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Physicochemical Characteristics and Heavy Metals Contents in Soils and Cassava Plants from Farmlands along A Major Highway in Delta State, Nigeria

***[1]OSAKWE, STEPHEN ANAPUWA; [2]OKOLIE, LUCKY PRECIOUS**

Department of Chemistry, Delta State University, Abraka, Nigeria
**Correspondence Author e-mail: saosakwe@gmail.com*

ABSTRACT: Soil samples and cassava tubers and leaves collected from farmlands along Agbor-Asaba expressway were analysed for their heavy metal levels in order to assess their levels of contamination on the environment as a result of traffic activities. Physicochemical properties of the soil samples were also determined. The soil pH had a mean value of 5.15 $\pm$ 0.48 indicating that the soils were moderately acidic. Total Organic Carbon and Total Nitrogen mean values were 1.20 $\pm$ 0.13% and 0.09 $\pm$ 0.80% respectively showing presence of some organic matters. Electrical conductivity of the soil samples had the mean value of 5.94 $\pm$ 1.32µscm^{-1} indicating significant presence of ionisable materials in the soils. Particle size was dominated by sand size fractions followed by clay and then silt which revealed that the soils were coarse and have low supply of nutrients and moisture. The mean levels of heavy metals in the soil samples were (mgkg^{-1}) 142.93 $\pm$ 42.16 for Fe, 59.34 $\pm$ 25.21 for Zn, 14.27 $\pm$ 5.39 for Cr, 13.63 $\pm$ 5.41 for Pb and 24.98 $\pm$ 15.57 for Ni. These metal levels were in the abundance trend of Fe> Zn> Ni> Cr > Pb. The mean metal concentrations obtained in the cassava leaves and tubers respectively were (mgkg^{-1}) 21.70 $\pm$ 3.45 and 9.62 $\pm$ 3.53 for Fe, 4.15 $\pm$ 1.01 and 1.15 $\pm$ 0.44 for Zn, 5.12 $\pm$ 2.75 and 0.37 $\pm$ 0.63 for Cr and 3.46 $\pm$ 1.58 for Pb only in leaves. For both the soil and plant samples, the heavy metal levels were significantly higher than the levels obtained in the control sites confirming some heavy metal enrichments in the soils studied. The plant concentration factor values were in the order Cr > Pb > Fe > Ni showing that chromium was the easiest to migrate among all the metals studied and that all the metals fall into the category showing medium accumulation except for Nickel which fell into the category of elements lacking accumulation. The overall results show that there is some metal enrichments on the soils and cassava plants as a result of automobile emission on the highway.© JASEM

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KEYWORDS: *Heavy metals, pollution, busy expressway, farmland soils, cassava plants.*

INTRODUCTION

Heavy metals are natural components of the earth crust and as a result they are found naturally in soils and rocks with a subsequent range of natural concentrations in soils, sediments, waters and organisms (Hutton and Synmon, 1986). Human activities through industrial, agricultural, traffic, domestic, mining and other anthropogenic processes have contributed to elevated and toxic levels of these metals when compared to those contributed from geogenic or lithorlogical processes (Pam et al 2013).

Traffic associated environmental pollution is one of the most critical or challenging sources, because it is a non point source and vehicular emissions spread beyond the expected distances polluting the air, land and water bodies. Onianwa and Fakayode (2000) reported that automobile exhaust accounts for about 80% of the air pollution by heavy metals in Nigeria and this was corroborated by Adriano (2001), who stated that automobile emission is perhaps the greatest single source of contamination. Onder et al., (2007) reported high content of heavy metals in urban road side soils and plant samples and attributed it mostly to high density of traffic.

