SOIL BASED HEAVY METALS ORIGINATING FROM ANTHROPOGENIC ACTIVITIES ON FLORISTIC COMPOSITION OF SOME SELECTED SITES IN KADUNA NORTHERN GUINEA SAVANNA OF NIGERIA

ABSTRACT

Soil based heavy metals originating from anthropogenic activities on floristic composition of some selected sites in Northern Guinea savanna of Nigeria were investigated. 50m x 50m plots were laid in each of the three (3) selected sites with 30m espacement between each plot. This is replicated three (3) times to make a total of nine (9) plots in all. Soil samples were collected at a depth of 25m with a soil auger and heavy metal analysis was carried out with the use of atomic spectrophotometer. The floristic compositions were evaluated using line transect method. Flora were enumerated in all the sites irrespective of the growth form, (i.e. trees, shrubs and herbs). The data collected were subjected to descriptive statistic, Anova using SPSS while the diversity index was calculated using Shannon Weiner method. The study revealed the presence of six (6) soil based metals in the selected sites, Cd; Cu; Mn; Ni; V and Zn. Significance differences ($P<0.05$) exist in soil based heavy metal between sites. A total of two thousand two hundred and sixty one (2,261) floral species were evaluated. The population densities of the floristic composition are higher in site A than all the other sites while species diversity decrease significantly ($P<0.05$) from Site A to C. It is concluded that population densities and diversity of the floristic composition in the selected sites are influenced as a result of soil based heavy metals originating from anthropogenic activities in the sites. It is however recommended that there should be provision of guidelines for the abatement of pollution establishing standard for the control of fuel additives with respect to heavy metals. Also, there should be prescribed standard for the level of emission from automobile exhaust and energy generating plants and stations.

Key Words: Ecosystem, Shannon Weiner, Pollutants, Accumulation, Growth forms, Diversity, Population density

INTRODUCTION

Human activities either through necessity or ignorance often interfere with natural balance of ecosystem. The resultant products often end up polluting the earth. The pollutants have had adverse effects on life, species extinction, loss of forest ecosystem, acid rain, global warming, ozone depletion, hazardous waste disposal problem, frequent and intense eco-accident (Bako, 2000; Odiwo, 2004 and Bako *et. al*., 2008). Evidence shows that endurance of ecosystem to stress put upon them by human activities has exceeded a limit. This has however caused an imbalance in the environmental equilibrium (Podani, 1992; Cairn, 1999). Heavy metal in general terms apply to the group of metals or metalloids with atomic density greater than 5g/cm3 in their elemental form (Ademoroti, 1996).

Deposition of heavy metals in soil from anthropogenic activities have been said to be responsible for an increase in heavy metal concentration above the background and recommended levels (Maine *et.al.*, 2004; Bako *et.al.*, 2008; Tanimu *et al.*; 2013 and Bako *et. al*, 2014). 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). Combustion of fuel from petroleum, automobile abrasion of tyres, brake lining, corrosion of the body work of vehicles and engine wear have been associated with elevated concentration of heavy metal (Albasel *et.al.*, 2011 and Bako *et.al.* 2014). Excessive concentration of heavy metals in the environment is of great concern because of their non-biodegradability. Therefore, their persistence in the environment causes health hazard to flora and fauna and consequently trigger ecological imbalance in the ecosystem (Ekmekyapar, *et.al.*, 2012; Bako *et.al.*, 2014). Concentration of heavy metal in shoot of plants may vary with season as a result of inherent growth dynamics of plant, metal concentration and its bio-availability in the environment. Data on various responses of plants to human activities modification of the environment, particularly in relation to soil and air pollution by heavy metals in Northern Nigeria is limited, thus necessitating this research. This study was carried out to determine the spatial and seasonal variation of heavy metal originating from anthropogenic activities deposition in soils as its effects on the floristic composition of some sites in order to assess the extent of pollution in Northern Guinea Savanna of Nigeria.

MATERIALS AND METHODS

STUDY AREA

The study was conducted in Kaduna State. Kaduna is one of the most industrialized States in Northern Nigeria. The State lies within the Guinea Savanna Eco-region. It is located between longitude 06^{o}15’E, 08^{o}5’E and latitude 09^{o}2’N, 11^{o}32’N. It covers an area of about 48,473sq.km and has a human population of 3.96million (NPC, 2006).

