Environment and Pollution; Vol. 2, No. 4; 2013
ISSN 1927-0909 E-ISSN 1927-0917
Published by Canadian Center of Science and Education

Contamination of Roadside Soil and Bush Mint (*Hyptis suaveolens*) with Trace Metals along Major Roads of Abuja

Ahmed Usman[1] & Umar Ibrahim Gaya[1]

[1] Department of Pure and Industrial Chemistry, Bayero University, Kano, Nigeria

Correspondence: Umar Ibrahim Gaya, Department of Pure and Industrial Chemistry, Bayero University, P.M.B. 3011, Kano State, Nigeria. Tel: 234-803-916-9418. E-mail: uigaya.chm@buk.edu.ng

Received: June 4, 2013 Accepted: July 10, 2013 Online Published: August 22, 2013

doi:10.5539/ep.v2n4p44 URL: http://dx.doi.org/10.5539/ep.v2n4p44

Abstract

There has been a growing concern over environmental pollution by trace metals from automobile source. Abuja, like most urban cities has a high road traffic density. The present study investigates the levels of trace metals in roadside plant and soils along some major roads in Abuja. Thirty samples, consisting of equal number of plants and soils from Airport, Kubwa and Nyanya road were analyzed for Pb, Fe, Cu, Zn, and Cr levels using atomic absorption spectroscopy. The findings reveal trace metal contamination gradient, with the maximum levels closer to the road. Copper is prevalent in the study area with concentrations standing at 76.66 ± 12.02 µg g^{-1} and 300.00 ± 50.00 µg g^{-1} in the plant and soil respectively. There is a significant correlation in the concentration of the metals studied regardless of sample class. The average distribution of the metals in the samples decreased in the order Cu > Zn > Fe > Pb > Cr with the exception of Nyanya soil and the plant samples from Kubwa road. Evidence for Pb transfer from soil to *Hyptis suaveolens* was established and accumulation of Pb, Cu and Fe has reached alarming levels. Chromium traces were as low as 11.91 ± 1.38 µg g^{-1} in the plant but reached up to 39.68 ± 6.87 µg g^{-1} in the soil. Concentration of the metals investigated in the soil except for Cu, are within the safety limit recommended by FAO/WHO.

Keywords: contamination, pollution, trace metals, bush mint, soil

1. Introduction

Soil and plant pollution by trace metals from automobile emissions is an important environmental issue. 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). The United Nations (UN) estimated that over 600 million people worldwide are exposed to hazardous traffic generated pollutants (UNO, 1989). Mobile sources can contribute to the formation of toxic particulate matter leading to serious public health problems, including premature mortality, aggravation of respiratory and cardiovascular diseases, damage to lung tissues and structures, altered respiratory defense mechanisms, and chronic bronchitis (USEPA, 2007). Besides toxicity, 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. Toxicity studies have established that trace metals can directly damage the human body via impairment of mental and neurological function and alteration of numerous metabolic body processes (Greenwood & Earnshaw, 1986). For example, Pb diminishes Ca in the bones, precludes the synthesis of haemoglobin and affects the kidney and central nervous system (Essian, 1992; Bhata, 2002; Bridges & Zalups, 2005). In fact, this metal has no known importance in human biochemistry and physiology, and consumption even at very low concentration can have serious health implications (Bryan, 1976; Nolan, 2003). Copper is non-toxic, but its soluble forms are poisonous when present in large amounts (Scheinberg, 1991). Zinc is an essential micronutrient that can be found in all tissues of the body and is essential for cell growth, differentiation, healthy immune system and DNA synthesis (Sandstead, 1991; WHO, 1996). Zinc toxicity and gastric distress can occur from moderately high intakes of Zn greater than 150 mg day^{-1} over long period of time (Samman, 2002). Although Cr^{3+} is an essential dietary nutrient for normal glucose metabolism and to potentiate insulin (Cohen et al., 1993; Mertz, 1993), toxicity to lungs and gastrointestinal tract may occur when present in +4 oxidation state (Yu, 2008). Iron is the most abundant trace mineral in the body and is an essential element in most biological systems (Greentree, 1995; Goyer, 1996). It is likely that iron was essential for developing aerobic life on earth, but it is toxic to cells in excessive amount (Williams, 1990). Iron toxicity is largely based on Fenton and Haber Weiss chemistry, where catalytic amounts of iron are sufficient to yield hydroxyl radical ($OH^{•}$) (Halliwel & Gutteridge, 1990). Free radicals formed in these reactions may promote oxidation of protein, peroxidation of membrane lipids and modification of nucleic acid.

Fenton: $Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^{-} + OH^{•}$

$Fe^{3+} + O_2^{-} \rightarrow Fe^{2+} + O_2$

Net reaction (*Haber-Weiss*): $H_2O_2 + O_2^{-} \rightarrow OH^{-} + OH^{•} + O_2$

In order to prevent risk to natural life and public health, it is imperative to assess trace metal pollution in different components of the environment. Although trace metals are naturally present in soil, anthropogenically introduced trace metals from industrial processes, agricultural practices, combustion of fossil fuels and transport are more damaging to fauna and flora than the naturally occurring trace metals (EEA, 1995). Toxic elements such as aforementioned can accumulate in organic matter in soils and these may be uptaken by growing plants (Dara, 1993). Interestingly, high concentration of trace metals in soil is reflected by higher concentration of trace metals in plants and consequently in animals because of the food web (Farago, 1994). Plants having the ability to absorb and accumulate xenobiotics can therefore be used as indicators of environmental pollution (Farago, 1994). This study aimed at the determination of the level of trace metals (Pb, Fe, Cu, Zn, and Cr) as indicated in roadside bush mint plant (*Hyptis suaveolens*) and soil. *Hyptis suaveolens* (L.) (bush mint) is a popular medicinal plant which is found along roads of Abuja, the capital city of Nigeria. We preferred to examine Kubwa, Nyanya and Airport road which have traffic density of 28,000, 90,300 and 80,000 respectively (FRSC, 2011).

2. Materials and Methods

2.1 Sample and Sampling

The soil and plant materials of *Hyptis suaveolens* (L.) were collected from three different sampling areas along Kubwa (A1, A2, A3), Nyanya (B1, B2, B3) and Airport road (C1, C2, C3). The sampling areas were separated from one another by interval of 500 meters. There were 30 samples consisting of 15 plants and 15 soils collected; 5 sampling per sampling area. The sampling points were 2 m, 4 m, 6 m, 8 m & 10 m away from the edge of the road (Figure 1). Whole plant was cut excluding the root. Soil samples were taken down to 10 cm depth beneath each bush mint plant. All samples were collected in polythene bags and taken for further treatment.

2.2 Sample Preparation

Bush mint plant samples were prepared according to the procedures followed by Munson et al. (1990). Grass samples were washed, air dried, crushed to a powder and finally sieved using 25 μm sieve. One (1) g of each plant sample was ashed for 6 hr at 500 ^{o}C in a muffle furnace and kept in desiccators before use. The ash was moistened with water and 3 ml of nitric acid was added. The solution was heated on a hot plate to evaporate excess nitric acid. The solution was cooled, filtered into 50 ml volumetric flask using Whatman 40 filter paper. The filtrate was made up to mark with de-ionized water.

