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SPATIAL DISTRIBUTION AND HEALTH RISK ASSESSMENT OF HEAVY METALS IN URBAN PARKS AND GARDENS SOILS IN LAGOS STATE, NIGERIA

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ABSTRACT

Distribution and health risk assessment of heavy metals in urban parks and gardens Gani Fawehinmi Park, Ojota, (GFP), Oshodi Heritage Park Oshodi (OHP), Ikorodu/Ipado Garden (IIG), MKO Abiola Gardens, Ojota (MKO), and MOE Garden, Alausa (MOE) soils in Lagos Metropolis, Nigeria were examined using Index of Geo-accumulation (I_{geo}), Potential Ecological Risk Index (RI) and health risk model. Urban parks and gardens soils were substantially polluted by Cu and Pb due closeness to highways where heavy metals emitted from motor vehicles are deposited. Geoaccumulation index (I*geo*) values for Pb were 10.616, 10.060, 9.027, 8.862 and 8.665 for GFP, OHP, IIG, MKO and MOE respectively. RI values for all the sites showed high pollution as they were all above 200. Health risk assessment revealed that children who visit the urban parks and garden in Lagos State are more exposed to cancer risk from Pb especially through ingestion. Results from this study provided valuable information on the pollution levels of urban parks in Lagos, Nigeria as a result of traffic related emissions and calls for proper monitoring of anthropogenic activities in the metropolis and reduce the human health impacts. The planting of hedge plants and erection of low walls could serve as shield against traffic pollution for the roadside parks

Keywords: Cancer risk, Emission, Heavy metals, Parks, Pollution, Urban soil.

INTRODUCTION

Urban parks and gardens are delineated open spaces where people can have recreational pleasure, exercise, and appreciate nature (Loukaitou-Sideris, 2006; Konijnendijk *et al*., 2013). The parks contribute directly to public health by reducing stress and mental disorders (Ward Thompson *et al*., 2012); increasing the effect of physical activity (Mitchell, 2013), and increasing perception of life quality and self-reported general health (Stigsdotter *et al*., 2010). However, in the urban environment rapid developments and other human activities have greatly affected the functioning of the parks as the soils in the areas are exposed to contaminations from heavy metals and other pollutants from different sources of anthropogenic activities (Rodríguez Martín *et al*., 2014). Elevated heavy metal concentrations for urban soils have been reported in major studies globally especially due to the potential environmental and health risks associated with the contamination, persistence and toxicity (Guo *et al*., 2010; Alloway, 2013; Li *et al*. 2013). In urban parks and gardens, users come in contact with heavy metals in the soil through inhalation, ingestion and dermal contact absorption (Madrid *et al*., 2002; De Miguel *et al*., 2007; Wei *et al*., 2009; Zheng *et al*., 2013; Li *et al*., 2014; Mugoša *et al*., 2016). Children can be more affected by soil contamination, particularly in urban parks, due to frequent hand-mouth activity and higher absorption rate in comparison to adults ((Zheng *et al*., 2010a, b; Basta and Juhasz, 2014). The importance of this phenomenon needs to be viewed in the incessant urban growth context, which is common in most parts of the world (Lv *et al*., 2013) and can be linked to adverse health hazard effects (Kelepertzis, 2014).

In Nigeria, there is the paucity of information on heavy metal concentration and fewer studies reported the potential human health risks to either children or adults due to exposure to heavy metals from recreational areas such as the parks and gardens. Hence there is need to conduct studies on exposure to heavy metals from different sources of anthropogenic activities (Allan, 2015). This paper therefore investigated the spatial distribution of Cd, Co, Cu, Ni, and Pb in the soils of urban parks and gardens in Lagos State, Nigeria using GIS, 2) determined the degrees of contamination of the soil by the selected heavy metals using environmental indices such as geo-accumulation index, pollution load index and potential ecological risk index (RI), and 3) conducted potential health risk assessment of the heavy metals on the users of the parks and gardens.

MATERIALS AND METHODS

The study area

The study was conducted in Lagos metropolis, Lagos State, southwestern Nigeria. The State occupies only about 0.39% (3577 sqkm) of Nigeria's total landmass of 923,773 sqkm but it is the most populated with an estimated population of over 20 million as of 2010. The State is mostly metropolitan because the Lagos metropolis is made up of 17 Local Government Areas out of the 20 LGAs in the State. About 70% of country's industrial investments and over 65% of Nigeria's commercial activities are located in different parts of the state. As the hub of West/Central Africa maritime and aviation activities and Sub-Saharan African largest market, Lagos is well known for its rapid population growth, urbanization, high volume of traffic and increasing waste generation and pollution. Recently, many abandoned open spaces, wetlands and forests in urban areas have been conserved and transformed into parks and recreational areas. These public parks are to ensure the provision and integrity of high quality and diverse parks with a safe, aesthetic and comfortable urban environment to meet urban lifestyle. Major parks and gardens, which are located in the Lagos metropolis, are along major roads and they include Kernel St. Park, Surulere; Muri Okunola Park; Victoria Island; BRF Park, Alausa; Ikorodu-Ipado Park ; MKO Abiola Gardens, Ojota; Gani Fawehinmi Park, Ojota; MOE Garden, Alausa and Oshodi Heritage Park, Oshodi.

The selected parks and gardens for this study are Gani Fawehinmi Park, Ojota, (GFP), MKO Abiola Gardens, Ojota (MKO), MOE Garden, Alausa (MOE), Ikorodu/Ipado Garden (IIG) and Oshodi Heritage Park Oshodi (OHP). The locations of the parks are shown in Fig 1. The parks and garden were selected based on the considerations that: urban areas have become subject to increased accumulation of metal concentrations in surface soil and the capability for metals to accumulate via air deposition depends on the type and proximity of emitting sources (Alloway, 2013). According to Allan (2015), site specific factors that may affect transport and fate of metals in soils include: park areas located near major highways, park areas located near industrial sites, park areas located near contaminated sites and park areas located on former contaminated sites.

