QUANTIFICATION OF TRAFFIC-RELATED HEAVY METAL POLLUTION IN SOILS AND PLANTS: A CASE OF ILORIN-IBADAN ROAD, NIGERIA

[1, 2]Oyedeji, S., [1]Ogunkunle, C.O., [1]Isamotu, T.T. and [1]Fatoba, P.O.
[1]Plant Diversity and Environmental Management Unit,
Department of Plant Biology University of Ilorin, Ilorin, 240003 Nigeria.
[2]International Research Centre, Sathyabama University, Chennai, 600119 India.

ABSTRACT
The increased use of vehicles coupled with lack of emission standards have increased the deposition of traffic-related metals in the environment. This study quantified heavy metals concentrations in soils and plants in relation to distances from Ilorin-Ibadan road, in order to determine the contributions of vehicular emissions to the environmental pollution status. Soil and plant samples were collected at 2 m and 5 m distances from the road at Eyenkorin, Ogbomosho, Iwo and Olodo. The collected soil and plant samples were analysed for Zn, Pb, Cd, Cr, Ni and Cu concentrations using standard methods. Results showed that Pb was higher than Ni, Cr, Cu, Cd and Zn in the soil. Differences between metals concentrations at 2 m and 5 m distances from the road was inconsistent. The highest total concentrations of soil Zn (11.57 µg.g^{-1}) and Pb (45.98 µg.g^{-1}) were in Iwo and Ogbomosho respectively. Eyenkorin had the highest total concentrations of Cd (17.10 µg.g^{-1}), Cr (10.23 µg.g^{-1}), Ni (15.95 µg.g^{-1}) and Cu (12.59 µg.g^{-1}). Total Zn, Pb and Cr contents in the sampled plant at Ogbomosho were highest. Plant samples from Eyenkorin and Iwo had the highest Ni (1.95 µg.g^{-1}) and Cu (2.07 µg.g^{-1}) contents respectively. The levels of Zn and Cu in the plants were within the permissible limits. The correlation of plant Ni concentrations with soil Pb, Cd, Ni and Cu concentrations could serve as tool to ascertain the levels of these metals in the soil. Ilorin-Ibadan road thus reflect varying degree of heavy metals contamination.

Keywords: *contamination, environment, heavy metal, roadside, soil.*

INTRODUCTION

Pollution is the introduction into the environment of substances or energy liable to cause hazards to human health, harm to living organisms and ecological system, damage to structure or amenity of interference with legitimate uses of the environment by man (Holdgate, 1979). Pollution has increased considerably in recent years as a result of increasing human activities such as burning of fossil fuels, industrial and automobile exhaust emissions (Zaidi *et al.*, 2005). The rapid increase in the use of vehicles for day to day transportation in most developing countries, coupled with lack of emission standards in these countries, have contributed a great deal of concern for vehicular pollution (Amusan *et al.*, 2003; Olukanni and Adebiyi, 2012). Nigeria crude oil is known to have about 0.003 – 42.31mg/kg of transition metals such as V, Cr, Mn, Fe, Co, Ni and Cu (Nwachukwu *et al.*, 1995) and are readily emitted to the environment during combustion (Bada and Oyegbami, 2012).

The coarse particles which are formed mechanically by the abrasion of road materials, tyres and brake linings are also sources of pollution to the environment (Palmgren *et al.*, 2003). Although, many studies have shown the extent of contamination of roadside topsoil and vegetation in relation to the traffic volume and proximity to the highway (Lagerwerff, and Specht, 1970; Frion-Frenet *et al*., 1994; Daniel *et al.*, 1997; Jaradat and Momani, 1999; Turer and Maynard, 2003; Uwagboe and Hymore, 2008; Abechi *et al.* 2010; Demirayak *et al.*, 2011; Yan *et al.*, 2012), only few of such studies relates to roads within south-western Nigeria (Amusan *et al.*, 2003, Bada and Oyegbami, 2012, Olukanni and Adebiyi, 2012).

Through the atmospheric deposits and road run-offs, heavy metals are transported to soil along roadside, where they are absorbed by plants (Yan *et al.*, 2012). The concentrations of these metals in soil and plants have been linked to several factors including traffic volume (Abechi *et al.*, 2010; Chen *et al.*, 2010), highway characteristics (Bai *et al.*, 2009), topography/terrain of road and roadsides (Saeedi *et al.*, 2009), distance from roadside (Mmolawa *et al.*, 2011), wind direction (Jaradat and Momani, 1999) and rainfall/water action (Ghrefat and Yusuf, 2006). Traffic-related heavy metals build up in soil can be at significant concentration even at 100 m from the road. Absorption of heavy metals from roadside soils by the root hairs, consequently result in translocation to the stem and leaves of the plant (Yan *et al.*, 2012). Therefore, the factors influencing accumulated heavy metals in plants are related to the soil's heavy metal content. Moreover, the concentration of heavy metals in developed areas has been found to be higher than in underdeveloped areas (Saeedi *et al.*, 2009). Hence, plants along roadsides that accumulate heavy metals can be used as tool in bio-monitoring of the soil's heavy metal concentration (Aksoy *et al.*, 2012).

