Heavy Metals Content in Playground Topsoil of Some Public Primary Schools in Metropolitan Lagos, Nigeria

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Abstract: Assessing the concentration of potentially harmful heavy metals in playground topsoil from public primary schools in metropolitan Lagos, is imperative in order to evaluate the potential risks to the children in the schools. The study was conducted in order to determine if the concentrations of heavy metals in the soil is high enough to constitute a risk to children. Samples were collected from 20 schools in the Lagos metropolis and were subjected to microwave aqua regia digestion. Subsequently, the concentrations of the metals in the samples were measured using Graphite Furnace Atomic Absorption Spectrometry (GFAAS). The investigation revealed that Pb has the highest concentrations of all the metals. Mean metal concentration in playground soils were PbHD: 23.08±11.11, PbLD: 23.54±14.55; CrHD: 5.99±5.79, CrLD: 3.80±3.83; CdHD: 0.33±0.33, CdLD: 0.39±0.31; MnHD: 1.60±0.14, MnLD: 1.61±0.05 μg/g. Univariate analysis of variance showed that the metal concentrations in the high or low population density areas were not significantly different (p>0.05). The results generally indicated that pollution by metals in the dusts and soils is minimal for Pb and Cr and negligible for Mn and Cd while geographical location of the schools in high and low population density areas of Lagos state, Nigeria was not a determinant in the evaluation of children’s exposure to heavy metals.

Key words: Children, heavy metals, playgrounds, topsoil, Cancer, urban

INTRODUCTION

Soil ingestion has been recognized as an equally important exposure route of contaminants to humans (especially for children) as water and food ingestion (McKone and Daniels, 1991). Not only are children more susceptible to the negative health effects of soil contaminants because of physiological factors, but they are also closer to the ground when playing and may thereby ingest soil through mouthing dirty hands and objects, eating dropped food and even consuming soil directly. Pica behaviour includes the ingestion of several non-food materials and when soil is ingested in a pica manner this is termed geophagy. Ingestion of non-nutritive substances via hand-to-mouth transfer is common in children between 18 months to 2 years (Ljung et al., 2006). In a study of geophagy undertaken by Geissler et al., (1997) on the ingestion of soil in 285 Kenyan school-children aged 5-18, 73% were reported to consume soil, with the prevalence decreasing with age.

Soil has long been recognized as a repository for pollutants due to the adsorption processes which binds inorganic and organic pollutants to it. Urban survey data indicate wide variations in metal concentrations of dust and soil in different activity areas (Hseu, 2004; Kumpiene et al., 2006). Heavy metals may come from many different sources in urbanized areas, including vehicular emissions, industrial discharges and other activities (Thornton, 1991). Topsoils and roadside dust in urban areas are indicators of heavy metal contamination from atmospheric deposition. It has been reported that roadside soils near heavy traffic are polluted with Pb and other metals (Arowolo et al., 2000; Xiangdong et al., 2001).

Studies of metal concentrations in playground soil ingested by children via the hand to mouth pathway have been carried out in a number of places according to Watt...
et al., 1993; Higgs et al., 1997. There is substantial evidence that a high Pb level in the environment could affect blood Pb level, intelligence and behavior (Bellinger et al., 1990; Lanphear et al., 1998). It is especially important that soil contents of potentially harmful substances are kept low in areas frequented by children. Other metals such as Cd, Cu, Pd and Zn are good indicators of contamination in soils because they appear in gasoline, car component, oil lubricants and industrial incinerator emissions.

Trace amount of some metals such as trivalent chromium and cadmium entering the body via various routes can induce genetic and epigenetic alteration in different cancer related genes of somatic and stem cells, thus involving in cancer stem cell formation and increasing the incidence of cancer. Trivalent chromium is an epigenetic carcinogen factor because it can form stable compounds with macromolecules such as DNA and cysteine residue of proteins and glutathione (Zhitkovich et al., 1995).

Epigenetic variations in the etiology of cancer have led to increasing cancer research studies in last recent years. Although epigenetic effects of these metals have more prominent role than their genetics effects, these metals in addition are able to alter the pattern of cancer-related genes’ expression profiles (Sanjay et al., 2010).

