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Levels of Some Selected Heavy Metals in Roadside Soil Samples of Bauchi Metropolis, Bauchi State, Nigeria

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### ABSTRACT

*In this study, the levels of zinc, copper and cadmium in roadside soil samples collected from five different major road networks of Bauchi and its environs were determined using Atomic Absorption Spectrophotometric technique. The concentrations of zinc, copper and cadmium under study ranged from 96.67-191.33, 12.33 – 29.67 and 3.67 – 4.00 mgkg<sup>-1</sup> respectively. Soil samples from Bauchi – Gombe road were found to contain the highest levels of zinc (191.33 mgkg<sup>-1</sup>), copper (29.67 mgkg<sup>-1</sup>) and cadmium (4.00 mgkg<sup>-1</sup>) respectively. Soil samples from Bauchi – Dass and Bauchi – Maiduguri roads were respectively and equally found to have the highest levels of cadmium (4.00 mgkg<sup>-1</sup>). The variations in the levels of zinc and copper in all the road networks were found to be significantly different ( $p \leq 0.05$ ), whilst the variations in the levels of cadmium in all the road networks were found to be significantly the same ( $p \leq 0.05$ ) as determined by one-way analysis of variance (ANOVA). The least significant difference ( $LSD_{0.05}$ ) further revealed that significant differences exist in the respective levels of zinc and copper in all the road networks of Bauchi. The highest concentrations of all the metals determined were found to be within the threshold limits specified by World Health Organization, WHO [(Zn = 300.00 mgkg<sup>-1</sup>, Cu = 100.00 mgkg<sup>-1</sup> and Cd = 50.00 mgkg<sup>-1</sup>)] which shows that the soil samples from the road networks of Bauchi are not polluted with the heavy metals determined and the inhabitants are therefore presently safe.*

**Keywords:** Zinc, copper, cadmium, road networks, soil samples, one-way ANOVA, Least Significant Difference and threshold limits

### INTRODUCTION

Heavy metals are natural components of soil and most elements are only present in minimal or insignificant concentration in undisturbed areas. Heavy

metals that are essential to the body are also toxic above certain levels. Heavy metals can persist and accumulate in the environment, especially soils. These metals especially lead, zinc, copper, manganese and iron are

potentially toxic and environmentally important (Dauda, 1999).

Heavy metals in roadside soils may come from various human activities such as industrial and energy productions, constructions, vehicle exhausts, waste disposals as well as coal and fuel combustions (Li *et al.*, 2001). In developing countries like Nigeria, improved road accessibility creates a variety of ancillary employments such as vehicle repairs, vulcanizing work and welding, auto-electrical and battery charging work. These activities may lead to deposition of heavy metals into nearby soils, which are absorbed by plants on such soils (Abechi *et al.*, 2010). There is a close relationship between heavy metal concentrations in roadside soils and those in the dust falls. Heavy metals in the soils can also generate airborne particles and dusts, which may affect the air quality (Hutchison *et al.*, 2007).

Heavy metals are of environmental importance because there are various ways

through which they find their ways into the environment. Some of the ways are increased industrializations, traffic road users and extensive agricultural practices or activities. Soil can accumulate metals on a relatively long term basis since many metals in the soil are mobile. This explains the overall higher contamination level of metals in the soil and why in sampling, the top layers of soil are often taken (Ho and Tai, 1988). Heavy metals such as iron, copper, zinc and manganese are essential components of many alloys, pipes, wires and tyres in motor vehicles and are evolved into the roadside environment due to mechanical abrasion and usual wear and tear. The metallic pollutants in the air gradually and eventually precipitated on the ground surface depending on wind flow patterns and their concentrations are therefore elevated in adjacent areas (Hutchison *et al.*, 2007). However, urban soils are hardly used in food production; they receive higher than usual loads of contaminants from traffic and

industrial activities in heavily industrialized cities. In view of the increasing anthropogenic activities, the heavy metals pollution of soil, water and atmosphere represent a growing environmental problem and concern affecting food quality and human health.

Excessive accumulation of heavy metals in roadside soils could lead to heavy metal contaminations of roadside vegetation, wildlife, domestic animals and the human settlements. A number of studies have been carried out on the concentrations of heavy metals in roadside soils in developed countries with long histories of Industrializations and extensive use of vehicular traffic (Mateu *et al.*, 1995). Heavy metals are known as non-biodegradable and persist over a long period in aquatic as well as terrestrial environments. They can be transported from soil to ground waters or may be taken up by plants, including agricultural crops (Dosumu *et al.*, 2003).