The procedures of Ayodele and Gaya (1998) were used for the pretreatment of soil samples. The soil samples were crushed in porcelain mortar to break the lumps, sieved through a 25 μm sieve and dried to constant weight at 100 ºC. One (1) g portion of each soil sample was digested for 30 minutes with 30 ml of 6M HNO_3. The digest was filtered into 100 ml volumetric flask using Whatman 40 filter paper. The filtrate was made up to mark with de-ionized water.

Five (5) ml of aliquot of the resulting solutions from the foregoing steps was transferred into a 50 ml volumetric flask and was diluted to the mark with de-ionize water. Metal concentrations in these test samples were determined using a Buck Scientific model 210VGP Flame Atomic Absorption Spectrometer (FAAS) operated with a continuous source background correction.

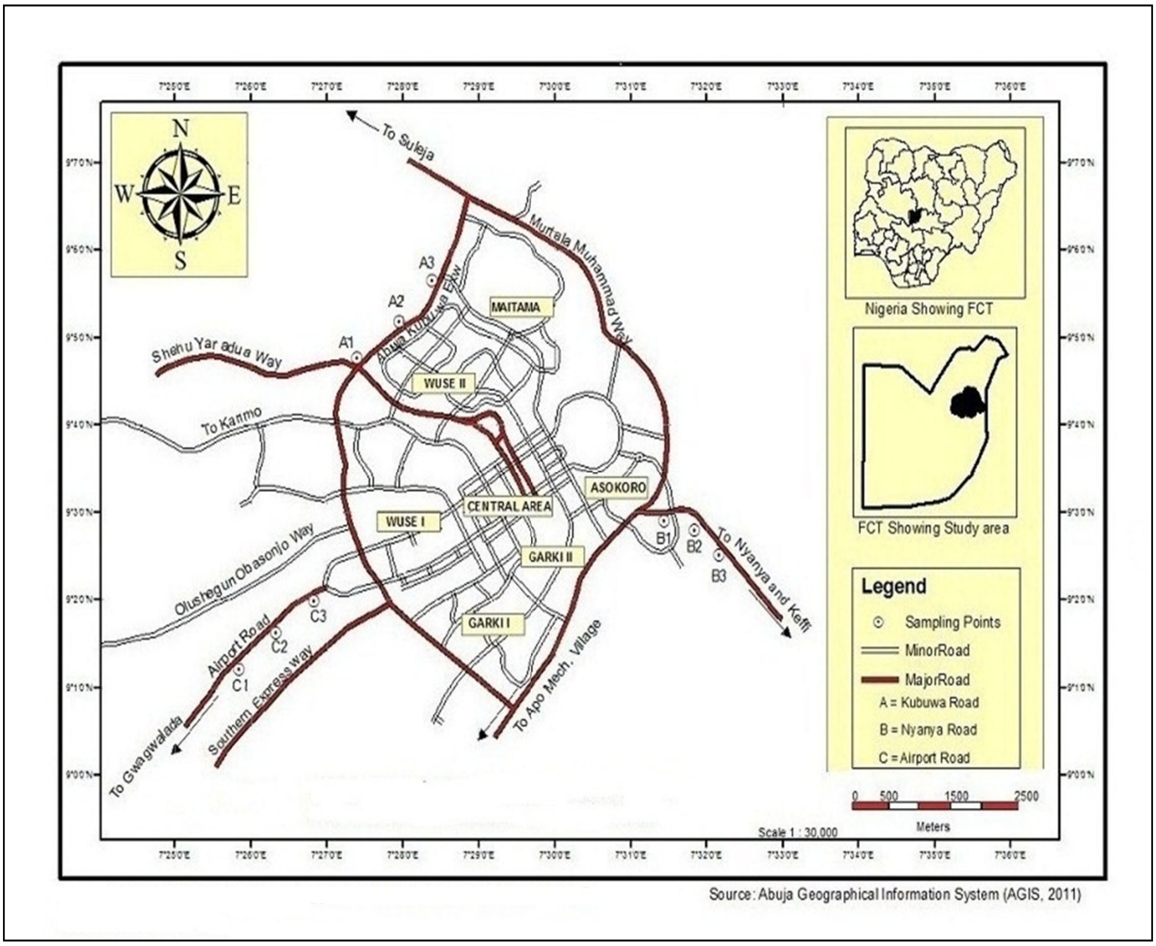


Figure 1. Map of Abuja showing sampling areas A, B and C along Kubwa, Nyanya and Airport road

The soil and plant samples were analysed in triplicate experiments. Analytical data were reported as mean ±SD. Statistical computations were done using Microsoft Excel. The correlation of trace metal in plant and soil samples were verified using Pearson correlation coefficient test, to determine significant difference between data sets of trace metal level in soil and plant, considering a level of significance of less than 5% ($p < 0.05$).

3. Results and Discussion

3.1 Levels of Trace Metals in Roadside Bush Mint

The average level of trace metals (Pb, Fe, Cu, Zn and Cr) in the three representative roads (Airport, Kubwa and Nyanya road) are presented in the following discussions. Figure 2 shows the level of Pb in *Hyptis suaveolens* on Airport road ranging between 32.59 ± 7.14 µg g^{-1} and 9.63 ± 3.57 µg g^{-1}. There was a drastic decrease in the amount of Pb in *Hyptis suaveolens* between 2 m to 6 m which turns gradual between 8 m to 10 m. This may be due to the fact that lead particulate are only transported through a short distance before settling. Similar observation was made in the study earlier reported by Tjell et al. (1979). The Pb level in *Hyptis suaveolens* along Airport road was higher than that of Kubwa road ranging between 32.59 ± 7.14 µg g^{-1} and 9.63 ± 3.57 µg g^{-1}). But the highest level of Pb in *Hyptis suaveolens* was recorded in the samples along Nyanya road (35.92 ± 7.14 µg g^{-1} to 11.11 ± 5.09 µg g^{-1}) which may be due to the fact that Nyanya road has the highest traffic density among the three roads under consideration. The levels Pb in *Hyptis suaveolens* and soil from the sampled areas were higher than that of control (10.44 ± 1.925 µg g^{-1} and 22.00 ± 6.367 µg g^{-1} in plant and soil respectively). Concentration of Pb in *Hyptis suaveolens* is above the limit permitted by FAO/WHO (2011). In each case, lead was found in higher concentration in the samples closest to the road edge specifically 2 m away from the road. This suggests that, the volume of traffic affect significantly the extent to which road side plant can be contaminated with Pb. In fact, the correlation between the plant Pb level and the volume of traffic is significant at 1% ($p<0.01$) (Table 1), that of soil Pb level and traffic volume was significant at 5% ($p<0.05$) (Table 2).

