Ecological Risk Assessment of Soil Metallic Pollution in Mechanic Villages, Abeokuta, Nigeria

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Abstract

A study on heavy metals load and ecological risk assessment in soil from four automobile villages (MVs): Campsite, Kobape, Obada and Sagamu in Abeokuta, Ogun State, Nigeria was conducted. Soils (top and sub soil) were collected in and around each mechanic village and analyzed for Pb, Cu, Cr, Fe, Cd, Ni, and Zn using atomic absorption spectrophotometer (Analyst 400 Perkin Elmer model). Data obtained from laboratory exercise were analysed using various multivariate geostatistical techniques such as: Enrichment factor (EF), pollution index (Pi), pollution classification (PC), geoaccumulation index ($I_{geo}$) and potential ecological risk index (RI). The EF shows that Pb and Cu are major pollutants having impacts on the study area, followed by Cd. The metals EF are significant ($r > 1.5$) in all the MVs except Obada. This suggests that Pb and Cu are probably from anthropogenic inputs. Ecological risk assessment results reveal that the environment is under varying degree of threats posed by the activities of the mechanic villages to the immediate environment. Therefore, the need for policies by relevant agencies including environmental education and training in respect of automobile wastes disposal practices that will ensure sustainable environment.

Keywords: Pollution Classification, Pollution Index, Mechanic Villages, Multivariate Geostatistics, Anthropogenic

1. Introduction

The activities of automobile repair workers generate huge wastes mainly of metal scraps and oils. Since no organised society or government will allow proliferation of automobile repair stations within the city without checks, considering the possible environmental effects, there is therefore the need set aside a special (and isolated) land area as automobile (mechanic) village, as it is been practiced globally (Iwegbue, 2007; Ipeaiyeda & Dawodu, 2008 and Nwachukwu et al, 2010). Factors such as volume of automobile repair activities, population, geographical, and political considerations dictate the numbers of such automobile villages per city. Ogun State Government created some mechanic villages in the ’80s and has increased in number by succeeding governments. However, the quest for cleaner cities which informed designating speci-al land areas as mechanic villages has some environment-al consequences. The areas that host these automobile villages are usually exposed to varying degree of environ-mental threa-
contaminated groundwater, reduction in food quality (safety and marketability) via phytotoxicity, reduction in land usability for agricultural production causing food insecurity, and land tenure problems (Nor et al, 2012) The non-biodegradability and tendency to bioaccumulate in the living cell, make the heavy metals more daring (Majolagbe et al, 2010). Dioka et al (2004) investigated Pb-level among a group of students on one side and a group of automobile mechanics from a mechanic village on another side. A high lead blood level was observed in the automobile workers, probably due to their continuous exposure to lead in petrol. This according to Nwachukwu et al (2010) could affect the level of uric acid and phosphate in human body function. Heavy metals naturally occur in ecosystems. However, the level is often raised remarkably by various anthropogenic activities, thereby causing serious heavy metal pollution of the environment, which constitutes threats to human beings and other forms of biological life (Tam & Wong, 1995).

Food chain contamination by heavy metals has attracted global attention in recent years (Milenkovic et al, 2005 and Ayejuoyo et al, 2009). There is a potential accumulate-on in biosystems through contaminated water, soil and air. Heavy metals in polluted soil are taken up by plants causing accumulation in plant tissues which are eventual-ly consumed by man (Zayed, 1998). Analysis of tree bark has proven to be informative as bio-indicator of metal pollution in the environment (Vinay et al, 2007; Odukoya, 2008 and Majolagbe et al, 2010). The high concentration of heavy metals in soils is reflected through higher concentrations of metals in plants, and consequently in animal and human.

Lead can cause Kidney damage, disruption of biosynthesis of haemoglobin and mental retardation in children (Osabohien & Otuya, 2006). Majolagbe et al (2010) pointed out that, heavy metals pollution is a potential health threat in Africa, largely due to non availability of data and absence of continuous monitoring facilities. Heavy metals come from a variety of sources. Human activities such as coal and ore mining, chemical manufacturing, petroleum exploration and refining, electric power generation, melting and metal refining, metal plating, domestic sewage and to some extent, geological formation of an area are principal sources (Gaszó, 2001).

