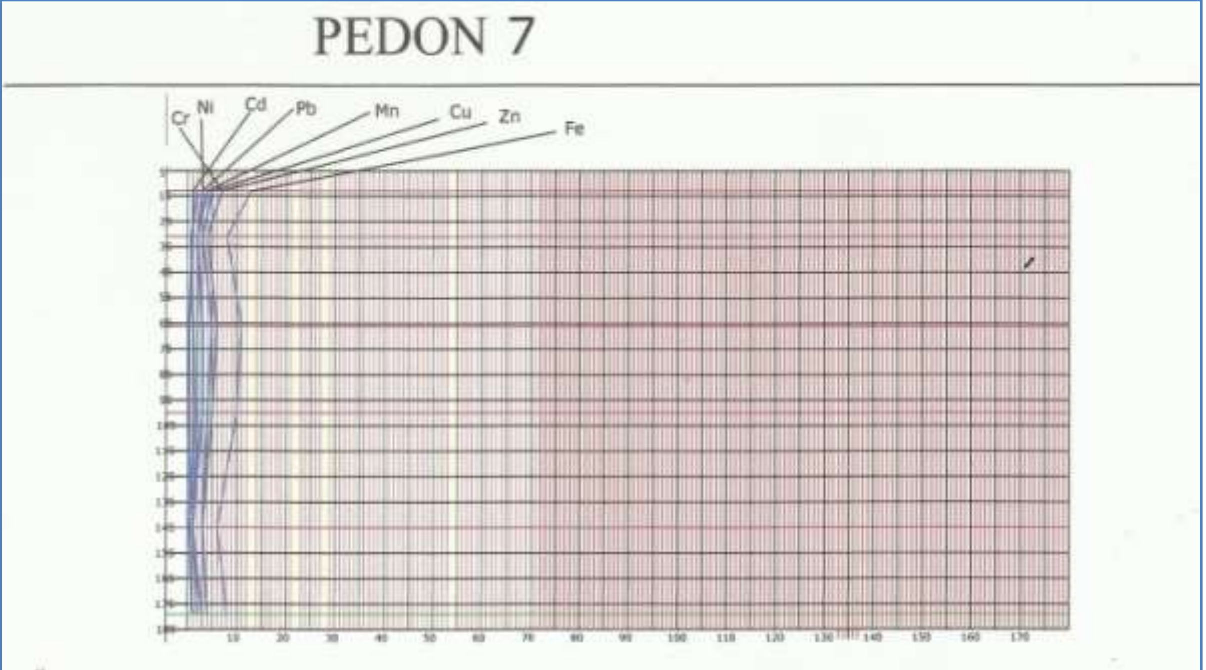
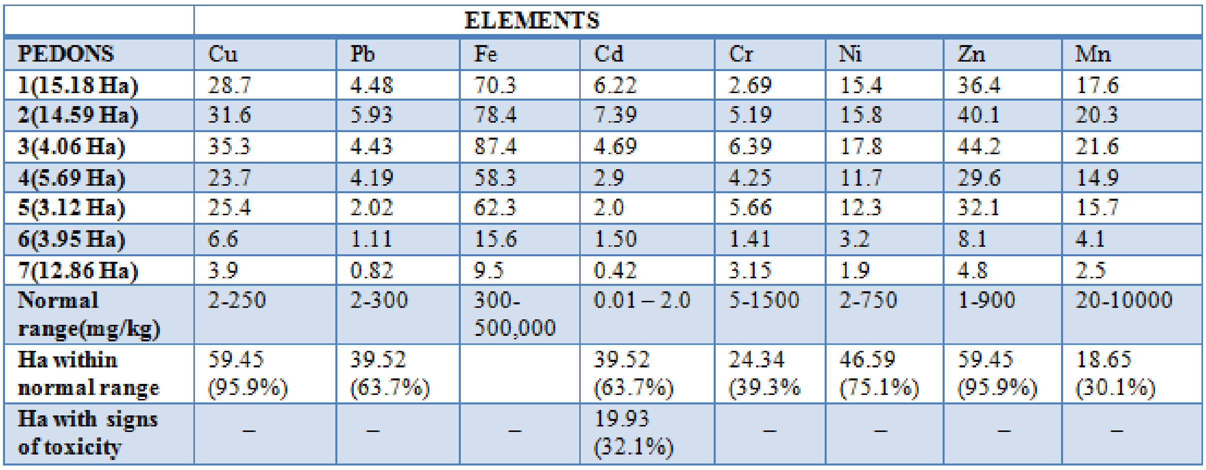


Fig.7:Vertical distribution of heavy metals in pedon 7.