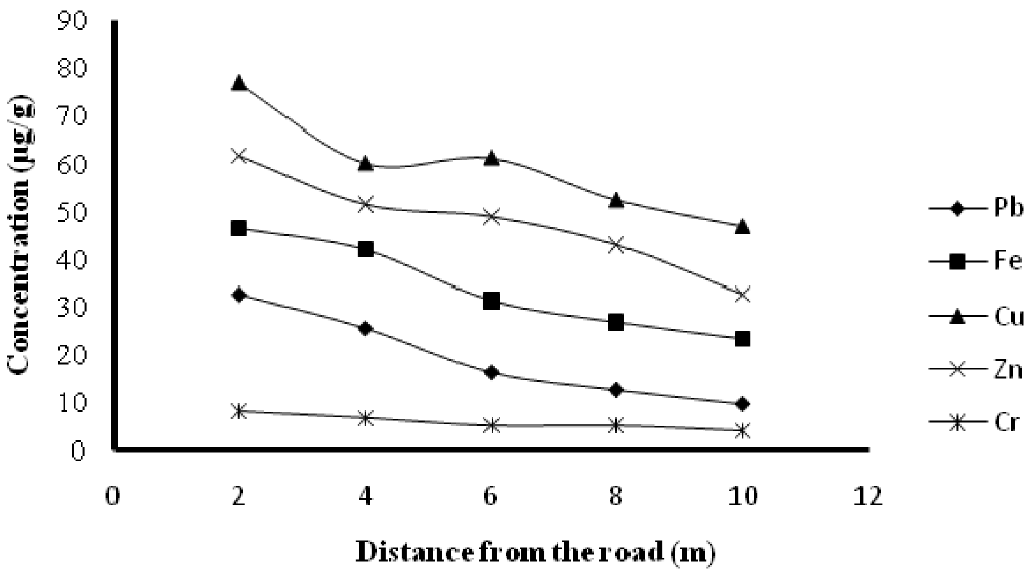


Figure 2. Average concentration of trace metals in *Hyptis suaveolens* away from Airport road

The amounts of Fe in plant tissues (*Hyptis suaveolens*) were of higher concentration on the sample along Nyanya road with maximum value of 50.00 ± 14.45 µg g^{-1} compared to those along Airport road (46.465 ± 13.665 µg g^{-1}) and Kubwa road (35.354 ± 6.123 µg g^{-1}) as shown in Figure 2, 4 and 6 respectively. This suggests that plants along Nyanya road are more exposed to Fe contaminant owing to the heavy traffic along this road. Kubwa road with the least traffic flow show the least level of Fe in *Hyptis suaveolens*. The maximum level of Fe in *Hyptis suaveolens* from all the roads investigated occurred at 2 m from the road edge while the minimum was at 10 m. The content of Fe in *Hyptis Suaveolens* from all the roads under study was above that of control of 17.727 µg g^{-1}. There is significant correlation between Fe in the bush mint plant and traffic volume and between the soil Fe level and traffic volume ($p<0.05$) (Tables 1 & 2).

Highest level of Cu in *Hyptis suaveolens* were at Airport road with concentration ranging between 76.667 ± 12.018 µg g^{-1} and 46.667 ± 10.000 µg g^{-1} (Figure 2). The plant Cu level along this road is higher than that of Nyanya road (containing 58.89 ± 5.09 µg g^{-1} to 35.56 ± 5.09 µg g^{-1} Cu) which has more traffic volume. This suggested that, apart from traffic, the other anthropogenic activities may have lent to the high Cu. Kubwa road with the least traffic volume has the lowest content of Cu in the plant sample (52.22 ± 5.09 µg g^{-1} to 33.33 ± 3.33 µg g^{-1}) (Figure 4). The level of Cu in *Hyptis suaveolens* for the control was 22.667 ± 3.054 µg g^{-1}. Copper content in roadside plant were reported to be in the range of 10.7 to 45.0 µg g^{-1} (Guan & Peart, 2006). Kabata-Pedias (1985) have reported that the normal content of Cu in most plants to be within 2 to 20 µg g^{-1}. Robson and Reuter (1981) explained that the critical level of Cu is 20 to 30 µg g^{-1} for most plants. Result of this investigation shows that *Hyptis suaveolens* from the study areas is at risk of Cu pollution.

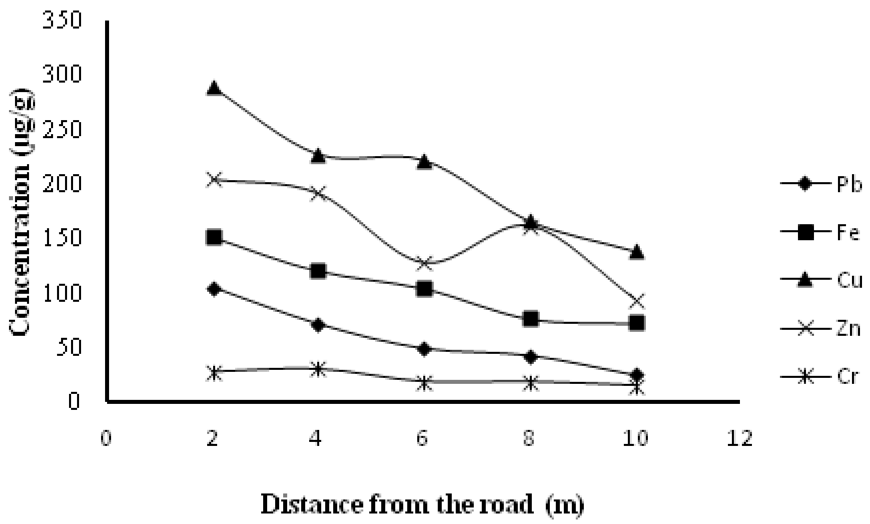


Figure 3. Average concentration of metals in soil away from Airport road

The concentration of Zn in *Hyptis suaveolens* along Airport road ranges from 61.54 ± 6.35 µg g^{-1} to 32.48 ± 3.92 $µgg^{-1}$ (Figure 2). Zinc in *Hyptis suaveolens* along Kubwa road ranges from 64.54 ± 14.29 µg g^{-1} and 41.15 µg g^{-1} ± 6.03 µg g^{-1} (Figure 4) while that of along Nyanya road ranges from 68.38 ± 13.16 µg g^{-1} to 44.69 ± 17.78 µg g^{-1} (Figure 6). The amount of Zn in the control was 25.641 ± 4.263 µg g^{-1}. The profile of Zn distribution in bush mint plant 2 to 10 m away from the three major roads of Abuja clearly indicates higher concentrations closer distance to the road (2 to 4 m). The critical toxic level of Zn for plant is 100 µg g^{-1} (Allen et al., 1974). However, the safety limit of Zn in plant by WHO/FAO (2011) was 60.0 µg g^{-1}, hence, the level of Zn in *Hyptis suaveolens* within 2 m from all the road under investigation were little above the permissible limit, those at 6 to10 m were within the safety limit. On the other hand, the level of Cr in *Hyptis suaveolens* along Airport road ranges from 7.94 ± 1.46 µg g^{-1} to 3.97 ± 0.75 µg g^{-1} with the maximum in the sample at 2 m from away from the road. The distribution of Cr levels in *Hyptis suveolens* along Kubwa road was similar to that of Airport road, with concentrations ranging from 7.23 ± 1.50 µg g^{-1} to 3.58 ± 0.70 µg g^{-1}. Nyanya road has the highest content of Cr in the plant sample which could be attributed to the density of traffic on this road. The Cr level in *Hyptis suaveolens* away from the road is in the range of 9.52 ± 3.46 µg g^{-1} to 5.29 ± 0.31 µg g^{-1}. The level of Cr in the control sample was 2.381 ± 0.873 µg g^{-1}. Generally, the mean concentrations of 3 µg Cr g^{-1} was obtained in the *Hyptis suaveolens* which indicates possible contamination or increased accumulation (Williams, 1988; Janus & Krajnc, 1989). This concentration is however lower than the critical toxic level (5 to 10 µg g^{-1}) (Cicek & Kopral, 2004). On the whole, the result of Cr level in bush mint plant from Nyanya road and Airport road in this investigation require some caution as the Cr concentrations in these areas are within this alarming range.