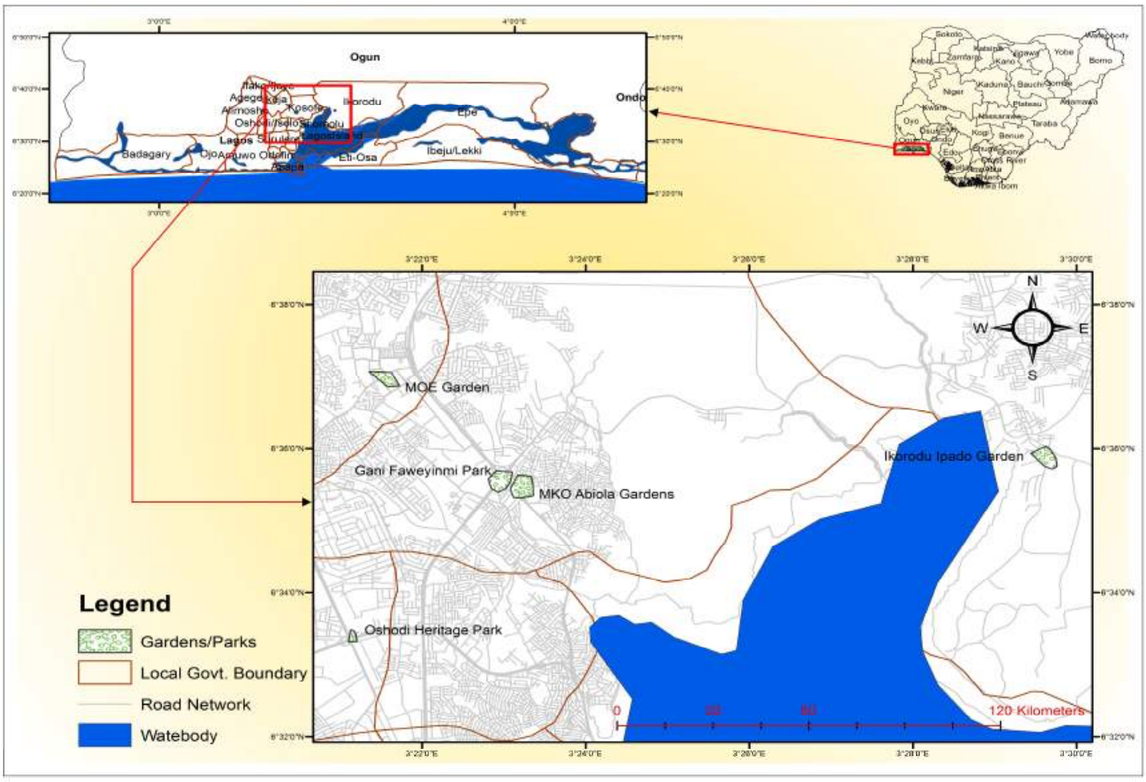

Figure 1: Map of the study area showing selected Parks and Gardens in Lagos State

Soil sampling and processing

Surface soil samples were randomly collected in 6th July and 5th August, 2014 from five selected parks and gardens situated in different parts of Lagos State. Five (5) composite samples of 500 g of soil each with ten (10) subsamples from the surface soil (0 -15cm) were collected from each park/ garden. Each composite sample consists of 10–15 soil cores taken from a 1×1 m area. There is no local data on background concentrations of heavy metals in major parts of Nigeria, therefore the soil samples from the uncontaminated site or comparable pristine site were taken to serve as control or reference for comparison with the urban parks and gardens. The control sites were far from the effect of traffic or industrial pollution. All soil samples were collected using stainless soil auger. Detailed description of the area surrounding each park is given in Table 1.

Table 1: Description of sampling areas

Studied Park	Area Description
GFP	The park is sited on a former refuse dump along the busy Lagos-Ibadan Expressway directly under the bridge and road intersection at Ojota where it is exposed to vehicular emission
MKO	It is located in the Alausa area of Ikeja, Lagos close to major streets such as Palm Avenue.
MOE	Established by the Ministry of Environment in the secretariat in Alausa, Lagos. Traffic volume is moderate and the area is covered with trees and lawns
IIG	Located in Ikorodu in the outskirt of Lagos Metropolis
OHP	It is located on the Apapa-Oworonshoki Expressway close to the Oshodi motor park. The traffic volume in the area it very high

The soil samples were put into polythene nylon and labelled for easy identification. Soil samples were air dried, and large rock and organic debris were removed before sieving through a 2 mm mesh. Samples were further ground to a fine powder and stored in polypropylene bottles. Soil pH (H_2O) and electrical conductivity (EC) were determined in distilled water (1:2.5 w/v), particle size composition (sand, silt, clay) was determined by the hydrometer method, soil organic carbon (SOC) contents were measured by the Walkey–Black wet oxidation method (Oviasogie et al., 2009). Total heavy metal content was determined by weighing 5 g of soil sample into a clean porcelain crucible and heated over a hot plate to ignite and carefully burn the sample. The residue was then heated in a muffle furnace at 550 °C until the carbon content (organic matter) was carefully and completely oxidized (about 1 hour). The residue left was dissolved in a few drops of aqua – regia (three parts concentrated HCl plus one part concentrated HNO_3) and then diluted with distilled water. The resulting mixture was then filtered, well rinsed and the filtrate made up to the 100 ml mark in a standard flask. The digested samples were then aspirated into the flame of the Atomic Absorption Spectrophotometer (AAS) Perkin Elmer Analyst 200 using air – acetylene flame for the metal analysis against standard metal solutions. Each metal was analyzed using the specific hollow cathode lamp at a specific wavelength. The quality controls for the strong acid digestion method included reagent blanks, certified reference material, replicate samples, and standard reference materials.

