Heavy Metal Composition of Agricultural Soil Samples from Ishiagu and Ugwuaji Communities in Ebonyi and Enugu States, South East Nigeria

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ABSTRACT

Soil samples from both areas were analysed for the presence of heavy metals using Atomic Absorbsion Spectroscopy (AAS). Heavy metal composition of soil from top-soil (0-15cm) and sub-soil (16-30cm) were measured. The results were compared with United States Environmental Protection Agency (EPA), 2009 Standard. The results revealed that the levels of zinc (Zn) (0.143-0.678mg/L) were significantly (P<0.05) lower than EPA standard (2.0mg/L) in all the samples. The levels of As (0.099-0.287mg/L), Cd (0.007-0.012) and Hg (0.0003-0.002mg/L) were lower, but not significant (P>0.05) than EPA standard (0.2mg/L for As, 0.01mg/L for Cd and 0.005mg/L for Hg) in some of the samples. The mean levels of Pb (0.018-0.0333mg/L) were higher but not significant (P>0.05) than EPA standard in some of the samples. The presence of toxic heavy metals in these areas possesses danger to the consumers of crops from these areas because of possible contamination of the crops with heavy metals.

Keywords: Soil samples, Ishiagu, Ugwuaji, AAS, Heavy metals and Contamination

INTRODUCTION

Pollution is the introduction of contaminants into a natural environment that causes instability, disorder, harm or discomfort to the ecosystem i.e. physical systems or...
living organisms (Begum et al., 2009)[1]. The components of pollution, can be either foreign substances/energies or naturally occurring contaminants Ajayi et al., 2009)[2]. Different types of pollution exist globally. These include: air, light, noise, water, and soil pollution among others (Suciu et al., 2008)[3]. Heavy metal contamination in soil is a major concern because of their toxicity and threat to human life and the environment [Lokeshwary and Chandrappa, 2006][4]. Heavy metals and other pollutants such as polycyclic aromatic hydrocarbons are major components of petroleum hydrocarbons including bitumen (De Vries et al., 2007)[5]. Toxic heavy metals entering the ecosystem may lead to geo-accumulation, bio-accumulation and bio-magnifications. They get accumulated in time in soils and plants and would have a negative influence on physiological activities of plants (e.g. photosynthesis, gaseous exchange and nutrient absorption) determining the reductions in plant growth, dry matter accumulation and yield (Edwin et al., 2015)[6]. Heavy metals get into plants via adsorption which refers to binding of materials onto the surface or absorption which implies penetration of metals into the inner matrix. Both mechanisms can also occur [7].

Heavy metal toxicity represents an uncommon but clinically significant medical hazard often unrecognized and inappropriately treated. In nature, Pb and Zn are often found together. Both metals have found extensive use in man’s activities. Waste resulting from their mining and use liter many places. In most cases, large ponds and heaps of wastes are left in the trail of excavations for these elements. While rains wash the waste heaps into the surrounding water bodies and farmlands, the ponds overflow their banks resulting in pollution even outside the area of production. A typical example is seen in Pb or Zn mining fields of Ishiagu, Ebonyi State in Nigeria.

The type of activities prevalent in any given environment determines the type of contamination in that area. Soil in a particular area may have been sinks for many hazardous wastes such as organic, sewage and several other waste types generated from different human activities. Many of these wastes contain heavy metals which contaminate the receiving sink. The soil serves several human needs and several other natural functions. Nature too, has placed several minerals (metallic and non metallic) in the soil. To reach and obtain them requires extensive drilling or
excavation. Most industrial wastes are often not well treated before disposal. The most commonly encountered heavy metals include: Pb, Cd, Zn, Hg and As [8].

Ishiagu is richly endowed with mineral deposits, which are mainly heavy metal sulfide ores, chiefly galena (PbS), and are intensively and competitively exploited by several mining industries. Other metal ores include sphalerite (ZnS), chalcopyrite (CuFeS₂), siderite (FeCO₃), argentite (AgS), limestone (CaCO₃) and cadmium sulphide (CdS) (Ezepue, 1994)[9]. During our visit to Ishiagu for sample collection, we observed that mining sites were at elevated land sites, which facilitate the run-off of dissolved metal species into the Ivo River, and metal ores were dumped openly on the ground surface while manual dressing processes were employed and this is agreement with observation made by (Ezepue, 1994)[9]. The river courses through the metal mining sites, and metal trails were scattered around after ore dressing and in abandoned mine pits. These mining activities and other geochemical processes often result in the generation of acid mine drainage (AMD), a phenomenon commonly associated with mining activities (Ezepue, 1994)[9]. It is generated when pyrite (FeS₂) and other sulphide minerals in the aquifer at present and former mining sites are exposed to air and water in the presences of oxidizing bacteria, such as Thiobacillus ferrooxidans, and oxidized to produce metal ions, sulphate and acids according to the following equations:

