Spatial Distributions of Cadmium and Lead in Roadside Soils Along Owerri-Umuahia Highway

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Abstract: **The research was conducted in 2019 to evaluate the spatial distribution of heavy metals (cd and pb) in roadside soil along Owerri-Umuahia highway Imo State Nigeria. Three locations were sampled-Owerri, Mbaise and Obowo. These locations are the major highways connecting Owerri-Umuahia. Soil samples were collected at a predetermined distance of 0-15 feet (ft), 15-30 ft, 30-45ft, and 45-60ft away (row) from the edge of the road. All were sample at a depth of 30 centimeter (cm) depth using soil auger. The locations were either cultivated with cassava or maize and in some cases vegetables. Reference (control) samples were also sampled from fallow (non-highway soil) lands but at a distance of 100meters (m) away from highway. Fifty four (54) samples were randomly collected, and bucked samples were replicated for treatment sources. Samples were air dried and sieved with 2mm sieve, crushed and stored in the polythene bag for laboratory activities. Analyses were done routinely. The physicochemical result (table 1) showed that the soils are mostly sandy and the pH were slightly acidic with mean value of (5.97) when compared with control (5.89). There were significant differences between locations and control with regard to macro nutrient levels. These ranges from (phosphorus (p) 14.43 to 16.06 mg/kg, Nitrogen 0.11 to 0.73 % and potassium 0.18 to 0.23 cmol.kg^{-1}). These were significantly different when compared with control (NPK 0.54. 23.74 and 1.15) as the locations levels were lower than non-highway soils. The organic Matter (OM) where lower in highway location. The mean value were 2-12% while the control. The mean value was 2-12%, and control was 3.41%. The result followed same trend with Base Saturation and Basic Cation levels. Base Saturation (BS) were significantly different between locations and also when compared with control. The BS mean value was 77.91% while control was 84.60%. Cadmium levels at various distances, and between one location and another did not change significantly. Cadmium at distances 0-15ft, 15-30ft, 30-45ft and 45-60 ft, the mean values were 2.21, 1.87, 1.77, 2.03 and for control 2.19, 2.19, 2.02, 2.19 mg/kg respectively (table 2). For lead, at the sample distance away from road edge- 0-15ft, 15-30ft, 30-45ft and 45-60ft, the mean values were 11.7, 13.2, 12.5 , 12.0 and for control 13.22, 14.42, 13.03 and 14.14 (table 3). These slightly differences in the locations from control were not significant at p<0.05. In some cases, the control levels were higher the locations in terms of spread. From the result of the study, cadmium and lead concentrations at all the distances and spread, depth and locations were at moderate levels when compared with critical Cd and Pb established standard. Automobile movement at Owerri-Umuahia highway did not increase cadmium and lead levels spatially. The result was discussion in line with the established standard for heavy metal permissible limits.**

***Keywords*: Cadmium, Lead, levels Owerri-Umuahia Road**

I. INTRODUCTION

Heavy metals are widely distributed in the environment with source mainly from soils and weathering of rocks. However, levels of these metals in the environment have increased tremendously as a result of human inputs, such as heavy vehicles oil leakage, wear-off tires and smoke from automobiles -cars, motorcycle etc.

Studies have shown that heavy metals and metalloids with atomic density greater than 6g/cm^3 can accumulate and persist in soils at environmentally hazardous level. This metals are hazardous to humans when injected even at relatively low levels through food chain (Baid *et al*., 2008).

Heavy Metals are defined as metallic elements that have relative high density compare to water. Examples are Mercury (Hg), Cadmium (Cd), Arsenic (As), Chromium (Cr), Thallium (Ti), Nickel (Ni), Iron (Fe) and Lead (Pb). These heavy metals are concerned with the relative high density, and is toxic at low concentrations. Meanwhile, Hg, Pb, Cd, Cr, and As have been the most common heavy metals that induce human poisonings.

Due to their persistence and non-biodegradation, these Metals accumulate in soil (Abida *et al*., 2009) and their concentration on surfaces and soil close to the highways are often high. Some may migrate to the groundwater through infiltration and percolation thereby causing contamination. Nonessential heavy metals are toxic to plants, animals, and humans at very low concentrations. Even the essential Heavy Metals also causes adverse health effects at high concentrations. Baid *et al*. (2008) revealed that many farmers cultivates vegetables and other crops very close to road edges where particulate matters from smoky vehicles can settle on the plant leaves later through dew and dust. These Heavy Metals causes serious chronic effect to human health such as high blood pressure, kidney infection, cancer (Basta *et al.*, 1985).

The study therefore was conducted to evaluate the spatial distribution and concentrations of this heavy metals (Cd and Pb) in the roadside soils along Owerri-Umuahia highway in Imo state. This was to ascertain if the heavy metals are present, at what concentration if present, and their distribution pattern.