Statistical Analysis

Statistical Package for Social Sciences (SPSS 17.0®) provided by IBM, Armonk, NY, USA, was used for statistical analyses. Data were subjected to descriptive statistical analysis (mean and standard deviations) and Pearson's correlation indexes were used to test for significant differences (95% confidence level). Indices of contamination namely the Index of Geo-accumulation (I_{geo}), and the Potential Ecological Risk Index (RI) were calculated to evaluate soil heavy metal contamination. To enable the qualitative assessment of contamination levels of the selected heavy metals in the urban parks and garden soils, an index of geo-accumulation (I_{geo})

introduced by Müller (1969) was computed using the equation below:

$$I_{geo} = \log_2 \left(\frac{C_n}{1.5 B_n} \right) \qquad \text{---------------(1)}$$

where *Cn* is the concentration of the element in the tested soil, while *Bn* is the geochemical background value in the average shale of element (Loska *et al*., 2004) and the constant 1.5 compensates for natural fluctuations of a given metal and for minor anthropogenic impacts (Taylor and Mclennan, 1995). Müller (1969) also proposed seven classes of *Igeo* as shown in Table 2 below:

Table 2: Classifications for *Index of geo-accumulation* (*Igeo*)

Class *Igeo*	Contamination Level
$Igeo \leq 0$,	uncontaminated (Class 0)
$0 < Igeo \leq 1$	uncontaminated to moderately contaminated (Class 1)
$1 < Igeo \leq 2$	moderately contaminated (Class 2)
$2 < Igeo \leq 3$	moderately to heavily contaminated (Class 3)
$3 < Igeo \leq 4$	contaminated (Class 4)
$4 < Igeo \leq 5$	heavily to extremely contaminated (Class 5)
$Igeo > 5$	extremely contaminated (Class 6)

Potential ecological risk index (RI) proposed by Håkanson (1980) was also calculated to assess the risk posed to the environment by the toxicity of the metals (Ruby, 2004). It is used to evaluate the heavy metal pollution in the parks and gardens soils and also to associate ecological and environmental effects with their toxicology (Shi *et al*., 2014). Potential ecological risk index (RI) is expressed as:

$$RI = \sum E_i \qquad \text{------------------(2)}$$

$$E_i = T_i f_i \qquad \text{------------------(3)}$$

$$f_i = \frac{C_i}{B_i} \qquad \text{------------------(4)}$$

where RI is calculated as the sum of all risk factors for heavy metals (Cd, Co, Cu, Ni, and Pb) in the parks and garden soils, E_i is the monomial potential ecological risk factor, T_i is the developed metal toxicity factor (Shi *et al*., 2014). Furthermore, f_i *is* the metal pollution factor, C_i is the practical concentration of metals in soil, and B_i is the background value for metals. The toxic factor for Cd is 30, while Cu, Ni, and Pb are all 5 (Shi *et al*., 2014). The adjusted evaluation criteria for the potential ecological risk index were $RI \leq 50$, low pollution; $50 < RI \leq 100$, moderate pollution; $100 < RI \leq 200$, considerable pollution; $RI > 200$, high pollution (Shi *et al*., 2014).

Health risk assessment is a method widely used to assess and determine the exposure of human receptors to soil contamination because of the land use (Ferreira-Baptista and De Miguel, 2005; Zhang, 2006; Zheng *et al*., 2010). The pathways of pollutants attached to the soil entering human body are hand-to-mouth ingestion, dermal absorption and mouth and nose inhalation (Ma and Singhirunnusorn, 2012). The dose received via each of the three pathways in the parks and gardens surface soil for both children and adults was calculated using the equations 5-7

$$D_{ing} = C \times \frac{IngR \times EF \times ED}{BW \times AT} \times 10^{-6} \quad \text{------------------(5)}$$

$$Dinh = C \times \frac{InhR \times EF \times ED}{PEF \times BW \times AT} \times 10^{-6} \quad \text{------------------(6)}$$

$$Ddermal = C \times \frac{SL \times SA \times ABS \times EF \times ED}{BW \times AT} \times 10^{-6} \quad \text{-------------------(7)}$$

where, D_{ing} is the daily dose via hand-to-mouth ingestion of soil substrate particles; D_{inh} is the daily dose via inhalation of re-suspended particles through mouth and nose; and D_{dermal} is the daily dose via dermal absorption of trace elements in particles adhered to exposed skin. Furthermore, IngR is the ingestion rate (*mg/d*), 200 for children and 100 for adult, ED is exposure duration (*y*) 6 for children and 24 for adult; EF is the exposure frequency (*d/y*) 180 (USEPA, 2001); BW is the average body weight (*kg*) 15 for children and 70 for adult (USEPA, 1989). InhR is inhalation rate (*m^3/d*) 7.6 for children and 20 for adult (Van den Berg, 1995); PEF: particle emission factor is 1.36 x 10^9 m^3 kg^{-1}, SA is the exposure skin area *cm^2* 2800 for children and 3300 for adult (Hu *et al*., 2012), SL for skin adherence factor (*mg/cm^2h*) 0.2 for children and 0.7 for adult (USEPA, 2001). AT is average time (*d*). AT is ED x 365 for non-carcinogenic and 70 x 365 for carcinogenic (USEPA, 1989); ABS is dermal absorption factor (*0.001*) (Ferreira-Baptista and De Miguel, 2005; USEPA, 2011a). The exposure-point concentration, $\mu g\ g^{-1}$ (C) in Equations 7-9 is an estimate of reasonable maximum exposure (Zheng *et al*., 2010a; Sun *et al*., 2013). It was calculated as the upper limit of the 95% confidence limit for the mean (Equation 8).

$$C_{95\%UCL} = \exp\{X + 0.5 \times S^2 + \frac{S \times H}{\sqrt{n-1}}\} \quad \text{------------------- (8)}$$

X is the arithmetic mean of the log-transformed data, *S* represents the standard deviation of the log-transformed data, H is the H-statistic, and n is the number of samples (Gilbert 1987; Li *et al*., 2013).

