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Research paper

Assessing the overwhelming metals in roadside soils of fundamental roads in Jos city, Nigeria

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A R T I C l E I N F O

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A B S T R A C T

Studying the heavy metals in roadside soils is very important in evaluating the probable automobile emission's environmental effects on the soil. To conduct the study, the soil samples were gathered and examined for the Pb, Zn, Mn, Cu, Ni, Cd, Co and Fe levels by the use of AAS. It was found that the order of the mean total metal content for the examined metals: Fe > Zn > Mn > Pb > Cd > Cu has a decreasing trend. Other than Cd, it was reported that all metals are lower compared to the levels of those found in other studies. Not involving Co and Ni shows that there is no pollution because of such metals. A correlation analysis was performed between metals and the traffic volume (V), indicating that there is a significant positive correlation ($p < 0.05$) between Pb, Cd and Mn, and V. In addition, the vehicular emissions are the main reason for originating the metal pollution in the soil for example motor vehicles. For this reason, the present study presents an applied approach to control the level of such metals.

INTRODUCTION

One of the social and economic activities which plays a main role is roads that has an important infrastructure. But, constructing the roads has many heavy environmental pollutions (Bai, 2008).

Many scholars have emphasized that it is required to better understand the trace metal pollution of roadside soils (Manta et al., 2002). Various human activities are involved in generating trace metals in roadside soils, some examples of which are as follows: construction, vehicle, waste disposal, exhaust, coal and fuel combustion, an well as industrial and energy production (Li et al., 2001). Adefolalu al., (1980) found that in some developing countries such as Nigeria, developed road availability makes different additional job opportunities, ranging from vulcanizer and welders to auto-electricians, vehicle repairs, dealers and battery chargers in other developers of motor transportation. Such performances deliver trace metals into the air, followed by depositing into nearby soils, and then absorbed by plants on such soils. Sakagami et al., (1982) found that a close relationship existed between trace metal concentration in roadside soil and the ones in the dust falls. Additionally, trace metals in the soils produce airborne particles and dusts, affecting the air quality (Gray et al., 2003). Regarding various pollutants in the environment, a major role can be attributed to heavy metals which their concentration in water, air and soils, are increasing constantly due to anthropogenic activity.

Lagerwerff et al., (1970) found that although some research has been conducted on lead, other trace metals' contamination in the roadside environment has not been considered. Some metals like Cu, Zn, and iron Fe are important principles of many pipe, wire, tyre and alloy in motor vehicles and are discharged into the roadside environment because of the normal wear and tear and mechanical abrasion (Harrison et al., 1981). Because many metals in the soil are so mobile, they are likely to collect metals based on a long term. This accounts for the total higher level of contamination of metals in the soil and thus the highest layer of soil should be taken in sampling (Ho and Tai, 1988). Despite the fact that a significant number of studies was conducted on the concentrations of heavy metals in roadside soils, a considerable study has been conducted in developed countries with a long duration of industrialization and a wide application of leaded gasoline since 1935 (Mateu et al., 1995). Not much studies were performed in developing countries like Nigeria and there is little information regarding pollutant metal concentrations and distribution in such a country. Therefore, the present study aimed to determine the heavy metal concentrations in roadside soils of main roads of Jos Metropolis as related to traffic volume.

Table 1. The volume of traffic in the sampling roads.

Location	Site code	Average traffic volume per day
Murtala Muhammed Way	A	1521
Yakubu Gowon Way 2	B	1340
Yakubu Gowon Way 1	C	1320
Turdan Wada Road	D	1001
Pam road	E	965
Rukaba road	F	930
Off Yakubu Pam road	G	603

MATERIALS AND METHODS

Sampling description

To cover a wide span of density of traffic and covering an appropriate geographical area in the Jos city, the sampling sites were selected. For this purpose, seven locations were chosen within the Jos environment and their sites are as determined below in declining trend of traffic volume. To determine the traffic density, the number of motor vehicles which passed the sampling sites during fifteen hours since 6.00 a.m. -6.00 p.m. were counted daily for three days (Abechi et al., 2010). As shown in Table 1, the mean number of vehicles which passes the location daily was then calculated.