Heavy metals such as Cu, Fe, Zn and Cr are essential metals needed in biochemical activities of the living body. They serve as components of enzymes, structural proteins, pigments and also helping to maintain the ionic balance of cells at trace levels. However, at higher concentration, they become toxic (Kosolapov et al, 2004 and Nwachukwu et al, 2010). Pb and Cd are generally toxic even at trace level in the body. Large quantities of metallic pollutants are continuously been introduced into ecosystems as a result of urbanization and industrialization. Heavy metals enter into the environment mainly via the many routes namely: deposition of atmospheric particulate, disposal of metal enriched sewage, sludge and effluents and by-products of some industrial activities such as metal mining process. Soil is one of the repositories of anthropogenic wastes. Plants can absorb such metals from soil. Biochemical processes can also mobilise the heavy metals to pollute underground water thereby endangering the food chains. Environmental pollution can lead to geo accumulation, bioaccumulation and biomagnifications of cations in ecosystems.

Iwegbue (2007) studied metal speciation in soil profiles at motor mechanic waste dumps around Port Harcourt, Nigeria and observed that the metals present were relatively mobile, but more in the surface soil than in the subsurface soil. Ipeaiyeda & Dawodu (2008) also studied heavy metals contamination of topsoil and their disperse-on in the vicinities of reclaimed auto vehicle repair workshops. Pb was observed the most significant contaminant, followed by Ni and Hg. The soil-plant barrier limits transmission of many heavy metals through the soil-crop-animal food chain, with the exception of Cd, Zn, Mo, and Se was also reported by Chaney et al (1994). Cadmium, which has lower affinity for metal-sorbing phases (for example, oxides) has the greatest potential for transmission through the food chain in levels that present risk to consumers (Chaney & Ryan, 1994 and Chaney et al, 1999). The use of multivariate geostatistical techniques in the assessment of metal load and dispersion in the soil is becoming more popular among researchers (Fatoba et al, 2012 and Aktaruzzaman, 2014). The multivariates techniques help reveal various trends and patterns in the results of laboratory analysis of heavy metals in soils.

Since thirty years ago, when the ‘mechanic villages’ scheme was introduced in Ogun state, there is still paucity of report on its environmental impact; hence this study seeks to undertake an assessment of heavy metal load of soil in four of the automobile villages in Ogun State south-west Nigeria and the potential ecological risks associated. The findings, can serve as a baseline for further studies and data purposes, as well as helping the relevant agencies in formulating needful policies towards a sustainable environment.

2. Materials and Methods

2.1. Description of Study Area

The study area involved four different mechanic villages: Campsite, Kobape, Obada and Sagamu, all at various major entry points of Abeokuta, in Ogun State. Ogun State is in the South-Western part of Nigeria. It lies within latitude 6° N and 8° N and longitude 2° E and 5° E (Figure 1).
The state borders Lagos State to the South, Oyo and Osun states to the North, Ondo State to the east and the Republic of Benin to the west. The State has a wide area of undulating lowlands belonging to the coastal sedimentary rocks of western Nigeria. Soils in sample areas are mostly sandy derived from the basement complex rocks and belong to the red types (Onakomaiya, 1992). The mechanical villages provide automobile repair services not only to vehicles registered in the state, but largely to many from neighbouring states, particularly Lagos. The resultant high volume of activities at the mechanic villages in the state therefore makes it imperative to probe the extent of environmental pollution caused by those automobile repair activities. A typical mechanic village in Ogun state occupies a land area of about 5 hectares contains about forty five auto-mechanic workshops. Activities conducted in these shops involve spilling of oils, greases, petrol, diesel, battery electrolyte, paints and other materials which are rich in heavy metals unto bare soil.

