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Heavy Metal Levels in Roadside Soils of some Major Roads in Maiduguri, Nigeria

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Abstract: *Inductively Coupled Plasma – Optimal Emission Spectrometry (ICP-OES), Optima 2000, Perkin Elmer was used to analyze the levels of Mn, Zn, Cu and Pb in samples from roadside soils of four major roads namely; Damboa, Baga, Bama and Kano roads in Maiduguri for possible heavy metals contamination due to anthropogenic activities. The results reveal that the roadside soils Cu levels ranged from 0.21±0.01 mg/kg in Damboa road to 2.51±0.02 mg/kg in Kano road. Pb was only detected in the road side soils of Kano road in the range of 0.03±0.00 to 0.11±0.01mg/kg. Mn levels obtained from this study ranged from 0.47±0.02 mg/kg in Bama road to13.83 ±0.01mg/kg in Baga road. Zn ranged from 0.07±0.02mg/kg in Bama road to 3.68 ±0.02 mg/kg in Damboa road. The concentrations of the heavy metals in the roadside soils were in the order: Mn> Zn > Cu >Pb. Possible accumulation of these heavy metals in the soils and eventually transfer to plants growing along the edges of the highways could occur as a result of continual usage of the roads by automobiles. This can also lead to accumulation of the heavy metals in the tissues of organisms that feed on the plants growing along the edges of the highways which can be transferred to other consumers in the food chain. The results obtained from this study will be used as baseline reference for future studies in the area and its environs.*
Keywords: *Accumulation, heavy metals, levels, roadsides, soils, transfer, food chain*

I. Introduction

Roads play a major role in stimulating social and economic activities. Roads constructions have resulted in heavy environmental pollution [1]. Cases of environmental pollutions, especially those that are caused by heavy metals are of great concern to the Environmental Protection Agency (EPA). Heavy metals are natural components of soil. Most elements are only present in minimal or insignificant eco-toxicological concentration in undisturbed area. Most heavy metals that are essential to the body are toxic above certain levels. Heavy metals can persist and accumulate in the environment, especially soils. These metals especially lead, zinc, copper, manganese, iron are potentially toxic and environmentally important [2]. 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 [3]. In developing countries like Nigeria, improved road accessibility creates a variety of ancillary employments such as vehicle repairers, vulcanizers and welders, auto-electricians and battery chargers. These activities may lead to deposition of heavy metals into nearby soils, which are absorbed by plants on such soils [4]. [5] Reported that 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 [6].

Heavy metals are of environmental importance because there are various ways through which they find their ways into the environment. These include; increased industrializations, traffic road users and extensive agricultural practices or activities. Soil tends to 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 layer of soil should be taken [7]. Heavy metals such as iron, copper, zinc, manganese are essential components of many alloys, pipes, wires and tyres in motor vehicles and are released into the road side environment as a result of mechanical abrasion and normal wear and tear [8]. Even though urban soils are rarely used for food production they receive higher than normal loads of contaminants from traffic and industrial activities in heavily industrialized cities. As a result of increasing anthropogenic activities, the heavy metals pollution of soil, water and atmosphere represent a growing environmental problem affecting food quality and human health.

Excessive accumulation of heavy metals in roadside soils may result in heavy metal contaminations of road side vegetations, 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 leaded gasoline since 1935 [9]. In developing countries such as Nigeria the opposite is the case. Maiduguri is the capital of Borno State. Borno State is the only state in Nigeria that is bordering three (3) countries (Chad, Niger and Cameroun), therefore a lot of cross border activities such as movement of all forms of vehicles and other human activities take place along the major roads in the area thereby leading to heavy metals pollution of the roadside soils. Borno State is one of the areas that have been

poorly studied in terms of environmental pollution; hence, the determination of heavy metals in environmental samples is very important. This study was carried out to ascertain the concentration levels of zinc, copper, manganese and lead in the roadside soils of four major roads (Damboa, Baga, Bama, Kano roads) in Maiduguri with a view to establishing baseline data that will serve as references for future studies in Maiduguri and it environs.