Despite implicating toxic metals such as Cd, Cr, Cu, Fe, Mn, Pb, and Zn associated with ambient particles from roadside dust in the production and release of inflammatory mediators in respiratory tract epithelium (Duan *et al*., 2012), increasing number of local settlements and farmlands along major roads and highways is raising serious health concerns. Considering the varying degree of traffic in major towns and the importance of Ilorin-Ibadan road as service linkage between north-central and south-western geopolitical zones of Nigeria, this study proves necessary as no previous attempt has been made to assess the continuous traffic-related deposition of heavy metals on soil and vegetation along this road. The present study quantifies the heavy metals concentrations in soil and plant in relation to roadside distances along Ilorin-Ibadan road which cuts across three states (Kwara, Oyo and Osun) of Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out along Ilorin-Ibadan road which spans about 120 km connecting Kwara, Oyo and Osun states of Nigeria. The approximate distance from Eyenkorin (near Ilorin) to Ogbomosho is 35.8 km, Ogbomosho to Iwo is 54.8 km, while Iwo to Olodo (near Ibadan) is 27.5 km. The road reflects varying degree of vehicular traffic and daily traffic density in Ogbomosho, the busiest point along the route, is above 5000 vehicles. Except for the scanty roadside mechanics, vulcanizers, battery chargers, panel-beaters and auto-electricians along this route, farming and agricultural produce marketing constitute the major economic activities. Arable crops cultivated in the region include cassava, maize, sorghum and yam, while cashew, cocoa, kola, mango and oil palm are the major tree crops. The vegetation belt of the area is rainforest with degraded portions now classified as derived savanna (Oladeji *et al.*, 2012).

Sampling procedure

Soil and plant samples were collected from 2 m and 5 m distances from Ilorin-Ibadan road at Eyenkorin (8.402ºN, 4.469ºE), Ogbomosho (8.133ºN, 4.250ºN), Iwo (7.633ºN, 4.183ºE), and Olodo (7.251ºN, 3.573ºE). The choice of the sampling distances (2 m and 5 m) from the road

was informed by close proximity of buildings and farmlands relative to the road. Sampling was carried out close to the points (speed breaks/ bumps) where there is usually speed reduction. The soil samples were collected (from 0-10 cm depth) in five replicates using polyethylene bags prewashed with 3% HNO_3 and rinsed with deionized water. The soil was air-dried, pulverized using acid washed porcelain mortar and pestle, passed through 2 mm nylon sieve and prior to digestion. The soil pH was determined by electrometric method and particle size distribution was determined by hydrometer method as outlined by Bouyoucos (1951). Soil organic matter was determined using the chromic acid oxidation method (Walkley and Black, 1934). 2 g of soil of each sample was wet-digested using 30 ml conc. HNO_3 of high purity, followed by 30 ml of 2 M HCl (Abechi *et al*., 2010). The digested samples were then warmed in 30 ml of 2 M HCl to re-dissolve the metal salts. Shoot materials of *Sida acuta*, widely distributed across the sampling points were collected, washed with deionized water, dried at 80 ºC for 24 hours and digested according to the method by Plank (1992). 2 g of each plant samples was charred and ashed in a muffle furnace at 500 ºC. The ash was dissolved in 1:1 $HClO_4$ - HF mixture and heated until a transparent solution was obtained. The soil and plant digested solutions were cooled to room temperature, filtered, transferred quantitatively to 25 ml volumetric flask and made up to volume with distilled water. Sample digestion was carried out in five replicates together with a blank in the same acid matrix. Quantification of metallic content in samples was carried out using Flame Atomic Absorption Spectrophotometer (Unicam model 929).

The data obtained were subjected to descriptive statistics and analysis of variance. Means were separated using Duncan's Multiple Range Test at 0.05 α-level. Pearson correlation coefficient was used to determine the relationship between soil metal content and accumulated metal in the plant.

RESULTS AND DISCUSSION

Physicochemical properties of the soil

Soil pH, organic matter (OM) and texture in the four towns varied (Table 1). Soil of Olodo had the significantly ($p < 0.05$) highest pH (6.52) and OM (2.77 %). The soil of Eyenkorin, Ogbomosho and Olodo were slightly acidic, while that of Iwo was moderately acidic. Textural class for soils of Eyenkorin, Ogbomosho and Olodo were loamy sand while that of Iwo was sandy loam (Table 1).

Heavy metal concentration in soil

Results from this study showed significant differences in the heavy metal contents in the soil across the four selected sites at both 2 m and 5 m from the road. The highest Zn concentration at 2 m point from the road was in Iwo (15.03±1.23 $\mu g.g^{-1}$), while the least was observed in Ogbomosho (5.03±0.12 $\mu g.g^{-1}$) (Table 2). The highest soil Zn concentration from the 5 m roadside point was in Iwo (8.12±0.53 $\mu g.g^{-1}$), and

Table 1: Physicochemical properties of soil collected from four towns along Ilorin-Ibadan highway

Location	pH (H_2O)	%				Textural Class
		OM	Sand	Silt	Clay	
Eyenkorin	6.26^{b}	1.09^{d}	86.64	6.48	6.88	Loamy sand
Ogbomosho	6.30^{b}	2.37^{c}	82.70	12.19	5.11	Loamy sand
Iwo	5.88^{c}	2.54^{b}	75.29	16.60	8.11	Sandy loam
Olodo	6.52^{a}	2.77^{a}	86.02	9.88	4.10	Loamy Sand

Means with same letter down the column are column are not significant at α = 0.05

Eyenkorin had the least (0.83±0.06 µg.g^{-1}) (Table 3). Soil from the 2 m roadside point had significantly ($p < 0.05$) higher Zn concentrations than the 5 m point for Eyenkorin, but lower for Ogbomosho (Table 4). The observed Zn concentration is less than 121.7 µg.g^{-1} reported for near distance (1.5 m) from roadside in Amman, Jordan (Jaradat and Momani, 1999) but within the range of 5.67-12.88 µg.g^{-1} reported by Abechi *et al*. (2010) for Jos, Nigeria.