However, attention has not been paid to the problem of heavy metal contamination in the school playgrounds in Lagos state. There is a lack of information on playground dust and consequently, there are no regulations, and guidelines for heavy metal contamination in the playgrounds. If dust laden with heavy metals provides a critical link in the exposure pathway for young children, contaminated playground soil can undoubtedly pose a potential hazard to their health. To provide a healthy city environment and protect young lives from heavy metal contaminants, it is important to have a thorough understanding of the nature and extent of heavy metal pollution in playgrounds. The aim of this study is to determine the levels of heavy metals (Pb, Cr, Cd and Mn) in 40 topsoil samples obtained from playgrounds of some public primary schools in Lagos State.

METHODOLOGY

The study area: Lagos state represents the most urbanized area in Nigeria with its almost 300 industries on 12 industrial estates, representing over 60% of all industrial activities in Nigeria. It is the smallest state in Nigeria, yet it has the second largest population of over 9 million, Federal Republic of Nigeria official gazette (2007). The rate of population growth is about 275,000 persons per annum with a population density of 2,594 persons per km². A list of primary schools in Lagos State was obtained from the Lagos State Primary School Education Board (SPEB), Maryland. Two schools were selected in each of the 20 local government areas, one in highly populated area and the other in the low density area. All the schools are located in residential areas. The schools were selected based on the nearness of the school to major roads and where possible, nearness to industrial activities. The Samples were collected in the playgrounds of 40 selected schools in Lagos state, Nigeria during the dry season (between October and February).

Sampling: A point was chosen at random in the playground and entrance and a squared grid of about 2 km side was drawn from the spot. Between 4 and 5 discrete soil samples were collected from each of this grid. The number of samples from each site was determined based on the circumstances existing at that site i.e spots where the children frequently play during recess in the playgrounds. A number of methods to collect urban dust have been used by researchers. Some workers have used small vacuum sweeper trucks to collect urban dust samples; some have used a battery-powered vacuum cleaner while others have used a simpler approach such as a polyethylene dustpan and brush (Robertson et al., 2003). This last method was favoured for this study because it is simpler to use, more readily available and coupled with the relative coarse grain size of the topsoil present. Composite samples were obtained by mixing all the subsamples (about 4-5 sub-samples) to form one single sample which was used for chemical analysis. Grass, leaves, polythene bags and papers present in some soil samples were discarded after gentle shaking to remove the soil attached around them. Topsoil samples collected in the playgrounds were kept in sealed polythene bags. A total of 40 samples were obtained.

Sampling preparation: The soil and dust samples were air-dried in the laboratory for 24 h (care was taken to prevent contamination from laboratory dusts). The dried soil samples were sieved in a 2 mm laboratory sieve to in order to remove the larger grits and dirt before being homogenized with mortar and pestle while the dust samples were retained for analysis. The collected samples were kept in sealed polythene vials for subsequent analysis at the Environmental Chemistry Laboratory at the Tshwane University of Technology, Nelson Mandela Drive, Pretoria, South Africa.

All laboratory glassware and plastic wares were first washed with high grade laboratory soap, rinsed with deionised water and soaked in 10% nitric acid (overnight), then rinsed again with double deionised water.

All reagents used in this work were of analytical grade and the acids used for pseudototal digestions were supplied by Merck Pty Ltd, South Africa. All solutions and dilutions were performed with double deionised water (18.2 MΩcm) obtained from Simplicity water purification system.

Microwave-assisted aqua regia digestion: The samples were digested with aqua regia, which provides the
pseudo-total metal contents since it extracts most of the potentially mobile fractions, but leaves the more resistant silicates undissolved. Vessels containing 1 g of the soil and 20 mL of acid were heated at temperature of 180°C and pressure of 120 psi for 10 min. Digests were filtered through Whatman No.125 filter paper into 100 mL volumetric flasks (Davidson et al., 1998). The digestion vessels were then rinsed with distilled water. The washings were also filtered into the flasks. Each filtrate was made up to the mark with further distilled water, to give a final sample solution containing 20% (v/v) aqua regia.

