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EFFECTS OF TRAFFIC DENSITY ON HEAVY METAL CONTENT OF SOIL AND VEGETATION ALONG ROADSIDES LEADING TO AKURE-ONDO STATE. NIGERIA

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ABSTRACT
The concentrations of Zn, Cu, Cr, Ni ,Mn Pb, Cd, and V were determined in the plant species *Chromolaena odorata* and soil samples along four heavy traffic density (HTD) roads with average daily traffic density (ATD) of 5,364 vehicles and one low traffic density (LTD) road of 1,358 vehicles per day in the metropolitan city of Akure Ondo State, Nigeria. Soil and plant samples were collected at distances of 5m, 50m and 100m from the road. Metal concentrations in plant samples were determined by UNICAM SOLA R32 Datta station V7. AAS model ,while metal level in soil samples were quantized using Inductively Coupled Plasma – Emmission Spectrometry (ICP-AES) and Graphite Furnace Atomic absorption spectrophotometer (GFAAS). The mean concentrations followed the order Zn > Pb > V > Ni > Cd for soil samples and Mn > Zn > Cu > Ni > Cd > Cr for plant samples respectively. The result of analysis showed that metal concentration decreased with increasing distances away from the edge of the road. The concentrations of these metals along the LTD were significantly lower than for the HTD. Further more metal concentrations in soil and plant samples were related positively to traffic densities, with soil and vegetation along the HTD having significantly higher (p>0.05) level of the investigated metals than those along the LTD road.
Keywords: Heavy metals, Low traffic density, High traffic density, Roadside soil, Plant samples.

INTRODUCTION

Roadside soil has been shown to have considerable contamination due to both depositions on vehicle derived metal and to relocation of metals deposited on the road surface (Harrison *et al*., 1981). Several researchers have indicated the need for a better understanding of trace metal pollution of roadside soils (Dekimpe and Morel, 2000; Manta *et al*., 2002). Heavy metals are naturally found in various amounts in water, air, soils and sediments. Anthropogenic sources from various industrial activities such as mining, foundries, smelters, combustions, and traffic contribute to the amounts of heavy metals in various media (Al-khashman, 2004). Although some heavy metals are essential for vital processes in many living organisms, including humans (Juvanovic *et al*., 1995; Lapitals *et al*., 1995), these metals are generally toxic when their concentrations exceed certain thresholds. The most common heavy metals introduced to the environment by overland transportation are Lead (Pb), Zinc (Zn) and Copper (Cu) (Kim *et al.*,1998; Sezgin *et al.*, 2003; Banerjec, 2003; Li *et al.*, 2004). Use of leaded gasoline is primarily responsible for the Pb exposure (Chen *et al.*, 2005), while tire wears and corrosion of roadside safety fences contribute to Zn pollution (Blok, 2005).

Copper (Cu) is mainly released from the wear of brake linings, which is also an important source of lead (Pb) and Zinc (Zn). Most researchers have reported the influence of the traffic load on heavy metal contents in top soils and their variability with distance (Ward *et al.*, 1977; Rodriguez and Rodriguez ,1982; Garcia and

Millan, 1998; Zhang *et al.,* 1999; Tuere and Mayhard, 2003). More recently, Viard *et al* (2004) reported that the deposition of metals, the levels of metals in surface soils decreased with increasing distances from the high way. Furthermore he also found that the impact of the high way was apparent up to 320m, particularly for lead. But the most important contamination was observed near the road. Nabuloa *et al.* (2006) also showed that total trace metal concentrations in roadside soils decreased exponentially with increasing distance from road ways. The concentrations of metals in the roadside soil were influenced by meteorological conditions (Othman *et al*., 1970; Sezgin *et al*., 2003), traffic density (Garcia and Millan 1998; Nabuola *et al.,* 2003) and soil parameters. Several studies have shown that metals such as Pb, Cd, Ni amongst others, are responsible for certain diseases that have lethal effects on man and animals. For this reason, various arms of government are much concerned about the effects of exhaust emission on the environment.

