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Geo-Accumulation and Ecological Risk Assessment of Heavy Metals from Roadside Dust around Forces Avenue, Old GRA, Port Harcourt, Nigeria

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Abstract- Samples from roadside dust collected from different stations in Forces Avenue, Old GRA, Port Harcourt, Rivers State, Nigeria were digested (mineralized) and subsequently analyzed for heavy metals concentration. The result of the investigation showed that Iron (Fe) was the most abundant metal detected in the roadside. The highest value of Fe was obtained in station 2, which was 81.40±8.12 mg/Kg. The order of concentration of the metals was iron (Fe) >zinc (Zn) > nickel (Ni) > copper (Cu) > lead (Pb) >cadmium (Cd) > chromium (Cr). The mean concentrations of the heavy metals from the various stations was: Fe (71.08±5.38), Zn (47.34±6.05), Ni (25.27±0.99), Cu (18.08±0.93), Pb (0.54±0.05), Cd (0.36±0.03) and Cr (0.18±0.05) mg/Kg. Contamination factor analysis showed that the Forces Avenue area is within contamination category, but not yet polluted with heavy metals. Geo-accumulation index and ecological risk assessment interpretations showed that the concentration of heavy metals in the environment arose from natural factors and pose no ecological risk to the environment. However, adequate care and control should be put in place to put the environment under check to avert possible rise in the concentrations of the metals especially Zn, Ni and Cu.

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I. Introduction

The continuous and ever increasing growth in population and expanse of cities is worldwide issue. In order to take care of the population geometric growth, there is a rise in urban drift and which is consequent on the need to build more industries. The building and functioning of industries have led to the continuous release or emission of heavy metals into both terrestrial and aquatic environment (Yiran *et al*., 2013).Heavy metals are known to portend serious health threat to humans and animals. The presence of heavy metals in any environment reveals the underlying contamination levels of that place. Moreover, metals are not easily degraded and as such has the capacity to accumulate to levels that are detrimental to human health and wellbeing, especially when their concentrations have exceeded threshold levels (Censi *et al*., 2006; Ubwa *et al*., 2013).

Dust from the Roadside is considered to be one of the main contributors of metal contamination in an urban settlement. Chronic exposure or contact with dust that has been polluted can cause chronic damage to vital organs or tissues of living organisms. Contact with contaminated dust can come through different ways such as inhalation, ingestion, and dermal or skin contact (Mafuyai et al., 2015).

The discharge of heavy metals is of utmost substantial environmental problem, which is caused by anthropogenic activities namely; construction of roads and bridges, mining and excavations, agricultural practices, waste burnings, disposal of sewage, forest and bush burnings, exhausts gases exhuming from vehicles, industrial effluents, lubricating oil, wear and tear from automobile parts, corrosion and disintegration of building materials, deposition from atmospheric drifts and particulate emission(Ho and Tai,1988; Sutherland, *et al*., 2000; Adriano, 2001).

The toxicity of majority of the heavy metals to living organisms cannot be overemphasized. Despite the fact that some of them are essential micronutrient, yet at some concentrations a bit higher than required also become toxic. Important biochemical processes are damaged by heavy metal and as such constitute threat or hazard to human well-being, plant life and animal welfare (Silva *et al*., 2005).This research was therefore conducted to evaluate the geochemical and ecological assessment of heavy metal contamination of Roadside dust around Forces Avenue, GRA I in Port Harcourt.

II. Materials And Methods

Roadside dusts were collected with plastic trowel around the Forces Avenue of Old GRA at six different points and transferred into polythene bags. The soil samples were taken to the Chemistry Research Laboratory of the Department of Chemistry, Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Rivers State. The samples were air dried for two weeks to constant weight in the laboratory.

The samples were powdered and sieved with a 2mm mesh. The samples were digested using aqua regia mixture (HNO_3: HCl) in the ratio of 1:3 using digestion vials. The temperature for digestion was maintained at a 100 –105 °C. At the end of the digestion, the vials were spun or centrifuged and the digest

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decanted into plastic sample containers (Akbar *et al*., 2006).

The digests were analyzed for heavy metals with Atomic absorption spectrophotometer (AAS). Triplicate determination of each metal was done and the result obtained validated.

The data obtained from the heavy metals were then examined with three model indices. They are:

$Contamination\ factor\ (Cf) = \frac{Cm}{Cb}$, where Cm is the measured concentration and Cb is the standard value (Lacatusu, 2000).

$Geo-accumulation\ (I-geo) = \log 2 \frac{Cm}{1.5\ Bn}$, where Cm is the measured concentration, Bn is the background value and 1.5 is a value added to correct lithological differences (Muller, 1969).