Sample collection

In February (2008), Field collection was performed approximately five months into the dry season in a way that it avoids the probable wash away or heavy metals' leaching. In addition, the samples where collection was carried out during two successive days in order to decrease temporal changes as much as possible.

Three reiterated samples were provided from the surface soil at each site, and then composite and represented samples were maintained in an acid prewashed cleaned polyethene bags, followed by treating and analyzing separately.

Sample digestion

All applied reagent had analytical grade and double distilled water was implemented in all preparation other than otherwise stated. The method proposed by Ho et al., (1988) was applied for sample digestions. The samples were tightened completely in polythene bag and dried in air. The researchers grinded the samples through an acid pre-washed mortar and pestle sieved by passing them through a 1 mm mesh. 1 g of each sample's soil was precisely weighed and then treated with 10 ml aliquots of high purity conc HNO_3. Then, the mixture was placed on a hot plate as long as the sample is approximately dried and then cooled. Such a procedure was reiterated with another 10 ml conc. HNO_3 subsequently by 10 ml of 2 M HCl. Then, the absorbed samples of the soil were warmed in 20 ml of 2 M HCl to re-dissolve the metal salts. The filter papers were used to filter the extract and the doubled distilled water was applied to adjust the volume to 25 ml. UNICAM SOLAR 32 Data station V7.15 AAS model was used to determine metal concentrations.

RESULTS AND DISCUSSIONS

Figure 1-6 shows the mean triplicate determinations of metal concentrations (Pb, Zn, Cu, Cd, Mn and Fe) in soils of different sampling.

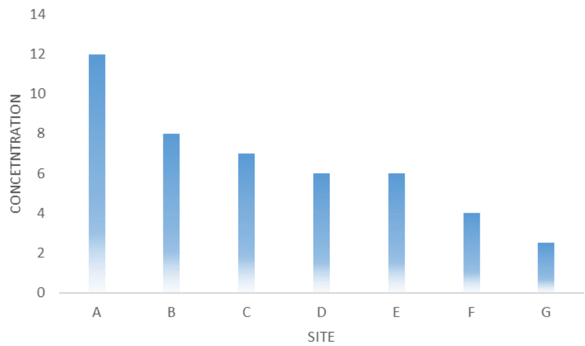

Figure 1. The concentration of Pb across the sampling site.

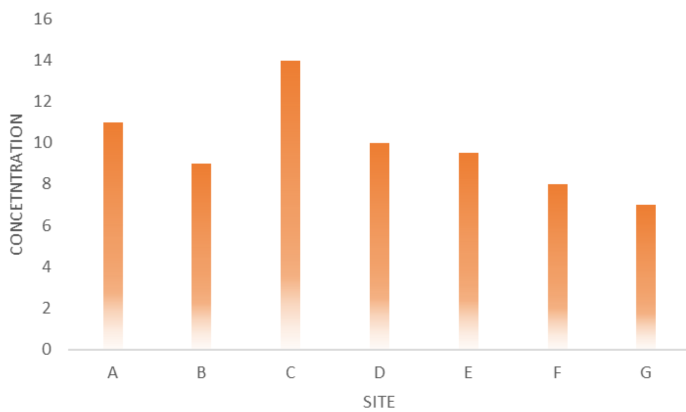

Figure 2. The concentration of Zn across the sampling site.

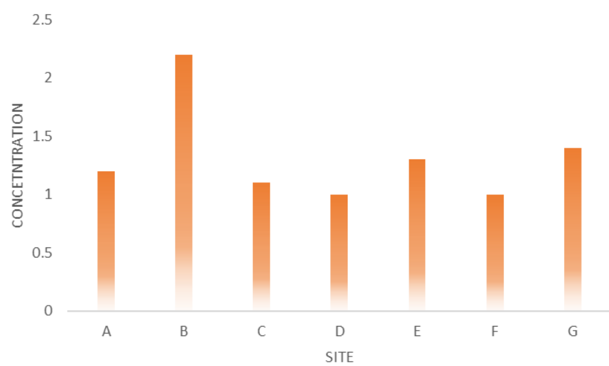

Figure 3. Concentration of Cu across the sampling site.