However, information on road side contamination with heavy metals in relation to vehicular emission in Nigeria is limited, and the attempt to bridge this gap forms the thrust of this study. This information is required to put in place appropriate land-use and management strategy that will enhance sustainable development.

The objective of this study, therefore, was to investigate the effect of traffic densities on heavy metal pollution of soils and vegetation along roadsides in Akure metropolis.

MATERIALS AND METHODS

Study Site

Five roads (four major and one minor) were chosen for this investigation. Akure-Owo, Akure-Ilesha, Akure-Ondo and Akure-Ado roads with an average daily traffic density (ADTD) of 5, 364 vehicles are regarded as having high traffic density, while Akure-Idanre road with ADTD of 1, 358 vehicles is regarded as having low traffic density (LTD). The major roads are both intra and interstate, while the minor road is mainly intrastate. The main socio-economic activities along these road are farming, food processing and marketing of farm produce. It should be noted that no industrial activity is apparent near the vicinity of the sampling locations.

Soil and Plant Sampling

Soil and plant samples were obtained from the road edge inwards up to 100m away from the roads, plant (*Chromolaena odorata*) sample growing along the roads were sampled using $1m^2$ quadrants at distance of 5m, 50m and 100m away from the edge of the roadside. Plants within the quadrant were cut with a stainless steel pen-knife at the ground level. Each plant sample was replicated three times along the roadsides. The plant samples were kept in labeled polyethylene bags and taken to the laboratory for analysis. Composite soil samples were taken at similar distances (5m, 50m and 100m) away from the edge of the road.

Ten core soil samples randomly distributed round the observation points were taken at 0-20cm with the aid of stainless steel Dutch auger and bulked. Each composite soil samples was replicated three times along the roads and the samples were kept in labeled polyethylene bags

Analysis of soil sample

Approximately 0.5g of the 2mm sieved soil was taken on an electrical balance and further made into powder by grinding in a laboratory mortal. This was introduced into the quartz microwave vessel (8 of $45cm^3$) each. HNO_3 ($9cm^3$) was added followed by $3cm^3$ HCl. The mixture was shaken to allow proper mixing and allowed to stand for 15minutes inside the fume cupboard. The samples were capped manually and further tighten using power capper (Milestone ECM-30) .The quartz vessels were arranged into the carousel and inserted into the microwave oven (MLS 1200) set at: 5 minutes 300W, 2 minutes 600W, 1 minutes 0W, 5 minutes 300W and 10 minutes vent. On completion the carousel was brought out and the vessels were allowed to cool down. The dig- estate were emptied into the centrifuge bottles and the vessels were rinsed into the centrifuge bottles and centrifuged on the analytical centrifuge(4222) for ten minutes at maximum speed (5max). The filtrate was decanted with the aid of a plastic syringe into 25ml standard flask which has been washed with 6% HNO_3 prepared with MQ water. The centrifuge process was repeated by adding 5ml MQ water to the residue and shaken vigorously and centrifuged for 5 minutes and the filtrate added to the standard flask and made up to the mark with MQ water. Quantitation of heavy metals was carried out using the Inductively Coupled Plasma – Emmission Spectrometry (ICP-AES) and Graphite Furnace Atomic absorption Spectrophotometer (GFAAS).

Analysis of Plant Samples

Sieved sample(0.5g) was accurately weighed into 100cm^3 beaker and a mixture of 5cm^{3}concentrated nitric acid and 2cm^3 perchloric acid was added and digested on low heat hot plate until the content was about 2cm$^{3.}$The digest was allowed to cool, filtered into 50cm^3 standard flask using 0.45 um millipore filter kit. The beaker was rinsed with small portions of distilled water and then filter into the flask. Triplicate digestion of each sample was carried out together with blank digest without the plant sample. Heavy metal quantitation was carried out by Atomic Absorption Spectrophotometer UNICAM SOLA R32 Datta station V7. AAS model