	ELEMENTS							
PEDONS	Cu	Pb	Fe	Cd	Cr	Ni	Zn	Mn
1(15.18 Ha)	28.7	4.48	70.3	6.22	2.69	15.4	36.4	17.6
2(14.59 Ha)	31.6	5.93	78.4	7.39	5.19	15.8	40.1	20.3
3(4.06 Ha)	35.3	4.43	87.4	4.69	6.39	17.8	44.2	21.6
4(5.69 Ha)	23.7	4.19	58.3	2.9	4.25	11.7	29.6	14.9
5(3.12 Ha)	25.4	2.02	62.3	2.0	5.66	12.3	32.1	15.7
6(3.95 Ha)	6.6	1.11	15.6	1.50	1.41	3.2	8.1	4.1
7(12.86 Ha)	3.9	0.82	9.5	0.42	3.15	1.9	4.8	2.5
Normal range(mg/kg)	2-250	2-300	300-500,000	0.01 – 2.0	5-1500	2-750	1-900	20-10000
Ha within normal range	59.45 (95.9%)	39.52 (63.7%)		39.52 (63.7%)	24.34 (39.3%	46.59 (75.1%)	59.45 (95.9%)	18.65 (30.1%)
Ha with signs of toxicity	–	–	–	19.93 (32.1%)	–	–	–	–

Table 5: Summary table showing area coverage (normal and toxicity range) of each element

Copper (Cu)

Table 6: Spatial distribution of Copper across all the pedons.

ELEMENTS	**PEDON1**	**PEDON2**	**PEDON3**	**PEDON4 mgkg^{-1}**	**PEDON5**	**PEDON6**	**PEDON7**
Cu	28.7^b	31.6^b	35.3^b	23.7^b	25.4^b	6.6^a	3.9^a

The means of the heavy metal concentrations for copper as shown in table 5a were 28.7,31.6,35.3,23.7,25.4,6.6,3.9 mgkg^{-1} for pedons 1 to 7 respectively. Pedon 3 had the highest mean concentration of 35.3mgkg^{-1} which is moderately high compared to mean values of other pedons and to that extent should be closely monitored. In terms of spatial distribution, total copper concentration in Pedons 7 and 6 were relatively low, with a range of 3.9-6.6 mgkg^{-1}, and were not significantly different and occupied a total area of 16.807ha.These two Pedons, 6 and 7, were significantly different from pedons 4,5,1,2 and 3 which occupied an area coverage of 42.64 ha. Pedons 4,5,1 ,2 showed no significant difference among means.

According to the critical concentration limits for Cu in soils 60-125 mgkg^{-1} ,(Alloway, 1995), the values for copper are below the critical point in all seven pedons and are therefore not toxic to humans when this metal enters the food chain.

The vertical distribution for copper in figures 1, 2,3, 4, 5, 6, and 7 show a Cu concentration that generally decreases with depth across the seven pedons. The distribution pattern for Copper concentration in figures 1,2,3,4 and 7 is such that there are increases at the top soil, slightly decreasing at the middle depths and further decreasing at the lower depths, while in figures 6 and 7, Cu shows a concentration that increases at the middle depth and decreases slightly at the upper and lower depths.

Manganese (Mn)

Table 7: Spatial distribution of Manganese across all the pedons

ELEMENTS	**PEDON1(A)** ←	**PEDON2(B)**	**PEDON3(C)**	**PEDON4(D) mgkg^{-1}**	**PEDON5**	**PEDON6**	**PEDON7** →
Mn	17.6^{b}	20.3^{b}	21.6^{b}	14.9^{b}	15.7^{b}	4.1^{a}	2.5^{a}

Pedon 5=E; Pedon 6=F ; Pedon 7=G

The means of the heavy metal concentrations for manganese as shown in table 5b were 17.6, 20.3, 21.6, 14.9, 15.7, 4.1, 2.5 mgkg^{-1} respectively. Pedon C had the highest mean concentration (21.6 mgkg^{-1}) which is moderately high compared to mean values of other pedons, thus, it should be closely monitored. In terms of spatial distribution, total manganese concentration in Pedons G and F was relatively low, with a range of 2.5-4.1 mgkg^{-1}, were not significantly different and occupied a total area of 16.807ha. These two Pedons, G and F, are significantly different from pedons D, E, A, B and C which occupies an area coverage of 42.64 ha. Pedons D,E ,A ,B show no significant difference among means. According to the critical concentration limits for Mn in soils (1500-3000 mgkg^{-1}) ,(Alloway, 1995), the values for manganese are far below the critical point in all seven pedons and are therefore not toxic to humans when this metal enters the food chain.

