Assessment of the Heavy Metal Contamination of Roadside Soils and Plants Alongside Alulu-Ugwogo Nike Road, Enugu State

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ABSTRACT

A study to investigate the levels of heavy metal pollution in soil and plants (*carpet grass*) along Alulu-Ugwogo Nike road in Enugu State of Nigeria was carried out. Five sampling points were chosen at random. A total of Fifteen soil samples were taken at the depth of 30cm from the road at each sampling location. Heavy metals such as Copper(Cu), Zinc(Zn), Chromium(Cr), Lead (Pb) and Cadmium(Cd) were analyzed. Soil pH, soil permeability, soil texture, electrical conductivity, bulk density, particle density and porosity were also determined. Results showed that the physicochemical properties of the soil had a pH range between (5.93±7.57), electrical conductivity (24.67±315.67 µscm^{-1}), permeability (2.83±10.17 cm/s), bulk density (1.23±1.47 cm/kg), particle density (2.20±3.33 cm/kg), porosity (39.30±55.63%), sand (82.33±94.00%), silt (2.00±5.33%), clay (2.00±14.00%), while heavy metals concentration in the soil are Pb (576.67±1851.67 mg.kg^{-1}), Cu (318.33±924.33 mg.kg^{-1}) Cr (208.33±1171.61 mg.kg^{-1}), Zn (260. 00±645 mg.kg^{-1}) and Cd (56.67±716.67 mg.kg^{-1}). Plants showed higher values of heavy metal contamination than the standard set by WHO, 1996. Values in the plants were in the range of Pb (20.00 ±291.67 mg.kg^{-1}), Cu (60.00±486.67 mg.kg^{-1}) and Cr (12.50±376.67 mg.kg^{-1}), Zn (30.00±390.67 mg.kg^{-1}) and Cd (30.00±148.33 mg.kg^{-1}). These values showed high contamination from one sampling point to another, suggesting the need for farmers to plant far away from roadsides. Therefore, economic hyperaccumulating plant should not be planted along the roadside of major roads to avoid heavy metal contamination.

Keywords: soil pollution, heavy metals, plant, contamination factor and automobile emissions.,

Introduction

Soil pollution, on account of heavy metals, has turned out to be a serious problem in developing countries due to the increasing number of pollution sources (Ahmad *et al.*, 2019). The anthropogenic sources include industrial and automobile emissions (UNEP/GPA, 2004). Based on the above, roadside soil, street dust, and plants can be exposed to significant levels of metals, owing to both vehicle emissions which carries harmful chemicals (Christoforidis and Stamatis., 2009; Burt *et al.*, 2013; Altaf *et al.*, 2021). The burning of fossil fuels, vehicle wear (tires, body and brakes) and vehicular fluids all contribute to increased metal levels in the environment (Sutherland *et al.*, 2000). It has been observed that roadside soil is highly contaminated with various heavy metals, namely Ni, Cd, Zn, Cu and Pb (Christoforidis and Stamatis., 2009; Burt *et al.*, 2013; Kaur *et al.*, 2021). Many studies found that human activities are the primary source of metal contamination in different environmental samples, such as soil, dust, sediments and plants. Thus, the study of heavy metal pollution in soils is the need of the hour. Many studies have been conducted to explore the spatial distribution of heavy metal pollution in roadside soils (Burges *et al.*, 2015; Cai *et al.*, 2019; Wang *et al.*, 2018; Zhang *et al.*, 2020; Filimon *et al.*, 2021; Gao *et al.*, 202; Tian *et al.*, 2021 and Zhao *et al.*, 2021).

There are reports of heavy metal accumulation by plants grown on roadsides in the developed countries, however, few studies have actually been carried out on this area in developing countries (Fakayode and Olu-Owolabi, 2003; Singh *et al.*, 2004; Chen *et al.*, 2005; Liu *et al.*, 2005; Wilson and Pyatt, 2007; Atayese *et al.*, 2009).