Figure 1. Map of Ogun State Showing Study Areas

The geographical positioning system (GPS) of the MVs are Campsite (Lat. 7°11.212 N and 7°11.109 N, Long 3°25.985 E and 3°25.970 E), Kobape (Lat. 7°06.935N and 7°07.009 N, Long 3°23.370 E and 3°23.475 E), Obada (Lat. 7°04.800 N and 7°04.843 N, Long 3°17.866 E and 3°17.624 E) and Sagamu (Lat. 6°52.078 N and 6°52.070 N, Long 3°35.894 E and 3°35.169 E).

2.2. Soil Sampling

A total number of twenty soil samples were randomly collected from ten different locations at depth of 0-15 cm as top soil sample and depth of 15-30 cm as sub soil sample in each of the four mechanic villages. Control samples were collected 500 m away from each MV against the direction of drainage. Samples were collected with the aid of a locally fabricated stainless soil auger. This equipment was thoroughly cleaned after each sampling to prevent cross contamination. The samples were stored in acid washed polythene bag and transported to laboratory.

2.3. Chemical Analyses of Soil Samples

2.3.1. pH Determination

The soil samples were air-dried and pulverized into a uniform size with the aid of pre-washed mortar to pass 2 mm mesh sieve and stored in acid dried polythene bottles with plastic screw cap prior the analysis. pH of the soil samples was determined using pH meter (Mettler Toledo IP67 model) which has been calibrated with buffer solutions of 4, 7 and 9.

10.0 g of the sieved soil sample was weighed into a 250 ml beaker and 10 ml of distilled water was added. The mixture was vigorously shaken and allowed to stand for 1 hour. A blot dried calibrated hand held pH meter was dipped into the mixture and pH value was displayed (ASTM, 1995 and SERAS, 2002).

2.3.2. Heavy Metal Analysis in Soils Samples

5.0 g of the oven-dried, ground soil samples was accurately weighed and digested with aqua regia (Majolagbe & Bamgbose, 2007). 50 ml of aqua regia was added into 250 ml round bottom flask containing 5.0 g soil sample. It was refluxed for 2 hours until no brown fumes were given off by the sample (US EPA, 1996) after which the sample was washed, rinsed with demineralised water, filtered using Whatman No. 1 filter paper and made up to 100 ml in standard volumetric flask. Heavy metal determination was done using Atomic Absorption Spectrometer (Analyst 400 Perkin Elmer model).

Calibration curve was prepared with standard solution of pure metals of concentration ranging from 0.0-40.0 mg/L at 5.0 mg/L increment. Triplicate determinations were carried out for each of the sample to test for the reproducibility of the method.

2.4. Statistical Analysis

Environmental quality assessment is often based on a comparative analysis of metal concentration in the soil from mechanic villages with their respective control values or environmental standard values. The use of geostatistical quality techniques is now gaining popularity among environmental researchers. Pollution assessment criteria in this study were based on the following soil geostatistical indices:

2.4.1. Pollution Index (Pi)

It is degree of soil pollution for a metal (Zango et al, 2013). Pollution index has been used to assess urban soil pollution. Liu et al (2007) obtained Pi as a ratio of metal concentration in a contaminated soil sample and its conce-
nantation in control sample. However, Diatta et al (2003) obtained Pi as a ratio of the metal concentration in a contaminated soil sample and the local Maximum Allowable Limit (MAL) values of the metal. Values considered as MAL of heavy metals vary from place to place and depend on local background values (Kloke, 1980). Pollution index had also been calculated as ratio of metal concentration in sample to background concentration (Lacatusu, 1998). The Pi in this study is calculated by the following mathematical relation (Liu et al, 2007):

\[ P_i = \frac{C_{(i)}}{C_{(i)}} \]

Where:

- \( C_{(i)} \) is the concentration of the \( i^{th} \) soil pollutant, and \( C_{(i)} \) is the relative metal concentration of pollutant in control sample or background value in mgkg\(^{-1}\).

### 2.4.2. Pollution Classification (PC)

This helps to establish the distinction between soil contamination range and soil pollution range. PC Values above 1.0 depicts the pollution range, while those below 1.0 indicate the contamination range. Pollution index obtained can be used to compute PC of an area using the formula of the Dutch system (Lacatusu, 1998 and Chee, 2006).

