ASSESSMENT OF SOME HEAVY METAL IN CHILDREN’S PLAYGROUNDS IN OWERRI METROPOLIS, IMO STATE, NIGERIA

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Abstract
Children at playgrounds are exposed to contaminants and so attempts to improve children’s environment could reduce environmental burden of illnesses. In order to assess contamination by heavy metals, 36 soil samples were collected from nine public schools within Owerri metropolis. Using AAnalyst 400 Perkin Elmer (AAS) concentrations of Mn (42.02± 31.16 mg/Kg); Co (6.26± 2.78 mg/Kg); Ni (35.05± 22.89 mg/Kg); Cu (35.42± 13.19 mg/Kg) and Zn (119.62 ± 31.16 mg/Kg) in 2012 and Mn (52.20 ± 29.08 mg/Kg); Co (10.94 ± 7.10 mg/Kg); Ni (32.16 ± 15.26 mg/Kg); Cu (43.85 ± 7.99 mg/Kg) and Zn (103.73 ± 26.82 mg/Kg) for 2013 were determined and data fitted into some models to assess contamination. Contamination factors (Cf) reveal that Central school Owerri, CSO (Cf : 68.45) and World bank primary school, WBP (Cf : 61.53) were the most contaminated sites. Playgrounds had degrees of contamination (Cd) greater than 50, categorized as very high pollution whereas Heavy metal hazard indices (HMHI) were bellow 1, suggesting unlikely multi-element contamination. Due to bioaccumulation and non biodegradability of heavy metals, there is a need for some form of remediation of highly contaminated sites in other to alleviate future possible risk to our children.

Keywords: Child health, Contamination, Multi-element, Metropolis, Exposure, heavy metals

Introduction
Urbanization has affected man’s environment to the extent that while studies are still being conducted in order to understand one kind of pollution other pollution problems begin to raise their ugly heads. For instance in recent years heavy metals have been implicated in the etiology of many deadly ailments peculiar to humans [1]. According to Medicines San Fronteers, Zamfara state recording the worst heavy metal disaster in human history in which lead (Pb) killed over 400 children in 2010 [2]. Jaronsinka et al., [3] studying environmental burden of diseases due to Pb established a linked between lead concentration and urbanization. A wide range of contaminants, which vary appreciably within and among cities have been studied but heavy metal levels in children play grounds have remained unnoticed for most third world countries. The damage to our children goes on daily [4,5] and so it is important that soil contents of potentially harmful substances are kept low in areas frequented by children.

The link between childhood diseases and playground soils has been established by some researchers [6,7]. Cities are usually highly populated giving rise to huge volumes of waste with consequent waste disposing problems. Thus it is no doubt that children’s playgrounds within these cities could be contaminated by a cocktail of contaminants of all types. Numerous human activities, including construction, industrial, commercial, agricultural and mining operations, release a variety of toxic and potentially toxic pollutants into the environment on a daily basis [8,9]. For most Nigerian cities the top 8 polluting industries are steel works, metal fabrication, food processing, tanneries, textiles, pharmaceutical petrochemical refineries and paints. Almost all industries discharge their effluents without prior treatment [10]. However Owerri metropolis can only boast of few steel works, metal fabrication and paints.

The metropolitan environment, experience vast accelerated and intense emissions of both metal pollutants there by rendering it particularly susceptible to environmental degradation and contamination [11,12]. One crucial property of heavy metals is that they are non biodegradable hence accumulate in the environment. Surface soil can be a significant indicator of heavy metal contamination in the urban environment. Heavy metals pollution of urban environment using dust deposited on road sides have been studied [13, 14]. Dust Pb content were found to explain most of the variance in blood lead levels in a study conducted among children in Rochester [15].

