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Full Length Research Paper

Grass contamination by trace metals from road traffic

J. T. Ayodele* and C. D. Oluyomi

Department of Pure and Industrial Chemistry Bayero University, P.M.B.3011, Kano-Nigeria.

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The increase in the deposition of trace metals as pollutants from vehicle exhausts on plants has raised concerns about the risks for the quality of food and in turn human health. Trace metals emitted by vehicles can enter food chain through deposition on grass growing by the road sides and grazed on by animals. Despite, many investigations knowledge on their spatial distribution near roads is scarce. The concentration of trace metals deposited on roadside Bahama grass, *Cynodon dactylon,* on roadside grass with over 70,000 vehicles per day were assessed. The spatial distribution of these metal deposits from vehicle emissions during the dry season was assessed by harvesting the grass at 1, 2, 3, 4 and 5 m away from the road. This method allowed an overview of deposition from vehicle emissions. Our results demonstrated the effect of pollution by comparing the levels on both grass and soil sampled. The pollution maps showed that the maximum deposition occurred near the road. The highest pollution levels of grasses were 625 µg/g iron in grass and 120.72 µg/g in soil dry weight. The results were recorded between 1 and 5 m on both sides of the roads. Pollution maps may hence be used to assess the impact of road traffic.

Key words: Pollution, Bahama grass, roadside trace metals.

INTRODUCTION

Increasing industrialization accompanied by the increasing road haulage, extraction and redistribution of heavy metals from natural deposits, all these have undergone chemical changes through technical processes into useful forms. Plants and animals take up metals from the soil and accumulate 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 like lead and cadmium may cause metabolic anomalies (Annexes, 2003). These metals are of public interest, as new techniques have made it possible to detect them in trace. The effects of consumption and accumulation on health, have startled the public and generated genuine hysteria (Ohnesorge and Wilhelm, 1991; Annexes, 2003).

Metals are circulated by biogeochemical processes. Some metals are essential and their deficiency results in impairment of biological functions (Annexes, 2003). When present in excess, essential metals could become toxic. Other metals not known to have essential functions could give rise to toxic manifestations when intake is in excess (Friberg and Nordberg, 1986). Unlike organic chemicals that can be eliminated from tissues by metabolic degradation, these metals are indestructible and therefore have potential for bioaccumulation. 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). There are three criteria for determining whether or not an element is essential. It must have influence on the organisms and be involved in its metabolism, the organism can neither grow nor complete its life cycle without adequate supply and the element can not 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 Zn 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 (kusaka et al.,1960;Li and, Shuman, 1996; Alloway, 1990; Ewers and Schlipkoter, 1991; Ely et al., 2001; Djingova et al., 2003).

*Corresponding author. E-mail: tjayodele@yahoo.com

Road traffic is one of the most important sources of pollution in urban centres and roadsides. The increase in private vehicle traffic has masked the reduction of emission rate .We are now confronted with the appearance and emergence of other pollutants, produced as a result of abrasion with dare consequences on public health by contact, inhalation or consumption of contaminated products (Gebel et al., 1997; Benes and Grieken, 2004). This paper is aimed at assessing the spatial distribution of heavy metals along the road, to assess the levels on grass, as a result of their proximity to road traffic.

MATERIALS AND METHODS

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

Sampling

The sampling areas are (KZ), (KM), (KS) and (KK) roads (Figure 1). Using biomonitoring method which has been widely employed to assess organic and metallic contamination in folder, the grass samples, a common folder widely used in ruminant rations, were taken on both sides of the road from each sampling area at a distance of 1 to 5 m away from the road. The soils were also sampled in the same way.

