Physicochemical and Heavy Metals Characteristics of Soil from Three Major Dumpsites in Ilorin Metropolis, North Central Nigeria

1,4* SHEHU-ALIMI, E; 2 ESOSA, I; 3 GANIYU, BA; 3 OLANREWAJU, S; 1 DANIEL, O

1Department of Chemistry, Delaware State University. Dover, DE. USA.
2Department of Environmental Science & Policy. Wilmington University, New Castle. DE. USA.
3Department of Civil Engineering. California State University, Los Angeles, CA. USA
4Department of Chemistry University of Ilorin, P.M.B. 1515. Ilorin Nigeria.
*Corresponding Author Email: selelu@desu.edu

ABSTRACT: Impact of waste disposal and management is a worldwide phenomenon leading to health impact most especially in underdeveloped and developing world. This study was undertaken to assess the major contaminants in some municipal waste disposal sites and the prospective impact to the surrounding domestic water supply source as well as the impact on the health of the people in the city. This is carried out by studying various physico-chemical parameters of soil which were collected from three municipal dump locations namely; Iita-Amodu, Sawmill garage and Kuntu areas in Ilorin metropolis, Kwara State Nigeria. The geochemistry of the dumpsites were studied with respect to important parameters such as pH, electrical conductivity, temperature, sulphates, chlorides, nitrates, moisture content, organic matter and heavy metals having the following constituents present in its composition- Cadmium (Cd), Lead (Pb), Zinc (Zn), Iron (Fe), and Copper (Cu). The study revealed that the three different soils samples ("A) Iita-Amodu," "B) Sawmill Garage", and "C) Kuntu") have pH of 7.1, 7.2 and 6.8, respectively. Temperature of 24.2, 26.4, and 28.0 °C, Organic matter compositions of 0.95%, 0.73%, and 1.14%. The Moisture contents were 3.93%, 2.89%, and 3.48% respectively. The chloride contents of the samples was found to be 31.76 mg/L, 48.98 mg/L, and 91.63 mg/L, while nitrates were found to be 0.10 mg/L, 0.06 mg/L and 0.23 mg/L, with a sulphate values of 1.96 mg/L, 2.35 mg/L, and 2.14 mg/L. The conductivities were 1.79 μs/cm, 2.23 μs/cm, and 1.15 μs/cm respectively. Heavy metal analysis from the waste soil were found to contained copper (Cu) - 0.516 mg/L, 0.62 mg/L, and 0.048 mg/L), Lead (Pb) - 0.063 mg/L, 0.07 mg/L, and 0.056 mg/L), and iron (Fe) - 0.518 mg/L, 0.62 mg/L, and 0.190 mg/L.

DOI: https://dx.doi.org/10.4314/jasem.v24i5.6

Copyright: Copyright © 2020 Shewu-Alimu et al. This is an open access article distributed under the Creative Commons Attribution License (CCL), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Dates: Received: 17 March 2020; Revised: 19 April 2020; Accepted: 23 April 2020

Keywords: Dumpsites, Heavy metals, Ilorin, Moisture contents, Nitrates.

Anthropogenic activities within a society generate large quantities of wastes problems for disposal. Improper disposal leads to unhygienic conditions which further leads to diseases spreading. The municipal solid waste (MSW) is heterogeneous in nature and contains paper, plastic, metal, glass, ash and compostable matter. In addition, other substances like scrap materials, waste papers, dead animals, improperly discarded chemicals, paints, hazardous hospital waste and agricultural residue are also categorized under MSW (Lauber, 2005). This solid waste disposal pose a serious health risk and concerns to the environment, as well as burning of these solid wastes creates heavy smoke and dust pollution. On inhalation, this results in various respiratory problems among the habitats (The Indian Express, Pune 2006). According to Anikwe and Nwobodo (2001), municipal wastes increase the nitrogen, pH, cation exchange capacity, percentage base saturation and organic matter.

Organic waste can provide nutrients for increased plant growth, and such positive effect will likely encourage continued land application of these wastes (Anikwe and Nwobodo, 2001; Nyles and Ray 1999). However excessive waste in soil may increase heavy metal concentration in the soil and underground water. Heavy metals may have harmful effects on soils, crop and human health (Nyle and Ray 1999; Smith et al., 1996). Consequently, the management of our environment and control of discharge of waste products from anthropogenic activities is of high interest to researchers, regulatory bodies, environmental advisory agencies and policy-makers all over the world. Rapid urbanization, industrialization and population growth have been the major causes of stress on the environment leading to...
problems like human health problems, eutrophication and fish death, coral reef destruction, biodiversity loss, ozone layer depletion and climatic changes (Bay et al., 2003; Sadiq, 2002).