Microwave assisted aqua regia digestion was applied on all the samples obtained from the playgrounds. At each stage of digestion, three quality-assurance samples were included. In the absence of standard reference materials, percentage recoveries were determined by spiking a known concentration of the metal. Reagent blanks and triplicate samples were used for each batch of analysis. The signal obtained using the reagents for each extraction stage was treated as the blank. Reagent blanks were negligible and no detectable contamination was found when aliquots of the digestion reagents were processed and analysed with the samples.

Instrumentation for total metal determination: One thousand µg/mL standard stock solutions of Cd, Pb, Cr and Mn were prepared from 100 mg/L certified standard solutions (supplied by Merck Ltd South Africa). The stock solutions were acidified with nitric acid and were used for calibration. Standard calibration solutions concentrations of 5, 10, 20, 30, 40, 50 and 60 ppb (µg/mL) were prepared respectively for Pb, Cr while 1, 1.5, 2, 2.5, 3, 3.5 and 4 µg/mL (ppb) were prepared Cd and Mn. Intermediate standards and reagent solution were stored in polythene bottles.

A Shimadzu AA-6300 Graphite Furnace Atomic Absorption Spectrophotometer (GFA-EX7) fitted with an Autosampler (ASC)-6100 was used for determination of the heavy metals. The GFAAS was equipped with Cd, Cr, Pb and Mn hollow cathode lamps (Varian cathode lamps and photron cathode lamps) were employed for the measurement of the absorbance.

Data analysis: Statistical data analysis of the research was done using SPSS version 12.0. Analysis of variance was used to test significant difference among the mean concentrations of the heavy metals in the samples from the high and low population density areas.
RESULTS AND DISCUSSION

Heavy metal concentration in the playground soil of some primary schools in Lagos state, Nigeria (Fig. 1) investigated in this study is characteristic of unpolluted soil.

Lead in playground soil: Lead concentration in playground soils show a wide range of concentrations. Mean values of high density playground soils (23.08 μg/g) are similar to the mean values of low density ones (23.55 μg/g), reflecting a general and diffuse contamination of soils in the playgrounds (Table 1). The mean lead content of aqua regia extractable playground soils in Lagos state are lower than what is obtained in some other cities in the world. The results of lead concentrations in mg/kg in playground soils from a mining and smelting district in northern Armenia shows the Pb concentrations to be between 938 and 99 (Petrosyan et al., 2004). Old industrial cities like Uppsala (in northern Europe) have the mean Pb level in playground dust to be 26 mg/kg (Ljung et al., 2006) while cities such as Hong Kong which have their mean Pb level in playground dust to be 77.3 μg/g (Sai et al., 2002). These levels may reflect the long history of industrial contamination coupled with traffic emissions (Pb in gasoline has been phased out in most of these countries) in urban environment of these playgrounds. The mean concentration obtained in this present study is lower than the range of 30-50 μg/g reported by Nriagu (1992) as the typical concentration of lead in urban soils and dusts of African cities while the lower lead levels in this study compared to Nriagu (1992) reports, still gives cause for concern since children spend appreciate time in the locations studied. Comparing the results of each sampling points, only one sample from Ibeju Lekki, low density area had the highest Pb concentration for the playground (81.40 μg/g) (Table 2). The only possible explanation for this is the proximity of the school to auto-repair workshop. The evidence for this point source of Pb comes from the fact that the three samples (collected from high density area and low density area dust samples) had very low Pb levels. Onianwa et al. 2003 had also reported very high Pb levels in the vicinity of auto-repair workshops in the city of Ibadan. To reduce the amount of Pb, one of a number of approaches can be implemented. They range from soil removal and replacement, landscaping the playgrounds, or covering them with an impervious material (Mielke et al., 1991). The large disparity between the Pb levels in high density and low density areas, of Ibeju Lekki (81.40 and 1.26 μg/g, respectively) can be said to be due to the fact that the low density area is fast becoming a favourite holiday resort centre for most people that desire a break from the hustling and bustling of the city while the high density area, populated mainly by the local inhabitants is still typically a rural environment.