Most studies on street dust have focused on elemental concentrations and source identification [16,17]. Urban survey data indicate wide variations in metal concentrations of dust and soil in different activity areas [18]. These heavy metals come from many
different sources in urbanized areas, including vehicular emissions, industrial discharges and other anthropogenic activities \[19,20\]. There is substantial evidence that a high Pb level in the environment could affect blood Pb level, intelligence and behavior \[21\]. This could be said same for many other heavy metals that are yet to be investigated because the mechanism of toxicity of heavy metals in cells is generally the same \[22\]. Metals such as Mn, Ni, Co, Cu, and Zn are good indicators of contamination in soils because they appear in gasoline, car component, oil lubricants and industrial incinerator emissions printing ink and rust from roof tops \[23,24\]. Exposure to high levels of vehicular emissions, industrial discharges and other different sources in urbanized areas, including connecting roads to neighboring states pass through the metropolis thereby increasing traffic volume \[33\].

There is substantial evidence that a high Pb level in the environment could affect blood Pb level, intelligence and behavior \[21\]. This could be said same for many other heavy metals that are yet to be investigated because the mechanism of toxicity of heavy metals in cells is generally the same \[22\]. Metals such as Mn, Ni, Co, Cu, and Zn are good indicators of contamination in soils because they appear in gasoline, car component, oil lubricants and industrial incinerator emissions printing ink and rust from roof tops \[23,24\]. Exposure to high levels of heavy metals can result in acute and chronic toxicity, such as damage to central and peripheral nervous systems, blood composition, lungs, kidneys, liver, and even death \[25,26\], especially children \[27\]. Two recent studies have demonstrated elevated body loadings of heavy metals and persistent toxic substances in children and e-waste workers, respectively, at Guiyu \[28\].

However, little attention has been paid to the problem of heavy metal contamination in the school playgrounds in most parts of Nigeria. Even when attempts are made few metals are often considered. There is a lack of information on playground dust and consequently, there are no regulations, and guidelines for heavy metal contamination in the playgrounds \[29\]. Since dust or surface soils with heavy metals provide a critical link in the exposure pathway for young children, contaminated playground soil is likely a potential hazard to their health. Metals are ubiquitous and so it is an inescapable reality to have children not exposed to heavy metals. The aim of this study was therefore to determine the if concentrations of Mn, Ni, Co, Cu, and Zn in surface oil samples from playgrounds of some public primary schools in Owerri metropolis were causing contamination. It is expected that baseline data on contamination factors and HMHH could assist in determining the level of remediation needed by polluted playgrounds over time. Data could alert appropriate agencies on the need to formulate and enforce a playground safety action plan for public schools in Owerri metropolis.

### Materials and Methods

**Site description** Owerri municipal is one of the three local government areas (LGAs) that make up Owerri city, the capital of Imo state of Nigeria set in the heart of the Igboland. It lies within topics and enjoys a tropical climate. This area is under heavy traffic all year round since it is home to the biggest and modern market as well as the seat of Imo state government. Even though there are no industries, connecting roads to neighboring states pass through the metropolis thereby increasing traffic volume \[33\].

### Sampling of soil

Nine different sampling sites were taken from playgrounds along major roads connecting Owerri municipality in Imo state as follows: Surface soil or dust samples at 0-5 cm depth were collected in the months of January (rainy season) and in June (dry season), of 2012 and 2013. At each sampling site, a ‘W’ shaped line was drawn on a 2 x 2m surface along which samples were collected from five points into previously washed polythene containers. For samples in the rainy season a perforated container was used to allow water to drain. Samples were sundried for two days, then oven dried at 50°C for 2days; grind in acid-washed porcelain mortar with pestle. The soil samples were pooled together, treated to coning and quartering to obtain a small laboratory sample \[30\]. The samples were sieved through a 200 μm sieve in order to normalize variations in grain size distributions. The samples were store in polythene containers with caps for further analysis.

