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X-Ray Fluorescence Spectrometry and Metal Pollution Assessment of Street Dusts Collected From Gasoline Service Stations and Roadsides within Ado Ekiti, Nigeria

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Abstract

This study is carried out to assess the pollution levels of selected metals in the street dusts collected from gasoline service stations and roadsides within the Ado Ekiti municipality. The concentrations of all the metals in the street dusts were higher than the local background values obtained at a control site except Ni and As. Multivariate statistics such as principal component analysis (PCA), coefficient of variation and Pearson correlation coefficient were used to analyze the results. Evaluation of enrichment factor, contamination factor and pollution index show that the street dusts of Ado Ekiti were contaminated with Ni, Zn, and Pb. Comparison with metal concentrations in other locations around the world shows that Pb concentration in the roadside dust of the study area is higher than the rates presented in the literature about China, Iran, Saudi Arabia and Thailand and is almost five times higher than the average concentration in the soil around the world.

Keywords: Heavy metals; pollution hazards; roadside dust; gasoline; contamination factor; X-ray fluorescence

1. Introduction

Metals are natural components of the earth's environment. They constitute the majority of the elements found in nature. Metals include, alkali, rare earth, heavy and trace metals. Human activities have introduced several pollutants such as heavy and trace metals to the urban settlements. The natural source of metals is generally referred to as geogenic, while those introduced as a result of human activities are known as anthropogenic sources. The background concentrations of heavy and trace metals vary from place to place depending on the composition of parent materials and pedogenic processes associated with different environments. Metals from natural and anthropogenic sources are ubiquitous in the environment and can contaminate urban soil with the associated risks to human health. Exposure to heavy and trace metals can be through dermal contact, ingestion of dust in playing grounds and inhalation of dust particles in streets and roadsides (Abrahams, 2002; Gurung and Bell, 2013; Lu et al., 2014).

Vehicular emission is one of the major sources of metal pollution in the urban environment. The mechanisms of metals emission from vehicles include fuel consumption, engine oil consumption, tire wear and road abrasion (Markus and McBratney, 1996; Wilcke et al., 1998; Zhang et al., 2012). All these processes release heavy metals into the roadside soil. Street dust such as roadside soil serves as reservoir for pollutants, including heavy and trace metals, which are toxic to human health. Street and roadside soil can generate airborne particles and dusts, which may affect the air quality in urban environment (Gray et al., 2003, Abech et al., 2010). These airborne particulate matters may consequently settle on agricultural soil through dry and wet deposition leading to plant uptake of heavy and trace metals. Through this mechanism, heavy and trace metals enter the food chain thereby affecting human health. Almost fifty-three out of the ninety naturally occurring elements belong to the class of heavy and trace metals (Weast, 1984, Aslam et al., 2013). Of these numbers, Fe, K, Ca, Mn, Mo and Mg are essential as micronutrients, while others such as Zn, Ni, Cu, As, Cr and Pb are toxic even at low concentrations. When absorbed, ingested or inhaled, heavy and trace metals can impair important biochemical processes posing threats to plant growth, animal life and human health (Aslam et al., 2013). The consequences of metal contamination in urban environments on the human health include reduced intelligence, renal failure, cardiovascular diseases, and the risk of cancer (Jarup, 2003).

The pollution of urban soil by heavy and trace metals from vehicular emission and petroleum products is a serious worldwide environmental issue. Studies have shown that Pb, Cd, Cu and Zn are the major pollutants in roadside environments due to vehicular activities (Akbar et al., 2006; Chen et al., 2010; Abechi et al., 2010; Zhang et al., 2012; Aslam et al., 2013). In recent years, many researchers have considered the concentration and distribution of heavy metals in street and roadside dusts (Lu et al., 2009; Al-Khashman, 2007; Shi et al., 2008; Aslam et al., 2013). Many of these researches show that a strong correlation exists between heavy metal concentration and human activities such as transportation and industrialization. However, little or no research have been conducted on metal concentrations in the street dust in Ado Ekiti metropolis. Therefore, the objective of this study is to determine the metal concentrations in street dusts collected from gasoline filling stations and roadsides in Ado Ekiti and to assess the pollution hazards resulting from toxic metals.