This study attempts to determine the accumulation of heavy metals in the studied plants and topsoil along some high vehicular traffic roads in Nigeria using Alulu-Ugwogo, Nike of Enugu State as a case study. It is expected that the findings obtained from this study will widen our knowledge on the danger of heavy metal pollution in our environment by providing information on its spread and to expose peasant rural farmers on the dangers of roadside farming which is a common practice.

2 MATERIALS AND METHODS

2.1 Site Description

The study area covers the road that leads to Nsukka from Enugu to Ugwogo Nike(Figure 1). It started from Alulu, which is situated in Abakpa Nike at latitude $6^{0}48^{1}94.72^{11}$N and longitude $7^{0}51^{1}71.59^{11}$W, while Ugwogo Nike is located at latitude $6^{0}46^{1}56.0^{11}$N and longitude $7^{0}25^{1}59.48^{11}$E all in Enugu, Enugu State. The activities around the Alulu–Ugwogo Nike road includes buying and selling, farming, etc, with transportation as the major activity along the road.

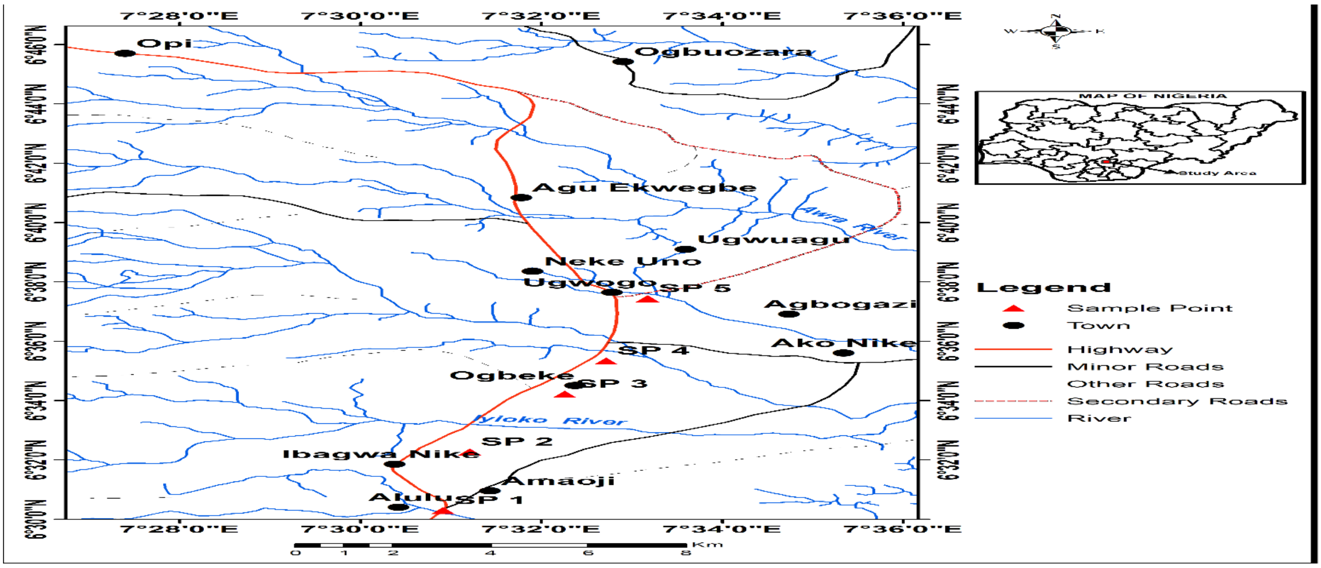

Figure 1: A map showing the sampling locations from Alulu to Ugwogo Nike.

