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Heavy Metals Contamination in Roadside Dust along Major Traffic Roads in Jos Metropolitan Area, Nigeria

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Abstract
Heavy metal concentration in roadside dusts are increasingly becoming of health concern. Five major traffic roadside dust were determined for Cu, Pb, Ni, Zn, Fe, Cd, Mn and Cr contamination. Metal concentration in the dusts indicated Cu concentration ranged from 24.5 – 67.0 mg/kg, Pb 25.0 – 66 mg/kg, Ni 1.23 – 3.88 mg/kg, Zn 35.0 – 123 mg/kg, Fe 48.5 – 125 mg/kg, Cd 1.54 – 2.58 mg/kg, Mn 1.15 – 2.58 mg/kg and Cr 1.13 – 2.79 mg/kg. The accumulation of the heavy metals in the soil dust is greatly influenced by traffic volume and the metals exhibited a significant reduction in roadside dust with increasing distance from the road. Four methods of assessing pollution were used to assess the extent of pollution. All the four methods revealed that site ABW, YGW and GJR are pollution impacted as compared MMW and BRR sites. The result suggest mixed origin of pollution sources including human activities, vehicular emissions and lithogenic occurrences of the metals from road construction currently in some of the sites studied. The findings herein will serve to create awareness of vehicular heavy metal pollution and therefore suggest a regular monitoring to ensure suitable management of the urban environment and reduction of traffic related contamination of soil, plants and water in Jos Nigeria.
Keywords: Roadside Soil Dust; Heavy Metals Contamination; Enrichment Factor; contamination Factor; Pollution Load Index; Geoaccumulation Index; Statistical Analysis.

1. Introduction

Heavy metals found in roadside dust are significant environmental pollutants of growing concern in recent years, that public and scientific attention has increasingly focused on its contamination and effects on human and other living creatures(Wang, *et al.,*2005).

The release of heavy metals is one of the most significant environmental problems caused by anthropogenic activities such as urban road construction, quarrying, agriculture, waste incinerations, sewage disposal, bush burning vehicle exhausts, industrial discharges, oil lubricants, automobile parts, (Ho and Tai, 1988), corrosion of building materials, atmospheric deposition (Adriano, 2001) and particulate emission (Sutherland, *et al.,* 2000). etc. The presence of heavy metals has been considered as useful indicators for contamination in surface soil, sediment and dust environments (Ubwa, 2003). These metals are bio-accumulative and there are possibilities that these metals can reach a critical value and threatened human health (Censi *et al.,* 2006). Young children are particularly more likely to ingest significant quantities of dust than adults because of the behaviour of mouthing non-food objects and repetitive hand/finger sucking (Bargagli,1998). More worrisome; studies have shown that children have higher absorption rate of trace metals from digestive system and higher haemoglobin sensitivity to trace metals than adults. Children are more vulnerable to heavy metals toxicities than adults. Studies have been carried out on street dust near places where children play since children are more sensitive to contaminant-bearing dust (Meza-Figueroa *et al.,* 2006). Particulates of smaller sizes are persistent in the environment and exert negative health impact to the exposed resident population, especially in the urban settings (Kinney and Lippmann,2000). .

Roadside dust is typically derived from anthropogenic activities via alteration of natural solid, liquid or gaseous material with pollutants sources such as water transported material from surrounding soil and slopes, dry and wet atmospheric deposition, biological inputs, road surface wear, road paints degradation, vehicle wear (tyres, body, brakes linings etc), vehicular fluid particulate emissions and discharge from metal processing industries (Al-Khashman, 2007, Arslan and Gizir, 2004).

Traffic congestion has a negative effect, exhaust from all combustion engine and industrial activities combine to emit this heavy metals so that soils, plants and even resident along roads are subjected to increasing levels of contamination with heavy metals (Ghrefat and Yusuf, 2006). Cities have became islands of toxic chemicals from the unrestrained use of fossil fuel in vehicles. Urban people are most affected and the worst sufferers are traffic policemen who are particularly close to the fumes of automobile exhaust. Studies have indicated that there is high rate of occurrence of respiratory tract infections, digestion, and skin irritation among the traffic police and significant number of them become victim of lungs disorder (Pirkle, *et al.,* 1994). The long term effect of living in urban areas and breathing fumes is widely studied, particularly cities where there is a lot of sunlight and no much air movement resulting in photochemical smog from high traffic fumes and industrial

gases hanging in the air (Pirkle, *et al.,* 1994). This effect is clearly seen in developing countries such as Nigeria which most of the diseases evident now (diabetes, renal failure, hypertension, nervous disorder, skin irritation etc), may be connected with exposure to heavy metals.