Sample treatment

The grass samples were air dried and grounded to powder and were sieved using 250 µm sieve (Munson aand Nelson, 1990). Each soil sample was oven dried at 100°C to constant weight. The powdered dried sample was sieved through a 250 µm sieve (Ayodele and Gaya, 1998; Ayodele and Ali, 2007). A quantity of 1 g of each grass sample was ashed for 6 h at 500°C in a muffle furnace and cooled in a desicator. The resulting ash was moistened with water and 3 cm^3 of nitric acid was added. The solution was heated on a hot plate to evaporate excess nitric acid (Munson and Nelson, 1990). The solution was cooled, filtered via an acid washed Whatman 40 filter paper into 100cm^3 volumetric flask and was made up to mark with water (Munson and Nelson, 1990). The resultant solution was analyzed for Cu, Fe ,Cr, Zn and Pb. The experiment was repeated using different samples. A quantity of 1 g of soil sample was digested for 30 min with 30 cm^3 of 6 M HNO_3 acid. The solution was filtered via an acid washed Whatman 40 filter paper into 100cm^3 volumetric flask and was made up to mark with water. 5 cm^3 was pipetted into a 50 cm^3 volumetric flask and was diluted with water (Ayodele and Gaya, 1994; Ayodele and Ali, 2007). The resultant solution was analyzed for Cu, Fe, Cr, Zn and Pb. The experiment was repeated using different 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. The distilled water used as blank was digested using the above procedures. A calibration curve of absorbance against concentration was plotted from the standards. The concentration of each element under investigation was determined from the calibration curve of its standard by extrapolation. The metal concentrations were expressed in µg/g (dry weight). The various sampling areas are Kano-Zaria, Kano-Maiduguri, Kano-Sokoto and Kano-Katsina roads. The metals under investigation are Fe, Pb, Cu, Zn and Cr.

Statistical analysis

All statistical computations were on the PC 486 66 MHZ microcomputer using the integrated statistical package for windows from Umstat Ltd.(London) or dedicated microinstructions for the Excel spread sheets from Microsoft. The approach enabled the advantages of the various computational and graphical facilities of both types of software's to be used with the ability to read different file formats. The analyses of variance (ANOVA) were carried out according to described procedures (O'Mahony, 1986).

RESULTS AND DISCUSSION

The results of trace metal concentrations in grass and soil samples from various sites are as shown in Figures 2 to 9. KZ road is a double lane highway with a traffic flow of about 120,000 vehicles per day (Federal Road Safety Corps (FRSC), 2009). The iron and other trace metal concentrations in grass and soil samples at 1 to 5 m away from the road are as shown in Figures 2 and 3. The iron concentrations in grass decreased from 447 µg/g at 1m to 177 µg/g at 5 m while in soil it decreased from 120 µg/g to 76 µg/g from 1 to 5 m respectively. The results showed that iron concentrations in grass and soil were significantly correlated with distance ($p \leq 0.05$). The nature of the graph for Fe in soil sample shows that the change in its concentration in soil was minimal compared to the change in grass. The high level of iron concentration in grass could be as a result of direct deposition of the metal particulates on the roadside grass. This deposition pattern is similar to results earlier reported by other workers (Van Dried et al., 1990; Uwagboe and Hymore, 2008).

The concentrations of heavy metals in grass samples along Kano-Maiduguri road at 1 to 5 m away from the road are as shown in Figure 4. At any distance away from the road, iron concentration was recorded highest followed by lead. At a distance of 1 to 3 m away, Cr concentration was higher than Zn, but decreased rapidly below Zn at 3 m away. Copper concentration in grass was least as shown on the graph.

The concentration of heavy metals in soil samples at 1 to 5 m away from the road is as shown in Figure 5. The concentrations of these metals along the road side soil followed a similar variation as the grass. Iron concentration was highest followed by Pb, Cu and Zn. Unlike in grass sample where Cu was detected as the least, its concentration in soil was higher than Zn and Cr. In both grass and soil samples, heavy metal concentrations varied with the distance from the road. Iron and lead were higher in concentrations because Fe is the predominant element in the source while Pb was produced at higher quantities from exhausted fuel