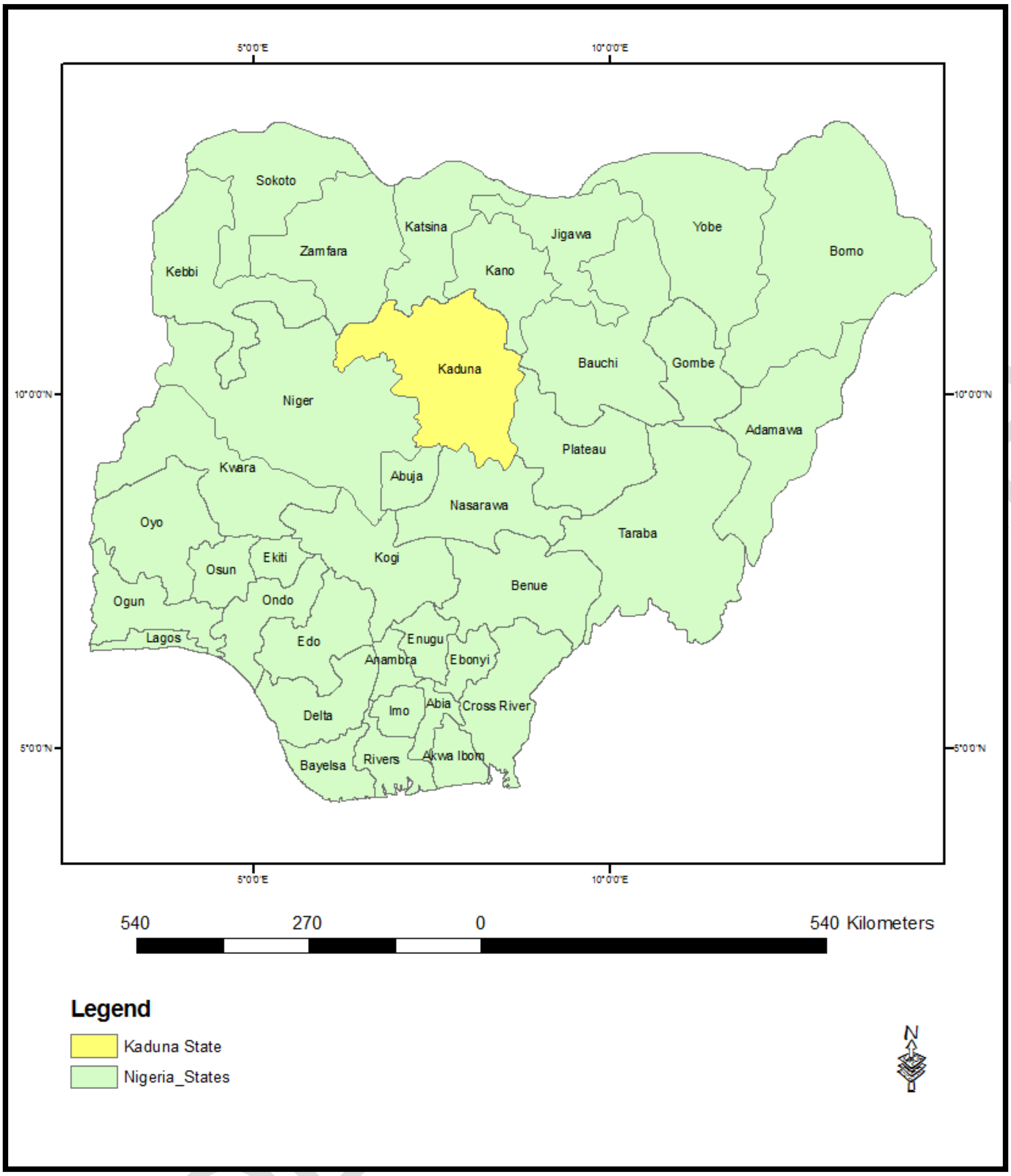

Figure 1: Map of Nigeria showing Kaduna State

Source: Field Survey, 2012

CHARACTERISTIC OF THE STUDY SITE

The study sites were located around Birnin Gwari and Kaduna axis. The first site (Site A) at Kamaku National Park, Birnin Gwari was used as a control site. Site B was along Kaduna – Lagos Road. It was an abandoned farmland with low vehicular traffic level. Site C was along Kaduna – Abuja Road, it was a cleared fruit garden with high vehicular traffic level. These sites have different sources and level man made emission and agricultural activities.