\[
2\text{FeS}_2 + 7\text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{FeSO}_4 + 2\text{H}_2\text{SO}_4 \\
2\text{FeSO}_4 + 2\text{H}_2\text{SO}_4 \rightarrow \text{Fe}_2\left(\text{SO}_4\right)_3 + \text{SO}_2 + 2\text{H}_2\text{O} \\
\text{Fe}_2\left(\text{SO}_4\right)_3 + 2\text{FeAsS} + 9/2\text{O}_2 + 3\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{AsO}_4 + 4\text{FeSO}_4 + \text{S}
\]

AMD results in the acidification of mine wastes, low total suspended solids (TSS), but high total dissolved solids (TDS); and are also associated with the releasing of trace amounts of heavy metals contained in pyrites [8]. Acidic waters resulting from AMD facilitate high dissolution of metals from their ores and mine wastes to pollute water sources at adverse concentrations. However, near neutral pH values (pH 6-7) have been established for some metals, such as Zn, Cd, and As. Other factors such as downstream distances from the mining sites, colloid loads, pH perturbations, and dilution also ultimately control the quality of water sources [10].

This work then aims at establishing the level of pollution in Ishiagu and Ugwuaji soil due to quarry activities going on in both areas. Also, there is lead mining activity going on in Ishiagu.
MATERIALS AND METHODS

SAMPLING SITE
Ishiagu Community in Ivo Local Government Area (LGA) of Ebonyi State is located in south-eastern Nigeria at latitudes 5.72° - 5.85°N and longitudes 7.97° - 7.58° E. Ishiagu has quarry/crush industries. The major occupation of the individuals in the community is stone crush work, lead mining and farming [11].

Ugwuaji is a community in Enugu South L.G.A. of Enugu State. It is a satellite town in Enugu urban. Ugwuaji community has manual stone crush sites and the major occupation of the community is stone crush work and farming Oje (2010)[12]. It is located within latitude 6.24° N and 6.30° N and longitude 7.27° E and 7.32° E. It is located along Enugu-Port Harcourt Express way. It is about one and half hour’s drive from Onitsha and two and half hour’s drive from Aba [13].

SAMPLE COLLECTION

Soil sample were collected from 10 different selected sites in Ishiagu, Ebonyi State and 3 selected sites in Ugwuaji. A distance of 1km separated each of the sampling sites from another. Both top-soil (0-15cm) and sub-soil samples (16-30cm) were collected at each site, thus making a total of twenty six (26) soil samples. This method is in accordance to work done by Iwegbue et al., 2010 [14]. Samples were collected in labeled polyethylene bags and subsequently transported to Project Development Institute (PRODA), Enugu for analysis.

DIGESTION OF SOIL SAMPLES AND DETERMINATION OF SOME HEAVY METALS PRESENT IN SOIL SAMPLES

Digestion of soil samples was done using Teflon digestion. The soil samples were dried and ground into power. Exactly 0.5 g of each sample was measured into Teflon crucible and 20 ml of aqua-regia (HCl: HNO₃ solution in the ratio of 3:1) was added. Then, 10 ml hydrofluoric acid was added. The preparation was covered and heated in oven set at 100 °C in a fume cardboard until the solution became clear. The preparation was cooled in a desiccators and transferred to 250 ml plastic volumetric flask (Hambidge and Krebs, 2007)[15]. Determination of the amount of each metal present was done using Atomic Absorbsion Spectroscopy (AAS). The metals determined include; zinc, arsenic, cadmium, mercury and lead.

Discussion

Pollution has posed a major challenge in our environment, affecting farm land for agriculture in Nigeria and beyond (Bitanihirve and Cunningham, 2009)[16]. This research has thrown some light on the possible pollutants in Ishiagu and Ugwuaji farm land.