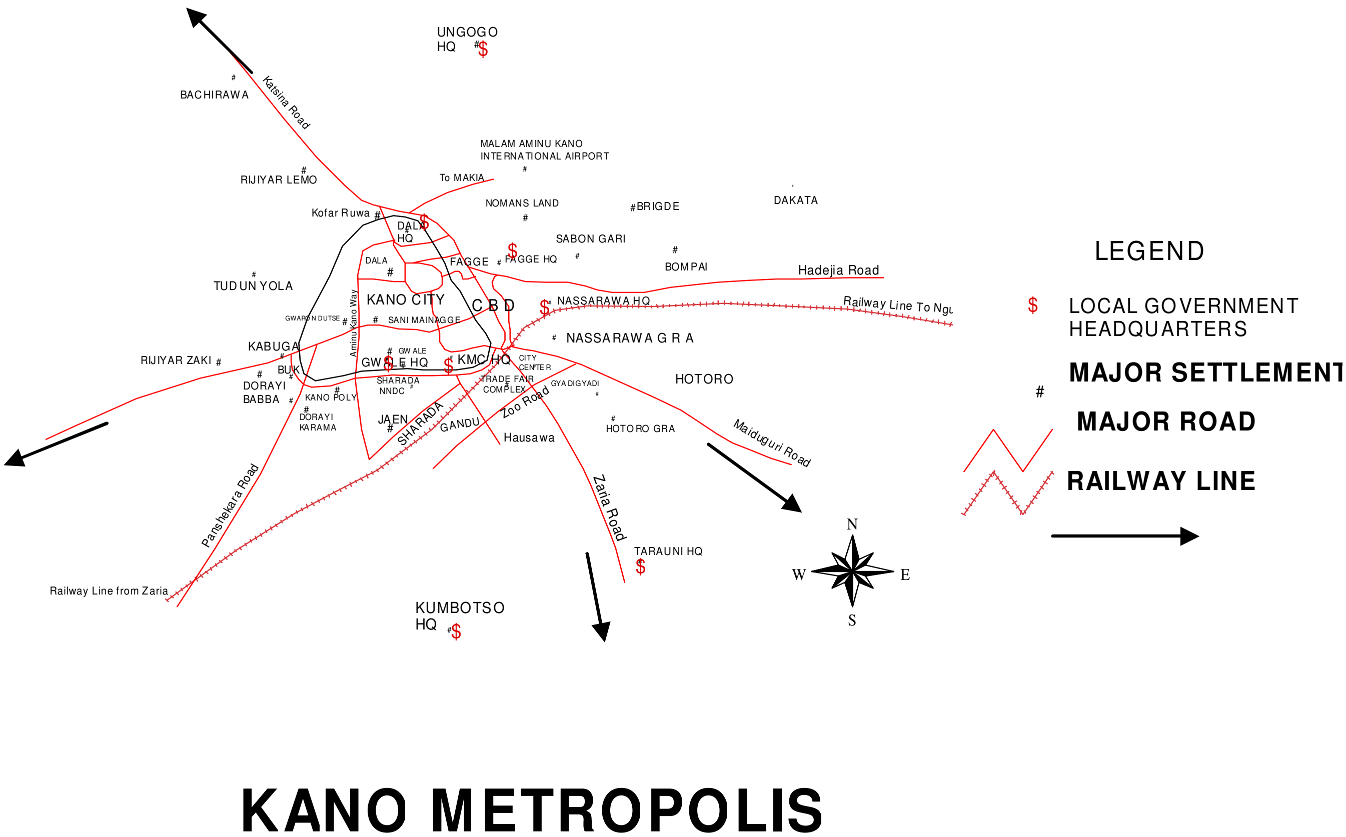

Figure 1. Map of Kano metropolis showing the exit routes. Source: Cartography and remote sensing laboratory. Geography Department, Bayero University Kano (Ali, 2011).