Pollution classification (PC) was calculated as reported by Chee (2006):

\[ PC = \frac{C_{(i)} - C_{(i)}}{P_i} \]

### 2.4.3. Enrichment Factor (EF)

Enrichment factor was used to assess the level of heavy metal contamination of soil, using iron as normalizing metal. It also indicates the source of origin of the metal. According to Ergin et al (1991), the metal enrichment factor (EF) is mathematically defined as follows:

\[ EF = \frac{C_{(i)}^{(sample)}}{C_{(i)}^{(control)}} \]

Where:

- \( EF \), the enrichment factor, is the ratio of metal and Fe concentration of the sample, \( (M/Fe)_{sample} \), and the metal and Fe concentration of a control \( (M/Fe)_{control} \).

According to Zhang & Liu (2002), EF values between 0.5 and 1.5 indicate that the metal is entirely from crustal materials or natural processes; whereas EF values greater than 1.5 suggest that the sources are more likely to be anthropogenic (Ergin et al, 1991 and Zhang & Liu, 2002).

### 2.4.4. Geo Accumulation Index (I\(_{geo}\))

The I\(_{geo}\) of heavy metals in the soil can be calculated through the mathematical relationship:

\[ I_{geo} = \log_2 \left( \frac{C_{metal\_sample}}{1.5 \times C_{metal\_control}} \right) \]

Where

- \( C_{metal\_sample} \) is the concentration of the heavy metal in the enriched sample and \( C_{metal\_control} \) is the concentration of the metal in the unpolluted sample control.

The factor 1.5 is introduced to minimize the effect of the possible variations in the background or control which may be attributed to lithogenic variations in the soil (Mediolla, 2008). The degree of metal pollution is assessed in terms of seven contaminant categories based on increasing value of index as follow: \( I_{geo} \leq 0 \) means unpolluted, \( 0 < I_{geo} < 1 \) means moderately polluted, \( 1 < I_{geo} < 2 \) means moderately polluted, \( 2 < I_{geo} \leq 3 \) means moderately to strongly polluted, \( 3 < I_{geo} < 4 \) means strongly polluted, \( 4 < I_{geo} \leq 5 \) means very strongly to very strongly polluted, and \( I_{geo} > 5 \) means very strongly polluted.

### 2.4.5. The Potential Ecological Risk Index (RI)

Ecological Risk Index was originally introduced by Hakanson (1980) to assess the degree of heavy metal pollution in water environment, according to the toxicity of metals and the response of the environment. It has however been successfully used for quality assessment of heavy metals in soil and sediment (Aktaruzzaman, 2014). RI could evaluate ecological risk caused by toxic metals comprehensively. RI is the potential ecological risk caused by the overall contamination. The calculating method of RI is shown below (Aktaruzzaman, 2014):

\[ F_i = C_{i}^{(n)} / C_{o} \]

\[ E_{i}^{r} = T_{i}^{r} \times F_{i} \]

\[ RI = \sum_{i=1}^{n} E_{i}^{r} \]

Where:

- \( F_{i} \) is the single metal pollution index; \( C_{i} \) is the concentration of metal in the samples; \( C_{o} \) is the reference value for the metal; \( E_{i}^{r} \) is the monomial potential ecological risk factor; \( T_{i}^{r} \) is the metal toxic response factor.

The \( T_{i}^{r} \) values for each element are in the order: Zn = 1 < Cr = 2 < Cu = Ni = Pb = 5 < As = 10 < Cd = 30. The categories of \( E_{i}^{r} \) and RI are shown in Table 1:
3. Results and Discussions

Results of heavy metal distribution in both top and sub-soils in the four mechanic villages are presented in Table 2.