Olodo had the highest Pb concentration (48.61±1.09 µg.g^{-1}) at 2 m from the roadside while Eyenkorin had the least (12.06±0.55 µg.g^{-1}) (Table 2). Soil Pb concentration at 5 m from the road was significantly ($p < 0.05$) highest in Ogbomosho (53.50±1.28 µg.g^{-1}) and several folds lower than was reported by Ndiokwere (1984) in Nigeria. Iwo and Olodo had significantly ($p < 0.05$) higher Pb concentration at 2 m than at 5 m from the roadside (Table 4). Jaradat

Table 2: Concentration of heavy metals (µg.g^{-1} dry weight) in soil samples at 2 m roadside point in four towns along Ilorin-Ibadan highway

Location	Heavy metal concentration (µg.g^{-1})					
	Zn	Pb	Cd	Cr	Ni	Cu
Eyenkorin	7.67±0.42^{b}	12.06±0.55^{d}	18.07±1.14^{a}	4.05±0.02^{c}	15.47±1.48^{a}	14.02±1.13^{a}
Ogbomosho	5.03±0.12^{b}	38.46±0.91^{b}	2.12±0.55^{c}	9.66±0.38^{a}	8.48±1.37^{b}	15.05±0.51^{a}
Iwo	15.03±1.23^{a}	33.06±1.67^{c}	0.77±0.08^{c}	1.41±0.30^{d}	12.20±0.28^{a}	13.04±0.58^{a}
Olodo	6.43±0.54^{b}	48.61±1.09^{a}	6.46±0.38^{b}	7.75±0.23^{b}	1.66±0.02^{c}	3.42±0.38^{b}

Values (mean ± standard error) with the same letter down the column are not significant at α = 0.05

Table 3: Concentration of heavy metals (µg.g^{-1} dry weight) in soil samples at 5 m roadside point in four towns along Ilorin-Ibadan highway

Location	Heavy metal concentration (µg.g^{-1})					
	Zn	Pb	Cd	Cr	Ni	Cu
Eyenkorin	0.83±0.06^{b}	26.82±1.25^{d}	16.13±0.53^{a}	16.41±0.06^{a}	16.42±0.34^{a}	11.16±0.10^{a}
Ogbomosho	6.92±0.70^{a}	53.50±1.28^{a}	3.04±0.05^{c}	10.04±0.05^{b}	8.68±0.72^{b}	0.93±0.05^{c}
Iwo	8.12±0.53^{a}	43.66±0.09^{b}	1.64±0.05^{d}	8.88±0.77^{b}	8.44±0.33^{b}	11.89±0.70^{a}
Olodo	6.88±0.52^{a}	38.93±1.06^{c}	6.41±0.07^{b}	4.06±0.03^{c}	2.06±0.11^{c}	6.22±0.25^{b}

Values (mean ± standard error) with the same letter down the column are not significant at α = 0.05

Table 4: t-test comparison between heavy metal concentration in soil samples from 2 m and 5 m roadside points from four towns along Ilorin-Ibadan highway

Location	p-value					
	Zn	Pb	Cd	Cr	Ni	Cu
Eyenkorin	0.008	0.903	<0.001	0.001	0.737	<0.001
Ogbomosho	<0.001	0.032	<0.001	<0.001	0.140	0.068
Iwo	0.288	0.002	0.001	0.176	0.002	0.751
Olodo	0.147	<0.001	0.002	0.315	0.335	<0.001

and Momani (1999) also observed decreasing Pb concentrations with increasing distance from roadside. Soil Pb concentrations in this study is outside the range of 1.59–12.10 $\mu g.g^{-1}$ reported by Abechi *et al.* (2010).

Decreasing order of Cd concentration in the soil at 2 m from the road was Eyenkorin > Olodo > Ogbomosho > Iwo (Table 2), while at 5 m the order was Ogbomosho > Iwo > Eyenkorin > Olodo (Table 3). Cd concentration in Ogbomosho and Iwo were lower than the range (5.15-5.79 $\mu g.g^{-1}$) reported by Abechi *et al* (2010), while those of Eyenkorin and Olodo were higher. Soil Cd concentration for the 2 m and 5 m points was different ($p < 0.05$) in the towns studied. The level for Iwo and Ogbomosho fall within the worldwide range of 0.5-4.0 $\mu g.g^{-1}$ (Fergusson and Kim, 1991). The concentrations at 2 m (0.77±0.08 $\mu g.g^{-1}$) and 5 m (1.64±0.05 $\mu g.g^{-1}$) for Iwo were lower than 2.11 $\mu g.g^{-1}$ for soil reported by Amusan *et al.* (2003) in Osun State. Cd contamination in soils is attributed to release from motor accumulators/batteries and carburettors (Arslan and Gizir, 2006), wearing of paints on vehicle body/parts (Asthana and Asthana, 2006; Ogbonna and Okezie, 2011), tears and wears of tyres (Smolders and Degryse, 2002).