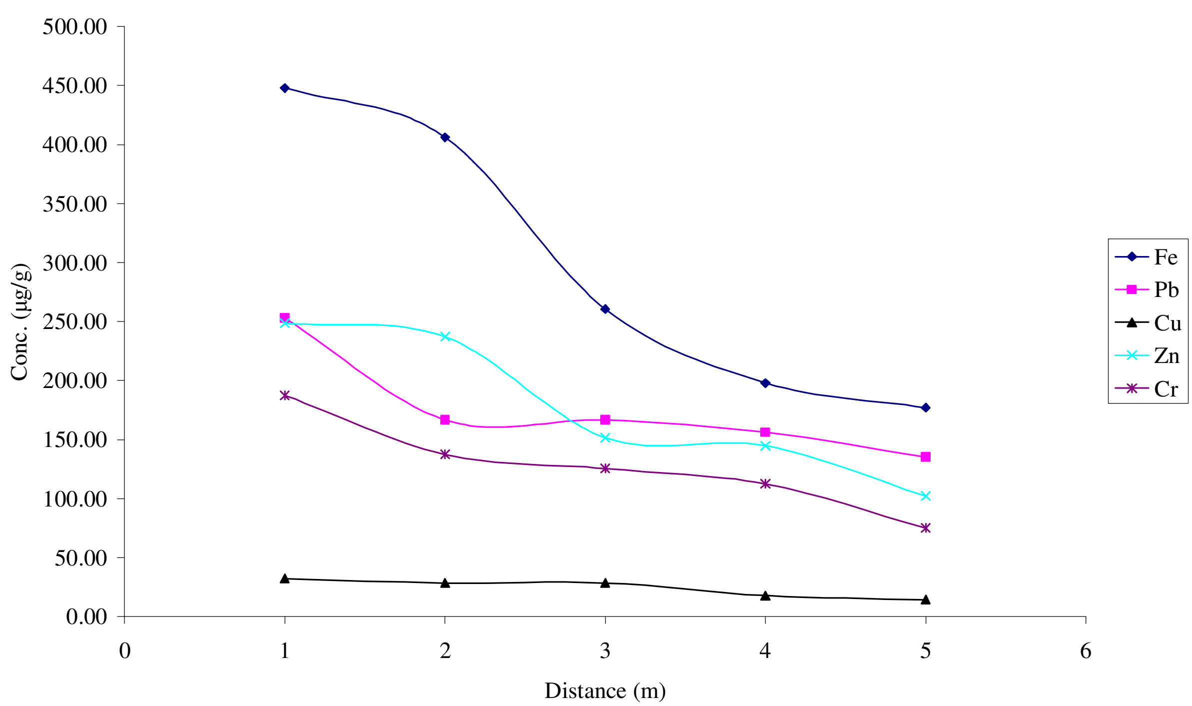

Figure 2. Trace metal concentrations in grass along Kano-Zaria road.

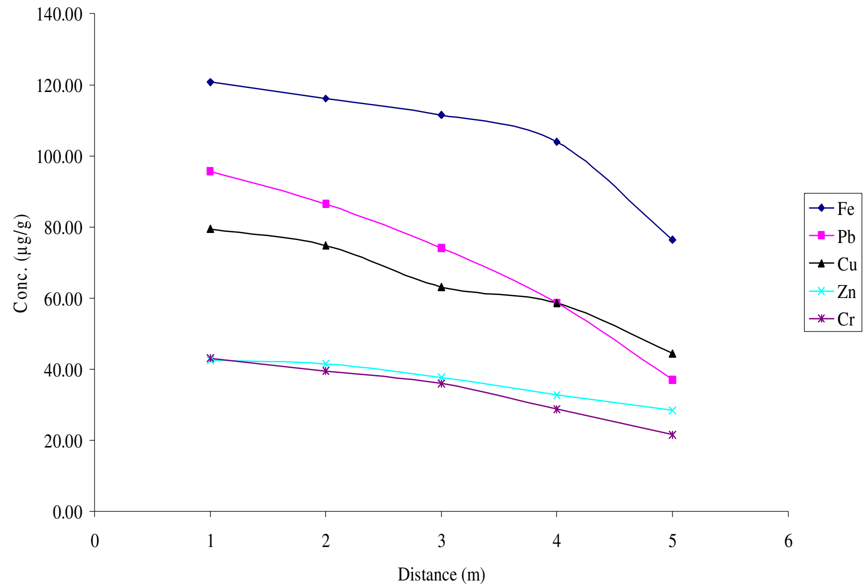

Figure 3. Trace metal concentration in soil along Kano –Zaria road.

