Analysis of Heavy Metals in Soils and Plants Along Roadsides in Lafia, Nigeria

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ABSTRACT The menace of air pollution through vehicular movements in many urban cities across the world has increased tremendously. This study aimed at determining the heavy metal accumulation in soils and plants growing by the roadside in Lafia, Nasarawa State, Nigeria. Two common plants (*Hyptis suaveolens* and *Urena lobata*) by the roadsides together with the soils were sampled using a simple stratified random sampling technique. Sampling was done at three locations (0m, 10m and 20m) away from three most plied highways in Lafia. The concentrations of the heavy metals (Lead (Pb), Copper (Cu) and Zinc (Zn)) were determined in all the samples in triplicates using standard methods. The results revealed varying concentrations of the heavy metals in the soils and plants at the three study sites. The concentration of Cu in the soils and plants ranged from 0.08 – 0.4ppm and 0.1 – 0.4ppm respectively while that of Zn in soils and plants ranges from 0.1 – 1.5ppm and 0.1 – 1.3ppm respectively. The pattern of concentrations of the heavy metals in both the soils and plants are in the order of Pb < Cu < Zn across all the sites. Even though there was no significant difference in the heavy metals concentrations between 0m, 10m and 20m away from the road sides, the metals are still more concentrated at the 0m of the sites. Pb was found to be below the detection limit at most of the sites.

KEYWORDS: Air pollution; *Hyptis suaveolens*; Lafia; Phytoremediation; *Urena lobata*
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INTRODUCTION

Air pollution is considered an environmental challenge in many industrialized areas in the world (Kambezidis *et al*., 1996). Vehicular movement has contributed about 57%-75% of the total emissions of air pollution in several urban parts of the world (WHO, 2006). In general, metropolitan areas have higher pollution than rural areas (Sawidis *et al*. 2001). Therefore, urban plants are of high importance for the inhabitants, but may also be endangered by exposure to pollution. One of the factors limiting the productivity of plants is the air pollution which is also considered as an environmental stress (Woo *et al*., 2007). There are primary and secondary pollutants. The primary ones are those discharged into the atmosphere and then contaminate the air while the secondary ones are those that are formed as a result of the interactions between primary pollutants (Agbaire, 2009).

Soil and plant pollution by trace metals from automobile emissions is an important environmental issue. The plants growing by the roadsides are more prone to these heavy metals pollutions which might have accumulated in them over a long period of time (Feng *et al.*, 2011; Sulaiman & Hamzah, 2018). Metals are released in significant levels during different transport activities by different processes such as combustion, components wear, fluid leakage and corrosion of metal (Dolan *et al.*, 2006). Besides toxicity to plants, trace metals are also persistent and pose serious danger to human and wildlife (Schwela, 2000). Trace metals have varied toxicity and can act as biological hazards even at low levels. Air pollution can influence plants directly through the leaves and indirectly through the acidification of the soil (Shahid *et al.*, 2017). When exposed to airborne pollutants, most plants experienced physiological changes before exhibiting visible damage to leaves (Liu and Ding, 2008). Plants vary with respect to their adaptation to environmental pollutants. This, according to Garner (2002) is based on their genetic constitution (genotype), stage of growth at time of exposure, and microhabitat in which they are growing. The aim of this research is to investigate the heavy metal accumulation of plants growing by the roadside (*Hyptis suaveolens* and *Urena lobata*) in Lafia, Nasarawa State, Nigeria.

METHODOLOGY

Study Site

The study was conducted in Lafia, Nasarawa State, Nigeria. Lafia is a city found in the North Central, Nigeria (Figure 1). The climate in Lafia is characterized by dry and rainy seasons.