Due to the disturbance and acceleration of nature's slowly occurring geochemical cycle of metals by man, most soils of rural and urban environments may have one or more of the heavy metals above defined background values, high enough to cause risks to human health, plants, animals and ecosystem (Alloway, 1995). The aim of this research work is to determine the levels of some selected heavy metals (zinc, copper and cadmium) in roadside soil samples of Bauchi, Bauchi State, Nigeria.

## MATERIALS AND METHODS

### Materials

In the preparation of all the solutions that were used in the research work, chemicals of analytical reagent grade purity and distilled water were used throughout the study. All the glass and plastic wares used in the research work were thoroughly washed with detergent solution, followed by 20.00 % (v/v) trioxonitrate (V) acid, rinsed with tap water, distilled water and finally with the solution that was used in them. The

apparatus were then allowed to dry (Hassan *et al.*, 2017).

## Methods

### *Sampling of Soil Samples and Treatment*

Soil samples were collected on 7<sup>th</sup> July, 2018 in polyethylene bags. The soil samples were collected from ten (10) different spots along each road network making a total of fifty (50) soil samples. The samples were collected five (5) meter away from the road shoulders and over a depth of 0 – 15 cm. The samples from each road network were homogenized (mixed) to form a composite sample, air-dried for a week and all clods and clumps were removed. A total of five (5) composite soil samples were obtained from Bauchi Central Road Network (BCRN), Bauchi-Jos Road (BJR), Bauchi-Dass Road (BDR), Bauchi-Gombe Road (BGR) and Bauchi-Maiduguri Road (BMR) respectively. The air-dried composite samples were ground using wooden pestle and mortar. The crushed samples were sieved through a 2

mm sieve in order to eliminate pebbles (coarse particles) before analysis. The samples were stored in plastic containers and labeled accordingly.

### *Digestion of Soil Sample*

The sieved soil samples from each road network were acid digested separately using the technique adopted by Hassan *et al.* (2009). A 1.00 g of the sieved aliquot soil sample (in triplicate) was weighed into a 250 cm<sup>3</sup> conical flask and digested using 10.00 cm<sup>3</sup> of tetraoxochlorate (VII) acid and trioxonitrate (V) acid solution (HClO<sub>4</sub>-HNO<sub>3</sub>) in a volume ratio of 1:2. The conical flask and its content were gently heated on a hot plate in a fume cupboard until a clear solution was formed. The conical flask and its content were allowed to cool and 10.00 cm<sup>3</sup> of the cold acid mixture was again added and gently heated until a clear solution was formed. The conical flask and its content were allowed to cool. 20.00 cm<sup>3</sup> of water was added to the digest residue and filtered using a Whatman Filter Paper Number 1 into a 100

cm<sup>3</sup> volumetric flask and made to volume with water. The sample solution was transferred into a screw-capped polyethylene sample bottle. The same procedure was employed for other treated samples. The sample solutions were then labeled accurately for further determinations of the metals of interest.

### ***Determination of Heavy Metals***

The sample solutions prepared above were analyzed for zinc, copper and cadmium

at their respective wavelengths using Buck Scientific Atomic Absorption Spectrophotometer VGP 210 Model.

## **RESULTS AND DISCUSSION**

### ***Results***

The levels of zinc, copper and cadmium determined in the road networks of Bauchi and the variations between the levels of the metals from five different road networks studied are shown in Table 1.