The Pb concentration for Lagos Island playground (42.45 μg/g) is the second highest. It would have been expected that the highest concentration ought to have come from this area because Lagos Island represent the nerve-centre

Table 2: Concentrations of metals in playground topsoil samples from schools in the 20 local government areas of Lagos state

<table>
<thead>
<tr>
<th>Local government areas</th>
<th>Pb (μg/g)</th>
<th>Cr (μg/g)</th>
<th>Cd (μg/g)</th>
<th>Mn (μg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badagry</td>
<td>19.60±0.01</td>
<td>93.26±0.03</td>
<td>0.04±0.01</td>
<td>1.20±0.01</td>
</tr>
<tr>
<td>Oshodi/Isolo</td>
<td>24.85±0.25</td>
<td>75.75±0.54</td>
<td>0.19±0.39</td>
<td>0.58±0.00</td>
</tr>
<tr>
<td>Shomolu</td>
<td>18.58±0.52</td>
<td>78.92±0.91</td>
<td>0.91±0.16</td>
<td>0.28±0.01</td>
</tr>
<tr>
<td>Agege</td>
<td>31.65±0.03</td>
<td>86.24±1.67</td>
<td>6.66±0.25</td>
<td>0.49±0.00</td>
</tr>
<tr>
<td>Alimosho</td>
<td>17.42±0.07</td>
<td>83.43±0.39</td>
<td>0.33±0.17</td>
<td>0.10±0.01</td>
</tr>
<tr>
<td>AmuwoOdofin</td>
<td>20.02±0.24</td>
<td>86.33±0.15</td>
<td>0.57±0.27</td>
<td>0.47±0.00</td>
</tr>
<tr>
<td>Mainland</td>
<td>41.34±0.30</td>
<td>90.02±0.66</td>
<td>11.4±0.05</td>
<td>5.55±0.10</td>
</tr>
<tr>
<td>Surulere</td>
<td>28.40±0.45</td>
<td>90.19±0.36</td>
<td>14.4±0.26</td>
<td>6.87±0.34</td>
</tr>
<tr>
<td>Lagos Island</td>
<td>42.45±1.20</td>
<td>103.36±0.11</td>
<td>13.32±0.37</td>
<td>1.19±0.03</td>
</tr>
<tr>
<td>Eti-Osa</td>
<td>25.79±0.40</td>
<td>154.44±0.05</td>
<td>1.91±0.14</td>
<td>0.11±0.00</td>
</tr>
<tr>
<td>Ifako/Ijaiye</td>
<td>29.26±1.21</td>
<td>150.07±0.11</td>
<td>0.79±0.07</td>
<td>0.52±0.25</td>
</tr>
<tr>
<td>Ajeromiifeioudun</td>
<td>31.4±0.09</td>
<td>88.08±0.07</td>
<td>2.45±0.09</td>
<td>0.70±0.01</td>
</tr>
<tr>
<td>Ibeju/Lekki</td>
<td>126.0±0.26</td>
<td>81.40±0.02</td>
<td>0.10±0.01</td>
<td>0.10±0.01</td>
</tr>
<tr>
<td>Ibeju/Lekki</td>
<td>40.00±0.46</td>
<td>109.8±0.49</td>
<td>0.33±0.19</td>
<td>0.02±0.03</td>
</tr>
<tr>
<td>Kosofe</td>
<td>27.95±0.94</td>
<td>24.60±0.36</td>
<td>5.41±1.12</td>
<td>0.08±0.01</td>
</tr>
<tr>
<td>Apapa</td>
<td>21.19±0.30</td>
<td>22.24±1.22</td>
<td>0.49±0.06</td>
<td>0.08±0.01</td>
</tr>
<tr>
<td>Ojo</td>
<td>10.81±0.10</td>
<td>9.77±0.44</td>
<td>13.8±5.36</td>
<td>0.60±0.00</td>
</tr>
<tr>
<td>Mushin</td>
<td>20.44±0.15</td>
<td>19.15±0.55</td>
<td>0.01±0.00</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>Ikorodu</td>
<td>15.01±0.18</td>
<td>7.57±0.05</td>
<td>0.20±0.02</td>
<td>0.01±0.00</td>
</tr>
<tr>
<td>Ikeja</td>
<td>22.31±0.49</td>
<td>15.65±0.11</td>
<td>17.46±0.49</td>
<td>0.01±0.00</td>
</tr>
</tbody>
</table>
of business activities in Lagos state and has a big terminal bus stop and very large open air market. It is one of the busiest areas of the state and it attracts thousands of people on a daily basis. It was also observed that a significant degree of Pb pollution exists in playground soil obtained from the Lagos Mainland high density area (41.34 μg/g). This area represents another nerve-centre of business activities on the mainland in the state as it is a very busy route in the metropolis which connects most bus stops in the state. Schools located close to these areas are subjected to metal pollution almost on a daily basis.

