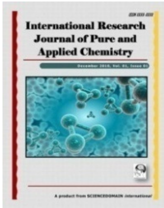

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Evaluation of Heavy Metals in Road Dust in Jos, Plateau State, Nigeria

Temitope Ruth Alonge-Emmanuel[1*], Fatai Afolabi Ayeni[1], Dorcas Joseph[1], Emily Dada[1] and Florence Dennis Uzuh[1]

[1]National Metallurgical Development Center, P.M.B. 2116, Jos, Plateau State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Authors TRAE and FAA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Authors DJ, ED and FDU managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An investigation of the heavy metal contents in road dust is vital in assessing the potential environmental impacts of vehicular emissions on the soil. In this study, dust samples were collected from Jos metropolis and were analysed for heavy metals (Pb, Zn, Mn, Cu, Co, Cd and Fe) using Atomic absorption spectrophotometer (AAS). The average distribution of the heavy metals decreased in the following order: Fe>Mn>Zn>Cu>Pb>Co>Cd, Fe had the highest values in all sampled areas while Cd showed no pollution due to the metal in all the sampled areas.

Keywords: *Heavy metals; environmental impacts; automobile emission; atomic absorption spectrophotometer; mean total metal content; pollution.*

**Corresponding author: Email: ayeflo@yahoo.com;*

1. INTRODUCTION

Increasing levels of pollutants in the environment, largely due to rapid urbanization and growth in the emission of vehicular transportation are in recent times a major cause of concern [1].

Pollution of the natural environment by heavy metals has become a universal problem in recent time because these metals are indestructible and most of them have toxic effects on living organisms when they exceed the permissible concentration levels.

The urban environment receives various deposits of pollutants from several sources such as vehicle emissions, domestic heating, industrial discharges, wastes incinerations, anthropogenic activities amongst a host of others [2].

According to Adefolalu [3] and Mabogunje [4], in a developing country like Nigeria, availability of good roads enhance diverse ancillary jobs such as auto-mechanics, vulcanizer and welders, auto-electricians, battery chargers and a host of other vehicular related facilitators [5]. All these activities releases trace metals into the immediate environment which eventually return back into the soil surface and could be absorbed by the plants on such soils.

Trace metals in the soil can also generate air borne particles and dusts, which may affect the air quality [6].

Road dust which consists of intricate chemical make-up originates from the resulting effects of activities between solid, liquid and gaseous materials [7]. According to Singh et al. [8], dust is made up of intricate materials (pollutants and contaminants) series of anthropogenic sources and processes. Research has identified road dusts as a potential store-house for pollutants such as heavy metals and organic substances [9,10].

According to Lagrewerff and Specht [11], while many studies have been done on lead, not much attention has been given to the contamination of other trace metals in the roadside environment. Although, considerable number of studies had been done on the heavy metal contents in road dust in developed countries with a long historical record of industrialization and urbanization coupled with its widespread use of leaded gasoline since early years of the 20^{th}century [5,12], not much research has been done in developing countries like Nigeria where data on the environmental impacts of these heavy metal concentrations and distribution is very limited.

Thus this present work was carried out to assess the heavy metal concentrations of road dusts within the Jos metropolis.

2. MATERIALS AND METHODS

2.1 Sampling Description

The sampling sites are a representation of the Jos metropolis, covering areas of different traffic densities [5] as shown in Table 1.

2.2 Sample Collection

Dust samples were obtained using brush and plastic scoop by gently sweeping the top surface of the soil along the streets.

A total of ten street dust samples were obtained from the sampling sites within the area of study and this was done during the dry season to avoid rain washing out the heavy metals.

2.3 Sample Preparation

The collected soil samples were carefully transferred into clean polyethylene bags. The samples were air-dried in the laboratory for one week and then grinded in an acid pre-washed mortar and pestle before being screened through a 90µm sieve fraction [13]. Table 1 represents the samples and sampling sites accordingly:

Table 1. Samples and sampling sites in Jos, Nigeria

S/N	Sample	Sampling site
1.	A	Terminus main market
2.	B	Joseph D Golmwalk Way
3.	C	Federal Government college, Zaria Road
4.	D	Bauchi Road
5.	E	Murtala Mohammed Way
6.	F	Ahmadu Bello Way
7.	G	Katako Market, Laranto
8.	H	Chobe junction
9.	I	University of Jos
10.	J	Enugu road

2.4 Sample Digestion

All the reagents used were of analytical grade. The method of Ho and Tai [13] was used in the digestion of the samples.1g of the 90µm sieved fraction of the sample was accurately weighed and treated with 10 mls aliquots of high purity conc.HNO_3. The mixture was kept to almost dryness on the hot plate. On cooling, the procedure was repeated with another 10mls conc. HNO_3 followed by 10 ml of 2M HCL digested soil samples were then warmed in 20 ml of 2M HCL to re-dissolve the metal salts. The extract was filtered through filter papers and the volume was made up to 25 ml with distilled water. The digested samples were then analyzed for heavy metals using UNICAM SOLAR Data station V7.15 AAS.

