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Quantification of Cadmium and Lead Spatial Distributions in Roadside Soils along Owerri-Okigwe Highway Using Standard Indices

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ABSTRACT: The research conducted in 2021 to evaluate the spatial distribution of Heavy Metals (cd and pb) in roadside soils along Owerri-Okigwe highway Imo State Nigeria, was carriage out inAkabo, Anara and Onuimo. These locations are the major highways connecting Owerri-Okigwe. From the depth 0-30cm, soilsamples 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 roadusing soil auger. Actively growing crops, Maize and Cassava were predominant at the locations. 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 moderate acidic with highest mean value of (5.89) when compared with control (5.80). There were significant differences between locations and control with regard to macro nutrient levels. These ranges from (phosphorus (p) (minimum) 49.45 to 56.52 mg/kg^{-1}, Nitrogen0.08 to 0.29 % and potassium 0.11 to 0.39 cmol.kg^{-1}). These were significantly different when compared with control (NPK 0.24. 42.70 and 0.22) as the locations levels were lower than non-highway soils. The organic Matter (OM) was highest in Akabo(4.26) followed by control (3.89)and the lowest in Onuimo.The result did not follow the same trend with Base Saturation and Basic Cation levels.
Base Saturation (BS) were not significantly different between locations and also when compared with control. The BSranges from 83.96 to 80.70 when compared with control 83.72. for Cadmium and Lead, Cadmium levels at various distances, and between one location and another changed significantly. Cadmium at distances 0-15ft, 15-30ft, 30-45ft and 45-60ft, were 5.5, 6.35, 5.40, 5.97and for control 2.35, 1.93, 2.01 and 2.31 mg/kg^{-1} 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 19.09, 20.94, 21.82 , 21.70 and for control 15.88, 17.07, 18.01 and 17.75 (table 3). These differences in the locations from control were significant at $p<0.05$. In some cases, the control levels were higher than other locations. The result of the study showed that both cadmium and Lead concentrations at all the distances and spread, depth and locations werehigh when compared with critical Cd and Pb established critical l(ceiling) standard. Automobile movement at Owerri-Okigwe highway increased the cadmium and lead levels spatially. The result was discussed in-line with the established standard (indices) for Heavy Metal permissible limits in soils. Therefore influx old vehicles to the country should be checked while high automobile oil should be used during servicing of engines and maintenance of automobiles to reduce emission rate and levels which can increase the levels of addictive 'which are not both human and environmentally friendly.

KEYWORDS: Cadmium, Lead, Owerri-Okighwe Highway

I. INTRODUCTION

Levels of Heavy Metals in the environment have continued to increase due to anthropogenic activities such as pesticides applications, heavy vehicles oil leakage, wear-off tires and more worrisome smoke emissions from

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automobiles such as cars and motorcycles. The influx of second hand vehicles with higher smoke emission ration coupled with low grade Engine Oils sold for automobiles in Nigeria may increase the rate of emissions. Low attitude of automobile users to regular or adequate engine servicing and maintenance may also increase the chances of higher levels Heavy Metals to the environment through depositions of particulate matters

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 at a later time through dews and dusts. 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-Okigwe highway in Imo state to ascertain the levels of heavy metals if present and also their distribution pattern.

II. MATERIALS AND METHOD

i Study Area

The study was conducted along Owerri-Okigwe Highway. The highway connects Enugu from Fire Okigwe round-about Owerri municipal through Owerri north, to Ikeduru, Isiala Mbano, Onuimo and Okigwe as boundaries. Owerri-Okigwe road has the following coordinates Owerri 5.4891^{o}N 7.0176^{0}E; Mbano5.7084° N, 7.1783° E Onuimo5°45′5″N 7°10′39″E.

ii Field Operations

In owerri, Mbano and Onuimo 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, Mbano and Onuimo highway respectively. The same sampling pattern was followed for reference (control) samples but at a distance awayof 100m (row) from high way. A total sample of 54 were collected from predetermined distances 0-15ft, 15-30ft, 30-45ft, 45-60ft.

iii Laboratory Operations

Soil 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+}].

