Studies on the Impact of Municipal Waste Dumps on Surrounding Soil and Air Quality of Two Cities in Northern Nigeria

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Abstract: Atmospheric pollution from municipal refuse dumps and vehicular traffic are matters of growing interest, often leading to temporary restrictions in urban areas. This study aimed at evaluating bioaccumulation and effects caused by airborne pollutants from refuse dumps. Specimens of the moss Funaria capsularis collected in five sites in the urban areas of Zaria and Kaduna, Nigeria and trace metals (cadmium, chromium, copper, iron, lead and zinc) were measured. The overall results of this exploratory study suggest the utility of F. capsularis as a lower plant for biomonitoring the environmental impact of atmospheric pollution in urban areas. The impact of these dump sites on surrounding soils was also studied.

Key words: Air pollution, municipal dumps, Vehicular exhausts, bioaccumulation

INTRODUCTION

The amount and variety of waste material have increased with the growing of technology and population. Increased vehicular traffic and emissions from refuse dumps are major contributors to air pollution and a matter of growing importance in many city centres. Of the priority pollutants, heavy metals cause adverse effects on the environment. Normative limits and international guidelines indicate the maximum levels for a number of individual pollutants in air samples. However, no restrictions have yet been given in many Nigerian cities. Municipalities have often suffered from smoke emanating from refuse dumps, which makes air quality sometimes very low.

There are numerous human activities which result in the release of toxic materials to the atmosphere. The identity of these sources has been established in most cases but their quantitative importance is rarely determined. For example, Okuo and Ndiokwere (2005) reported that in Warri (south-south Nigeria), the major sources of elemental pollution were due to re-entrained soil, automobile exhaust, residual oil combustion, petroleum activities, refuse and biomass incineration.

Indiscriminate dumping of refuse can influence soil physicochemical properties, but can still be used for farming provided the risks associated with its usage are continuously assessed and controlled. The introduction of metal contaminants into the environment could result from various sources; a few of which are application of sewage materials and leaching of garbage (Forstner and Wittmann, 1983). The impact on man would be felt if these metals enter into the food chain and accumulate in living organism (Moore and Ramamoorthy, 1984; Altundag and, 1998).

Waste handling facilities are lacking in many highly populated areas in most developing and under developed countries due to cost and lack of proper planning. This results in the discharge of household sewage and refuse into the environment untreated. Most waterways passing through urban centre are used as dump sites with open gutters leading from household direct to the waterways. A lot of toxic materials are leached by rain into soil and waterways from such dump sites. Waste amended soils have been reported to have high organic matter content (Anikwe, 2000). Soil organic matter influences the degree of aggregation and aggregate stability and it can reduce bulk density and increase total porosity and hydraulic conductivity in heavy clay soils (Anikwe, 2000).

Continuous disposal of municipal wastes in soil may increase heavy metal concentration. Heavy metals may have harmful effect on soils, crops and human health (Smith et al., 1996). However, Voutsas et al. (1996) maintain that there is generally not strong relationship between the concentration of heavy metals in soils and plants, because it depends on many factors such as soil metal bioavailability, plant growth and metal distribution to plants parts.

In contrast to automatic monitoring techniques, the study of bioindicator organisms can reveal the biologic impact of pollution over a geographical and temporal scale, depending on the selected species and approach.

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In this study mosses and lichens have been recognized as suitable biomonitors or bioaccumulators for air pollution (Bargagli, 1998; Bargagli et al., 2002) and terrestrial invertebrates are used for monitoring air and soils (Dallinger, 1994; Bambose et al., 2005). In this study a moss F. capsularis was used to monitor trace metal pollution resulting from burning refuse dumps in the Zaria, Nigeria.

MATERIALS AND METHODS

Collection and treatment of samples: This study was carried out in the city of Zaria and Kaduna in northern Nigeria, where five locations were chosen in each case. Four dump sites were sampled in Zaria and another four dump sites from Kaduna. In each of these sites composite samples of soils were collected seven meters within the vicinity of the dump sites (K<sub>1</sub>, K<sub>2</sub>, K<sub>3</sub>, K<sub>4</sub>, Z<sub>1</sub>, Z<sub>2</sub>, Z<sub>3</sub>, Z<sub>4</sub>). Soil samples were also collected from uncontaminated areas in Zaria and Kaduna. The samples were air-dried, ground and sieved using 300 μm sieve. The moss plants identified as Funaria capsularis at the Biological Sciences Department, Ahmadu Bello University, Zaria, Nigeria, were collected from buildings near four major roads Zaria. Control samples were also collected from uncontaminated sites, which are essentially residential. They were scooped with plastic spoon and transferred into polythene bags. The samples were rinsed first with tap water and then with distilled water to remove any attached soil particles. They were then air-dried, ground and stored for analysis.

