ChemSearch Journal 4(1): 6 – 13, June, 2013
Publication of Chemical Society of Nigeria, Kano Chapter

Received: 28/02/2013 Accepted: 02/04/2013

Analysis of Some Heavy Metals in Grass (*Paspalum Orbiculare*) and Soil Samples Along Major Highways in Kano.

Sa'idu, U., Sa'id, M.D. and Ayodele J.T.
Department of Pure and Industrial Chemistry, Bayero University, Kano, Nigeria
usmaniyya2000@gmail.com, dayyibmds@yahoo.com

ABSTRACT

The increased deposition of trace metals from vehicle exhausts on plants has raised concerns about the risks of the quality of food consumed by humans since the heavy metals emitted through the exhaust by vehicles can enter food chain through deposition on grass grazed by animals. Grass (*Paspalum Orbiculare*) and soil samples were collected from four major highways in Kano, at distance interval of 1,2,3,4 and 5 meters away from the edge of the road. The samples were analyzed for Cd, Fe and Pb using Atomic Absorption Spectrophotometer (AAS). The levels of Fe, Pb and Cd in grass were found to be 5.80±3.11 – 12.60±5.53μg/g, 8.60±4.16 – 12.00±8.19μg/g and 0.12±0.06 – 0.19±0.07μg/g dry weight respectively. The ranges of concentrations in soil were from 5.40±2.51 – 8.20±4.66μg/g, 7.80±3.96 – 13.80±4.60μg/g and 0.18±0.08.25±0.08μg/g dry weight for Fe, Pb and Cd respectively. Heavy metals in the four major roads were significantly higher ($P < 0.05$) than those on the reference site. The results showed that the levels of Cd and Pb exceeded the limit levels (0.01 – 0.03μg/g for Cd, <7.00μg/g for Pb) and signifies that metal dynamics up the food chain is highly possible.

Keywords: Food chain, Grass, Heavy metals, *Paspalum orbiculare*, Soil.

INTRODUCTION

Increasing industrialization accompanied by road haulage, extraction and redistribution of heavy metals from natural deposits has made many of these undergone chemical changes through biochemical processes into useful forms. Plants and animals take up metals from the soil and concentrate them. Some of these metals are essential in low concentration for the survival of all forms of life and are described as essential trace elements. When present in greater quantities the heavy metals may cause metabolic anomalies (Annexes, 2003). These metals are of public interest as new techniques have made it possible to detect them in traces. Their warnings, particularly with regard to the effects on health of chronic consumption and the accumulations to which this leads, have startled the public and, at times, have generated genuine hysteria (Ohnesorge and Wilhelm, 1991; Annexes, 2003).

Metals are circulated by biogeochemical processes. Some are essential and their deficiency result in impairment of biological functions (Annexes, 2003).When present in excess, essential metals may become toxic. Other metals not known to have essential functions may give rise to toxic manifestations when intakes are in excess (Friberg and Nordberg, 1986). Unlike organic chemicals eliminated from tissues by metabolic degradation, the metals are indestructible and therefore have potential for accumulation. Accumulation in tissues does not necessarily imply the occurrence of toxic effects because inactive complexes or storage may be formed by certain metals (Clarkson,1986). The criteria for determining whether or not an element is essential are its influence on the organisms and in its metabolism such that the organism can neither grow nor complete its life cycle without adequate supply and the element cannot be wholly replaced by any other (Alloway, 1990). Food plants that tolerate high concentrations of potentially hazardous metals create greater health risks to their consumers than those that are more sensitive. In general, food plants are more sensitive to Cu and zinc than to Pb and Cd (Alloway, 1990). Excessive uptake of both essential and non essential metals may result in adverse effects on soil biota, plants and transfer via the food chain on mammals, birds and human consumers (Alloway, 1990). Heavy metals may be emitted into the environment in different ways, i.e. transportation, industry, fossil fuels, agriculture and other human activities (Onder *et al.*, 2007). The most economical and reasonable method for monitoring heavy metal levels in the atmosphere is using vegetation and soil samples. Scots pines (Yilmaz and Zengin, 2003), acacia (Aksoy, et. al., 2000), grass (Fatoki, 2003), and other organisms have also been used for monitoring (Onder *et al*., 2007).

This paper is aimed at assessing the levels of contamination of roadside grass and soil by Cd, Pb and Fe along four major roads in Kano and to assess how these levels may pose risks on animals and human health through food chain.