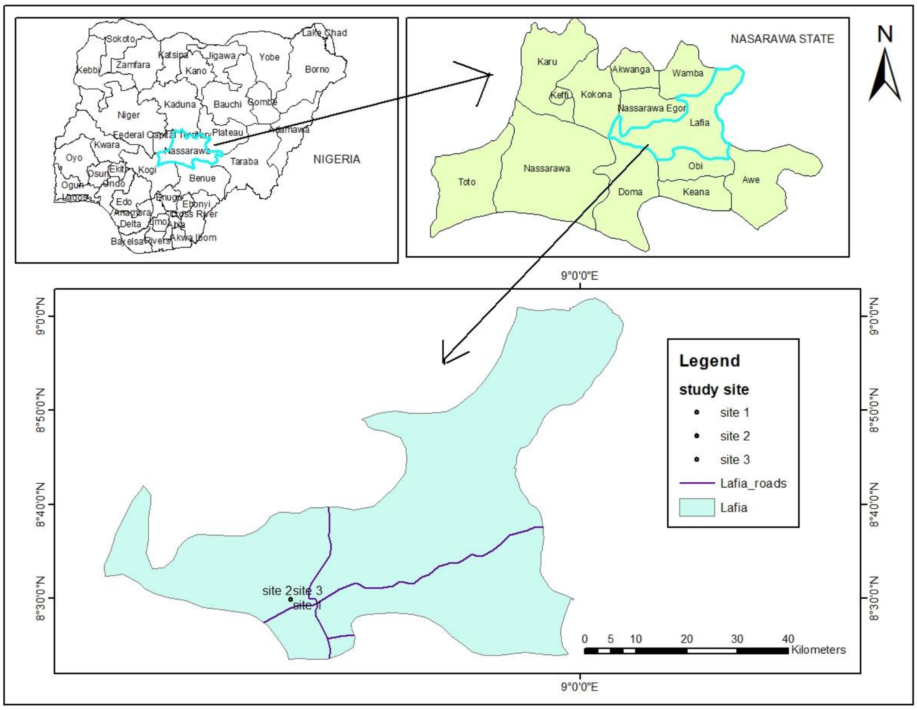

Figure 1. Study area map of Lafia, Nigeria.

Plants and Soil Samples Collection

Two plants found populating the roadsides in Lafia were used for this study. They include *Urena lobata* and *Hyptis suaveolens.* These plant samples were obtained from three separate locations along major highways in Lafia. These highways were known to be so busy with traffics. They include Lafia-Abuja road, Makurdi-Lafia road and Lafia-Doma road. Each road location is approximately separated from the other by distance of 10,000 meters. The sampling method adopted for the study is a simple stratified random sampling. The plant collection was done at three different locations at each roadside i.e. 0m (by the roadside), 10m far from the roadside and 20m far from the roadside. In the same vein, the soil was also collected by using a soil auger up to the level of 15cm. These samples were all collected in three replicates each. After collection of the samples, they were taken to the laboratory for the experimental procedures.

Preparation of Samples and the Determination of Heavy Metals Contents

Three (3) different heavy metals such as Lead (Pb), Zinc (Zn) and Copper (Cu) were determined in the plant and soil samples collected by following the methods of Augustine *et al.* (2016). These heavy metals were chosen because they have been found to emanate from engine oil usage, car breaks, tyres tears and wears (Ugolini *et al.,* 2013; Zhang *et al.,* 2012). The plant samples were air dried, crushed and sieved using 2mm sieves. One (1) g of each sample was subjected to ashing for 6 hours at 500^{o}C in a muffle furnace and kept in desiccators before use. The ash was moistened with water and 3 ml of HNO_3 was added. The resulting solution was heated for the excess nitric acid to evaporate. After cooling, the solution was filtered using the Whatman 40 filter paper. The procedures of Ayodele and Gaya (1998) were used for the pretreatment of the soil samples. The soil samples were crushed in porcelain mortar to break the lumps, sieved using 2mm sieve and dried to constant weight at 100 ºC. One (1)g of each sample was subjected to digestion for 30 minutes using 30 ml of 6M HNO_3. The digest thereafter was filtered into 100 ml flask using the filter paper. Five (5) ml of aliquot of the solutions resulting from the above pretreatments was transferred into a 50 ml volumetric flask. The heavy metals concentrations in these samples were determined with the aid of a Buck Scientific model 210VGP Flame Atomic Absorption Spectrometer (FAAS). This was operated with a continuous source background correction.

