

Assessment of Heavy Metals, Organic Carbon and Physico-Chemical Properties of Roadside Dust from a Nigerian School Campus

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ABSTRACT

University of Ilorin is one of the most populated Universities in Nigeria. Roadside dust was collected from the busiest roads of the university permanent site and level of heavy metals (Fe, Cu, Zn, Cd and Pb), organic carbon and physico-chemical properties of the dust were assessed. Atomic Absorption Spectrometry (Buck Scientific 210/211VGP) was used to analyse for heavy metals while appropriate standard methods were employed for the determination of organic carbon, pH, conductivity, particle density and bulk density of the roadside dust. The pH of dust from all roads was almost alkaline (7.2 – 7.6), particle density ranged from 1.60 - 2.14 gml⁻¹, bulk density ranged from 1.03 – 1.62 gml⁻¹, electrical conductivity ranged from 0.25 to 0.57µScm⁻¹, organic carbon (OC) content of all roadside dust ranged from 0.9 % - 1.2 %. While Pb was obtained to be absent in all the roadside dust samples, it was observed that the abundance of other heavy metals at all the various sampling points and control followed the order Fe >>>Zn >> Cu > Cd. The average level of Fe in the control site was 2443.85 mg/kg which was very lower to that from other sites in the study. The results for the metal pollution index (MPI) show that all the roads were polluted with Fe, Cu, Zn and Cd. The levels of the metals showed a dependence on anthropogenic pollution such as vehicle density compared with the control site.

Keywords: Roadside Dust, Heavy Metals, Organic Carbon, University Campus

1.0. Introduction

Particulate matter (PM) is the solid and liquid particles dispersed into ambient air. Roads are characterised by generation of PM in form of dust particles which have been realised to be popular form of air pollution in cities and towns. Road dust is generated by lifting of roadside soil particles as a result of movement by vehicles, pedestrian and other human activities. The dust usually deposits and accumulates on ground surfaces, along roadsides, which is usually contaminated by heavy metals and organic matters (Marchand *et al* 2011). Heavy metals are characterized by high stability in the environment and generally are not biodegradable or leached (Mmolawa *et al.*, 2011). The ability of soil to accumulate heavy metals is associated with its type, texture and chemical properties as well as the nature of the individual heavy metal (Kabata-Pendias, 2011). Moreover, human activities contribute to the increase in the levels of metal contamination in the road dust due to vehicle exhaust particles, tire wear particles, weathered street surface particles, brake lining wear particles, emission from power plants, coal combustion, metallurgical industry, auto repair shop and chemical plant (Nasser *et al.*, 2012). Other anthropogenic activities include domestic emission, weathering of building and pavement surface, atmospheric deposition and so on (Nwosu and Olayinka, 2019). Accumulation of heavy metals in the soil disrupts the usual biochemical processes taking place in it, which can in consequence have a negative effect on the biological activity (Zawadzka and Lukowski, 2010). Road dust, particularly the fine particle, can get into human body through ingestion, inhalation, and dermal absorption, which consequently becomes hazardous to the body (Kinney and Lippmann, 2000). Therefore, the

determination of metal in environmental samples like dusts is very necessary for monitoring environmental pollution.

Various studies outside Nigeria such as that of Obaidullah *et al.*, (2015) characterized indoor PM into three sizes of particles such as PM₁, PM_{2.5} and PM₁₀ at three different enclosed parking garages in two cities of Belgium with varying vehicle intensity and varying layout with results indicating average particles mass concentrations in garages ranging from 28 µg/Nm³ to 50 µg/Nm³ for PM₁, 43 µg/Nm³ to 60 µg/Nm³ for PM_{2.5} and 58 µg/Nm³ to 90 µg/Nm³ for PM₁₀. Suryawanshi *et al.*, (2016) measured the concentration levels and sources of heavy metals contamination in road dust samples collected from industrial, highways, residential and mixed use in Delhi, India. Metal content in road dust was analyzed with results indicating high concentration levels of Ni, Cr and Pb in industrial areas. Also, the levels of toxic heavy metals like Pb, Cd, Co, Ni, Zn, Cr, Mn and Total Petroleum Hydrocarbons (TPH) were determined in the roadside topsoil collected near a national highway of Upper Assam-India by Arundhuti and Pranjali (2014). It was observed that heavy metal concentrations were higher in polluted sites than the control site.