SAMPLING TECHNIQUE

Three (3) replicates of 50m x 50m were demarcated with 30m espacement between each plot. Complete Randomized Design (RD) was used. Each site was evaluated for floristic composition using line transect method while the soil was sampled with a hand Dutch Auger at 15cm depth. Mean records for the replicates were used to determine the diversity and population density.

ANALYSIS OF DATA

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

Biodiversity Index

Biodiversity Index was calculated using Shannon-Weiner method.

$$H^1 = \Sigma^1{}_1 = 1\ PiLogPi$$

OR

$$H^1 = \Sigma_1 Pi\ in\ Pi$$

Where $Pi = \frac{ni}{N}$

n = Number of individual species

N = Total number of individual

H^1 = Measure of diversity

Pi = Proportion of the 11^{th} species in a site (Daniel *et.al.*, 1996).

DESCRIPTIVE STATISTIC

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

ANALYSIS OF VARIANCE (ANOVA)

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

RESULTS AND DISCUSSION

Soil Based Heavy Metal

Concentration of heavy metal in the soil was generally observed to be higher in site C than all the other sites. Figure 1 shows the presence of six (6) soil based heavy metals which are recorded, these include; Cd, Cu, Mn, Ni, V and Zn. The result showed that there are significant difference ($P<0.05$) when metal concentration were compared among the sites. V is the highest soil based metal recorded in all the sites. This may be attributed to fossil fuels combustion, application of phosphate fertilizers, abrasion of tyres, brake lining, etc. (Alloway, 1995; Knox *et.al.*, 1999 and Bada, 2000). Site C is significantly higher ($P<0.05$) in concentration than the other two (2) sites. This variation could be attributed to anthropogenic activities (mainly agriculture and combustion of fossil fuels) going on around in the sites. Similar observations were made by Alfani, *et.al.*, (2004); Odiwo, (2004) and Bako *et.al.*, 2014).

Population Density and Diversity Index

The population density and diversity index of the floristic composition in the study sites showed that a total of two thousand two hundred and sixty one (2,261) floral species were recorded irrespective of their growth forms (trees, shrubs and herbs) with site A having 1,317 species, site B (494 species) and lastly site C having 450 species. Tables 1, 2 and 3 below show the population density and diversity of the various sites. Trees species population density and diversity index in relation to soil based heavy metals originating from anthropogenic activities. The result in table 1 revealed that the family Bombacacae and Rufaceae had the highest number of 10 plant species. In site A, *Adansonia digitata* had the highest population density of 10 individual / ha closely followed by *Ceiba pentandra* and *Daniellia oliveri* with population density of 6 individuals / ha while other trees species varied between 4 and 2 respectively. In site B, family Myrfaceae and Malvaceae had the highest population density of 4 individuals / ha while the tree species varied between two (2) and zero (0) respectively. However in site C, Rutaceae family had the highest population density of 10 individuals / ha while others varied between six (6) and zero (0). Diversity index was 2.83 (site A); 1.26 (site B) and 1.07 (Site C). This implies that trees species in the reference points (Site A) where pollution and anthropogenic activities are minimal are more diverse than the two other sites (B and C). The order of the sites are; A>B>C.

Shrub Species Population Density and Diversity Index in relation to Soil Based Heavy Metal originating from Anthropogenic Activities

Table 2 revealed that in Site A, *Cassia occidentalis* had the highest shrub population density of 193 individual / ha followed by *Sida acuta* with 162 individual / ha while the shrub species with the least frequency (*Piliostigma thonningii*) had a population density of 12 individual / ha. In site B, *Cassia* *tora* had the highest shrub population density of 156 individual / ha followed by *Sida acuta* with 120 individual / ha while the shrub with the least frequency had a population density of 8 individual / ha.

However, in site C, *Cassia occidentalis* also had the highest population density of 164 individual / ha closely followed by *Sida acuta* with population density of 124 individual / ha while the shrub with the least frequency had a population density of 6 individual / ha. The species diversity index are 2.56 (site A); 1.63 (site B) and 1.38 (site C). The order of diversity of the sites are A>B>C. This implies that site C is significantly lower in diverse of the entire sites in shrub growth form.