MATERIALS AND METHODS

In the preparation of reagents, analytical grade chemicals and distilled deionised water were used. All glass wares were washed with detergent and rinsed with distilled water before drying in the oven at 105^{o}C. All weighing were on Toledo AB54 analytical weighing balance

.

Sampling

The sampling sites are Kano - Zaria, Kano - Katsina, Kano - Maiduguri and Kano - Gwarzo roads (Fig. 1). 20 samples were taken on both sides of the road from each sampling area. Each sides with 2 rows, 10m away from each other. On each row, grass samples were taken at a distance interval of 1,2,3,4 and 5 meters from the edge of the road. Similarly, the soil was also sampled in the same way as the grass. The control samples were taken in a site characterized by no traffic densities. The site is sparsely populated and basically residential with no industrial activity taking place.

Sample Treatment

The grass samples were dried in an oven at 100^{O}C for 48hrs (Atayese *et al*., 2009). The dry samples were crushed in a mortar and passed through 250µm sieve (Munson and Nelson, 1990). Each soil sample was oven dried at 110^{O}C to constant weight. The resulting powder was packaged in a polyethene bottle for the analysis of the heavy metals.

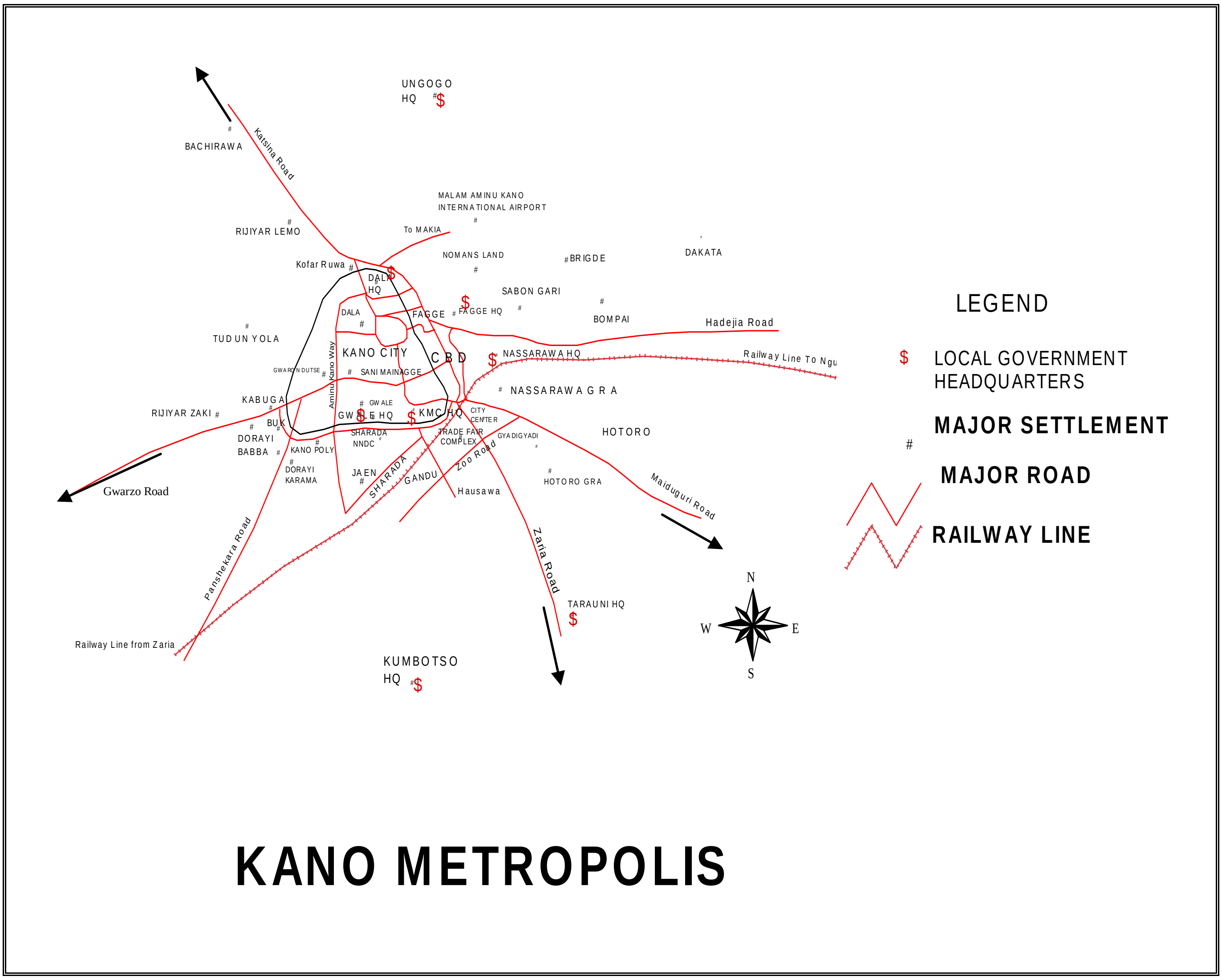

Fig 1:Map of Kano Showing the Sampling Sites

Procedure

0.5g of the grass sample was transferred to a $25cm^3$ conical flask; $5cm^3$ of concentrated H_2SO_4 was added followed by $25cm^3$ of conc. HNO_3 acid and $5cm^3$ of conc. HCl. The contents of the conical flask were heated at 200^OC for 1hr in fuming hood, and then cooled to room temperature. Then, $20cm^3$ of distilled water was added and the mixture was filtered using filter paper to complete the digestion (Atayese *et al*., 2009). The mixture was transferred to a $50cm^3$ volumetric flasks, filled to the mark, and allowed to settle (Atayese *et al*., 2009). The resultant solution was analyzed for Cd, Fe and Pb. The same procedure was used for the soil samples.

Metal concentrations were determined on a Buck Scientific Model 210VGP Atomic Absorption Spectrometer (AAS). The result of each sample was the average of four replicate readings. Distilled deionised water used as blank was digested using the above procedures.

RESULTS AND DISCUSSION

The trace metal concentrations in grass and soil samples from various sites are as shown in Figs 2-9. The various sampling areas are Kano-Zaria, Kano-Katsina, Kano-Maiduguri, and Kano-Gwarzo roads.

Kano- Zaria road has a traffic flow of about 120,000 vehicles per day (FRSC, 2009). The concentration of heavy metals in grass and soil samples along Kano-Zaria road at 1-5 meters from the edge of the road is shown in Figs. 2 and 3 respectively. The Pb concentrations in grass decreased from 18.00µg/g to 5.00µg/g (Fig. 2), while in soil it decreased from 15.00µg/g to 0.5µg/g (Fig. 3). Heavy metals concentrations in both grass and soil samples were found to follow the order; Pb > Fe > Cd. The result showed that the heavy metals concentration in both grass and soil samples were significantly correlated with distance ($P \geq 0.05$). The high concentrations of Pb and Fe in grass are as a result of its direct deposition. This deposition pattern is similar to results earlier reported by other workers (Van and Smilde, 1990; Uwagboe, et al., 2008).