Risk assessment is a function of hazard and exposure and is defined as the process of estimating the probability of occurrence of an event and the probable magnitude of adverse health effects on human exposures to environmental hazards over a specified time (Wongsasuluk *et al*., 2014). After calculating the dose received via each of the three paths, a Hazard Quotient (HQ) based on non-cancer toxic risk was then calculated by dividing daily dose to a specific reference dose (RfD). In the parks and gardens, children and adults alike are exposed to heavy metal pollution from the soil. Assessment of each potentially toxic metal is usually based on the quantification of the risk level and is expressed in terms of a carcinogenic or a non-carcinogenic health risk. The non-carcinogenic risk was evaluated by the hazard quotient (HQ). Hazard Quotient (HQ) and carcinogenic risks (CR) were calculated by the equations 9 and 10:

$$HQ = \frac{D_{ing}}{RfD_{o}} = \frac{D_{dermal}}{RfD_{o} \times GIABS} = \frac{D_{inh}}{RFC_{i} \times 100\,\mu g\,mg^{-1}} \quad (9)$$

$$CR = D_{ing} \times SF_{o} = D_{dermal} \times {}^{SF_{o}}/_{GIABS} = IUR \times D_{inh} \quad (10)$$

where RfD_o is oral reference dose, mg $kg^{-1}day^{-1}$; RfCi is inhalation reference concentrations, mgm^{-3}); SF_o is oral slope factor, mg $kg^{-1}day^{-1}$; GIABS is gastrointestinal absorption factor; IUR is inhalation unit risk, mgm^{-3} (USEPA, 2011a, b). Carcinogenic risk (CR) is the probability of an individual developing any type of cancer from lifetime exposure to carcinogenic hazards with the acceptable or tolerable risk for regulatory purposes ranging between 1×10^{-6} - 1×10^{-4}. Risk above 1×10^{-4} is unacceptable, while risk below 1×10^{-6} is considered not to trigger any health effect. When $HQ\leq1$ indicates no adverse health effects and $HQ\geq1$ indicates, likely adverse health effects (Sun *et al.*, 2013). The hazard index (HI) which is equal to the sum of HQ is used to assess the overall potential for non-carcinogenic effects posed by more than one chemical were also calculated. Hazard index of less than one (HI<1) indicates that there is no significant risk of non-carcinogenic effects and HI>1 indicates that there is a chance of non-carcinogenic effects occurring (USEPA, 2011b).

RESULTS AND DISCUSSION

Soil pH of the urban parks ranged from 8.2 to 8.54 with the mean value of 8.30 and standard deviation of 0.30. Electrical conductivity ranged from 69.8 µS/cm to 239.5 µS/cm with the mean value of 135.4 µS/cm and standard deviation of 58.72µS/cm (Table 3). The surface soil at the Oshodi Heritage Park (OHP) has the highest conductivity of 239.5 µS/cm. Soil organic carbon (SOC) for surface soils from the parks ranged from 0.6 % to 26.5 % with the average mean of 12.41 %. Mean concentrations of Cd, Co, Cu, Ni, and Pb relative to surface soil samples from selected urban parks and gardens in Lagos are given in Table 3. In view of the fact that Nigeria has no national guidelines for heavy metals in soil, the values obtained in this study were compared against international guidelines (USEPA, 2011a) and other similar studies around the world. Mean concentration of cadmium in the surface soil samples in the parks and gardens ranged from 0.05 $mgkg^{-1}$ at OHP to 2.43 $mgkg^{-1}$ at MOE Gardens. The highest concentration of Cd was also found in the MOE Gardens (2.47 $mgkg^{-1}$). These values are however; lower than the WHO permissible limit of 10 $mgkg^{-1}$ dry soil for Cd in soil (Lokeshwari and Chandrappa, 2006). However, McBride (1994) considers soil Cd concentration exceeding 0.5 $mgkg^{-1}$ as showing evidence of soil pollution

Table 3: Mean±SD of heavy metal in urban parks and garden surface soil samples

Parks	Abbr. name	Heavy Metals [α]				
		Cd	Co	Cu	Ni	Pb
Gani Fawenmi Park	GFP	2.03±0.03	1.34±0.01	20.39±0.02	0.48±0.01	93.8±0.07
MKO Gardens	MKO	0.34±0.01	1.29±0.01	4.03±0.01	0.51±0.01	27.82±0.06
Min. of Environment	MOE	2.43±0.01	0.76±0.01	2.24±0.01	3.69±0.02	24.27±0.06
Ikorodu/Ipado Garden	IIG	0.08±0.02	3.76±0.02	6.75±0.02	4.76±0.05	31.18±0.05
Oshodi Heritage Park	OHP	0.05±0.02	1.03±0.01	3.89±0.02	0.54±0.01	63.8±0.03
Max		2.47±0.01	3.76±0.02	23.06±0.01	5.02±0.02	98.05±0.02
Min		0.05±0.01	0.45±0.01	2.29±0.02	0.46±0.01	24.11±0.01
Background		0.01±0.01	0.02±0.01	0.5±0.01	0.4±0.01	12.0±0.02