In herb category, the result in table 3 shows that *Tridax procumbens* had the highest population density of 39 individual / ha closely followed by *Ipomoea asarifolia* with population density of 32 individual / ha while *Euphorbia heterophylla* had the least population density of 14 individual / ha in site A. In site B, two (2) species of herb growth form were recorded with *Achyranthesi aspera* had the highest population of 10 individual / ha and *Ipomoea asarifolia* had population density of 2 individual / ha. In site C, no herb growth form was recorded. The species diversity index are 1.89 (site A), 0.45 (site B) and none in site C. The order of the diversity of the sites are A>B>C.

Generally, the flora diversity in the control site was more than those in the other sites. This could be noticeable from all the growth form assessed. (Trees, shrubs and herbs). This implies that the combustion of fossil fuel, application of phosphate fertilizers, abrasion of tyres, brake lining, corrosion of the body work of vehicles and engine wear have been associated with a continuity increase in concentration of pollutant which in turn affect the population density and diversity index of the floristic composition of the study site. Similar observations were recorded by Alfani, *et.al.*, (2004); Odiwo, (2004); Zu *et.al.*, (2005) and Bako *et.al.*, (2008). However, changes in the composition and distribution of species within the study sites occur as a result of soil based heavy metals originating from anthropogenic activities that had taken place in those sites (Addo, *et.al.*, 2005).

In conclusion, it was observed that there was a decline in floristic composition density and diversity when vehicular traffic level increased and possible accumulation of the metal in the soil can be transferred to plants growing along the edge of the road which could occur as a result of continual usage of the road. This can also lead to accumulation of the metal in the tissues of organism that feed on the plant and other plants growing along the major road which can be transferred to other consumers in the food chain. Thus this can cause health risk to both humans and faunas. Therefore, it is recommended that there should be provision of guidelines for the abatement of pollution establishing standard for the control of fuel additives with respect to trace element. Also, there should be prescribed standard for the level of emission from automobile exhausts and energy generating plants and station.

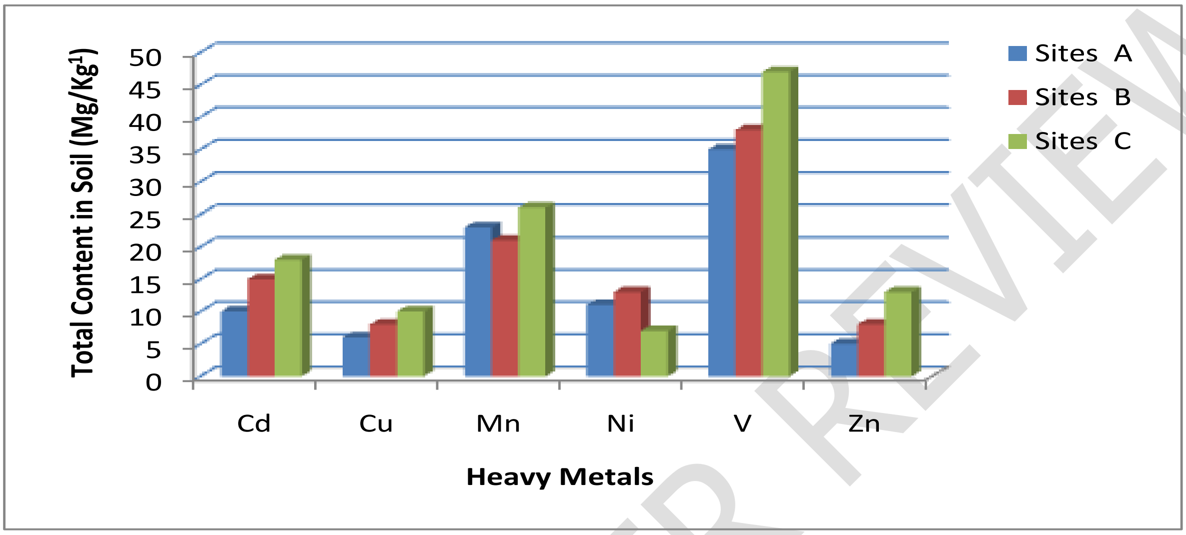

Figure 2: Variation in Soil Based Heavy Metals originating from Anthropogenic Activities

Table 1: Available Trees Species in the Study Site in Relation to Soil Based Heavy Metals originating from Anthropogenic Activities.