The distributions of the seven heavy metals investigated in the top soil (0-15 cm) depicted is LI, while sub-soil (15-30 cm) is depicted as LII. The pH values in all villages for both top and sub soil, showed slightly acidic condition except for Sagamu top soil, which was neutral. The pH influences the mobility of metals in soil environment. Most of the metals concentration were higher in top soil than sub soil, this indicates that the metals are most probably sourced anthropogenically (automobile repair services) and the concentration was observed to decrease with the depth of the soil. This trend may be largely due to the higher ease of the metal to infiltrate down the soils in the mechanic villages. Except for Fe, the result generally showed decreasing trend of heavy metal abundance down the soil profile.

However, the concentration of Fe in Obada and Sagamu mechanic villages (Table 2) were found higher in sub soil than top soil. This observation could imply that there is possibly other source(s) of the Fe in the geosphere. Therefore, it may be safe to infer that heavy metals in the four mechanic villages investigated are both of natural geology or the process of weathering and (anthropogenic) deposition from poor waste management practices in the mechanic villages. Generally, the concentrations of heavy metals soil (top and sub layers) in the four mechanic villages are well

Table 1. Grades of Single and Overall Ecological Potential Risk

<table>
<thead>
<tr>
<th>$E_i^r$</th>
<th>Single Ecological Potential Risk</th>
<th>RI</th>
<th>Overall Ecological Potential Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;40</td>
<td>Low ecological potential risk</td>
<td>&lt;90</td>
<td>Low ecological potential risk</td>
</tr>
<tr>
<td>40&lt;$E_i^r$&lt;80</td>
<td>Moderate ecological potential risk</td>
<td>90&lt;$E_i^r$&lt;180</td>
<td>Moderate ecological potential risk</td>
</tr>
<tr>
<td>80&lt;$E_i^r$&lt;160</td>
<td>Considerable ecological potential risk</td>
<td>180&lt;$E_i^r$&lt;360</td>
<td>Strong ecological potential risk</td>
</tr>
<tr>
<td>160&lt;$E_i^r$&lt;320</td>
<td>High ecological potential risk</td>
<td>360&lt;$E_i^r$&lt;720</td>
<td>Very strong ecological potential risk</td>
</tr>
<tr>
<td>&gt;320</td>
<td>Significant very ecological potential risk</td>
<td>&gt;720</td>
<td>Highly strong ecological potential risk</td>
</tr>
</tbody>
</table>

Table 2. Descriptive Statistics of the Concentration of the Metals in the Mechanic Villages Soil

<table>
<thead>
<tr>
<th></th>
<th>Campsite</th>
<th>Kobape</th>
<th>Obada</th>
<th>Sagamu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean*</td>
<td>SD</td>
<td>SEM</td>
<td>CONTR</td>
</tr>
<tr>
<td>Pb</td>
<td>LI 261</td>
<td>120</td>
<td>51.2</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>LII 193</td>
<td>83</td>
<td>33.9</td>
<td>111</td>
</tr>
<tr>
<td>Ni</td>
<td>LI 18.9</td>
<td>9.1</td>
<td>3.72</td>
<td>13.9</td>
</tr>
<tr>
<td></td>
<td>LII 12.4</td>
<td>6.4</td>
<td>2.61</td>
<td>13.2</td>
</tr>
<tr>
<td>Cd</td>
<td>LI 17.7</td>
<td>11</td>
<td>10.1</td>
<td>1.33</td>
</tr>
<tr>
<td></td>
<td>LII 1.13</td>
<td>0.41</td>
<td>0.03</td>
<td>1.33</td>
</tr>
<tr>
<td>Fe</td>
<td>LI 3200</td>
<td>300</td>
<td>155</td>
<td>1120</td>
</tr>
<tr>
<td></td>
<td>LII 2700</td>
<td>200</td>
<td>97.1</td>
<td>520</td>
</tr>
<tr>
<td>Cu</td>
<td>LI 79.8</td>
<td>13</td>
<td>19.9</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>LII 35.9</td>
<td>17</td>
<td>7.22</td>
<td>16.0</td>
</tr>
<tr>
<td>Cr</td>
<td>LI 64.0</td>
<td>35</td>
<td>27.9</td>
<td>67.8</td>
</tr>
<tr>
<td></td>
<td>LII 35.2</td>
<td>29</td>
<td>30.3</td>
<td>55.0</td>
</tr>
<tr>
<td>Zn</td>
<td>LI 10.8</td>
<td>6.0</td>
<td>2.43</td>
<td>4.29</td>
</tr>
<tr>
<td></td>
<td>LII 8.79</td>
<td>3.4</td>
<td>1.39</td>
<td>4.01</td>
</tr>
<tr>
<td>pH</td>
<td>LI 6.9</td>
<td>0.31</td>
<td>1.02</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>LII 6.7</td>
<td>0.26</td>
<td>0.92</td>
<td>6.8</td>
</tr>
</tbody>
</table>