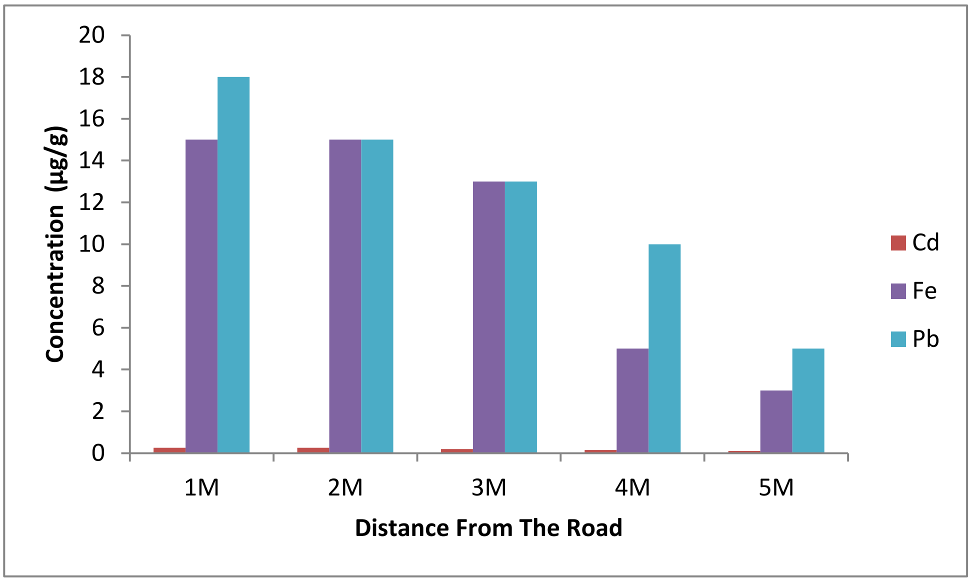

Fig. 2: Heavy metals concentration in grass along Kano-Zaria Road

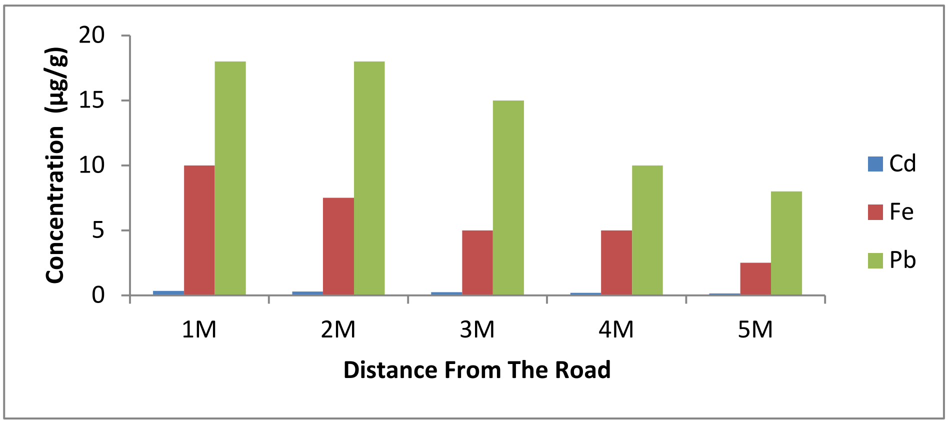

Fig. 3. Heavy metals concentration in soil along Kano-Zaria Road

The concentrations of heavy metals in grass and soil samples along Kano- Katsina road are as shown in Figs. 4 and 5 respectively. The Fe concentrations in grass decreased from 10.00µg/g to 3.00µg/g (Fig. 4), while in soil it decreased from 8.00µg/g to 3.00µg/g (Fig. 5). The concentrations of these heavy metals in roadside grass and soil followed the order; Pb > Fe > Cd. There is general decreased in concentration with increased in distance in all the samples analyzed. This result is in line with other result earlier reported (Atayese et al., 2009).

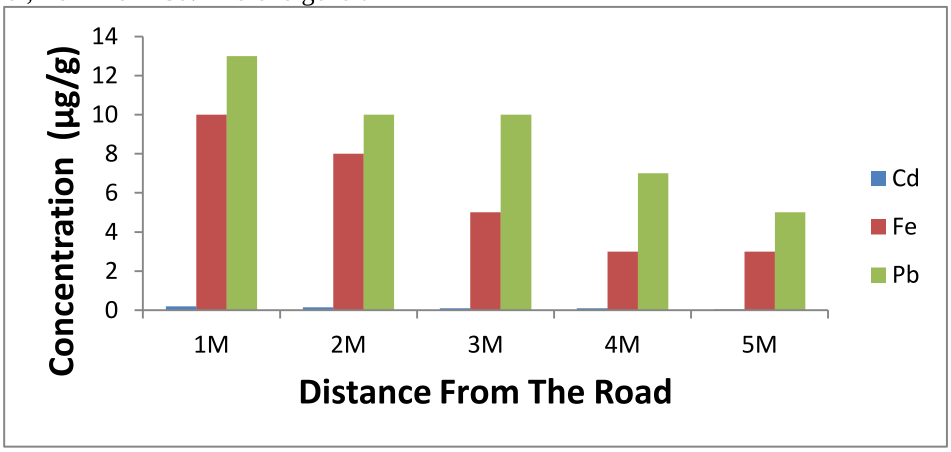

Fig. 4. Heavy metals concentration in grass along Kano – Katsina Road.