$Ecological\ risk\ Index\ (Er) = Tr\ x\ Cf$, where Tr is the toxic response factor of the individual metal and Cf is the contamination factor of the corresponding metal (Hakanson, 1980).

III. Results And Discussion

The concentrations of the heavy metals obtained in the Forces Avenue locations is given in Table 1. Iron (Fe) was observed to be the most concentrated metal in the area, which was followed by zinc (Zn), then nickel (Ni) and copper (Cu). The metal with the lowest concentration in the dust by the roadside was chromium, followed by the value obtained for cadmium (Cd) and then lead (Pb).

Lead: The concentrations of lead (Pb) varied from 0.48 ± 0.00 – 0.61 ± 0.05 mg/Kg, with a mean value of 0.54 ± 0.05 mg/Kg in the sample locations. The value observed for Pb in this work is lower than values obtained by Mafuyai *et al*., (2015) along busy highways in Jos; Popoola *et al*., (2012) in selected classroom dust in different areas in Lagos metropolis and Ogundele *et al*., (2015) along highways in North Central Nigeria. The low values of Pb observed in this work is attributable to the complete absence of industries within the area, the soil type and free flow of traffic which would have caused deposition due to vehicular emissions.

Cadmium: The concentration of cadmium (Cd) ranged from 0.31 ± 0.00 - 0.40 ± 0.02 mg/Kg. These were lower than the ones obtained in Katsina, Nigeria from selected major roads (Lawal *et al*., 2017) and those observed by Inuwa *et al.,* (2007) in parts of North West Nigeria, but higher than those observed by Ogundele *et al*., (2015) in some traffic roads in North Central Nigeria. Cadmium sources include cadmium-nickel battery production, paints, stabilizer in plastic fabrications and deterioration of tyres. Chronic exposure to Cd toxicity can result in different disease conditions (Lee, *et al*., 2005).

Chromium (Cr): The values obtained for Cr ranged from 0.11±0.02 – 0.25 ± 0.01 mg/Kg. These values are lower than the values observed by other authors (Wei and Yang, 2010; Popoola *et al*., 2012; Ogundele *et al*., 2015).The growth of industries in any environment usually increases the concentration of Cr. This is mostly observed in places where chemical and tanning industries predominate. Roadside Cr can also result from decomposition or decay of vehicular components (Lu *et al*., 2009).

Iron (Fe): The values obtained for Fe varied from 63.46±4.67 - 81.40±8.12 mg/Kg. the concentration of Fe observed in this work is either lower or higher than those observed by Mafuyai *et al*., (2015), but lower than the values obtained by Lawal *et al*., (2017).Iron (Fe) is a natural component of the earth's crust. However, its concentration in any soil environment is dependent on the nature of the soil and other environmental considerations such as human inputs. Sources of Fe in the environment are industrial activities and decomposition or decay of metal parts.

Zinc (Zn): The concentrations of Zn in the sampled locations varied between 39.96 ± 4.22 - 55.55 ± 5.01 mg/Kg. These values were about four times lower than the values obtained in a study by Wei and Yang, (2010) in urban soils, urban roadside soils and agricultural soils in different urban Cities of China and also about four to eight times lower than the values recorded by Yiran *et al*., (2013) from different parks in Beijing, China. Zinc (Zn) in the environment can originate from deteriorated or worn out tyre, electrical materials, brake linings and from fuel containers (Dolan *et al*., 2006).

Nickel (Ni): The concentrations of Ni in the present study varied from 23.98 ± 3.08 - 27.27 ± 3.12 mg/Kg. The values of Ni observed in the present study were higher than those obtained by Marcus *et al*., (2017) in leachate contaminated soils within Port Harcourt, Rivers State, Nigeria and those observed by Edori and Kpee, (2017) in selected abattoirs in Port Harcourt, Rivers State, Nigeria.

Copper (Cu): The concentration of Cu in the sampled stations varied from 16.49 ± 2.06 – 19.05 ± 1.67 mg/Kg. The level of Cu observed in this work is lower than those observed in a similar study in roadside soils in Northern England (Akbar, 2006) and those observed by Mafuyai *et al*., (2015) in Jos, Nigeria roadside dust, but either lower or higher than those observed by Ogundele *et al*., (2015) along traffic roads in North Central Nigeria.