II. MATERIALS AND METHOD

i Study Area

The study was conducted along Owerri-Umuahia Highway. The highway connects Umuahia from Fire Service Station round-about Owerri municipal through Owerri north, to Aboh Mbaise, Ahiazu Mbaise, Obowo and Umuahia south as boundary. Owerri-Umuahia road has the following coordinates Owerri 5.4891^{o}N 7.0176^{0}E; Mbaise 5.5379^{0}N 7.2869^{0}E; Obowo 5.6027^{0}N 73220^{o}E.

ii Field Operations

In owerri, Mbaise and Obowo highways (representative samples), samples were collected from 0-15feet (ft), 15-30 ft, 30-45 ft and 45-60ft away from the edge of the road at a depth of 0-30cm respectively using soil auger. Three (3) locations each were sampled for Owerri, Mbaise and Obowo highway respectively. The same sampling pattern was followed for reference (control) samples but at a distance away (row) of 100m from high way. A total sample of 54 were collected from predetermined distances 0-15ft, 15-30ft, 30-45ft, 45-60ft.

iii. Laboratory Operations

Samples were air dried, sieved with 2mm sieve and crushed and stored in the polythene bag for laboratory activities.

Soil pH (pH) was determined in 1:2.5 soil/water using pH meter. **Organic carbon (OC)** was determined by wet oxidation method, while organic matter was calculated by multiplying with 1.724 ie Van Bemmellen factor. **Total Nitrogen (TN)** was determined by regular micro Kjeldhal method (Brown, 1987). **Available Phosphorous (AP)** was determined using Bray II solution (Heanes, 1984). **Total Exchangeable Bases** extracted with NH_4OAC, the calcium and magnesium in the extract was determined by EDTA titration. **Exchangeable Acidity** were determined by leaching the soil with 1mkcl and titration with 0.05 NaOH. **Cation exchangeable capacity (CEC)** was determined by calculating the sum of exchangeable cations [k, Na, Ca^{2+} and mg^{2+}] and exchangeable acidity [H^+ and Al^{2+}].

Heavy Metals were determined using the DTPA method (Lindsay and Norvell, 1979). A 10g of soil sample were mixed with 20ml DTPA (0.05 M – adjusted to pH 7.3 with TEA), then shaken on a reciprocation shaker or (mechanical shaker) for 30 – 45 minutes before filtering through whatman

Table 1: Physicochemical Properties of the soil of the samples (Locations)

Samples	Tex ture	pH	P	N	OC	OM	BS	Ca	Mg	K	Na	EA	ECEC	
		H20	Mg/kg	%	%	%	%	……………………..…Cmol.kg1……………………….. …						mean
Owerri	SL	6.41	14.53	0.11	1.28	1.86	75.90	2.40	1.43	0.18	0.15	1.27	5.49	9.25^d
Mbaise	Sl	6.28	16.06	0.16	1.16	1.99	75.76	2.80	2.00	0.19	0.10	1.42	6.15	9.50^c
Obowo	Sl	5.23	15.67	0.73	1.31	2.50	82.07	3.56	2.31	0.27	0.13	1.40	7.84	10.25^b
Control	**SL**	**5.89**	**23.74**	**0.54**	**1.98**	**3.41**	**84.60**	**4.29**	**3.72**	**1.15**	**0.40**	**1.51**	**10.79**	**11.83^a**
Mean		**5.97**	**15.42**	**0.53**	**1.25**	**2.12**	**77.91**	**2.92**	**1.91**	**0.21**	**0.13**	**1.36**	**6.49**	

Within column, mean(S) with same superscript are not significantly different at ($p<0.05$). Key: pH= power of hydrogen, P= phosphorous, N= nitrogen, OC= organic carbon, OM= organic matter, BS= base saturation, Ca= calcium, Mg= magnesium, K= potassium, Na= Sodium, Ea= Exchangeable acidity, ECEC= effective cation exchange-capacity.