*N.B: LI - top soil layer (0-15 cm), LII- sub soil layer (15-30 cm), Control samples, SD- Standard deviation, SEM- Standard error mean, MAL- maximum allowable limit, mg/L is the unit for the mean of all metals except pH*
above their corresponding levels in control samples. This reflects contribution of mechanic villages to the metal load which can lead to varying degree of contamination in the environment and consequently public health hazard.

Table 3 compares the level of metals investigated in the mechanic villages with some international standards. The concentration of Pb observed in this study was found above all the permitted limits as shown in Table 3, except that of United State Environmental Agency (US EPA, 1996). Cd in campsite MV was also observed higher than the Canadian standards. Except for permissible limit from Germany, the copper levels in all the mechanic villages investigated were found within the limit of all other international standards.

The EF values for the four MV are shown in Table 4. By using Fe as a normalizing element, all the mechanic villages showed EF >1.5 for Cu and Pb (except at Obada MV). This indicates a significant contribution of Cu and Pb from non-natural or anthropogenic sources, thus suggesting the impact of the automobile repair works on the environment. However, except for Cd at Campsite MV, all the sampling sites exhibited EF values lower than 1.5 for Cr, Cd, Ni and Zn indicating input from natural sources which may include weathering processes and geological formation of the environment.

The pollution index (P_i) variability analysis (Table 5) indicates significant spatial variation of metal pollution with respect to depth across the mechanic villages. The order of the metals pollution potential is as follows: Campsite, Pb> Cd> Zn> Cu> Fe> Ni> Cr; Kobape, Pb> Cu> Fe>Zn> Ni; Obada, Cu> Cr> Pb; Sagamu, Cd and Sadamu, Pb> Cu> Fe> Ni> Cr> Cd and Sagamu, Pb> Cu> Fe> Ni> Cr> Zn> Cd. Metals with the highest pollution potentials are Fe, Pb and Cd. The P_i variability-

### Table 3. Comparison between Concentration of Metals in the Mechanic Villages and Various Standards around the World

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>Austria</th>
<th>Germany</th>
<th>France</th>
<th>Sweden</th>
<th>Spain</th>
<th>Canada</th>
<th>Great Britain</th>
<th>EPA*</th>
<th>Campsite MV</th>
<th>Kobape MV</th>
<th>Obada MV</th>
<th>Sagamu MV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>0.4</td>
<td>1.0</td>
<td>5.0</td>
<td>3.0</td>
<td>85</td>
<td>9.42</td>
<td>3.08</td>
<td>1.63</td>
<td>1.58</td>
</tr>
<tr>
<td>Cu</td>
<td>100</td>
<td>50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>100</td>
<td>-</td>
<td>57.9</td>
<td>59.2</td>
<td>128</td>
<td>48.0</td>
</tr>
<tr>
<td>Ni</td>
<td>50-70</td>
<td>100</td>
<td>50</td>
<td>30</td>
<td>30</td>
<td>-</td>
<td>50</td>
<td>75</td>
<td>15.7</td>
<td>17.1</td>
<td>25.5</td>
<td>23.8</td>
</tr>
<tr>
<td>Pb</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>40</td>
<td>40</td>
<td>200</td>
<td>100</td>
<td>400</td>
<td>227</td>
<td>214</td>
<td>249</td>
<td>341</td>
</tr>
<tr>
<td>Zn</td>
<td>300</td>
<td>300</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>300</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Lacatusu, 1998; USEPA, 2008; USDA 2000

The high concentration of Pb observed across the four mechanic villages can be attributed to many activities leading to direct and uncontrolled discharge of leaded fluids and waste onto bare soil. Gasoline used in Nigeria is still largely leaded and remains the primary fluid at mechanic workshops in the country. Frequent release of huge emissions from automobile exhausts in the workshops is also a major contributor to high Pb concentration.