Road construction has been the main activity for developing countries and industrial units. This has led to the loss of forest cover and subsequent loss of soil fertility. Roadside soil often show high degree of contamination that can be attributed to automobile. Various researchers have shown that the concentration of heavy metals decreases rapidly within 10-50m from roadsides (Joshi, *et al.,* 2010 and Mmolowa, *et al.,* 2010, Pagotto, *et al.,* 2001). Pollution of roadside soil by combustion of leaded petrol products is localized and usually limited to a belt of several metres wide on either side of the road and that similar topography and vegetation, the level of pollution decreases with distance from roadside.

Although there have been a considerable number of studies of heavy metals in roadside dust, the vast majority of these have been carried out in developed countries with long history of industrialization and extensive used of leaded gasoline. Very few studies have been carried out in developing countries such as Nigeria where data on the concentration and distribution of heavy metals in street dust is scarce. Therefore, this study evaluates the effect of progressive and localised anthropogenic activities on trace metals concentration of environmental indices need to be evaluated periodically in the developing countries to monitor the trend of the relationship between emission source and concentrations of heavy metal content in relation to high traffic zones in an urban setting.

2. Materials and Methods

2.1 Study Area

Jos is one of the most densely populated areas in Plateau State, Nigeria (900,000 inhabitants based on the 2006 population census estimate). Jos city (latitude 9^{o} 56' north and Longitude 8^{o} 53' East) is at an elevation of about 1238 metres above sea level and host many industrial sites for steel, brewery, textile, smelting etc. It also includes power plant and experiences some of the state heaviest road traffic. It enjoys a more temperate climate than much of the rest of Nigeria. The state is characterized with landscape of undulating highlands and peaks like the famous Shere Hill over 4829 meters above sea level.

Table 1. Description of the roadsides studied and Number of Vehicles per Hour

Site No.	Name of site	No.of vehicles per hour	Site description
ABW	Ahmadu Bello way	2986	Heavy Traffic, commercial, residential area, high population.
BRR	Bauchi Ring Road	2267	Medium Traffic, semi-urban commercial areas, Religious places.
MMW	Murtala Mohammed way	1654	Medium traffic, urban area with religious place, recreational and commercial centre.
YGW	Yakubu Gowon way	3618	Industrial(chemicals dyes, paint, engineering and road construction sites, Food and beverages)
GJR	Goodluck Ebele Jonathan road	2765	Educational institutions, recreational centres, commercial centres.