[α] mg kg^{-1}

The pollution sources of Cd in the parks and gardens soils could be attributed to vehicular traffic emissions (Shi *et al*., 2014). Cadmium is a very toxic heavy metal, which can devastate children's immune system within a short period of exposure (Atiemo *et al*., 2012). Co concentration in the surface soil ranged from 0.76 $mgkg^{-1}$ at MOE Gardens to 3.76 $mgkg^{-1}$ at IIG, which is also the highest concentration of Co in the surface soil of the selected parks and gardens (Table 3). High concentration of cobalt may be due to some industrial activities around the area. Long time exposure to very high levels of Co can cause health effects such as asthma, pneumonia, and wheezing and children tend to be more affected by exposure to high concentration of cobalt because they have smaller body weights. Co was found below detection limits in the background soil, which is similar to research carried out by Guo *et al*. (2010) in Yibin, China. Concentration of Ni in the surface soil samples ranged from the minimum of 0.46 $mgkg^{-1}$ at OHP to 5.02 $mgkg^{-1}$ at IIG. Ni concentration obtained in the surface soil in the urban parks and gardens in Lagos, Nigeria were below the levels obtained in the soils of Beijing, China by Chen *et al. (*2005). Average Ni concentration in dust from urban park in Beijing was 25.97 $mgkg^{-1}$ (Du *et al*., 2013). In another study within Baghdad City, Iraq, Abdul *et al.,* (2013) obtained a concentration of 80.44 $mgkg^{-1}$ for Ni in urban soils. Ni and Co belong to the group of rare metals and every change of the chemical balance in the natural environment causes not only disturbances in the growth and development of flora and fauna, but also (indirectly or directly) on human health (Baralkiewicz *et al*., 1997). Nickel toxicity is not very high in the urban parks and gardens soil in Lagos State, however, it can cause respiratory diseases (Poggio *et al*., 2009) especially when inhaled via particulate matters.

Concentration of Cu in the surface soil ranged from a minimum of 2.29 $mgkg^{-1}$ at MOE Gardens to a maximum of 23.06 $mgkg^{-1}$ at Gani Fawehinmi Park (GFP). Cu concentration found in all the parks and gardens are above the maximum limit of 0.05 $mgkg^{-1}$

for soils (WHO, 1996). The sources of Cu emission in urban soils are mainly related to traffic, such as brake abrasion and corrosion of metallic parts of cars (Pacyna and Pacyna, 2001). Chen et al. (2005) stated that anthropogenic inputs are the result of human activities including atmospheric deposition of entrained particulates (air pollution), such as vehicle and industry exhaust, as well as air emissions and sedimentation of suspended particles from water (water pollution). The value obtained is lower than 72.13 $mgkg^{-1}$, which is the average Cu concentration in dust from urban park in Beijing (Du *et al*., 2013). In a similar study of soil heavy metal concentrations in parks and green areas in Seville, Spain, Madrid *et al*. (2002) indicated that the concentrations of Pb, Zn and particularly Cu in the soil often exceeded the acceptable limits for residential, recreational and institutional sites. Soils from Gani Fawehinmi Park (GFP) has highest mean concentration of Pb with a concentration of 93.8 $mgkg^{-1}$, which is higher than WHO standard limit of 70 $mgkg^{-1}$ dry soil for Pb (Lokeshwari and Chandrappa, 2006). In a similar study in the city of Tuscany, Italy, Bretzel and Calderisi (2006) recorded a mean concentration of 218.58 $mgkg^{-1}$ for Pb in urban soils.

Most of the parks and gardens in Lagos metropolis are located close to areas charactrerized by high density of traffic and human activities (Alloway, 2013). According to Zheng *et al.* (2010b) road traffic emission is one of the major sources for Pb pollution in urban soil. The concentrations were 9-fold and 3-fold higher than the MOE Gardens for both Cu and Pb respectively indicating that Cu and Pb pollution existed in the park soils samples. Cu normally accumulates in the surface zones, a phenomenon explained by the bioaccumulation of the metal and recent anthropogenic sources such as traffic-related emissions (Argyropoulos *et al*., 2012; Abdul *et al*., 2013).

Spatial distribution of Heavy Metals

The spatial distributions of Cd, Co, Cu, Ni and Pb in the selected urban parks and gardens in Lagos, Nigeria are shown in the maps (Fig. 2 and 3 respectively). Fig. 2 shows the distribution in the topsoil which indicated that the Gani Fawehinmi Park (GFP) is relatively more polluted in terms of Pb and Cu than the other parks as it has higher concentrations of these metals in the topsoils. High concentrations of Cu and Pb in the urban parks and gardens in Lagos State may be due to anthropogenic sources (Martin, 2001). The concentrations were 9-fold and 3-fold higher than the MOE Gardens for both Cu and Pb respectively indicating that Cu and Pb pollution existed in the park soils samples. Cu normally accumulates in the surface zones, a phenomenon explained by the bioaccumulation of the metal and recent anthropogenic sources (Abdul *et al*., 2013). Heavy metals such as Pb, Ni, Cu and Cd are released in different particles sizes (Argyropoulos *et al*., 2012) in the urban environment and these can be primarily associated with traffic-related emissions due to incomplete fossil-fuel combustion from vehicles or industrial processes (Nicholson *et al*., 2003). Furthermore, car wear, including brakes and tyres has been reported to be responsible for about 50% of the total Cu emissions from road transport (Ven der Gon *et al*., 2007).