No 1 filter. The filtrate were analyzed for Heavy Metals (Cd and Pb) on Atomic Absorption Spectrophotometer (AAS).

iv Data Analysis

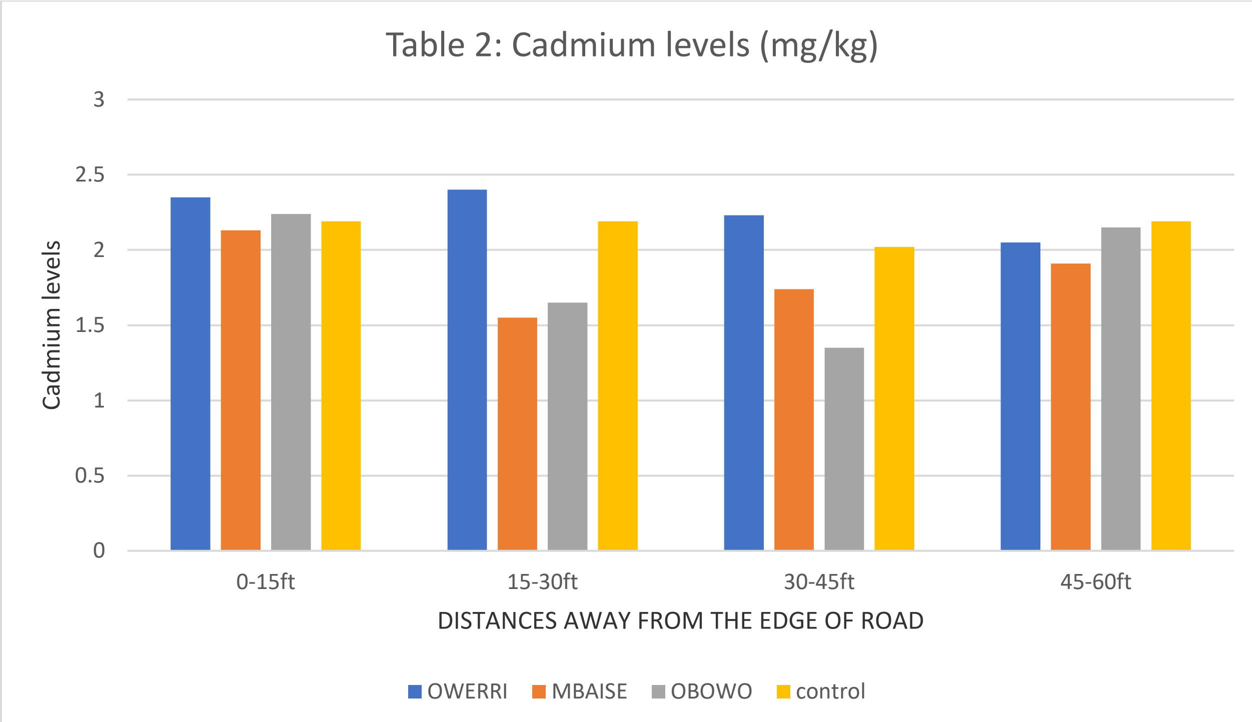
The data collected were summed and divided to produce means, respectively. Means were separated using the Least Significant Difference (LSD) according to Snedecor and Cochran (1980) and comperism were made with results from the control and already established (critical) levels.

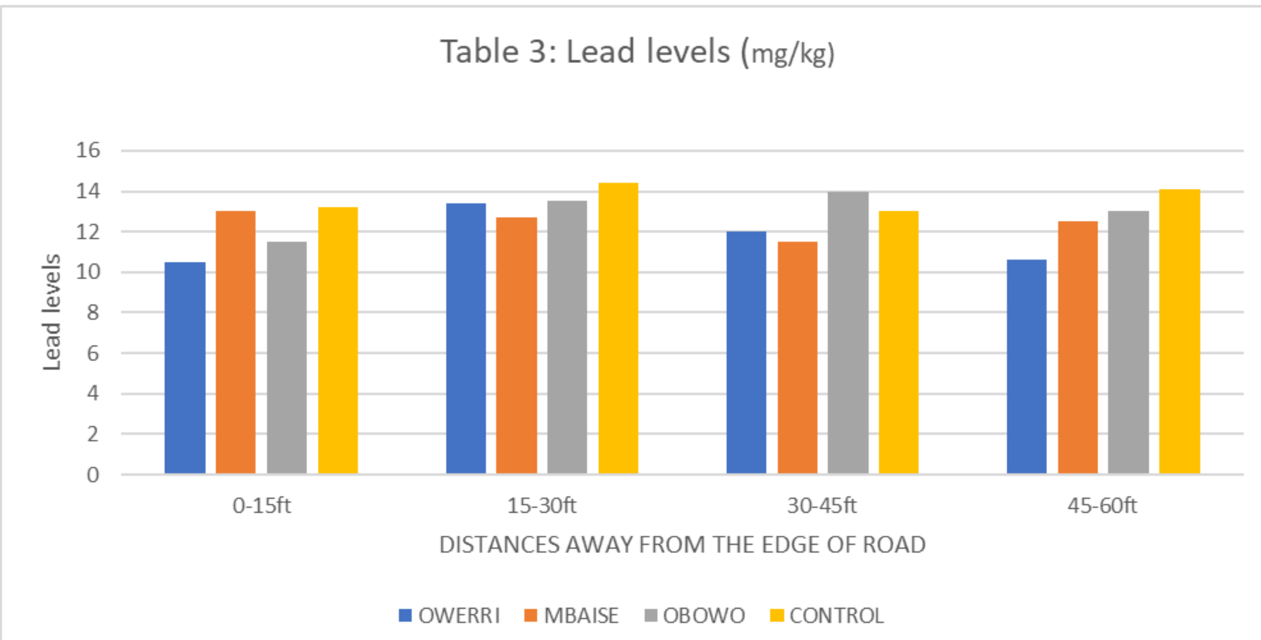
III. RESULTS AND DISCUSSION

i The physicochemical properties of the soil.