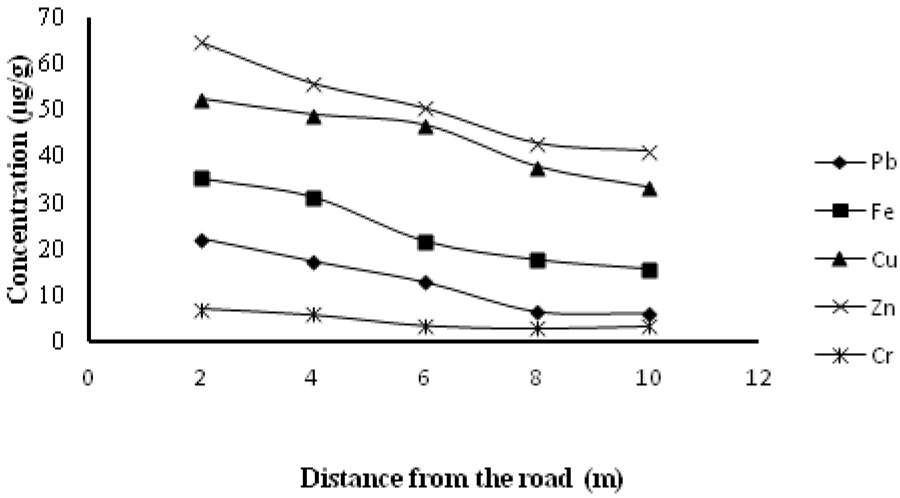


Figure 4. Average concentration of trace metals in *Hyptis suaveolens* along Kubwa road

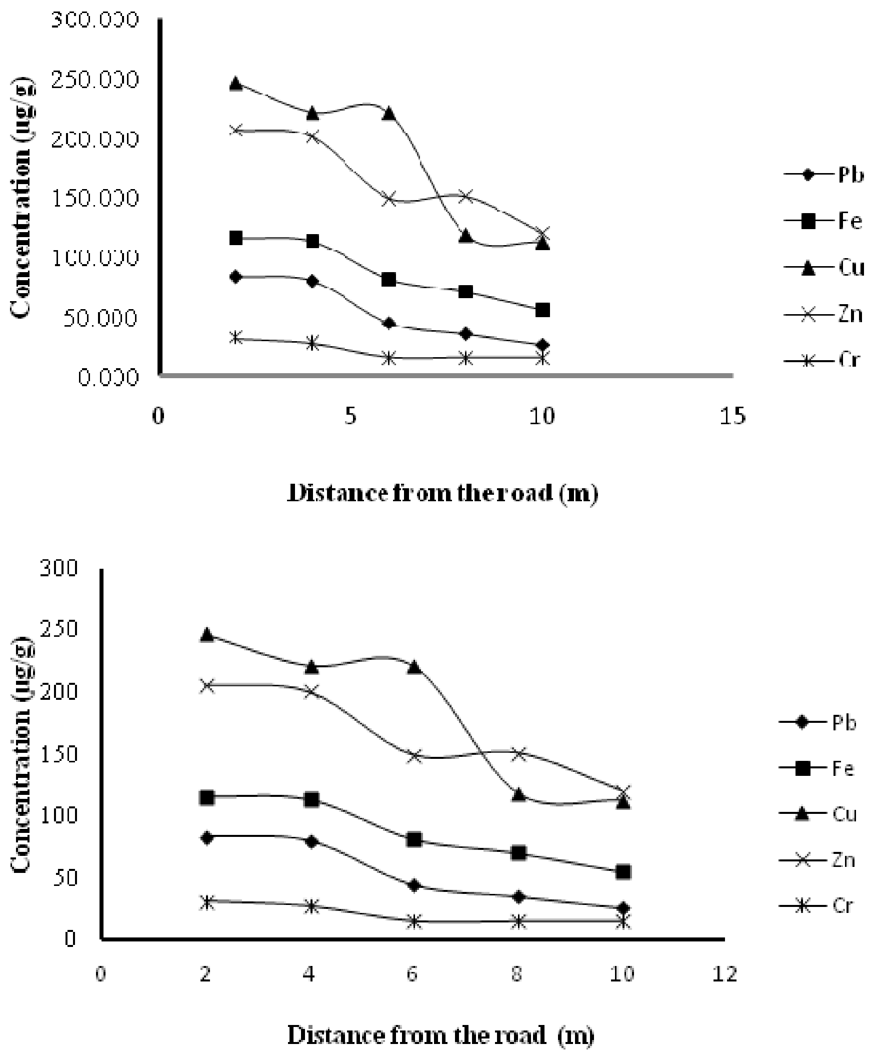
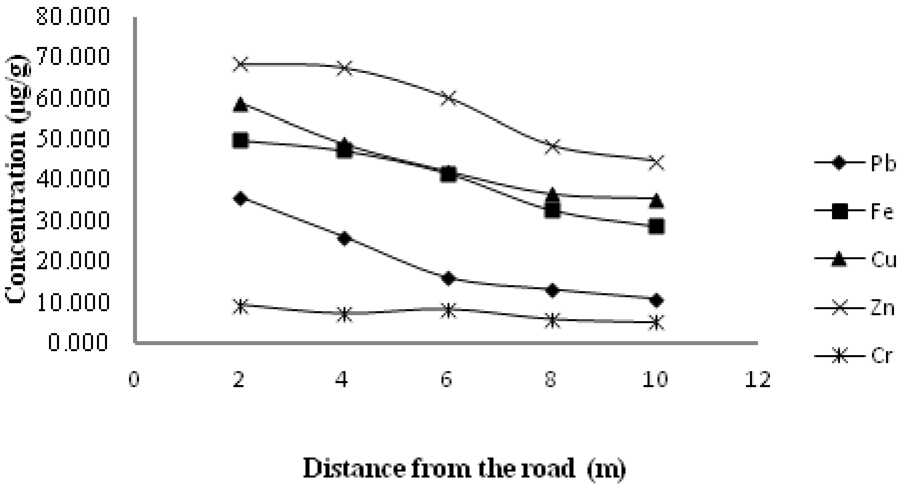


