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Heavy metal contamination of Ilorin – Omu-Aran roadside soils and vegetation

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ABSTRACT

*Heavy metal contamination of roadside soils and vegetation along Ilorin – Omu-Aran road was investigated to identify the effects of vehicular emissions and distance on the extent of pollution of the roadside soil and vegetation One hundred samples of each of soil and plants were collected at 10m and 20m from the roadside in the study sites. with stainless soil auger and bulked into separate polyethylene bags. These samples were separately digested by Aqua Regia method, filtered and analyzed for Cu, Cd, Ni, Zn, Pb and Cr contents with Air Acetylene Flame Atomic Absorption Spectrophotometer at 324.8nm wavelength. Data generated were statistically tested with ANOVA, Student t- Test and Carl Pearson's correlation Coefficient at P≤0.05 level of significance. It was found that Cu, Cd, Ni, Zn, Pb and Cr were present in the roadside soil and vegetation. The concentrations of these heavy metals vary with distance from roadside with more of these metals at 10m points and in the valley. Soil samples collected at 10m points had higher concentrations of Ni (0.233±0.045mg/l), Cd (0.272±0.014) and Zn (0.806±0.194mg/l),than those of 20m Ni (0.173± 0.045mg/l,Cd (0.243±0.017mg/l and Zn (0.494±0.098 mg/l)***.***Plant samples had less of these heavy metals than the soil. The valley had more of Pb (1.912±0.137mg/l),Zn (0.256±0.096mg/l) and Cd (0.182 ±0.023mg/l) than other locations. Roadside soils along Ilorin –Omu-Aran were polluted with all the heavy metals except Chromium because their values were higher or more than the permissible limits of European Commission and World Health Organization. The high and significant correlation found between the Ni (r=0.552),Zn (r=0.474),Pb (r=0.632), and Co (r=0.348) of the soils and plants showed that the latter absorbed the metals from the former. It could be recommended that farming activities should not be at roadsides but must be at least 20m away from the road.*
Keywords : *pollution; topography; valley; heavy metals; roadside*

INTRODUCTION

Roadside soils have long been known to contain high levels of heavy metals. Vehicular emission is an important anthropogenic source of soil contamination with heavy metals (Mortvedt *et. al.,* 1981; Nriagu, 1990; Ikedia, 2000). Alfani *et. al*. (2004) identified exhaust emission and combustion of fossil fuel as the primary sources of atmospheric burden.The major source of atmospheric metal is associated with fuel combustion and the operation of smelters and metal refineries (Morgan and Stuum, 1991; Puxbaum, 1991). Alloway (1995) described the soil as the sink of Cd, Pb, Hg, Cr and other heavy metals while Davis *et. al*. (2003) described the soil as the sink of atmospheric pollutants. Pollutants from these sources and other sources settle on the soil and may gain entrance into plants growing on this soil. In this way, heavy metals get accumulated in plants and crops cultivated along the highways (Chen *et. al.*, 2006) which when consumed by man and other livestock accumulate and reach the lethal levels quickly (Wang *et. al.*, 2006).Heavy metals bring about health hazards to man and other organisms when accumulated within the biological system (Viard *et.al.*, 2004).

Heavy metal pollutants are of significant environmental concern because they are not degradable and have long half- life in the soil with the potential of a far reaching effects on the biological systems: plants and other soil biota (Raskin *et. al.*, 1997). Excessive accumulation of heavy metals on agricultural land through traffic emission may result into soil contamination and elevated heavy metals uptake by the plants/crops thus affecting the soil quality and safety (Cunningham *et. al.*,1997). Ogbuagu *et.al.*(2001) identified the composition of crude fuel and reported that it contained 0.003- 42.31 mg/kg transition metals: Vanadium; Chromium; Manganese; Cobalt; Nickel and Copper, some of which cannot be totally removed during refining process of the fuel, hence are readily emitted during combustion.

