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Assessment of Soil Based Heavy Metals from Anthropogenic Activities in Kaduna Northern Guinea Savanna of Nigeria

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ABSTRACT

Soil based heavy metals resulting from anthropogenic activities in Kaduna Northern Guinea Savanna of Nigeria was assessed. Soil samples were collected at a depth of 15m with a soil auger using 50m × 50m plots laid in each of the four sites (ST1, ST2, ST3 and ST4) replicated three (3) times to make a total of twelve (12) plots. The assessment was done in two (2) seasons (wet season and dry season). Soil based heavy metals were carried out according to AOAC using atomic absorption spectrophotometer. The data collected were analyzed with descriptive statistic as well as Anova using SPSS package. Eleven (11) soil based heavy metals; V, Cr, Mn, Zn, Co, Ni, Cu, Br, Pb, Cd and Fe were revealed in each of the selected sites. There were significant differences ($P<0.05$) when concentration are compared between seasons within the sites. Higher soil heavy based metals were recorded in the wet season than the dry season in all the sites. The sites behind Kaduna Refinery and Petrochemical Company (KRPC) is significantly higher ($P<0.05$) in concentration than all other sites while the control (Kamaku National Park) has the least concentration ($P<0.05$). Pearson correlation showed a significant and positive association between soil based heavy metals and automobile / farming activities in wet season ($R = 0.40^{**}$) and dry season ($R = 0.95^{**}$) as well as in industrial / farming activities in wet season ($R = 0.88^{**}$) and dry season ($R = 0.94^{**}$) at 0.01 probability level. It is concluded that variation in the assessment of soil based heavy metals in the selected sites are influenced by anthropogenic activities (mainly agriculture and fossil fuel combustion) in the sites. It is recommended that there should be provision for licensing and registration of all major industrial polluters and monitoring their

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compliance with laid down standard; further research into anthropogenic air pollution and farming activities which leads to increase in soil based heavy metals especially in the Northern Guinea Savanna where there are limited research should be investigated.

***Keyword*:** Assessment, Anthropogenic, Soil Based, Heavy Metals, Northern Guinea Savanna

1. INTRODUCTION

Heavy metals in general terms apply to the group of metals or metalloids with atomic density greater than 5g/cm^3 in their elemental form. Heavy metals can be explained in terms of toxic level, excessive level and below excessive level. The toxicity of heavy metals depends on the types of metals, its role and types of organism that are exposed to the heavy metals. Heavy metal belongs to a group of geochemical substances described as trace element because they collectively comprise of less than 1% of the rock in earth crust; they cannot be degraded or destroyed. All heavy metals are toxic to living organisms at extreme concentration. The elements that can be classified as heavy metal comprises of 38 elements, 17 of which are considered to be toxic and relatively accessible

Deposition of heavy metals in the soil from various anthropogenic activities have been said to be responsible for an increase in heavy metal concentration above background and recommended levels.

Heavy metals are important components of agro-allied products such as pesticides, herbicides, fertilizers, manufacturing and other synthetic products such as paints and batteries (USDA, 2000).

Farming practices constitute very significant non-point sources of metals which make significant contribution to their total concentration in soil in many part of the world, especially in regions on intensive agricultural activities. Combustion of fuel from petroleum, automobile, abrasion of tyres, brake lining, corrosion of body work of vehicles and engine wears have been associated with elevated concentration of heavy metal in the soil

Consequently, this research was carried out to assess the soil based heavy metals from anthropogenic activities in Kaduna Northern Guinea Savanna of Nigeria where data on soil based heavy metals resulting from anthropogenic activities are limited.

2. MATERIALS AND METHODS

2. 1. STUDY AREA Study area

The study was carried out in Kaduna State. Kaduna State is one of the most industrialized States in Northern Nigeria. The State lies within the Northern Guinea Savanna Eco-region. It is located between longitude 06º15’E, 08º5’E and latitude 09º2’N, 11º32’N (Figure 1). It covers an area of about 48,473 sqkm and has a human population of 3.96 million (NPC, 2006) There are two marked seasons, the wet usually between April to September and the dry between October to April.