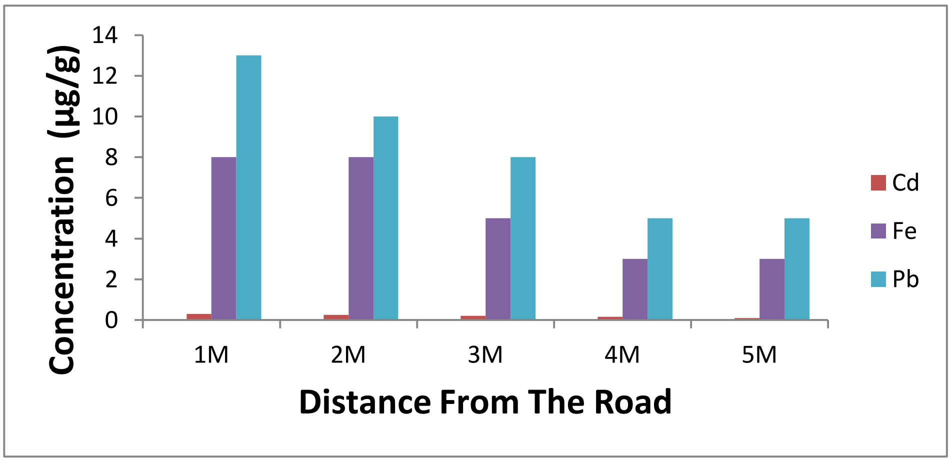

Fig. 5. Heavy metals concentration in soil along Kano-Katsina Road

Kano- Maiduguri road has a traffic flow of about 95,000 vehicles per day (Federal Road Safety Corps (FRSC), 2009). The concentration of heavy metals in grass and soil samples along Kano – Maiduguri road at 1-5 meters from the edge of the road is as shown in Figs. 6 and 7 respectively. At a meter away from the road, iron concentration in grass was 20.00μg/g while in soil was 15.00μg/g. As the distance increased, its concentrations in both grass and soil decreased to 5.00μg/g. The concentrations of these heavy metals in both grass and soil samples followed the order; Fe > Pb > Cd. The result showed that iron concentrations in grass and soil were significantly correlated with distance ($P > 0.05$).