Various studies in Nigeria like that of Mafuyai *et al.*, (2015) had observed Cu concentration to range 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 in the roadside dust from five major traffic roads in Jos metropolitan area which showed that accumulation of heavy metals in soil dust was greatly influenced by traffic volume and there was a significant reduction in roadside dust when moving away from the road. A study carried out by Nwosu *et al.*, (2016) to measure the heavy metal loading in dust fall from some universities in Nigeria and that carried out by Nwosu and Olayinka (2019) for chemical components of dust fall at various motor parks in the University of Ilorin had shown higher levels of metals. However, a minute study have been carried out to measure heavy metals in the road side dust in school campuses especially, University of Ilorin, Nigeria. This present study was carried out to investigate the levels of heavy metals from the busiest roads of University of Ilorin permanent site campus. The levels of Organic Carbon and physic-chemical properties of the dust were also obtained.

2.0. Materials and Methods

2.1. Study area

The University of Ilorin is an academic institution, located in Ilorin, Kwara State, North Central of Nigeria. The university is one of the most populated Universities in Nigeria with about 30,084 number of student as at 2017. This study was carried out in the permanent site of the University, located within the latitude (8°30'N) and longitude of (4°40'E). The roadside dust samples were collected from the busiest roads in the University (as provided in Figure 1) in November 2016 and February; April; May, 2017. Table 1 gives the names and description of the sampling road sites.

2.2. Sampling method

The road side dust samples were collected from the side of the roads with clean plastic dust pan and brush (Nasser *et al.*, 2012) while the surface soil was collected by sweeping the soil with new hard brooms to a depth of about 1cm. Each sample was taken by mixing together three sub-samples obtained at about 1m distance to each other along the sampling roads as shown in Figure 1. Such sampling strategy was adopted in order to reduce the possibility of random influence of urban waste (Glewa and Al-Alwani, 2012). The samples were transported into the laboratory in clean sealed polythene bags where they were air dried to get rid of moisture, grounded into fine powder using mortar and pestle. Dry samples were sieved with 0.125mm standard sieve and homogenized (Adaramodu *et al.*, 2012). The sieved samples were then packed in a properly tied polythene bag and ready for analysis.