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2. Materials and Methods

2.1. Study area

Ado-Ekiti is a city located on latitude 7^0 3' and longitude 5^0 5' in the southwest Nigeria. It is the administrative capital of Ekiti State with a population of about 3.2 million people according to the Nigeria national population census of 2006. The geology of the area consists of Pre-Cambrian basement complex rock with granitic rocks outcropping at several locations within and around the city. The granitic rocks found in the study area are of the charnokite series, mainly referred to as older granites (Okwoli et al., 2014). The climate consists of wet and dry seasons over the year. The wet season occurs between May and October, while the dry season lasts from November to April.

2.2. Sample collection and preparation

Street dust samples were collected from sixteen gasoline service stations spread across various parts of the city and five major roads within Ado Ekiti metropolis. The sampling sites were selected based on spread and the volume of activities and on vehicular density. Fig. 1 shows the Google map of Ado Ekiti indicating the major road networks where samples were collected. Fig. 2 shows the coordinates and spread of the sampling points along the major roads within Ado Ekiti. At each service station, five dust samples were collected at different locations and composited to one. For the roadside, one sample was collected from both sides of the road to make a single composite sample. Samples were collected with a soft touch hand brush and a plastic dust pan. Debris and other unwanted materials were removed immediately after the collection of the sample. In all, 104 sub-samples were collected and formed to twenty-eight composite samples consisting of sixteen street dust and twelve roadside dust samples for x-ray fluorescence (xrf) analysis. For comparison with local background values, a site that is free from traffic, agricultural practices and other human activities was selected from which a composite sample of five replicates was collected to serve as control values for the metal concentrations. The composite samples were taken to the laboratory for further preparations. At the laboratory, the composite samples were dried at the laboratory temperature to eliminate moisture. The dried samples were then sieved using a 100 µm mesh. To avoid the cross contamination of samples, acetone was used to clean the sieve between samples. The sieved samples were then formed into pellets using steel moulds and hydraulic press. Aluminum foil was used as a binder to hold the sample particles together after removal from the moulds.

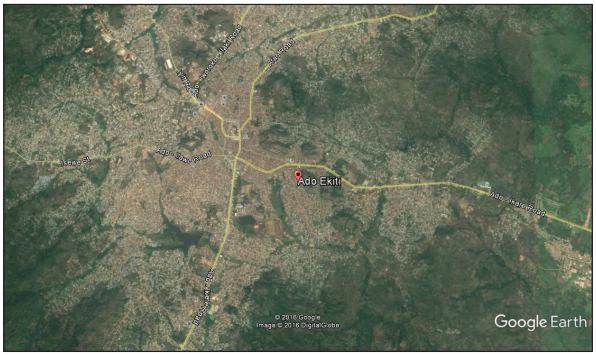

Figure 1. Google map of Ado Ekiti Showing the major roads where samples were collected.