Chemical analysis: The soil and moss samples were digested by standard methods described in Awofolu (2005). The digested samples were analyzed for metals (cadmium, copper, iron, lead and zinc) using Atomic Absorption Spectrophotometer (SOLAR 32) at the chemistry laboratory of National Research Institute for Chemical Technology, Zaria, Nigeria and expressed as micrograms per gram dry weight. The Cation Exchange Capacity (CEC) was determined and calculated using method described by Agbeni (1995).

RESULTS AND DISCUSSION

The values obtained for the different dumpsite samples in Kaduna were varied. In all the cases the pH of the dump sites were found to be higher than pH of the control site. Of the dump sites analyzed, K<sub>4</sub> had the highest pH (Table 1). The pH of soil samples collected in the vicinity of the dump sites were also found to be higher than that obtained for the control site. The pH of soil affects all soil its properties i.e., chemical, physical and biological (Brady and Weil, 1999). Even though the pH of soil may be dependent on several factors such as chemical activities taking place in it, it appears that leaching or runoff from these dump sites could have contributed to the relatively higher pH observed in these soil samples (Table 1). This means that dump sites could impact on the characteristics of soil in close proximity to them, which in turn affect plant growth because pH has been widely accepted as exerting a controlling influence on the availability of micro-nutrients to plant (Sanders, 1982). The increase in pH of the dump sites may be because of high organic matter which tend to buffer the soil by preventing excessive pH changes due to release of exchangeable cations during mineralization of organic matter (Woomer et al., 1994).

Organic matter is the reservoir of essential and non-essential elements for plant growth and development, hence increased organic matter may lead to increased soil productivity (Anikwe and Nwobodo, 2002). The control site had the lowest organic matter content of 1.96%, while the site K<sub>4</sub> had the highest organic matter content of 7.10% of all the dump sites investigated (Table 1). The organic matter content of the soils in the vicinity of these dump sites was found to be higher than that of the control sites. The high organic matter content of the dump sites may be attributed to the decaying municipal wastes. The relatively higher organic matter content in soils around the dump sites also gives an indication that the source of organic matter is the dumpsite. K<sub>4</sub> samples with the highest organic matter content also showed highest concentration for cadmium, copper, lead and iron, with the exception of zinc these metals are capable of being
Table 2: Pearson correlation coefficient metals and other parameters analyzed in soils (Kaduna)

<table>
<thead>
<tr>
<th>Metals</th>
<th>Soil pH</th>
<th>Soil organic matter</th>
<th>Cation exchange capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>0.98</td>
<td>0.78</td>
<td>0.91</td>
</tr>
<tr>
<td>Copper</td>
<td>0.89</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Lead</td>
<td>0.91</td>
<td>0.68</td>
<td>0.81</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.68</td>
<td>0.93</td>
<td>0.82</td>
</tr>
<tr>
<td>Iron</td>
<td>0.64</td>
<td>0.91</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Table 3: Pearson correlation coefficient metals and other parameters analyzed in soils (Zaria)

<table>
<thead>
<tr>
<th>Metals</th>
<th>Soil pH</th>
<th>Soil organic matter</th>
<th>Cation exchange capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>0.33</td>
<td>0.17</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>0.73</td>
<td>0.82</td>
<td>0.72</td>
</tr>
<tr>
<td>Lead</td>
<td>0.98</td>
<td>0.72</td>
<td>0.65</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.81</td>
<td>0.94</td>
<td>0.91</td>
</tr>
<tr>
<td>Iron</td>
<td>0.77</td>
<td>0.99</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Table 4: Heavy metal concentration in Funaria capsularis (μg g⁻¹)

<table>
<thead>
<tr>
<th>Sites</th>
<th>Cd</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁</td>
<td>0.0487</td>
<td>1.3781</td>
<td>0.1151</td>
<td>1.0498</td>
<td>0.9153</td>
</tr>
<tr>
<td>M₂</td>
<td>0.0246</td>
<td>1.3856</td>
<td>0.9560</td>
<td>0.9826</td>
<td>0.8515</td>
</tr>
<tr>
<td>M₃</td>
<td>0.0362</td>
<td>1.4092</td>
<td>0.1092</td>
<td>1.2361</td>
<td>0.5827</td>
</tr>
<tr>
<td>M₄</td>
<td>0.0101</td>
<td>1.0267</td>
<td>0.0986</td>
<td>1.5782</td>
<td>0.0005</td>
</tr>
<tr>
<td>Control</td>
<td>0.0000</td>
<td>0.0726</td>
<td>0.0026</td>
<td>0.0098</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

The organic matter content of the control site was the lowest (3.44%) while that of Z₁ was the highest (7.40%) (Table 1). The highest and lowest values here were also higher than the values obtained for sites in Kaduna. The organic matter content of the control site was higher than that of Z₁, which shows that the soil at the control site had a higher concentration of organic matter compared to the sample sites. The high organic matter content of the control site may be attributed to the use of the soils for dumping of municipal wastes. Site Z₁, with the highest organic matter content also showed highest concentration of Cu, Pb, Zn and Fe with the exception of Cd. This contrasts site K₁, with highest organic matter showing highest concentration of all metals analyzed with the exception of Zn. Organic matter showed high positive correlation with all metal analyzed in the soils with exception of Cd, which showed low correlation (Table 3).