2.2 Research Design and Sample Collection.

This research was conducted using the Completely Randomized Design(CRD). The soil samples were collected randomly along the Alulu – Ugwogo, Nike road at five (5) different locations. Topsoil samples were collected using soil auger. A total of Fifteen (15) soil samples were collected from five (5) different locations. Three (3) soil samples were collected from each location at a depth of 0-20cm and each of the soil sample was collected every 5meters up to 15meters away from the road. All samples were transported to the laboratory where analytical procedure commenced instantly. Fifteen (15) Plant samples (*carpet grass*) were collected from the five (5) locations, three (3) from each location. Geographical information of the sample locations was collected using a GPS. The soil samples were collected in April, 2022.

2.3 Labouratory Analysis

2.3.1 Heavy Metal Analysis

The soil and plant samples were taken to the laboratory for routine and heavy metal analysis. The soil was spread on a clean plastic sheet and air dried in open air in the laboratory under room temperature of within 23-27^{0}C for 24 hours. Afterwards the soil was sieved on a 2mm sieve and 5gram of sample was taken from the sieved soil and put in a beaker, 10ml of nitric /perchloric acid 2:1 was added to the samples. These samples were digested at 105^{O}C. Next, HCl and distilled water of a ratio of 1:1 was added to the digested samples and the mixture was transferred to the digester again for 30minutes. The digestate were then removed from the digester and allowed to cool to room temperature of 25^{O}C. The cool digestate was washed into a standard volumetric flask and was made up to the mark with distilled water. Heavy metal concentration was determined in the standard way using Atomic Adsorption Spectrophotometer (AAS Model 210 VGP). The pH was determined by an electronic Jenway glass electrode pH meter (Model 3510). Particle size was determined by the hydrometer method using sodium hexametaphosphate as the dispersant (Bouyoucous, 1962).

2.3.2 Determination of Soil Electrical Conductivity (EC)

5.0 grams of each soil sample was added to 50ml of distilled water. The lump of the soil was stirred to form homogenous slurry, then EC meter (Jenway 4010 Model) probes was immersed into the sample and allowed to stabilize at 25^{0}C and EC recorded.

2.3.3 Soil Bulk Density

Soil bulk density is given as the ratio of mass of the soil to the volume of soil particles and the pore spaces occupied. Soil bulk density is essential in quantitative analysis of soil and indicates the quality of soil structural conditions. Soil particles size distribution; bulk density and porosity are some of the factors that affect the bulk density of soil (Wherrett, 2018).

200g of oven dried soil was poured into a measuring cylinder; the resulting volume of the soil was recorded. The soil bulk density was then calculated using Eqn. 1. The experiment was repeated three times with an error range of ±0.05 g/cm^3.

$$\text{Bulk density} = \frac{Mass\ of\ soil\ (M)}{Volume\ of\ soil\ (V)} \qquad \text{Equation 1.}$$

Where, M = the mass of dried soil (g), and
V = the volume of the soil (cm^3)

2.3.4 Determination of Soil Porosity

The portion of the soil volume occupied by pore spaces was calculated as a percentage of the ratio between bulk density and particle density of the soil: i.e.

$$\%Porosity = {}^{Bulk\ density}\!\Big/_{particle\ density\ (g/cm^3)} \times 100/1 \qquad Equation\ 2$$

2.3.5 Determination of Soil Particle Density (Textural Class)

It was carried out by Bouyoucous hydrometer method as modified by Pansu and Gautheyrou (2006). The soil samples were dispersed with solution of sodium hexametaphosphate – $Na_2O_{18}P_{16}$ (Calgon 44g/l) and sodium Carbonate – Na_2Co_3 (8g/l). pH of the solution was maintained at about 8.3. The textural class was determined using textural triangle diagram.