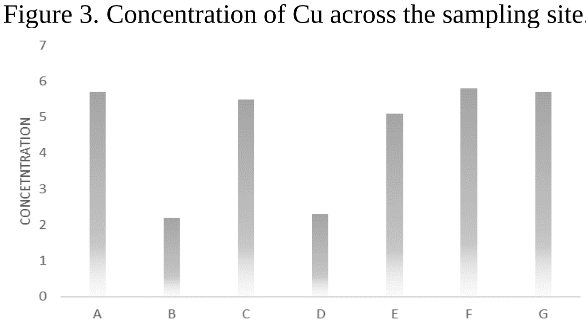

Figure 4. Concentration of Cd across the sampling site.

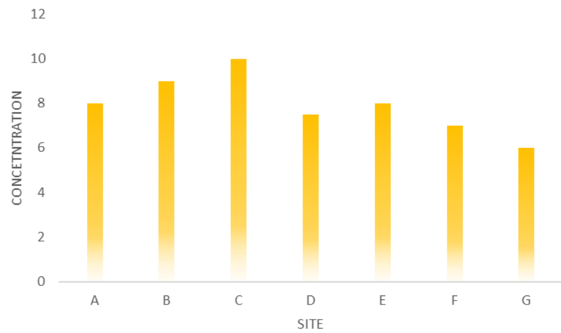

Figure 5. Concentration of Mn across the sampling site.

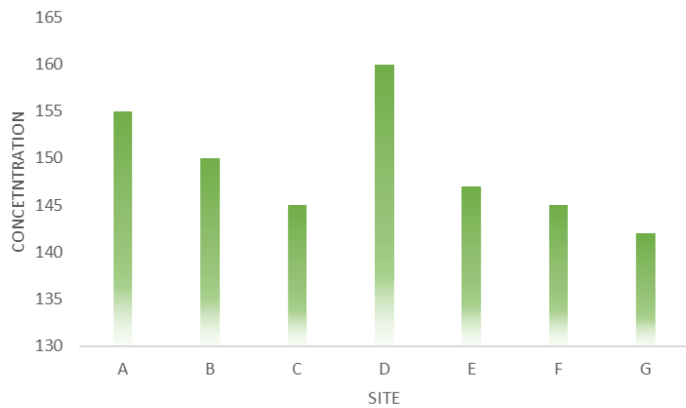

Figure 6. Concentration of Fe across the sampling site.

The analysis of variation in metals among the site showed that there is a significant variation ($p < 0.05$) for all metals other than Cd and Cu. The soil pH is somewhat alkaline over the sites except for Site A which is slightly acid. The level of roadside soil lead varies from a very low to a high concentration of 1.59 (low traffic volume, Site G) and 12.10 ug/g (high traffic volume, Site A), respectively. The high mean amount of the concentrations validated the total level of contaminations of this metal in the roadside environments. This finding is in line with the report of Lagerwerff et al., (1970). The high concentrations of the observed lead are due to lead particle from combusting the gasoline which then settles on roadside soils. The case of Site A which is more predominant is assigned to the heavy traffic of the route. Simultaneously, vehicles are not often moving fast because of the heavy traffic congestion in this region which this may explain the high level of lead. This finding is in agreement with that of Francek (1992), reporting that traffic junction and cross roads record higher levels of metals. Furthermore, not surprisingly, the high level of Pb is related to Sites B and C junctions, serving as a mini garage for heavy trucks. In addition, the auto mechanic work is the same which dominates the business in the area. However, Site G has expectedly the least concentration amount of Pb (1.59 ug/g) which is due to the minimum volume of vehicles recorded on the road. Although, the maximum average soil lead level indicates that generally the roadside environment is lead enriched in spite of a comparatively low traffic volume than those of other studies (Ho and Tai, 1988).

Zn varied from 5.67 (Site G)-12.88 ug/g (Site C). Comparing with other studies, such a value is small (JARADAT and Momani, 1999). In the present study, the ratio of Pb/Zn in soil was less than unity except for Site A, as opposed to the report which automobiles may pollute soil lead (JARADAT and Momani, 1999). Conversely, other reports indicated that there was a ratio of less than unity, which was associated with the local conditions. Due to the fact that there is no major industry in the study areas like smelting operations, it is assumed that the attrition of motor vehicle tire rubber exacerbated by poor road surfaces is probably the main sources of Zn, as well as the lubricating oils where Zn is considered as part of many additives like zinc dithiophosphates.