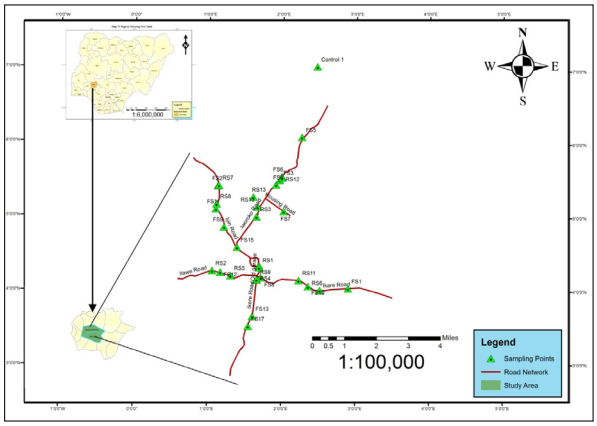

Figure 2. Major road network of Ado Ekiti showing the sampling locations

2.3. Sample irradiation and measurement

The elemental analyses of the samples were performed using energy dispersive X-ray fluorescence (EDXRF) spectrometry. All the analyses were carried out at the XRF laboratory, Centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ile Ife. To analyze the elemental concentrations in the samples, 0.1 g of dust samples were formed into pellets and each pellet was placed in the sample chamber for irradiation. The spectrometer is an ECLIPSE III, self-contained miniature X-ray tube supplied by AMTEK Inc., USA. The detector is a high performance thermoelectrically cooled Si-PIN photodiode (XR-100CR model). The source X-ray tube is maintained at a voltage of 25 kV and a current of 50 µA and each sample was irradiated for 1000 sec. The detector is coupled to a 8000A multichannel analyzer. The resolution of the detector at FWHM peak of 55Fe is 220 eV. Quantitative analysis of the metal concentrations in the irradiated samples was carried out with XRF-FR software package using fundamental parameter approach.

2.4. Pollution index assessment

The pollution levels of Mn, Ni, Cu, Zn, As, and Pb in the street dust samples were determined to assess the extent of potentially toxic metal contamination and to detect the source of metals in the street dusts. In this study, four different pollution indices were used, which are; enrichment factor (EF), contamination factor (CF) and pollution index (P_i). The enrichment factor is one of the most widely used indices to estimate the degree of anthropogenic pollution in the environment (Zakir et al., 2008, Goher et al., 2014). It is used to differentiate between metals originating from human activities or those originating from natural sources (Lu et al., 2014). The enrichment factor was calculated using the following mathematical equation:

$$EF = \frac{C_n / C_{n(ref)}}{B_n / B_{n(ref)}} \quad \text{.....(1)}$$

where, C_n and $C_{n\,(ref)}$ are the measured concentrations of trace and reference metals in the dust samples, respectively. B_n and $B_{n\,(ref)}$ are the background values of the trace and reference metals, respectively. Three classes of enrichment factor exist, which are; EF lower than 0.5 indicating that trace metal is purely geogenic in origin, EF between 0.5 and 1.5 implying that the trace metal could either be geogenic or anthropogenic

in origin, and EF greater than 1.5 showing that the trace metal is purely anthropogenic in origin (Zhang et al., 2007, Hiller et al., 2016). Researchers usually adopt Fe, Al, K, Mn and Ti as reference metals due to their abundance and low occurrence variability in most soil (Liu et al., 2005, Yongming et al., 2006, Turner and Simmonds, 2006, Zhang et al., 2007, Iqbal and Shah, 2011, Lu et al., 2014, Hiller et al., 2016).

The contamination factor (CF) was calculated to assess the degree of contamination in the dust samples by heavy and trace metals. The calculation was carried out using the following mathematical formula:

$$CF = \frac{C_n}{B_n} \quad \text{.....(2)}$$

Where C_n is the measured concentration of metal in the dust sample and B_n is the background values of the same metal. Since data on regional or national heavy and trace metal concentrations are not available in Nigeria, values reported in Taylor (1964) were used as pre-industrial background concentrations (Table 7). The contamination factor is generally classified into four groups: CF lower than 1 shows low contamination, CF between 1 and 3 indicates a moderate contamination, CF greater than 3 up to 6 implies considerable contamination, while CF greater than 6 represents very high contamination (Hiller et al., 2016).

To further assess the quality of the dust samples for trace metal, pollution index (index), as suggested by Huang (1987), was used. It is defined as:

$$P_i = \frac{C_n}{X_a} \quad (C_n \le X_a) \quad \text{.....(3)}$$

$$P_i = 2 + \frac{C_n - X_b}{X_c - X_b} \quad (X_b < C_n \le X_b) \quad \text{.....(4)}$$

$$P_i = 3 + (C_n - X_c)/(X_c - X_b) \quad (C_n > X_c \quad \text{.....(5)}$$

Where C_n is the measured concentration of metal n in the dust samples, X_a is the threshold value for no-pollution, X_b is the threshold value for lowly polluted site and X_c is the threshold value for highly polluted site. X_a, X_b and X_c are given as 40, 50 and 200 mg/kg for Ni, 35, 100 and 400 mg/kg for Cu, 100, 250 and 500 mg/kg for Zn, 35, 300 and 500 mg/kg for Pb 15, 30 and 40 mg/kg for As, respectively (Chen et al., 2010). P_i is generally classified as no contamination, low contamination, moderate contamination, and high contamination.