Determination of adverse effects of various elements upon human health and our ecosystem has been gaining momentum recently. Hence, there is a presumption that sound scientific data base is needed to define maximum exposure levels of specific chemical compounds of health implications (Fortner and Wittman, 1983). Ilorin is the state capital of Kwara-State, Nigeria it is an industrial and commercial center of the state with a population of over 4 million people to have generates the major deposits of both domestic and industrial waste in the state. These waste products are dumped in landfill untreated, posing environmental risks to life in the areas as shown in figure 1. Landfill is a practice adopted as a substitute to ocean outfall of sewage, domestic and industrial waste, after the outlawing and termination of the latter due to its effects on the lives in the ocean.

\[ pH \text{ has a scale of value ranging from 1 to 14 where} \]
\[ \text{a solution from pH 1-6.9 is considered acidic and a solution from PH 7.1 – 14 is alkaline while 7 is a neutral pH (Convingto A.K. 1985). The pH of the samples was 7.10, 7.21 and 6.8 respectively. These were found to be favorable as pH of water around 4.0 – 4.5 has been reported to be dangerous for human life (ACS 1969). pH which is at par with others reported in the literature (Abu-Rukah and Al-Kafahi, 2001; Keimowitz, 2005; Futta et al., 1997). This agrees with the postulate that the pH of leachate increases with landfill age (Futta et al., 1997) which is probably due to the fact that leachates have, to a large extent, witnessed washing-away by rainfall or percolated over time into the soil. However, the pH distribution of soil affects the availability, retention and mobility of metals with increasing pH (Itanna, 1998; Bhattacharya et al., 2002). The pH levels that are acidic tend to have an increased micronutrient solubility and mobility as well as increased heavy metal concentration in the soil, thus rendering the soil unsuitable for waste land filling. And the value falls with the range by WHO; 6.5 – 8.5. Elevated pH values can indicate potential losses of nitrate and subsequent water contamination. The tendency for soil acidification can suggest insufficient use of ammonia fertilizers and increased leaching losses (Smith and Doran 2006).}

\[ \text{The organic matter: Is the reservoirs of essential and} \]
\[ \text{non-essential elements for plants growth and developments, hence increased organic matter may} \]
\[ \text{increase soil productivity (Anikwe and Nwobodo 2002) The organic matter of the samples were found} \]
\[ \text{to be0.95, 0.73 and 1.14%. The relative organic matter} \]

\[ \text{Results and Discussion: The result of physicochemical properties of the leachate samples is presented in Table 1. The analysis of the samples collected reveals some level of compliance with regulated standards and the significant deviations were equally noticed.} \]

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Soil Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>A</td>
</tr>
<tr>
<td>pH</td>
<td>7.10</td>
</tr>
<tr>
<td>Conductivity (µS/cm)</td>
<td>1.79</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>3.93</td>
</tr>
<tr>
<td>Organic Matter (%)</td>
<td>0.95</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>24.2</td>
</tr>
<tr>
<td>Chlorides (mg/L)</td>
<td>31.76</td>
</tr>
<tr>
<td>Sulphates (mg/L)</td>
<td>1.96</td>
</tr>
<tr>
<td>Nitrates (mg/L)</td>
<td>0.10</td>
</tr>
</tbody>
</table>

\[ \text{Materials and method: Sample Collections: The soil-sample was taken from} \]
\[ \text{dumpsite located at Ita-Amudu, Sawmill garage and Kuntu areas, which are interior parts of Ilorin} \]
\[ \text{metropolis in Ilorin West Local Government, Kwara State, Nigeria. All the reagents used are of analytical} \]
\[ \text{grade.} \]

\[ \text{Physicochemical Analysis: The physico-chemical} \]
\[ \text{parameters determined from the samples are Moisture} \]
\[ \text{content (Dhyan et al., 1999), Temperature, Organic} \]
\[ \text{matter, Conductivity, pH, Chlorides, Sulphates,} \]

\[ \text{Nitrates, Heavy Metal analysis, detection and analysis} \]
\[ \text{of heavy metals ions such as Cu, Zn, Cd, Pb and Fe} \]
\[ \text{from the soil samples was carried out by standard} \]
\[ \text{procedure recommended by Ademoroti, 1996.} \]
of the soil samples may be attributed to the decay of the
dump waste. The organic matter values were
recorded to be 0.95, 0.73 and 1.14%. The lower
organic matter value was reported from the sample B
and higher organic matter value was reported from the
sample C. The higher organic matter content may be
due to decaying of plant

Moisture content: This is the soil water holding
capacity and it’s essential to the evaluation of regional
soil water balance (SWHC, 2005). The moisture
content of the samples were reported to be 3.93, 2.89
and 3.48% respectively, which correlate with the result
reported in the physicochemical analysis of soil from
Chorwad Hehsil-Bhusawal (Narkhede et al., 2011).
Soil water content in air dried samples and saturated
wet samples are given in table1 Soil texture greatly
influences water availability. The sandy soil can
quickly be recharged with soil moisture but is unable
to hold as much water as the soils with heavier
textures. As texture becomes heavier, the wilting point
increases because fine soils with narrow pore spacing
hold water more tightly than soils with wide pore
spacing (SRNF, 2007). The texture of soil on the basis
of water holding capacity was found to be Loam sandy