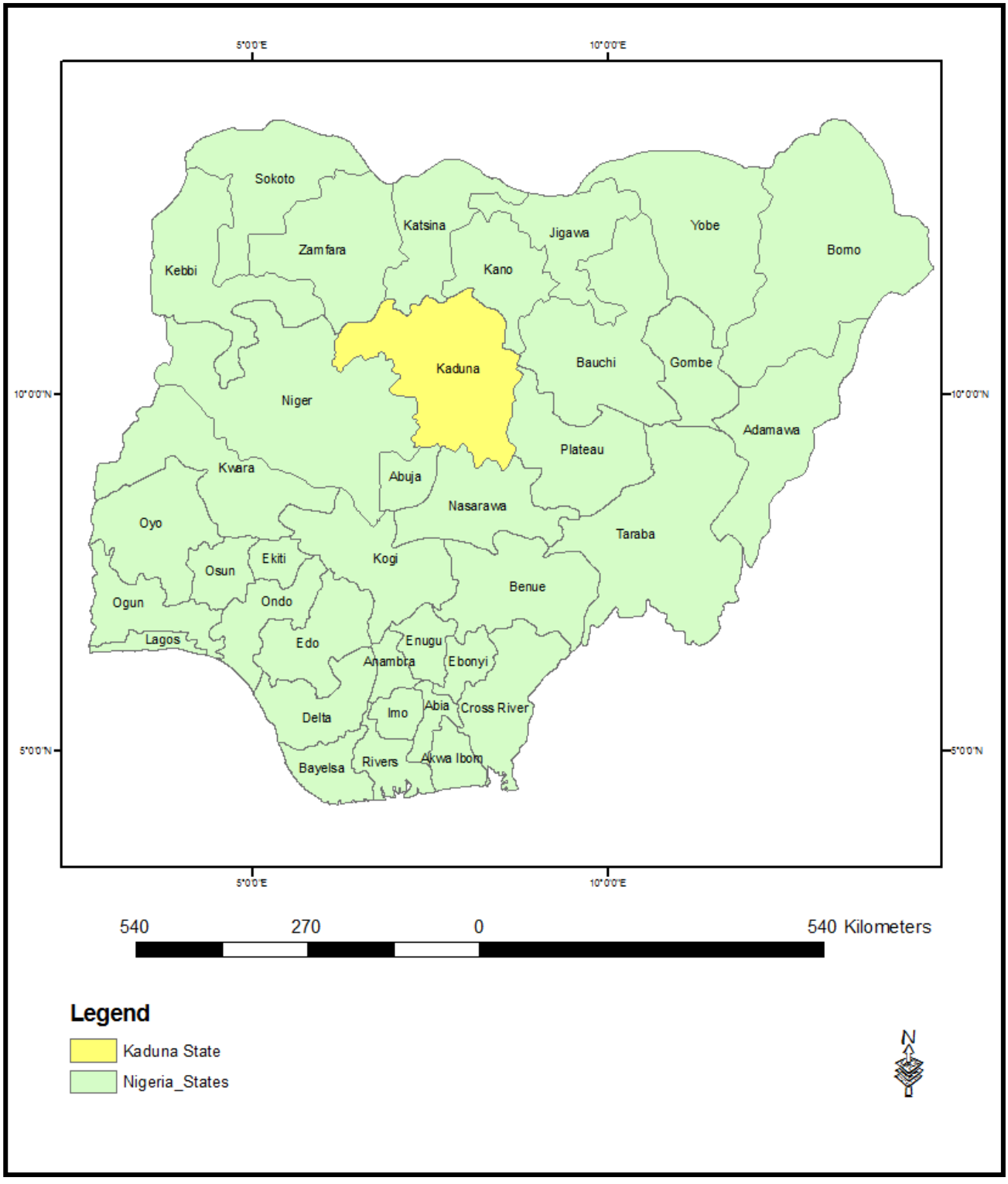

Figure 1. Map of Nigeria showing Kaduna State
Source: Field Survey, 2012

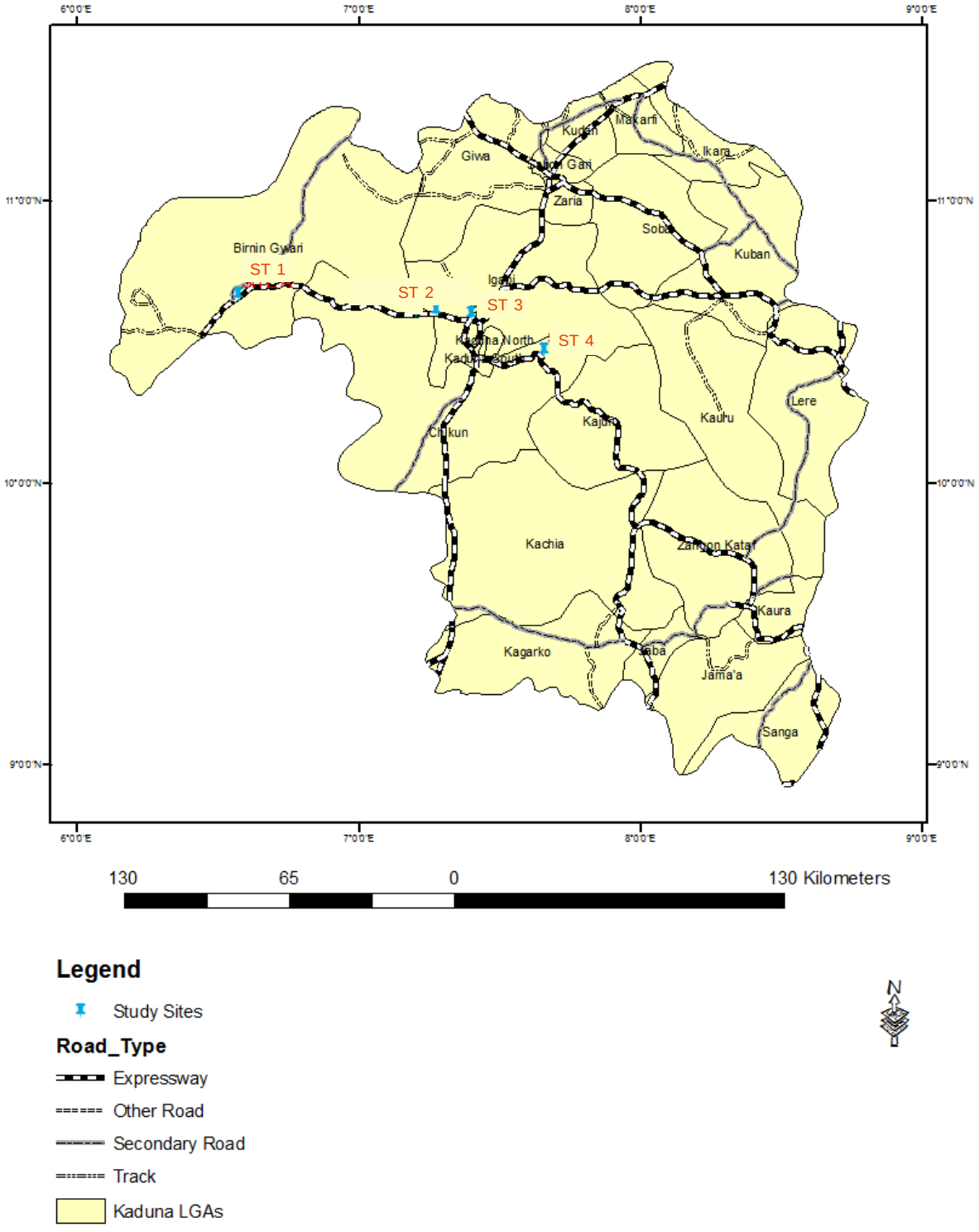

Figure 2. Map of Kaduna State showing the Study Sites
Source: Field Survey, 2012

2. 2. Characteristic of the study site

The first site (ST1) at Kamaku National Park, Birnin Gwari is used as control. Here, vehicular traffic and farming activities are minimal. It is a natural eco-system being devoted to recreation, eco-tourism, scientific research and for the promotion of culture, handcraft and other values. Site 2 (ST2) is along Kaduna – Abuja Road, it is a cleared fruit garden with high vehicular traffic level (Traffic level is characterized high when it consist of about three thousand five hundred (3500) automobiles which include city public transit and cargo transit between 6.00 am and 12.00 noon). Site 3 (ST3) is along Kaduna – Lagos Road. It is an abandoned farmland with low vehicular traffic level (Traffic level is characterized low when it consist of about one thousand five hundred (1500) automobiles which include city public transit and cargo transit between 6.00 am and 12.00 noon). Site 4 (ST4) is directly behind Kaduna Refinery and Petrochemical Company (KRPC), It is an abandoned farmland characterized by high emission from the industry. The sampling site was located close to the industry (Figure 2).