3. Results and discussion

The basic statistical descriptions of major elements and trace metal concentrations in street dusts collected from gasoline service stations and roadsides are presented in Tables 1 and 2. The mean values for the major elements in the gasoline station samples were 9,727 mg/kg for K, 20,657 mg/kg for Ca, 9,290 mg/kg for Ti, 701 mg/kg for Mn and 31,500 mg/kg for Fe. For the trace metals, the mean values were 140.6 mg/kg for Ni, 23.9 mg/kg for Cu, 182.8 mg/kg for Zn, 124.8 mg/kg for Pb and 16.7 mg/kg for As. The statistical mean concentrations for the major elements in roadside samples were 9,909 mg/kg for K, 14,949 mg/kg for Ca, 9,370 mg/kg for Ti, 765 mg/kg for Mn and 36,269 mg/kg for Fe. For the trace metals, the mean concentrations obtained were 143.3 mg/kg for Ni, 22.5 mg/kg for Cu, 156.0 mg/kg for Zn, 180.3 mg/kg for Pb and 10.4 mg/kg for As. The concentrations of the major elements and trace metals in the street and roadside dusts were highly variable as indicated in the high standard variations shown for each metal in Tables 1 and 2. The variability in metal concentrations was further confirmed by the calculation of coefficient of variation (CV) values. All the major elements (Ca, Ti, Mn and Fe) except K present higher CV in roadside dusts than in street dusts collected from gasoline stations. The same is true for Cu and Zn. This proves that Ca, Ti, Mn, Fe, Cu and Zn show more variability at the roadsides than at the gasoline service stations. Whereas, K, Ni, Pb, and As show more variability at the gasoline stations than at roadsides. For the heavy metals, the concentrations obtained at the sampling locations are higher than those obtained at the control site implying that there is enhanced concentration of metals due to traffic and other human activities. Cu, Zn, and Pb are also higher at the sampling locations compared to the control site. Ni and As are lower at the sampling site compared to the control site. Possible sources of major elements and trace metals in urban soils can be determined by comparing their concentrations in street dust with background values (Atapour, 2015; Lu et al., 2016; Hiller et al., 2016). As seen from Tables 1 and 2, the median concentrations of all the major elements (K, Ca, Ti, Mn and Fe) were higher than their corresponding background values. This suggests that at least half of the street dust samples have their metal origin possibly from anthropogenic sources. For the trace metals (Ni, Cu, Zn, As, and Pb), the median concentrations were either lower or slightly above the background values showing that most of the trace metals originated from the parent rocks. Table 3 shows the Pearson's correlation matrix for the interactions among the metals in street dust samples collected from gasoline service stations. As seen from the table, strong positive interactions existed between K and Ca , Ti , and Mn, Ti and Fe, Mn, and Zn, Fe and Mn, and Zn, Mn and Zn, Cu and Pb and As. All the trace metals (Cu, Zn, Pb and As) except Ni show positive correlation with the heavy metals with the exception of Ca which shows negative correlation with Pb. Table 4 presents the results of Pearson correlation analysis for metals interactions in the roadsides dust samples. The results show that only K and Ca, Ti and Mn, Ti and Ni, Fe and Mn and Cu and Pb exhibited strong relationships. All the trace metals in roadside soil were positively correlated, while Ti shows negative correlation with all the trace metals. Positive correlation among metals indicated a strong possibility for the metals to have originated from the same source, such as anthropogenic or geogenic in origin. Table 5 shows the result of principal component analysis (PCA), which was based on the correlation coefficient matrix for the major and trace metals in street dusts from gasoline service stations. The coefficient is assumed significant only if the value is greater than 0.30 (Gbadebo and Ekwue, 2014). Therefore, metals having PCA coefficient values lower than 0.30 were considered to have no significant contribution to the overall variation observed in the dust samples. From Table 5, four principal components were identified with Eigen values greater than 1.0. The Eigen values for the respective components were 4.172, 2.136, 1.246, and 1.105. The four components jointly account for 86.588 % of the total variation observed in the analyzed samples. PC1 accounted for 41.715 % of the variability K (0.814), Ca (0.454), Ti (0.888), Mn (0.853), Fe (0.877), Cu (0.501),