The results of the study showed that Cation Exchange Capacity (CEC) had highest value in site Z₁ (28.00 emol kg⁻¹) while control site had the lowest value with 10.20 emol kg⁻¹ (Table 1). The higher value obtained in the soil collected in the vicinity of the dumpsite compared to the control sites may be a result of the effect of dumpsite has on it. The highest value of CEC obtained in Z₁ was not unexpected because soils with high pH and high humus content also have high CEC (Brady and Weil, 1999). This is result is similar to that obtained for site K₁, where the high CEC showed high concentration of all metals except Zn.

The result obtained in the analysis Funaria capsularis revealed the presence of cadmium, lead, zinc, copper and iron in the samples (Table 4). Cadmium concentration were found to be 0.0487, 0.0246, 0.0326, 0.0101 and 0.0000 μg g⁻¹ for sites M₁, M₂, M₃, M₄ and the control site, respectively. The highest value of 0.0487 μg g⁻¹ was obtained from site M₁, while 0.0000 was obtained as the lowest concentration from the control site. The values obtained from M₁, M₂, M₃ and M₄ were higher than the 0.005 μg g⁻¹ limit given by USEPA (1993), but lower than 1 μg g⁻¹ limit by EFPA (1991) and 1-3 μg g⁻¹ limit by EC Council (1986) directive 86/278/EC. The values were lower when compared with the range of 0.10-0.58 given by Sardans and Penuelas (2005) in a similar study using the moss Hypnum cupressiforme.
The result showed copper concentration of 1.3781, 1.3856, 1.4092, 1.0267 and 0.0726 μg g⁻¹ for sites M₄, M₂, M₃ and M₄ and the control site, respectively. 1.4092 μg g⁻¹ was obtained here as the highest concentration from site M₄ with 0.0726 μg g⁻¹ was obtained as lowest from the control site. The concentration in sites M₁, M₂, M₃ and M₄ were higher than the 1 μg g⁻¹ limits by USEPA and FEPA, but lower than the 5-10 μg limits by EC Council directive 86/278/EEC. The values were lower than the 20-115 μg g⁻¹ range given by Sardans and Penuelas (2005) in a study in which the Moss Hypnum cupressiforme was used.

Lead concentration were found to be 0.1151, 0.9560, 0.1092, 0.0986 and 0.0025 μg g⁻¹, respectively for sites M₁, M₂, M₃, M₄ and the control sites. The highest value of 0.9560 μg g⁻¹ was obtained from M₁, while the lowest concentration of 0.0025 μg g⁻¹ was obtained from the control site. The values obtained were higher than zero limited given by USEPA, but lower than the 1 μg g⁻¹ limit given by FEPA. The values obtained here were lower than the 5-57 μg g⁻¹ range given by Sardans and Penuelas (2005) in a study using the moss Hypnum cupressiforme. The high level of lead may be as a result of the busy nature of the road.

Zinc concentration was found to be 1.0498, 0.9826, 1.2361, 1.5782 and 0.0098 μg g⁻¹ for site M₁, M₂, M₃ and M₄ and the control site, respectively. The highest concentration of 1.5782 μg g⁻¹ was obtained from M₁, while the lowest of 0.0098 μg g⁻¹ was obtained from the control site. The values for M₂, M₃ and M₄ were all higher than 1 μg g⁻¹ limit by FEPA, but lower than the 5 μg g⁻¹ limit by USEPA. The values obtained here were lower than the 30-180 μg g⁻¹ range given by Sardans and Penuelas (2005) in a study using the moss Hypnum cupressiforme.

Iron concentration was found to be 0.9153, 0.8451, 0.5682, 0.6281 and 0.0005 μg g⁻¹ for sites M₁, M₂, M₃ and M₄ and control site, respectively. The highest value of 0.9153 was obtained from site M₁ while the control site had the lowest with 0.0005 μg g⁻¹. The value obtained in sites M₂, M₃ and M₄ were higher than the 0.3 μg g⁻¹ limit by USEPA, but lower than 20 μg g⁻¹ limit given by FEPA.

**CONCLUSIONS**

The result revealed that all the sites had values of soil pH, soil organic matter and cation exchange capacity higher than the ‘unpolluted sites’. The level of cadmium, copper, lead and iron obtained in some sites were above the limits given by some international environmental protection agencies, but the levels of zinc obtained were less than these limits. The result also revealed that the constant burning of these dump sites could contribute significantly to the concentration of these trace metals in the environment and this could possibly enter into the food chain as revealed by the high concentration observed in Fumaria capsularis.

**REFERENCES**