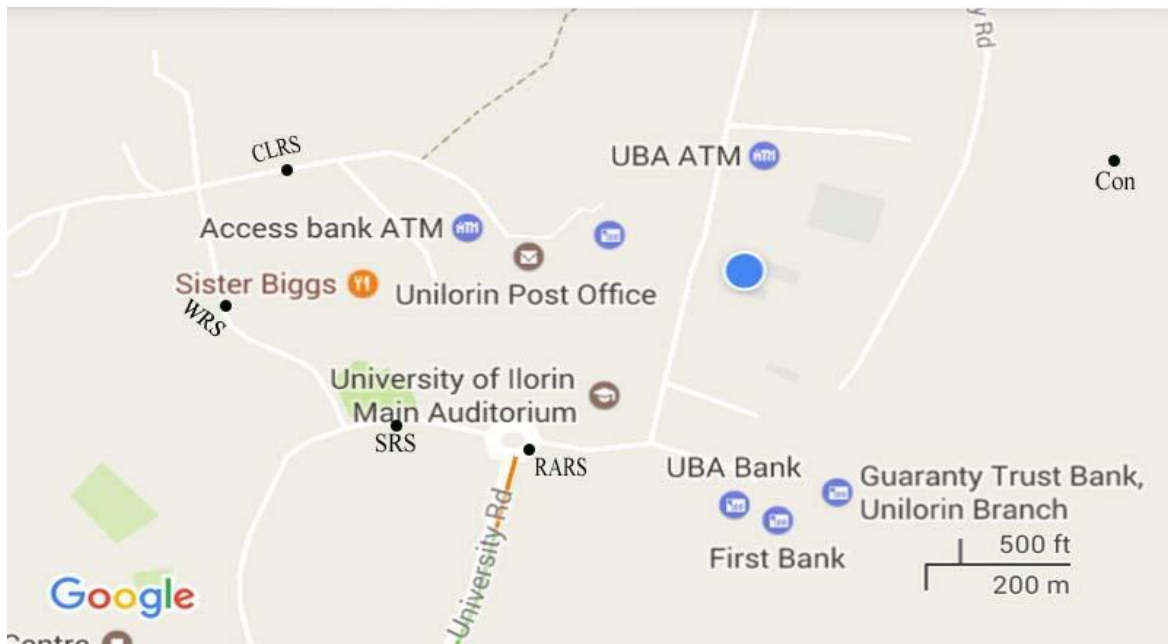


Figure 1: Map of University of Ilorin indicating the roads of study

Table 1: Names and description of sampling road sites

Sites	Name of sites	Traffic density (hr ⁻¹)	Description
WRS	West Park Road Side	1561	Characterised with roadside trees and connected the major motor parks to various food canteens on campus.
SRS	South Park Road Side	622	With high commercial activities in metal container shops and passed the side of the first park leading to the school auditorium.
CLRS	Clinic Road Side	53	Characterised by roadside trees and passed in front of the school clinic leading to the school library and the motion ground.
RARS	Round About Road Side	863	School central round - about, in front of the senate building where almost all the private vehicles must pass.
Con	Control	-	The control surface soil sample, Con was taken from an agricultural farmland at about 5 km from the road side.

2.3. Particle and bulk density determination

Bulk density of a substance is the mass per unit volume of dry soil in its natural state. For bulk density, soil mass was determined by subtracting the mass of an empty cylinder from the mass of the same cylinder when containing soil sample (after it's been stabbed on a table for 132 times). The volume of the sample was also noted on the cylinder after the stabbing on the table. Bulk density was then determined using Equation (1).

$$B_d(g/cm^3) = \frac{\text{soil mas}}{\text{soil volume}} \quad (1)$$

Also, for particle density, the mass of sample was first determined by subtracting the mass of an empty curvet from the mass of the curvet when it was filled with sample. After this, a measuring cylinder was filled with water and the volume of water in the cylinder was noted. The same curvet while empty was dipped inside the cylinder containing water such that the increase in the level of water was recorded. The same curvet, after it was filled with dust sample was well dipped inside the measuring cylinder containing water. The increase in volume of water level in the cylinder was also noted. The volume of the sample was then determined by subtracting the increase in volume of water for the empty curvet from the increase in volume of water for curvet containing sample. The particle density was therefore calculated using Equation (2).

$$P_d(g/cm^3) = \frac{\text{mass of sample}}{\text{volume of sample}} \quad (2)$$

2.4. pH and conductivity

Soil pH is an indication of the acidity or alkalinity of the soil and is measured in pH units. The sample pH and conductivity were measured with well calibrated pH meter and conductivity meter respectively using sample slurry prepared with distilled water. The conductivity of soil sample was determined using the prepared sample for pH with a conductivity meter.

2.5. Organic carbon determination

The organic carbon content of the dust samples was determined following the Walkey-Black Procedure (Adedeji *et al.*, 2013). A known mass of pulverised dust sample (2g) was weighed into a dry 250 mL conical flask. A 10 mL of 1 N $K_2Cr_2O_7$ was added and swirl gently to disperse the soil in the solution. This was followed by adding a 20 mL of concentrated H_2SO_4 with proper swirling until proper mixture. A 200°C thermometer was inserted into the mixture as the mixture was being heated and swirled on a hot plate until the temperature reaches 135°C. After this, the heated sample was set aside to cool slowly on an asbestos sheet in a fume cupboard. When cooled (20–30 minutes), it was diluted to 200 mL with deionised water and titrated with the 0.4 N $FeSO_4$ adding 3 or 4 drops "ferroin" indicator. As the end point is approached, the solution became greenish colour, changed to a dark green and finally until the colour changed sharply to reddish-grey. Two blanks were run in the same way to standardise the $FeSO_4$ solution. The Organic Carbon was then computed using the Equation (3).

$$\text{Organic Carbon}(\%) = \frac{[0.003g \times N \times 100ml \times (1-T/S) \times 100]}{ODW} \quad (3)$$

Where N = Normality of $K_2Cr_2O_7$ solution, T = Volume of $FeSO_4$ used in sample titration (mL), S = Volume of $FeSO_4$ used in blank titration (mL), ODW = Oven-dry sample weight (g).