Statistical Analysis

The heavy metals concentrations in the plants and soil samples between the roadside locations were subjected to a non-parametric Kruskal-Walis test in order to determine if the differences are significant ($P \leq 0.05$).

RESULT AND DISCUSSION

The heavy metals concentrations in the soils

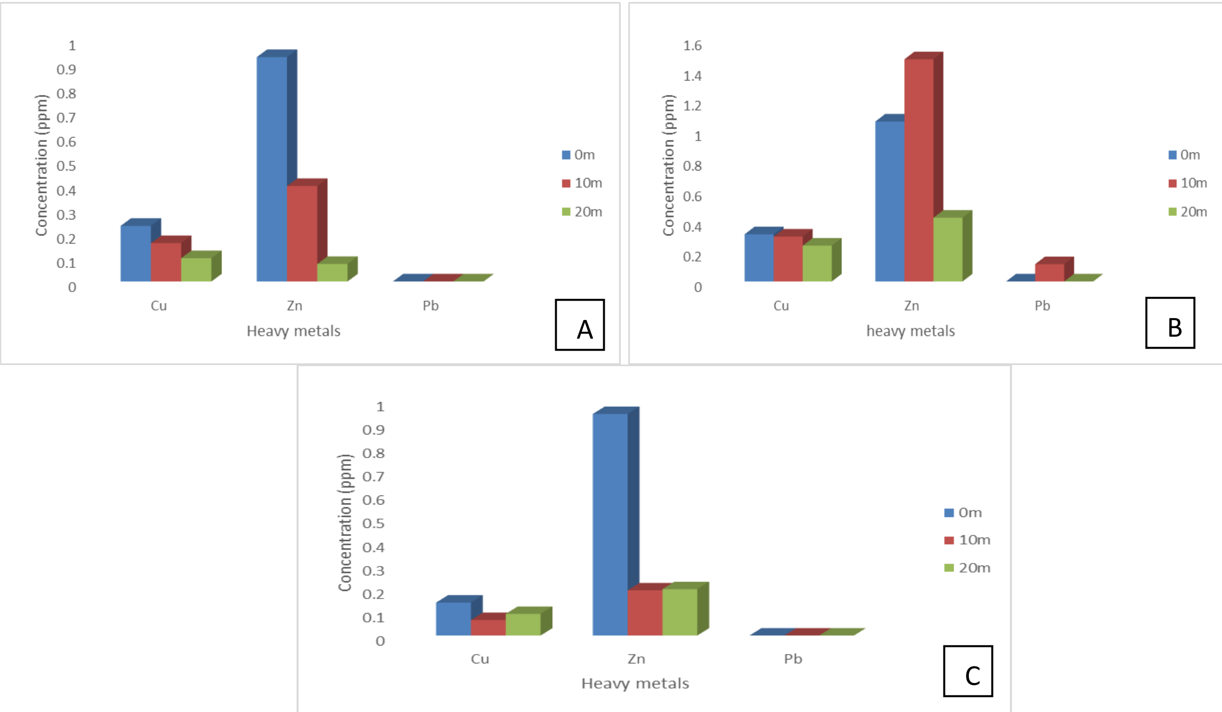

Figure 2. The heavy metal concentrations in the soil at (A) Site 1 (B) Site 2 (C) Site 3

The results of the concentration of heavy metals in soil at site 1 is shown in the figure 2A. The concentration of metals in the soils between the various locations at site 1 are not significantly different (p=0.081). The concentrations of Cu and Zn at 0m are higher (0.3ppm and 1.0ppm respectively) than at other locations (10m and 20m). Pb was not observed in the soil at this site 1. As for site 2, the concentrations of Cu are also not significantly different (p=0.072) between various locations (Figure 2B). The highest concentration of Cu (0.4ppm) was still observed at 0m. Whereas, the concentration of Zn at 10m is the highest (1.6ppm). Pb (0.19ppm) was observed only at 10m in this site. At site 3, the Cu and Zn concentrations in the soils at 0m were observed to be the highest

(0.2ppm and 1.0ppm respectively), though the difference was not significantly different (p=0.078) from the other locations (Figure 2C). Pb was also not observed at this site.