The vertical distribution for Mn in figure 1-7 shows a Mn concentration that generally decreases with depth across the seven pedons. The distribution pattern for manganese concentration in figures 1,2,3,4 and 7 is such that there are increases at the top soil and gradually decreasing at the middle depths and the lower depths, while in figures 6 and 5, Mn shows a concentration that increases at the middle depth and decreases gradually at the upper and middle depths.

Lead (Pb)

Table 8: Spatial distribution of Lead across all the pedons

ELEMENTS	**PEDON1** ←	**PEDON2**	**PEDON3**	**PEDON4 mgkg^{-1}**	**PEDON5**	**PEDON6**	**PEDON7** →
Pb	4.48^{a}	5.93^{ba}	4.43^{a}	4.19^{a}	2.02^{a}	1.11^{a}	0.82^{a}

The means of the heavy metal concentrations for lead as shown in table 5c were 4.48, 5.92, 4.43, 4.19, 2.02, 1.11, 0.82 mg/kg respectively for the seven pedons. Pedon B had a high mean concentration of 5.92mg/kg which is moderately high compared to mean values of other pedons and to that extent should be closely monitored. In terms of spatial distribution, total lead concentration in Pedons G and F is relatively low, with a range of 0.82-1.11 mgkg^{-1}, and were not significantly different and occupied a total area of 16.807 ha. Pedons G F, E, D, C, and A occupied a total area of ....ha, shows no significant difference among means but pedon G and B are significantly different with a total ar...ha. According to the critical concentration limits for Pb in soils 100-400 mgkg^{-1}, (Alloway, 1995), the values for lead are below the critical point in all seven pedons and are therefore not toxic to humans when this metal enters the food chain. The vertical distribution for lead in figures 1, 2, 3, 4, 5, 6, and 7 shows a Pb concentration that generally decreases with depth across the seven pedons. The distribution pattern for lead concentration in all the pedons is such that there are increases at the top soil, slightly decreasing at the middle depths and at the lower depths,

Cadmium (Cd)

Table 8: Sparial distribution of Cadmium across all the pedons

ELEMENTS	PEDON1	PEDON2	PEDON3	PEDON4 mgkg^{-1}	PEDON5	PEDON6	PEDON7
Cd	6.22^{bca}	7.39^{bca}	4.69^{bca}	2.90^{a}	2.00^{a}	1.50^{a}	0.42^{a}

The means of the heavy metal concentrations for cadmium as shown in table 5d were 6.22, 7.39, 4,69, 2,90, 2.00, 1.50, 0.42 mgkg^{-1} respectively. Pedon B had the highest mean concentration of 7.39 mgkg^{-1} which is moderately high compared to mean values of other pedons and to that extent should be closely monitored. In terms of spatial distribution, total cadmium concentration in Pedons G and F is low, with a range of 0.42-1.50 mgkg^{-1}, were not significantly different and occupied a total area of 16.807 ha. pedons G, F, E, and D occupied a total area of ...ha, show no significant difference among means. Pedons C, A, and B occupied 33.83 ha and shows no significant difference among means. According to the critical concentration limits for Cd in soil, 3-8 mgkg^{-1} (Alloway, 1995), the values for cadmium in pedon A, B, C, and D are above the critical point and are therefore toxic to humans when this metal enters the food chain, while the mean values for Cd in pedon E, F, and G are below toxic point. The vertical distribution for cadmium in figures 1, 2,3, 4, 5, 6, and 7 shows a Cd concentration that generally decreases with depth across the seven pedons. The distribution pattern for cadmium concentration in all the pedons is such that there are increases at the top soil, slightly decreasing at the middle depths and at the lower depths.