Figure 5. Distribution of trace metals in soil away from Kubwa road

3.2 Levels of Trace Metals in Roadside Soil

In the previous decades, vehicular traffic was the most widespread lead source (Lagerwerf & Specht, 1970) as a result of the use of tetramethyl and tetraethyl lead as anti-knock agent (Ewers & Schliphoter, 1991). Despite the fact that these chemicals are currently discontinued and replaced by environmentally friendly ones, traces of vehicular added lead need to be monitored. Nyanya road contains the highest soil Pb with value ranging from 118.00 ± 7.00 µg g^{-1} to 26.93 ± 4.34 µg g^{-1}. The high density of traffic on this road may be responsible for this. The soil Pb level along Airport road which is next to Nyanya in terms of traffic volume ranges from 105.30 ± 9.07 µg g^{-1} to 25.93 ± 3.21 µg g^{-1} (Figure 3). The soil Pb level along Kubwa road was however the lowest. This is probably as a result of the relatively lower traffic volume along this road compared to that of Nyanya and Airport road. The soil Pb level was above that of control (containing 22.000 ± 6.367 µg g^{-1} of Pb). The concentration of Pb in the soils was however within the safety limit specified by FAO/WHO (2011). Excessive concentrations of lead were observed closer to the road edge which may well be attributed to vehicular sources. Lead contamination of road side soil has previously been established (Jaradat et al., 1999; Abechi et al., 2010; Yahaya et al., 2010). The results obtained in this study agrees with previous study by Onder et al. (2007) to determine trace metal pollution in city green area, where Pb concentration was found to be higher at road edge and then decreases on increasing distance from the road.



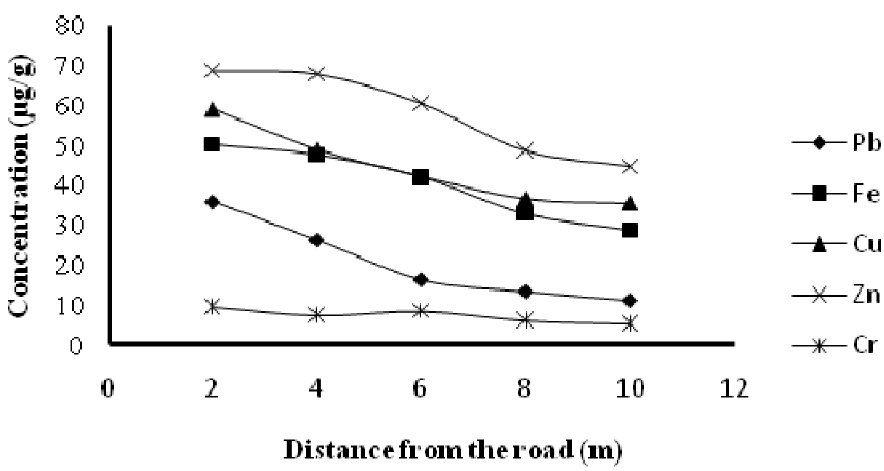
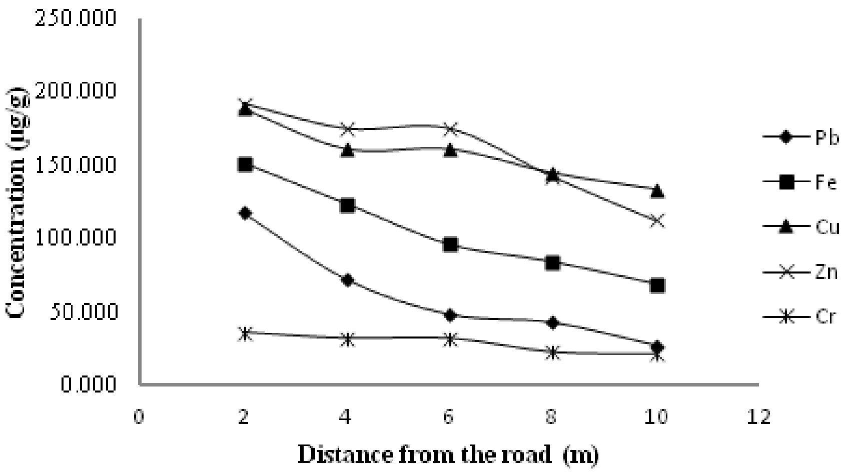


Figure 6. Profile of trace metals in *Hyptis suaveolens* away from Nyanya road

The variation in the level of Fe in the soil samples at various distances of the roadside follow a similar trend as observed in that of plant. The levels of Fe in the soil was however higher than that of the plant bush. The highest soil level of Fe was in the samples along Airport road with soil Fe level of 152.32 ± 16.38 µg g^{-1} compared to Nyanya road (151.52 ± 13.12 µg g^{-1}) and that of Kubwa road of 116.16 ± 11.57 µg g^{-1} (Figures 3, 5 & 7). There is no significant difference in the soil Fe content along Nyanya and Airport road, despite Nyanya road having a higher traffic volume. The soil along Airport road seems to be naturally richer in Fe compared to that of Nyanya. However, the decrease in the Fe level in the soil as the distance from the road increases is as a result of input from vehicular traffic. The soil level of Fe in the control was 68.182 ± 0.000 µg g^{-1}. Iron (Fe) is a major composition of soils, its distribution in decreasing trend as the distance from the road increase as observed in the figures above could be as a result of mechanical abrasion and component wear, from engine, from thrust bearings, bushing and bearing metals. The result obtained is in agreement with that of similar study of some roads in Jos (Abechi et al., 2010).



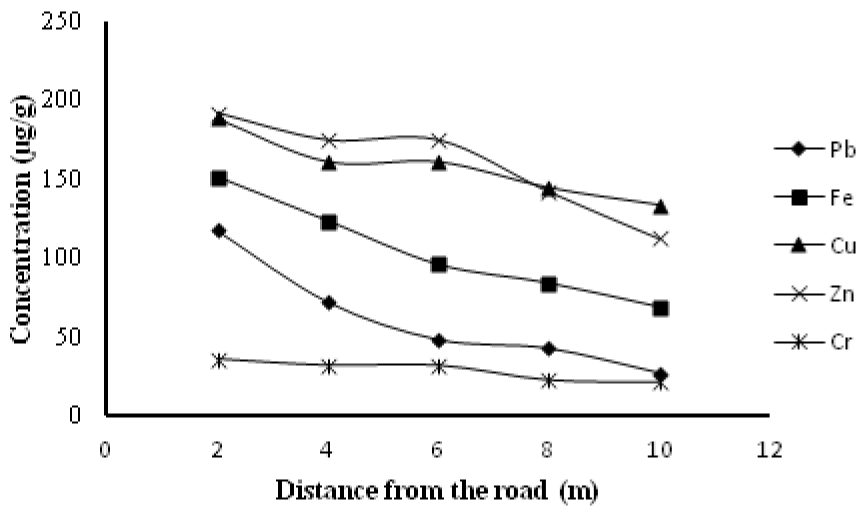


Figure 7. Trace metal concentrations in soils away from Nyanya road

The soil Cu levels in the three busy roads follow a similar pattern observed in the case of plant. Soil sample along Airport road has the highest Cu content (288.89 ± 19.245 µg g^{-1} to 138.89 µg g^{-1} ± 9.623 µg g^{-1}) (Figure 3) followed by Kubwa road (246 ± 16.67 µg g^{-1} to 112.78 µg g^{-1} ± 8.22 µg g^{-1}) (Figure 5). However, the soil samples along Nyanya road however have the lowest level of soil Cu with value (188.89 ± 25.46 µg g^{-1} to

133.33 ± 16.67 μg g^{-1}) (Figure 7), despite having the highest traffic volume. This observation may be attributed to slight change in the natural soil Cu content. The control sample contain 71.667 ± 8.680 μg g^{-1} of Cu. Ordinarily, copper is usually present in soils in concentration range of 0 to 250 μg g^{-1} (Alloway, 1995; Zheng et al., 2000). McGrath and Loveland (1992) reported the Cu content of 1.2 to 150.7 mg kg^{-1} for soils of England and Wales. Relatively however, Cu content in urban and roadside soils, can reach 5 to 10 times higher than these normal concentrations (Nriagu, 1979; Baker & Senft, 1995).