**Table 1:** Levels of Heavy Metals (mgkg<sup>-1</sup>) in Road Networks of Bauchi, Bauchi State

Sample Sites	Metals		
	Zn	Cu	Cd
BCRN	97.00 <sup>d</sup> ± 9.00	12.33 <sup>e</sup> ± 3.00	3.67 <sup>a</sup> ± 1.00
BJR	127.33 <sup>b</sup> ± 1.00	17.00 <sup>b</sup> ± 0.00	3.67 <sup>a</sup> ± 1.00
BDR	99.33 <sup>c</sup> ± 2.00	15.33 <sup>c</sup> ± 2.00	4.00 <sup>a</sup> ± 0.00
BGR	191.33 <sup>a</sup> ± 1.00	29.67 <sup>a</sup> ± 2.00	4.00 <sup>a</sup> ± 0.00
BMR	96.67 <sup>e</sup> ± 1.00	14.00 <sup>d</sup> ± 2.00	4.00 <sup>a</sup> ± 0.00

Values are mean ± range (n = 3).  
Values with the same letter on the same column are significantly the same (p ≤ 0.05)

as revealed by one – way ANOVA, while those with different letters on the same column are significantly different (p ≤ 0.05)

as revealed by same one – way ANOVA and Least Significant Difference ( $p \leq 0.05$ ).

## DISCUSSION

Table 1 shows the levels of some heavy metals ( $\text{mgkg}^{-1}$ ) in five different road networks of Bauchi, Bauchi State, Nigeria (Bauchi – Central Road Network, Bauchi – Jos, Bauchi – Dass, Bauchi – Gombe and Bauchi – Maiduguri roads).

The levels of zinc in the road networks of Bauchi ranged from  $96.67 \pm 1.00$  (Bauchi – Maiduguri road) to  $191.33 \pm 1.00 \text{ mgkg}^{-1}$  (Bauchi - Gombe road) with Bauchi Central Road Network ( $97.00 \pm 9.00 \text{ mgkg}^{-1}$ ), Bauchi – Dass ( $99.33 \pm 2.00 \text{ mgkg}^{-1}$ ) and Bauchi – Jos roads ( $127.33 \pm 1.00 \text{ mgkg}^{-1}$ ) falling in between the two extreme levels of the zinc determined. The differences in the concentrations of zinc in the road networks may be as a result of the differences in the wide distribution of consumer infrastructure, agricultural and industrial products (Callender and Rice, 2000). This may also be due to

disposal of local spent dyes, effluents and garbage containing zinc wastes or galvanized wastes. These values are all lower than the maximum permissible limit of zinc ( $300.00 \text{ mgkg}^{-1}$ ) in soil (WHO, 2014). The observed values ( $96.67 \pm 1.00$  to  $191.33 \pm 1.00 \text{ mgkg}^{-1}$ ) are higher than reported literature zinc values of 17.50 to  $29.80 \mu\text{gg}^{-1}$  (17.50 to  $29.80 \text{ mgkg}^{-1}$ ) reported by Kabiru *et al.* (2018). Zinc is considered to be relatively non-toxic to humans. This is because the oral lethal dose ( $\text{LD}_{50}$ ) of zinc according to Toxnet Database of the U.S National Library of Medicine has been reported to be close to  $3.00 \text{ g/kg}$  body mass (Plum *et al.*, 2010). Zinc is an essential micronutrient that plays a vital role in biological processes, especially in the proper functioning of proteins in all living organisms (Andreni *et al.*, 2006). It is also significant in cell division, nitrogen regulations, photosynthesis and growth.

The concentrations of copper as determined in all the road networks of Bauchi ranged from  $12.33 \pm 3.00$  (Bauchi

Central Road Network) to  $29.67 \pm 2.00 \text{ mgkg}^{-1}$  (Bauchi – Gombe Road). The levels of  $14.00 \pm 2.00$  (Bauchi – Maiduguri Road),  $15.33 \pm 2.00$  (Bauchi – Dass Road) and  $17.00 \pm 0.00 \text{ mgkg}^{-1}$  (Bauchi – Jos Road) fell in between the extreme concentrations of copper determined. The levels of copper found in the other roadside soil samples of Bauchi are individually less than the highest level of  $29.67 \text{ mg copper kg}^{-1}$  soil found in Bauchi – Gombe road. This may be due to deliberate disposal of various domestic wastes and organic matter containing copper. The highest level of copper found is less than the permissible limit of  $100.00 \text{ mgkg}^{-1}$  of soil sample (WHO, 2014). The concentrations ranged of copper determined ( $12.33 \pm 3.00$  to  $29.67 \pm 2.00 \text{ mgkg}^{-1}$ ) are relatively lower than  $15.00$  to  $74.40 \mu\text{gg}^{-1}$  or  $15.00$  to  $74.40 \text{ mgkg}^{-1}$  (Kabiru *et al.*, 2018). Copper is an essential element that promotes the activity of certain enzyme systems in the body. It has emetic tendency and it is also toxic to man and animals when ingested in large quantities

(Pearson, 1976). The variations in the levels of copper in the road networks could be as a result of the differences in the main sources of copper such as offal and green vegetables (Aaseth and Norseth, 1986). Chronic exposure to copper toxicity was reported to be characterized in patients with Wilson's disease, which is a genetic disorder that is responsible for unusual accumulation of copper in the body tissue (Goyer, 1991). Copper is an essential element involved in haemoglobin synthesis, bone and elastic tissue development as well as in the normal functioning of the central nervous system.