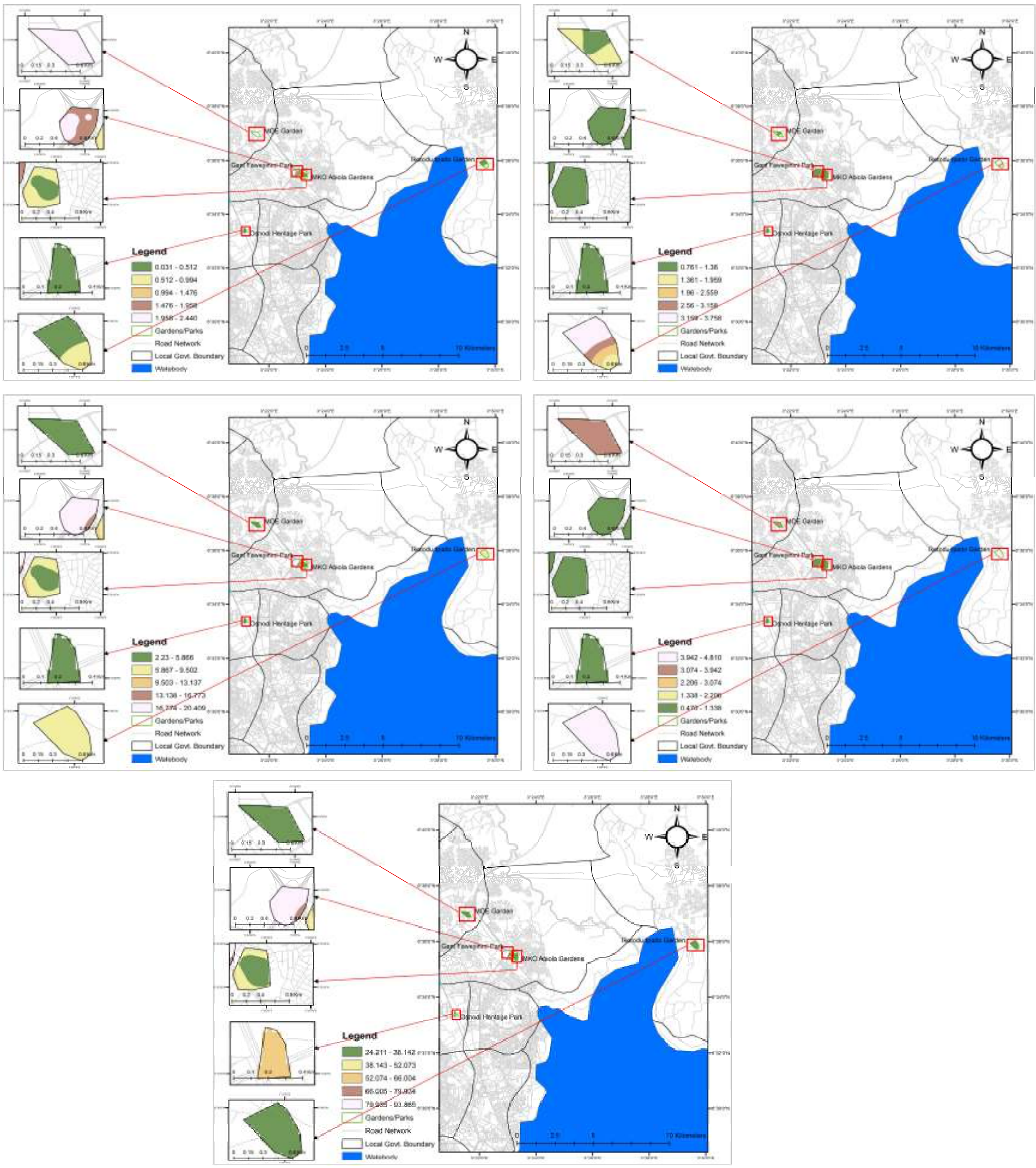

Figure 2: Spatial distribution of Cd, Co, Cu, Ni and Pb concentrations in topsoil of Parks and Gardens in Lagos State

Fig. 3 shows the spatial distribution of the heavy metals in the subsoil. The air-borne emissions from nearby highways are deposited on the soils in the parks and gardens. Gani Fawehinmi Park (GFP) is relatively more polluted in terms of Pb and Cu than the other parks. The highest concentration of Pb in the park and garden soils is lower than threshold limit for soil (200 $mgkg^{-1}$) as reported by Tanzania Local Standards (2003). Pb as a toxicologically relevant element is introduced into the environment by man in extreme amounts, despite its low geochemical mobility and has been distributed worldwide (Oehlenschlager, 2002). The toxic effects of Pb affect several organs, causing biochemical imbalance in the liver, kidneys, spleen and lungs, and causing neurotoxicity, mainly in infants and children (Jaishankar et al., 2014). Pb toxicity through ingestion by children can increase their risks for damage to the brain and nervous system, slowed growth and development, learning and behavior problems (e.g., reduced IQ, ADHD, juvenile delinquency (Morgan, 2013).