2.3.6 Soil Permeability

Permeability can be determined in the laboratory in two standard methods. These methods are constant head and falling head. The falling head permeability test is commonly used for laboratory measurements because of the wide range of soil particles that this method can measure (Akhtar *et al.*, 2014). In this study, falling head permeability test was used to measure the soil permeability following procedure adopted from Das, (2002). 200g of dry soil was used for this experiment. The setup has a column of 5 cm with internal diameter of 5 cm and height of 17.5 cm. The top and bottom of the column were fitted with a wire gauge to ensure proper filtration and to prevent washing out of the soil particles. It was secured to a tripod stand by means of a clamp for support. Water was then discharged at regulated manner and timed. The drain out was recorded and the coefficient of permeability (K) was determined using Eqn.3.

$$K = \frac{a}{A}\,\frac{L}{\Delta t}\; In\left(\frac{h_1}{h_2}\right) \qquad \text{Equation 3.}$$

Where, K = permeability(cm/s)

a = cross-sectional area of the inlet water valve (cm^2)
A = cross-sectional area of specimen (cm^2)
L = height of specimen (cm) and
Δt = time (s) needed for the total head to drop from clearly marked graduations h_1 to h_2 h_1= height of water at initial time t_1 h_2 = height of water at time t_2.

2.4 Transfer Factor Determination

The transfer coefficient was calculated by dividing the concentration of heavy metals in plant by the total heavy metals concentration in the soil.

$TF = C_{plant} / C_{soil}$

where, C_{plant} = metal concentration in plant tissue, mg/kg fresh weight and

C_{soil} = metal concentration in soil, mg/kg dry weight.

The metal concentrations in the extracts of the soils and plants were calculated on the basis of dry weight. If the ratios >1, the plants have accumulated elements, the ratios around 1 indicate that the plants are not influenced by the elements, and ratios <1 show that plants exclude the elements from the uptake Olowoyo *et al.*, 2010. If the plants have higher TF values, they can be used for phytoremediation.

2.5 Statistical Analysis

The results were analyzed using the GenStat statistical package. Multivariate analysis (ANOVA) was used to determine differences between treatment means and was separated using the Duncans new multiple range test (DNMRT) at 5% level of significance ($P < 0.05$). Correlation to predict the association between heavy metals concentration in the soil and plant at the study areas was also determined.

RESULT AND DISCUSSION

3 Characterization of soil and plants

3.1 Physicochemical properties of soil

Table 1 shows some physicochemical properties of soil sites from five locations along Alulu – Ugwogo Nike road. Significant differences($P<0.05$) were observed in electrical conductivity, permeability, bulk density, particle density and porosity. No Significant difference was recorded in pH of the five locations (table 1). The soil pH is acidic and similar result have been reported by Abii and Nwosu, (2009). Electrical conductivity was similarly highest ($P<0.05$) in Alulu, Ibagwa and Ogbeke 1. The Electrical

conductivity of all the sample locations is high, this corroborates with the work of (Tanee and Albert, 2013). Permeability was significantly highest ($P<0.05$) in Ogbeke 1 and least ($P<0.05$) in Ugwogo. Bulk density reversely was significantly highest ($P<0.05$) in Ogbeke 2 followed by Ibagwa, Ogbeke 1 and Ugwogo, but least in Alulu. For porosity, Ogbeke 1 was more porous($P<0.05$) followed by Ibagwa, Ogbeke 2 and Ugwogo, whereas the Alulu soil site recorded the least ($P<0.05$) porosity.
Soil texture is as presented in Table 1, it shows the soil texture of soil sites from five locations along Alulu Ugwogo road. Highest Significant differences($P<0.05$) was observed in Alulu for sand percentage fraction, followed by Ogbeke 2 and Ugwogo with the same level of significance($P<0.05$) and then Ibagwa with the least percentage sand fraction. Percentage silt was significantly highest ($P<0.05$) in the two locations Ibagwa and Ugwogo and least in Ogbeke 2. Percentage clay was most significant ($P<0.05$) in Ogbeke 1 followed by Ibagwa and least ($P<0.05$) in Alulu and Ogbeke 2. This result shows that all the soil locations are more percentage of sand than clay or silt fractions.