Higher heavy metal concentrations can result to an increased metal uptake by plants and this can be influenced by metal species, plant species, age of plant and plant part (Amusan *et. al.*, 2005; Moreno *et.al.*,2005; Juste and Mench,1992). Plants therefore absorb these metals mobile ions in the soil solution through their leaves or their roots thus making these plants unfit for human consumption (Cinar and Elik, 2002; Zu *et.al.*, 2003).The quality of the crops produced may be affected by the high concentration of these heavy metals especially when they get accumulated within the upper surface layer of 0 – 20cm (Cicek and Kopara,2004; Munch *et. al.*,1993). Dushenkov (2000) opined that heavy metal polluted soil enhances their uptake and accumulation in plant tissues and eventual phyto-toxicity and change of plant community.

Heavy metals are of public health concern because some of them like Cd and Pb are not required at all by living organisms. The toxicological effect of lead ,which is the most toxic of the toxic heavy metals (Wang *et.al.*, 2006) includes inhibition of haemoglobin formation, sterility, hypertension and mental retardation in children (Amdur *et.al.*,1991).Hg causes brain damage, chest pain, stomach pain and cough while cadmium causes dysfunction of the kidney(Patterson, 1987). Ghosh and Singh (2005) described the soil as the third environmental component and one of the most extensive habitat containing diverse assemblages of living organisms. In Nigeria, many people farm along the roadsides of major roads raising crops for family consumption and for the market. The land tenure, pressure on land or other reasons may have led these farmers to the roadside. The crops produced from these farms are consumed without knowing their safety in respect of the effects of the vehicular emissions on the qualities of these products. It is therefore imperative to investigate the effects of the vehicular emissions on the produce of these farms so as to advise the consumers on the safety or health implications. so as to reduce the threat to the vegetation, man and animals and the quality of life through the food chain.

This study was designed to investigate the roadside heavy metal deposition type and concentration, with respect to the distance along Ilorin – Omu-Aran road.

MATERIALS AND METHODS

Ilorin – Omu-Aran has an average daily traffic density of 4,873 vehicles and is a distance of 73 kilometres. This road was chosen because of it's high traffic density .The Ilorin - Omu-Aran road links Ilorin with Abuja, the Federal Capital Territory. Top soil and Elephant grass (*Pennisetum purpureum* Schumach) were collected at 10m and 20m from the road side and with interest in the physiographic features (depression /valley, the elevation /hill and the plain) along Ilorin – Omu-Aran road. Samples of soil and elephant grass were also collected from Ile -Apa, a remote village, around Ilorin with little or no vehicular emission. The village is about 20 km to Ilorin – Omu-Aran road. A total of 200 samples were collected. Soil samples (top soil) were collected with stainless soil Auger and the plant materials with stainless steel pen knife into different polyethylene bags, well labelled and brought to the laboratory for further analyses. The soil and plant samples collected were separately digested by Aqua Regia method (Allen *et al*., 1974). The filterates of the digested samples were separately and appropriately transferred into well labelled sterile plastic bottles.

The concentrations of Cu, Cd, Ni, Zn, Pb and Cr in the samples were determined with an Air Acetylene Flame Atomic Spectrophotometer at 324.8 nm wavelength. Data generated from the analyses were subjected to descriptive and inferential statistics. ANOVA was used to compare the heavy metal loads of collected samples of the four major locations. Student t -test was used to compare the means of the soil and plant samples, Duncan Multiple Range Test was used to separate the means, in case of any significant difference at $P \leq 0.05$ and Carl Pearsons Correlation Coefficient Analysis Statistical package described by Panje *et al*.,(1993) was used to determine the relationship between the heavy metal loads of soil and plants

RESULTS

The concentrations of the different heavy metals in the soil and the vegetation along the Ilorin – Omu-Aran roadside are shown in Table 1. Generally, the concentration of each metal in the soil was greater than in the plants samples except for cobalt which was more in the plant samples collected from the hill and plain locations than the soils. When these concentrations were compared statistically, it was found that they were statistically greater in the soil than in the plants at $P\leq 0.05$ except for Ni. A mean range of 0.183 ±0.041 mg/l to 0.262 ± 0.068 mg/l Cu was found in the soil with the valley soil samples having the greatest concentration which was statistically greater than the samples in the Control, plain and hill. The mean concentration of Ni ranged between 0.192 ± 0.053 mg/l and 0.229 ± 0,071 mg/l, all were statistically the same at $P \leq 0.05$ (Table 1).