Table 1: Concentrations of Heavy Metals in Roadside Dust at Different Location in Forces Avenue

Sample location	Concentrations of Heavy Metals (mg/Kg)						
	Pb	Cd	Cr	Fe	Zn	Ni	Cu
1	0.61±0.04	0.31±0.00	0.25±0.01	70.32±6.33	45.60±4.35	25.14±2.98	19.05±1.67
2	0.49±0.01	0.40±0.02	0.18±0.03	81.40±8.12	39.96±4.22	27.27±3.12	17.96±2.03
3	0.52±0.03	0.36±0.01	0.24±0.00	68.50±5.38	44.65±3.85	24.91±3.33	17.36±3.76
4	0.56±0.04	0.38±0.00	0.15±0.00	63.46±4.67	55.55±5.01	25.01±2.18	16.49±2.06
5	0.60±0.10	0.37±0.03	0.16±0.05	72.29±2.45	42.78±2.66	23.98±3.08	19.04±3.76
6	0.48±0.00	0.35±0.02	0.11±0.02	70.52±5.13	55.52±6.25	25.33±3.26	18.56±2.66
Mean±SD	0.54±0.05	0.36±0.03	0.18±0.05	71.08±5.38	47.34±6.05	25.27±0.99	18.08±0.93

The contamination factor values obtained from this work is shown in Table 2. The values of contamination factor obtained in this work when compared with the values given for comparison as proposed by Lacatusu (2000) indicated that the stations are uncontaminated with Pb, Cr and Fe. The stations are moderately contaminated with Cd and Zn, severe or moderate contamination with Cu and severely – very severe contamination with Ni. However, the values of contamination factor were lower than those observed by Marcus *et al.*, (2017) in soils contaminated with leachates from dumpsites within Port Harcourt, but higher than those observed by Edori and Kpee (2017) in abattoirs in Port Harcourt.

Table 2: Contamination Factor of Heavy Metals in Roadside Dust at Different Locations in Forces Avenue

Sample location	Contamination Index of Heavy Metals						
	Pb	Cd	Cr	Fe	Zn	Ni	Cu
1	0.0072	0.388	0.0025	0.00185	0.326	0.718	0.529
2	0.0058	0.500	0.0018	0.00214	0.285	0.779	0.499
3	0.0061	0.450	0.0024	0.00180	0.319	0.712	0.482
4	0.0066	0.475	0.0015	0.00167	0.397	0.715	0.458
5	0.0071	0.463	0.0016	0.00190	0.306	0.685	0.529
6	0.0056	0.438	0.0011	0.00186	0.397	0.724	0.515

The geo-accumulation index of heavy metals from the various stations is given in Table 3. The result of geo-accumulation from this work when compared to I-geo pollution assessment index as proposed by Muller (1969) indicated that all the sample stations were pollution free. The stations are practically uncontaminated with Pb, Cr, and Fe, but may have little contamination tendencies of Ni, Cu, Cd and probably Zn. Geo-accumulation index revealed that these metal concentrations observed in the area (Forces Avenue, Old GRA) have not been influenced by anthropogenic activities, but rather of natural factors.

Table 3: Geo-accumulation Index of Heavy Metals in Roadside Dust at Different Locations in Forces Avenue

Sample location	Geo-accumulation Index of Heavy Metals						
	Pb	Cd	Cr	Fe	Zn	Ni	Cu
1	0.00144	0.0777	0.00050	0.0004	0.065	0.144	0.106
2	0.00116	0.100	0.00036	0.00043	0.057	0.156	0.100
3	0.00123	0.090	0.00048	0.00120	0.064	0.143	0.097
4	0.00132	0.095	0.00032	0.00036	0.079	0.143	0.092
5	0.00142	0.093	0.00032	0.00038	0.061	0.137	0.106
6	0.00113	0.088	0.00050	0.00037	0.079	0.482	0.103

The ecological risk index of the heavy metals in the various stations is shown in Table 4. Results of the ecological risk index when juxtaposed with the Hakanson (1980) terminologies used to describe it showed that the metals did not pose ecological risk to the environment.

Table 4: Ecological Risk Index of Heavy Metals in Roadside Dust at Different Locations in Forces Avenue

Sample location	Ecological Risk Index of Heavy Metals						
	Pb	Cd	Cr	Fe	Zn	Ni	Cu
1	0.036	11.64	0.0050	-	0.326	3.590	2.645
2	0.029	15.00	0.0036	-	0.285	3.895	2.495
3	0.031	13.50	0.0048	-	0.319	3.560	2.410
4	0.033	14.25	0.0030	-	0.397	3.575	2.290
5	0.036	13.89	0.0032	-	0.306	3.425	2.645
6	0.028	13.14	0.0022	-	0.397	3.620	2.575

IV. Conclusion

The concentrations of the heavy metals from the roadside dust in the study area were lower than the background values given by DPR for all the metals. The heavy metals most likely have originated from natural causes rather than human influence (anthropogenic factors). Despite the fact that the extent of contamination is very low (ie within the stipulated limit), yet adequate steps should be taken to keep any incidence of increase under control to avoid any consequence or implications that will arise from such occurrence.

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