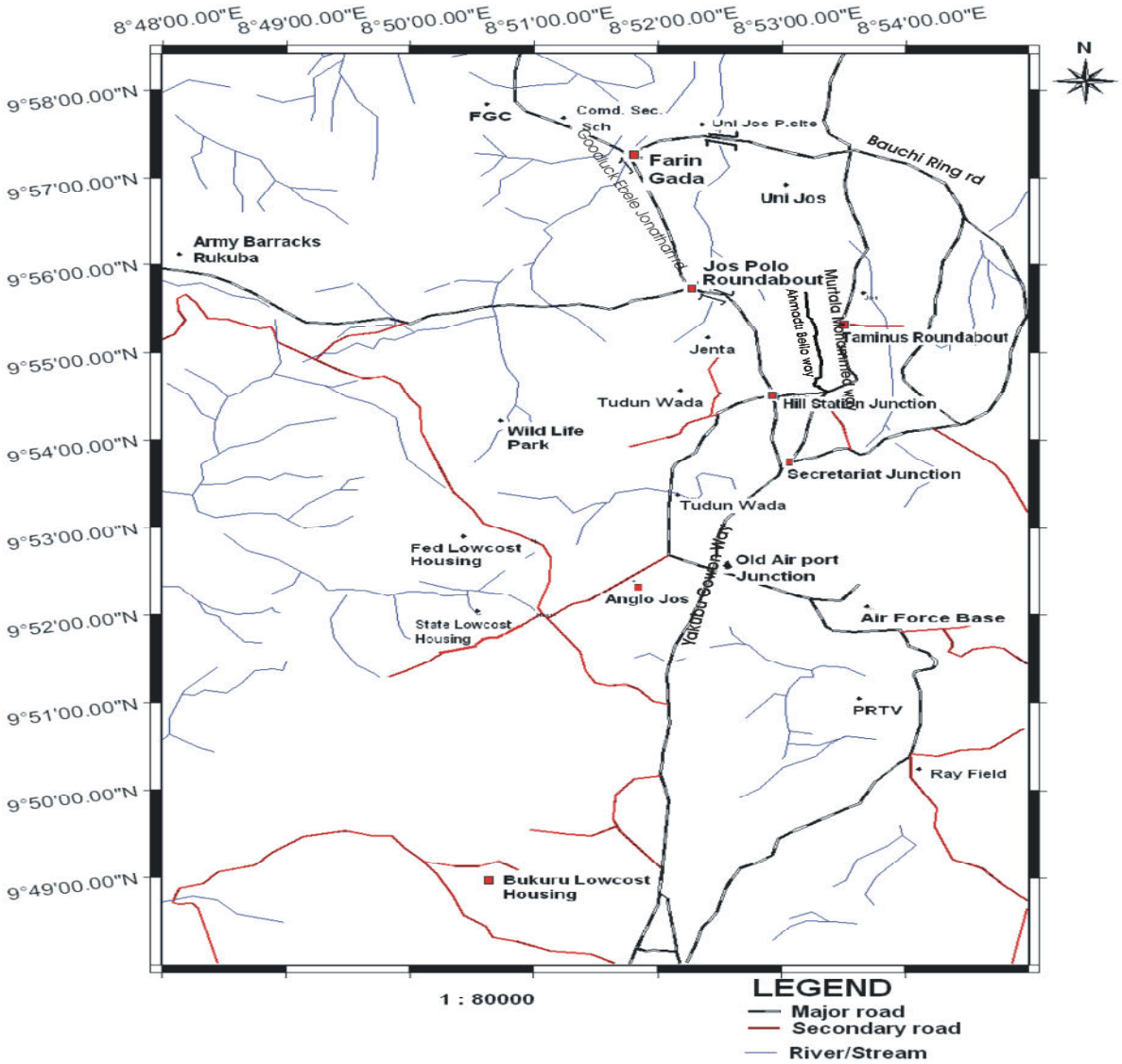

Figure 1. Map of Jos Indicating the Studied Roads

2.2. Sampling

Five major roadsides in Jos were selected for dust collection (Fig. 1). These were selected on the basis of traffic load, population density and human activities occurring within the areas. Detailed description of the traffic sites selected is given in (Table 1). This description of the traffic load and site related information was collected from National Union of Road Transport Workers (NURTW) Office in Jos and Jos metropolitan Development Board (JMDB). Dust sample were collected from individual sampling point in the interval of 100m from both sides of each roadway under stable weather conditions in November, 2014. Samples were collected from pavement edges using plastic dust pans and brushes and between each sampling, brushes were cleaned thoroughly. Sites with obvious pollution sources such as industries, gasoline stations and parking lots or recently soiled or oil stained sample were not collected. Samples collected were sealed in plastic bags and carried to the Laboratory for analysis.

2.3. Sample preparation and analysis

The collected dust samples were air-dried to constant weight and sieved through a stainless mesh wire. The pH, electrical conductance and the organic carbon of the samples determined. 0.5g of each of the sample were digested in 20ml freshly prepared aqua-regia (1:3 HNO_3:HCl) on a hot plate for 3hrs, then evaporated and diluted to required volume to determine the concentration of Cu, Pb, Ni, Zn, Fe, Cd, Mn and Cr in the samples using flame atomic absorption spectrometer (FAAS) PG990 at various wavelength of the metals. Standard reference material was prepared using stock solution from SAARCHM and MERCH and was used to have a check on the accuracy of the results.

2.4. Enrichment factor (*EF*)

The assessment of metal and level of contamination in soil dust require pre-anthropogenic knowledge of metal concentration to act as pristine values. A number of different enrichment calculation methods and reference material have been reported (Sutherland *et al.,*2000; Valdes *et al.,*2005; Abrahim and Parker, 2008; Akoto *et al.,* 2008; Charkravarty and Patgirl, 2009; Harikumar and Jisha, 2010; Sekabira, *et al.,* 2010; Olubunmi and Olorunsola, 2010). In this manuscript, the degree of anthropogenic pollution was established by adopting enrichment factor ratios (*EF*) used by Sutherland *et al.,* (2000), as follows:

$$EF = \frac{C_m\ sample}{median\ C_m\ Background + 2MAD\ C_m\ Background} \quad \text{-------- (1)}$$

Where, C_m Sample is the concentration of a given metal along roadside. Median C_m background is the median concentration of an element in the background soil sample and *MAD* C_m Background is the median absolute deviation from median defined as:

$$MAD = median|x_1 - median(x_j)|, j = 1,2, \ldots n \text{---------- (2)}$$

This method is less affected by extremes in the tail often encountered with geochemical data, because the data in the tails have less influence on the calculation of the median than they do on the mean (Chester *et al.,*1985; Galero *et al.,* 1997).