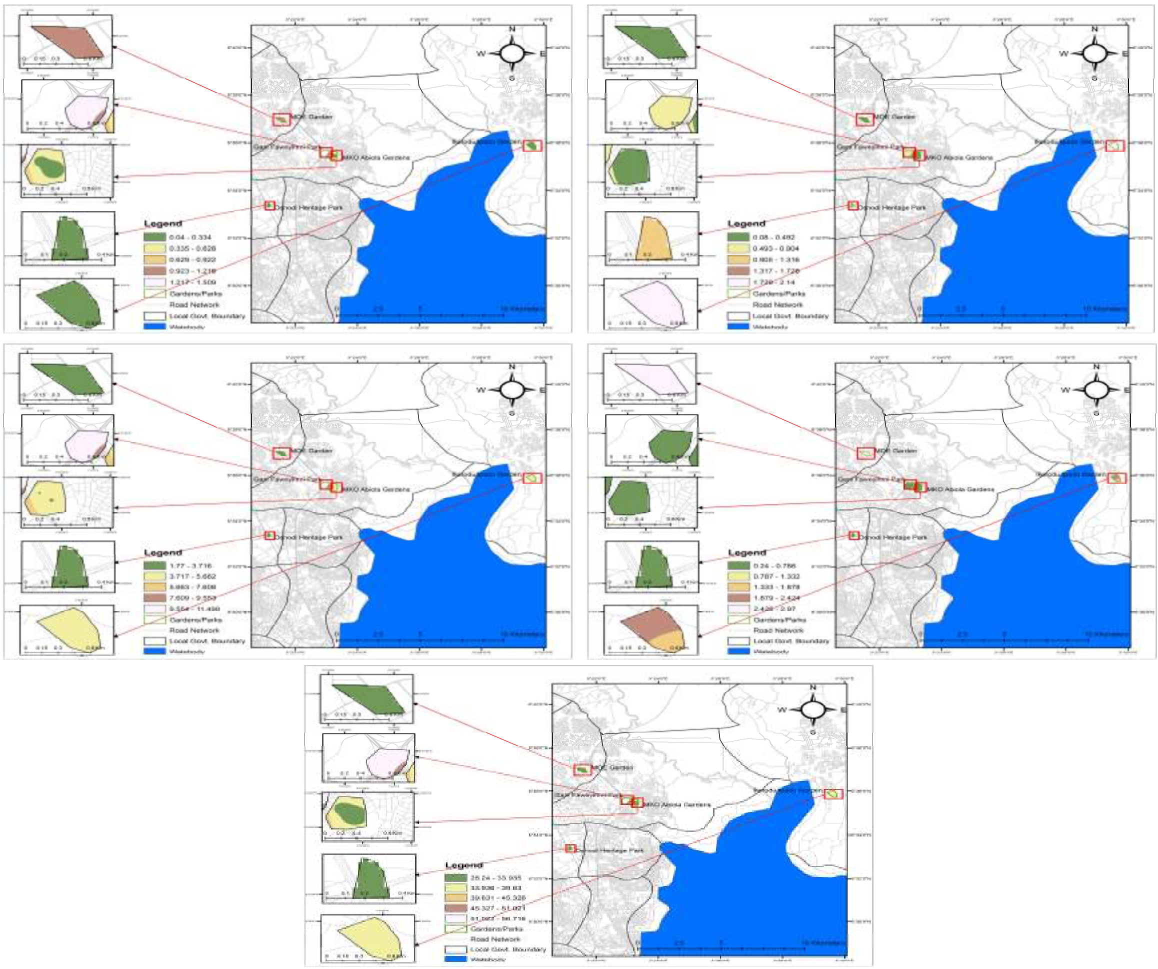

Figure 3. Spatial distribution of Cd, Co, Cu, Ni and Pb concentrations in subsoil of Parks and Gardens in Lagos State

Most of the parks and gardens in Lagos metropolis are located close to areas charactrerized by high density of traffic and human activities. Such areas are associated with higher levels of airborne heavy metals. This emphasized the need for more trees to be planted in the parks and gardens. Paoletti *et al.* (2011) stressing the importance of trees in urban parks revealed that increased tree cover would lead to greater total removal of air borne pollutants. Researchers have also shown that urban trees helps air pollution reduction by intercepting atmospheric particles and absorbing various gaseous pollutants (Yin *et al.,* 2011). Studies have shown that urban soils contain higher levels of heavy metals relative to the natural background levels (Madrid *et al*., 2002) and this may influence public health via direct contact with contaminated dust or soil or by inhalation (Sieghardt *et al*., 2005). Most important, children were found to be the most sensitive target group exposed to the contaminated soils (Granero and Domingo, 2002; Ajmone-Marsan *et al*., 2008) due to their higher sensitivity, as well as characteristic behaviours (outdoor activities, hand–mouth activity, deficient hygienic habits, etc).

Assessment of the environmental quality for the soils of urban parks and gardens

To assess the contamination levels of heavy metals in the urban parks and garden soils, the index of geoaccumulation (I*geo*) according to Ji *et al*. (2008) was employed. The values obtained for each heavy metal in the study sites are shown in Table 4.

Table 4: Index of Geo-accumulation (*Igeo*)

Parks	**Index of Geoaccumulation (I_{geo}) Surface soil**				
	Cd	**Co**	**Cu**	**Ni**	**Pb**
GFP	-6.207	-5.807	3.793	-2.644	10.616
MKO	-8.785	-5.861	1.454	-2.556	8.862
MOE	-6.179	-6.625	0.707	0.299	8.665
IIG	-10.873	-4.318	2.198	0.666	9.027
OHP	-11.551	-6.186	1.403	-2.474	10.060

Pb has highest values for I*geo* in the urban parks and gardens. The I*geo* values for Pb in the surface soil were 10.616, 10.060, 9.027, 8.862 and 8.665 for GFP, OHP, IIG, MKO and MOE respectively. This indicates that the parks and gardens soils are extremely contaminated with Pb. Furthermore, Cu in the surface soil was found to have high I*geo* for all the sites except MOE and OHP, which were less than zero. The I*geo* values obtained for Cu at MOE and OHP were 0.707 and 1.403, which classified them as uncontaminated to moderately contaminated (Class 1). The I*geo* for other heavy metals indicated that their concentration levels are very low and the sites are uncontaminated. The potential ecological risk index (RI) calculated for all the sites showed high pollution (Fig. 4), as they were all above 200, high pollution (Shi *et al*., 2014).

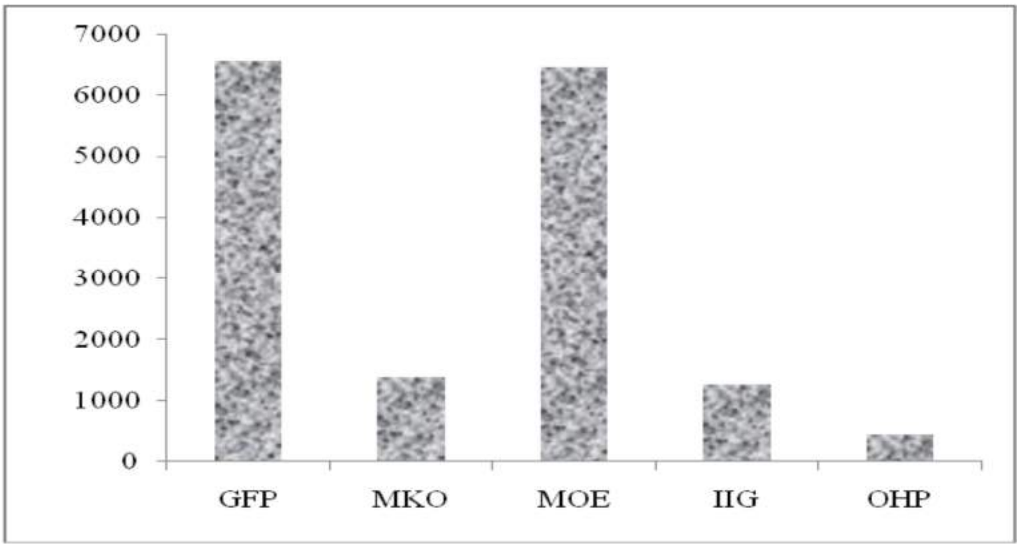

Figure 4. Potential ecological risk index (RI) for top and sub soil in the urban parks and gardens