Soil serves as a sink or reservoir for the metal contaminants of the automobile emissions. Some metals like zinc, copper, iron and cadmium are important components of many alloys, wires, tyres and many industrial processes and could be released into the road side soil and plants as a result of mechanical abrasion and wear (Quasem and Kamal, 1999). Since these metals are not biodegradable, they persist and accumulate over a long time in the soils and vegetation resulting to serious environmental pollution (Mtuazi et al, 2015). This calls for an increasing concern because the pollution may eventually result in negative influence on plants, animals and humans through food chain (Mtuazi et al, 2015). The determination of metals in soil and vegetation samples is very important in monitoring environmental pollution (Al-Khashman, 2012).

The main objective of this study was to determine the heavy metals in roadside soils and cassava plants from farms located along a major highway. This will provide knowledge of the distribution of these metals in soils and vegetation and then evaluate the environmental impact caused by automobile emission on the surrounding environment.

MATERIALS AND METHODS

Study Area: The study area is Agbor-Asaba expressway which has relatively very high traffic density along, Benin-Asaba expressway. The highway passes through four local government areas of Delta State, Nigeria.

Roads from different parts of the Northern States and Edo States as well as roads from some parts of Delta State join the highway at Uromi junction in Agbor, thereby increasing the traffic density. It is this part of the Benin-Asaba expressway that links the rest of the country with the South eastern states and the famous Onitsha market through Asaba via Niger bridge.

The towns where samples were collected include.
Agbor in Ika South Local Government Area, with geographical coordinates of longitude 6.19^0 East and latitude 6.25^0 North.

Onitsha-Ugbo and Issele-Ukwu in Aniocha South Local Government Area, located at longitude 6.28^0 East and latitude 6.19^0 North.

Okpanam in Oshimili North Local Government Area, situated at longitude 6.39 East and latitude 6.14^0 North
Asaba in Oshimili South Local Government Area with the coordinates of longitude 6.73^0 East and latitude 6.2^0 North.

Sample Collection: Soil samples and cassava tubers and leaves were collected from farmlands along the expressway in each of the five towns. Cassava (esculenta grantz) was selected for this study because it is the most commonly cultivated food crop and staple food of the inhabitants of the study area. At each town, soil samples were collected from farms along both sides of the highway at depths of 0-15cm, 15-30cm and 30-45cm representing top, middle and bottom soils respectively. The soil samples for each depth from both sides of the road, were bulked and properly mixed using coning and quartering method (Ayodele and Gaya,1994) to get a composite or representative sample. Cassava tubers and leaves were also collected from the farms and separately bulked to form composite samples. The farm from where the samples were collected had no history of fertilizer, herbicide and pesticide application or industrial activity. Control samples were also collected in each town from farms far remote from any automobile or industrial activities and free from usage of any fertilizer, pesticide or herbicide.

Sample Preparation: The soil samples were air-dried at room temperature in a well-ventilated laboratory until constant weight. They were ground separately using an acid pre-washed porcelain motar and pestle and then passed through a 2mm plastic sieve prior to analysis.

The cassava tubers and leaves were washed thoroughly with distilled water to remove soil materials and possible aerial deposits on the leaves. The tubers were peeled and sliced before they were dried in the oven at 60^0C separately with the leaves. The dried leaves and tubers were also separately homogenized into powder in a porcelain motar. The powdered samples were stored in clean stopperred sterile bottles (Djingova et al., 1993).

The samples for metal analysis were digested using a mixture of $2cm^2$ of 60% perchloric acid, $15cm^3$ of concentrated nitric acid and $1cm^3$ of concentrated sulphuric acid (Burrell, 1974).

Sample Analysis: Analysis of physicochemical properties of the soil samples: The soil physicochemical properties were determined using the approved specific standard methods for each of them. Soil pH was measured in a soil – water ratio of 1:2.5 (Davey and Conyers 1988). Electrical conductivity (EC), total organic carbon (TOC) and total Nitrogen (TN) were determined using the methods described by Chopra and Kanzar, (1988), Nelson and Sommers, (1982), and Bremner, (1965) respectively. Phosphate was analysed using the method of Bray and Kurtz, (1945) as modified by Juo (1979) while soil particle size was determined according to the method of Bouyocous, (1962).