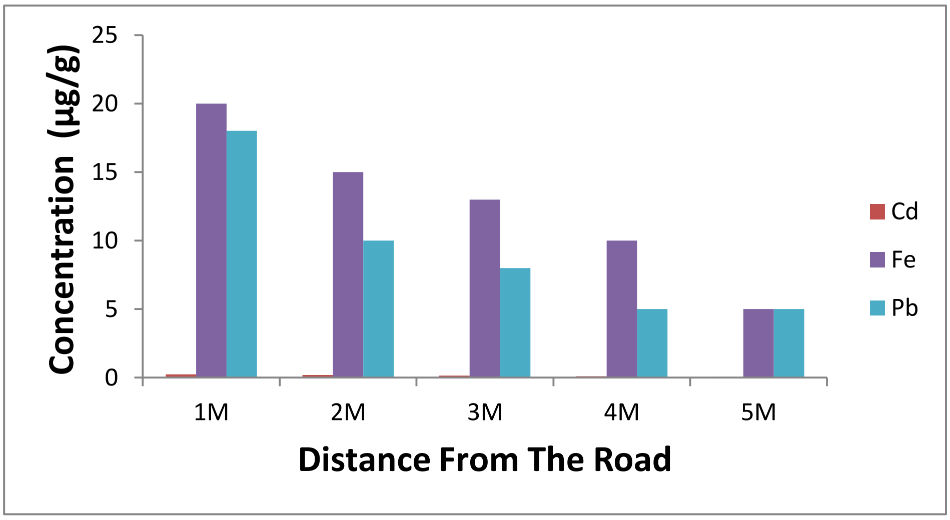

Fig. 6. Heavy Metals Concentration in Grass Along Kano – Maiduguri Road

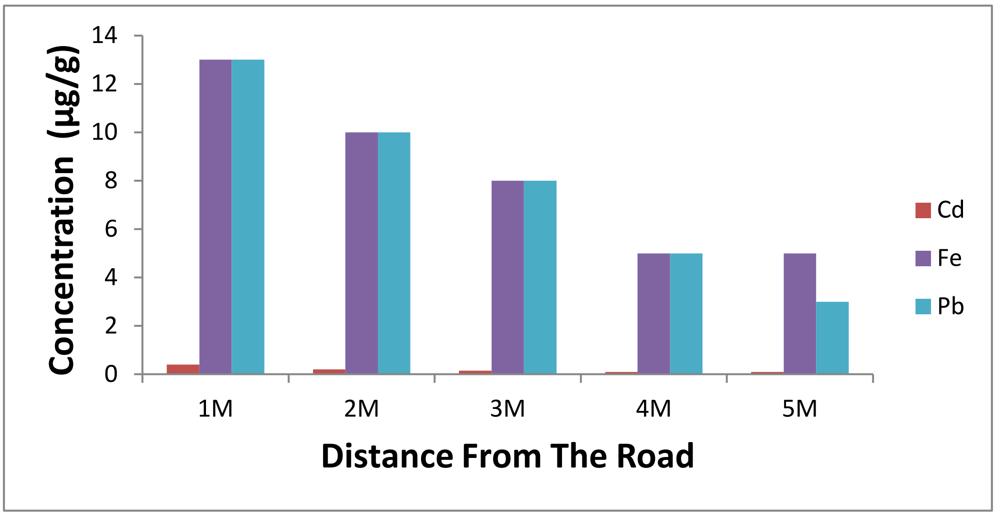

Fig. 7. Heavy metals concentration in soil along Kano-Maiduguri Road

The concentrations of heavy metals in grass and soil samples along Kano - Gwarzo road at 1-5 meters from the edge of the road are as shown in Figs. 8 and 9 respectively. The Fe concentration in grass decreased from 25.00μg/g to 3.00μg/g, while in soil, it decreased from 15.00μg/g to 3.00μg/g. The concentrations of these metals in grass samples followed the order; Fe > Pb > Cd, while the concentrations in soil were