II. Materials and Methods

Sample collection and treatment

The sampling locations were chosen to give a good geographical coverage of Maiduguri Metropolis. Four sites were selected for study as designated below:

Locations	**Sites codes**
Damboa Road	$Da_1 – Da_2$
Baga Road	$Ba_1 – Ba_2$
Kano Road	$Ka_1 – Ka_2$
Bama Road	$Bm_1 – Bm_2$

Samples were collected in November, 2012. From each site, six replicate samples were taken from the surface soil (about 5cm deep) in two rows from the tarred road. The first row (Da_1, Ba_1, Ka_1, Bm_1) of three replicate were taken at about 20cm from the tarred roads, while the second row (Da_2, Ba_2, Ka_2, Bm_2) of three replicates were taken about 40cm. The distance between points of collections along each of the roads was about 100 m. The three replicate samples for each site/road were homogenized to obtain two composite and representative samples ($Da_1 – Da_2$, $Ba_1 – Ba_2$, $Ka_1 – Ka_2$, $Bm_1 – Bm_2$). In all a total of eight (8) samples were obtained. The samples were properly labeled and carried in clean polyethene bags to the laboratory for subsequent analyses.

III. Methodology

The samples were dried in an oven and later grinded using an acid pre-washed mortar and pestle and then sieved by passing them through a 1mm mesh. 1g of each samples were accurately weighed and treated with 20 ml of concentrated HNO_3.The mixture was place on a hot plate until the sample was almost dried and then cooled. This procedure was repeated with another 20 ml concentrated HNO_3 followed by 20 ml of 2M HCl. The digested soil samples were then warmed in 20ml of 2M HCl to dissolve the metal salts. The extracts were filtered through filter papers and the volumes were adjusted to 25ml with distilled water. The heavy metal concentrations were determined by Inductively Coupled Plasma – Optimal Emission Spectrometry (ICP-OES), Optima 2000, Perkin Elmer.

IV. Results And Discussion

The results of this study are as shown in Tables 1 to 4. Table 1 showed the Concentration (mg/kg) of some heavy metals in road side soils of Damboa Road, Maiduguri. Table 2 showed the Concentration (mg/kg) of some heavy metals in road side soils of Baga Road, Maiduguri. Table 3 showed the Concentration (mg/kg) of some heavy metals in road side soils of Kano Road, Maiduguri and Table 4 showed the Concentration (mg/kg) of some heavy metals in road side soils of Bama Road, Maiduguri. The road side soils Cu levels ranged from 0.21±0.01 mg/kg in Damboa road to 2.51 ±0.02 mg/kg in Kano road. Pb was only detected in the road side soils of Kano road with the values of 0.03±0.00 and 0.11±0.01mg/kg. Mn levels obtained from this study ranged from 0.47 ±0.02 mg/kg in Bama road to 13.83 ±0.0.01 mg/kg in Baga road. Zn ranged from 0.07±0.02 mg/kg in Bama road to 3.68 ±0.01 mg/kg in Damboa road. From the results, it is seen that the concentrations of the heavy metals detected in the sites decrease as we move away from the edges of the highways into the bush. This could be due to lots of cross border activities such as movement of all forms of vehicles and other human activities that take place along the major roads in the area, taking into considerations that there is no major industry in the area. Statistical tests of significance using the t-test indicate that the values of some of the heavy metals in each of the study sites were statistically different, $P< 0.05$ between the two sample spots. The values of Cu reported in this study were less than 27, 61, 24 and 29.7µg/g reported in literature [10]. This could be attributed to little or lack of industrial activities in the area.