2. 3. Samplingtechnique

Three (3) replicates of 50m × 50m were demarcated. Subjective sampling method was used. Soil was sampled with the use of hand Dutch auger at 15 cm depth. On removal, the core was divided into three (3) portions of about 5 cm, each being treated as separate samples. A number of cores are taken at each sampling point. The ten (10) portions were bulked to form one sample. Similar procedure was followed for each site; all being placed in a plastic bag serves as one sample. The samples were later taken to Federal Ministry of Agriculture and Rural Development Annex at Gonin Gora, Kaduna State for analysis of possible heavy metals using Atomic Absorption Spectrophotometer.

2. 4. Soil heavy metal analysis using atomic absorption spectrophotometer

Soil analysis was carried according to AOAC. A sample of 0.5g of air dried ground soil was transferred to a 25 ml conical flask, 5 ml of concentration H_2SO_4 was added followed by 25 ml of conc. HNO_3 acid, and 5ml of conc. HCl. The contents of the tube were heated at 200 ^oC for 1 hour in a furning hood and then cooled to room temperature. After cooling, 20 ml of distilled water was added and the mixture was filtered using filter paper number one (1) (11 cm) to complete the digestion. Finally, the mixture was transferred to a 50 ml volumetric flask, filled to the mark and let to settle for at least 15 hours. The supernatant was analyzed for possible heavy metal by using Atomic Absorption Spectrophotometer.

2. 5. Analysis of data

The following tools of analysis were used to analyze the data collected:

1) Descriptive Statistics
2) Analysis of Variance (ANOVA)
3) Pearson Correlation

2. 5. 1. Descriptive Statistics

Descriptive statistics such as histogram was used to show variation in soil heavy metal content in all the sites. Mean standard errors were also calculated for each treatment and parameter evaluated.

2. 5. 2. Analysis of Variance (ANOVA)

Analysis of Variance using SPSS at (P<0.05) significance level was used to test the significant differences between each parameter.

2. 5. 3. Pearson Correlation

Pearson Correlation was used to establish the relationships that exist between various human activities and soil based heavy metals at 0.01 probability level.

3. RESULTS AND DISCUSSION

Chemical analysis of soil from various study area in the study sites revealed the presence of a long list of pollutants in them. The results showed the presence of V, Cr, Mn, Zn, Co, Ni, Cu, Pb, Br, Cd and Fe (Figures 3, 4, 5 and 6). There were significant differences (P<0.05) when metal concentration were compared between seasons within the sites. However, Site 4 (ST4), an abandoned farmland behind Kaduna Refinery and Petrochemical Company had significantly higher (P<0.05) metal contents than all the other sites during the wet and dry seasons (WS – 25.1; ± 5.6; DS – 22.7; ± 5.3). This site is closely followed by site 2 (S2) an abandoned fruit orchard farmland along Kaduna – Abuja Road (WS – 16.6; ± 4.3; DS – 15.1; ± 4.0). This is followed by site 3, an abandoned farmland along Kaduna – Lagos Road, Buruku Village (WS – 15.4; ± 3.3; DS – 13.4; ± 3.0) while site 1 (ST1) Kamaku National Park, Birnin Gwari is the least (WS – 15.1; ± 3.2; DS – 11.9; ± 2.8). Higher soil based heavy metals were recorded in the wet season than in the dry season which could be attributed to the fact that the metal generated from car exhaust and petrochemical company are blown from the road and stay on surface soil which are in turn leached down into the soil by rain water during the wet season but during the dry season, they are blown by wind from one place to the other (Table 2).