Five of the following categories are recognized on the basis of enrichment factor:

EF < 2: Deficiently to minimal enrichment
2 ≤ *EF* < 5: Moderate enrichment
5 ≤ *EF* < 20: Significant enrichment
20 ≤ *EF* < 40: Very high enrichment
EF ≥ 40: Extremely high enrichment

2.5. Contamination factor (*CF*)

The level of contamination of the soil dust by metal is expressed in terms of a contamination factor (*CF*) calculated as:

$$CF = \frac{C_m\ sample}{C_m\ Background} \quad \text{---------- (3)}$$

Where, the contamination factor *CF* < 1 refers to low contamination; 1≤ *CF* < 3 means moderate contamination; 3 ≤ *CF* ≤6 indicates considerable contamination and *CF* > 6 indicates very high contamination.

2.6. Pollution Load Index (*PLI*)

Each side was evaluated for the extent of metal pollution by employing the method based on the pollution load index (*PLI*) developed by Thomilson *et al.*,(1980) as follows:

$$PLI = (\prod_{i=1}^{n} CF_i)^{\frac{1}{n}} \quad \text{---------- (4)}$$

Where, n is the number of metals studied and CF is the contamination factor calculated as described in equation 3. The *PLI* provides simple but comparative means for assessing a site quality, where a value of *PLI* < 1 denote perfection; *PLI* = 1 present that only baseline levels of pollutants are present and *PLI* > 1 would indicate deterioration of site quality (Thomilson *et al.,*1980).

This type of measure has however, been defined by some authors in several ways for example, as the numerical sum of eight specific contamination factors (Hakanson, 1980). whereas, Abrahim (2008) assessed the site quality as the arithmetic mean of the analysed pollutants. In this study, the authors found it appropriate to express the *PLI* as the geometric mean of the studied pollutants since this method tends to reduce the outliers, which might bias the reported results.

2.7. Geo-accumulation Index(*Igeo*)

To quantify the degree of metal contamination in the roadside dust the geo-accumulation index (*Igeo*) (Doung and Lee, 2011) was calculated base on the

$$Igeo = \log_2 \frac{C_n}{1.5B_n} \quad \text{---------- (5)}$$

Where *Cn* = metal concentration in the roadside dust and *Bn* = concentration in unpolluted soil. Due to the non-availability of the studied heavy metals in background soil dust *Igeo* was calculated using the global average shale data (Doung and Lee, 2011). The 1.5 is a factor used because of the possible variations of the background data due to lithological variations. This method assessed the metal pollution in terms of seven (0 to 6) enrichment classes ranging from background concentration to very heavily polluted as below.

Table 2. The *Igeo* classes with respect to soil quality

Igeo value	*Igeo* class	Designation of soil quality
> 5	6	Extremely contaminated
4 – 5	5	Strongly to extremely contaminated
3 – 4	4	Strongly contaminated
2 – 3	3	Moderately to strongly contaminated
1 – 2	2	Moderately contaminated
0 – 1	1	Uncontaminated to moderately contaminated
0	0	Uncontaminated

3. Results and Discussions

Roads are known as the second largest non-point source of creating pollution in urban environment (Fakayode and Olu-Owolabi, 2003). The dust sampling sites were associated with high frequency of stop and start-up of vehicles.

The pH of the roadside soil dust of the studied sites ranged from 7.5-8.0 close to the neutral value suggesting that urban soil is most neutral to the high content of carbonate, ash and cinder of anthropogenic origin (Lu, and Bai, 2010). and could be partly explained by the extraneous materials such as brick and construction debris included in the soil that could increase the pH (Jim, 1998), this could also be attributed to the alkali components in the atmosphere which can eventually deposit on the ground and affect pH in the soil.(Kim, *et al.,* 1996). The electrical conductance in all the sites is relatively high indicative of the present of ionic species, the ranged is from 0.18 - 0.30 $mScm^{-1}$.