Table 1: Concentration (mg/kg) of some heavy metals in roadside soils, of Damboa Road, Maiduguri

Site codes	Heavy metals			
	Cu	Pb	Mn	Zn
Da_1	0.88^a ±0.02	BDL	13.57^a±0.02	3.68^a ±0.02
Da_2	0.21^b ±0.01	BDL	5.55^a ±0.02	1.74^a ±0.01

Results of triplicate determinations ±S.D; Within Columns Mean with different letters are statistically different, $P< 0.05$; BDL = below detection limits

Table 2: Concentration (mg/kg) of some heavy metals in roadside soils, of BagaRoad, Maiduguri

Site codes	Heavy metals			
	Cu	Pb	Mn	Zn
Ba_1	1.66^a ±0.01	BDL	13.83^a ±0.01	2.01^a ±0.01
Ba_2	0.71^a ±0.02	BDL	6.76^a±0.02	0.56^a ±0.01

Results of triplicate determinations ±S.D; Within Columns Mean with different letters are statistically different, P< 0.05; BDL = below detection limits

Table 3: Concentration (mg/kg) of some heavy metals in roadside soils, of Kano Road, Maiduguri

Site codes	Heavy metals			
	Cu	Pb	Mn	Zn
Ka_1	2.51^a±0.02	0.11^a±0.01	0.96^a ±0.02	0.56^a±0.01
Ka_2	1.80^a ±0.01	0.03^b±0.00	0.88^b±0.01	0.15^b ±0.02

Results of triplicate determinations ±S.D; Within Columns Mean with different letters are statistically different, P< 0.05

Table 4: Concentration (mg/kg) of some heavy metals in roadside soils, of Bama Road, Maiduguri

Site codes	Heavy metals			
	Cu	Pb	Mn	Zn
Bm_1	0.91^a ±0.01	BDL	0.62^a ±0.03	0.08^a ±0.02
Bm_2	0.14^a ±0.02	BDL	0.47^b±0.02	0.07^a ±0.02

Results of triplicate determinations ±S.D; Within Columns Mean with different letters are statistically different, P< 0.05; BDL = below detection limits

The fact that Pb was almost absence in the results obtained from this study is obvious as the issue of Pb contamination or Pb poisoning has never been reported in Maiduguri. Manganese (Mn) forms the composition of soils in northern Nigeria. The availability of Mn in a trace amount as obtained in this study could be due to local condition of soil weathering [11]. The levels of Zn obtained are low compared with other studies like [12] and [1]. However, since no major industry such as smelting operations exists in the study areas, we may assume that the primary sources of Zn are probably the attrition of motor vehicle tire cause by poor road surfaces, and lubricating oils in which Zn is found as part of many additives such as zinc dithiophosphates [11].

The results of correlation analysis between the levels of the heavy metals obtained from each of the sampling sites are as presented in Figures 1 to 4. A correlation tells us whether the two variables vary together, i.e. as one goes up the other goes up (or goes down). The Pearson product-moment correlation coefficient (r) was adopted in this study. In all the cases, there were strong positive correlations, $p < 0.05$ except for one (Figure 4) which was a rather low positive correlation. The concentrations of the heavy metals in the soils were in the order: Mn> Zn > Cu >Pb. Possible accumulation of these heavy metals in the soils and eventually transfer to plants growing along the edges of the highways could occur as a result of continual usage of the roads by automobiles. This can also lead to accumulation of the heavy metals in the tissues of organisms that feed on the plants growing along the highways which can be transferred to other consumers in the food chain [13].

V. Conclusion

Based on the analyses, the following conclusions were arrived at:

i. The results of this study generally revealed the presence of some of the heavy metals (Cu, Pb, Mn and Zn) in the roadside soils of some major roads (Damboa, Baga, Bama, Kano roads) in Maiduguri, Nigeria due to human activities.
ii. The concentrations of the heavy metals in the road side soils were in the order of Mn> Zn > Cu >Pb. Pb was however not detected in three of the sampling sites.
iii. Possibilities of accumulation of these heavy metals in the soils and eventually transfer to plants growing along the edges of the highways could occur as a result of continual usage of the roads by automobiles. This can also lead to accumulation of the heavy metals in the tissues of organisms that feed on the plants growing along the highways which can be transferred to other consumers in the food chain.
iv. The results obtained from this study could be used as baseline reference for future studies in the area and its environs.