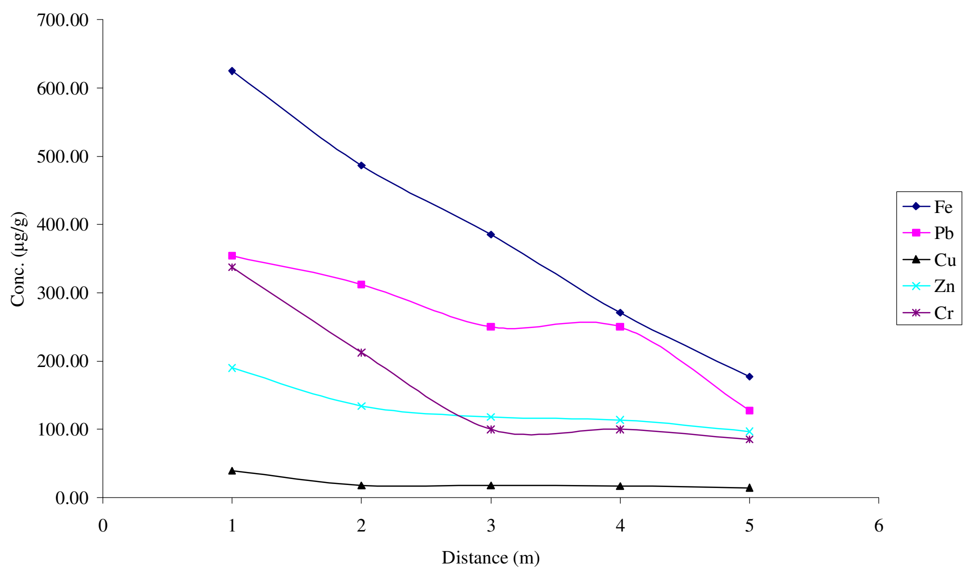

Figure 4. Trace metal concentrations in grass along Kano-Maiduguri road.

fuel combustion. All these are responsible for their higher concentration than other parameters in grass and soil samples. These results are in line with results earlier reported (Tjell et al., 1979; Dobra et al., 2006). This implied that metal concentrations were higher in samples along KM and KS than (KZ) that accommodated more vehicles. This could be as a result of double lane on KZ highway which presumably affected metal deposition. Iron and lead concentrations were higher in samples along all the sampling areas as a result of predominance of these metals in the pollution source. The Fe composition in vehicles may be responsible for its higher level in the samples. Lead particulates are emitted in large quantities as a result of exhausted fuel combustion. Cu metal was least in concentration in the samples along all the highways considered. This may be associated to the fact that its composition in vehicles is minimal compared to other metals. KS road is a single lane highway with a daily traffic flow of 70,000 vehicles (FRSC, 2009). The iron and other metal concentrations in grass and soil samples at 1 to 5 m away from the road are as shown in Figures 6 and 7. At 1 m away from the