With the organic carbon ranging from 2.02- 3.20%, the relative high organic carbon along BRR road reflects the distribution of vegetation and grasses along the road which passes through semi- urban settlement, while J_1 had least organic carbon.

The values Cu ranged from 24.5 – 72.0mg/kg, this is in line with literature report that surface soil contain higher concentration of metals (Bhattacharya *et al.,* 2011). The observed values are lower than the threshold maximum value prescribed limit of 100mg/kg (Fabis,1987), the highest values where obtained in the higher traffic sites, YGW (67.0) and GJR(64.2) mg/kg. The toxicity for humans is not very high (Poggio, *et al.,* 2009), it normally accumulate in the surface horizon a phenomenon explained by bioaccumulation of metals and recent anthropogenic activities.

The mean concentration of Pb ranged from 25.0 – 66.0mg/kg in all the sites with MMW(64.3), GJR(66.0) and ABW(61)mg/kg, these values were found to be consisted with studies such as that of 90-210mg/kg for Michigan (Francek, 1997) and 98-136.1mg/kg for Osogbo, Nigeria (Fakayode and Olu-Owalabi, 2003). These values of Pb obtained at the sites studied were within permissible soil dust value of 100mg/kg. However, (Pb) comes mainly from automobile exhaust and vehicular emission for example tire wear, bearing wear, break lining wear (Paggio, *et al.,* 2009).

The concentration of Ni ranged from 0.88 to 3.88mg/kg, with highest value obtained at GJR (3.88)mg/kg and the lowest concentration obtained at BRR (0.88)mg/kg. The sources of Ni in roadside dust is believed to be due to corrosion of vehicular parts (Lu, *et al.,* 2009). The rate of high corrosion and wear from old vehicle (as a result of high patronage in imported used cars) plying the roads could have accounted to the significant levels of anthropogenic contributions of Ni in roadside dust.

The concentration of Zn ranged from 35.5 - 123mg/kg as seen in table 1. The highest value was observed at GJR (123)mg/kg, this value lower than the literature value reported by several scholars and below the acceptable value of 300mg/kg. (Fabis, 1987). However, the presence of this amount of Zn in the samples may be accounted by the fact that Zn compounds are used extensively as anti-oxidants and as detergent/depressants improving agents for motor oil. Vehicle brake linings and tire wear have been identified as possible sources of Zn (Bai *et al.,* 2008).

The mean Cr level in the roadside dust ranged from 1.13 - 2.79mg/kg these values are within the acceptable values of 100 mg/kg. the highest value was obtained at GJR (2.79)mg/kg and lowest at ABW (1.13)mg/kg these show slight dependence with traffic volume as seen in table 1 respectively. However, the mean concentration of Cr for the roadside dust samples was lower than for dust samples reported at the city of Bahrain (Nwachukwu and Okiri, 2013). Chromium is one of those heavy metals whose concentration steadily increases due to industrial growth especially the development of chemical and tanning industries. Other source of Cr in roadsides dust is believed to be due to corrosion of vehicular parts (Lu, *et al.,* 2009).

The concentration of iron ranged from 48.5 - 125mg/kg with the concentration trend in the sampling sites as BRR < MMW < ABW < YGW < GJR.

Iron had the highest concentration in the soil dust from GJR (125)mg/kg and lowest in the MMW (48.5)mg/kg. It also has highest concentration among all the metals in the reference sites, however, the concentration were lower compared to some literature report (Ahumada*, et al.,* 1999)

The mean concentration was found to ranged from 1.54 – 2.85mg/kg at the sites. In this work, Cd concentrations were found to be lower than the other studied metals. Naturally in soils, acceptable values of Cd concentrations vary around (3mg/kg) dry soil (Fabis 1987).The concentrations found in this study are lower than of dust samples reported by other literature. Cadmium (Cd) is the by-product in the production of zinc and lead and the pyrometallurgy production of zinc is the most important anthropogenic source to the environment and combination with other metals (Su and Wong, 2003). Cadmium has been observed in road dust due to its presence in automobile fuel and in the soil. Therefore inhalation exposure to Cd can occur from road dust. After inhalation, the absorption of Cd compounds may vary greatly depending upon the particle sizes and their solubility. Cadmium is a metal, which can cause severe toxicity in humans. Prolonged exposure to Cd can affect a variety of organs with the kidney being the principal target.