Soil Cr concentration at 2 m from roadside was highest in Ogbomosho (9.66±0.38 $\mu g.g^{-1}$) (Table 2) while Eyenkorin had the highest Cr concentration (16.41±0.06 $\mu g.g^{-1}$) at 5 m distance from the road (Table 2). Eyenkorin and Ogbomosho had significantly ($p < 0.05$) higher concentrations of Cr at 5 m than the 2 m sampling distances (Table 4). Cr concentration was less than 36.20 $\mu g.g^{-1}$ reported for roadside vehicular pollution in Qinghai-Tibet Plateau, China (Yan *et al*., 2013). Eyenkorin had the highest Ni concentrations at 2 m (15.47±1.48 $\mu g.g^{-1}$) and 5 m (16.42±0.34 $\mu g.g^{-1}$) roadside distances (Table 2 and 3). There was however no significant ($p > 0.05$) difference in Ni concentration in the 2 m and 5 m roadside points, except at Iwo (Table 4). The observed soil Ni concentration was less than 31.93 $\mu g.g^{-1}$ reported by Yan *et al.* (2013). The association of Cr and Ni in decorative plating, as to providing bright surfaces with wear and tarnish resistance in motor parts and other metal alloys (Papp, 1994), could be responsible for the close range of Cr (1.71-16.47 $\mu g.g^{-1}$) and Ni (1.68-16.76 $\mu g.g^{-1}$) in the soils. Soil Ni concentration for Iwo is higher than 7.55 $\mu g.g^{-1}$ reported by Ayodele and Dawodu (2008), but within the range reported in Ogun state, Nigeria (Olukanni and Adebiyi, 2012), Ethiopia (Melaku *et al.*, 2005), India (Abida *et al.*, 2009), Poland (Dudka, 1992) and USA (Bradford *et al.*, 1996). Cu concentration in Ogbomosho at 2 m from the road was significantly ($p < 0.05$) highest (Table 2), but the concentration was highest at 5 m roadside distance in Iwo (Table 3). Cu concentration for 2 m and 5 m roadside distances was not statistically different ($p < 0.05$) except in Eyenkorin and Olodo (Table 4). Mean Cu concentrations in the soils was generally less than those reported by Ekmekyapar *et al.* (2012). The greater amount of metals at roadside distance of 2 m than at 5 m suggest contamination from anthropogenic sources, rather than from natural source like parent rock. This is in line the report of Osibanjo and Ajayi (1989). Fakayode and Olu-Owolabi (2003) also reported decreasing heavy metal concentrations from the roadside to be due to vehicular emissions in particulate form that settle under gravity at decreasing concentrations from the road edge.

Heavy metal concentration in plant

Zn concentration in plant samples collected at 2 m from the road was highest in Ogbomosho (1.02±0.01 $\mu g.g^{-1}$), and significantly ($p < 0.05$) different from plants at Iwo, Olodo and Eyenkorin (Table 5). Ogbomosho and Iwo had significantly ($p < 0.05$) higher Zn than Eyenkorin and Olodo at 5 m from the roadside (Table 6). This observed concentrations was less than 98.7 $\mu g.g^{-1}$ reported in Amman, Jordan (Jaradat and Momani, 1999).

There was no significant ($p > 0.05$) difference in Pb concentration for plant samples at 2 m from the road in Eyenkorin (3.01±0.03 $\mu g.g^{-1}$) and Iwo (2.98±0.08 $\mu g.g^{-1}$), however samples from

Table 5: Concentration of heavy metals (µg.g^{-1} dry weight) in plant samples at 2 m roadside point in four towns along Ilorin-Ibadan highway

Location	Heavy metal concentration (µg.g^{-1})					
	Zn	Pb	Cd	Cr	Ni	Cu
Eyenkorin	0.08±0.01^{b}	3.01±0.03^{b}	0.97±0.01^{a}	1.19±0.01^{a}	1.94±0.05^{a}	1.18±0.01^{b}
Ogbomosho	1.02±0.01^{a}	7.79±0.54^{a}	0.99±0.02^{a}	1.18±0.17^{a}	1.06±0.01^{b}	1.28±0.01^{b}
Iwo	0.09±0.01^{b}	2.98±0.08^{b}	0.18±0.09^{b}	1.21±0.07^{a}	1.08±0.01^{b}	2.08±0.02^{a}
Olodo	0.08±0.02^{b}	1.23±0.01^{c}	0.92±0.12^{a}	0.06±0.01^{b}	0.08±0.02^{c}	2.02±0.09^{a}

Values (mean ± standard error) with the same letter down the column are not significant at α = 0.05

Table 6: Concentration of heavy metals (µg.g^{-1} dry weight) in plant samples at 5 m road side point in four towns along Ilorin-Ibadan highway

Location	Heavy metal concentration (µg.g^{-1})					
	Zn	Pb	Cd	Cr	Ni	Cu
Eyenkorin	0.04±0.01^{b}	3.09±0.59^{c}	0.19±0.02^{b}	1.06±0.01^{b}	1.96±0.23^{a}	1.02±0.01^{c}
Ogbomosho	0.09±0.01^{a}	6.04±0.04^{a}	0.06±0.01^{c}	2.02±0.02^{a}	1.09±0.01^{b}	1.64±0.14^{b}
Iwo	0.08±0.01^{a}	4.66±0.22^{b}	1.05±0.05^{a}	1.08±0.04^{b}	1.01±0.00^{c}	2.06±0.04^{a}
Olodo	0.05±0.01^{b}	6.21±0.46^{a}	0.09±0.01^{c}	0.08±0.01^{c}	0.06±0.01^{d}	0.81±0.01^{c}