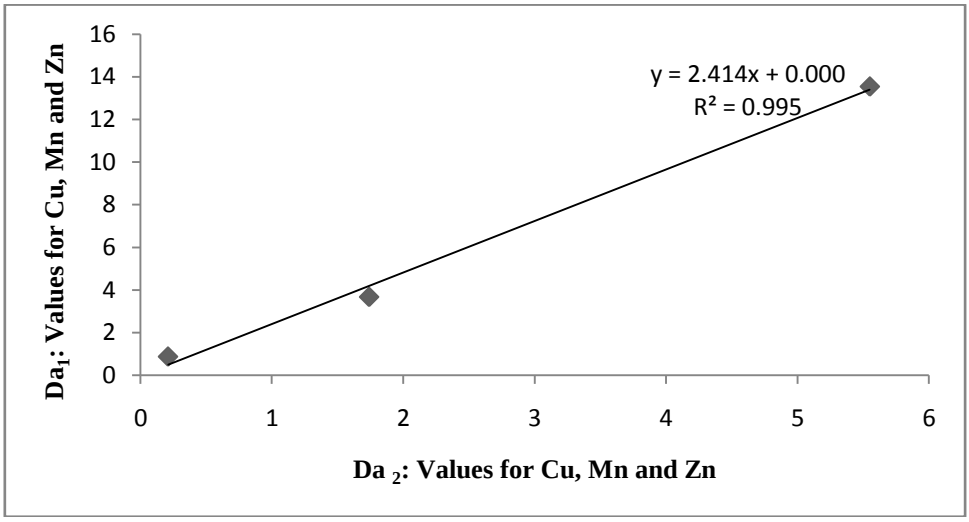

Figure 1: Correlation analysis between the levels of the heavy metals obtained from Damboa Road

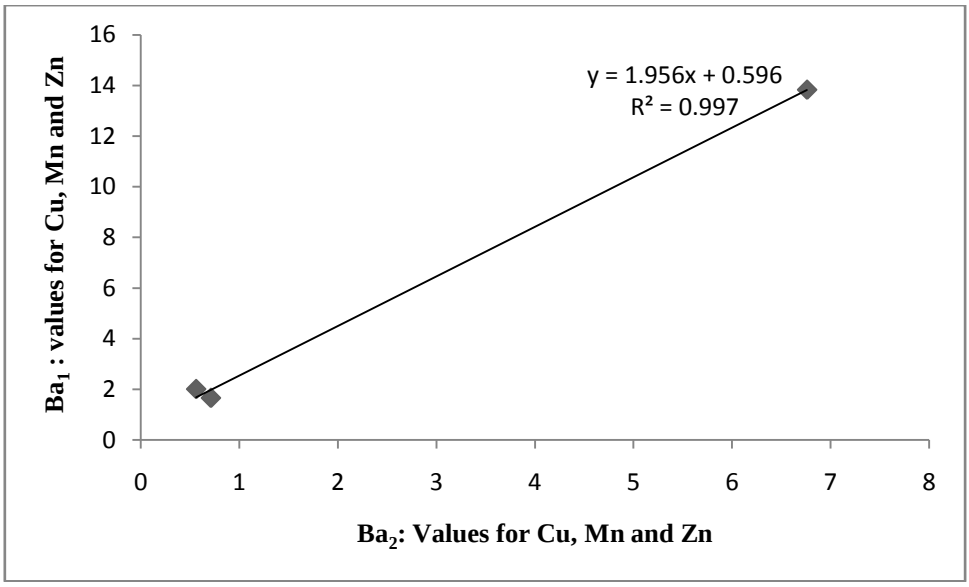

Figure 2: Correlation analysis between the levels of the heavy metals obtained from Baga Road