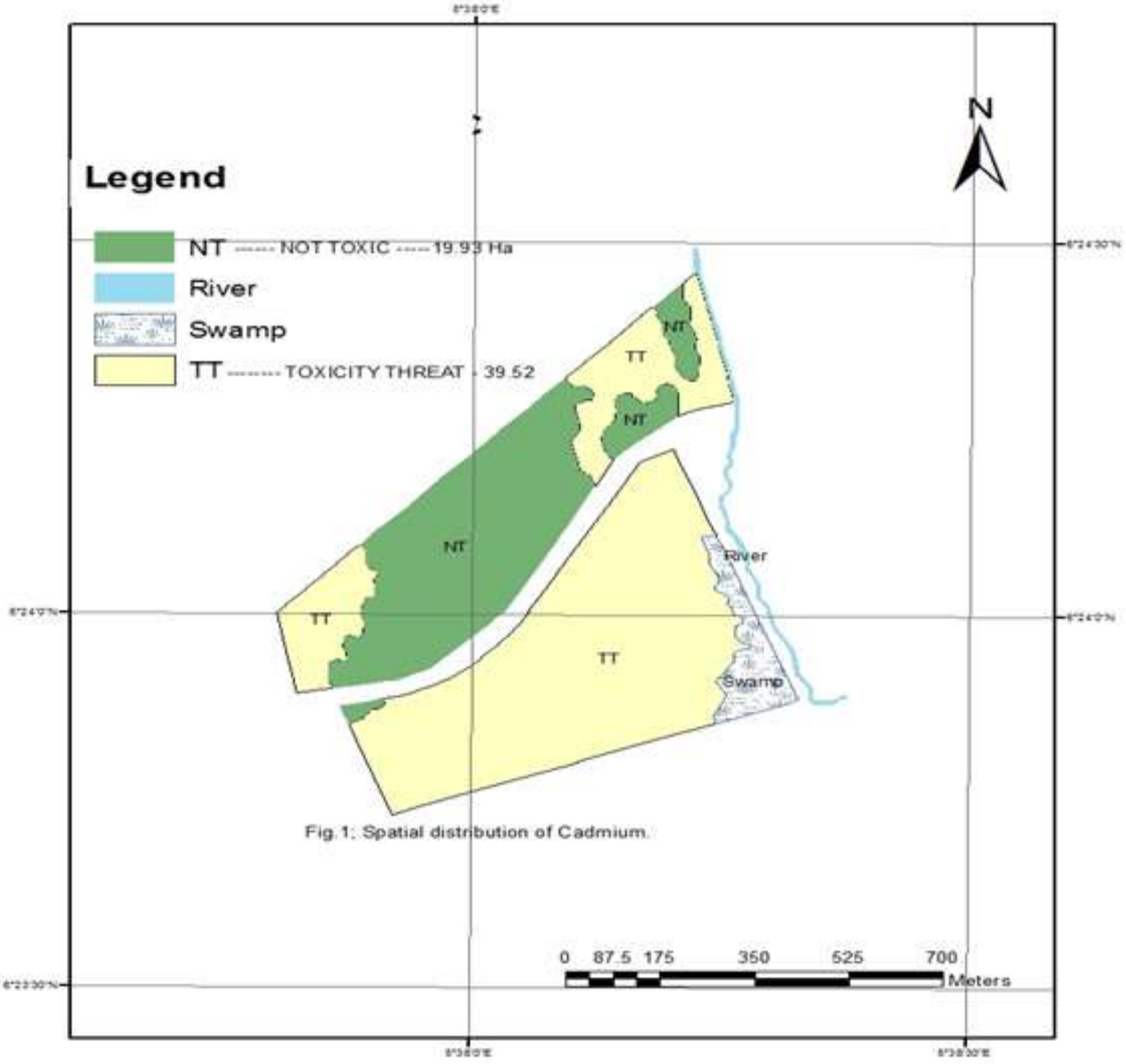


Fig.1: Spatial distribution of Cadmium.

Zinc (Zn)

Table 9: Spatial distribution of Zinc across all the pedons

ELEMENTS	PEDON1	PEDON2	PEDON3	PEDON4 mgkg^{-1}	PEDON5	PEDON6	PEDON7
Zn	36.4^{bc}	40.1^{bc}	44.2^{bc}	29.6^{bc}	32.1^{bc}	8.1^{a}	4.8^{a}

The means of the heavy metal concentrations for zinc as shown in table 5e were 36.4, 40.1, 44.3, 29.6, 32.1, 8.1, and 4.8mg/kg respectively. Pedon C had the highest mean concentration of 44. mgkg^{-1} which is moderately high compared to mean values of other pedons and to that extent should be closely monitored. In terms of spatial distribution, total copper concentration in Pedons G and F is relatively low, with a range of 4.8-8.1 mgkg^{-1} were not significantly different and occupied a total area of 16.807 ha. These two Pedons, G and F, were significantly different from pedons D,E,A,B and C which occupies an area coverage of 42.64 ha. Pedons D,E,A ,B and C show no significant difference among means. According to the critical concentration limits for Zn in soils, (70-100 mgkg^{-1}) (Alloway, 1995), the values for zinc were below the critical point in all seven pedons and are therefore not toxic to humans when this metal enters the food chain.