2.6. Digestion for heavy metals

A known mass (2g) of dust samples were treated by adding mixture of concentrated nitric acid (HNO_3), sulphuric acid (H_2SO_4) and hydrofluoric acid (HF) in 10 ml, 2 ml and 1 ml respectively to the measured dust sample in a 250 ml beaker. The content of the beaker was heated up to 250°C until partial dryness. The beaker was then cooled, washed with distilled water and filtered using Whatman filter paper (42). Clear solution (filtrate) was transferred into 25 ml standard volumetric flask and completed to the mark with double-distilled water (Nasser *et al.*, 2012). The concentration of heavy metals (Cd, Cu, Fe, Pb, Mn and Zn) in the samples was then determined using an Atomic Absorption Spectrometry (Buck Scientific 210/211VGP) instrument with a detection limit of 0.01, 0.005, 0.05, 0.08, 0.03, 0.005 mg/L for Cd, Cu, Fe, Pb, Mn and Zn respectively. A standard solution for each element under investigation was used for calibration of the instrument. Blank samples were also analysed.

2.7. Traffic density

The estimation of the traffic on various roads was conducted in duplicate during the periods of heavy traffic.

2.8. Contamination factor (C_f) and degree of contamination (C_d)

The contamination factor (Equation (4)) and degree of contamination (Equation (5)) as given by Khairy *et al.*, (2011) were followed.

$$C_f = \frac{C_s}{C_b} \quad (4)$$

$$C_d = \sum_{i=1}^N C_f \quad (5)$$

Where N is the number of metals analysed, C_s is the measured concentration of the examined metal in the dust sample and C_b is the geochemical background concentration or reference value for heavy metals in the uncontaminated soil (Khairy *et al.*, 2011).

2.9. Modified contamination degree

The Modified Contamination Degree (mCd) is the degree of contamination C_d for a given set of pollutants divided by the number of analysed pollutants. The modified equation for a generalised approach to calculating the degree of contamination as given by (Alfred *et al.*; Sarala and Uma, 2013) is shown in Equation (6).

$$mCd = \frac{C_d}{N} \quad (6)$$

Where N is the number of metals analysed and C_d is calculated as in equation (5).

2.10. Metal pollution index

The MPI was obtained using the relationship given by Sarala and Uma, (2013).

$$MPI = \log \sum_{i=1}^N \frac{x}{ref_i} \quad (7)$$

Where; ref_i represents a background or reference value for each of the analysed metals, N is the number of metals analysed and x represents mean value of metal concentration from the study area.

2.11. Geo-accumulation index (I_{geo})

The geo-accumulation index (I_{geo}) was estimated for the degree of contamination of various metals at various sites following the relationship given in Equation (8) (Nweke and Ukpai, 2016).

$$I_{geo} = \log_2 \frac{C_i}{1.5Ref_i} \quad (8)$$

Where C_i is the concentration of i metal in the roadside and Ref_i is the background or reference concentration value of metal i and factor 1.5 is to minimise the effect of possible variations in the background values.

3.0. Results and Discussion

3.1. Physico-chemical properties of roadside dust

The Table 2 depicts the results of particle density. The value of particle density for November ranged from the values $1.69 \pm 0.04 \text{ gml}^{-1}$ for WRS to $1.92 \pm 0.01 \text{ gml}^{-1}$ for RARS, February ranged from the values $1.57 \pm 0.01 \text{ gml}^{-1}$ for CLRS site to $2.22 \pm 0 \text{ gml}^{-1}$ for RARS site, April ranged from values $1.58 \pm 0.01 \text{ gml}^{-1}$ for CLRS to $2.1 \pm 0.02 \text{ gml}^{-1}$ for RARS site and the May ranged from values of $1.52 \pm 0.01 \text{ gml}^{-1}$ for CLRS site to $2.31 \pm 0.02 \text{ gml}^{-1}$ for RARS site. The average particle density for all sites ranged from 1.60 gml^{-1} for CLRS to 2.14 gml^{-1} for RARS. The particle density is higher if large amount of heavy minerals is available in the soil and therefore leads to decrease in the level of organic matter in the soil (MAIB, 2017). This means that the dust from RARS could contain more minerals than others while the CLRS had the least mineral content.

As given in Table 2, the values of bulk density for November ranged from the values $0.80 \pm 0 \text{ gml}^{-1}$ for Con site to $1.31 \pm 0 \text{ gml}^{-1}$ for RARS, February ranged from the values $1.07 \pm 0.26 \text{ gml}^{-1}$ for CLRS site to $2.07 \pm 0.93 \text{ gml}^{-1}$ for RARS site, April ranged from the values $0.89 \pm 0.07 \text{ gml}^{-1}$ for CLRS site to $1.05 \pm 0.19 \text{ gml}^{-1}$ for the Con site and the May ranged from the values of $1.06 \pm 0.21 \text{ gml}^{-1}$ for Con site to $1.45 \pm 0.06 \text{ gml}^{-1}$ for RARS site. The average bulk density for all sites ranged from $1.03 - 1.62 \text{ gml}^{-1}$. The bulk density of soil depends greatly on the mineral make up of soil and the degree of compaction (ScienceDirect, 2017). Bulk density decreases as the mineral soils become finer in texture and it gives a good estimate of soil porosity (MAIB, 2017). Meanwhile, the smaller the dust particle, the stronger its potential impact on human health because it can be more easily inhaled (USEPA, 2005). Therefore, the RARS with average bulk density of 1.62 gml^{-1} could be more prone to health hazard.