The heavy metals concentrations in Hyptis suaveolens

The results of the heavy metal concentrations in *Hyptis suaveolens* at site 1 are shown in figure 3A. The result revealed that the concentration of Cu is the lowest (0.15ppm) at 0m, while the highest (0.19ppm) was at 20m. The differences in the Cu concentrations between the road distances are not significantly different (p=0.127). Zn concentration at 0m was the highest (0.57ppm) and the lowest (0.13ppm) was at 10m. Pb was also observed to be absent in the plant at site 1. Cu concentration in *H. suaveolens* at 0m of site 2 remained to be the lowest (0.25ppm) while the highest (0.3ppm) was at 20m. Also, the plants at 0m showed lowest Zn concentration (0.65ppm), though it is not significantly different (p=0.141) from the other locations (Figure 3B). Figure 3C shows the results of the concentration of heavy metals of *H. suaveolens* at site 3. Here, the concentrations of Cu and Zn at 0m were observed to be the highest (0.38ppm and 1.2ppm respectively) unlike at the other sites. Pb was still not present in the plant at this site just as in the other sites. The differences in the metal concentrations between the road locations are not significant (p=0.117).

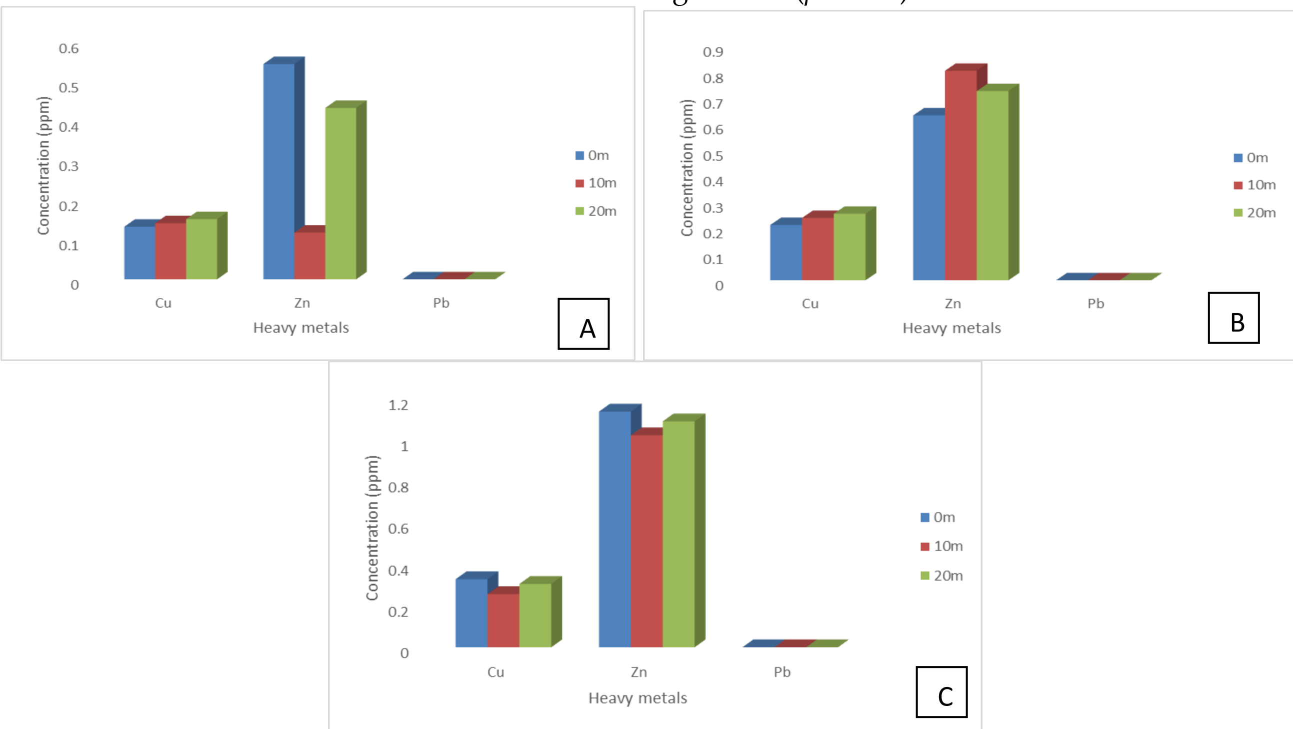

Figure 3. The heavy metal concentrations in *Hyptis suaveolens* at (A) Site 1 (B) Site 2 (C) Site 3

The heavy metal concentrations in Urena lobata

The results of the heavy metal concentrations in *Urena lobata* at site 1 are shown in figure 4A. The concentrations of heavy metals are not significantly different between the road locations (p=0.213). The Cu concentration at 0m was the lowest (0.12ppm) while that at 20m was the highest (0.15ppm). However, Zn concentration at 0m was the highest (0.6ppm). Pb was not observed in the plant at this site. At site 2, the Cu and Zn concentrations at 20m were higher (0.22ppm and 1.3ppm respectively) than at the other locations (Figure 4B). At site 3, the Cu concentration in *U. lobata* at 0m was the lowest, though not significantly different (p=0.147) from those at other locations (Figure 4C). The highest Zn concentration (0.81ppm) was observed at the 0m and it is significantly different from the ones at other locations (p=0.042). Pb still maintained its absence at this site.