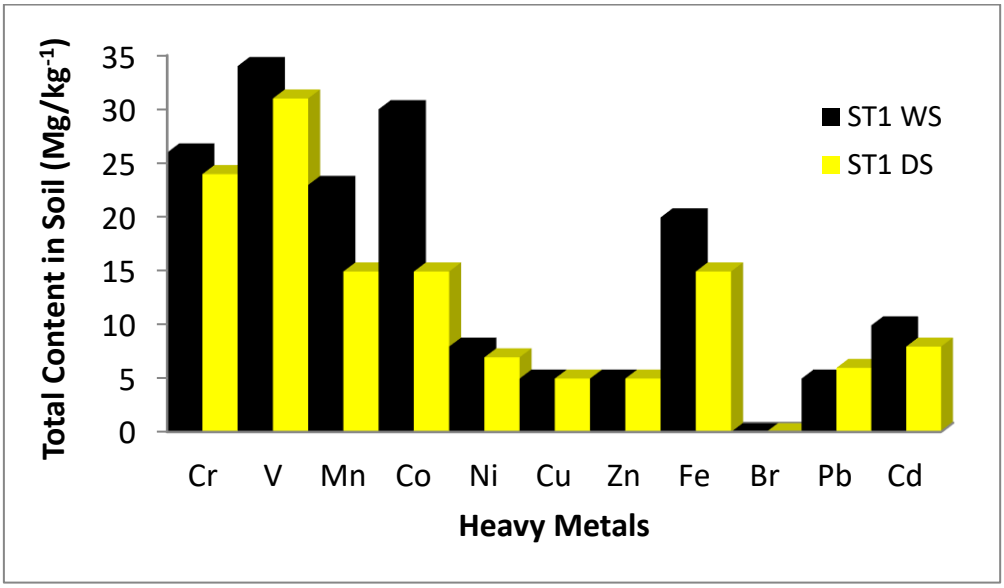

Figure 3. Seasonal variation in heavy metal contents of soil from Kamaku National Park Birnin Gwari (ST1)

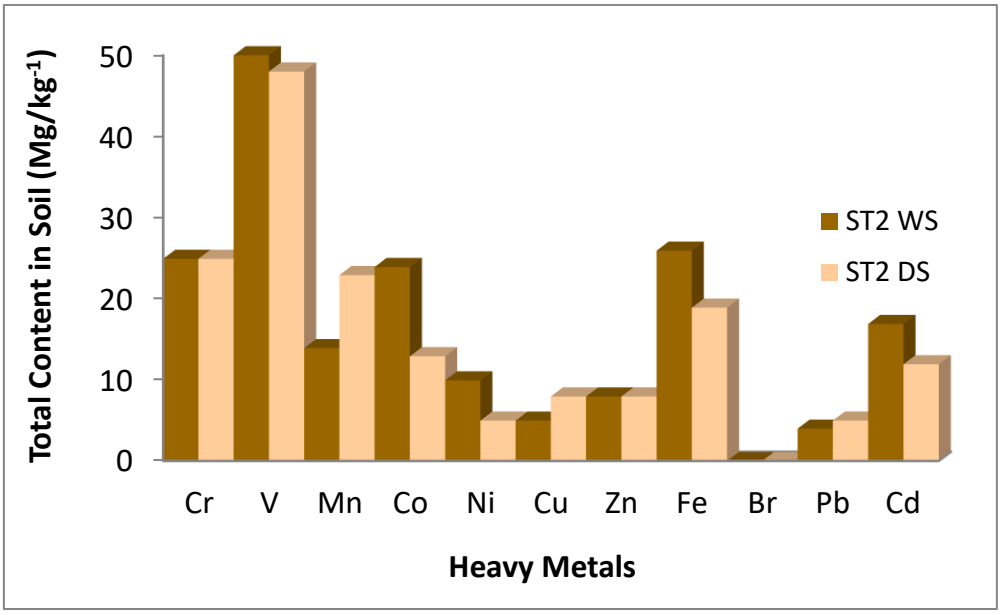

Figure 4. Seasonal variation in heavy metal contents of soil from an abandoned farmland before Buruku Village (ST2) along Kaduna – Lagos Road