Cadmium ranged from 0.184 ± 0.038 mg/l to 0.349 ± 0.177 mg/l, with the soil samples in the hilly areas containing the greatest concentration. These values were found to be statistically greater than the other soil samples with the Control having the least. Table 1 further shows the range of the mean concentration of zinc as 0.280 ± 0.159 to 0.643 ± 0.276 mg/l. Soils from the hilly locations had the greatest concentration but statistically the same with the valley but statistically greater than the plain and the Control. Moreover, Pb had a mean range of 3.586 ± 0.629mg/l to 4.683 ± 0.770 mg/l, the valley had the greatest Pb concentration which was statistically different from samples from other locations at $P \leq 0.05$.Co was the same statistically in all the samples and ranged between 0.155 ± 0.0302 mg/l and 0.199±0.060 mg/l. Summarily, the Cu, Cd and Pb contents of samples collected in the valley were statistically greater than those collected from the other locations at $P \leq 0.05$.The zinc contents of the soil of the valley and the hill were statistically the same but greater than the other two locations at $P \leq 0.05$.In respect of concentrations, Pb >>> Zn > Cd >Ni >Cu >Co, Pb >>>Zn > Cd >Cu >Co >Ni, Pb >>> Zn > Cd >Cu ≥Co >Ni and ,Pb >>> Zn >Ni >Cd >Cu >Co for the soil samples of the hill, valley, plain and Control respectively.

As for the plant samples, a mean range of 0.061 ± 0.028mg/l - 0.120 ± 0.067 mg/l, 0.106 ± 0.043 - 0.179 ± 0.042 mg/l, 0.063 ± 0.052 – 0.124 ± 0.037mg/l,0.145 ± 0.061 – 0.240 ± 0.089 mg/l, 0.911 ± 0.366 – 1-315 ± 0.243 mg/l and 0.118 ± 0.063 – 0.745 ± 0.470 mg/l for Cu, Ni, Cd, Zn, Pb, and Co respectively. All the concentrations per metal were statistically different at $P \leq 0.05$ except Cu that was statistically the same. The nickel concentrations of plant samples of the Control and the valley were the same statistically likewise, were those of the hill and plain but statistically greater than the former at $P \leq 0.05$.The Cd contents of samples from the hill, valley and the plain were significantly higher than the Control at $P \leq 0.05$. The Zn contents of the valley were more than the plain but the same statistically with the Control and the hill at $P \leq 0.05$.Pb contents of the Control was statistically the same with the plain and that of the valley was the same as the hill but the two groups were statistically different at $P\leq0.05$.Furthermore ,the Co contents of the Control and the hill were the same but greater than that of the valley but less than the plain statistically at $P\leq 0.05$. Generally, the heavy metal loads in the plant samples were far less than those in the soil.A concentration trend of Pb>>>Zn ≥ Ni, Cd ≥ Cu ≥ Co, Pb >>>Co>>Zn ≥ Ni >Cd >>Cu, Pb >>> Co >>Ni >Zn >Cd >>Cu and Pb >>Co > Zn > Ni > Cd, Cu for the plant materials collected in the valley, hill, plain and Control respectively.

The concentrations of heavy metals at 10m and 20m distances from the road along Ilorin – Omu-Aran road are shown in Table 2 .When these values were compared statistically, the soil samples of both locations had same Cu, Cd, Zn, Pb and Co concentration at $P\leq 0.05$ though numerically different. The Cu, Ni, Cd and Zn contents of the valley were statistically different from one another but the Pb and Co were statistically the same at $P \leq 0.05$. The Ni, Cd, Zn,Pb and Co concentration were more in the soil of 10m than 20m while Cu was more in 20m than 10m locations. In the samples collected in the plain,only Zn was statistically greater at 20m than 10m points at $P \leq 0.05$.All except the Cu and Zn were more at 20m than

10m in the plain. This shows that more of these heavy metals are more at the point nearer to the road than farther ones.