### Digestion of soil samples

1g of each soil sample was accurately weighed in Pyrex glassware and treated with 10 ml of high purity concentrated nitric acid (HNO\textsubscript{3}). The mixture was placed on a hot plate at 90°C for 6 hours until it became dry. It was then cooled. This procedure was repeated with another 10 ml aliquot of concentrated HNO\textsubscript{3} followed by 10 ml of 2 M HCl. Each digested soil sample was then warmed in 20 ml of 2 M HCl to redissolve the metal salts. The extract was centrifuged at 30000 rpm for 15 mins and the collected clear volume was then adjusted to 25 ml with double distilled water.

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 purest grade available.

### Determination Heavy Metal in Soil Samples

The total heavy metal concentration in the soil samples was determined by the use of The AANALYST 400 Perkin Elmer absorption spectrophotometer. Quantification was carried out using appropriate calibration curves prepared in the same acid matrix with standard metal solutions for atomic absorption spectrophotometer \[31\].

### Statistical Analysis

Mean and standard deviation were calculated using coupled Microsoft Excel 2009 + Analyse-it® v2.2. T-test was used to compare the mean metal concentrations among the sites and statistical significance was described at P < 0.05. Regression equations were determined for soil physicochemical parameters and degree of contamination.
Results and Discussion
Some statistical data of heavy metals in public schools playground soils are shown on table 1. The contamination factors of heavy metals in school playground soils were assessed by use of contamination factors ($C_f$); degree of contamination ($C_d$) and heavy metal hazard index (HMHI). The $C_f$ and $C_d$ were calculated according to [32, 33,34, 35,37,38] through these formulae:

$$C_f = \frac{C_s}{C_b} \ldots \ldots (1)$$

$$C_d = \sum C_f \ldots \ldots \ldots (2)$$

$C_s$ is the measured concentration of the examined metal in the playground soils while $C_b$ is the background levels of metals in soil reported with the following concentration in mg/Kg 25, 90, 40,30, 8 for Mn, Zn, Ni, Cu and Co respectively [33].

Table 1: Some statistical parameters of heavy metals (mg/Kg) in studied in playgrounds

<table>
<thead>
<tr>
<th>Metal</th>
<th>Mn</th>
<th>Co</th>
<th>Ni</th>
<th>Cu</th>
<th>Zn</th>
<th>Mn</th>
<th>Co</th>
<th>Ni</th>
<th>Cu</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>42.03</td>
<td>6.26</td>
<td>35.06</td>
<td>35.42</td>
<td>119.62</td>
<td>52.20</td>
<td>10.94</td>
<td>32.16</td>
<td>43.85</td>
<td>103.73</td>
</tr>
<tr>
<td>Min.</td>
<td>6.55</td>
<td>3.03</td>
<td>11.36</td>
<td>16.5</td>
<td>81.19</td>
<td>17.9</td>
<td>4.08</td>
<td>12.8</td>
<td>32.96</td>
<td>69.76</td>
</tr>
<tr>
<td>Max.</td>
<td>82.19</td>
<td>10.38</td>
<td>69.35</td>
<td>55.05</td>
<td>178.62</td>
<td>98.04</td>
<td>23.66</td>
<td>55.92</td>
<td>56.80</td>
<td>147.35</td>
</tr>
<tr>
<td>SDV</td>
<td>31.16</td>
<td>2.78</td>
<td>22.89</td>
<td>13.91</td>
<td>33.39</td>
<td>29.08</td>
<td>7.10</td>
<td>15.26</td>
<td>7.99</td>
<td>26.82</td>
</tr>
<tr>
<td>CV</td>
<td>74</td>
<td>44</td>
<td>65</td>
<td>39</td>
<td>28</td>
<td>56</td>
<td>65</td>
<td>48</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>WHO</td>
<td>1500</td>
<td>-</td>
<td>600</td>
<td>100</td>
<td>7000</td>
<td>1500</td>
<td>-</td>
<td>600</td>
<td>100</td>
<td>7000</td>
</tr>
<tr>
<td>BV</td>
<td>25.00</td>
<td>8.00</td>
<td>40.00</td>
<td>30.00</td>
<td>90.00</td>
<td>25.00</td>
<td>8.00</td>
<td>40.00</td>
<td>30.00</td>
<td>90.00</td>
</tr>
</tbody>
</table>
Min.: minimum value; Max.: maximum value; SDV: standard deviation; CV: coefficient of variation; WHO: world health organization; BV: Baseline value