Quality control was assured through three replicate samples, use of reagents of pure analytical grade, reagent blanks and standard reference materials.

Analysis of Heavy Metals: The digested samples were analysed for the metals using atomic absorption spectrophotometer (Perkin Elmer Model A Analyst 2002) fitted with deuterium lamp for background correction.

RESULTS AND DISCUSSION

Soil physicochemical properties: Table 1 presents the results of the physicochemical properties of the soil samples

Table 1: Physicochemical properties of the soil samples

Sample site	Depth (cm)	pH	E.C (μs/cm)	TOC%	TON%	PO^{2-}_4 (mgkg^{-1})	Soil Particle size (%) Clay	Silt	Sand
	0-15	5.70	7.91	2.08	0.141	10.5	3.5	1.1	95.4
	14-30	5.50	5.15	1.09	0.081	63.35	5.3	0.7	ɫ.0
	30-45	5.30	3.65	0.99	0.064	1.93	11.6	0.4	88.0
B	0-15	5.70	6.74	2.05	0.131	3.90	5.0	2.6	92.4
	15-30	5.50	5.45	1.14	0.087	3.19	8.0	1.6	90.4
	30-45	4.90	3.84	0.61	0.043	2.20	11.0	1.0	88.0
C	0-15	5.80	13.07	1.69	0.131	17.5	5.0	2.1	92.9
	15-30	5.70	6.35	1.06	0.089	9.18	5.5	1.6	92.9
	30-45	5.50	5.37	0.82	0.061	3.51	8.0	1.1	90.9
D	0-15	5.51	5.51	1.47	0.124	6.54	5.0	2.1	92.9
	15-30	3.79	3.79	0.93	0.071	4.10	5.5	1.6	92.9
	30-45	3.54	3.54	0.64	0.042	2.15	8.0	1.1	90.9
E	0-15	4.90	7.31	1.47	0.123	4.62	6.0	3.1	90.9
	15-30	4.80	6.51	1.01	0.086	2.74	7.0	3.1	89.9
	30-45	4.70	4.91	0.88	0.051	2.07	9.0	2.6	88.4
Mean±SD		5.15±0.48	5.94±1.32	1.20±0.13	0.09±0.006	6.41±1.131	8.20±2.25	1.65±0.730	90.9±88.4
Control Mean		5.40	4.89	1.118	0.123	3.40	7.48	1.30	91.67

Key:

A = Agbor
B = Asaba
C = Isele-Ukwu
D = Okpanam
E = Onicha -Ugbo

Soil pH: The pH values of the soil samples in all the sites ranged from 4.20 to 5.80 with mean value of 5.15 ± 0.48. This shows that the soils were moderately acidic. The values decreased with depth indicating that the acidity of the soils increased with depth. The pH values obtained in this study are in the same range with the values reported by Osakwe (2013), Osakwe (2014) Egbeda et al., (2015) but lower than those reported by Chaudhari (2013), Matthews-Amune and Kakulu (2013), Idugboe et al., (2014). Soil pH and other soil properties are especially important in soil processes responsible for solubility of heavy metals in soil and their transportation (Matthews – Amune and Kakukulu, 2012). At high pH, metals tend to form metal mineral phosphates and carbonates which are insoluble while at low pH they tend to be found as free ionic species or as soluble organometals and are more bioavailable (Rensing and Maier, 2003; Hoffman, 2007; Egbeda et al., 2015). Since at low pH (acidic) metals are more soluble and more bioavailable in the soil solution, the range of pH values obtained in this study will favour plant uptake of heavy metal and hence toxicity problems are possible.