Table 1: Mean concentrations of heavy metals (mg/l) in the roadside soils and plants.

Location	Heavy Metal	Soil : Mean ± SD	Plant : Mean ± SD	r- value
Control	Cu	0.183 ±0.041[a]	0.061 ± 0.028[a]	0.018
	Ni	0.214 ± 0.045[a]	0.106 ± 0.044[a]	0.128
	Cd	0.184 ± 0.038[a]	0.064 ± 0.052[a]	0.085
	Zn	0.332 ± 0.093[a]	0.212 ± 0.080[ab]	0.417
	Pb	3.745 ± 0.465[a]	0.911 ± 0.366[a]	0.204
	Co	0.155 ± 0.030[a]	0.477 ±0.459[b]	0.191
Hill	Cu	0.204 ± 0.057[a]	0.083 ± 0.041[a]	0.291
	Ni	0.229 ± 0.071[b]	0.177 ± 0.055[b]	0.353
	Cd	0.349 ± 0.177[b]	0.107 ± 0.048[a]	0.266
	Zn	0.643 ± 0.276[b]	0.108 ± 0.091[ab]	0.536
	Pb	3.586 ± 0.629[a]	1.243 ± 0.116[b]	0.306
	Co	0.199 ± 0.060[a]	0.745 ± 0.470[bc]	0.099
Valley	Cu	0.262 ±0.068[b]	0.120 ± 0.067[b]	0,242
	Ni	0.192 ± 0.053[a]	0.124 ± 0.042[a]	0.099
	Cd	0.255 ± 0.026[a]	0.124 ± 0.037[b]	0.248
	Zn	0.577 ± 0.230[b]	0.240 ± 0.089[b]	0.119
	Pb	4.683 ± 0.770[b]	1.315 ± 0.243[b]	0.602
	Co	0.195 ± 0.048[a]	0.118 ± 0.063[a]	0.500
Plain	Cu	0.204 ± 0.065[a]	0.084 ± 0.046[a]	0.106
	Ni	0.195 ± 0.073[a]	0.179 ± 0.042[b]	0.552
	Cd	0.263 ± 0.099[a]	0.107 ± 0.045[a]	0.273
	Zn	0.280 ± 0.159[a]	0.145 ± 0.061[a]	0.473
	Pb	4.159 ± 0.379[a]	0.949 ± 0.408[a]	0.632
	Co	0.199 ± 0.042[a]	0.828 ± 0.349[c]	0.348

Same metal with same superscript within same column are statistically the same at $P< 0.05$

The different concentrations of the heavy metals in the plant materials collected at 10m and 20m points from the road are shown in Table 3. Higher concentrations of these metals were found in samples collected from 10m locations than the those of 20m except copper that was more in the 20m locations of the hill. All the plant samples of the hilly locations were found to be statistically the same at $P \leq 0.05$ except copper that was more significant at 20m than 10m point. The valley samples had more of Cd, Zn, Pb, and Co at 10m points than 20m while Cu and Ni were more in 20m locations than 10m. Only cadmium was statistically different at $P\leq 0.05$ out of all the heavy metals of the valley plant samples. As for the plain, all except Zn were statistically the same at $P\leq0.05$ and The Zn and Cu were more in samples collected at 20m points than 10m points (Table 3).However ,all the heavy metal contents of the plant materials were less than those of the soils.

The correlations between the heavy metal loads of the soil and plant samples collected along Ilorin – Omu-Aran road are shown in Table 1. A high and significant correlation was found between Ni (r=0.552),Zn (r=0.474)and Pb (r= 0.632) in samples collected from the plain. Moreover, in the samples from the valley, only Pb (r=0.602) and Co (r= 0.500) had high and significant correlations. Only Zn (r=0.536) and (r= 0.417) was high and significant in materials of the hill and Control respectively.