The Zn levels were within FEPA (1991)[17] standard values in all the samples (P<0.05). This is in agreement with Esam et al., 2015[18], who obtained values between 0.127 and 0.678mg/L for zinc on his research on soil (Abechi et al., 2010)[19]. The presence of zinc in the soil could be as a result of deposit of zinc in the area (Baccerelli and Bollati, 2009)[20]. In humans, zinc plays many biological roles”. In brain, zinc is stored in specific syntactic vessels by glutamatergic neuron and can “modulate brain excitability”. It plays key role in synaptic plasticity and so in learning. However it has been called “the brain’s dark horse”, since it also can be
a neurotoxin, suggesting zinc homeostasis plays a critical role in normal functioning of the brain and central nervous system [21].

The arsenic (As) levels in most of the soils samples were within APHA (1995)[22] standard. This in agreement with Ekwe et al., 2012[23] that obtained values between 0.02-1.971mg/L for arsenic in their soil samples Swandulla and Armstrong (1999)[24]. The presence of As in the soil could be as a result of deposit of As containing minerals in the areas Wittman(2002)[25]. Arsenic has adverse health effects on the body; such as inhibition of the enzyme pyruvate dehydrogenase, the enzyme that convert pyruvate to acetyl CoA and this could lead to coma and subsequently death [26].

The cadmium levels in some of the soil samples were within APHA (1995)[22] standard. This in agreement with Esam, et al., 2015[18] who obtained values 0.017 to 1.099mg/L for cadmium in soil samples used for their research Edo et al., 2014[27]. The presence of cadmium in the soil could be as a result of deposit of cadmium containing minerals in the areas Edo et al., 2014[27]. Cadmium is released from car exhaust into the environment and it find their way into water. Once in air it spreads with the wind and settles into the ground or surface water as dust. Cadmium has no benefit on the human system [20].

The mercury levels in all the soil samples were within APHA (1995)[22] standard. This in agreement with Edo et al., 2014[27], that obtained values 0.000 - 0.001mg/L for mercury in soil samples they used for their research Nriagu and Kim (2000)[28]. This means that they could be presence of mercury containing minerals in the areas. Mercury occurs naturally in the earth crust. Mercury is founds in many rocks and gets into the water bodies through weathering and leaching. Amount of mercury in the environment could be controlled by government regulations because of its toxicity to the brain, heart, kidneys, lungs and immune system of all ages [29].

The level of lead in most of the soil samples were within the APHA (1995)[22] standard. This in agreement with Agbozu et al., 2015[30] who obtained values 0.025-0.121mg/L for lead in soil samples used for their research Ademoroti (1988) [31]. This is because of lead deposit in Ishiagu Ademoroti (1996a)[32]. Lead is toxic to the body because it inhibits prophobilinogen synthase and ferrochelatase, preventing both prophobilinogen formation and incorporation of iron into protoporphyrin (ix), the final step in home synthesis. Leads also acts as calcium analog, interfering with ion channels during nerve conduction. It is toxic to many organs and tissues including the heart, bones, intestine, kidney, reproductive and nervous system [33].

However, the degree of concentration of the heavy metals in increasing order is as follows: In Ishiagu soil samples it is: Hg<Cd<As<Zn<Pb, In Ugwuaji soil samples it is: Hg<Cd<Pb<As<Zn.

CONCLUSION

The research showed presence of toxic heavy metal such as lead in the Agricultural soil samples from both areas and these may pose danger to human that consume crops from both areas.
REFERENCES


Table 1. Levels of heavy metal of soil samples from Ishiagu and Ugwuaji communities of Ebonyi and Enugu State (P<0.05).

<table>
<thead>
<tr>
<th>Source of soil samples</th>
<th>Zn (mg/L)</th>
<th>As (mg/L)</th>
<th>Cd (mg/L)</th>
<th>Hg (mg/L)</th>
<th>Pb (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ishiagu Top-Soil</td>
<td>0.143±0.040&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.099±0.001&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.012±0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0003±0.00004&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.018±0.004&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ishiagu Sub-Soil</td>
<td>0.023±0.001&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.318±0.025&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.01±0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0003±0.00006&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.0281±0.003&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ugwuaji Top-Soil</td>
<td>0.0125±0.001&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.046±0.007&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.004±0.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.0005±00001&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.0075±0.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ugwuaji Sub-Soil</td>
<td>0.678±0.011&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.287±0.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.007±0.001&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.002±0.00002&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.0333±0.006&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>EPA Standard (2009)</td>
<td>2.0±0.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.2±0.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.01±0.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.005±0.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.01±0.0&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*All values are means ± SD of thirty determinations

*Means with the same letter on the same column are not significantly different at 0.05 probability level.