The level of Zn in soils off Airport road (205.13 ± 12.82 μg g^{-1} to 94.02 ± 7.40 μg g^{-1}) (Figure 3) was lower than that of Kubwa road (206.58 ± 7.92 μg g^{-1} to 120.62 ± 3.36 μg g^{-1}) (Figure 5). Nyanya road with highest traffic volume has the least level of soil Zn (192.31 ± 46.23 μg g^{-1} to 112.74 ± 5.91 μg g^{-1}). Zinc levels in the study areas fall within the normal concentrations in soils (1 to 900 μg g^{-1}) (Alloway, 1995). The soil Zn level was higher than that of control (88.205 ± 6.206 μg g^{-1}). There is positive correlation between the level of Zn in the plant sample and the traffic volume but this is less significant at 5% ($p>0.05$) (Table 1). A decrease in the average level of zinc was observed as the distance from the road increases which may be as a result of roadside activities. Aksoy (1996) has reported higher zinc concentrations (410 μg g^{-1}) in urban roadside soils of Bradford.

Comparatively, soil Cr levels were lower than those of other trace metals investigated. The maximum level of Cr was in the soil samples along Nyanya road (35.71 ± 14.31 μg g^{-1}). This decreased for Kubwa road (746 ± 3.97 μg g^{-1}) and then for Airport road (29.10 ± 2.29 μg g^{-1}) (Figures 3, 5 and 7). Since, the toxic level of Cr in soil is around 50 μg g^{-1} (Bergmann, 1992), the study areas can be declared safe with respect to Cr toxicity.

3.3 Relationship between Trace Metal Concentrations in Soil Vis-A-Vis Hyptis suaveolens

The relationship between traffic volume and trace metal levels in the bush mint and soil is shown in Table 1 and Table 2 respectively. The correlation between the concentration of Pb, Fe, Zn, and Cu in soil and Plant was significant ($p<0.05$). Positive correlation for metal content between *Hyptis suaveolens* and soil may be linked to the uptake of these elements from soil by the bush mint plant. However, there was insignificant correlation between Cr level and the plant. The concentration of Cr in the soil is higher than that of plant. Accordingly, many studies have demonstrated that chromium uptake from soils or nutrient solution and translocation to plant cells can be very low. However, concentrations of Cr in the edible portions of the plant may remain low, even when growing on chromium-contaminated soil (Dowdy & Ham, 1977; Lahouti & Peterson, 1979; Sykes et al., 1981; De Haan et al., 1985). Nyanya study area contained the highest Cu concentration in the soil. The changes in concentration of the trace metals in soil were always more drastic compared to that of the plant *Hyptis suaveolens*. Similarly, the bush mint plant contained more Cu than any other trace metal except along Kubwa roadside where Zn was present in exceeding concentrations. The variation in the Cu content in both the plant and soil samples from the road edge shows that the activities of Cu in the samples is as a result of road traffic. This is however independent of traffic as the correlation between the traffic volume, soil and plant Cu is less significant ($p>0.05$) (Tables 1 and 2).

Table 1. Correlation analysis among traffic volume and metals in Bush mint

Distance (m)	Pb	Fe	Cu	Zn	Cr
2	0.994*	0.994*	0.616	0.197	0.817
4	0.999*	0.976**	0.386	0.375	0.900
6	0.992*	0.911	0.168	0.491	0.798
8	0.874	0.961**	0.326	0.588	0.973**
10	0.884	0.953**	0.525	0.110	0.765

*–Correlation is significant at 0.01; **–Correlation is significant at 0.05.

Chromium is a natural component of plant tissues, although concentrations vary considerably between different plant species, plant tissues, and soil types. Levels in shoots of plants grown on uncontaminated soil usually do not exceed 0.5 mg kg^{-1}. The concentration of Cr in plant and soil were highest in the samples close to the road edge and decreases as the distance from the road increases. Chromium concentration in plant and soil sample did not show any significant correlation. However, the plant and soil Cr levels are significantly correlated with the traffic volume ($p<0.05$) (Tables 1 and 2).

Table 2. Correlation analysis among traffic volume and metals in soil

Distance (m)	Pb	Fe	Cu	Zn	Cr
2	0.970**	0.989**	-0.215	-0.837	0.240
4	-0.992	0.993*	-0.531	0.756	0.992*
6	0.896	0.866	-0.173	-0.277	0.779
8	0.969**	0.921	0.935	0.177	0.961**
10	-0.338	-0.106	0.984**	0.991*	-0.091

*–Correlation is significant at 0.01; **–Correlation is significant at 0.05.

Lead is the most common environmental contaminant found in soils. Among trace metals, Pb has long been known as potential hazard to health (Rowchowdhury & Gautum, 1995; Nariagu et al., 1996; Shannon & Graef, 1996). Unlike most other trace metals, Pb has no biological role, and is potentially toxic to organisms (Sobolev & Begonia, 2008). Undesirable and unnatural concentrations of Pb are found in air, water, soil and vegetation, particularly near heavily ply automobile ways (Fuller, 1997; Habashi, 1992). Jaradat et al. (1999) reported that the increasing number of vehicle on the road during the last few years, in Jordan, mostly operated by leaded fuel, have lead to high levels of some trace metals and other pollutants in soil and plants near highways in both rural and urban areas. According to Fergusson (1990), Pb-containing particles in motor vehicle exhausts tend to be larger near motorways in urban areas. Roadsides soils and vegetations are prone to Pb particles and this could be as a result of wind action and vehicular emission (Naima et al., 2010). Plants near road ways have relative increase of Pb deposition due to vehicles using leaded petrol (Bu-Olayan & Thomas, 2002).

3.4 Transfer Factors from Soils to Plant

Transfer factor (TF) defined as the ratio of trace metal concentration in plant and trace metal concentration in soil were computed in order to surmise the extent of transfer of soil trace metals into the plant. The transfer factor ranges for Pb, Fe, Zn, Cu and Cr from the soil to the plant *Hyptis suaveolens* are displayed in Table 3. Notably, the TF values of lead from soil to plant varied from 0.304 to 0.413 by Nyanya road, 0.288 to 0.354 by airport road, 0.189 to 0.292 by Kubwa road. Generally, from the table it may be inferred that Cr is relatively transferred to the plant largely poorly while great uptake of Pb and Fe are observed. The accumulation factor of Cu in the plants did not show particular pattern along the roads.