RESULTS

Metal concentration soil and *Chromolaena odorata* (µg/g) are shown on Tables 1 and 2. Soil contamination with Pb, Cd, Ni, V and Zn were obvious in soils and plant along the high traffic density roads. Generally the concentrations of metals in soil were found to be highest at 5m and decreases with increasing distance away from the highway. Pb contamination could be attributed to lead particle from gasoline combustion which consequently settles on roadside soils. At the same way vehicles are often moving slowly as a result of the heavy traffic jam in this area and this may account for the high level of Pb. Since no major industries exist in the study area, the presence of metals such as Zn, Cd, Ni and V are probably the attrition of motor vehicle tire exacerbated by poor road surfaces and the lubricating oils in which some of these metals are found as part of many additives. Pb ranged between 0.5-5.5, 1.35-17.5,0.5-7.5, 0.3-7.0 , 0.5-1.0 , Cd ranged between 1.9-5.5, 0.5-5.95, 0.85-10.0, 0.5-1.55 , 0.06-1.0 0, Ni ranged between 0.37-1.9, 0.55-5.95, 0.25-0.85, 0.28-1.55 , 0.006 , V ranged between ND-10.0, 0.2-2.7, 0.5-10.5, 1.3-14.5 , 0.5-2.0. Zn ranged between 0.6-7.5, 2.6-36.5, 0.5-5.0, 0.75-15.0, 0.75-1.7 along Akure-Owo, Akure-Ilesha, Akure-Ondo, Akure-Ado and Akure-Idanre roads respectively. In *Chromolena odorata* Zn ranged between 43.4-101.5, 43.8-64.1, 43.8-64.1, 55.9-89.9, 5.9-20.9,Cu ranged between 13.6-35.5, 14.7-29.9, 14.7-29.9, 14.8-19.7, 4.8-9.7, Cr ranged between 0.3-10.5, 10.2-20.7, 10.2-29.9, 0.3-16.0, 3.3-2.4, Ni ranged between 2.2-26.6, 2.7-13.3, 2.7-13.3, 5.1-16.4, 1.4-10.0, Mn ranged between 86.1-123.5, 92.9-117.2, 92.9-117.2, 93.8-185.2 and 9.818.2 along Akure-Owo, Akure-Ilesha, Akure-ondo, Akure-Ado and Akure-Idanre roads respectively.

Table 1: Heavy metal concentration (µg/g) of soils from roadsides

Metal	Sampling Distance	Akure-Owo Road	Akure-Ilesha Road	Akure-Ondo Road	Akure-Ado Road	Akure-Idanre Road
	5	5.5± 0.5^{b}	17.5±0.01^{d}	7.5±0.02^{ab}	7.0±0.01^{b}	1.10±0.02^{ab}
Pb	50	1.2±0.00^{ab}	2.85±0.01^{b}	5.00±0.04^{a}	0.75±0.01^{a}	0.5±0.01^{a}
	100	0.5±0.01^{a}	1.35±0.00^{ab}	0.5±0.00^{ab}	0.30±0.01^{ab}	0.5±0.00^{a}
	5	25±0.01^{e}	7.0±0.00^{c}	10.0±0.04^{a}	1.5±0.02^{a}	1.5±0.00^{ab}

Cd	50	5.5±0.01^{b}	2.5±0.01^{b}	10.0±0.00^{ab}	0.5±0.01^{ab}	1.0±0.00^{ab}
	100	2.0±0.01^{ab}	0.5±0.00^{a}	2.0±0.01^{ab}	1.0±0.01^{ab}	0.5±0.00^{a}
	5	1.9±0.00^{ab}	5.95±0.01^{c}	0.85±0.06^{a}	1.55±0.01^{a}	0.06±0.01^{a}
Ni	50	0.4±0.02^{a}	1.05±0.00^{ab}	0.25±0.01^{a}	0.28±0.01^{a}	0.06±0.00^{a}
	100	0.37±0.01^{a}	0.55±0.00^{a}	0.55±0.01^{c}	0.08±0.01^{a}	0.06±0.01^{a}
	5	1.0±0.00^{a}	2.7±0.01^{b}	10.5±0.04^{c}	14.5±0.01^{c}	2.0±0.01^{b}
V	50	1.0±0.01^{ab}	0.45±0.00^{a}	2.2±0.02^{ab}	12.0±0.01^{c}	1.3±0.00^{ab}
	100	ND	0.28±0.00^{a}	0.5±0.00^{c}	1.3±0.01^{ab}	0.5±0.01^{a}
	5	7.5±0.01^{e}	36.5±0.01^{e}	5.0±0.01^{b}	15.0±0.01^{c}	1.7±0.00^{ab}
Zn	50	1.0±0.02^{ab}	5.30±0.00^{c}	5.0±0.00^{a}	6.0±0.01^{b}	1.6±0.00^{ab}
	100	0.6±0.00^{a}	2.60±0.00^{b}	0.5±0.00	0.75±0.01^{a}	0.75±0.00^{a}