### Table 2: Metals Contamination factors and degree of contamination in 2012

<table>
<thead>
<tr>
<th></th>
<th>January 2012</th>
<th>June 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mn</td>
<td>Co</td>
</tr>
<tr>
<td>HEO</td>
<td>0.34</td>
<td>0.45</td>
</tr>
<tr>
<td>MNO</td>
<td>0.42</td>
<td>0.78</td>
</tr>
<tr>
<td>SCP</td>
<td>2.73</td>
<td>0.58</td>
</tr>
<tr>
<td>CSO</td>
<td>6.25</td>
<td>0.61</td>
</tr>
<tr>
<td>TSO</td>
<td>4.9</td>
<td>0.87</td>
</tr>
<tr>
<td>WSP</td>
<td>5.53</td>
<td>0.93</td>
</tr>
<tr>
<td>WBP</td>
<td>3.95</td>
<td>0.79</td>
</tr>
<tr>
<td>IKS</td>
<td>1.43</td>
<td>1.34</td>
</tr>
<tr>
<td>UPS</td>
<td>1.22</td>
<td>1.60</td>
</tr>
<tr>
<td>∑Cf</td>
<td>26.77</td>
<td>7.95</td>
</tr>
<tr>
<td>Min.</td>
<td>0.34</td>
<td>0.45</td>
</tr>
<tr>
<td>Max.</td>
<td>6.25</td>
<td>1.6</td>
</tr>
<tr>
<td>Mean</td>
<td>2.97</td>
<td>0.88</td>
</tr>
</tbody>
</table>

HEO: Housing Estate Nursery Primary School; MNO: Model Nursery; SCP: Shell camp Nursery/Primary School; CSO: Central School; TSO: Township school; WSP: Water side Primary; WBP: World Bank Nursery /Primary School; IKS: Ikenegbu Primary School and UPS: Urban nursery/primary school

Four categories of $C_f$ and $C_d$ as suggested by Håkanson [39] were used to evaluate metal contamination levels. The values obtained for contamination factor ($C_f$) for each of the metal in their specific location are shown in table 2. Contamination factors ranged from 0.49 for Co to 68.45 for Zn. Low $C_f$ were recorded for Co (0.49, 0.69 and 0.77) at UPS, WBP, SCP and IKS respectively. Mn also showed low contamination at TSO and UPS with $C_f$ of 0.73 and 0.74 respectively. Moderate contamination ($1 < C_f < 3$) was observed for Mn at SCP, CSO and WSP while nickel showed moderate contamination at HEO and UPS. Also UPS soil was moderately contaminated by Cu. Values of $C_f$ reveal that CSO ($C_f$: 68.45) and WBP ($C_f$: 61.53) were the most contaminated sites.