3. RESULTS AND DISCUSSION

Fe had the highest concentration followed by Mn, Zinc, Cu, Pb, Co, and Cd in the ten different sampling sites.

In Fig. 1, the high value of lead observed in the roadside soil ranging from 2.2-90.5µg/g is not unusual bearing in mind the generally high traffic density of sites C, D and F. In fact it is lower than the values of 154.5µg/g observed by Schmitt [14] and Harrison [2]. The high mean value of the concentrations affirms the overall high level of the contamination of the roadside soil by this metal. This observed result is in agreement with that of Lagrewerff and Specht [11]. The high concentrations of lead observed could be attributed to lead particulates from gasoline combustion which settles along the roadsides as dust. The high values observed in sites C, D and F could be attributed to the heavy traffic volume in that area coupled with heavy traffic jam. This agrees with the report of Francek [15] that traffic junction and cross roads records a higher level of the metal. Conversely the lowest lead value observed in site G (2.2µg/g) is expected due to the relatively low vehicular activities in the area. Other sources of lead contamination could be from paints, gasoline additives, pesticides, lead pipes and other materials [16].

Although the high mean level of lead observed in the roadside soil confirms that the environment is generally lead enriched. The observed mean lead level reported in this work is far lower than that reported by Ho and Tai [13], Francek [15], M.I. Yahaya, et al. [16] (35.9-306.7ug/g) and Shinggu et al. [17] (20.7-241.3ug/g).

The values for Zinc ranged between 217.0 - 490.3µg/g. This value agrees with that of Shinggu et al. [17] (216.0 – 350.4µg/g) and higher than that reported by Ahmed Usman et al. [18] (156.7 - 210µg/g). The Lead to Zinc ratio (Pb:Zn) observed in this study shows that the soil was less than unity which is contrary to report that soil lead pollution may be caused by automobiles [19]. This finding is however not limited to this work as some other reports also found a ratio of less than unity, which was ascribed to the local conditions within the soil environment [20].

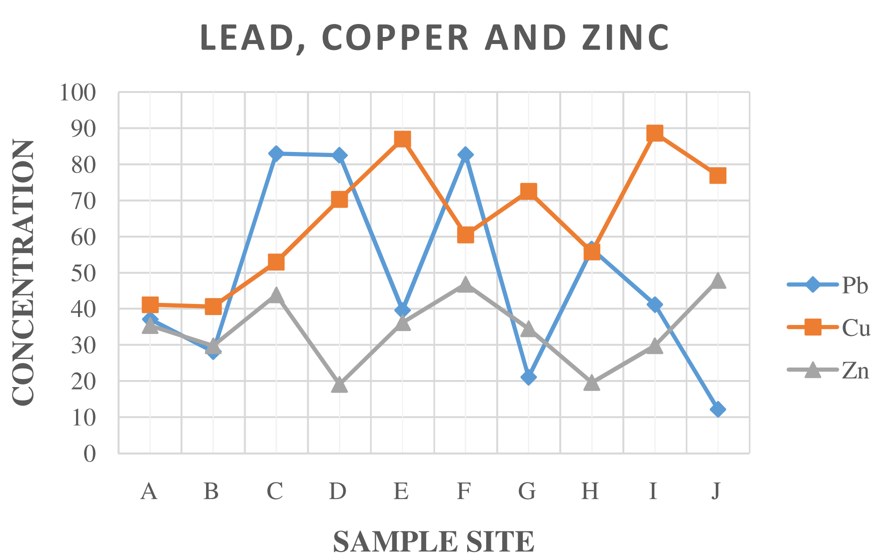

Fig. 1. Concentration (µg/g) of Lead, Copper and Zinc across the sampling site

Due to the absence of any operations or industrial activities that could contribute to Zinc pollution within the study area, we may assume that the primary sources of Zn in the study area are most likely due to the wear and tear of motor vehicle tyre rubber caused by poor road surfaces and the lubricating oil in which Zn is an additive component in the form of Zinc di-thio phosphates [5].

Furthermore, the movement, displacement, translocation of the metal depends amongst other factors on the soil pH, organic matter and granulometric composition of the soil. An acidic pH makes easier the solublization of the Zinc compounds even though the soils in this study are alkaline, an indication that Zn and other metals remain in soils for a longer period of time.

The Jos city roadside Copper level ranges from 41.1 – 108.5µg/g with higher values obtained from sites A, C, D and F. The values are somewhat high compared to reports in other studies [18,19,20]. The high values obtained in this area could be as a result of the associated ancillary vehicle workshops located along it.

Cadmium in roadside soil of Jos metropolis was not detected in any of the ten sites sampled. The level of Cobalt as shown in Fig. 2 is relatively low, which implies that the contamination of the soil by this metal is quite mild. This is similar to the findings of Albasel [21].