S/NO	SPECIES	Family	SITEA Population Frequency	Pilog in Pi	SITE B Population Frequency	PilogPi	SITE C Population Frequency	Pilog in Pi
1	*Musanga cecropoides R. Br.*	Cecropiaceae	02 (3.23)	-0.1109	-	-	-	-
2	*Vitex doniana Sweet*	Verbenaceae	02 (3.23)	-0.1109	-	-	-	-
3	*Parkia biglobosa (Jacq) Benth*	Fabaceae	02 (3.23)	-0.1109	02 (18.2)	-0.3099	-	-
4	*Khaya senegalensis Ders.*	Meliaceae	04 (6.45)	-0.1768	-	-	-	-
5	*Eucalyptus cammadulensis L.*	Myrtaceae	04 (6.45)	-0.1109	04 (36.4)	-0.3679	06(27.3)	-0.3543
6	*Psidium guajava L.*	Myrataceae	02 (3.23)	-0.1109	-	-	06 (27.3)	-0.3543
7	*Tamarindus indica L.*	Fabaceae	02 (3.23)	-0.1109	-	-	-	-
8	*Citrus sinensis L.*	Rutaceae	10 (16.1)	-0.1109	-	-	10 (45.5)	-0.3584
9	*Adansonia digitata L.*	Bombaceae	02 (3.23)	-0.2943	-	-	-	-
10	*Azadirachta indica L.*	Meliaceae	02 (3.23)	-0.1109	-	-	-	-
11	*Ficus exasperate Vahl.*	Moraceae	02 (3.23)	-0.1109	-	-	-	-
12	*Dalbezia sisso Roxb.*	Fabaceae	02 (3.23)	-0.1109	-	-	-	-
13	*Ficus thonningii Blume*	Moraceae	02 (3.23)	-0.1109	01 (9.09)	-0.2180	-	-
14	*Jacaranda mimosifolia D.Don*	Bignoniaceae	02 (3.23)	-0.1109	-	-	-	-
15	*Ceiba pentandra L.*	Malvaceae	06 (4.68)	-0.2260	04 (36.4)	-0.3679	-	-
16	*Delonix regia Boj. Ex Hook*	Fabaceae	02 (3.23)	-0.1109	-	-	-	-
17	*Anacardium occidentale L.*	Anacardiaceae	02 (3.23)	-0.1109	-	-	-	-
18	*Daniellia oliverii Rolfe*	Leguminiaceae	06 (4.68)	-0.2260	-	-	-	-
19	*Albizia Labbeck (Linn)*	Fabaceae	04 (6.45)	-0.1768	-	-	-	-
20	*Raphia sudanica A. Chev.*	Arecaceae	02 (3.23)	-0.1109	-	-	-	-
			62 (100)	**2.8293**	**11 (100)**	**1.2637**	**22 (100)**	**1.067**

Source: Field Survey, 2016

Tree species diversity = 2.8293 (Site A)

Tree species diversity = 1.2637 (Site B)

Tree species diversity = 1.067 (Site C)

Table 2: Available Shrub Species in the Study Site in relation to soil based Heavy Metals originating from Anthropogenic Activities