Furthermore, the metal's mobility is dependent on soil pH, the organic matter, and the soil's granulometric composition. Acidic pH makes the solubilization of the Zn compounds easier;

however, the soils in the present study are alkaline except for Site A which is somewhat acidic, indicating that Zn and other metals keep in soils for a longer time.

The Jos city roadside copper level varies from 1.01 ug/g at Site F - 2.19 ug/g at Site B, which this road is along Yakubu Gowon road, serving as one of the main roads with related accessory vehicle workshops which are located along it. If the value of Cu is compared to other studies, it reveals that it is less than 27, 61, 24 and 29.7 ug/ (Abechi et al., 2010), although, it can be compared to 2.78 ug/g obtained along Sixao highway in Southwest China (Bai, 2008).

On the other hand, Cd was made available from all the sites, ranging from 5.15 (Site E) - 5.79 ug/g (Site F). It was shown that the soils in the present study had higher levels of contamination than 0.75 ug/g (JARADAT and Momani, 1999), 2.11 ug/g (Amusan et al., 2003) and 0.88 ug/g (Bai, 2008). Conversely, Cd level in the present study can be compared to 6.8 ug/g which was reported in North Wale (Davies and Houghton, 1984) and approximately 5 times that reported by Ndiokwere (1984). If any main industry in the sampling sites is not involved, the levels of Cd is because of the lubricating oils and/or old tires which are often used on the roads' rough surfaces, leading to increasing the wearing of tires.

Mn and Fe gotten from the present study varied from 5.51 (Site G) - 9.61 ug/g (Site C) and 141.80 (Site G) - 159.00 ug/g (Site D), respectively. Both Fe and Mn constitute the main elements of soils in northern Nigeria, which their accessibility in a trace amount as found in the present research could be because of the local condition of soil weathering.

Table 2. Correlation analysis among traffic volume and metals

Parameter	Traffic Volume	Pb	Zn	Mn	Cu	Cd	Fe
Traffic Volume	1						
Pb	0.839**	1					
Zn	0.714*	0.521	1				
Mn	0.726*	0.425	*	1			
Cu	0.359	0.258	-0.158	0.328	1		
Cd	-0.098	-0.271	-0.287	-0.248	-0.529	1	
Fe	0.682	0.528	0.458	0.326	0.157	0.214	1

** and * are significant at 0.01 and 0.5

Table 2 displays the calculations related to correlation, among concentrations of the heavy metals in traffic volume (V) and surface soil. The coefficient mentioned above evaluates the strength of a linear relationship between any two variables on a scale of -1 (perfect inverse relation) through 0 (no relation) to +1 (perfect sympathetic relation). The raw geochemical data was applied to calculate the correlation coefficient through the SPSS (Statistical Program for the Social Sciences) computer software package (SPSS Inc., version 13). It was found that there were significant positive correlations ($p < 0.05$) among V: Pb, Zn and Mn, and Mn and Zn. Despite the fact that a mild positive and negative correlation existed between metals, a negative correlation between Cd and V shows that other sources except from automobile emission could lead to the concentration of this metals in the soils. There was a significant positive correlation between metals and V, indicating a probable contamination of the soils by automobile emissions.

Conclusion

In the present research, it was found that all metals generally exist Ni in the roadside soils except for Co and Ni. The metals' concentrations in the soils are arranged as Fe > Zn > Pb > Mn > Cd > Cu. Compared to other studies in Nigeria, the level of Cd at the moment is high. Therefore, the soils can be accumulated and transferred to plants growing along the edge of the highway because of the continuous application of the road by automobile. Additionally, it may result in accumulating the metal in the organisms' tissues which feed on the plant and other plants which grow along the highway. Such an issue can be carried to other users in the food chain (Akinola and Adedeji, 2007).

Conflict of interest

The authors declare that they have no conflict of interest.

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