The pH values for various sites are shown in the Table 1. The average pH for Con was observed to be 6.2 which indicate that the soil from the control site is slightly acidic. The pH from all the roads were almost alkaline 7.2 – 7.6. This indicates neutralizations as a result of alkaline deposition from the atmosphere. Also, metals and ash from anthropogenic could also be source of neutralization (Mafuyai *et al.*, 2015). High pH values might reduce the mobility of some metal species down the soil strata while low pH value usually enhances metals distribution and transport in soil (Idzi *et al.*, 2013).

Table 2 shows the electrical conductivity (EC) from various sites. The average EC at various sites were obtained for RARS as $0.53 \mu\text{Scm}^{-1}$, WRS as $0.29 \mu\text{Scm}^{-1}$, SRS as $0.47 \mu\text{Scm}^{-1}$, CLRS as $0.25 \mu\text{Scm}^{-1}$ and Con as $0.57 \mu\text{Scm}^{-1}$. The electrical conductivity of a solution indicates the total concentration of ions. The highest EC being $0.57 \mu\text{Scm}^{-1}$ for Con shows that there were likely more ions in the Con sample than others. These ions which is necessary not of heavy metals could be of simple mineral elements like sodium, magnesium and others. However, samples RARS ($0.53 \mu\text{Scm}^{-1}$) and SRS ($0.47 \mu\text{Scm}^{-1}$) had values higher than ^{values} (ABW; $0.23 \mu\text{Scm}^{-1}$, BRR; $0.21 \mu\text{Scm}^{-1}$, MMW; $0.18 \mu\text{Scm}^{-1}$, YGW; $0.31 \mu\text{Scm}^{-1}$ and GJR; $0.24 \mu\text{Scm}^{-1}$ for some major traffic roads in Jos metropolitan area of Nigeria by Mafuyai *et al.*, (2015).

3.2. Total organic Carbon in roadside dust

As given in Table 2, the average organic carbon (OC) content of various roadside dust and control ranged from 0.9 % for RARS and Con to 1.2 % for CLRS. Decaying grasses and leaf shed from trees along the road could be the contributors to the level of organic carbon. The Bauchi Ring Road in the study of Mafuyai *et al.*, (2015) had 3.20% while it Con had 4.64% which were greater than that of this study in University of Ilorin roadside dust.

Table 2: Levels of physico-chemical properties at various sites (N=2)