The vertical distribution for zinc in figures 1, 2,3, 4, 5, 6, and 7 shows a Zn concentration that generally decreases with depth across the seven pedons. The distribution pattern for Zinc concentration in figures 1 and 2 is such that there are increases at the top soil, slightly decreasing at the middle depths and further decreasing at lower depths. In fig 3 and 4, Zn concentration increased at the upper and middle depths and decreased at lower depths. Fig 5 and 6 show a Zn concentration that increases rapidly at the middle depth compare to the upper depth and lower depth, while fig 7 shows a distribution that is virtually the same at all depth.

Nickel (Ni)

Table 10: Spartial distribution of Nickel across all the pedons

ELEMENTS	PEDON1	PEDON2	PEDON3	PEDON4 mgkg^{-1}	PEDON5	PEDON6	PEDON7
Ni	15.4^{bc}	15.8^{bc}	17.8^{bc}	11.7^{bc}	12.3^{bc}	3.2^{a}	1.9^{a}

The means of the heavy metal concentrations for Nickel as shown in table 5f were 15.4, 15.8, 17.8, 11.7, 12.3, 3.2, 1.9 mgkg^{-1} for Pedon A, B, C, D, E, F, G respectively. pedon C recorded the highest mean concentration of 17.8 mgkg^{-1} which is moderately high compared to mean values of other pedons and to that extent should be closely monitored. In terms of spatial distribution, total nickel concentration in Pedons G and F is relatively low, with a range of 1.9-3.2 mgkg^{-1}, and were not significantly different and occupied a total area of 16.807 ha. These two Pedons, G and F, are significantly different from pedons D, E, A, B and C which occupied an area coverage of 42.64 ha. Pedons D, E, A, B and C showed no significant difference among means. According to the critical concentration limits for Ni in soils,100 mgkg^{-1} (Alloway, 1995), the values for nickel are below the critical point in all seven pedons and are therefore not toxic to humans when this metal enters the food chain.

The vertical distribution for nickel in figures 1, 2,3, 4, 5, 6, and 7 shows a Ni concentration that generally decreases with depth across the seven pedons. The distribution pattern for Nickel concentration in figures 1-4, is such that there are increases at the top soil, slightly decreasing at the middle depths and further decreasing at the lower depths, while in figures 5 and 6, Ni shows a concentration that increases at the middle depth and decreases slightly at the upper and lower depths. Figure 7 shows a distribution that is virtually the same at all depth.

Chromium (Cr)

Table 11: Spatial distribution of Chromium across all the pedons

ELEMENTS	PEDON1	PEDON2	PEDON3	PEDON4 mgkg^{-1}	PEDON5	PEDON6	PEDON7
Cr	2.69^{ade}	5.19^{ace}	6.39^{bc}	4.25^{acd}	5.66^{ac}	1.41^{a}	3.15^{a}

The means of the heavy metal concentrations for chromium as shown in table 5g were 2.69, 5.19, 6.39, 4.35, 5.66, 1.14, 3.25 mgkg^{-1} for pedons A,B,C,D,E,F,G respectively. Pedon C had the highest mean concentration of 6.39 mgkg^{-1} which is moderately high compared to mean values of other pedons therefore, it should be closely monitored. In terms of spatial distribution, total copper concentration in Pedons F and A is relatively low, with a range of 1.42-2.69 mgkg^{-1}, were not significantly different and occupied a total area of 19.129 ha. These two Pedons, F and A were not significantly different from pedon G. Pedon F is significantly different from D, E, B and C which occupies an area coverage of 27.457 ha. pedon A was not significantly different from pedons G, D and B, but was significantly different from pedons E and C. Pedons D, B, E and C showed no significant difference among means. According to the critical concentration limits for Cr in soils 75-100 mgkg^{-1}, (Alloway, 1995), the values for chromium are below the critical point in all seven pedons and are therefore not toxic to humans when this metal enters the food chain.