Total organic carbon **(TOC):** The total organic carbon in the soil samples from all the sites ranged from (%) 0.61 to 2.08 with mean value of 1.20 ± 0.13%. The values obtained in this study are almost in the same range with those reported by Oviasogie and Omoruyi,(2007). These levels are however, by far lower than those reported by Tukura et al., (2007); Osenwota, (2009), Chaudhari, (2013) but higher than the values reported by Idugbose et al., (2014). According to Yun (2003), total organic carbon is a measure of organic content in soil and contributes significantly to the acidity of soil through organic acids and biological activities through the complexion of metals (Zoumis et al 2001). Nelson and Sommer observed that high total organic carbon content entails larger adsorption surfaces and more metals are adsorbed to organic material. Total organic carbon content obtained in this study may be attributed to vehicular discharge on the high way.

*Total Nitrogen***:** Total Nitrogen (TN) ranged from (%) 0.042 to 0.14 with mean value of 0.09 ± 0.80%. Similar range of values has been reported (Osakwe, 2009). Nitrogen can be introduced into the soils by natural processes such as lightening, decay of plant tissues (Eddy et al, 2006).

Phosphate: Phosphate values varied from (mgkg^{-1}) 1.93 to 17.54 with mean value of 6.41 ± 1.13. The values recorded in this study are higher than those reported by Iwegbue et al., (2006), Chaudhare (2013). Cassava tuber is a rich source of phosphorus (Jung et al, 2002), therefore the level of phosphate recorded in this study could be attributed to some decayed cassava tubers in the farmlands. According to Isirimah et al., 2003, phosphorus is essential for the seeds and development of fibrous root system in plants.

Electrical conductivity (EC): The electrical conductivity (EC) of the soil samples from al the sites ranged from (µScm^{-1}) 3.54 to 13.07 with mean value of 5.94 $\pm$ 1.32. The range of values obtained in this study is higher than that reported by Chaudhari et al., (2013), Egbenda et al., (2015) but lower than the values reported by Obasi et al., (2012), Badejo et al., (2013), Idugboe et al., (2014). These values indicate significant presence of trace metal ions or ionisable materials in the soil (Fuller et al., 1995, Egbenda et al., 2015).

Particle Size: For particle size distribution, sand size fraction was highest, followed by clay and then silt. These proportions show that the soils were coarse and as such have low supply of nutrients and moisture unlike fine textured soils that have sufficient water holding capacity, good aeration and high supply of nutrients (Wilde et al., 1972). The soils have low sorption capacity for ions due to their sandy texture.

*Heavy Metals: Soil Samples***;** The concentrations of heavy metals in soils from all the sites are shown on Table 2.

Table 2: Concentration of heavy metals in all the sites (mgkg^{-1})

Sample site	Depth (cm)	Fe	Zn	Cr	Ni	Pb
A	0-15	204.12	104.4	14.25	58.23	14.85
	15-30	170.24	67.30	10.54	38.42	12.14
	30-45	95.46	40.28	7.10	24.58	6.82
B	0-15	109.64	93.52	18.62	49.42	17.13
	15-30	138.23	58.21	13.10	25.62	13.74
	30-45	62.32	38.04	8.64	17.81	9.46
C	0-15	184.72	105.78	28.52	18.62	18.21
	15-30	146.81	56.12	16.48	13.42	14.43
	30-45	103.42	39.24	12.23	8.56	10.64
D	0-15	166.23	55.29	19.26	15.82	15.83
	15-30	146.22	42.45	15.47	9.62	10.56
	30-45	99.24	30.34	11.67	6.92	6.84
E	0-15	204.32	75.73	17.28	41.24	26.67
	15-30	173.68	51.87	12.24	30.23	19.42
	30-45	139.29	31.47	8.58	16.24	7.681
Mean+SD		142.93$\pm$42.16	59.34$\pm$25.21	14.27$\pm$5.39	24.98$\pm$15.57	13.63$\pm$5.41
Control Mean		37.87	8.72	0.88	0.28	0.103

All the metals studied were detected in all the sites. Generally the concentrations of the metals were highest at the top soils. This is expected since the top soil is the point of contact. The metal levels in all the sites were significantly higher than the levels observed in the control sites.