Table 7: -test comparison between heavy metal concentration in plant samples from 2 m and 5 m roadside points from four towns along Ilorin-Ibadan highway

Location	p-value					
	Zn	Pb	Cd	Cr	Ni	Cu
Eyenkorin	<0.001	<0.001	0.198	<0.001	0.566	0.065
Ogbomosho	0.214	0.001	0.172	0.377	0.902	<0.001
Iwo	0.007	0.003	0.001	0.001	0.001	0.278
Olodo	0.576	0.003	0.909	<0.001	0.021	0.003

Ogbomosho had the highest Pb concentration (7.79±0.54 µg.g^{-1}) (Table 5). Decreasing order of Pb content in plant samples at 5 m from the roadside was Olodo > Ogbomosho > Iwo > Eyenkorin (Table 6). Except for Ogbomosho, accumulated Pb in plant samples at 5 m was higher than that at 2 m. This contradicts the report of Naser *et al*. (2012), where heavy metals in plants decreased with distance from the road. Pb concentration in this study is within the range of 7.3±3.1 µg.g^{-1} in roadside plants of Jordan (Jaradat and Momani, 1999.)

The highest Cd and Cr concentration were in Ogbomosho (0.97±0.01 µg.g^{-1}) and Iwo (1.21±0.07 µg.g^{-1}) respectively. Iwo had significantly higher Cd at 5 m from the roadside than at 2 m (Table 7). Cd concentrations in the plant tissues was within the range of 0.03-1.93 µg.g^{-1}reported by Shah *et al*. (2013). All the towns, except Ogbomosho showed differences in Cr concentration for the 2 and 5 m sampling points (Table 7). Cr concentration in plant was generally less than 9.61 µg.g^{-1} reported for *Rhazya stricta* in Pakistan (Shah *et al*., 2013). Eyenkorin

had the highest Ni concentration at 2 m (1.94±0.05 µg.g^{-1}) and 5 m roadside distances (1.96±0.23 µg.g^{-1}). Except for Iwo with lower Ni concentrations, the result for Ni fall within the range reported by Shah *et al.* (2013). Iwo however had the highest Cu concentration at 2 m and 5 m sampling points (Tables 5 and 6). Cu concentration was significantly ($p < 0.05$) higher in the plant at 2 m than at 5 m in Olodo. The reverse was the case for the sample from Ogbomosho (Table 7). Cu concentrations in plant tissues in this study is less than 31.4 µg.g^{-1} reported for traffic-related contamination in Jordan (Jaradat and Momani, 1999).

Relationship between heavy metals in soil and plant

Table 8 shows a significant negative correlation between soil Zn and Cd ($r = -0.518$; $p < 0.05$), Zn and Cr ($r = -0.805$; $p < 0.05$) as well as Pb and Cd ($r = -0.740$; $p < 0.05$). The relationship between soil Pb with both Ni and Cu in the soil were of the same magnitude and significant ($r = -0.684$; $p < 0.05$). A positive correlation exist between soil Cd content and soil Ni ($r = 0.530$; $p < 0.05$) as well as between soil Ni and soil Cu ($r = 0.561$). There was significant negative correlation between with Ni uptake in plant and the soil Pb content ($r = -0.675$; $p < 0.05$) but a positive relationship exist between Cu uptake and Pb content in soil ($r = 0.452$; $p < 0.05$). Also, a negative correlation exist between soil Cd and plant total Cu content ($r = -0.574$; $p < 0.05$) while the relationship of Ni content in plant had a positive correlation with soil Cd ($r = 0.572$; $p < 0.05$). Both Cr and Ni uptake in plants are positively correlated with soil Ni content. Uptake of Pb and Zn in plants were positively related ($r = 0.611$; $p < 0.05$) while Cr and Ni content were also related ($r = 0.649$).

Zn accumulation in plants did not correlate with values obtainable in the soils. Generally, the values from all the locations were lower as compared to those of Ekmekyapar *et al.* (2012). There was however tendency of Zn uptake by

Table 8: Pearson correlation of total heavy metal contents in soil and plant samples across the selected sites along Ilorin-Ibadan highway

	Zn-soil	Pb-soil	Cd-soil	Cr-soil	Ni-soil	Cu-soil	Zn-plant	Pb-plant	Cd-plant	Cr-plant	Ni-plant	Cu-plant
Zn-soil	1.000											
Pb-soil	0.041	1.000										
Cd-soil	-0.518*	-0.740*	1.000									
Cr-soil	-0.805*	0.166	0.251	1.000								
Ni-soil	-0.070	-0.684*	0.530*	0.241	1.000							
Cu-soil	0.162	-0.684*	0.161	-0.098	0.561*	1.000						
Zn-plant	-0.096	0.064	-0.309	0.135	-0.058	0.413*	1.000					
Pb-plant	-0.103	0.256	-0.400	0.088	-0.181	0.058	0.611*	1.000				
Cd-plant	-0.059	-0.150	0.040	-0.024	-0.060	0.396	0.391	-0.103	1.000			
Cr-plant	0.117	-0.018	-0.100	0.218	0.595*	0.120	0.147	0.292	-0.158	1.000		
Ni-plant	-0.205	-0.675*	0.572*	0.346	0.960*	0.539*	0.008	-0.098	0.038	0.649*	1.000	
Cu-plant	0.548*	0.452*	-0.574*	-0.204	-0.140	-0.105	-0.143	-0.375	0.258	0.136	-0.210	1.000

Correlation is significant at the 0.05 level (2-tailed)

plants to increase with increasing Pb concentration in soil. This report agrees with that of Mmolawa *et al*. (2011) but was contrary to the report of Ekmekyapar *et al.* (2012).

