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Analysis of heavy metals in roadside soils and crops along the Obansandjo way in the Accra metropolis

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ABSTRACT

This paper discusses the levels of some heavy metals (Ni, Cu, Pb and Zn) in roadside soils and crops along the Obansandjo way in the Accra metropolis of Ghana. Soil and plant samples were collected from three different sites; Kawukudi (K), Ebony (E), and Dzorwulu (D) all along the Obansandjo way in Accra. The samples taken were preserved and later acid digested and analyzed along side control soil and plant samples using standard analytical methods. The following mean levels of Ni, Zn, Cu and Pb on the roadsides were detected: 228.65 ± 102.98, 35.98 ± 18.39, 24.577 ± 9.04 and 18.25 ± 13.05 (all in mg/kg) respectively. The mean level of Ni was above the critical permissible concentration. Ni, Zn, Cu and Pb in the crops were: 3.343 ± 2.0, 6.97 ± 4.5, 1.909 ± 0.71 and 3.515 ± 1.3 (all in mg/kg) respectively. Ni, Pb, Cu and Zn were detected in both soils and crops. The levels of all the metals except Ni were below the phototoxic levels.

Keywords: Obansandjo way, heavy metals, roadside soils and plants.

INTRODUCTION

The presence of heavy metals in soils and crops grown along roadsides in urban communities is of concern because of the hazards caused by heavy metals. According to Garcia and Millan (1988), Sithole et al. (1993) and Fatoki (1996), heavy metal pollution of roadside soils and crops grown along road verges are largely due to releases from automobiles.

Chow (1970) has observed that proximity to road with high traffic density may contribute substantially levels of these metals in the soil. Lead for example has been found in the top 5 cm of soil at a level of 403 mg/kg. Studies have shown that vegetation in contaminated soils may absorb high concentrations of heavy metals which are potentially toxic to crops, animals and humans (Okoronkow, 2005).

Urban agriculture has been practiced in Accra for over two decades; but with the increasing lack of access to land, due to infrastructure development and high rate of urbanization accompanying the ensuing rapid growth of unemployment, cultivation of food crops along road verges, banks of drainage channels and other unsuitable areas has become increasingly common. With increasing traffic density in Accra, heavy metal pollution of soils and vegetation along the roadside due to releases from automobile is probable and therefore warrants investigation. The study seeks to investigate the levels of some heavy metals, Pb, Zn, Cu and Ni contamination in some soils and food crops grown along the Obasandjo way in the

Accra metropolis of Ghana, as a basis for future monitoring of the impact of the automobile releases on soils and crops along that roadside, and to ascertain if the levels of the metals are above recommended levels.

MATERIALS AND METHODS

Sampling

The selected sites at Kawukudi, Ebony and Dzorwulu, are all settlements along the Obasandjo way at Accra. The sites were chosen because of the variable traffic densities in those areas, the cultivation of crops along the sides of the roads and the proximity of the selected soils and crops to heavy metal pollution. Samples were collected in the dry season, between November and December 2007, when the soils contain relatively lower moisture, since heavy metals adhere to the soil when the water content in low.

Soils and plants samples, including control samples were collected from pre-selected sites or farms close to the sides of the Obasandjo road at Kawukudi, Ebony and Dzorwulu, urban communities. Each sample site was divided into four areas before sampling. Ten samples of soils were collected at random at a depth of 0-10 cm, from each of the demarcated areas using a garden trowel into a plastic container, mixed to obtain a homogenous sample and then placed into a labeled plastic polyethylene bags for laboratory analysis. Four sets of samples were obtained for each of the three pre-selected sites.

Plant samples were collected using a pair of scissor and placed into labeled plastic bags for laboratory analysis. Control samples of soils and plants were collected at a distance of 50-70 m from the road.

Sample treatment

pH and moisture content determination

The pH and the moisture content of the soils were determined using standard methods (David, 1994).