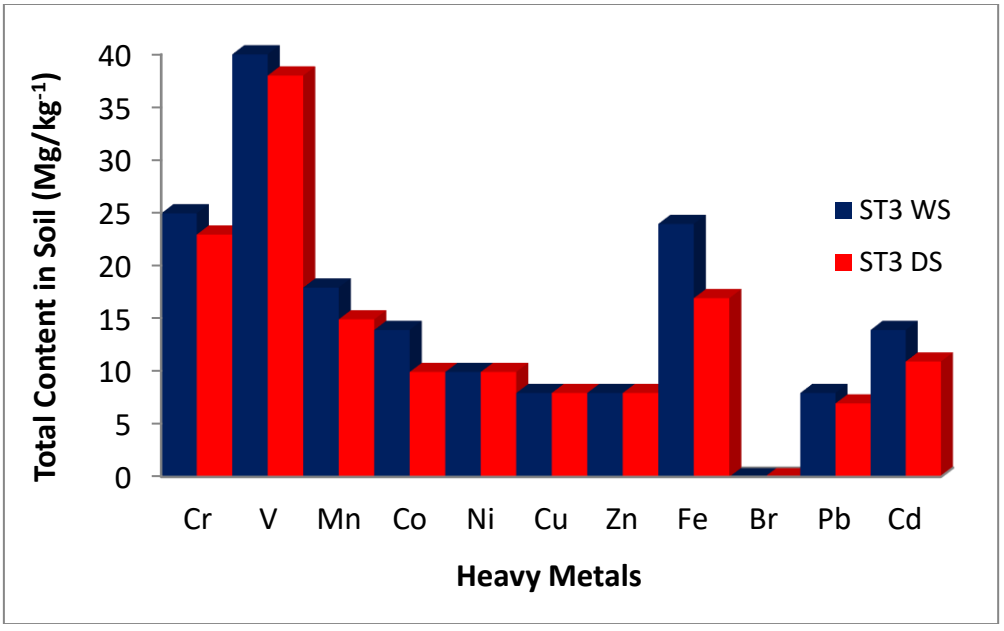

Figure 5. Seasonal variation in heavy metal contents of soil from an abandoned fruit orchard (ST3) along Kaduna – Abuja Road

This differs with the findings who observed a higher concentration of these metals in dry season than the wet season. However, it is important to note that general variations in patterns of metal deposition could be related to intensity and direction of climatic variables such as

precipitation, temperature, etc. that interface with topography, drainage, soil structure / texture etc. to determine the physiochemical properties of the soil in a particular location.

Soil physiochemical properties have complex interdependent effects on metal solubility with the most important these include solution composition (inorganic and organic soluble), pH, type and density of change on soil colloids and reactive surface area that interact with factors like metal concentration and form, particle size distribution, quantity and reactivity of hydrous oxide, mineralogy, degree of aeration and microbial activity.