found to follow the order; Pb > Fe > Cd. Generally, there is the evidence of decreased in concentration of these heavy metals with increase in distance from the edge of the road in both grass and soil samples. This result is similar to that of Atayese et al., (2009).

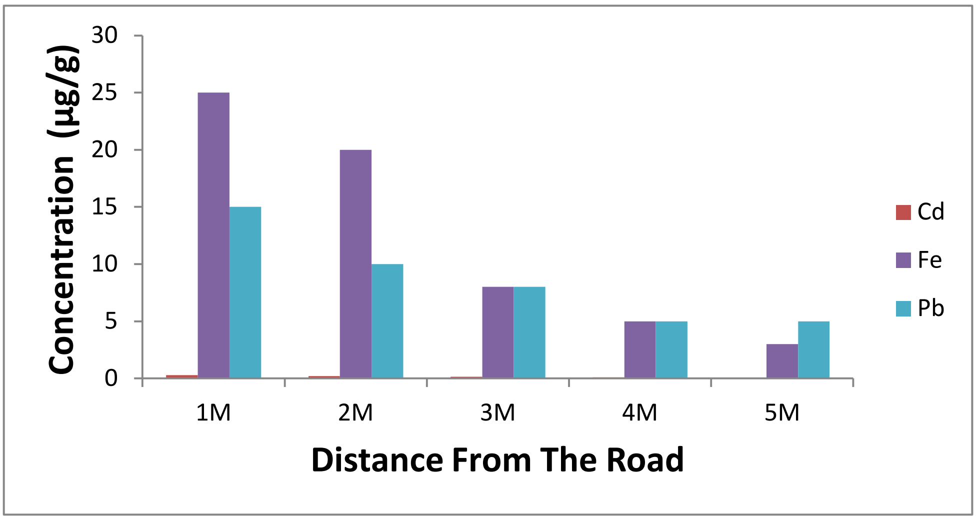

Fig. 8. Heavy Metals Concentration in Grass Along Kano-Gwarzo Road

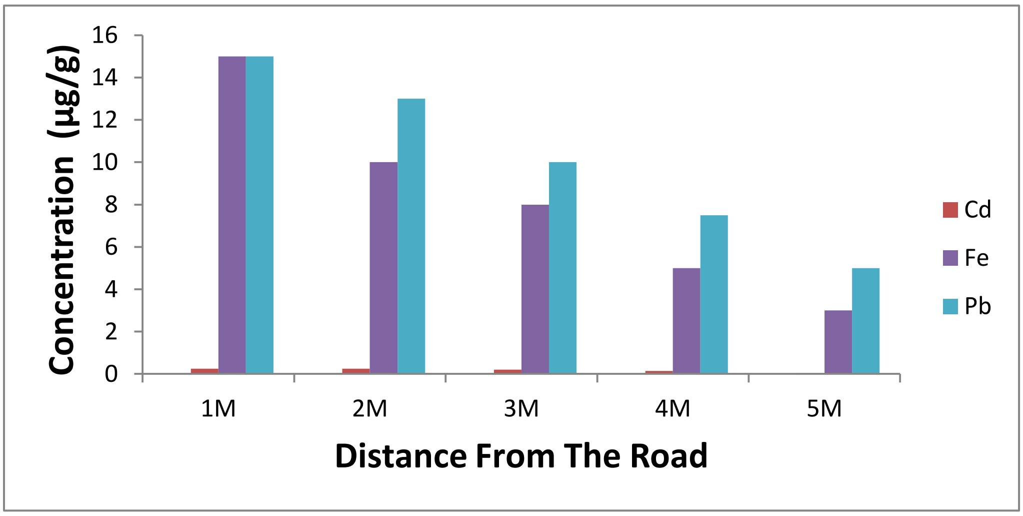

Fig. 9. Heavy Metals Concentration in Soil Along Kano-Gwarzo Road

The mean concentrations of heavy metals under study in roadside grass and soil samples along major highways in Kano are as shown in Tables 1 and 2 respectively.