Table 2: Comparative heavy metal contents (mg/l) of roadside soil at 10m and 20m points.

Location	Point(m)	Cu	Ni	Cd	Zn	Pb	Co
Control	10	0.189 ±0.037	0.225 ±0.057	0.175 ±0.049	0.281 ±0.073	3.675 ±0.516	0.147 ±0.027
	20	0.177 ±0.047	0.203 ±0.029	0.193 ±0.025	0.383 ±0.085	3.815 ±0.445	0.163 ±0.034
	t-test	0.494^{NS}	0.868^{NS}	0.812^{NS}	2.241^{S}	0.504^{NS}	0.910^{NS}
Hill	10	0.225 ±0.074	0.212 ±0.060	0.417 ±0.221	0.632 ±0.338	4.110 ±0.458	0.206 ±0.050
	20	0.189 ±0.030	0.259 ±0.078	0.294 ±0.088	0.655 ±0.231	4.069 ±0.954	0.182 ±0.063
	t-test	1.089^{NS}	1.182^{NS}	1.259^{NS}	0.139^{NS}	0.096^{NS}	0.729^{NS}
Valley	10	0.224 ±0.053	0.233 ±0.048	0.272 ±0.014	0.806 ±0.194	4.954 ±0.545	0.194 ±0.072
	20	0.307 ±0.038	0.173 ±0.045	0.243 ±0.017	0.494 ±0.098	4,078 ±0.787	0,172 ±0.035
	t-test	3.091^{S}	2.229^{S}	3.447^{S}	3.507^{S}	0.574^{NS}	0.239^{NS}
Plain	10	0.158 ±0.060	0.185 ±0.103	0.283 ±0.072	0.169 ±0.143	4.274 ±0.459	0.297 ±0.024
	20	0.231 ±0.057	0.205 ±0.028	0.235 ±0.125	0.344 ±O.120	3.923 ±0.419	0.210 ±0.048
	t-test	2.161^{NS}	0.451^{NS}	0.812^{NS}	2.291^{S}	1.374^{NS}	0.600^{NS}

Table 3: Comparative heavy metal contents (mg/l) of roadside plants at 10m and 20m points.

Location	Point(m)	Cu	Ni	Cd	Zn	Pb	Co
Control	10	0.078 ±0.023	.0.072 ±0.030	0.039 ±0.034	0.215 ±0.053	0.921 ±0.364	0.717 ±0.472
	20	0.050 ±0.030	0.139 ±0.025	0.089 ±0.057	0.291 ±0.106	0.900 ±0.402	0.238 ±0.321
	t-test	1.404^{NS}	4.189^{S}	1.844^{NS}	0.104^{NS}	0.094^{NS}	2.057^{NS}
Hill	10	0.052 ±0.010	0.200 ±0.059	0.192 ±0.045	0.171 ±0.126	1.821 ±0.095	0.793 ±0.546
	20	0.115 ±0.035	0.156 ±0.043	0.122 ±0.050	0.190 ±0.049	1.266 ±0.139	0.697 ±0.428
	t-test	4.275^{S}	1.499^{NS}	1.113^{NS}	0.336^{NS}	0.643^{NS}	0.337^{NS}
Valley	10	0.076 ±0.017	0.111 ±0.050	0.182 ±0.023	0.256 ±0.096	1.912 ±0.137	0.191 ±0.058
	20	0.163 ±0.238	0.138 ±0.031	0.146 ±0.037	0.224 ±0.088	1.418 ±0.292	0.145 ±0.059
	t-test	0.894^{NS}	1.105^{NS}	2.502^{S}	0.610^{NS}	1.563^{NS}	1.604^{NS}
Plain	10	0.079 ±0.050	0.192 ±0.041	0.183 ±0.021	0.109 ±0.066	1.735 ±0.451	0.892 ±0.383
	20	0.089 ±0.046	0.166 ±0.043	0.131 ±0.050	0.181 ±0.038	1.162 ±0.231	0.763 ±0.333
	t-test	0.386^{NS}	1.055^{NS}	2.173^{NS}	2.464^{S}	2.064^{NS}	0.627^{NS}