Relatively high concentration of 40.00 μg/g Pb was obtained for high density area in Epe (Epe is considered a rural area in Lagos state); this can also be explained as point sources. This may be due to proximity to spray painters or battery recharge centre. Also flooding is not rampant since the area is not as congested as in metropolitan Lagos. Ajayi and Kamson (1983), previously reported that lead contents of Lagos roadside can exceed 700 μg/g, the lower Pb levels obtained in this study may be due mainly to direct emissions from refuse burning, vehicular exhaust etc. rather than from the industries since most industrial activities have slowed from in the past few years. Most manufacturing industries are not producing at full capacity because of the down turn in the economy and the erratic electricity supply by Power Holding Company of Nigeria (PHCN). In fact as a result of this, a lot of companies and small scale industries have folded up and with big multinational like Dunlop, Michelin etc relocating to other countries in Africa such as South Africa and Ghana. There is no doubt that this will have its own effect on the environment particularly when compared to the oil-boom era of the seventies and early eighties. Some schools located in the low density areas (areas with minimal business, human and vehicle activities such as the government reserved areas), have been observed to have higher lead levels than their high density areas counterparts and they include areas such as Agege, Ajeromi Ifelodun, and IbejuLekki. This observation may be partially due to sources from influx of imported power generating sets that have flooded the country in recent times due to poor existence of power generation.

It is expected that Oshodi-Isolo area will have one of the highest lead levels as reported by Arowolo et al. (2000) however; the contrast was obtained in this study in which flooding episodes have been recorded in the area and indeed in many parts of the state and has worsened in the recent times (Nigerian Punch Newspapers, 2008). As expected, Ikorodu local government area has the lowest Pb level for both high and low density. This may however change soonest as there are greater influx of people relocating to Ikorodu due to congestion on the Island and mainland.

**Chromium in playground soil:** The chromium levels are very low compared to the levels recorded in India. Banerjee (2003) reported an area that is well known for metal processing industries (electroplating pickling and galvanizing). These industries are not in existence in the Lagos state in the recent times because of the down turn in the economy. The lower chromium concentrations obtained for areas such as Epe, (0.02 μg/g), Badagry (2.11 μg/g) low density area is expected for areas far removed from industrial and commercial activities unlike what was obtained in Oshodi Isolo (15.75 μg/g) and Lagos Island (13.33 μg/g) high density, areas well known for their high traffic densities. The highest Cr concentrations was obtained for Ikeja high density area as expected for a school close to an industrial area (Ikeja has the largest number of industries in the state).

**Cadmium in playground soil:** Concerns about the increasing amounts of Cd in the human environment have caused many countries to place limits on soil usage depending on cadmium content. Some examples of critical limits, values above which concentrations cause the soils to be considered inappropriate for any human use range from 0.3-2.0 μg/g. Cadmium levels in the playgrounds obtained in this study for areas such as Oshodi Isolo, Surulere, Lagos Island high density areas, Agege low density area etc. are above the critical limits for cadmium in soils for most countries. Itai-ita is a disease that seems to have occurred only in Asia where it is linked to a staple diet of rice grown, the disease was observed at Cd-soil concentrations as low as 2 mg/kg (Lalor, 2008). The children in these schools are not likely to be affected by itai-ita disease immediately but they may be at risk from accumulated cadmium concentration in the soil.

**Manganese in playground soil:** Manganese was not detected in most playground soils. The interest in Mn as an environmental contaminant was generated because of its increase use in the form of methyl Cyclopentadienyl Manganese Tricarbonyl (MMT) as replacement for Pb in unleaded petrol (gasoline).

**CONCLUSION**

The metal concentrations in the playground soil studied is characteristic of unpolluted soils, except for some areas with levels above those considered as acceptable limits for recreational and institutional sites such as Lagos Island and Mainland local government areas. Maintaining ground cover will however provides a margin of safety from exposure to heavy metals in playground soils.
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REFERENCES