Samples	Parameters	November	February	April	May	Average
RARS	pH	6.13 ± 0.01	6.86 ± 0.03	7.45 ± 0.01	8.23 ± 0.06	7.2
	EC (µScm ⁻¹)	0.32 ± 0.05	1.26 ± 0.03	0.40 ± 0.07	0.13 ± 0.01	0.53
	Particle Density (gml ⁻¹)	1.92 ± 0.01	2.22 ± 0	2.1 ± 0.02	2.31 ± 0.02	2.14
	Bulk Density (gml ⁻¹)	1.31 ± 0	2.07 ± 0.93	1.65 ± 0.01	1.45 ± 0.06	1.62
	OC (%)	1.19 ± 0.02	1.03 ± 0.03	1.14 ± 0.01	0.24 ± 0.01	0.9
WRS	pH	6.76 ± 0.06	7.10 ± 0.01	7.39 ± 0.01	8.87 ± 0.05	7.5
	EC (µScm ⁻¹)	0.25 ± 0.09	0.25 ± 0.01	0.58 ± 0.23	0.08 ± 0.01	0.29
	Particle Density (gml ⁻¹)	1.69 ± 0.04	1.63 ± 0.02	1.62 ± 0.02	1.58 ± 0.01	1.63
	Bulk Density (gml ⁻¹)	1.17 ± 0	1.23 ± 0.30	1.25 ± 0.15	1.39 ± 0.21	1.26
	OC (%)	1.21 ± 0.01	1.04 ± 0.01	1.03 ± 0.03	0.78 ± 0.04	1.02
SRS	pH	6.82 ± 0.03	7.63 ± 0.01	7.03 ± 0.03	8.54 ± 0	7.5
	EC (µScm ⁻¹)	0.77 ± 0.22	0.23 ± 0.01	0.81 ± 0.11	0.06 ± 0	0.47
	Particle Density (gml ⁻¹)	1.8 ± 0.01	1.72 ± 0.06	1.67 ± 0.01	1.71 ± 0.02	1.73
	Bulk Density (gml ⁻¹)	0.87 ± 0	1.32 ± 0.09	1.15 ± 0.25	1.44 ± 0.06	1.10
	OC (%)	1.18 ± 0.03	0.92 ± 0.03	1.22 ± 0.03	0.71 ± 0.03	1.0
CLRS	pH	7.26 ± 0.01	6.68 ± 0.03	7.49 ± 0.03	8.93 ± 0.03	7.6
	EC (µScm ⁻¹)	0.31 ± 0.02	0.31 ± 0.02	0.35 ± 0.04	0.04 ± 0	0.25
	Particle Density (gml ⁻¹)	1.74 ± 0.01	1.57 ± 0.01	1.58 ± 0.01	1.52 ± 0.01	1.60
	Bulk Density (gml ⁻¹)	0.92 ± 0	1.07 ± 0.26	0.89 ± 0.07	1.22 ± 0.33	1.03
	OC (%)	1.30 ± 0.02	1.01 ± 0.06	1.26 ± 0.01	1.19 ± 0.01	1.2
Con	pH	6.24 ± 0.01	6.62 ± 0.02	7.15 ± 0.04	8.25 ± 0.07	6.2
	EC (µScm ⁻¹)	0.42 ± 0.06	0.65 ± 0.04	0.67 ± 0.03	0.53 ± 0.01	0.57
	Particle Density (gml ⁻¹)	1.83 ± 0.02	1.82 ± 0.01	2.1 ± 0.02	2.0 ± 0.04	1.94
	Bulk Density (gml ⁻¹)	0.80 ± 0	1.87 ± 0.34	1.05 ± 0.19	1.06 ± 0.21	1.20
	OC (%)	1.04 ± 0.01	0.84 ± 0.02	0.84 ± 0.02	0.89 ± 0.02	0.9

(EC) Electrical Conductivity, (OC) Organic Carbon, (±) Standard Deviation

3.3. Heavy metals in roadside dust

The results for monthly concentration of heavy metals in the road side dust samples and traffic density at various roads are as shown in the Table 3. Pb was observed to be absent in all samples from various sites. This could mean that Pb was not present in the campus soil or probably not generated by vehicular activities from the combustion engine of the vehicles because it was not present in their fuels. Although Fe is naturally abundant in the environment and it is needed in the body with its deficiency leading to anaemia, higher ingestion of Fe may acutely poison young children. It also causes conjunctivitis and retinitis if it continuously remains in the tissues after contact (Lenntech, 2005). In this study, Fe was found to be the major heavy metal which was in line with the observation of Shinggu *et al.*, (2007) in Adamawa, Nigeria. The average level of Fe in the control site was 2443.85 mg/kg which was very lower to that from other sites in this study. The average concentration of Cu for CLRS and Con were very

close such that they had 2.7 and 2.8 mg/kg respectively which were lower than that of other sites with higher traffic densities. The average value of Zn for SRS (19.65 mg/kg) was lower than that of Con (25.1 mg/kg). However, that of Con (25.1 mg/kg) was very close to that of CLRS (28.95 mg/kg). A prolonged inhalation exposure to Cd can affect a variety of organs in the body with the kidney being the principal target (Glewa and Al-Alwani, 2012).