Table 3. Transfer factor of trace metals from soil to plant 2-10 m away from Abuja roads

Distance (2-10 m)	Pb	Fe	Cu	Zn	Cr
Nyanya road	0.304-0.304	0.330-0.437	0.254-0.312	0.341-0.396	0.233-0.271
Airport road	0.288-0.371	0.298-0.346	0.263-0.336	0.263-0.380	0.208-0.273
Kubwa road	0.189-0.292	0.250-0.304	0.211-0.318	0.277-0.341	0.196-0.233

4. Conclusion

The result of this study revealed the distribution of trace metals (Pb, Fe, Zn, Cu, and Cr) in the roadside soils and bush mint plant along some major roads in the capital city of Nigeria. Trace metal profiles decreased with distance away from Abuja roads which indicate the impact of vehicular traffic on the environment. The concentrations of trace metals in both the soils and plants are in the order of Cu > Zn > Fe > Pb > Cr in decreasing order of concentration except in the soil sample from Nyanya and the plant sample from Kubwa road where Zn is present in the highest amount. The levels of the metals are high compared to those of the control samples which indicated that there is accumulation of these metals in the soil and subsequent transfer to plants growing along the highway. Transfer factors have shown relatively higher accumulation of Pb and Fe.

Generally, the maximum levels of Pb, Fe, Zn, and Cr in soil along each road were within the safety limit guidelines proposed by most regulatory bodies. The level of copper in soil however calls for concern. Similarly, the concentration of the metals Pb, Cu and Fe in the bush mint is alarming as this was found to exceed the safety limit guidelines set by most regulatory bodies. There is significant correlation between the Pb and Fe in plant tissues and traffic volume which indicates contributions from anthropogenic activities.

Acknowledgements

The authors acknowledge the contribution of Mr Joshua Kubai of the Analytical laboratory at the Department of Pure and Industrial Chemistry, Bayero University, Kano.

References

Abechi, E. S., Okunola, O. J., Zubairu, S. M. J., Usman, A. A., & Apene, E. (2010). Evaluation of heavy metals in roadside soils of major streets in Jos metropolis, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology, 2*(6), 98-102.

Aksoy, A. (1996). *Autecology of Capsella bursa-pastoris (L) Medic* (Unpublished PhD thesis, University of Bradford, Bradford, 1996).

Allen, S. E., Grimshow, H. M., Parkinson, J. A., & Quarmby, C. (1974). *Chemical analysis of Ecological materials. Osney Mead*. Oxford, UK: Blackwell Scientific Publication.

Alloway, B. J. (1995). *Heavy Metals in Soils*. London: Chapman & Hall. http://dx.doi.org/10.1007/978-94-011-1344-1

Ayodele, J. T., & Gaya, U. M. (1998). Chromium Manganese and Zinc in Kano Municipality Street dust. *J. Chem. Soc. Nigeria, 23*, 24-34.

Baker, D. E., & Senft, J. P. (1995). Copper. In 'Heavy Metals in Soils. In B. J. Alloway (Ed.), *Heavy metals in soils* (2nd ed., pp. 179-205). London: Blackie Academic and Professional.

Bergmann, W. (1992). *Nutritional disorder of plants*. New York: Gustav Fischer.

Bhata, S. C. (2002). *Environmental Chemistry* (pp. 442). New Delhi: CBS Publishes and Distributors.

Bhatia, I., & Choudhri, G. N. (1991). Impact of automobile effusion on plant and soil. *International Journal of Ecology and Environmental Sciences, 17*, 121-127.

Bridges, C. C., & Zalups, R. K. (2005). Molecular and ionic mimicry and the transport of toxic metals. *Toxicol. and Appl. Pharmacol., 204*(3), 274-308. http://dx.doi.org/10.1016/j.taap.2004.09.007

Bryan, G. W. (1976). Heavy Metal contamination in sea. In R. Johnson (Ed.), *Marine pollution* (pp.185-302). Academic Press.

Bu-Olayan A. H., & Thomas, B. U. (2002). Biomonitoring studies on the Lead levels in Mesquite (Prosopis juliflora L.) in the arid ecosystem of Kuwait. *Kuwait J. Sci. Eng., 29*(1), 65-73.

Cicek, A., & Koparal, A. S. (2004). Accumulation of soil heavy metals in soil and trees leaves sampled from the surrounding of Tuncbilek Thermal Power Plant. *Chemosphere, 57*, 1031-1036. http://dx.doi.org/10.1016/j.chemosphere.2004.07.038

Cohen, M. D., Kargacin, B., Klein, C. B., & Costa, M. (1993). Mechanisms of chromium carcinogenicity and toxicity. *Critical Reviews in Toxicology, 23*(3), 255-81. http://dx.doi.org/10.3109/10408449309105012

Dara, S. S. (1993). *A text book of environmental chemistry and pollution control* (pp. 167-206). New Delhi: Rjendra Rarindra Printers (PVT) Ltd Ram Niger.

De Haan, S., Rethfeld, H., & van Driel, W. (1985). *Acceptable levels of heavy metals (Cr, Cu, Pb, Zn) in soils, depending on their clay and humus content and cation-exchange capacity*. Haren, The Netherlands: Instituut voor Boodenvruchtbaarheid.

Dolan, L. M. J., Van Bohemen, H., Whelan, P., Akbar, K. F., O'Malley, V., O'Leary, G., & Keizer, P. J. (2006). Towards the sustainable development of modern road ecosystem (pp. 275-331). In J. Davenport, & J. L. Davenport (Eds.), *The Ecology of Transportation: Managing Mobility for the Environment*. Netherlands: Springer. http://dx.doi.org/10.1007/1-4020-4504-2_13

Dowdy, R. H., & Ham, G. E. (1977). Soybean growth and elemental content as influenced by soil amendments of sewage sludge and heavy metals: Seedling studies. *Agron. J., 69*, 300-303. http://dx.doi.org/10.2134/agronj1977.00021962006900020024x

EEA. (1995). Soil Pollution by heavy metals. *Europe's environment the Dobris assessment* (p. 676). European Environmental Agency, Luxembourg: Office des Publications.

Essian, E. U. (1992). Differential accumulation of lead on selected edible vegetables associated with roadside gardening in Nig. Trop. *J. Applied Sciences, 1*(2), 83-86.

Ewers, U., & Schlipkoter, H. W. (1991). Chronic Toxicity of metals and metals compounds. In E. Merian (Ed.), *Metal and their compounds in the Environment* (pp. 591-603). VCH, Weinheim, New York: Verlag SegSell Schaft Mbh.

FAO/WHO. (2011). Joint FAO/WHO food standards Programme. *Report of the 5th session of the codex committee on contaminants in foods* (CCCF) (pp. 64-89), March 21-25, 2011, The Hague, The Netherlands.

Farago, M. E. (1994). Plants as indicators of mineralization and pollution, In M. E. Farago (Ed.), *Plants and chemical elements* (pp. 221). VCH, Wienheim.

Fergusson, J. E. (1990). *The heavy elements: Chemistry, environmental impacts and health effects*. Oxford: Pergamon press.

FRSC. (2011). *Road count details, Federal Road Safety Corps, Federal Capital Territory (FCT) sector command, Abuja*.

Fuller, E. C. (1997). *Chemistry and Man's Environment* (pp. 22-26). Boston: Houghton Mifflin Publishing Company.