Table 3: Arithmetical mean, standard deviation of metal concentrations in soil dust samples (mg/kg)

Variables	ABW	BRR	MMW	YGW	GJR	$J_{6contrl}$
pH	7.7	7.8	7.5	7.9	8.0	7.5
EC ($mScm^{-1}$)	0.23	0.21	0.18	0.31	0.24	0.12
OC (%)	2.13	3.20	2.02	2.12	2.82	4.64
Cu	56.5 ±0.64	24.5 ±1.04	37.5 ±1.55	67.0 ±0.94	64.2 ±1.11	26.2 ±0.05
Pb	61.0 ±0.91	25.0 ±0.82	40.5 ±1.5	64.3 ±0.85	66.0 ±1.22	18.1 ±0.02
Ni	1.23 ±0.06	0.88 ±0.04	2.18 ±0.09	3.20 ±0.08	3.88 ±0.11	0.47 ±0.04
Zn	72.0 ±1.68	35.3 ±0.85	85.0 ±2.19	110 ±3.82	123 ±0.85	26.3 ±0.13
Fe	69.0 ±1.08	48.5 ±1.04	54.5 ±1.19	123 ±0.91	125 ±1.38	27.7 ±0.11
Cd	1.54 ±0.06	1.79 ±0.07	2.50 ±0.10	2.85 ±0.13	2.10 ±0.07	0.63 ±0.02
Mn	1.15 ±0.03	1.23 ±0.01	2.10 ±0.02	2.50 ±0.08	2.58 ±0.06	0.43 ±0.01
Cr	2.00 ±0.05	1.13 ±0.02	1.74 ±0.09	2.25 ±0.12	2.79 ±0.08	0.17 ±0.02

Enrichment factor

The values obtained for the enrichment factor of the various metals in the roadside dust sampled sites are presented in figure 2.

These result suggest that all metals are deficiently to minimally enriched. These results are contrary to those previously reported by Mmolawa *et al* (2010). In their preliminary studies various authors reported moderate (Cu, Fe Co and Ni) to extreme (Pb) enrichment in most roadside soils studied. However, this differences may be ascribe to the different approaches used in the enrichment factor calculation methods. The previous study employed a normalised enrichment factor approach for metal concentration using uncontaminated background soils values, and iron as the a metal of normalization, an approach which is less reliable since it ignores the fact that some geologic materials may have naturally high element concentrations and that the world reference values could be higher or lower compared to local conditions.

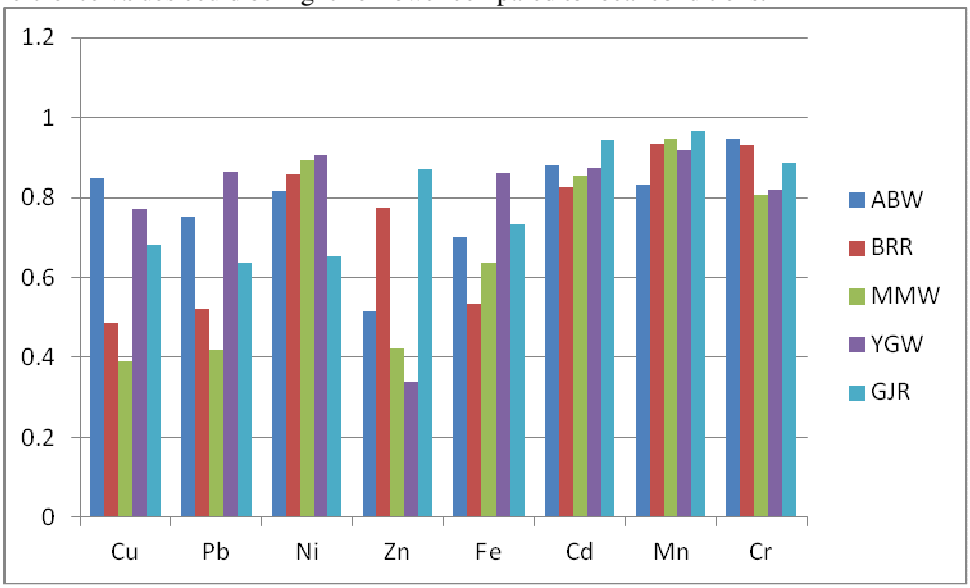

Figure 2. Enrichment factors for heavy metals along roadside dust in Jos

Contamination Factor (CF)

The contamination factors of the various metals in the roadside soil dust sampled are presented in Table 3. This study shows that all the sites suffer moderate contamination of these heavy metals except for site MMW which show low contamination of Cu while BRR, MMW and GJR Ni, BRR and GJR also displayed low contamination with Zn, MMW in Fe, ABW and YGW in Cr, BRR and MMW Cd and Mn respectively.