The degree of pollution in the study areas was revealed using geo-accumulation index as computed in Table 4. Going by the classification of I_{geo} (Mediolla, 2008), the degree of pollution in the four mechanic villages varied between moderately polluted and strongly polluted in respect of Copper and Lead, particularly, in Sagamu and Obada MVs. Cadmium was only moderately polluted in Campsite and Kobape MVs, while Zn was moderately polluted in all MVs except Sagamu MV. However, all mecha-

### Table 4. Metal Enrichment Factor (EF) and Geo Accumulation Index (I_{geo}) of Four Mechanical Villages

<table>
<thead>
<tr>
<th>Metals</th>
<th>Campsite MV</th>
<th>Kobape MV</th>
<th>Obada MV</th>
<th>Sagamu MV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EF</td>
<td>I_{geo}</td>
<td>EF</td>
<td>I_{geo}</td>
</tr>
<tr>
<td>Pb</td>
<td>5.3</td>
<td>1.23</td>
<td>1.79</td>
<td>0.61</td>
</tr>
<tr>
<td>Cu</td>
<td>2.2</td>
<td>1.44</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Cr</td>
<td>0.3</td>
<td>-0.9</td>
<td>0.3</td>
<td>0.62</td>
</tr>
<tr>
<td>Cd</td>
<td>4.6</td>
<td>1.7</td>
<td>1.3</td>
<td>1.31</td>
</tr>
<tr>
<td>Ni</td>
<td>0.5</td>
<td>0.17</td>
<td>0.7</td>
<td>0.63</td>
</tr>
<tr>
<td>Zn</td>
<td>0.9</td>
<td>1.2</td>
<td>0.5</td>
<td>1.35</td>
</tr>
</tbody>
</table>

The pollution index (P_i) variability analysis (Table 5) indicates significant spatial variation of metal pollution with respect to depth across the mechanic villages. The order of the metals pollution potential is as follows: Campsite, Pb> Cd> Zn> Cu> Fe> Ni> Cr; Kobape, Pb> Cu> Fe>Zn> Ni; Obada, Cu> Cr> Pb; Sagamu, Cd and Sadamu, Pb> Cu> Fe> Ni> Cr> Zn> Cd. Metals with the highest pollution potentials are Fe, Pb and Cd. The P_i variability-
ty analysis shows that Pb and Cd concentrations in Camps-
site MV soil deviate most significantly from the control
value and indicates a very high pollution potential due to
the metals. The pollution potential as measured in Pi of all
metals investigated in the four mechanic villages was
significant except for Cr in Campsite and Kobape MVs as
well as Cd in Sagamu MV. This may indicate that there is
additional source of these metals in the environment which
may include the geological format-ion of the area.

The pollution classification index for the four mechanic
villages as shown in Table 5 revealed wide range of pollu-
tion classifications. Apart from Cd that showed Pc values<
1.0 in Campste, Obada and Kobape MVs (contamination
status), other metals in all MVs had Pc> 1.0 reflecting
pollution status of the soils in the mechanic villages.

However, the pollution status vary from excessive (>16.0),
severe (8.1-16.0) to moderate (1.0-8.0). Fe and Cr showed
excessive pollution throughout the MVs while Cu had severe pollution in Campsite, Obada and Kobape MVs.
The PC of other metals showed moderate pollution.