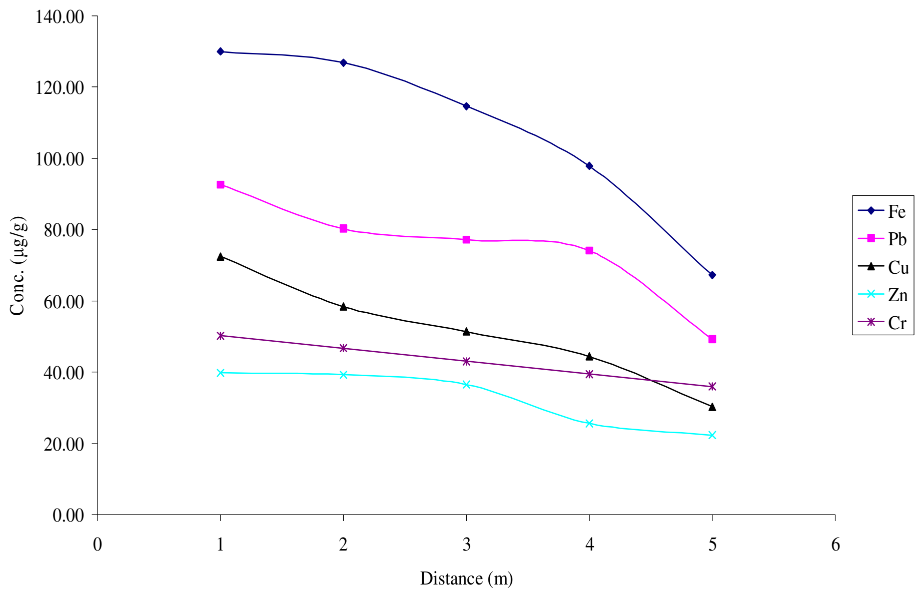

Figure 5. Trace metal concentrations in soil along Kano-Maiduguri road.

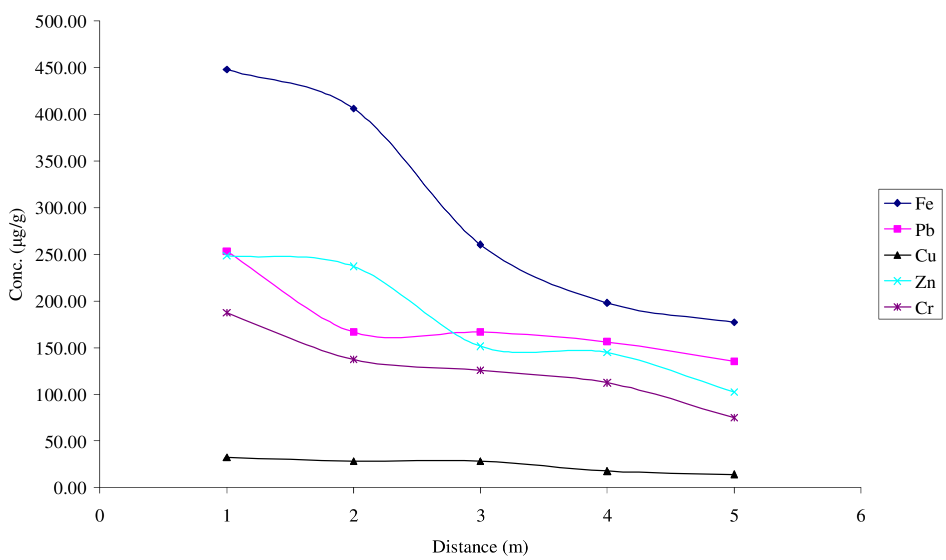

Figure 6. Trace metal concentrations in grass along Kano-Sokoto road.

road, iron concentration in grass was 260 µg/g while in soil it was 96 µg/g. As the distance increased, its concentrations in both grass and soil decreased to 135 µg/g and 61 µg/g respectively. This decrease was minimal in soil but drastic in grass. The result showed that iron concentrations in grass and soil were significantly correlated with distance ($p \leq 0.05$). The nearly linear curve for iron in soil sample implied a low level of its concentration in the soil than grass. Hence, Fe concentration is higher in grass than in soil as a result of its direct deposition on road side grass. This is in line with the results earlier reported by other workers working under similar conditions (Alloway et al., 1990; Abdourahama et al., 2008). At a metre away, Pb concentration in grass sample was 281 µg/g but with increasing distance, it decreased to 114 µg/g. In soil sample, the Pb concentration decreased from 55 to 30 µg/g. These decreases in concentrations were minimal in soil but notable in grass. The Pb concentrations in grass and soil samples showed a negative correlation with increasing distance ($p \leq 0.05$). The nearly linear nature of the curve for Pb in soil shows that its concentration in the