Zn (0.617), and As (0.585), PC2 accounted for 21.362 % of the total variation and was related to Ti (0.303), Ni (0.624), Cu (0.827), Zn (0.400), Pb (0.609), and As (0.560), PC3 accounted for 12.461 % of the total variation mainly from Ca (0.775), Ni (0.331), Zn (0.337) and Pb (0.433), while PC4 accounted for 11.050 % of the variations from Ni (0.603), Zn (0.397) and Pb (0.608). PCA results for the roadsides samples revealed that four of the principal components also have Eigen values higher than 1.0 (Table 6). The four principal components recorded Eigen values of 3.136, 2.853, 1.706 and 1.084, respectively, all accounting for 87.778 % of the overall variation among the roadsides samples. PC1 accounted for 31.359 % of the variation mainly from K (0.622), Ca (0.672), Ti (0.485), Ni (0.709), Cu (0.726), Zn (0.594), Pb (0.646), and As (0.470), PC2 accounted for 28.525 % with Ti (0.622), Mn (0.982), Fe (0.944), Ni (0.308) Cu (0.0.489), and Zn (0.376), PC3 accounted for 17.059 % with K (0.715), Ca (0.616), Ti (0.400), Ni (0.565) and Zn (0.403), while PC4 accounted for 10.835 % of the total variation and was related to only Pb (0.609) and As (0.751).

Table 1. Statistics of metal concentration in dust samples from gasoline service stations in Ado Ekiti

Statistics	Major elements (mg/kg)					Trace metals (mg/kg)				
	K	Ca	Ti	Mn	Fe	Ni	Cu	Zn	Pb	As
Mean	9,727	20,657	9,290	701	31,501	140.6	23.9	182.8	124.8	16.7
Median	9,234	17,995	8,331	707	29,153	144.0	17.5	169.0	81.50	14.0
SD	3,220	13,367	5,546	248	12,332	80.1	14.2	47.3	96.2	11.8
Minimum	4,304	3,994	2,866	363	16,806	18.0	9.0	126.0	ND	ND
Maximum	14,397	48,921	25,337	1296	54929	348.0	48.0	269.0	294	44
Background values in soil	8,929	3,400	5,611	382.5	17,832	258.5	18.0	128.5	95.5	12.5

Table 2. Statistics of metal concentration in dust samples from roadsides in Ado Ekiti

Statistics	Major elements (mg/kg)					Trace metals (mg/kg)				
	K	Ca	Ti	Mn	Fe	Ni	Cu	Zn	Pb	As
Mean	9,909	14,950	9,380	765	36,268	143.3	22.6	156.0	171.4	10.4
Median	9,959	8,722	6,702	699	32,161	150.5	16.5	128.0	133.0	10.5
SD	3,161	14,258	8,025	379	18,134	66.6	14.5	71.0	107.5	5.1
Minimum	5,221	2,246	3,002	431	21,084	7.0	6.0	91.0	ND	ND
Maximum	16,246	46,875	33,362	1,726	86,596	241.0	43.0	349.0	332.0	19.0
Background values in soil	8,929	3,400	5,611	382.5	17,832	258.5	18.0	128.5	95.5	12.5

Table 3. Pearson's correlation matrix for metal in street dust samples collected from gasoline service stations

	K	Ca	Ti	Fe	Mn	Ni	Cu	Zn	Pb	As
K	1.000									
Ca	**0.621**	1.000								
Ti	**0.739**	0.382	1.000							
Fe	0.476	**0.192**	0.737	1.000						
Mn	**0.668**	**0.292**	**0.888**	0.838	1.000					
Ni	0.071	-0.027	-0.188	-0.064	-0.214	1.000				
Cu	0.470	0.108	0.197	0.309	0.196	0.491	1.000			
Zn	0.269	**0.031**	**0.584**	**0.656**	0.544	-0.209	0.036	1.000		
Pb	0.383	-0.057	0.223	0.302	**0.307**	0.126	0.751	-0.226	1.000	
As	0.359	0.075	0.194	0.260	**0.166**	0.337	0.738	0.243	0.453	1.000