The potential ecological risk assessment result of the
mechanic villages is presented in Table 6. The average
mono-mial ecological risk (Ei) for all metals investigated
posed low risk (<40) except for Pb and Cu in Sagamu MV
and Obada MV respectively, with moderate risk on the
environment. The overall ecological potential risk indices
(RI) in soil of Campsite, Kobape and Obada MVs were
below risk level. However, RI value of Sagamu MV
indicated moderate risk the automobile repair works posed
on the surrounding ecosystem. The moderate potential eco-
logical risk in the Sagamu Mechanic Village could be
traced to the high concentration of Pb and Cu in the study
area. This observation is at variance the result reported by
Fatoba et al (2012), in which Cd play a major role in

4. Conclusion and Recommendations

The four mechanic villages investigated show elevated
levels of Pb, Fe, Cd and Cu in comparison to their control
values; this shows the impact of the automobile repair activ-
ties on the environment and an indication of threat, the
automobile repair works pose to public health. The
enrichment factor (EF) reveals significant contribution of
Cu and Pb, followed by Cd pollution in the study area and
are of anthropogenic source. The overall ecological risk
assessment (RI) puts Sagamu with the highest value
(131.5) as moderate ecological risk area, followed by

Table 5. Pollution Index and Pollution Classification in the Soil of Four Mechanical Villages

<table>
<thead>
<tr>
<th></th>
<th>Campsite</th>
<th>Kobape</th>
<th>Obada</th>
<th>Sagamu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pi</td>
<td>8.46</td>
<td>6.59</td>
<td>4.53</td>
<td>15.6</td>
</tr>
<tr>
<td>PC</td>
<td>31.7</td>
<td>29.1</td>
<td>45.1</td>
<td>21.2</td>
</tr>
<tr>
<td>Pb</td>
<td>7.60</td>
<td>2.58</td>
<td>1.29</td>
<td>1.97</td>
</tr>
<tr>
<td>Ni</td>
<td>3.92</td>
<td>3.33</td>
<td>5.14</td>
<td>4.34</td>
</tr>
<tr>
<td>Cd</td>
<td>3.22</td>
<td>3.73</td>
<td>8.09</td>
<td>1.94</td>
</tr>
<tr>
<td>Fe</td>
<td>1.14</td>
<td>2.67</td>
<td>2.02</td>
<td>2.04</td>
</tr>
<tr>
<td>Cu</td>
<td>6.38</td>
<td>3.57</td>
<td>4.79</td>
<td>3.13</td>
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<tr>
<td>Cr</td>
<td>1.80</td>
<td>0.98</td>
<td>1.97</td>
<td>1.94</td>
</tr>
<tr>
<td>Zn</td>
<td>4.36</td>
<td>2.67</td>
<td>2.33</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Table 6. Heavy Metal Ecological Potential Risk Indices in Soil of Mechanic Villages

<table>
<thead>
<tr>
<th>Mechanic Villages</th>
<th>Monomial Ecological Risk For Single Metal Ei</th>
<th>RI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pb</td>
<td>Ni</td>
</tr>
<tr>
<td>Campsite</td>
<td>17.7</td>
<td>5.8</td>
</tr>
<tr>
<td>Kobape</td>
<td>7.10</td>
<td>7.7</td>
</tr>
<tr>
<td>Obada</td>
<td>18.7</td>
<td>21.0</td>
</tr>
<tr>
<td>Sagamu</td>
<td>74.1</td>
<td>10.6</td>
</tr>
</tbody>
</table>

The most vulnerable communities are those in the vicinity-
es of the mechanic villages that depend on surrounding
waters (streams, wells) for their source of water, and farm-
land for their farming activities. There is an urgent need
for intensive public enlightenment on severe health implic-
ations of uncontrolled discharge of heavy metal laden
waste onto the environment. The government relevant
agencies in charge of maintaining the environment need to
step up policies to ensure sustainable environment. There
is a need of environmental education and trainings for the
automobile repair workers on how to dispose the automob-
ile wastes in an environmental friendly manner, thereby
ensuring environmental protection and safety of human
health. The campaign of reduce; recycle and reuse will go
a long way preserving our environment. The need for a
comprehensive waste management plan for mechanic villages in Nigeria cannot be overemphasized.

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References