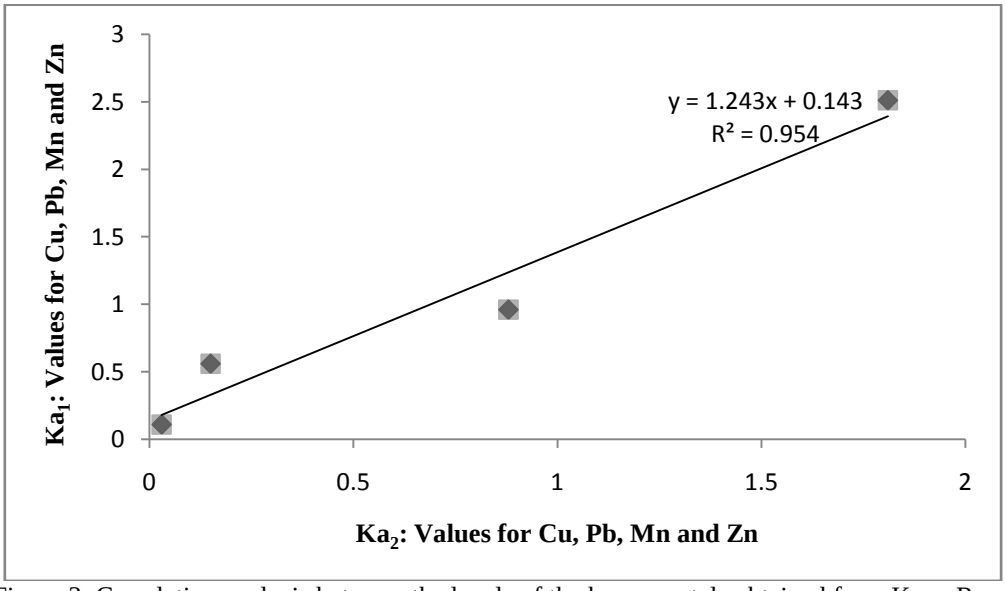

Figure 3: Correlation analysis between the levels of the heavy metals obtained from Kano Road

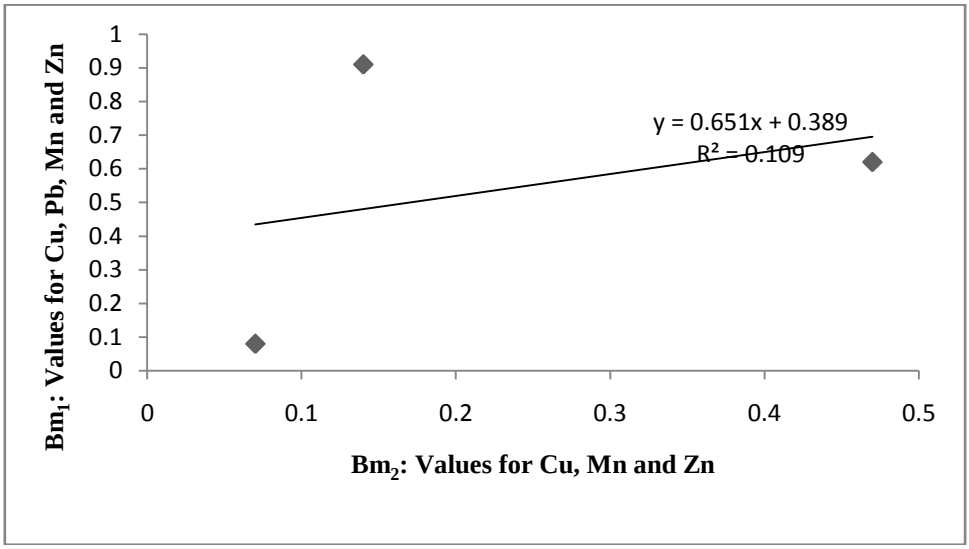

Figure 4: Correlation analysis between the levels of the heavy metals obtained from Bama Road

Since these heavy metals pose a great health problem to humans at concentrations greater than the recommended standards, it is recommended that the levels of heavy metals in soils should be constantly monitored. There is therefore the need to study the contamination of heavy metals in different dimensions such as; determining their levels in plants, animals and aquatic organisms which served as the routes through which heavy metals gets to man.

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