Iron has the highest mean concentration among all the metals studied and its levels ranged from (mgkg^{-1}) 62.32 to 204.32 with mean value of 142.93 $\pm$ 42.16. High concentrations of iron in soils relative to other metals have been reported in various studies, confirming that natural soils contain significant levels of iron (Dara, 1993; Ademoroti, 1996; Aluko and Oluwande, 2003). The mean value of iron obtained in this study is lower than those reported by Osakwe, (2010); Nwachukwu et al., (2011); Idugboe et al., (2014), but higher than the values reported by Okorie and Egila (2012), Suleman, (2014).

Zinc concentrations (mgkg^{-1}) vary from 30.34 to 105.78 with mean value of 59.34 $\pm$ 25.21. Similar range of values was reported by Iwegbue et al., (2013). The range of values obtained in this study is lower than those reported by Zakir et al., (2014), Ojo et al., (2015); but higher than the levels reported by Nwachukwu et al., (2013), Ubwa et al., (2013). Zinc is also the second most abundant metal obtained in this study. This high level of zinc in roadside soil could be attributed to the wear and tear of vehicle bodies with galvanized steel surfaces (Zakir et al, 2014). Zinc is used in brake linings of vehicles because of its heat conducting properties and can be released during mechanical abrasion of vehicles and from combustion of engine oil and also from vehicle tyres (El-Gamal, 2000, Akbar et al., 2006; Manno et al., 2006, Matthews – Amune and Kakulu 2013). Elik, (2003) reported that high concentration of Zinc in heavy traffic zones indicate that fragmentation of car tyres is a likely sources of the metal. Other possible sources of zinc in relation to automobile traffic in addition to wearing of brake lining are losses of oil and cooling liquid of vehicles and wearing of road paved surface (Saeedi et al., 2009). The amount of zinc recorded at Issele-Ukwu was the highest probably because of the access road leading to many Aniocha towns and many vehicles move to and fro from the towns to the expressway.

Chromium concentrations ranged from (mgkg^{-1}) 8.52 to 28.52 with a mean value of 14.27 $\pm$ 5.39. These values are higher than those reported by Okoye and Egila (2012); Iwegbue et al., (2013); Ubwa et al., (2013), Idugbose et al., (2014); but lower than the values reported by Ferronato et al., (2013); Zakir et al., (2014). According to Al-Rhashman (2007), chromium level in road side soil is associated with the chromic plating of some vehicle parts used for preservation of corrosion. Chromium is carcinogenic resulting in cancer of respiratory organs in workers exposed to chromium containing dust (Langard, 1980).

Lead levels in all the sites were in the range of ($mgkg^{-1}$) 6.82 to 26.67 with mean value of 13.63 $\pm$ 5.41. Similar range of values for lead has been reported (Zakir, et al., 2014; Das et al; 2015). However the lead levels observed in this study are significantly higher than those reported by Matthews-Amune (2013), Ubwa et al., (2013) and lower than those of other similar studies (Nwachukwu et al., 2011; Najib et al., 2012; Pam et al., 2013). The concentration of lead in the soil is likely to have derived from vehicle exhaust fumes containing some lead-rich aerosols. (Zakir et al., 2014). Studies have shown that the use of tetraethyl lead as an antiknocking agent in gasoline gives rise to its release during emissions from automobiles and fossil fuel combustion (Oztas and Ata, 2002, Akbar et al., 2006, Onder et al., 2007, Sharma and Parasade, 2010). Sherene (2010) reported that major sources of lead pollution are exhaust gases of petrol engines, which account for nearly 80% of the total lead in the air. Kakulu, (2003) also reported that lead content of leaded gasoline in Nigeria ranges from 0.60 to 0.80g/l. In addition, lead levels in roadside can also be attributed to wearing down of vehicle breaklinings and tyres (Sharma and Prasade 2010, Zhang et al., 2012), Soerme and Langerkvsith, 2002). Elevated levels of lead constitute serious health risk. Purefoy, (2010) reported several deaths in a village in Zamfara State, Nigeria as a result of lead poisoning. Sometime this year similar situation occurred in the same State claiming the life of about twenty eight children resulting from lead poisoning.