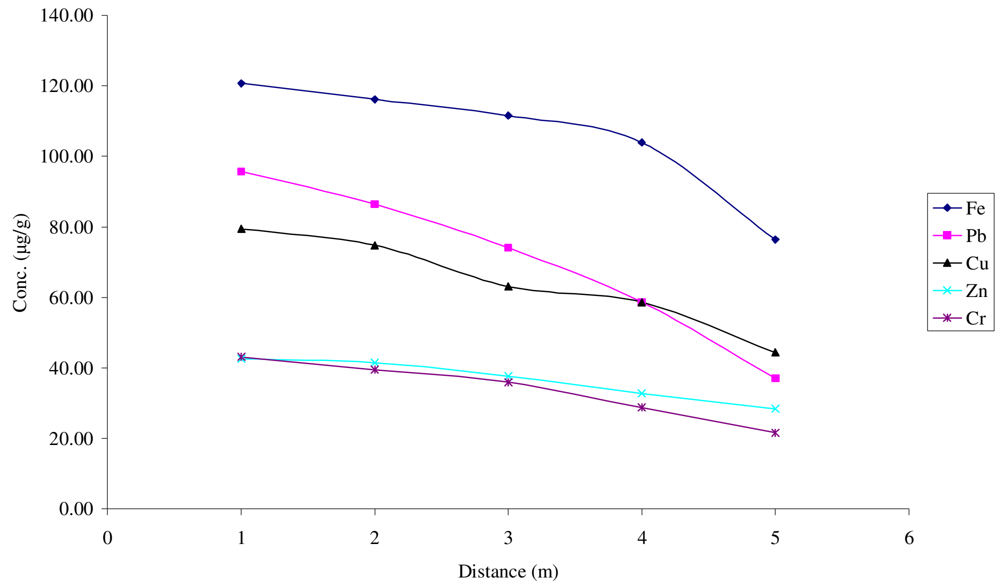

Figure 7. Trace metal concentrations in soil along Kano-Sokoto road.

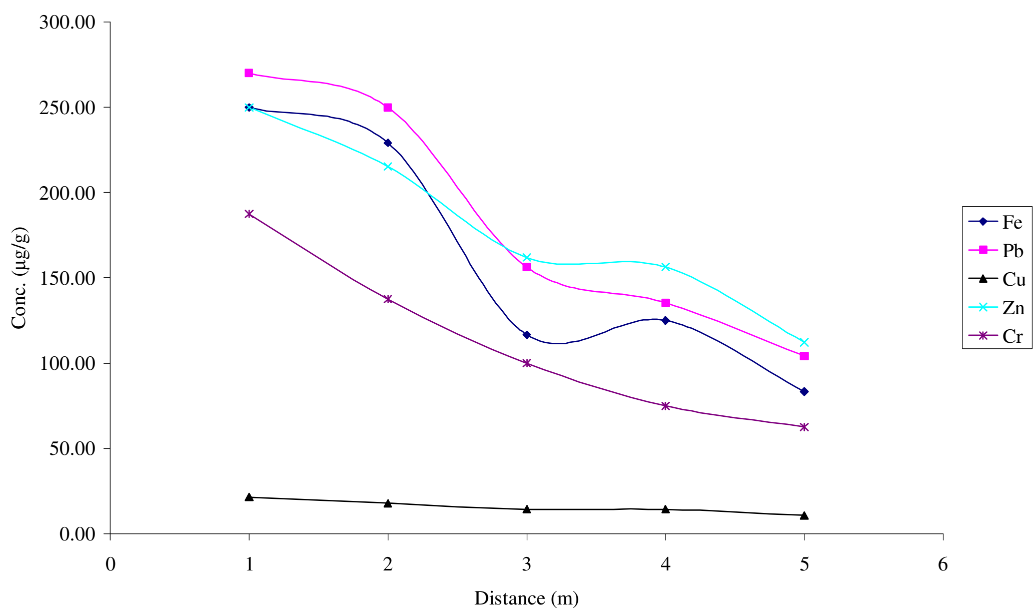

Figure 8. Trace metal concentration in soil along Kano-Katsina road.

soil is low compared to its level in grass. The Pb concentration in grass decreased rapidly at 1 to 3 m but minimally from there to 5 m. This is in agreement with report that Pb particulates cannot be actively transported through long distances before deposition (Tjell et al., 1979). Therefore, lead concentration is higher in grass than in soil samples. This could be as a result of the direct deposition of the metal particulates from vehicles on the roadside grass. This deposition pattern is similar to earlier results reported (Van Driel et al., 1990; Abdourahama et al., 2008).