HTD- Akure-Owo, Akure-Ilesha, Akure-Ondo, Akure-Ado
LTD- Akure-Idanre
Values with the same letters are not significantly different using new Duncan Multiple Range Test.

Table 2. Heavy metal concentration μg/g of leaves of *(Chromolaena odorata)* along the roadside.

Metal	Sampling Distance	Akure-Owo Road	Akure-Ilesha Road	Akure-Ondo Road	Akure-Ado Road	AKure-Idanre Road
	5	101.5±0.07^{e}	64.1±0.02^{c}	64.1±0.01^{c}	89.9±0.02^{c}	20.9±0.01^{d}
Zn	50	46.8±0.03^{c}	57.5±0.01^{c}	57.5±0.01^{c}	58.8±0.04^{b}	9.9±0.01^{c}
	100	43.4±0.02^{c}	43.8±0.01^{e}	43.8±0.01^{c}	55.9±0.04^{b}	5.9±0.01^{b}
	5	35.5±0.03^{b}	29.9±0.01^{b}	29.9±0.01^{b}	19.7±0.03^{ab}	9.7±0.01^{c}
Cu	50	15.4±0.04ab	21.8±0.01^{b}	21.8±0.01^{b}	19.7±0.02^{ab}	5.2±0.01^{b}
	100	13.6±0.01^{ab}	14.7±0.00^{ab}	14.7±0.01^{ab}	14.8±0.01^{ab}	4.8±0.01^{ab}
	5	10.5±0.00^{ab}	20.7±0.00^{b}	20.9±0.01^{b}	16.0±0.01^{ab}	3.0±0.00^{ab}

Cr	50	11.6±0.00[ab]	11.3±0.00ab	11.3±0.01[ab]	5.2±0.01[a]	2.4±0.00[a]
	100	0.3±0.01[a]	10.2±0.01[ab]	10.2±0.01[ab]	0.3±0.01[a]	3.3±0.00[ab]
	5	26.6±0.01[b]	13.3±0.01[ab]	13.3±0.01[ab]	16.4±0.01[ab]	1.4±0.01[a]
Ni	50	2.8±0.00[a]	4.9±0.01[a]	4.9±0.01[a]	6.4±0.01[a]	10.0±0.01[c]
	100	2.2±0.00[a]	2.7±0.01[a]	2.7±0.00[a]	5.1±0.01[a]	2.1±0.02[a]
	5	123.5±0.04[e]	117.2±0.01[e]	117.2±0.00[e]	185.2±0.00[e]	18.2±0.02[d]
Mn	50	98.8±0.02[d]	106.7±0.01[e]	106.7±0.04[e]	105.0±0.04[d]	9.8±0.04[c]
	100	86.1±0.01[d]	92.9±0.01[d]	92.9±0.02[d]	93.8±0.02[e]	9.8±0.04[c]

HTD- Akure-Owo, Akure-Ilesha, Akure-Ondo, Akure-Ado
LTD- Akure-Idanre
Values with the same letters are not significantly different using new Duncan Multiple Range Test.