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

Sources	Tex-ture	pH (H_20)	P Mg/kg	N	OC	OM	BS	Ca	Mg	K	Na	Ea	ECEC
				…… %				…….…… Cmol.Kg^{-1} ……..……..					
Akabo	**SL**	5.89	56.52	0.29	3.39	4.26	82.77	4.69	3.31	0.39	0.23	1.75	10.41
Anara	SL	5.70	49.50	0.21	2.26	3.91	83.96	3.60	2.80	0.23	0.17	1.28	07.98

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Onuimo	SL	5.61	49.45	0.28	1.71	1.96	80.70	2.40	1.60	0.11	0.08	1.00	05.19
Control	SL	5.80	42.70	0.24	2.26	3.80	83.72	4.00	2.41	0.22	0.06	1.28	07.86

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

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 for 45 minutes before filtering through whatman No 1 filter. The filtrate were analyzed for Heavy Metals (Cd and Pb) on Atomic Absorption Spectrophotometer (AAS).

iv Data Analysis

Data were summed and means produced, 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 established (critical) standard.

III. RESULTS AND DISCUSSION

i The physicochemical properties of the soil.

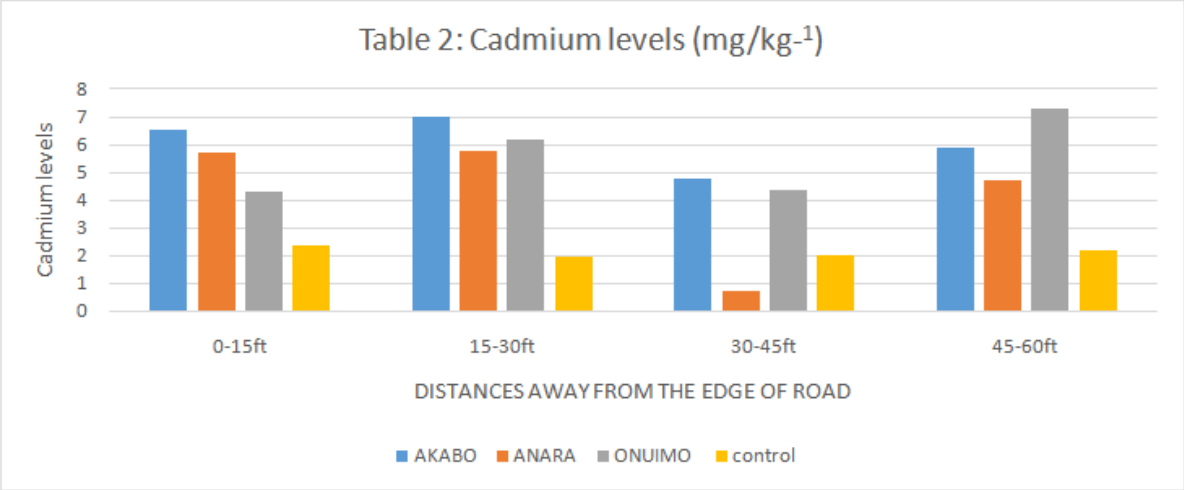
Table 1 showed the physicochemical properties of the soil The textural class is sandy loam. Most Ultisol are sandy in nature. There were significant differences in the pH of the samples and all were slightly acidic. Ultisols are generally acidic (Westerman, 1990)). The macronutrient elements are significantly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

The **Organic Matter**levels are significantly different and were all higher than control except Onuimo. According to (Westerman, 1990). Except with fertilizer application, 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 but not significantly and cultivations reduces the basic cation, and basic cation is good for soil buffering. High ECEC in control sites showed significant different when compared with other locations and all locations were at their best.

ii Cadmium and Lead levels

There were random concentrations of Cadmium and Lead as the sprayed did not follow any specific pattern between one location to another and when compared between distances (row) away from the edge of the road as indicated in table 2 and 3, which were significantly different.