The concentrations of nickel in the soils from all the sites ranged from ($mgkg^{-1}$) 6.92 to 58.23 with a mean value of 24.98 $\pm$ 15.57. The mean value of nickel obtained in this study is consistent with the values reported by Najeb et al., (2012), Ogundiran and Osibanjo, (2009);, Oguntimehin and Ipinmoroti, 2007), Nwachukwu et al., 2013). The mean level of nickel obtained in this study is however higher than that reported by Pam, et al., (2013); Matthews – Amune and Kakulu, 2013; Ubwa et al, (2013). Airborne particles emitted by brakes and wears from vehicle tyres can contain considerable amounts of nickel (Onder et al., 2007). This is a probable source of nickel in the recorded soils. Anthropogenic imput of nickel in the study areas could also be from the diesel used in the automobiles (Iwegbue, 2013). Exposure to intake of large amount of nickel from plants, grown on nickel rich soil leads to higher chances of developing cancer of the lungs, nose, larynx and prostrate as well as respiratory failures, birth defects and heart disorders (Duda-Chodale and Blaszezyk, 2008; Lentech, 2009).

Cassava Samples: All the metals studied. were detected in the cassava leaves except nickel, and also cassava tubers except nickel and lead. Plants are known to take up and accumulate metals from contaminated soils (Kasheem and Abdul Singh, 1999), hence their detection in the cassava tubers and leaves is not surprising.

The mean concentrations of heavy metals in cassava leaves and tubers from all the sites are presented on Tables 3 and 4 respectively.

Table 3: The mean concentrations of Fe, Zn, Cr, Pb and Ni in cassava leaves. ($mgkg^{-1}$)

Sample Site	Fe	Zn	Cr	Pb	Ni
A	13.93	1.88	0.81	ND	ND
B	12.73	0.91	0.24	ND	ND
C	6.58	0.86	0.49	ND	ND
D	8.63	1.26	0.33	ND	ND
E	6.24	0.84	1.79	ND	ND
Control Mean	5.20	0.74	0.26	ND	ND

Table 4: The mean concentrations of the metals in cassava tubers (mg/kg^{-1})

Sample site	Fe	Zn	Cr	Pb	Ni
A	16.49	2.93	1.46	1.67	ND
B	21.96	4.92	4.23	5.57	ND
C	22.39	4.70	5.36	4.27	ND
D	21.53	3.19	5.55	2.19	ND
E	26.15	5.02	9.10	3.59	ND
Mean$\pm$SD	21.70$\pm$3.45	4.15$\pm$1.01	5.12$\pm$2.75	3.46$\pm$1.58	ND
Control Mean	15.18	3.20	2.89	1.93	ND

The mean values of all the metals obtained in this study in the cassava leaves and tubers are significantly higher than the mean values recorded in the control samples indicating some heavy metal enrichments on the vegetation as a result of traffic activities. Nickel and lead were similarly not detected by Akaniwor et al, (2005) in raw and processed Nigerian staple foods from oil producing areas of Rivers and Bayelsa States of Nigeria.

The mean values observed in the leaves and tubers respectively were ($mgkg^{-1}$) 21.70 $\pm$ 3.45 and 9.62 $\pm$ 3.53 for Fe, 4.15 $\pm$ 1.01 and 1.15 $\pm$ 0.44 for Zn, 5.12 $\pm$ 2.75 and 0.37 $\pm$ 0.63 for Cr, 3.46 $\pm$ 1.58 for Pb only in leaves. The general trend is that the metal levels were higher in the leaf samples than in the tuber samples. Similar observation has been reported (Ano et al, 2007, Nabulo, 2006, Osakwe, 2009). The concentrations of all the metals obtained are higher than those reported for cassava plants grown around some oil flaring zones by Osaobhien and Otuya (2006), and for stem bark of Moringa olei fera lam, by Gupta et al., (2014) but lower than those reported by Osakwe, (2009) on cassava plants grown along Warri – Abraka expressway and also the values reported by Abidemi (2013) in vegetation from an industrial area. The higher levels of these metals in leaves than in tubers could be attributed to the fact that leaves in addition to the metals translocated from the soils also have aerial foliage enrichment or folier absorption from the surrounding air. There could also be some loss of metals from the soil through leaching. It is worthy to note that the levels of heavy metals obtained in the cassava plants are below FAO/WHO guidelines for metals in food and vegetables. (FAO/WHO 1976). The FAO/WHO guidelines for metals in foods and vegetables are shown on table 5.