DISCUSSION AND CONCLUSION

The heavy metal contents of plants collected from the Ilorin – Omu-Aran road were higher than the Control sites. This shows that the high concentration of the heavy metals in the soil and their absorption were responsible for the high concentration in plants. This is because the soil is the reservoir of nutrients, water and other heavy metals. The higher concentration of heavy metals in the soils and plant materials of the study area than the Control suggests an enhanced level of atmospheric metal pollution in high traffic density sites as reported by Ho and Tai(1988). Ward *et al*.(1975) implicated vulcanization as the source of cadmium contamination. WHO (1984) reported that the permissible levels of Cd in plants is within the range of 0.002 – 0.2mg/l suggesting that the Cd level is still within the permissible range. The range reported in this study was less than 0.26 mg/l reported by Ho and Tai (1988) and Awofolu (2005). However, the accumulation of Cd has been linked with increase in soil salinity (Soler and Soler, 1996).

The heavy metal contents of the soils and plants of the study locations along major road can be attributed to vehicular emission. This assertion compared favourably with the findings of Fakayode and Olu – Owolabi (2003). The concentration of lead in the soil of Ilorin – Omu-Aran road ranged between 0.38 mg/l and 6.14 mg/l. In this study, the range obtained is higher than the maximum tolerable levels proposed for agricultural soils (0.09 – 0.3mg/l) (Kabata – Pendias and Pendias, 1984). They are also higher than European Commission (EC) upper limit of 0.3mg/l (EC, 1986). The higher concentration of Pb around the major roads has also been reported by Oyedele *et al*. (1995). Alfani *et al.* (2004) observed that the elevated levels of elements above their normal content in the reference soils could be regarded as potential pollutant or contaminant arising from vehicular emissions especially gasoline additives such as Ni, Pb and Cr. The use of 0 – 15 cm top layer of the soil (top soil) is a better indicator of metallic burden, its organic matter bind and hold the soil together thereby retaining the water soluble metals (Turer and Maynard, 2001). Garcia and Millan (1998) remarked that the top soil is the region that plant roots are found.

Cadmium content of the soil samples in this study ranged between 0.11 and 0.66 mg/l.The values are lower than the findings of Ward *et al*.(1975) but compared favourably with the result of Baker and Brooks (1989).Pollution of soil with cadmium could be attributed to the wears and tears of tyres (Soler and Soler ,1996).This is supported by the finding of Awofolu (2005) who reported that car tyres contain cadmium range of 0.02 – 0.09mg/l. Moreover, nickel ranged between 0.02 and 0.04mg/l which is within the permissible range of 0.005 – 0.5mg/l(WHO,1984) thus this study area has no critical nickel pollution. Nickel toxicity is generally associated with the soils irrigated with waste water (Salt *et al.*,1995).

WHO (1984) gave the critical limit of cobalt as 0.001 – 0.15 mg/l but the cobalt concentration of the studied roadside was higher. This shows that the roadside soils are highly polluted with cobalt. Copper content in the soils differ according to soil types and pollution sources (Wang *et al*.,2006). Different values of copper concentrations in the soil have been reported, 0.0014 – 0.0038 mg/l (Madejon *et al*.,2002),0.06- 0.23 mg/l (Shallari *et al*.,1992) but the normal Cu content of the soil ranged between 0.02 – 0.1 mg/l. The copper content of the soil under study was higher hence the soil is polluted. This can be attributed to the anthropogenic activities, engine wears and the wears of thrust bearing and bearing metals.