The soil samples were air-dried and passed through 2 mm mesh. 1 g of each of the homogenized samples of soils was put into a 100 ml beaker and digested using the method described by MAFF (1981). The plant samples were first dried in the sun, and in the oven at 105 ^{o}C. The samples were milled after drying and 2 g placed into a 50 ml flask. The sample was digested using 1 ml of (5:1:1) 60% perchloric: sulphuric: nitric acids mixture and finally diluted to 50 ml (Allen et al., 1979). Blank solutions were also prepared for the soil and plant samples. All the digests and the blank solutions were analyzed for Pb, Cu, Zn and Ni with an ICP atomic absorption spectrometer 112S INTEPID model. All analyses were carried out in duplicate.

Reproducibility studies

In order to validate the precision of the analysis, reproducibility studies were carried out by analyzing double distilled water containing 2, 5 and 10 ppm of Pb, Zn, Cu and Ni. Three replicate analyses were carried out.

RESULTS AND DISCUSSION

The mean percentage recoveries of the double distilled water were; Pb, 95.7 ± 0.46-100.1 ± 0.40; Zn, 96.1 ± 0.72-99.56 ± 2.4; Cu, 96.6 ± 0.15-100.9 ± 0 .1 and Ni, 97.1± 0.53-98.4 ± 0.35. The moisture content and pH of the soils are shown in Table 1. The results of the metal analysis have been shown in Figures 1-3. The overall mean (mean ± RDS) distribution of Pb, Cu, Zn and Ni in the soils were 18.25 ± 13.045, 24.577 ± 9.04, and 35.964 ± 18.39 and 228.648 ± 102.98 mg/kg respectively. The ranges of the metal concentration in the soils were Pb, 2.52 -52.39 mg/kg; Cu, 2.43- 143.0 mg/kg; Zn 7.967-63.43 mg/kg and Ni, 47.98-421.2 mg/kg. Ni had the highest concentration and Pb the least. The levels of metals in the crops were much lower than those in the soils. The mean and ranges of the metals in the crops were respectively; Pb, 3.515 ± 1.3 and 1.12 -5.856 mg/kg; Cu 1.907± 0.71 and 1.189 -3.262 mg/kg; Zn 6.97 ± 4.5 and 2.636-16.142 mg/kg; and Ni 4.611 ± 2.0 and 0.155 -5.089 mg/kg. Zn had the highest concentration in the crops and Cu the least. The overall mean levels of the heavy metals in the soils and crops at the three sites are shown in, Figures 1 and 6 respectively. The mean levels of the metals in the soils was in the order Pb< Cu < Zn < Ni whereas in the crops the order was, Cu< Ni <Pb <Zn (Figure 3).

Figures 2 to 4 show the mean concentrations and the trends in the distribution of the metals in soils and crops at the three sites. Generally the trend in the distribution of the heavy metals in the roadside soils at Kawukudi, Dzorwulu and Ebony were similar with considerably variations in the metal levels (Figure 2).

Table 1: Mean moisture contents of soils.

Sampling site	Percent moisture (Mean ± SD)
Ebony	1.46 ± 0.44
Kawukudi,	0.565 ± 0.102
Dzorwulu	1.39 ± 0.209

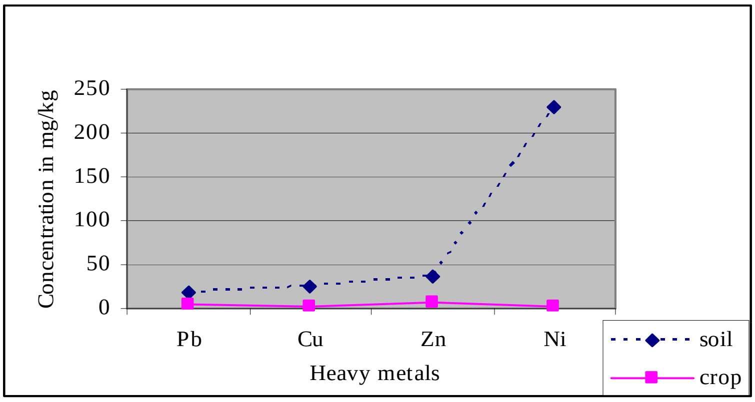

Figure 1: Overall mean levels of heavy metals in roadside soils and crops.