Bolded values are significant at p<0.05

Table 4. Pearson's correlation matrix for metal in street dust samples collected from roadsides

	K	Ca	Ti	Fe	Mn	Ni	Cu	Zn	Pb	As
K	1.000									
Ca	**0.826**	1.000								
Ti	-0.068	-0.153	1.000							
Fe	-0.160	-0.117	**0.617**	1.000						
Mn	-0.214	-0.182	0.510	**0.978**	1.000					
Ni	0.030	0.103	**-0.689**	-0.374	-0.363	1.000				
Cu	0.310	0.324	-0.155	0.385	0.391	0.466	1.000			
Zn	0.003	0.213	-0.094	0.294	0.226	0.529	0.464	1.000		
Pb	-0.114	-0.141	-0.074	0.302	0.270	0.309	0.360	0.490	1.000	
As	0.417	0.401	-0.151	0.220	0.210	0.515	**0.871**	0.559	0.058	1.000

Bolded values are significant at p<0.05

Trace metal concentrations in roadside dusts in Ado Ekiti were compared with those in other cities around the world as obtained by other researchers. The comparison is shown in Table 8 with the world average background concentrations in soil used as reference values. Ni concentration in the roadside dust of the study area is higher than the values presented in the literature about other countries. It is almost three times higher than the mean concentration in the soil around the world. This is due to the high concentration of Ni (258.5 mg/kg) in the local background soil (Table 2). Cu is lower in this study than the values obtained in other locations. The mean value of Zn in Ado Ekiti is higher than the values obtained in Angola (Luanda), Iran (Iran), and China (Beijing). The level of Pb in the roadside dust within Ado Ekiti is considered to be in the median range of values reported about other locations, but it is almost five times higher than the world mean value in the soil as reported in Martins and Whitfield (1983). Arsenic concentration in Ado Ekiti is comparable to values from China (Beijing and Xian) and Saudi Arabia (Jeddah). The concentrations of the potentially toxic metals (Ni, Cu, Zn, Pb and As) were compared with threshold levels for toxic metal in the soil used in Finland, Australia, USA, and Canada because such standards are not available for Nigeria (Table 9). As seen from the table, the concentration of Ni is greater than the threshold levels set for all countries. Cu is lower than the standards except for USEPA (US Environmental Protection Agency). Zn and Pb concentrations at the gasoline service stations and roadsides are higher than USDOE (US Department of Energy), USEPA and C-EQG (Canadian Environmental Quality Guidelines) standards. The concentrations of As in street dusts are lower than the ecological investigation level set for the Australian soil.

Table 5. Principal Component Analysis (PCA) of metals in street dusts from gasoline stations

	PC1	PC2	PC3	PC4
Eigen value	4.172	2.136	1.246	1.105
Total variance (%)	41.715	21.362	12.461	11.050
Cumulative variance (%)	41.715	63.077	75.538	86.588
K	**-0.814**	0.116	0.382	-0.248
Ca	**-0.454**	-0.059	**0.775**	-0.207
Ti	**-0.888**	**-0.303**	0.045	-0.052
Mn	**-0.853**	-0.161	-0.239	0.213
Fe	**-0.877**	-0.293	-0.093	-0.101
Ni	0.037	**0.624**	**0.331**	**0.603**
Cu	**-0.501**	**0.827**	-0.072	0.041
Zn	**-0.617**	**-0.400**	**-0.337**	**0.397**
As	**-0.585**	**0.560**	-0.124	0.222
Pb	-0.204	**0.609**	**-0.433**	**-0.608**