Goyer, R. A. (1996). Toxic effects of metals. In C. D. Klaassen (Ed.), *Casarett & Doull's toxicology: the basic science of poisons* (5th ed., pp. 715-716). New York: McGraw-Hill.

Greentree, W. F., & Hall, J. O. (1995). Iron toxicosis. In J. D. Bonagura (Ed.), *Kirks current therapy XII. Small animal practice* (pp. 240-242). Philadelphia: W. B. Saunders Co.

Greenwood, N. N., & Earnshaw, A. (1986). *Chemistry of the elements*. Oxford, U.K.: Pergamon Press.

Guan, D., & Peart, M. R. (2006). Heavy metal concentration in plants at roadside locations and parks of urban guangzou, *Journal of Environmental Sciences, 18*(3), 495-502.

Habashi, F. (1992). *Environmental issues in the metallurgical Industry Progress and Problems, Environmental issues and Waste Management in Energy and Mineral Production* (pp. 1143-1153). Rotherdam: Balkama.

Halliwell, B., & Gutteridge, J. M. C. (1990). The role of free radicals and catalytic metal ions in human disease: an overview. *Methods Enzymol. 186*, 1-85. http://dx.doi.org/10.1016/0076-6879(90)86093-B

Janus, J. A., & Krajnc, E. I. (1989). *Integrated criteria document chromium: Effects* (Appendix to report no. 758701001). National Institute of Public Health and Environmental Protection, Bilthoven, Netherlands.

Jaradat, Q. M., & Moman, K. A. (1999). Contamination of Roadside Soil, Plants, and Air With Heavy Metals in Jordan, A Comparative Study. *Turk J. Chem, 23*, 209-220.

Kabata-Pedias, A. (2000). *Trace elements in soil and plants* (pp. 57-59). CRC Press Book.

Lagerwerf, J. V., & Specht, A. W. (1970). Contamination of roadside soil and vegetation with cadmium, nickel, lead and zinc. *Environmental Science and Technology, 4*, 583-586. http://dx.doi.org/10.1021/es60042a001

Lahouti, M., & Peterson, P. J. (1979). Chromium accumulation and distribution in crop plants. *J. Sci. Food Agri., 30*, 136-142. http://dx.doi.org/10.1002/jsfa.2740300207

Mcgrath, S. P., & Loveland, P. J. (1992). *The Soil Geochemical Atlas of England and Wales*. London: Blackie Academic & Professional.

Mertz, W. (1993). Chromium occurrence and function in biological systems. *Physiol. Rev. 49*, 163-239.

Munson, R. D., & Nelson, W. L. (1990). Principle and Practices in Plant Analysis. In R. L.Westerman. (Ed.), *Soil testing and Plant analysis* (pp.359-389). Madison, USA.

Naima, H. N., Aima, I. B., Fayyaz, U., & Uzma, H. (2010). Leaves of roadside plants as bioindicator of traffic related lead pollution during different seasons in Sargodha, Pakistan. *African Journal of Environmental Science and Technology, 4*(11), 770-774.

Nariagu, J. O., Blankson, M. L., & Ocran, K. (1996). Childhood lead poisoning in Africa: A growing public health problem. *Sci. Total Environ, 181*(2), 93. http://dx.doi.org/10.1016/0048-9697(95)04954-1

Nolan, K. (2003). Copper toxicity syndrome. *J. Orthomol. Psychiatry, 12*(4), 270-282.

Nriagu, J. O. (1979). Copper in the atmosphere and precipitation. In J. O. Nriagu (Ed.), *Copper in the Environment. Part 1* (pp. 43-75). Chichester: John Wiley.

Onder, S., Dursun, Gezgin, .S., & Demirbas, A. (2007). Determination of Heavy Metal Pollution in Grass and Soil of City Centre Green Area. *Polish Journal of environ. Stud., 16*(1), 145-154.

Robson, A. D., & Reuter, D. J. (1981). Diagnosis of Copper deficiency and toxicity. In J. F. Loneragen, A. D. Robson, & R. B. Graham (Eds.), *Copper in soils and plants* (pp. 287-312). London: Academic press.

Rowchowdhury, A., & Gautum, A. K. (1995). Alteration of human sperms and other seminal constituents after lead exposure. *Ind. J. Physiol. Allied Sci., 49*(2), 68.

Samman, S. (2002). Trace Elements. In J. Mann, & A. S. Truswell (Eds.), *Essentials of human nutrition* (2nd ed.). New York: Oxford University Press.

Sandstead, H. H. (1991). Zinc deficiency. A public health problem? *Am. J. Dis. Child, 145*(8), 853-9.

Scheinberg, I. H. (1991). Copper. In E. Meria (Ed.), *Metals and their compounds in the environment* (pp. 893-908). Weinheim, New York: VCH. Verlags segsellschaft Mbh.

Schwela, D. (2000). Air pollution and health in urban areas. *Reviews on Environmental Health, 15*(1-2), 13-42. http://dx.doi.org/10.1515/REVEH.2000.15.1-2.13

Shannon, M., & Graef, J. W. (1996). Lead intoxication in children with pervasive developmental disorders. *J. Toxicol. Clin. Toxicol., 34*(2), 177. http://dx.doi.org/10.3109/15563659609013767

Sobolev, D., & Begonia, M. F. T. (2008). Effects of Heavy Metal Contamination upon Soil Microbes: Lead-induced Changes in General and Denitrifying Microbial Communities as Evidenced by Molecular Markers. *Int. J. Environ. Res. Public Health, 5*(5), 451. http://dx.doi.org/10.3390/ijerph5050450

Sykes, R. L., Corning, D. R., & Earl, J. (1981). The effect of soil-chromium III on the growth and chromium absorption of various plants. *J. Am. Leather Chem. Assoc, 76*, 102-126.

Tjell, J. C., Hovmand, M. F., & Mosback, H. (1979). Atmospheric pollution of grass grown in a Background area in Denmark. *Nature, 2080*, 425-426. http://dx.doi.org/10.1038/280425a0

UNO. (1988). Prospects of world urbanization. *United Nations Organisation, Population study no. 112*. New York.

USEPA. (2007). *Mobile source air toxics-regulations. Control of hazardous air pollutants from mobile sources.* Office of Transportation and Air Quality, United State Environmental Protection Agency. Retrieved from http://www.epa.gov/otaq/toxics-regs.htm#02262007

Williams, J. H. (1988). *Chromium in sewage sludge applied to agricultural land*. Office of Official Publications for the Commission of the European Communities, Brussels.

Yahaya, M. I., Ezeh, M. I., Musa, Y. F., & Mohammad, S. Y. (2010). Analysis of heavy metals concentration in road sides soil in Yauri, Nigeria. *African Journal of Pure and Applied Chemistry, 4*(3), 22-30.

Yu, D. (2008). Chromium toxicity. In: *Case studies in Environmental Medicine*. Agency for toxic substances and disease registry (ATSDR). Retrieved from http://www.atsdr.cdc.gov/csem/chromium/docs/chromium.pdf

Zheng, C. R., Tu, C., & Shen, Z. G. (2000). Chemical method and phytoremediation of soil contaminated with heavy metals. *Chemosphere, 41*, 229-234. http://dx.doi.org/10.1016/S0045-6535(99)00415-4