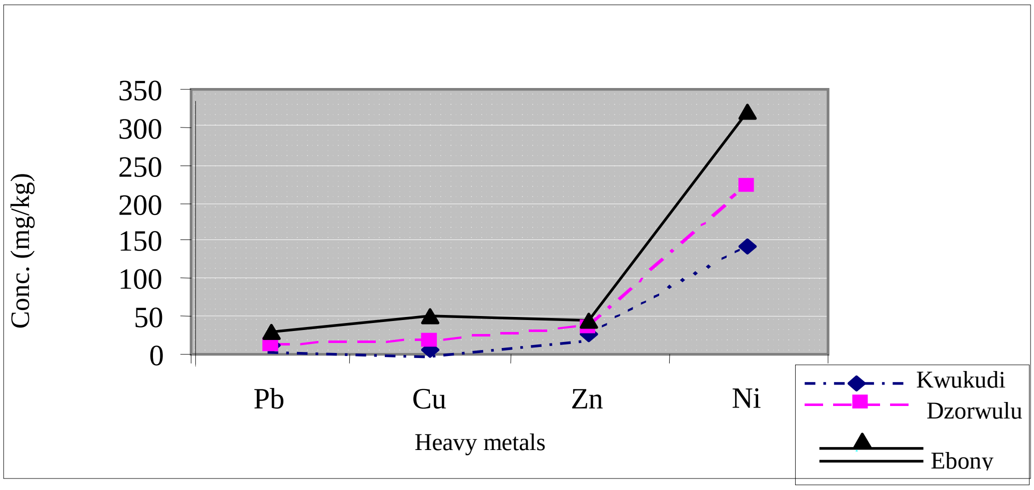

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Figure 2: Mean levels of heavy metals in roadside soils at Kawukudi, at Dzorwulu and Ebony. Conc. = Concentration.

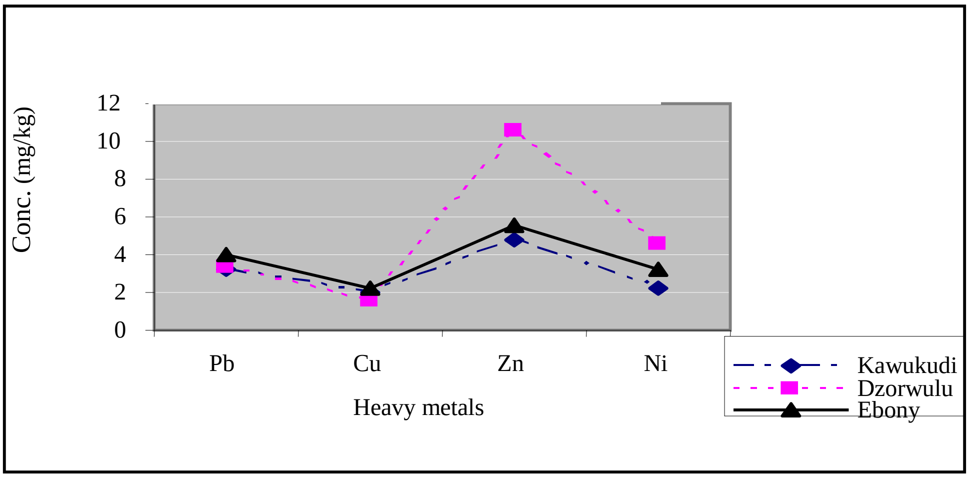

Figure 3: Mean levels of heavy metals in roadside crops at Kawukudi, Dzorwulu and Ebony.