Table 4. Contamination factors for heavy metals along roadside soil dust for each sampled site

Metals	ABW	BRR	MMW	YGW	GJR
Cu	1.000	1.000	0.995	1.000	1.003
Pb	1.000	1.042	0.988	1.005	1.008
Ni	1.025	0.978	0.991	1.016	0.992
Zn	1.000	0.994	1.000	1.014	0.996
Fe	1.007	1.032	0.982	1.000	1.004
Cd	1.013	0.973	0.988	1.011	0.991
Mn	1.000	0.992	0.991	1.033	1.028
Cr	0.988	1.001	1.012	0.966	1.033

Pollution Load Index (PLI)

To effectively compare whether the five sites suffer contamination or not, the pollution load index, PLI, described in equation 3, was used. The PLI is aimed at providing a measure of the degree of overall contamination at a sampling site. Figure 3, shows the result of the PLI for the eight metals studied at these sites.

Based on the results presented, the degree of contamination by the eight metals is of the order GJR > YGW > ABW > BRR > MMW. However, all the sites shows signs pollution or deterioration of site quality, except MMW which is almost at baseline level. Relatively, the slight pollution at YGW and GJR , ABW, BRR, and to some degree, MMW, suggest input from anthropogenic sources attributed to increase in human activities and /or vehicular emissions. These sites connecting a number of settlements having higher populations and establishments are frequently used by commercial trucks for transportation of goods to and from Jos and other states and countries in West Africa.

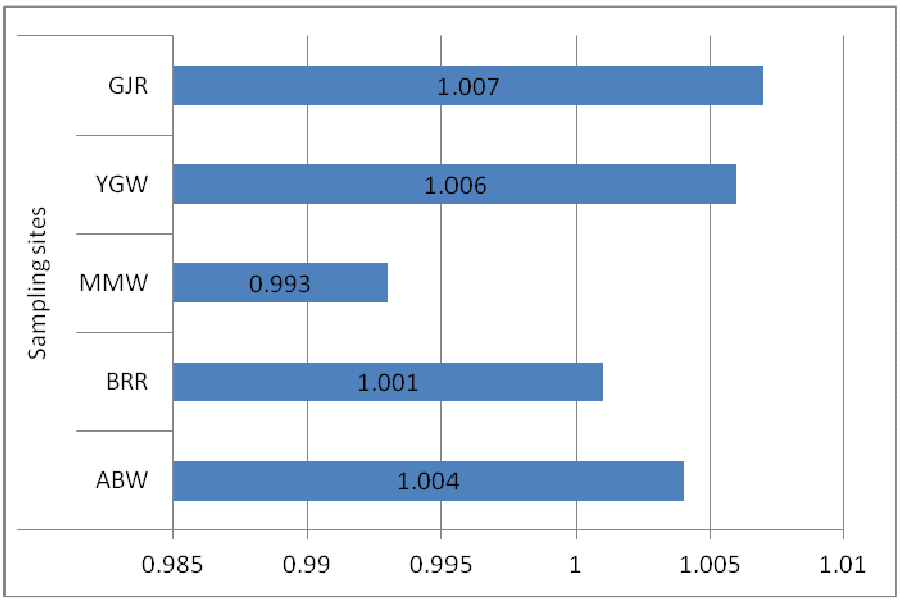

Figure 3. Pollution load index, PLI for the eight metals studied at the site

Geo-accumulation Index(Igeo)

The calculated geoaccumulation (I*geo*) values are presented figure 4. The result shows that ABW, YGW and GJR did not or exceed the moderate polluted level whereas BRR and MMW were uncontaminated. The geo-accumulation index (Igeo) of the soil dust generally can be classified as uncontaminated or moderately contaminated because the Igeo index were within the range of - $0 < Igeo < 1$.