S/NO	SPECIES	Family	SITEA Population Frequency	Pilog in Pi	SITE B Population Frequency	PilogPi	SITE C Population Frequency	Pilog in Pi
1	*Senna tora L. Syn.*	Caesulpainaceae	146(13.47)	-0.2700	156(33.12)	-0.3660	100(23.37)	-0.3397
2	*Combretum serisecrum*	Combretaceae	22(2.03)	-0.0791	-	-	-	-0.1119
3	*Hyptis suaveolens Poit*	Labiateae	24(2.21)	-0.0844	08(1.70)	-0.0692	14(3.27)	-0.3589
4	*Urena lobata Linn*	Malvaceae	16(1.48)	-0.0622	-	-	-	-
5	*Sida acuta Burm.f.*	Malvaceae	162(14.95)	-0.2841	120(25.48)	-0.3484	124(28.97)	-
6	*Blepharis maderaspatensis L.*	Acanthaceae	24(2.21)	-0.0844	-	-	-	-
7	*Amorphophallus abyssinicus R. Rich*	Araceae	18(1.66)	-0.0681	-	-	-	-
8	*Cochlospermum planchoni Hook.f.*	Bixaceae	22(2.03)	-0.0791	-	-	-	-
9	*Acalypha hispida Burm.f.*	Euphorbiaceae	30(2.77)	-0.0993	-	-	-	-
10	*Jatropha curcas L.*	Euphorbiaceae	44(4.06)	-0.1301	16(3.40)	-0.1150	-	-
11	*Sida garckeana Polak*	Malvaceae	28(2.58)	-0.0944	-	-	-	-
12	*Senna occidentalis Linn*	Caesalpinioldeae	193(17.80)	-0.3073	70(14.86)	-0.2833	-	-
13	*Lantana camara L.*	Verbenaceae	116(10.70)	-0.2392	78(16.56)	-0.2978	164(38.32)	-0.3676
14	*Thevetia peruviama (Pers.)*	Apocynaceae	34(3.14)	-0.1086	-	-	-	-
15	*Oldenlandia herbacea (Linn) Roxb*	Rubiaceae	17(1.57)	-0.0065	-	-	-	-
16	*Philostigma thonningii (Schum)*	Caesaliniaceae	12(1.11)	-0.0450	0	-	-	-
17	*Physalis angulata Linn*	Solanaceae	17(1.57)	-0.0065	-	-	20(4.67)	-0.1432
18	*Aloe buettneri A. Berger*	Liliaceae	21(1.94)	-0.0764	-	-	-	-
19	*Asystasia gangetica Linn*	Acanthaceae	40(3.70)	-0.1218	23(4.88)	0.1474	-	-
20	*Hypoestes cancellata Nees*	Acanthaceae	26(2.40)	-0.0895	-	-	-	-
21	*Calotropis procera L.*	Apocynaceae	25(2.31)	-0.0870	-	-	-06(1.40)	-0.0598
22	*Stachytarpheta angustifolia Linn.*	Verbenaceae	47(4.34)	-0.1361	-	-	-	-
			1084 (100)	**2.5591**	**471 (100)**	**1.6271**	**428 (100)**	**1.3811**

Source: Field Survey, 2016

Tree species diversity = 2.5591 (Site A)
Tree species diversity = 1.6271 (Site B)
Tree species diversity = 1.3821(Site C)

Table 3: Available Herbs Species in the Study Site in relation to soil based Heavy Metals originating from Anthropogenic Activities

S/NO	SPECIES	Family	SITEA Population Frequency	Pilog in Pi	SITE B Population Frequency	PilogPi	SITEC Population Frequency	Pilog in Pi
	***Herbs**							
1	*Euphorbia heterophylla Linn*	Euphobiaceae	14(8.19)	-0.2050	-	-		
2	*Physalis anguirata Linn*	Solanaceae	20(11.70)	-0.2510	-	-		
3	*Ipomoea asarifolia (Desr.)*	Convolvulaceae	32(19.71)	-0.3136	02(16.67)	-0.2986		
4	*Nelsonia canescencs Lam*	Aecanthaceae	26(15.20)	-0.2864	-	-		
5	*Polycarpoea corymbasa Linn*	Caryophyllaceae	20(11.70)	-0.2510	-	-		
6	*Tridax procumbens Linn*	Asteraceae	39(22.80)	-0.3371	-	-		
7	*Vernonia ambigua Kotschy & Peyr*	Asteraceae	20(11.70)	-0.2510	-	-		
8	*Achyranthesi aspera L.*	Amaranthaceae	-	-	10(83.33)	-0.1520		
			171 (100)	**1.8951**	**12 (100)**	**0.4506**		

Source: Field Survey, 2016

Tree species diversity = 1.8951 (Site A)
Tree species diversity = 0.4506 (Site B)
Tree species diversity = - (Site C)

REFERENCES

Abeles, F., Legge, A.H., Begner, J.C. and Krupa, S.U. (1983). Foliar Sulphur Species in Pine: a new indicator of a forest ecosystem under air pollution stress. *Environmental Pollution*. 55, 15 – 27.