The levels of cadmium obtained in the road networks of Bauchi ranged from  $3.67 \pm 1.00$  (Bauchi Central Road Network and Bauchi – Jos road) to  $4.00 \pm 0.00 \text{ mgkg}^{-1}$  (Bauchi – Dass, Bauchi – Gombe and Bauchi – Maiduguri roads) with Bauchi Central Road Network and Bauchi – Jos road having the same levels of cadmium ( $3.67 \pm 1.00 \text{ mg/kg}$ ) as well as Bauchi – Dass, Bauchi – Gombe and Bauchi – Maiduguri roads having

the same levels of cadmium ( $4.00 \pm 0.00$  mg/kg). These values obtained are far below the tolerable dose of  $50.00 \text{ mgkg}^{-1}$  (WHO, 2014). The experimental or determined values ( $3.67 \pm 1.00$  to  $4.00 \pm 0.00 \text{ mgkg}^{-1}$ ) are comparatively higher than  $0.70$  to  $2.20 \text{ } \mu\text{gg}^{-1}$  ( $0.70$  to  $2.20 \text{ mgkg}^{-1}$ ) determined in the soil samples obtained from Garki Area Council of Abuja (Kabiru *et al.*, 2018). Cadmium is widely used in electroplating industries, solders, batteries, television sets, ceramics, photography, insecticides, electronics, metal-finishing industries and metallurgical activities.

It can also be introduced into the environment by metal-ore refinishing, cadmium containing pigments, alloys and electronic compounds, phosphate fertilizers containing cadmium, detergents and refined petroleum products. Cadmium exposure can cause renal dysfunction, bone degeneration, liver and blood damage (Pearson, 1976). Cadmium is a toxic metal and has been reported that there is sufficient evidence for

carcinogenicity of cadmium (Roney, 2005). Cadmium also causes gastrointestinal hemorrhage on temporary basis. Cadmium can equally cause outbreak of osteomalacia disease as a result of food poisoning (Gimmler *et al.*, 2002).

## STATISTICAL ANALYSES

### *Range*

The range, which is a measure of precision of the observed values of the heavy metals in the road networks of Bauchi were calculated and presented in Table 1. Precision is the closeness between several observed determinations of the same parameter. All the ranges computed showed relatively good precision in the replicate determinations of the observed values in the heavy metal contents of the roadside soil samples of Bauchi.

### *One – Way Analysis of Variance (ANOVA)*

The results of the selected heavy metal contents in all the road networks of Bauchi were subjected to one-way analysis of



variance ( $p \leq 0.05$ ). Significant differences exist in all the levels of the metals found in the road networks, except for the level of cadmium found in all the roadside soil samples.

### ***The Least Significant Difference (LSD)***

The least significant difference test ( $p \leq 0.05$ ) was further carried out in order to determine where the significant differences are. As could be seen in Table 1, the LSD further corroborated that significant differences exist only in zinc and copper respectively in all the road networks of Bauchi, Bauchi State, Nigeria.

### **CONCLUSION**

Based on the highest levels of 191.33 mg zinc  $\text{kg}^{-1}$  soil, 29.67 mg copper  $\text{kg}^{-1}$  soil and 4.00 mg cadmium  $\text{kg}^{-1}$  soil respectively found in the various road networks of Bauchi, the inhabitants of Bauchi metropolis can be said to be free from zinc, copper and cadmium potent harmful effects as the levels of the metals studied are within the

acceptable limits as established by World Health Organization (2014). The levels of the metals studied, therefore, indicated that the levels of zinc, copper and cadmium in the roadside soil samples of Bauchi are still within the tolerable limits and the inhabitants of Bauchi are presently safe.

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