### Table 3: Metals Contamination factors and degree of contamination in 2013

<table>
<thead>
<tr>
<th></th>
<th>January 2013</th>
<th>June 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mn</td>
<td>Co</td>
</tr>
<tr>
<td>HEO</td>
<td>0.70</td>
<td>0.48</td>
</tr>
<tr>
<td>MNO</td>
<td>1.05</td>
<td>0.57</td>
</tr>
<tr>
<td>SCP</td>
<td>1.13</td>
<td>0.45</td>
</tr>
<tr>
<td>CSO</td>
<td>6.40</td>
<td>0.32</td>
</tr>
<tr>
<td>TSO</td>
<td>4.95</td>
<td>0.82</td>
</tr>
<tr>
<td>WSP</td>
<td>6.11</td>
<td>0.79</td>
</tr>
<tr>
<td>WBP</td>
<td>3.46</td>
<td>0.46</td>
</tr>
<tr>
<td>IKS</td>
<td>2.41</td>
<td>0.59</td>
</tr>
<tr>
<td>UPS</td>
<td>2.75</td>
<td>0.68</td>
</tr>
<tr>
<td>∑Cf</td>
<td>28.96</td>
<td>5.16</td>
</tr>
<tr>
<td>Min.</td>
<td>0.70</td>
<td>0.32</td>
</tr>
<tr>
<td>Max.</td>
<td>6.40</td>
<td>0.82</td>
</tr>
<tr>
<td>Mean</td>
<td>3.217</td>
<td>0.573</td>
</tr>
</tbody>
</table>
At lower pH metals solubility tends to decrease and absorption reactions become more important than precipitation and complexation reactions. This encourages percolation of metals into deeper soil horizon [40], thereby lowering the contamination factors of metals especially in the rainy season. Risk. The models used in this investigation provides useful tools for risk assessment in identifying the relative children health risks of the heavy metals in dust at different locations, however, there are inherent uncertainties.

Figure 2: Degrees of contamination of the various playgrounds

When the Cd value exceeds 20, then it is necessary to take immediate counter measures to reduce heavy metal contamination in the soil. All school playgrounds showed degrees of contaminations greater than 50, i.e above twice the value categorized as very high pollution. This implies that all nine schools in Owerri municipality are under very high contamination by one or some of the metals Mn, Co, Ni, Cu and Zn.

Heavy metal hazard index (HMHI)
The Heavy metal hazard index (HMHI) was calculated for each sample site following the equation according to Verla et al. [41]. The expression for

\[
\text{HMHI} = \frac{[\text{Mn}]_{\text{PL}} + [\text{Zn}]_{\text{PL}} + [\text{Cu}]_{\text{PL}} + [\text{Ni}]_{\text{PL}}}{4}
\]

The permissible levels (PL) for the metals used in calculating HMHI in this study were those of threshold values for children playgrounds by WHO with concentrations in mg/Kg: 1500, 7000, 600 and 1000 for Mn, Zn, Ni, and Cu respectively. The number 4 is the number of metals used in the calculation, rather than 5 because the permissible level of Co was not found in literature. HMHI < 1 suggests unlikely adverse health effects, HMHI of 1, suggest baseline pollution while HMHI > 1, suggests the probability of adverse health effects and deterioration of site quality. An HMHI >10 is considered to be high chronic risk [41].

TSO showed highest HMPI while WSP had lowest. All nine school play grounds had HMPI lower than 1 suggesting that there may be unlikely multi-element contamination. However when the cumulative effect due to bioaccumulation and non biodegradability of heavy metals are considered, there is a need for some form of caution in other to contain future possible

Figure 3: Heavy metal pollution index of the various playgrounds.

These include actual heavy metal concentrations in the soil owing to its heterogeneous nature. However this study shows that playground soil is a significant possible source of children risk. As recommended [42] that periodic replacement of playground surface soil could help prevent excessive contamination especially for playgrounds located in areas prone to pollution. Roads and premises of nearby public facilities such as a schoolyard could be adversely impacting on children playgrounds. It is hoped that the results can serve as a case study for similar studies in the country so that preventive measures could be undertaken.

Conclusion
Though all playgrounds studied had degrees of contamination \( \left( C_d \right) \) greater than 50, some metals show no contamination and there could be unlikely multi-element contamination. Ranking playgrounds in order of decreasing degrees of contamination and indices of heavy metals pollution is as follows:

\( C_d: \) TSO> CSO> WBP> IKS> HEO> SCP> WSP> MNO> UPS
HMHI: TSO> CSO> WBP> IKS> HEO> SCP> MNO> UPS> WSP

As a result of bioaccumulation there is a need for some form of caution at uncontaminated playgrounds.
at same time remediation of highly contaminated sites
is important in other to reduce possible risk to our
children.

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