Heavy metal content of soils is as presented in table 1. The content of Pb in the soils of Alulu, Ogbeke 2 and Ugwogo had the same and highest level of significance ($P<0.05$) followed by Ogbeke 1 and the least at Ibagwa. Pb content in all the roadside soil was observed to be above 530mg/kg (WHO, 1996). The high level of Pb might be from the depositions from automobile exhaust since most petroleum fuel contains tetraethyl Lead as antiknock (Leentech Water Treatment and Air Purification, 2004). Cr content of the soils at Ibagwa had the highest level of significance ($P<0.05$) followed by Alulu, Ogbeke 2, Ugwogo and Ogbeke 1 which showed the least level of significance. The source of Chromium in roadside soil is believed to be due to corrosion of vehicular parts (Lu *et al.*, 2009). The content of Cd in the soil of Alulu, had the highest level of significance ($P<0.05$) followed by Ibagwa, Ogbeke 2 and Ugwogo with same level of significance while the least is at Ogbeke 1. The likely source of Cd in these locations includes: automobile fuel metal plating, lubricating oils, old tyres that are frequently used and the rough surfaces of the road which increases the wearing of tyres (Oghuvwu, 2014). Table 2 showed that the values of Pb, Cd and Cu were above the target and permissible limit by WHO, 1996. Cr value at Alulu, Ibagwa and Ugwogo were above the target and permissible limits while Cr values at Ogbeke 1 and Ogbeke 2 were not above the permissible limit in the soil.

The concentration of Cd, Cr, Zn, Cu and Pb in soil samples at the study area agrees to the contamination of the site which may be attributed to high level of traffic and vehicular emission Alulu-Ugwogo nike road. This result corroborates with the result of Ogundele *et al*., (2015). The result of the soil contents of Cu, Pb, Zn and Cd in this work is very high when compared to that of (Tanee and Albert,2013).

Table 1: Physicochemical properties

PARAMETERS	LOCATION					SEM
	Alulu	Ibagwa	Ogbeke 1	Ogbeke 2	Ugwuogo	
pH.	6.70	5.93	6.87	6.43	7.57	0.28
Electrical conductivity (µscm^{-1})	228.20^{a}	260.79^{a}	315.67^{a}	79.73^{b}	24.67^{b}	23.13
Permeability(cm/s)	10.17^{b}	8.33^{b}	18.33^{a}	9.33^{b}	2.83^{c}	1.07
Bulk density(cm/kg)	1.37^{abc}	1.27^{bc}	1.23^{c}	1.40^{ab}	1.47^{a}	0.03
Particle density(cm/kg)	2.20^{b}	2.47^{ab}	3.20^{ab}	3.33^{a}	2.57^{ab}	0.16
Porosity(%)	39.30^{b}	49.97^{ab}	55.63^{a}	50.97^{ab}	43.63^{ab}	2.17
Sand(%)	94.00^{a}	83.67^{b}	82.33^{b}	90.00^{ab}	89.67^{ab}	1.51
Silt(%)	3.67^{ab}	5.33^{a}	3.67^{ab}	2.00^{b}	4.33^{a}	0.35
Clay(%)	4.00^{c}	11.00^{ab}	14.00^{a}	2.00^{c}	6.67^{bc}	1.12
Pb(mg.kg^{-1})	1851.67^{a}	1108.33^{ab}	576.67^{b}	1796.67^{a}	1706.67^{a}	153.53
Cu(mg.kg^{-1})	643.33	924.33	318.33	766.67	826.67	87.72
Cr(mg.kg^{-1})	605.00^{b}	1171.67^{a}	208.33^{b}	248.33^{b}	416.67^{b}	94.46
Zn(mg.kg^{-1})	645.00	355.00	350.00	260.00	297.50	75.09
Cd(mg.kg^{-1})	716.67^{a}	340.00^{ab}	56.67^{b}	172.50^{ab}	405.00^{ab}	88.37

^{abc} **Means along the rows with different superscripts differ significantly at $P<0.05$; SEM- Standard Error of the Mean.**