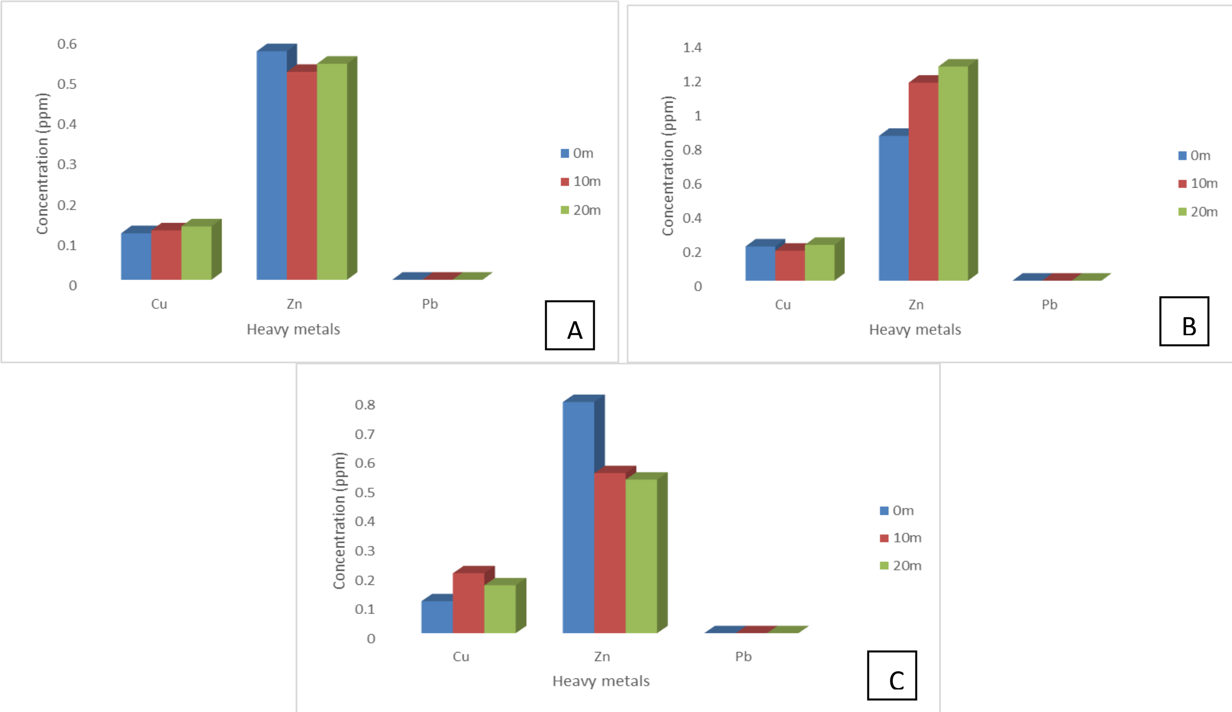

Figure 4. The heavy metal concentrations in *Urena lobata* at (A) Site 1 (B) Site 2 (C) Site 3

The insignificant differences observed in the heavy metal concentrations of plants and soils between the distances from the roadsides could be as a result of the gaseous state of the pollutants which made them almost evenly distributed over the entire roadside (i.e. between 0m and 20m). So, there might not be a precise form of heavy metal deposit particularly between 0m and 20m from the road. Possibly, if the distance is farther away (maybe 50 meters), then there might be significant differences in the heavy metals concentrations in both plants and soil. However, the availability of heavy metals in plants is dependent on two factors namely; the nature of the soil and the adaptability of the plants to the metals (Keshavarzi *et al.*, 2015; Liu *et al.*, 2007). It is possible that the soil properties supported the ability of these plants to be adapted to the metals, thereby making them good phytoremediators. The concentrations of Cu and Zn of the soils at all the study sites were still observed to be more concentrated at the 0m distance away from the roadside. The higher amount of Zn observed in the two plants in this study also agrees with a similar study on the *Azadiractha indica* growing along some roads in Lafia Nigeria, whereby Zn was the highest among the metals (Augustine *et al*. 2016).

Cu and Zn were found in all the study sites and at various locations from the roadsides, except Pb which was only concentrated in the soil at 10m at site 2 (Lafia-Doma road). This may be because Pb particulates are only transported through short distances before settling on this site. Pb contamination of roadside soil has been previously established (Jaradat *et al.