Electrical conductivity: is used to estimate the soluble
salt concentration in soil, and is commonly used as a
measure of salinity. Soil with EC below 400 µScm⁻¹ are
considered marginally or non-saline, while soils above
800 µScm⁻¹ are considered severely saline. Electrical
conductivity at dumpsite C was lowest (1.15 µScm⁻¹)
while it was highest at site B (2.23 µScm⁻¹). This
indicates that at site C movement of charge particles
are more than other two sites which is a good indicator
for the growth of plants. The electrical conductivity at
adjoining areas was higher than dumpsites (Table 1).
The EC result obtain correlates with that of (Tripathi
and Misra, 2012)

Chloride ion: concentrations of soil samples are given
in table 1. The chloride concentration ranges from
31.76, 48.98 and 91.63mg/kg of the soil. These results
are slightly below the optimal concentration range of
chlorides in most crops is between 1.0 to 100 mg Cl
/kg dry matter (Marschner, 1995). The negative effects
of higher chloride ion concentrations on crops are
common in coastal areas. The amount of chloride
found in plants varies with habitat because both the
external chloride concentration and the balance of
other available anions influence the content

Sulphate: (SO₄²⁻) values are observed from 1.96, 2.23
and 2.14 mg/l for the soil samples. Lower sulphate
values were recorded in the sample A and higher
sulphate value was recorded in the sample B. It may
be due to the addition fertilizers during the plantation
of crop and sowing of seeds.

Heavy Metal Concentration: Heavy metals are
elements having some atomic weight between 63.54
and 200.59, and a specific gravity greater than 4
(Kennish, 1992). Although trace amount of some
heavy metals are required by living organisms, any
excess amount of these metals can be detrimental to
the organisms (Berti and Jacobs, 1996). Metals also
have a high affinity for humic acids, organic clays,
and oxides coated with organic matter (Elliot et al., 1986;
Connell and Miller, 1984). The solubility of the metals
in soils and groundwater is predominantly controlled
by pH (Baker and Walker, 1990; McNeil and Waring,
1992; Henry, 2000), amount of metal and cation
exchange capacity (Martinez and Motto, 2000),
organic carbon content (Elliot et al., 1986) and the
oxidation state of mineral components as well as the
redox potential of the system (Connell and Miller,
2011). The results of the heavy metal
investigation in the landfill (Table- 2) show Cd and Fe
to be the most predominant metals in the landfill
(0.516, 0.620 and 0.048 mg/L; 0.518, 0.620 and
0.190mg/l), while Zn concentration was the lowest
(0.04, 0.009 and 0.066mg/L) while Cu and Pb were
found in considerable amounts in each of the soil
samples (0.03, 0.028 and 0.031; 0.063, 0.07 and
0.056mg/L) respectively. Pb, Cd and Zn are from
anthropogenic sources because of their high
correlation with measures of organic matter and their
high correlation with each other (Table 2).

Table 2: Concentration of metals (mg/kg) for soils in selected
dumpsites in Ilorin metropolis Kwara State, Nigeria

<table>
<thead>
<tr>
<th>Heavy metals</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>2.0</td>
<td>0.030</td>
<td>0.028</td>
</tr>
<tr>
<td>Zinc</td>
<td>3.0</td>
<td>0.040</td>
<td>0.009</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.003</td>
<td>0.516</td>
<td>0.620</td>
</tr>
<tr>
<td>Lead</td>
<td>0.01</td>
<td>0.063</td>
<td>0.070</td>
</tr>
<tr>
<td>Iron</td>
<td>0.005</td>
<td>0.518</td>
<td>0.620</td>
</tr>
</tbody>
</table>

*PL = permissible limits, mg/kg

Although metals are essential, at higher concentrations
they become toxic and present different problems to
soil microorganisms, because they cause oxidative
stress by formation of free radicals. They can also
replace essential metals in pigments or enzymes, thus
disrupting their function (Henry, 2000) and may
render the land unsuitable for plant growth and destroy the biodiversity.

**Conclusion:** This study indicates the level of contamination at the municipal waste dumpsites and explores the relationship between ranges of quantitative variables. The dumpsites were found to be heavily contaminated with heavy metals. Thus, open dumping of waste should be discouraged and proper monitoring and remediation plan is needed to reduce the chances of ground water pollution by leaching of contaminants. Presence of organic matter in dumpsite indicates that these soils have composting potential. The study provides indication of contamination at such open dumpsites and thus will be helpful in making any remediation plan for these contaminated sites. Artificial reclamation with mature soil is recommended for these sites.

**REFERENCE**


Bhattacharya, P; Arun BM; Gunnar J; Sune, N (2002). "Metal contamination at a wood preservation site: characterisation and experimental studies on remediation." *Sci. Total Environ.* 290: (1-3): 165-180


He, PJ; Xiao, Z; Shao, LM; Yu, JY; Lee, DJ (2006). In situ distribution and characteristics of heavy metals in fullscale landfill layers. *J. Hazard. Mater.* 137 (3), 1385–1394


Vanderlinden, K; Juan VG; Marc, VM ((2005)). Soil water-holding capacity assessment in terms of the average annual water balance in southern Spain. *Vadose Zone J.* 4 (2): 317-328


The Indian Express (2006). Pune Urali-Devach Fire Depot Kept Fire, 3