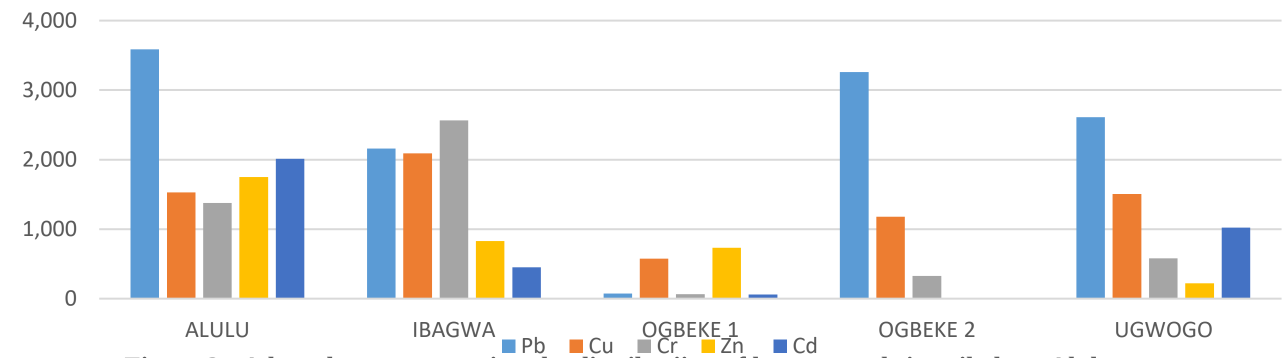

Figure 2: A bar chart representing the distributiion of heavy metals in soil along Alulu-Ugwogo road.

Figure 2 below shows that Alulu had the highest of Pb, Cr, Zn and Cd when compared to other sampling points while Ibagwa had highest concentration of Cu when compared to other sampling locations. Ogbeke 1 had the least in all the heavy metals in the soil along the road.

3.1.4 Heavy Metals in Plant

Heavy metal content in plant is as presented in table 4. The content of Pb in the plant at Ibagwa had the highest level of significance ($P<0.05$) followed by Alulu and Ugwogo while Ogbeke 2 had the least level of significance ($P<0.05$). Ibagwa had the highest level of significance ($P<0.05$) for Cu followed by Alulu, Ogbeke 2, Ugwogo and Ogbeke 1 which showed the least and same level of significance ($P<0.05$). The content of Cr in the plant of Ogbeke 1, had the highest level of significance ($P<0.05$) followed by Alulu, Ibagwa, Ogbeke 2 and Ugwogo with same and least level of significance ($P<0.05$). while the least is at Ogbeke 1. Table 2 showed that the values of heavy metals (Pb, Cu, Cr and Cd) in plants were high when compared to that permissible limit by WHO, 1996.

Table 2: Heavy Metals in Plant

Parameters	LOCATION					SEM
	ALULU	IBAGWA	OGBEKE 1	OGBEKE 2	UGWUOGO	
Pb($mg.kg^{-1}$)	226.67^{ab}	291.67^{a}	113.33^{bc}	20.00^{c}	240.00^{ab}	28.60
Cu($mg.kg^{-1}$)	213.33^{b}	486.67^{a}	220.00^{b}	106.67^{b}	60.00^{b}	39.25
Cr($mg.kg^{-1}$)	65.00^{b}	376.67^{a}	51.67^{b}	12.50^{b}	32.50^{b}	37.12
Zn($mg.kg^{-1}$)	52.50^{b}	115.00^{b}	397.50^{a}	30.00^{b}	52.50^{b}	42.70
Cd($mg.kg^{-1}$)	148.33	35.00	35.00	40.00	30.00	23.94

^{abc} Means along the rows with different superscripts differ significantly at $P<0.05$; SEM- Standard Error of the Mean

Table 3: Permissible limits of heavy metals in soil and plants.

Metal	Target value of soil ($mg.kg^{-1}$)	Intervention value($mg.kg^{-1}$)	Permissible value of soil ($mg.kg^{-1}$)
Cd	**0.80**	**12**	**0.02**
Cr	**100**	**360**	**1.3**
Cu	**36**	**190**	**10**
Pb	**85**	**530**	**2**
Ni	**35**	**200**	**10**

Source: WHO (1996).