Fleming and Parle (1977) identified that Pb, Zn, Cu, Ni, and Cd are usually higher in the soils than the plants in uncontaminated soils. The result of this study compared favourably with this finding. Fatoki (1996) reported that there is usually elevated Pb and Zn concentrations in the roadside vegetations .The level of heavy metals in the plants along Ilorin – Omu-Aran road is a reflection of the high traffic density. This is further supported by the findings of Ademoroti (1986) that the levels of heavy metals in the bark and fruits of trees along roads in some parts of Nigeria varied directly with traffic volumes. The Ni contents of plants analyzed were lower than the critical range of 2.0 – 5 mg/l. Ni is absorbed easily and rapidly by plants. The heavy metals are returned back to the soil through the washing down of heavy metals deposited on the leaves of roadside plants by precipitation and shedding of leaves (Cunningham *et al.,* 1997)

The copper content of plants reported in this study showed that the study areas are less polluted with copper. Plants exhibit different tolerance levels for Cu but the critical level for plants is within the range of 0.02 to 0.15 mg/l for most plants. However, Zu *et al.* (2004) reported that the normal copper level in shoots of plants is 0.1 mg/l. The Cu concentration obtained in this study is still within the critical range hence no Cu pollution. The much cobalt concentration in these plants could be attributed to the absorption and accumulation of this heavy metal in the plants. Mobility of Co is slow in plants (Robson *et al.*, 1997) and its toxic level for plants is about 0.5mg/l (Pendias and Pendias, 1992).The values of Co obtained in the plain and hill in this study were higher than 0.5mg/l thus suggesting a contamination of the roadside by Co. The high Co content in the twigs may be due to a direct deposition and foliar absorption rather than its translocation. The Co level of the valley and the Control suggest that they are within the critical value. The differences among these values may be attributed to topography such that those in the plain and hills might have been washed away in run off or erosion into the valley.

Zinc levels in plants as reported in this study is still within the permissible range (0.01 – 0.3mg/l (Awofolu, 2005).The Zn contents in plants was lower than the soil content. Zn is an essential trace element required by plants but its excess may result to toxic symptoms such as reduction in root growth for the less tolerant plants (Ruana *et al*., 2004).The higher and significant contents of Cu, Ni, Cd, and Zn in the valley soil may be due to the run off or washing down of deposited heavy metals into the valley. The higher values of these heavy metals in the soils and plants at 10m points than 20m could be attributed to distance to the source of pollution. The otherwise situation of Cu and Zn may be due to their weights or particulate size and the time taken to settle. The concentrations of heavy metals recorded in this study can only be due to emissions from vehicle exhaust in particulate form which are forced to settle under gravity closer to the road edge as observed by Ho and Tai (1988). Distance has effect on the accumulation of heavy metals in both the soil and plants. Cd, Pb, and Co decrease with distance in all locations. This suggests that these heavy metals originate from atmospheric deposition rather than from parent materials (Amusan *et al.,* 2005).Wang *et al*. (2006) reported that the accumulation of Pb and Cd above background levels take place up to a distance of approximately 33m from the highway. The result of this study agreed with this observation. Decreased elemental concentration with distance from roadside indicates surface soil contamination by extraneous sources whereas unchanging levels show that the heavy metal concentration is a function of the soil itself (Osibanjo and Ajayi, 1989).

The strong and significant correlation of Pb in the soils and plants implies that Pb had the highest penetration from soil into the plants. This also confirms that the source of Pb to plant is from the soil through absorption. The accumulated Pb in plants gains entrance into ruminant animals that feed on these plants and eventually lodge in man through the food chain causing serious hazard (Fergusson, 1990).High level of Pb is a reflection of the intensity of vehicular emission in the studied road (Ademoroti, 1986).The average level of Pb at 10m and 20m from the road compared with the result obtained by Ebong *et al.* (2008) and Fakayode and Olu – Owolabi (2003). Decrease in Pb content in the highway with distance indicates that edible crops for human and animals should be restricted to distances of at least 20m from both sides of heavily trafficked roads (Ikedia *et al*., 2000).Vehicles consume more fuel and release more emissions while ascending hills which may fall under gravity into the valley and roadsides where they get accumulated. This is because more effort is required to subdue the resistance. Therefore, the higher concentrations of these six heavy metals in the soils and plants in the study area suggest that these metals are released by vehicles.

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