A comparison of the concentrations of heavy metals in the grass and soils reveals that the values in the four major highways are higher than in the reference site (control samples). This is probably due to vehicular traffic. A similar finding was reported by Jaradat and Momani, (1999) who reported that roadside soil and plants had significantly high contents of heavy metals and their levels increased with increasing traffic densities.

Table 1: Mean heavy metal concentration (µg/g) in grass samples

Sites	Cd	Fe	Pb	Vehicles/day
K - Z	0.19±0.07	10.2±5.76	12.2±4.97	120,000
K – K	0.12±0.06	5.8±3.11	9.0±3.08	69,000
K – M	0.15±0.08	12.6±5.59	9.2±5.36	95,000
K – G	0.16±0.10	12.2±5.53	8.6±4.16	70,0000
REFERENCE	0.03	3.55	1.20	-

Key: K-Z = Kano-Zaria, K-K = Kano-Katsina, K-M = Kano-Maiduguri, K-G = Kano-Gwarzo.

Table 2: Mean heavy metal concentration (µg/g) in soil samples

Sites	Cd	Fe	Pb	Vehicle/day
K - Z	0.25 ±0.08	6.0 ±3.28	13.8 ±4.60	120,000
K – K	0.20 ±0.08	5.4 ±2.51	8.2 ±3.42	69,000
K – M	0.19 ±0.12	8.2 ±3.42	7.8 ±3.96	95,000
K – G	0.18 ±0.08	8.2 ±4.66	10.1 ±5.93	70,0000
REFERENCE	0.05	2.50	0.15	-

Key: K-Z = Kano-Zaria, K-K = Kano-Katsina, K-M = Kano-Maiduguri, K-G = Kano-Gwarzo.

Cadmium concentration ranges from 0.12 – 0.19µg/g in grass and 0.18 – 0.25µg/g in soil samples. The highest Cd concentration was found in Kano – Zaria road soil (0.25µg/g). In the uncontaminated soils, Cd concentrations vary between 0.01 – 0.03µg/g (Allen, 1989). The sources of Cd in the urban areas are much less well defined than those of Pb, but metal plating and tire rubber were considered the likely sources of Cd (Atayese et al., 2009).It was reported that the cadmium level in car tires is in the range of 20 to 90 µg/g as associated Cd contamination in the process of vulcanization (Jaradat and Momani, 1999). In the absence of any major industry along these roads, the level of Cd could be due to old tires that are frequently used, and the rough surfaces of roads which increase the wearing of tires. Indication shows that ruminant that wonders and grazes along roadside feed on these grasses and metal accumulation in their bodies is highly probable, indirectly entering the food chain.

Iron is a metal of low toxicity, but concentrations in excess of 200mg/day are considered toxic for human (Bowen, 1979). Iron concentrations vary from site to site. The highest mean iron value was found in Kano – Maiduguri road grass (12.60µg/g). Iron concentration is higher in grass than in soil. This could be as a result of direct deposition of iron particulates on roadside grass rather than absorption from the soil. The Fe contents of the study sites are relatively low when compared to its levels in normal agricultural soils (Awokunmi et al., 2010).

The highest Pb concentration (13.80µg/g) was found in Kano – Zaria road soil. Normally, plants metal levels for Pb vary in the range of 0.1 – 0.12µg/g dry weight (Fleming and Parle, 1977). High level of Pb in plant has been reported in similar studies (Ho and Tai, 1988). The normal lead soil level was estimated to be less than 7µg/g. The sources of Pb obtained in the soil samples may have come from the deposition of Pb following emission from vehicle. Similar findings have been reported by Atayese *et al*. (2009).