3.2 Correlation Between Heavy Metals in the Soil and Plants at different locations

3.2.1 Correlation Between Heavy Metals in the Soil and Plants at Alulu

Table 3 shows the correlation between heavy metal concentration in soil and plant at Alulu. The result showed a very high significant positive correlation coefficient for all the heavy metals in the soil against the following heavy metals; Pb, Cu, Cr, Cd and Zn present in the plant. The positive correlation suggests that an increase in the heavy metal concentration in the soil was associated with a corresponding increase in the heavy metal concentration in the plant.

Table 4: Correlation for Alulu

Parameters	Heavy Metal in Soil and Plants($mg.kg^{-1}$)				
	Pb	Cu	Cr	Zn	Cd
Pb	0.996**	0.988**	0.895**	1.000**	0.980**
Cu	0.912**	0.984**	0.702*	1.000**	0.991**
Cr	0.990**	0.995**	0.871**	1.000**	0.989**
Zn	0.958**	0.999**	0.790*	1.000**	1.000**
Cd	0.958**	0.999**	0.790*	1.000**	1.000**

** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level

3.2.2 Correlation Between Heavy Metals in the Soil and Plants at Ibagwa

Table 7 shows the correlation between heavy metal concentration in soil and plant at Ibagwa. The result showed a very high significant positive correlation coefficient for all the heavy metals in the soil against the following heavy metals; Pb, Cu, Cr, Cd and Zn present in the plant. The positive correlation suggests that an increase in the heavy metal concentration in the soil was associated with a corresponding increase in the heavy metal concentration in the plant.

The result also recorded a very strong high negative correlation between the heavy metals in the soil and heavy metal content of Cd in the plant. The negative correlation suggests that an increase in the heavy metal concentration in the soil was associated with a corresponding decrease in the heavy metal concentration in the plant.

Table 7: Correlation for Ibagwa

Parameters	Heavy metal in Soil and Plants(mg.kg^{-1})				
Heavy metal in soil	Pb	Cu	Cr	Zn	Cd
Pb	0.891**	0.882**	1.000**	1.000**	-0.991**
Cu	0.870**	0.860**	1.000**	1.000**	-0.991**
Cr	0.899**	0.891**	0.999**	1.000**	-0.991**
Zn	0.946**	0.939**	0.986**	1.000**	-0.990**
Cd	1.000**	1.000**	1.000**	0.999**	-0.987**

** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level

3.2.3 Correlation Between Heavy Metals in the Soil and Plants at Ogbeke 1

Table 8 shows the correlation between heavy metal concentration in soil and plant at Ogbeke 1. Significantly negative correlations (P<0.001) was recorded between Pb/Cr in the soil and heavy metals Cu, Zn and Cd in the plant. similar observation was recorded for the association though positive (P<0.001) between Cu in the soil and the heavy metals Cu, Zn and Cd in the plants. Just like the Pb AND Cr, the heavy metal Zn in the soil had significantly negative correlation with the heavy metals Zn and Cd in plant but on the contrary, a significantly positive correlation with Cu in the plant. Significantly positive correlation was observed between Cd in soil and the heavy metal Pb, Zn and Cd and also a significantly negative correlation with Cr in plant.

Table 8: Correlation for Ogbeke 1

Parameters	Heavy metal in Soil and Plants(mg.kg^{-1})				
Heavy metal in soil	Pb	Cu	Cr	Zn	Cd
Pb	0.514	-0.955**	-0.590	-1.000**	-1.000**
Cu	0.000	0.972**	0.106	1.000**	1.000**
Cr	-0.301	-0.852**	0.206	-1.00**	-1.000**
Zn	-0.231	1.000**	0.329	-1.00**	-1.000**
Cd	0.900**	0.166	-0.800**	0.951**	0.952**

** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level

3.2.4 Correlation Between Heavy Metals in the Soil and Plants at Ogbeke 2.

Table 9 shows the correlation between heavy metal concentration in soil and plant at Ogbeke 2. Significantly negative correlations (P<0.001) was recorded between Pb in the soil and heavy metals Cr in the plant and a positive correlation with Cu and Zn. the heavy metal Cu in the soil had significantly negative correlation with the heavy metals Cu and Cr in plant and a significantly negative correlation with Cd. Cr had same case as Cadmium. Zn and Cd had significantly negative correlation with Pb, Cu, Cr, Zn and Cd in the plant.