Pb levels in soil at Ogbomosho and Eyenkorin followed the same pattern as those accumulated in the plants (Fig. 1). This also agrees with the report of Naveed *et al.* (2010). The patterns of accumulated Cd and Cr in the plants did not correlate with the soil contents of both metals. However, the higher value of Ni in plants at Eyenkorin was comparable to its soil contents (Fig. 1). This was evident as Ni and Cr uptake in plant had positive correlation with soil Ni content. There was the possibility of increased soil Pb content translating to increase uptake of Cu, since Pb concentration in soil relates to traffic density. The average Cu concentration in plants in this study were less than 45.10 $\mu g.g^{-1}$ as reported by Demirayak *et al*. (2011) in *Phoenix dactylifera*. Accumulated Cu content in the plants from this study were within the range (5-20 $\mu g.g^{-1}$) reported by Yilmaz *et al*. (2006).

CONCLUSION

Ilorin-Ibadan highway showed high contamination with lead (Pb) than any other metals studied. The low concentrations of Zn in the soil and corresponding low concentration in the plant was possibly due to its uptake and utilization by the plant, as it is an essential component of thousands of plant proteins. High concentrations of the metals at near proximity to the road discourage farming and food processing activities at such short distances from the road. The Zn and Cu levels in the plant tissues were within permissible limits, hence biochemical processes regulated by these elements in the plant will be sustained. The significant correlations of plant

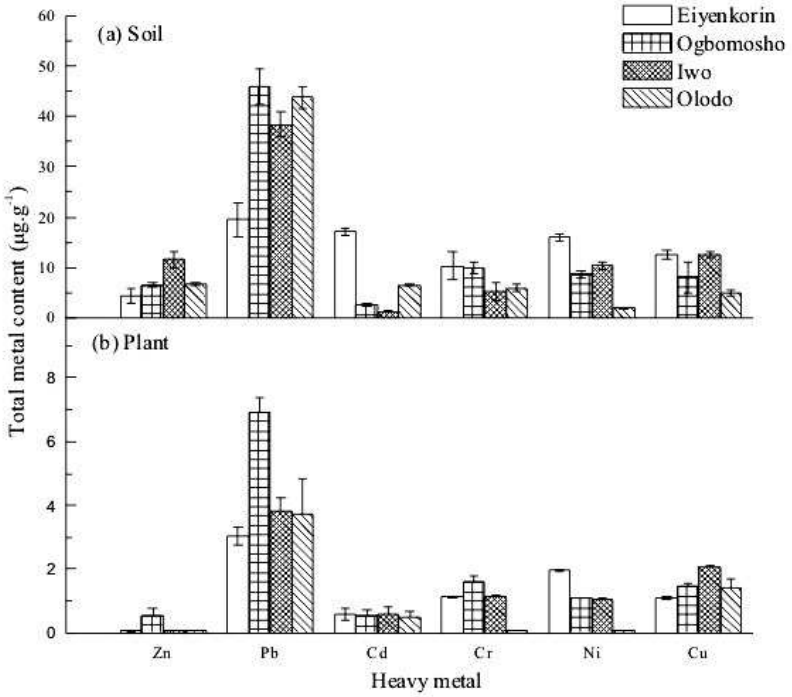


Fig. 1: Total concentration of heavy metal in (a) soil and (b) plant from four locations along Ilorin-Ibadan road

Ni with soil Pb, Cd, Ni and Cu could serve as tool to ascertain the levels of these metals in the soil.

REFERENCES

Abechi, E.S., Okunola, O.J., Zubairu, S.M.J., Usman, A.A. and Apene, E. (2010). Evaluation of heavy metals in roadside soils of major streets in Jos metropolis, Nigeria. *J. Environ. Chem. Ecotox.*, 2(6): 98-102.

Abida, B., Ramaih, M., Harikrishma, I.K. and Veena, K. (2009). Analysis of metal concentrations in soils and lichen from various localities of Hosur road, Bangalore, India. *eJournal of Chemistry*, 1: 13-22.

Aksoy, A., Osma, E. and Leblebici, Z. (2012). Spreading Pellitory (*Parietaria judaica* L.): a possible biomonitor of heavy metal pollution. *Pak. J. Bot*., 44: 123-127.

Allen, J.G., Masters, H.G., Peet, R.L., Mullins, K.R., Lewis, R.D., Skirrow, S.Z. and Fry J. (1983). Zinc toxicity in ruminants. *J. Comp. Pathol*., 93(3): 363-77.

Amusan, A.A., Bada, S.B. and Salami, A.T. (2003). Effects of traffic density on heavy metal content of soil and vegetation along roadsides in Osun State, Nigeria. *West Afr. J. App. Ecol.*, 4: 107-114.