Addo, M.A., Darko, E.O., Gordon, C., Nyarko, BJB, Gbadago, J.K., Nyarko, E., Affum, H.A., and Botine, B.O. (2012). Evaluation of Heavy Metals contamination of Soil and Vegetation in the Vicinity of Cement Factory in the Volta Region, Ghana. International Journal of Science and Technology. 2(1): 40 – 50.

Albasel, N. and Cottecene, A. (2011). Lead, Copper and Zinc Concentration in Roadside Topsoil of Niger State, Nigeria. In: Iyaka, Y.A. and Kakulu, S.E. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS)* 2(5): 754 – 758.

Alfani, A., Maisto, G, Baldantoni, D., Anna, D.M. and Desanto, A.V. (2004). Trace Metals in the Soil and in *Quercus ilex* leaves at anthropic and remote sites of the campina region of Italy. Geoderma. 122: 269 – 279.

Alloway, B.J. (1995). The origins of heavy metals in soils, 2nd Ed. Blackie Academic and Professional Publisher Pp

Bada, B.S. (2000). Heavy Metal Concentration of Soil and Vegetation associated with Highways of two different traffic densities in Osun State. MSc. Thesis. Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife. 75pp.

Bako, S.P., Ezealor, A.U. and Yahuza, T. (2014). Heavy metal deposition in soils and plants impacted by anthropogenic Modification of two sites in Sudan Savanna of North Western Nigeria. INTECH 697 – 721.

Bako, S.P., Odiwo, J.E., Ezealor, A.U. (2008). Plant diversity in relation to anthropogenic trace metals in soils of selected sites in Nigeria's Savanna International Journal of Environment and Pollution: Special issue on Biogeochemistry of toxic trace metals in water, soil and plant. 332/3): 185 – 194.

Bako, S.P. (2000). The effects of high temperature and air pollution on growth physiology and reproduction of Maize. Ph.D thesis. Ahmadu Bello University, Zaria. 238pp.

Cairn, J. Jr. (1999). Biological Monitoring, Part 1: Early Warning Systems, Water Research 14 PP. 1179 – 1196.

Ekmekyapar, F., Sabudak, T., Seren, G. (2012). Assessment of Heavy Metal Contamination in Soil and Wheat (Triticum aestivium L.) Plant around the Corlu-Cerkezkoy highway in: Thrace Region.

Global Nest Journal. 14 (4): 496 – 504.Knox, A.S.; Gamerdinger, A.P,; Adriano, D.C; Kolka, R.K; Kaplan, D.I. (1999). Sources and Practices contributing to soil contamination. In: Adriano, D.C; Bollag, Bioremediation of contaminated soils. Agronomy series No 37, ASA, CSSA, SSSA Madison, Wisconsin, USA. P53-87.

Maine, M.A., Sune, N.L., Lagger, C. (2004): Chromium Bio-Accumulation: Comparison of the Capacity of Floating Aquatic Macrophytes. Water Research, 38: 1494 – 1501.

NPC (2006). National Population Commission (NPC) News bulletin, Kaduna State, Pp. 13.

Odiwo, J.E. (2004). Effect of some Anthropogenic Factors on Heavy Metal Contents and Biodiversity. M.Sc. Thesis. Ahmadu Bello University, Zaria. 106pp.

Podani, J. (1992). International Network for Monitoring Environmental Pollution In: Biological Indicators of Environmental Protection. Kovacs, M. (ed) Ellis Horwood, New York, London, Toronto, Sydney, Tokyo, Singapore. Pp 16 – 18.

Tanimu, Y., Bako, S.P., Tiseer, F.A. (2013): Effects of Sewage Pollution on Water Quality of Samaru, Zaria, Nigeria. In: Fernado Sebastian Garcia Einschlag and Luciano Carlos (Eds). Waste Water: Treatment Technologies and Recent Analytical Development, INTECH Publishers, Rijeka, Croatia. Pp 189 – 195.

USDA (2000). United States Department of Agriculture). Heavy Metal Soil Contamination. Soil – Quality – Urban Technical Note. No3, 1 – 7.

Zu, Y., Ce, Li, Chen, J.J., Chen, H.Y., Cein, L., Schvartz, C. (2005). Hyper accumulation of Pb, Zn, and Cd in herbaceous plants grown on lead – zinc mining area in Yunna, China. Environment International, 31, 755 – 762.