Table 3: Monthly levels of heavy metals (N=2), average heavy metals and traffic densities at various sites

Samples	Heavy metal	Nov (mg/kg)	Feb (mg/kg)	Apr (mg/kg)	May (mg/kg)	Average (mg/kg)
RARS	Fe	8990.81 ± 197.9	3380 ± 68.1	15116.13 ± 192	3917.38 ± 47.4	7851.1
	Cu	2.91 ± 0.06	5.28 ± 0.05	8.29 ± 0.05	1.61 ± 0	4.5
	Zn	18.78 ± 0.07	41.86 ± 0.06	58.16 ± 0.06	5.99 ± 0.03	31.2
	Cd	< 0.01	< 0.01	< 0.01	0.86 ± 0.02	0.2
WRS	Fe	9350.38 ± 133.3	12795.81 ± 80.5	13586.25 ± 113	11575.38 ± 98.5	9491
	Cu	6.41 ± 0.009	3 ± 0.09	5.45 ± 0.02	6.9625 ± 0	13.8
	Zn	39.74 ± 0.04	14.97 ± 0.5	42.21 ± 0.5	28.59 ± 0.04	31.4
	Cd	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
SRS	Fe	4165.19 ± 17.4	5447.75 ± 13.3	1121.75 ± 4.8	27603.44 ± 226	9584.5
	Cu	0.51 ± 0.03	5 ± 0.1	2.24 ± 0.02	8.23 ± 0	4.0
	Zn	8.24 ± 0.02	39.88 ± 0.11	17.89 ± 0.1	12.6 ± 0.04	19.7
	Cd	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
CLRS	Fe	4640.88 ± 19.1	5097.94 ± 63.6	2559 ± 30.8	10473.56 ± 7.2	5692.8
	Cu	1.86 ± 0.02	0.84 ± 0.02	2.06 ± 0.03	6.11 ± 0.009	2.7
	Zn	13.33 ± 0.01	7.9 ± 0.4	39.72 ± 0.1	54.84 ± 0.03	28.9
	Cd	< 0.01	< 0.01	4.75 ± 0.2	< 0.01	1.2
Con	Fe	1242.94 ± 20.2	1299.56 ± 28.7	3852.94 ± 17.2	1242.9 ± 0.4	2443.9
	Cu	0.44 ± 0.03	0.75 ± 0	3.68 ± 0.02	1.51 ± 0.07	2.8
	Zn	5.66 ± 0.03	5.45 ± 0.05	41.56 ± 0.1	11.53 ± 0.02	25.1
	Cd	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

(±) Standard Deviation, (-) Not Available

The least observed concentration in this study was that of Cd which was according to the observation of Nwosu et al., (2016) at Ilorin, Nigeria. It was observed that the abundance of other heavy metals at all the various sampling points and control followed the order Fe >>>Zn >> Cu > Cd.

Table 4 presents the comparison of average level of metal in roadside dust of university of Ilorin with some standards and roads from other cities in Nigeria and beyond. At university of Ilorin campus, average levels of metal in road dust were very low to USEPA standards. They were low to ROMANIA but Cd has closer value of 0.7 mg/kg. The average level of Cu and Zn were lower to that from other studies why Cd was more than obtained by Chen et al, (2010) for Beijing and Pranjal and Arundhuti, (2014) for India.

Table 4: Comparison of average metals from University of Ilorin campus road with standards and roads from other cities

Study	City/Site	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)
This Study Average	Ilorin, Nigeria (University Campus)	8154.9	6.3	27.8	0.7
US-EPA Standard Maximum allowable limit	*	50000	4300	7500	85
Romania Standard for Normal Level	*	-	20	100	1
Mafuyai <i>et al.</i> , (2015)	Jos Metropolitan Area, Nigeria (Educational institutions, recreational centres, commercial centres)	123	64.2	123	2.1
Suryawanshi <i>et al.</i> , (2016)	Delhi (industrial, highways, residential and mixed use)	-	191.7	284.5	2.65
Aktas <i>et al.</i> , (2010)	Edrine, Turkey	-	20.04	242.46	-
Chen <i>et al.</i> , (2010)	Beijing	-	29.70	92.10	0.22
Bhattacharya <i>et al.</i> , (2011)	Anand City, India	-	83.6	66.6	-
Khan <i>et al.</i> , (2011)	Pakistan	-	12.98	56.72	0.84
Pranjal and Arundhuti, (2014)	Upper Assam, India (National Highway)	-	21.9	115.22	0.25

(*) Not applicable, (-) Not available

The Pearson Correlation coefficient was estimated to examine the level of relationship between metals as given in Table 5. Positive coefficients were observed for Fe-Cu ($r = 0.587$) and Cu-Zn ($r = 0.422$) which means that Fe-Cu and Cu-Zn could have originated from a common anthropogenic source, vehicular activities.