Arslan, H. and Gizir, A.M. (2006). Heavy-metal content of roadside soil in Mersin, Turkey. *Fresenius Environ. Bull*., 15(1): 15-20.

Asthana, D.K. and Asthana, M. (2006). A Textbook of Environmental Studies. Chand and Co. Ltd. Ram Nagar, New Delhi. pp. 268-275.

Ayodele, R.I and Dawodu, M. (2008). Heavy metals contamination of topsoil and dispersion in the vicinities of reclaimed autorepair workshops in Iwo, Nigeria. *Bull. Chem. Soc. Ethiop*., 22(3): 339-348.

Bada, B.S. and Oyegbami, O.T. (2012). Heavy metals concentration in roadside dust of different density. *J. Environ. Earth Sci*., 2 (8): 54-59.

Bai, J., Cui, B., Wang, Q., Gao, H. and Ding, Q. (2009). Assessment of heavy metals contamination of roadside soils in Southwest China. *Stoch. Environ. Res. Risk Assess.*, 151: 341-347.

Bradford, G.R., Chang, A.C. and Page, A.L. (1996). Background concentrations in trace and major elements in California soils. Kearney Foundation Special Report, University of California, Riverside. pp. 1-52.

Bouyoucos, C.J. (1951). A recalibration of the hydrometer method for making the mechanical analysis soils. *Agronomy Journal*, 43: 434-438.

Chen, X. Xia, X., Zhao, Y. and Zhang, P. (2010). Heavy metal concentrations in roadside soils and correlation with urban traffic in Beijing, China. *J. Hazard. Mater*., 181: 640-646.

Daniel, P. Kovaes, B., Prokisck, J. and Gyori, Z. (1997). Heavy metal dispersion detected in soil and plants along roads in Hungary. *Chem. Speciation & Bioavalability*, 9(3) 83-93.

De Vos, C.H.R., Schat, H., De Waal, M.A.M., Voorja, R, and Ernst, W.H.O. (1991). Increased resistance to copper-induced damage of root cell plasmalemma in copper tolerant Silene cucubalus. *Physiol. Plant*., 82: 523-528.

Demirayak, A., Kutbay, H.G., Kilic, D., Bilgin, A. and Huseyinova, R. (2011). Heavy metal accumulation in some natural and exotic plants in Samsun City. *Ekoloji*, 20: 1-11.

Doncheva, S., Stoyanova, Z. and Velikova, V. (2001). The influence of succinate on zinc toxicity of pea plant. *J. Plant Nutr.*, 24: 789-806.

Duan, J.C., Tan, J.H., Hao, J.M., Wang, S.H., Hao, J.M. and Cha, F.H. (2012). Size distributions and sources of elements in particulate matter at curbside, urban and rural sites in Beijing. *J. Environ. Sci.*, 24(1): 87–94

Dudka, S. (1992). Factors analysis of total element concentrations in surface soils of Poland. *Sci. Total Environ.*, 121: 39-52.

Ekmekyapar, F., Sabudak, T. and Seren, G. (2012). Assessment of heavy metal contamination in soil and wheat (*Triticum aestivum* L.) plant around the Corlu-Cerkezkoy highway in Thrace region. *Global Nest Jr*., 14(4): 496-504.

Fakayode, S.O. and Olu-Owolabi, B.I. (2003). Heavy metal contamination of roadside topsoil in Osogbo, Nigeria: Its relationship to traffic density and proximity to highways. *Environ. Geol.*, 44(2): 150-157.

Fergusson, J.E. (1990). *The Heavy Elements: Chemistry, Environmental Impact and Health Effects*. Pergamon Press, Oxford. pp.19-79.

Fergusson, J.E. and Kim, N.D. (1991). Trace elements in street and house dusts: sources and speciation. *Sci. Total Environ*., 100: 125 -150.

Francek, M.A. (1992). Soil lead levels in a small environment: a case study from Mt. Pleasant, Michigan. *Environ. Pollut. J*., 76: 251-257.

Frion-Frenet, M., Bureau, F and Pineau, A. (1994). Lead accumulation in surface roadside soil: its relationship to traffic density and meteorological parameters. *Sci. Total Environ*., 144: 297-304.

Ghrefat, H. and Yusuf, N. (2006). Assessing Mn, Fe, Zn and Cd pollution in bottom sediments of Wadi Al-Arab Dam, Jordan. *Chemosphere*, 65: 2114-2121.

Holdgate, M.W. (1979). A perspective of environmental *In*: Alloway, B.J. (ed.) Heavy Metal in Soil. Blackie and Sour Ltd., Glasgow. pp. 15-23.

Ikeda, M., Zhang, Z.W., Shimbo, S., Watanabe, T., Nakatsuka, H, Moon, C.S., Matsuda-Inoguchi, N. and Higashikawa, K. (2000). Urban population exposure to lead and cadmium in east and south-east Asia. *Sci. Total Environ.*, 249: 373-384.

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.

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.

Lagerwerff, J.V. and Specht, A. (1970). Contamination of roadside soil and vegetation with cadmium, nickel, lead, and zinc. *Environ. Sci. Technol*., 4: 583-586.

Melaku, S., Wondimu, T., Dams, R. and Moens, L. (2005). Multi-element analysis of Tinishu Akaki River sediment, Ethiopia. By ICP-MS after microwave assisted digestion. *Can. J. Anal. Sci. Spec*., 50: 1.