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.



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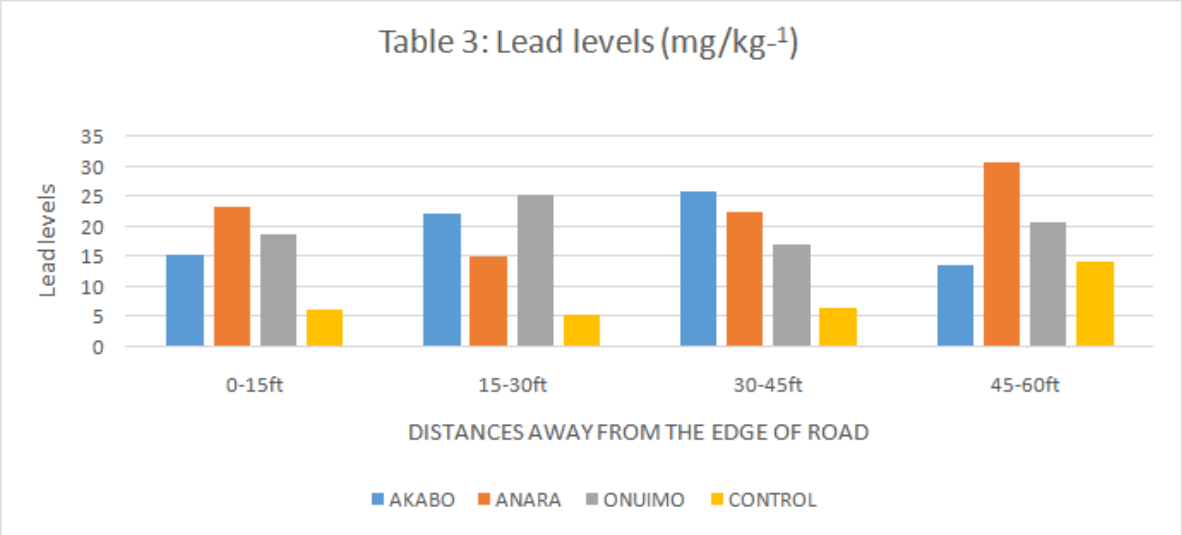

Assupported by (Bennett, 2003),the differences did not According to Alloway (1995), heavy metals are generally most mobile under acid polymer conditions.

Distances away from the edge of the road had marked changes and concentrations of the Heavy Metals Cd and Pb which indicated presence and significantly different from control. Movement away from the edge of the road did not corresponding increase in concentration,

The result showed highly elevated levels of Cd and Pb in locations 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

There were 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 a distance and another. The levels did not increase with increase in movement away from highway edge. The sprayed is random and this may be justified by air movement. There were additions of Cd and Pb in the study area, but

the levels were not affected by factors that increases heavy metal retention and bioavailability such as flood, organic matter content and low pH.

Though the levels werehigh, they were not above critical limits for Cd and Pb at which toxicity can occur (table 4). Unchecked addictions may increase or lead to levels that may trigger concentrations that will affect food chain.

And for agricultural purposes, except external addiction is made, Heavy Metal levels does not exceed background levels because their mobility is low. Automobile and its movement increased the soils cadmium and Lead levels but the addition does not follow a specific pattern of spatial and horizontally movement in the study area.

RECOMMENDATIONS

Influx of low grade vehicles into the country should be discourage while adequate measure should be put in place to check road worthy vehicles. High grade oil should be formulated and sold, and significant servicing of automobiles using quality oil and oil rings when necessary should be monitored. Leaded gasoline can be cut low by using unleaded fuel or using more electric vehicles.

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APPENDIX: Map of Imo State Showing Study Area