Table 5: Pearson Correlation between various metals in roadside dust of University of Ilorin

Metal	Pearson Correlation Coefficient (r)			
	Fe	Cu	Zn	Cd
Fe	1.000	0.587	-0.348	-0.959
Cu		1.000	0.422	-0.526
Zn			1.000	-0.210
Cd				1.000

3.4. Heavy metals and pollution indexes

The world surface rock average concentration of Cu (11.2 mg/kg), Cd (0.3 mg/kg), Fe (46700 mg/kg), and Zn (95 mg/kg) for shale (Emad *et al.* 2012; Raju *et al.*, 2012) was considered as the background or reference values. Four classes of contamination factor (C_f) were employed in evaluating the metal contamination levels. These include; Low ($C_f < 1$), Moderate ($1 \leq C_f < 3$), Considerable ($3 \leq C_f < 6$) and Very high ($6 \leq C_f$) (Loska *et al.*, 2004). Also, four categories of contamination degree (C_d) were employed to evaluate metal Contamination degree (C_d) which are; Low contamination degree (< 6), Moderate contamination degree (6-12), Considerable contamination degree (12-24) and Very high contamination degree (> 24) (Sarala and Uma, 2013). The classifications of modified contamination degree (mCd) are: very low ($mCd < 1.5$), low ($1.5 \leq mCd < 2$), moderate ($2 \leq mCd < 4$), high ($4 \leq mCd < 8$), very high ($8 \leq mCd < 16$), extremely high ($16 \leq mCd < 32$) and ultra high ($mCd \geq 32$). MPI distinguishes "polluted" from "non-polluted" environment. An environment is regarded as polluted if $MPI > 1$ because it means that it has elevated concentrations of trace metals (Sarala and Uma, 2013). The classes of I_{geo} have been given as; class 6; extremely contaminated ($I_{geo} > 5$), class 5; strongly to extremely contaminated ($4 - I_{geo} - 5$), class 4; strongly contaminated ($3 - I_{geo} - 4$), class 3; moderately to

strongly contaminated ($2 - I_{geo} - 3$), class 2; moderately contaminated ($1 - I_{geo} - 2$), class 1; uncontaminated to moderately contaminated ($0 - I_{geo} - 1$) and class 0; uncontaminated (I_{geo} less or equals 0) (Nweke and Ukpai, 2016).

Table 6 shows the results for the pollution indexes. The contamination factors (C_f) for all the metals at all sampling sites showed a low contamination ($C_f < 1$) while it was moderate for Cu ($C_f = 1.2$) at WRS.

The degree of contamination (C_d) was low (< 6) at all the sampling sites; the modified contamination degree (mC_d) was very low ($mC_d < 1.5$) at all the sampling sites. The results for the metal pollution index (MPI) show that all the roads were polluted with Fe, Cu, Zn and Cd ($MPI > 1$). The geo-accumulation Index (I_{geo}) for all metals at various sites showed that the roads were uncontaminated with the metals except that CLRS was moderately contaminated with Cd ($I_{geo} = 1.4$).

Table 6: Pollution indexes of metals at various sites

Sites	Fe		Cu		Zn		Cd		C_d	mC_d	MPI
	C_f	I_{geo}	C_f	I_{geo}	C_f	I_{geo}	C_f	I_{geo}			
RARS	0.2	-3.2	0.4	-1.9	0.3	-2.2	0.7	-1.1	1.6	0.4	3.8
WRS	0.2	-2.9	1.2	-0.3	0.3	-2.2	0	*	1.8	0.4	3.9
SRS	0.2	-2.9	0.4	-2.1	0.2	-2.9	0	*	0.8	0.2	3.9
CLRS	0.1	-3.6	0.2	-2.6	0.3	-2.3	4.0	1.4	4.6	1.2	3.7

(*) Not available

4.0. Conclusion

This study has observed that the major roads in the University of Ilorin permanent site campus were not yet contaminated with individual heavy metals such as Fe, Cu, Zn, Cd and Pb because they were found to be below the limit of certain standards such as US-EPA and Romania. However, the results for the metal pollution index (MPI) which is for combination of all metals, showed that all the roads are polluted with heavy metals. There was elevated level of Fe at various roads in the University of Ilorin campus. The geo-accumulation Index (I_{geo}) for all metals at various sites showed that the roads were uncontaminated with the metals except that CLRS was moderately contaminated with Cd. The levels of the metals showed a dependence on anthropogenic pollution such as vehicle density compared with the control site. Therefore, there should be continuous monitoring and proper maintenance such as wetting and paving of various roads. Also, vehicles with old bodies should be avoided evacuated from roads in order to correct the level pollution.

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