The results of the risk assessment are shown in Table 5. Daily dose of ingestion of soil particles for all metals were much higher than those of inhalation of soil particles and dermal absorption for all the heavy metals examined. The children had highest levels of risks associated with the route of ingestion of soil particles for all the metals, followed by dermal contact. Exposure through inhalation of soil particles via the mouth and nose was lower than the other two pathways. The results of this study corroborated similar study by Zheng (2010) in a study of exposure to heavy metals in street dust in the zinc smelting district, Northeast of China. Non-cancer hazard indexes i.e. HI of heavy metals were Pb>Ni>Cu>Cd>Co for children and Cu>Pb>Ni>Cd>Co for adults. The sum of HQs and HIs for all heavy metals are lower than 1, indicating a relatively light adverse health impact on children and adults due exposure to heavy metals in urban parks and garden soil in Lagos State. However, for the children, very toxic metals especially Pb, the cancer risk (CR) calculated showed that the level of cancer risk associated with exposure to this element in the urban parks and garden soils (i.e. $3.18\ x10^{-4}$) was slightly higher than the range of threshold values (10^{-6} - 10^{-4}). This indicates there may be cancer risk from Pb to children who visit the urban parks and garden in Lagos State especially through ingestion. Children playing in the parks and gardens can easily ingest soil laden with heavy metals due to their tendency to play on the floor and habit of putting things in their mouth (Zheng *et al*., 2010a, b; Olujimi *et al*., 2015).

Table 5: Cancer and Non-cancer Risks for children and adult in soil

	Children					Adult				
Metals	Cd	Co	Cu	Ni	Pb	Cd	Co	Cu	Ni	Pb
C	9.45E-01	1.65E+00	7.48E+00	2.03E+00	4.82E+01	9.45E-01	1.65E+00	7.48E+00	2.03E+00	4.82E+01
Ding	6.21E-06	1.08E-05	4.92E-05	1.34E-05	3.17E-04	6.66E-07	1.16E-06	5.27E-06	1.43E-06	3.40E-05
Dinh	1.74E-10	3.02E-10	1.37E-09	3.73E-10	8.86E-09	9.79E-11	1.71E-10	7.75E-10	2.11E-10	5.00E-09
Dder	1.74E-08	3.03E-08	1.38E-07	3.74E-08	8.88E-07	1.54E-08	2.68E-08	1.22E-07	3.31E-08	7.85E-07
ingRfd	4.00E-02	3.00E-01	1.00E-03	3.00E-04	1.10E-02	4.00E-02	3.00E-01	1.00E-03	3.00E-04	1.10E-02
InhRfd			1.00E-02	8.57E-05	5.91E-05			1.00E-02	8.57E-05	5.91E-05
derRfd	4.00E-02	3.00E-01	2.50E-05	2.10E-05	4.40E-04	4.00E-02	3.00E-01	2.50E-05	2.10E-05	4.40E-04
HQing	1.55E-04	3.61E-05	4.92E-02	4.45E-02	2.88E-02	1.66E-05	3.87E-06	5.27E-03	8.57E-05	3.09E-03
HQinh			1.37E-07	4.36E-06	1.50E-04			7.75E-08	2.10E-05	8.46E-05
HQdermal	4.35E-07	1.01E-07	5.51E-03	1.78E-03	2.02E-03	3.84E-07	8.93E-08	4.87E-03	1.57E-03	1.78E-03
HI	1.54E-04	3.62E-05	5.47E-02	4.63E-02	3.10E-02	1.70E-05	3.96E-06	1.01E-02	6.35E-03	4.96E-03
CR	6.23E-06	1.09E-05	4.93E-05	1.34E-05	3.14E-05	6.81E-07	1.19E-06	5.39E-06	1.46E-06	3.48E-05

C = Concentration 95%UCL) mg/kg

Pearson correlation analysis showed significant correlation (P <0.01 and P < 0.05) between elements and sources of elements (Table 6). All the metals showed strong positive correlation with each other. Co and Ni are strongly correlated (0.985) at 0.01 significant level while Cu and Pb are strongly correlated (0.901) at 0.05 significant level. The strong correlation was attributed to the metals coming from the same sources and of same geochemical behaviour (Chen et al., 2005).

Table 6: Pearson's Correlation Analysis of Heavy Metals of Surface soil Samples from selected Parks and Gardens in Lagos State

	Co	Ni	Cd	Cu	Pb
Co	1				
Ni	0.985*	1			
Cd	0.998*	0.793*	1		
Cu	0.975*	0.989**	0.806*	1	
Pb	0.857*	0.853**	0.883**	0.901**	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION

The investigation of urban soil samples from selected parks and gardens in Lagos State revealed accumulation of heavy metals such as Cd, Cu and Pb on the surface soil. Cu and Pb concentration in soil of GFP was higher than standard guidelines. The I_{geo} values for Pb in the surface soil were 10.616, 10.060, 9.027, 8.862 and 8.665 for GFP, OHP, IIG, MKO and MOE respectively, which is an indication of extremely high contamination by Pb. The potential ecological risk index (RI) values for all the sites showed high pollution, as they were all above 200 thus potentially risky to the environment and the parks and gardens users. The overall degree of contamination by the 5 metals is of the order GFP > MOE > IIG > MKO > OHP for the surface soil. The cancer risk (CR) calculated showed that the level of cancer risk associated with exposure to this element in the urban parks and garden soils (i.e. 3.18 $x10^{-4}$) was slightly higher than the range of threshold values (10^{-6} - 10^{-4}).

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