The concentration of heavy metals in grass samples along Kano-Katsina road at 1 to 5 m away is as shown in Figures 8 and 9. The metal concentrations in grass samples were interwoven. At a certain distance, Pb concentrations appeared highest and at another distance, Zn concentration was higher followed by Fe. That is, the Fe, Pb and Zn concentrations were higher than Cu and

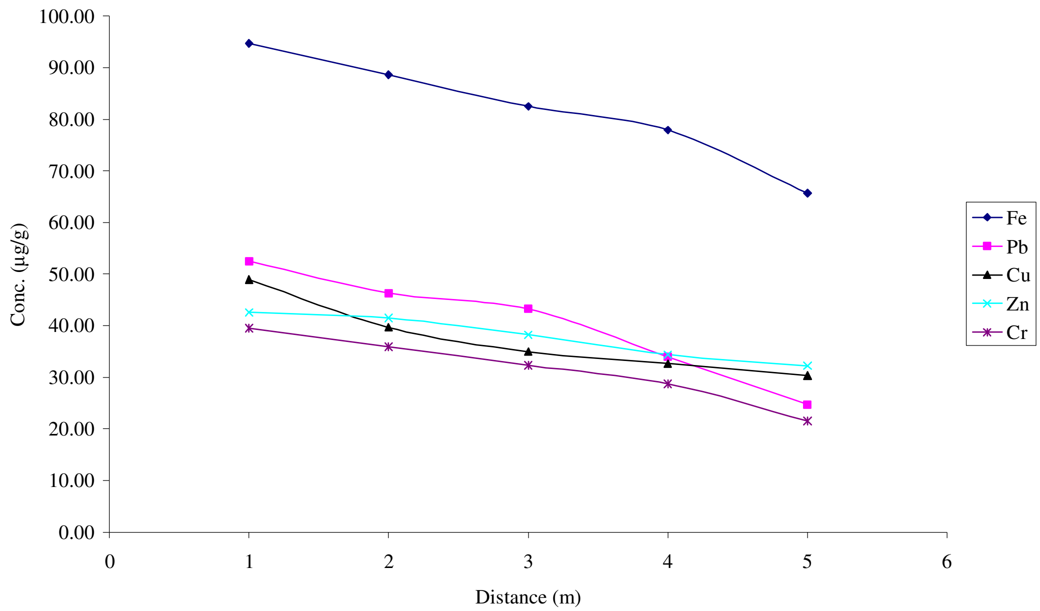

Figure 9. Trace metal concentrations in soil along Kano-Katsina road.

Cr in the sample attested to their uses. The linear curve obtained for copper in grass sample is an indication of its low concentration in the sample.

The concentrations of these metals in roadside soil followed a similar deposition pattern as the grass (Figure 8). Iron is the predominant element followed by lead, copper and zinc while chromium was the least. Unlike the grass sample, copper concentration was higher than Cr. In both grass and soil samples, metal concentrations decreased with distance away from the road. The concentrations of these metals in grass samples were higher compared to their levels in soil, except Cu which is the other way round. The higher concentration of metals in grass than in soil may be as a result of direct deposition of metal particulates that were emitted from the vehicles on grass, rather than soil along the road. This deposition pattern is similar to other researchers' reports (Abdourahama et al., 2008; Pinder and Mcleod, 1988; Dalenberg and Driel, 1990; Uwagboe and Hymore, 2008).

Conclusion

The concentrations of these metals in grass were higher compared to their levels in soil except for Cu because its level in automobiles is low compared to elements like lead or iron. The use of our adopted method allowed for the comparison of *Cynodon dactylon* grass contamination by heavy metals. The results showed that the metal concentrations could be detected and determined on the grass along the road. Heavy metal concentrations in grass and soil along highways at graduated distances from the road were high compared with the control sample area. The roadside metal concentrations in grass were higher and lower in roadside 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 5 m from the road; however, their concentrations were highest near the roads (1 to 5 m).

Since heavy metals can be transferred through food chain, there is a potential risk for ruminant animals 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.

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