Table 9. Correlation for Ogbeke 2

Parameters	Heavy metal in Soil and Plants(mg.kg^{-1})				
Heavy metal in soil	Pb	Cu	Cr	Zn	Cd
Pb	0.655	-0.520	-0.932**	1.000**	1.000**
Cu	0.222	-0.904**	-0.930**	.000**	1.000**
Cr	-0.364	-.940**	-0.923**	.000**	1.000**
Zn	0.886*	0.987**	1.000**	1.000**	1.000**
Cd	0.897*	0.990**	1.000**	.000**	1.000**

** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level

3.2.5 Correlation Between Heavy Metals in the Soil and Plants at Ugwogo

Table 10 shows the correlation between heavy metal concentration in soil and plant at Ugwogo. Significantly negative correlations (P<0.001) was recorded between Pb in the soil and heavy metals Pb and Cr in the plant and a positive correlation with Zn. The heavy metal Cr in the soil had significantly negative correlation with the heavy metals Pb, Cu and Cr in plant and a significantly positive correlation with Zn. Cd had significantly negative correlation with Cr in the plant and a positive correlation with Zn in the plant.

Table 10: Correlation for Ugwuogo

Parameters	Heavy metal in Soil and Plants(mg.kg^{-1})				
Heavy metal in soil	Pb	Cu	Cr	Zn	Cd
Pb	-0.134	0.427	-0.982**	1.000**	0.011
Cu	-.190	0.374	-0.982**	1.000**	0.017
Cr	-0.998**	-0.813**	-0.980**	0.984**	0.020
Zn	0.966**	-0.989**	1.000**	-0.999**	1.000**
Cd	-0.564	-0.023	-0.982**	1.000**	0.310

** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level

3.3 Transfer factor

The calculated transfer factor of heavy metals along the road showed that Ogbeke 1 had values around 1, which indicates that the plants are not influenced by the elements while those at Alulu, Ibagwa, Ogbeke 2 and Ugwogo had values <1, which shows that plants exclude the elements from the uptake, this is in line with the works of Olowoyo *et al.*, 2010.

Table 11: Transfer factor for all the sampling points along the road

LOCATION	NAME OF LOCATIONS	LOCATION/ COORDINATE POINTS	DISTANCE ALONG THE ROAD (CM)	TRANSFER FACTOR (TF = C_{plant} / C_{soil})				
				Pb	**Cu**	**Cr**	**Zn**	**Cd**
1	ALULU	E7^{0}30^{1}54.0^{II} N6^{0}30^{1}14.2^{II}	0	0.12	0.33	0.84	0.06	0.21
2	IBAGWA	E7^{0}31^{1}21.4^{II} N6^{0}32^{1}16.2^{II}	0	0.25	0.43	0.35	0.25	0.08
3	OGBEKE 1	E7^{0}32^{1}24.9^{II} N6^{0}34^{1}23.2^{II}	0	1	1	1	1	1
4	OGBEKE 2	E7^{0}33^{1}12.7^{II} N6^{0}35^{1}37.7^{II}	0	0.01	0.06	0.02	0	0
5	UGWUOGO	E7^{0}33^{1}20.2^{II} N6^{0}36^{1}24.1^{II}	0	0.04	0.04	0.02	0.46	0

Conclusion

Soil from five locations along Alulu-Ugwogo road were found to be contaminated. The grass harvested and analyzed from these locations were also found to be high. This suggests the need for taking measures for remediation.

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