Mmolawa, K.B., Likuku, A.S. and Gaboutloeloe, G.K. (2011). Assessment of heavy metal pollution in soils along major roadside areas in Botswana. *Afr. J. Environ. Sci. Tech*., 5(3): 186-196.

Naser, H.M., Sultana, S., Gomes, R. and Noor, S. (2012). Heavy metal pollution of soil and vegetable grown near roadside at Gazipur. *Bangladesh J. Agril. Res*., 37(1): 9-17.

Naveed, N.H., Batool, A.I., Rehman, F.U. and Hameed, U. (2010). Leaves of roadside plants as bioindicator of traffic related pollution during different seasons in Sargodha, Pakistan. *Afr. J. Environ. Sci. Technol.*, 4 (11): 770-774.

Ndiokwere, C.L. (1984). A study of heavy metal pollution from motor vehicle emission and its effect on vegetation and crops in Nigeria. *Environ. Pollut*., 7: 35-42.

Nwachukwu, J.J., Oluwole, A.F., Asubiojo, O.I. Filby, R.H. Grimm, C.A. and Fitzgerald, S. (1995). A geochemical evaluation of Niger Delta crude oils. *In*: Michael, N.O. and George, P. (eds.) Geology of Deltas. Brookfield VT, USA. pp. 287-300.

Ogbonna, P.C. and Okezie, N. (2011). Heavy

metal level and macronutrient contents of roadside soil and vegetation in Umuahia, Nigeria. *Terrest. Aquat. Environ. Toxicol*., 5: 35-39.

Oladeji, J.O., Ogunleye, K.Y. and Aderinto, A. (2012). Attitude of farmers towards the use of animal traction technology in savannah zone of Oyo State, Nigeria. *Global J. Sci. Front. Res. Agric. Vet. Sci.*, 12(8): 16-23.

Olukanni, D.O. and Adebiyi, S.A. (2012). Assessment of vehicular pollution of road side soils in Ota metropolis, Ogun State, Nigeria. *Int. J. Civ. Environ. Eng*., 12(4): 40-46.

Osibanjo, O. and Ajayi, S.O. (1989). Trace metal analysis of petroleum product by flame atomic spectrometry. *Nig. J. Nat. Sci.*, 3:33-40.

Palmgren, F., Waahlin, P., Kildeso, J., Afshari, A. and Fogh, C.L. (2003). Characterisation of particle emissions from the driving car fleet and the contribution of ambient and indoor particle concentrations. *Phys. Chem. Earth*, 28: 327-334.

Papp, J.F. (1994). Chromium Life Cycle Study. Bureau of Mines Information Circular 9411. United States Department of Interior. 102 pp.

Plank, C.O. (1992). Plant Analysis Reference Procedures for the Southern Region of the United States. Southern Cooperative Series Bulletin No. 368. 78 pp.

Princewill-Ogbonna, I.L. and Ogbonna, P.C. (2011). Heavy metal content in soil and medicinal plants in high traffic urban area. *Pakistan J. Nutri*., 10(7): 618-624.

Rauna, A., Poschenrieder, C.H. and Arcelo, J. (2004). Growth and biomass partitioning in zinc-toxic bush beans sampled form the surroundings of Tuncbilek thermal power plant. *Chemosphere*, 57: 1031-1036.

Saeedi, M. Hosseinzadeh, M., Jamshidi, A and Pajooheshfar, S. (2009). Assessment of heavy metals contamination and leaching characteristics in highway side soils, *Iran. Environ. Monit. Assess*., 151: 231-241.

Shah, A., Niaz, A., Ullah, N., Rehman, A., Akhlaq, M., Zakir, M. and Khan, M.S. (2013). Comparative study of heavy metals in soil and selected medicinal plants. *J. Chem.*, (Online): http://dx.doi.org/10.1155/2013/621265

Sharma, P. and Dey, R.S. (2005). Lead toxicity in plants. *Braz. J. Plant Physiol*., 17(1): 35-52.

Smolders, E. and Degryse, F. (2002). Fate and effect of zinc in tire debris in soil. *Environ. Sci. Technol*., 36: 3706-3710.

Turer, D.G. and Maynard, J.B. (2003). Heavy metal contamination in highway soils, comparison of Corpus Christi, Texas an Cincinnati, Ohio shows organic matter is key to mobility. *Clean Technol. Environ. Pollut*., 4: 235-245.

Uwagboe, A.I. and Hymore, F.K. (2008). Heavy metal contamination of roadside soils, stagnant pools and sediments in Warri, Nigeria. *J. Res. Nat. Dev*., 6(1): 1-8.

Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Science*, 37:29 – 38.

World Health Organization [WHO] (2005). *Quality Control Methods for Medicinal Plant Materials*. WHO, Geneva, Switzerland.

Yan, X., Zhang, F., Zeng, C., Zhang, M., Devkota, L.P. and Yao, T. (2012). Relationship between heavy metal concentrations in soils and grasses of roadside farmland in Nepal. *Int. J. Res. Public Health*, 9: 3209-3226.

Yilmaz, R., Sakcali, S., Yarci, C., Aksoy, A. and Ozturk, M. (2006). Use of *Aesculus hippocastanum* L. as a biomonitor of heavy metal pollution. *Pak. J. Bot*., 38: 1519-1527.