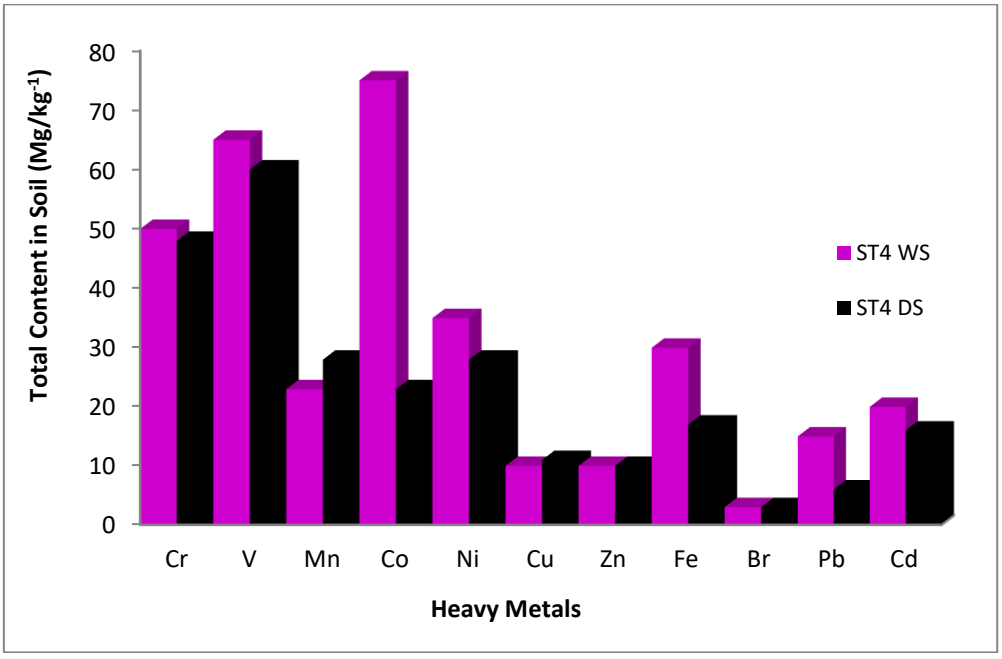

Figure 6. Seasonal variation in heavy metal contents of soil from an abandoned farmland behind Kaduna Refinery and Petrochemical Company (ST4)

Table 1. Pearson Correlation showing the relationship between various human activities and soil based heavy metals.

S/No	Human Activities	Pearson Correlation Coefficient (R) Wet Season	Pearson Correlation Coefficient (R) Dry Season
1	Automobile / Farming	0.90**	0.95**
2	Industrial / Farming	0.88**	0.94**

Field Survey, 2015
*** Correlation is significant at 0.01 level (1-tailed)*
R = Pearson Correlation Coefficient

Table 2. Soil Based Heavy Metals in the Study Sites in Mg/Kg.

S/No	Metals	Symbol	Site 1		Site 2		Site 3		Site 4	
			WS	DS	WS	DS	WS	DS	WS	DS
1	Chromium	Cr	26	24	25	25	25	23	50	48
2	Venadium	V	34	31	50	48	40	38	65	60
3	Manganese	Mn	23	15	14	23	18	15	23	28
4	Cobal	Co	30	15	24	13	14	10	75	23
5	Nicke	Ni	8	7	10	5	10	10	35	28
6	Copper	Cu	5	5	5	8	8	8	10	11
7	Zinc	Zn	5	5	8	8	8	8	10	10
8	Iron	Fe	20	15	26	19	24	17	30	17
9	Bromine	Br	0	0	0	0	0	0	3	3
10	Lead	Pb	5	6	4	5	8	7	15	6
11	Cadmium	Cd	10	8	17	12	14	11	20	16
	Mean (x)		15.1	11.9	16.6	15.1	15.4	13.4	25.1	22.7
	SE±		3.2	2.8	4.3	4.0	3.3	3.0	5.6	5.3

*P<0.05; LSD (WS) = 6.0; LSD (DS) = 5.3; WS = Wet Season, DS = Dry Season
ST1 = Kamaku National Park, Birnin Gwari
ST2 = Kaduna – Lagos Road before Buruku Village along
ST3 = abandoned fruit orchard along Kaduna – Abuja Road
ST4 = abandoned farmland behind Kaduna Refinery and Petrochemical Company

Consequently, the aggregate of this complex determines the bioavailability of metals to plants. The site behind Kaduna Refinery and Petrochemical Company is significantly higher (P<0.05) in concentration than all other sites while the control, Kamaku National Park has the least concentration (P<0.05). This variation could be attributed to the anthropogenic activities (mainly agriculture and combustion of fossil fuel) that had taken place in those sites. However, it could also be due to the closeness of the sites to the sources of pollution. Similar observations were recorded.

The results of the Pearson Correlation (Table 1) showed s significant and positive relationship between anthropogenic activities (automobile and farming) and soil based heavy metals in both wet season (WS) and dry season (DS); R = 0.90** and R = 0.95** respectively at 0.01 probability level. Similarly, industrial and farming activities was also found to be

positive and had a significant relationship with soil based heavy metals in both the wet season (WS) and dry season (DS); R = 0.88** and R = 0.94** respectively at 0.01 probability level.

4. CONCLUSION

Variations in the assessment of soil based heavy metals in the selected sites are influenced by anthropogenic activities (mainly agriculture and fossil fuel) in the sites It is therefore recommended that there should be provision for licensing and registration of all major industrial polluters and also monitoring their compliance with laid down standard. Further research should be carried out on variance of anthropogenic air pollution and farming activities which leads to increase in soil based heavy metals especially in Northern Guinea Savanna where little research has been carried out.

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