



Heavy Metals Analysis of Soil Samples from Selected Dumpsites in Ibarapa Central and Ibarapa East Local Government Areas, Oyo State

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Abstract

The growing dominance of urban environment with heavy metals through natural and anthropogenic depositions and the potential adverse health implications following environmental contaminations have focused attention on the disposal of municipal and industrial wastes. This study employed analytical procedures to investigate the concentrations of heavy metals such as chromium, copper, cadmium, lead and nickel at waste dump site of the study areas. Soil samples were randomly collected from different waste dumpsites across Ibarapa Central and East Local Governments, Oyo State. An undisturbed soil 100 meters away from the dumpsites was chosen as the reference. From the result obtained, it was observed that the concentrations of the selected heavy metals; Cu, Pb, Cd, Cr and Ni in all dumpsite locations was found to be in the range of 0.678 to 0.881 ppm, 1.072 to 1.414 ppm, 0.067 to 0.087 ppm, 1.433 to 1.683 ppm and 2.082 to 2.525 ppm respectively. Mean concentration of some the metals at the dumpsites was lower than the reference, which means there is an anthropogenic contribution from the environment. The concentrations of the heavy metals were generally lower than their respective guideline values for the protection of human and environmental health also lower than the permissible limit according to international recommended standards. However, with prolonged practice of dumping refuse at these locations; concentrations of the heavy metals may increase above the recommended limits. Therefore, it is recommended that further research be carried out on the heavy metals concentration of the waste materials to identify those that are potential sources of soil contamination to suggest appropriate treatment and disposal methods.

Keywords: Anthropogenic, Heavy Metals, Soils, dumpsites, elemental composition

Introduction

Rapid population growth coupled with urbanization and industrial growth are the most severe and growing problems in developing countries such as Nigeria as it causes the shortage of land for both agricultural practices and waste disposal in urban and peri-urban areas (Jafaru *et al.*, 2015).

All soils are formed from physical, biological and chemical weathering processes of crustal rocks, as such, possesses a characteristic physical and chemical property which shares a relationship to the source rocks/crustal rocks from which they were formed. The elemental composition of Soils formed from crustal rocks weathered from an igneous environment, are known to be different from soils formed from a metamorphic rock environment. Likewise, soils formed in either of these two environments (igneous and Metamorphic) are reported to be different from soils formed in a sedimentary environment (Igbinigie and Ogbamihumi, 2022; Parker and Fleischer, 1967). Anthropogenic factors (either

domestic or industrial) are also considered as a major factor that leads to substantial alteration of soil elemental compositional nature, for example, the application of NPK fertilizers to soil to increase cultivation plant yield and productivity in agriculture, results in the increase of the soil composition in PPM in that localized soil environment, in each of the constituent elements - Nitrogen (N), Phosphorus (P) and Potassium (K)) (Agyarko *et al.*, 2010).

In Nigeria, dumpsites are often used for farming activities due to the rich soil nutrient, in a research by Agyarko *et al.* (2010) it was observed that plants grown on dumpsites performed better than those built on the surrounding areas, as a result of the decayed and composted municipal solid wastes enhances soil fertility (Ogunyemi *et al.*, 2003) Apart from the local disturbance of the environs, soil profile and structure, heavy metals contained in municipal solid waste are taken up by plants which ends up in our food



chain causing widespread of health challenges leading to a loss of biodiversity, amenity and economic well-being of residents in the vicinity of waste dumpsites (Cui *et al.*, 2004).

The extent of soil pollution by heavy metals and base metal ions some of which are soil micronutrients is very alarming. It has been observed that the larger the urban area, the lower the safety quality of the environment.

Evaluation of dumpsite soils to determine the levels of heavy metals is of critical importance in risk assessment (Oguntimehin and Ipimoroti, 2008). Such metals could be harmful and persistent in the soils for several years. Inhabitants around such sites (which are somehow rich in nutrients) usually grow some vegetables and other arable crops (e.g. maize) for sustenance. These heavy metal leachates from dumpsites could end up in the food chain by plant uptake with its associated health hazards. People around such dumpsites may not be aware of the extent and dangers such heavy metals poses. Since these metals affect environmental quality, regular monitoring has become imperative to recommend appropriate remediation strategies (Oguntimehin and Ipimoroti, 2008).