The vertical distribution for chromium in figures 1, 2, 3, 4, 5, 6, and 7 shows a Cr concentration that generally decreases with depth across the seven pedons. The distribution pattern for Chromium concentration in figures 2, and 3 is such that there are slight increases at the middle depths compared with the upper and lower depths, while in figures 1, 4, 5 and 6 Cr shows a concentration that increases slightly at the top soil, further decreasing at the middle depth and lower depths.

Iron (Fe)

Table 12: Spatial distribution of Iron across all the pedons

ELEMENTS	PEDON1	PEDON2	PEDON3	PEDON4 mgkg^{-1}	PEDON5	PEDON6	PEDON7
Fe	70.3^{b}	78.4^{b}	87.4^{b}	58.3^{b}	62.3^{b}	15.6^{a}	9.5^{a}

The means of the heavy metal concentrations for iron as shown in table 12 were 70.3, 78.4, 87.4, 58.3, 62.3, 15.6, 9.5 mgkg^{-1} respectively for the seven pedons. Pedon C had the highest mean concentration of 87.4mg/kg which is moderately high compared to mean values of other pedons and to that extent should be closely monitored. In terms of spatial distribution, total manganese concentration in Pedons G and F is relatively low, with a range of 9.5-15.6 mgkg^{-1}, and were not significantly different and occupied a total area of 16.807 ha. These two Pedons, G and F, are significantly different from pedons D, E, A, B and C which occupies an area coverage of 42.64ha. Pedons D, E, A, B show no significant difference among means. According to the critical concentration limits for Fe in soils (>300/500 mgkg^{-1}) , (Dobberman and Fairhurst, 2001), the values for iron are far below the critical point in all seven pedons and are therefore not toxic to humans when this metal enters the food chain.

The vertical distribution for iron in figures 1, 2, 3, 4, 5, 6, and 7 shows a Fe concentration that generally decreases with depth across the seven pedons. The distribution pattern for iron concentration in figures 2, 3 and 4 is such that there are rapid increases at the top soil, rapid decreasing at the middle depths and slightly decreasing at the lower depths. In fig 5 and 6, Fe distributions increase rapidly at the middle depths. Figure 7 shows Fe distribution that is virtually the same at all depth.

VI. SUMMARY AND CONCLUSIONS

Heavy metals are often used as a group name for metals and metalloids that have been associated with contamination and potential toxicity, The term heavy metal refers to any chemical element with a specific gravity that is at least five times the specific gravity of water and is toxic or poisonous at higher amounts. In this project, heavy metal distribution involves knowing the levels of concentration these metals are toxic or deficient in the soils of the University of Benin Community Farm Land..

Therefore, the main objectives of this study include:

a. determine the levels of heavy metals (Fe, Zn, Cd, Pb, Mn, Cu, Ni, Cr)
b. Examine the pattern of distribution of the heavy metals; and
c. Predict the possible risk of either toxicity or deficiency of the heavy metals in the soils of the study area.

This study was carried out at the University of Benin community farm land, Benin City. Soil survey, by rigid grid method, was conducted that produced seven (7) mapping units. Each mapping unit was represented by a pedon that was appropriately described and sampled for laboratory analysis at Nigeria institute for oil palm research (NIFOR) chemistry laboratory.

The soil evaluated had seven pedons covering about 62 hectares. The heavy metals (Cu, Fe, Zn, Ni, Mn, Pb, Cr) concentration in all seven pedons of the site did not exceed the limits of values recommended by Alloway (1995) for soils. While for pedons 1, 2, 3 and 4 which occupied 39.52ha amounting to 63.7%, Cd concentration exceeded the standard normal range values in soils recommended by Alloway, which makes the land proned to the risks of this element in soils.. Cd concentration in areas of pedon 5, 6 and 7 occupied 19.93

ha amounting to 32.1% of the land area were within permissible limits recommended by Alloway. The pattern of distribution of the heavy metals in pedons 1, 2, 3, 4, 5, 6, and 7 decreased, generally, with depth as shown in figs 1-7.

Therefore, in terms of possible cadmium hazard, cultivation of crops should be restricted to areas of pedon 5, 6, and 7. With this alarm raised on the potential toxicity effects of Cd in this site, appropriate steps should be taken to closely and regularly monitor this element with the possible effort of improving this defect of Cadmium in areas of pedon 1, 2, and 3 and including cadmium content in subsequent land evaluation system in the University community land.

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