Table 5: FAO/WHO guidelines for metals in foods and vegetation

Metals (mgkg)	FAO/WHO	NAFDAC	EC/CODEX	NORMAL RANGE IN PLANT
Cd	1	-	0.2	<4
Cu	30	20	0.3	2.5
Pb	2	2	0.3	0.50-30
Zn	60	50	<50	20-100
Fe	48	-	-	400-500
Ni	-	-	-	0.20-50

Source: FAO/WHO, (1976)

Green plants use iron for energy transformation processes so its deficiency in plants leads to growth problems (Lenntech, 2012). Lead is highly hazardous for plants, animals and microorganisms (Suleiman, 2014).

*Plant Concentration Factor (PCF)***:** Studies have shown that plants grown on heavy metal polluted soils possess enhanced metal concentration (Grant and Dobbs, 1977) and the uptake of metal ions has been shown to be influenced by the metal species and plant parts (Juste and Mench, 1992). Based on this, plant concentration factor (PCF) was computed using the following equation (Liang et al., 2011).

$$PCF = \frac{Cplant}{Csoil}$$

Where Cplant = metal concentrations in plant
Csoil = metal concentrations in soils

The values indicate the levels of metals in the edible parts of the plant as a fraction of the total metal concentration in the soil and this soil-to-plant factor is one of the key components of human exposure to metals through the food chain. The values obtained for the metals in all the sites are presented on table 6.

Table 6: Plant concentration factor (PCF) of the heavy metals in the cassava samples.

Site	Fe	Zn	Cr	Ni	Pb
A	0.194	0.068	0.213	0.000	0.148
B	0.334	0.092	0.332	0.000	0.414
C	0.199	0.083	0.307	0.000	0.296
D	0.219	0.104	0.373	0.000	0.198
E	0.188	0.110	0.857	0.000	0.200

The plant concentration factor which is also called plant transfer ratio values obtained in this study are almost in the some range with those reported by Osakwe, (2009); Liang et al; 2011) Opaluwa et al., (2012). For all the sites, the soil plant transfer values were in the order Cr > Pb > Fe > Zn> Ni. This shows that among all the metals studied chromium is easiest to migrate. This trend signifies that plant absorbs a higher concentration of Cr from the soil compared to other metals while Ni is the least absorbed. Abedemi, (2013) similarly reported that Cr had highest value of plant transfer ratio among all the metals in his study and also more easily available for plant uptake. Soil electrolyte plays an important role in the process of heavy metal transfer, and influences transformation ability of heavy metals. The range of values recorded in this study indicates that all the metals fall into the category of elements showing medium accumulation (0.01-1.0) except for Ni which fell into the category of elements lacking accumulation Kabata Pendias and Pendias (1992).

Conclusion **:** The results obtained from the physicochemical analysis of the soil samples revealed that the roadside soils were moderately acidic and contained significant amounts of organic matters and some ionisable inorganic substances. The heavy metal analysis confirms heavy metal enrichment in the soils and cassava plants as a result of automobile exhaust emissions along the expressway. Although the plant concentration factor values indicate medium accumulation for the cassava food crops, further exposure of the farmlands to the traffic emission for a very long time may result to a high level of pollution of the soils and food crops which will eventually constitute serious health risks to humans. To minimise such health risks, farmlands should be located far away from busy expressways.

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