Some of the environmental problems arising from poor disposal of solid waste include health hazards, soil and water pollution, repulsive sight and offensive odour. The resultant of these is the degradation of our environmental quality (Abdus-Salam *et al.*, 2021). Most dumpsites are located within the vicinity of living communities and wetlands. The dumpsites are often not lined nor basement prepared for selective adsorption of toxic substances. Therefore, it is prone to release of pollutants to nearby water and to the air through leachates and dumpsite gases respectively (Alimba *et al.*, 2006).

In some dumpsites, wastes are burnt in the open and ashes abandoned at the sites, with no regard to environmental implications. This poses a direct safety threat because of the danger of explosion. The burning of wastes gets rid of the organic materials and oxidizes the metals, leaving the ash richer in metal contents. After the processes of oxidation and corrosion, these metals get dissolved in rain water and are then leached into soil from where they are picked up by growing plants thereby entering the food chain. Excess heavy metal accumulation in soils is toxic to humans and

other animals. Exposure to heavy metals is normally chronic (exposure over a longer period of time), due to food chain transfer (Benson and Ebong, 2005).

The term "heavy metal" refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration. To a small extent, they enter the body system through food, air, and water and bio accumulate over a period of time (Athalye *et al.*, 2001). Heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), manganese (Mn), Cobalt (Co), Nickel (Ni), silver (Ag), Arsenic (As), chromium (Cr), copper (Cu), Iron (Fe) and the platinum group elements (Upadhyay and Tripathi, 2007).

A typical refuse dump consists of organic wastes such as poultry litter, waste clothing and paper, wood waste and furniture, corn cob and chaff, vegetable residues, left over foods etc, inorganic wastes, glass, discarded battery cells, ceramics, acid wastes, metals automobile parts, broken pots, stoves, cans, tins, pipes, other waste metallic containers, polymeric materials plastics, foam, polythene bags, hair weaver etc, electrical and electronic wastes refrigerators, damaged phones and accessories, damaged computers and accessories, damaged fans and electric irons, waste bulbs and sockets and sundry wastes such as pharmaceuticals, paint products and containers (Nduka *et al.*, 2013). There is no doubt that these dumps contribute significant amounts of heavy metals migrating to the soil. Surface run offs from such refuse dumpsites also end up in the ground water or in the surface water, thereby increasing the metal burden of the aquatic ecosystem (Osakwe, 2012). Some heavy metals have bio-importance as trace elements but, the biotoxic effects of many of them in human biochemistry are of great concern, cranny of major cities in Nigeria.

Degradation of land is generally caused by solid wastes of different types. In order to solve the problem posed in our environment by waste disposal, there must be proper management of solid waste and also proper investigation of the heavy metals produced from anthropogenic activities. This study is then focused on the heavy metals of the soil samples obtained from some of the major dumpsites in Ibarapa Central and East Local Governments in Oyo State, to be used for future decisions and research as well.



Materials and Methods

Study Sites and Sample Collection

The study was conducted in Igboora and Eruwa, these towns are located within two Local Governments (Ibarapa Central and East respectively) of Oyo State, Nigeria. Soil samples were collected from 4 major dumpsites in Eruwa and Igboora at depth 0-15 cm, 15- 30cm and the reference location (RF) using depth calibrated soil auger depth of 0-20cm respectively. Reference samples were collected at 100 meters from the dumpsites. The samples of soil were collected into clean polythene bags and tightly sealed as recommended by Olayinka *et al.* (2014).

Heavy Metals Analysis

Soil samples were digested after drying in the oven and ground into fine earth (<2.00 mm)

fraction using pestle and mortar. Two grams of sample was weighed into a digestion flask followed by the addition of about 30 mL mixture of concentrated HNO₃ and concentrated HClO₄ in a ratio of 1:1.5. The mixture was digested by heating gently on a digestion rack in a fume chamber for about 30 min until the digest turned colourless with no charred organic matter remaining. It was then allowed to cool and then transferred with distilled water into a 100 mL volumetric flask and made up to volume. The filtrate was analysed for metals (Cd, Cr, Cu, Ni and Pb) by Atomic Absorption Spectrophotometer (AAS) (Pam *et al.*, 2013).