*, 1999; Abechi *et al.*, 2010; Yahaya *et al.*, 2010). Also, Pb has been reported to have a long period of residence in the soils (Shaw, 1989). Its non-detection in the soils and plants at most of the locations studied indicated its absence or probably the concentration is below the detection limit of the FAAS. The occurrence of *Hyptis suaveolens* at these roadsides clearly suggests that the plant is a good candidate for phytoremediation. This was also buttressed by another study where the same plant was found at several other polluted soils in Lafia, Nigeria (Akomolafe & Lawal, 2019). Other studies have also affirmed its phytoremediation ability (Abdulhamid *et al.*, 2017; Sivakuma *et al.*, 2016), hence why it is common at the roadsides. In the same vein, *Urena lobata* has been identified as a phytoremediator of heavy metals and as a plant adapated to growing in waste soils (Abidemi *et al.*, 2014; Tripathi & Misra, 2013).

CONCLUSION

This study revealed the distribution of trace metals (Pb, Zn, Cu,) at the roadside soils, *Hyptis suaveolens* and *Urena lobata* along some major roads in Lafia, the capital city of Nasarawa State, Nigeria. Trace metal profiles increased with distance away from various intervals. The concentrations of trace metals in both the soils and plants are in the order of Pb < Cu < Zn (i.e. increasing order of concentration). Generally, the maximum levels of Pb, Zn and Cu in plants and soils along each roadside were within the safety limit guidelines proposed by most regulatory bodies. The level of Zinc in plants, however, calls for concern.

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