The distribution showed that at all the three sites Ni had the highest concentration in all the soils (Figure 2). Also Ebony had the highest levels for all the metals. The trends in the distribution of the metals at the sites were: Kawukudi, Ni > Zn > Pb > Cu; Dzorwulu, Ni > Zn > Cu >Pb and Ebony, Ni >Cu > Zn >Pb. The distributions of these metals in the crops at all the three sites were also similar (Figure 3), with Zn having the highest overall mean concentration (6.97 ± 4.5 mg/kg) and Cu the least (1.909 ± 0.71 mg/kg). Ni and Pb were variable. The trends in the distribution of the metals in the crops were: Kawukudi, Zn > Pb > Ni > Cu; Dzorwulu, Zn > Ni > Pb > Cu and Ebony, Zn > Pb > Ni > Cu.

The results suggest that there has been heavy metal enrichment of roadside soils and crops close to the Obansandjo way. The results could not be related to previous findings since there are no records of previous findings. The distributions of the metal in all the sites follow a similar trend as shown in Figure 2. There were large variations in the levels of the individual metals in the soils compared to the crops. The variations observed in the levels of the metals in both the roadside soils and crops are not strange. Studies have revealed that the amount of metal adsorbed by the soils and uptake by plants along roadsides depends on traffic density and the proximity to the sources of release from the roadside soils and vegetation (Rodriguez-Flores et al., 1982; Sithole et al., 1993). The levels of the Pb, Cu and Zn in the soils and vegetables were comparable to levels of metals in roadside soils and vegetables in Jordan (Jaradat et al., 1999).

However the observed levels in the soils were lower than levels found in some roadside soils in Auckland (Ward et al., 1977), and Nigeria (Ndiokwere, 1984). The levels of Pb and Zn in the vegetables analyzed were between those found in vegetables in Kampala (Nabulo, 2004) The samples collected at Ebony had the highest metal concentration probably because of its closeness to the road, about 5-10 m and the very high volume of traffic compared to the other sites, which were further away from the road, 20 - 40 m, and also the nearness of the site at Ebony to an automobile mechanical shop. The exceptionally high levels of Cu in some of the soils particularly E_2 and D_2 which were 143 and 42.44 mg/kg, respectively, could be due to the application of fungicides ‘cocide 101’. Also, those two samples had higher levels of Zn, above 60 mg/kg. Even though the mean levels of all the metals were below recommended levels (ICRCL, 1987), Ni in samples E_2 and D_2 were within the tolerable level of 90-300 mg/kg recommended by Kabata Pendias and Pendias (1984). The mean nickel level in the soils was above the critical permissible concentration of 50 mg/kg as given by MAFF (1992). Copper levels were within the normal range of 2-250 mg/kg (Kabata Pendias and Pendias, 1984) and also below 300 mg/kg recommended by MAFF (1992). Generally the zinc levels were found to be above the normal range of 10-30 mg/kg observed by Logan (2000) and below the 100 mg/kg as given by MAFF (1992). The levels of the metals in the crops were below the phototoxic levels of 30 -300 mg/kg for Pb; Zn, 100-400 mg/kg and Cu, 20-100 mg/kg recommended by Alloway (1995). The levels of the Ni and Pb were within the ranges, 0.02-5.0 mg/kg for Ni and 5.0-10.0 mg/kg for Pb. Thus the levels of the metals in the crops are not enough to cause harm to the crops. With the exception of Ni, the concentrations of the other metals were far below the recommended dietary levels of the metals in foods by the United Kingdom Department of Health and the US (Ysart et al., 1999).

Generally the moisture content correlated positively with the concentration of metals in the crops, but the correlations were very weak ($P < 0.05$).

Conclusions

Nickel, Pb, Cu and Zn were detected in both soils and crops. The results suggest that heavy metal pollution of roadside soils and crops are largely due to releases from automobiles. The levels of all the metals except Ni were below the phototoxic levels and also lower than the recommended daily intake. Although the concentrations of the metals were below their recommended daily intake, their presences in the food samples analyze could lead to bioaccumulation in the body of consumers and pose health risk in future. The data obtained in this study could serve as a basis for further monitoring.

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