The Jos metropolis soil samples contained much higher levels of Manganese and Iron as shown in Figs. 3 and 4 respectively, than the other six elements analyzed. Both Mn and Fe form the composition of soil in Northern Nigeria. There availability may be attributed to metal construction works, iron bending and welding of metals, which is a common practice along the street of Jos.

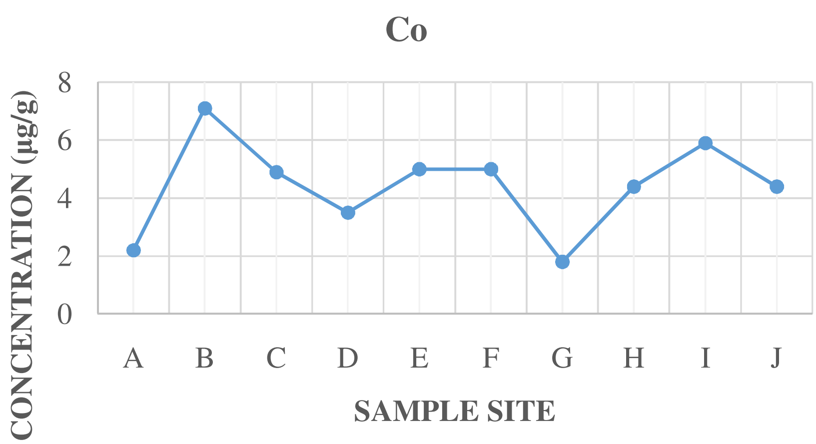

Fig.2. Concentration of Cobalt across the sampling site

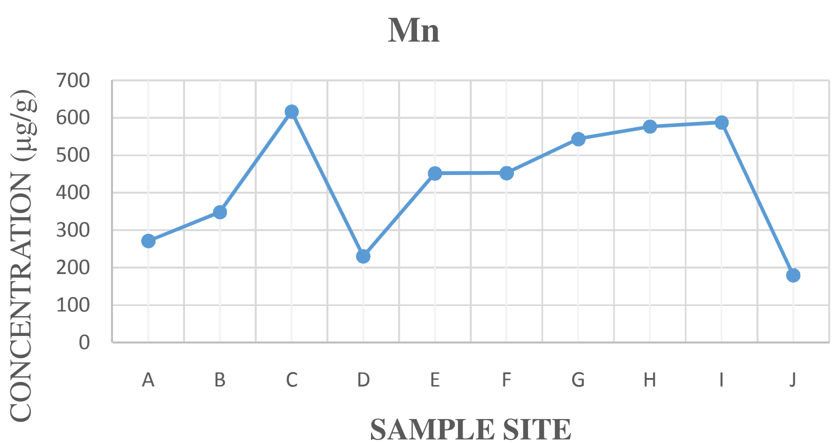

Fig. 3. Concentration of Manganese across the sampling site

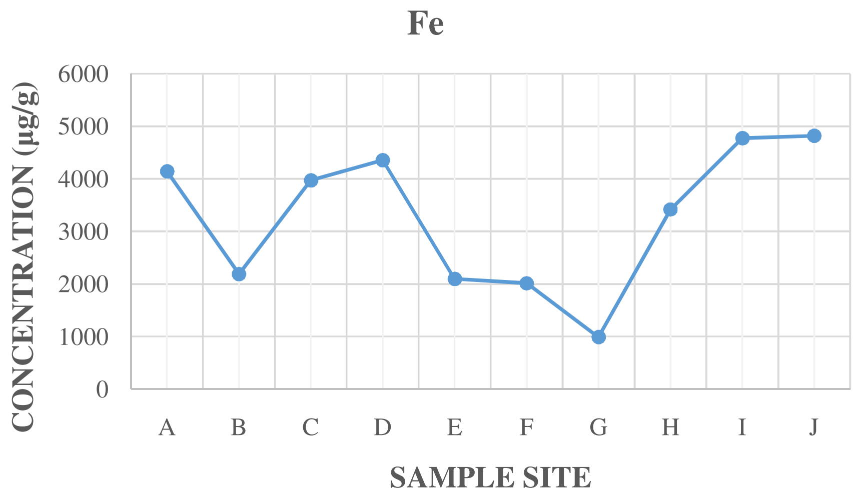

Fig. 4. Concentration of Iron across the sampling site

4. CONCLUSION

The result in this study has shown that the roadside soil of Jos is relatively contaminated with heavy metals. From the observations, it is evident that roads with rather high values of the metals are of high traffic density. Automobile emissions and metal construction works could be responsible for the buildup of the heavy metals in the roadside soil through the emission of particulates.

The high values iron observed in all the ten sites could be attributed to the nature of the soil parent rock; Biotite granite, which is very rich in iron and other accessory minerals associated cassiterite (Tin ore).

A few of the sampled areas with relatively high values are within areas of domestic activities, were food debris and other element containing materials are being carelessly thrown into the environment.

Finally, results obtained from this research work would now provide significant reference value for future studies of heavy metals in soil from these areas and other regions in Plateau state.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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