DISCUSSION

The average of triplicate determinations of metal concentration in soils of the various sampling sites was presented as µg/g in Table 1. The soil pH is generally slightly alkaline. The roadside soil Pb level ranged from a very low concentration of 1.10 µg/g for LTD to a high concentration of 17.5 µg/g for HTD (Francek, 1992). The high mean values of the concentrations attested to the overall level of contamination of roadside environments with this metal. This was in agreement with the report of Lagerweff and Specht (1970). The high concentrations of Pb observed could be attributed to Pb particle from gasoline combustion which consequently settled on roadside soil.). Zn ranged from 1.7 µg/g in Akure-Idanre road to 36.5 µg /g Akure- Ilesha road. Since no major industry exists in the study areas such as smelting operations, we may assume that the primary sources of Zn are probably the attribution of motor vehicles tire rubber exacerbated by as zinc dithophosphates. Also the mobility of the metal depends on soil pH and also depends on the organic matter and granulometric composition of the soil.

Cd obtained from all the sites, ranged from 25 to 1.5µg/g. Soils in this study exhibited higher levels of contamination with Cd compared to 0.75µg/g obtained by Jaradat and Momani, (1999). 2. 11 µ g/g by Amusan et al; 2003 and 0.88 µ g/g by Bai et al; 2008. However, the levels of Cd in this study is comparable to 6.8 µ g/g as reported in North Wale by Davies *et al.* (1985) and about 5 times for that reported by Ndiokoere (1984). In the absence of any major industry in sampling sites, the levels of Cd could be due to lubricating oils and old tires that are frequently used on the rough surfaces of the roads which can increase the wearing of tires.

Ni obtained from all the sampling sites ranged between 5.95 µ g/g for HTD and 0.06µg/g for LTD. The range of mean nickel concentration in worldwide street dust samples was 50-100 µg/g (Ferqusson and Kin, 1991). Nickel pollution on a local scales was caused by emissions from vehicle engines that use nickel gasoline and by the abrasion and corrosion of nickel from vehicle parts (Al-shayeband and Seaward, 2001). V ranged between 14.5µg/g along Akure-Ado road and 0.28µg/g at 100m away from Akure-Ilesha highway. Generally in all the sampling sites, metal concentration was higher at 5m away from the roadside and deceases with increasing distance away from the road. It was also observed that mean metal concentrations were higher for high traffic density roads (HTD). Akure-Owo, Akure-Ado, Akure-Ilesha, Akure-Ondo respectively. This agreed with the report of Amusan *et al*.(2003).

The metal concentrations in the leaves of *Chromolaena odorata* along the different roadsides are shown in Table 2. The plant along the HTD roads had higher concentrations of metal than the plant along the LTD road. This suggests that, with increasing concentrations of metals in soils, the uptake of the metals by the vegetation may also increase (Amusan *et al*., 2003). Also, the metal content of the plant tissue decreased with distance from the road. It was observed that the metal contents of the top soils and vegetation were significantly higher for HTD than LTD. Ademoroti (1986) also observed that levels of heavy metals in bark and fruit of trees along roads in Nigeria vary according to traffic volume. The metals are considered to arise from motor vehicle tyre wear and motor vehicle emissions (Lagerverff and Specht, 1970) both of which can account for up to 80% of the air pollution problems in urban areas of south-western Nigeria (Osibanjo and Ajayi, 1980). This study suggested that plants growing on soils having enhanced heavy metal concentration will have increased metal concentration in accordance with earlier reports by Alloway and Davies (1971) and Grant and Dobbs (1977). For experimental soil samples, the mean concentrations follow the decreasing orders: Zn > Pb > Ni > Cd. While for plants samples the mean concentrations follow the decreasing orders: Mn > Zn > Cu > Ni > Cd > Cr.

CONCLUSION

Results obtained in this study generally revealed the presence of metals in plants and soils along roads in Akure metropolis. Most probable sources of these metals are from motor vehicles, wastes from petroleum products such as lubricating oil that are dumped along these roads. This can lead to accumulation of the metal in the tissue of organism that feed on the plant and other plant growing along the highway.

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