Table 6. Principal Component Analysis (PCA) of metals in roadside dusts

	PC1	PC2	PC3	PC4
Eigen value	3.136	2.853	1.706	1.084
Total variance (%)	31.359	28.525	17.059	10.835
Cumulative variance (%)	31.359	59.883	76.942	87.778
K	**0.622**	-0.055	**-0.715**	0.228
Ca	**0.672**	-0.038	**-0.616**	0.123
Ti	**-0.485**	**0.622**	**-0.400**	-0.125
Mn	-0.127	**0.982**	0.031	-0.001
Fe	-0.161	**0.944**	0.103	0.044
Ni	**0.709**	**-0.308**	**0.565**	-0.174
Cu	**0.726**	**0.489**	0.151	-0.009
Zn	**0.594**	**0.376**	**0.403**	-0.181
As	**0.470**	0.280	0.248	**0.751**
Pb	**0.646**	0.226	-0.279	**-0.609**

Table 7. Mean values of enrichment factor (EF), contamination factor (CF) and pollution index (PI) obtained for streets dusts in Ado Ekiti

		Gasoline service stations			Roadsides		
Trace metal	Geochemical background (Earth crust)[a] (mg/kg)	Enrichment factor	Contamination factor	Pollution index	Enrichment factor	Contamination factor	Pollution index
Ni	75	2.64	1.87	2.54	2.59	1.91	2.58
Cu	55	0.55	0.43	0.68	0.48	0.41	0.64
Zn	70	3.40	2.61	1.55	2.92	2.16	1.35
Pb	12.5	8.92	7.49	1.05	10.5	9.61	1.01
As	13	1.43	1.13	0.98	0.91	0.67	0.60

aTaylor (1964)

Table 8**.** Comparison of trace metal concentrations in roadside dusts in Ado Ekiti with values from other countries

Country (City)	Trace metal concentration (mg/kg)					Reference
	Ni	Cu	Zn	Pb	As	
Angola (Luanda)	10	38	98	266	-	Ferreira-Baptista and De Miguel, 2005
China (Beijing)	26.7	29.7	92.1	35.4	8.1	Chen et al., 2010
China (Xian)	36.2	74.2	462.6	176.2	14.2	Lu et al., 2014
China (Xuzhou)	55	38	224	40	-	Wang and Fu, 2014
Greece (Kavala)	58	124	272	301	-	Christoforidis and Stamatis, 2009*
Iran (Tehran)	14.9	22.8	49.8	50.2	-	Sayadi and Sayyed, 2011**
Jordan (Amman)	88	177	258	236	-	Al-Khashman, 2007
Saudi Arabia (Jeddah)	46.7	-	222.2	47.5	13.9	Kadi, 2009
Thailand (Maha Sarakham)	-	11.23	35.96	14.35		Ma and Singhirunnusorn, 2012
Nigeria (Ado Ekiti)	143.3	22.6	156.0	171.4	10.4	Present study
World background value	50	30	90	35	6	Martin and Whitfield, 1983

**Industrial area soil* ***Nursery school dust*

Table 9**.** Comparison of potentially toxic metals in street dusts with toxicological reference levels for some countries

Metal	Gasoline service station (mg/kg)	Roadside (mg/kg)	Finland threshold level[b] (mg/kg)	Australia ecological investigation level[c] (mg/kg)	USDOE threshold effect concentration[c] (mg/kg)	USEPA[e] (mg/kg)	C-EQG Probable Effect level[f] (mg/kg)
Ni	140.6	143.3	50	60	39.6	16	-
Cu	23.9	22.6	100	100	28	16	35.7
Zn	182.8	156.0	200	200	159	110	123
Pb	124.8	171.4	60	600	34.2	31	35
As	16.7	10.4	5	20	-	-	12

[b]MEF (2007), [c]DEC (2010), [d]Jones et al. (1997), [e]USEPA (1999), [f]Environment Canada (2002)

Conclusion

Major element and trace metal concentrations in the street dust samples collected from gasoline service stations and roadsides in Ado Ekiti have been evaluated in order to estimate the pollution risks to the population. Results show that the concentrations of the analyzed metals in the street dusts were a little enhanced compared to local background concentrations except Ni and As. Though vehicular and human activities have increased the metal concentrations in the street dusts of Ado Ekiti, pollution indices assessments indicate that the street dusts are not highly contaminated with potentially toxic metals except for Pb, which exhibits a high degree of contamination.

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