The physicochemical properties of the soil are shown in the table 1. The textural class is sandy loam. Most Ultisol are sandy in nature. There were significant differences in the pH of the samples and all were slightly acidic. Ultisols are generally acidic (Westerman, 1990)). The macronutrient elements are significantly different between samples and low when compared with control. The actively growing cassava and Maize in the study area may have contributed to the reduction in nutrient contents of the soil.

The Organic Matter is significantly different and were all lower than control. According to (Westerman, 1990)), Cultivation reduces organic matter content in tropical region as a result of rapid decompositions and mineralization of organic residue especially with actively growing sites where nutrient demand is high. The Base Saturation were also affected significantly and cultivations reduces the basic cation which is good for soil buffering. Higher ECEC in control sites showed significant different when compared with other samples and were an indication of undisturbed soil.





ii Cadmium and Lead levels

Cadmium and Lead levels from 0-60 feet away from road edge at the depth of 0-30cm are presented in table 2 and 3. Levels of both Cd and Pb are significant different between locations, and between distances. Jakaite *et al.* (2008) supported this finding when he stated that automobiles increases the levels of heavy metals through smoke emission and their mobility is restricted to wind movement and vehicular direction. As supported by (Bennett, 2003), the differences did not follow a pattern of movement from the differences did not follow a pattern of movement from one location to another or according to distance away from the road. one location to another or according to distance away from the road. There is significant difference between locations and control without a definite pattern. According to Alloway (1995), heavy metals are generally most mobile under acid polymer conditions.

The result showed slightly elevated levels of Cd and Pb in treatments when compared with control. This was supported by Fakoyade and Owolabi (2003), who discovered elevated levels of heavy metals along highways in Oshogbo, Nigeria. When the automobiles are in good condition and gasoline unleaded, emissions are very minimal (Xian, (1989b).

Environmental contamination with lead causes foe toxicity of serious congenital malfunctions in human (Chaney and Ryan, 1993). Stunted growth, abnormal infants, spontaneous abortions in woman and brain damage may also occur (Mulchi *et al*., 1987), while Cadmium causes heart and kidney disease, and bone embrittlement (Brady and Weil, 1999).

Table 4:
Critical Element ranges in the Soil

Element	Low	Marginal	Sufficient	High	Excess
Nitrogen (N)%	0.05	0.10-0.15	0.20-0.25	0.2-0.3	0.3
Phosphorus (P) mg kg^{-1}	3	3-7	7-20	20	>20
Potassium (K) $Cmol.Kg^{-1}$	0.2	0.2-0.3	0.3-0.6	0.6-1.2	1.0-2
Sodium (Na) %	0.1	0.1-0.3	0.3-0.7	0.7-2	2
Calcium (Ca) $Cmol.Kg^{-1}$	2	2-5	5-10	10-20	20
Magnesium (Mg) mg kg^{-1}	0.3	0.3-1	1-3	3-8	8
Copper (Cu) mg kg^{-1}	3.0	3.0-4.5	4.5-25	25-50	50
Iron (Fe) mg kg^{-1}	15	15-20	20-250	250-500	500
Cadnium (Cd) mg kg^{-1}	1-3	3-5	5-8	8-10	>10
Lead (Pb) mg kg^{-1}	5=25	25-60	60-70	70-85	>85

Source: WHO (1996)

IV. CONCLUSION

This is elevated levels of Cd and Pb between locations and when compared with control. There is no definite pattern of sprayed, increase or movement between one location and another, or between one distances to another. The levels did not increase with increase in distance away from highway. The sprayed is random and this justifies air movement and parent material input. The levels were not affected by factors that increases heavy metal retention and bioavailability such as flood, organic matter content and low pH.

The increase in levels were not above critical limits for Cd and Pb at which toxicity can occur (table 4). And for agricultural purposes, except external addiction is made, Heavy Metal levels does not exceed background levels because their mobility is low. Automobile movement did not increase the soils cadmium and Lead levels spatially and horizontally in the study area.

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APPENDIX: Map of Imo State Showing Study Area