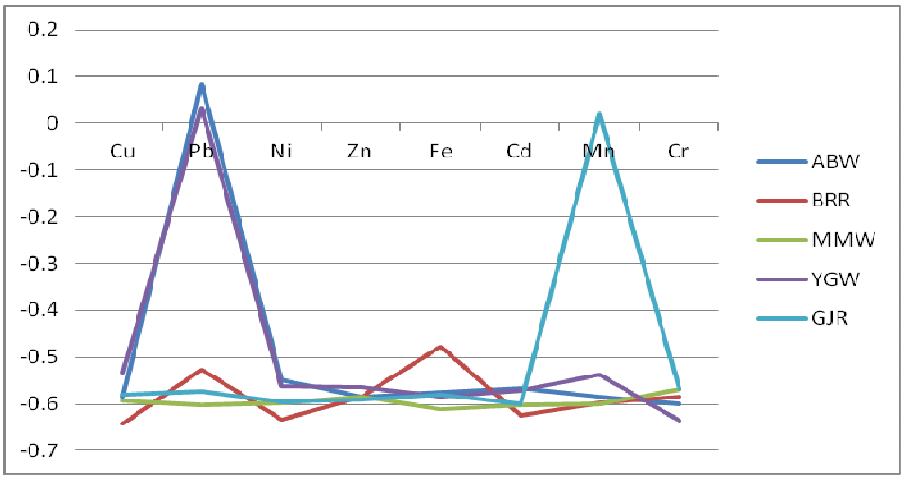

Figure 4. Geoaccumulation Index (*Igeo*) of heavy metals in Jos high traffic Areas.

Testing the significance differences between several mean concentrations of different locations

Statistical evaluation using one-way analysis of variance (ANOVA) was carried out to correlate the significant differences for the investigated metals between the different chosen locations. Sources of variance between different locations for each of the investigated elements was calculated base on the sum of squares between different sites (Bet ss), sum of squares within the different sites(with ss) and the total sum of squares (total ss). Difference F, values for the investigated metal are given in Table 5. The highest F value was obtained for iron while the lowest was obtained for cadmium.

The output of the analysis below clearly revealed that differences exist significantly in the mean value for all the elements across the study sites. The p-values for the eight elements were seen to be about (0.0001) much less than the level of significant (0.05). This means there is significant difference in the mean values of the elements such as Pb, Cr, Fe, Cd, Zn, Cu ,Mn and Ni across the study areas. The strong correlation signify that each paired element is dependent on common contamination sources.

Table 5: Analysis of Variance (ANOVA) for the different heavy metals at different locations

Source of variation		DF	SS	Ms	F	P
Cu	Bet ss	4	5363	1072.64	280.31	0.0001
	with ss	15	71.75	4.78		
	total	19	5434.75			
Pb	Bet ss	4	5144.8	1028.96	268.89	0.0001
	with ss	15	71.75	4.78		
	total	19	5216.55			
Ni	Bet ss	4	25.779	5.156	236.00	0.0001
	with ss	15	0.410	0.027		
	total	19	26.189			
Zn	Bet ss	4	18978	3795.66	250.37	0.0001
	with ss	15	284.25	18.95		
	total	19	19262.55			
Fe	Bet ss	4	21916	5479	1070.80	0.0001
	with ss	15	76.75	5.117		
	total	19	21992.55			
Cd	Bet ss	4	4.376	1.094	31.677	0.0001
	with ss	15	0.518	0.035		
	total	19	4.894			
Mn	Bet ss	4	7.602	1.901	190.78	0.0001
	with ss	15	0.149	0.010		
	total	19	7.751			
Cr	Bet ss	4	5.989	1.198	55.92	0.0001
	with ss	15	0.402	0.027		
	total	19	6.391			

Conclusion

Roadside soil dust from five major traffic roads in Jos Plateau State, Nigeria were examined for Cu, Pb, Ni, Zn,

Fe, Cd, Mn and Cr. The result generally showed that the concentration of the metal increases with traffic volumes. The pattern of the total mean concentration in the roadside soil dust followed Fe > Zn > Cu > Pb > Ni > Cd > Cr > Mn.

The enrichment factor, Contamination factor, Geoaccumulation index and Pollution load index were determined. The enrichment factor showed that the metals were deficiently to minimal enriched while the contamination showed there was low and moderate contamination of the heavy metals across the sites with the exception of MMW. The geoaccumulation index showed that ABW, YGW and GJR are uncontaminated to moderate contamination whereas, BRR and MMW are uncontaminated.

The measure of the degree of overall contamination Pollution load index indicate signs of pollution by all metals sites except MMW which is almost at the baseline level (1.0). The metals show strong correlation signifying that each paired element is dependent on common anthropogenic sources.

However, the mean concentration of the heavy metals were lower than the permissible limits set by European union standard (2002), but care must be taken to maintain a low level of heavy metal concentration on roadside dust as these metals are bioaccummulative and the dust can travel to long distance to human residence.

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