Conclusion

Heavy metal concentrations in grass along highways at graded distances from the road were high compared with the soil. By determining the concentrations of heavy metals in roadside grass and soil, the effect of road traffic can now be well managed. Heavy metals were detectable beyond 5meters from the road, however their concentrations were highest near the roads. The results showed that the levels of Cd and Pb exceeded the limit levels (0.01-0.03µg/g for Cd, and <7.00µg/g for Pb) and reach pollution levels. Since heavy metals can be transferred through food chain, there could be potential risk for ruminant grazing along the road. Based on these results, the following recommendations could be made: grazing along highways by ruminants should be discouraged. Planting of grains and vegetables along highways should also be discouraged. It is necessary to widen the study to other pollutants, other fodder crop species and to extend the distance to several metres away from the road. All these measures will go along way to reducing the rate of ingesting heavy metals into the body system

REFERENCES

Aksoy , A., Ahin , U., Duman , F. (2000). Robinia pseudo-acacia L. as a possible biomonitor of heavy metal pollution in Kayseri. *Tr. J.Bot.*, 24: 279-284.

Allen, S.E (1989). *Chemical Analysis of Ecological Materials*. 2nd ed., Blackwell Scientific Publ., Oxford. Pp245.

Alloway, B. J (1990). Heavy Metals in Soils. 2nd Edition. Blackie, Glasgow pp. 189-204.

Annexes (2003). Report on heavy metals and pesticides residue in the food stuff. Auroville Innovative Urban management IND-015.

Atayese, M.O., Eigbadon, A.I., Oluwa, K.A., and Adesodun, J.K., (2009). Heavy metal contamination of Amaranthus Grown along Major Highways in Lagos, Nigeria.

African Crop Science Journal, 16(4): 225-235.

Awokunmi, E.E., Asaolu, S.S. and Ipinmoroti, K.O. (2010). Effect of Leaching on Heavy Metal Concentration of Soil in some Dumpsites. Africa J. of Env. Sci. and Tech. 4(8): 495–499.

Bowen, H.J.M (1979). *Environmental Chemistry of the Elements.* Academic Press New York, pp 57 – 93, 100 – 1.

Clarkson, T.W. (1986). Effects-General Principles Underlying the Toxic Action of Metals. In Handbook on the Toxicology of Metals vol. 1: General Aspects, Edited by *L. Friberg, G. F. Nordberg, and V.B Vouk pp. 128-148*

Fatoki , O. S. (2003). Lead, Cadmium and Zinc Accumulation Along some Selected Major Roads of Eastern Cape. *Inter. J.Environ. Studies,* 60 : 199-204.

Fleming, G. and Parle, P. (1977). Heavy metals in soils, herbage and vegetables from an industrialized area of west of Dublin city. *Irish J. Agric. Res.* 16: 35-48.

Friberg, L. and Norberg, G.E (1986). Introduction. In Handbook on the Toxicology of Metals vol.1: General Aspects, Edited by Friberg, L.; Nordberg, G.E.; Vouk, V.B. Amsterdam: Elseivier *Science Publishers. B.V.pp.1-3*.

FRSC (2009). Federal Road Safety Corps (FRSC) (2009). Road Traffic Count Details Kano Branch., Nigeria.

Ho, I. B. and Tai, K.M., (1988). Elevated levels of lead and other metals in roadside soil and grass and their use to monitor aerial metal depositions in Hong Kong. *Environ pollu.* 49:37-51.

Jaradat, Q. M. and Momani K.A. (1999). Contamination of Roadside Soil, Plants and Air With Heavy metals in Jordan, A comparative study. *Turk J. Chem* 23:209-220.Munson, R.D, and Nelson, W. L (1990). Principle and Practices in Plants Analysis in "Soil Testing and Plant Analysis" (2nd ed) Westernan, R.L; Mandison, SSSA pp.359-387.

Ohnesorge, F.K. and Wilhelm, M. (1991). Zinc In: Meriana E. (5th ed). Metals and their Compounds in the Environment VCH. *Verlag Segsellschaft mbh Weinheim-New York. pp. 1309-1342*.

Onder, S., Dursun, S., Gezgin, S. and Demirbas, A. (2007). Determination of Heavy metal Pollution in Grass and Soil of City Center Green Areas (Konya, Turkey). *Polish J. of Environ. Stud.* 16 (1):145-154.

Uwagboe, A.I and Hymore, F.K (2008). Heavy Metal Contamination of Roadside Soils, Stagnant Pools and Sediment in Warri. Nigeria. *Journal of research in National Development 6 (1):1710-1719.*

Van, D. W. and Smilde K. W. (1990). Micronutrients and Heavy Metals in Dutch Agriculture. *Fertiliser Research 25: 115-126*.

Yilmaz , S., and Zen Gin , M. (2003). Monitoring environmental pollution in Erzurum by chemical analysis of Scots pine (Pinus sylvestris L.) needles. *Environmental International* 1097, 1-7.