3.9 Statistical Analysis

Data obtained were analysed using MINITAB (version 14.0), statistical software for Microsoft Excel. Results are presented as a mean ± standard deviation.

Results and Discussion

Results

Table 1: Copper concentration in ppm

Location	0-15cm	15-30cm	RF 0-20cm
A1	0.678 ± 0.002	0.807±0.000	0.64±0.000
A2`	0.837 ± 0.003	0.674±0.000	0.624±0.004
B1	0.812 ± 0.001	0.825±0.001	0.735 ±0.001
B2	0.851 ± 0.002	0.881±0.001	0.792±0.000

Value expressed as mean ± SEM key: RF – Reference location

Table 2: Lead concentration in ppm

Location	0-15cm	15-30cm	RF 0-20cm
A1	1.314 ± 0.001	1.248 ±0.000	1.078 ±0.021
A2`	1.204 ± 0.000	1.414 ±0.001	1.285 ±0.000
B1	1.344 ± 0.001	1.183 ±0.001	1.224 ±0.000
B2	1.168 ± 0.000	1.072 ±0.001	1.184 ±0.000

Value expressed as mean ± SEM Key - Reference location

Table 3: Cadmium concentration in ppm

Location	0-15cm	15-30cm	RF 0-20cm
A1	0.078 ± 0.000	0.081±0.000	0.093±0.001
A2	0.067 ± 0.001	0.087±0.000	0.095±0.004
B1	0.083 ± 0.000	0.075±0.001	0.066 ±0.001
B2	0.085 ± 0.001	0.081±0.001	0.187±0.001

Value expressed as mean ± SEM Key – Reference location

Table 4: Chromium concentration in ppm

Location	0-15cm	15-30cm	RF 0-20cm
A1	1.433 ± 0.001	1.613 ±0.000	1.546 ±0.008
A2`	1.650 ± 0.001	1.483 ±0.000	1.385 ±0.000
B1	1.638 ± 0.001	1.583 ±0.001	1.541 ±0.001
B2	1.494 ± 0.001	1.683 ±0.001	1.543 ±0.001

Value expressed as mean ± SEM Key – Reference location



Table 5: Nickel concentration in ppm

Location	0-15cm	15-30cm	RF 0-20cm
A1	2.434 ± 0.001	2.525 ± 0.001	2.345 ± 0.001
A2	2.417 ± 0.001	2.580 ± 0.000	2.486 ± 0.001
B1	2.516 ± 0.000	2.505 ± 0.001	2.492 ± 0.001
B2	2.445 ± 0.001	2.082 ± 0.000	2.135 ± 0.001

Value expressed as mean ± SEM Key – Reference location

Discussion

The tables revealed the concentration of heavy metals (Cu, Pb, Cd, Cr and Ni) in the samples of soils collected from different dumpsites locations in Eruwa and Igboora towns at two sampling locations each in varying depth (0-15cm) and (15-30cm) in comparison with the reference locations (RF) at 0-20cm.

The mean concentration of copper in soils from all dumpsites ranged from 0.624 ± 0.004 ppm to 0.881 ± 0.001 ppm. The values obtained for copper were higher than the values of reference point. The concentration values of copper in this study were below the maximum allowable limit in most countries; (100 mg/kg) in Australia, Canada, Poland, Great Britain, Japan (125 mg/kg), Nigeria (36 mg/kg) and Germany (50 mg/kg) (Pam *et al.*, 2013). Cu is used in numerous applications because of its physical properties. The levels of copper observed in this study were lower than the concentration of copper reported for soil of waste dump sites (Osakwe and Egharevba, 2008), mining sites (Gungshik and Mohammed, 2007), and foam manufacturing industry (Oviasogien *et al.*, 2007). High level of Cu at some dumpsites may also be envisaged from dumping of solid wastes, application of fungicides, livestock manures, sludge and atmospheric deposition (Nwachukwu *et al.*, 2010).

The concentration of lead found in these locations (1.072 ± 0.001 ppm to 1.414 ± 0.001 ppm) were lower than the range of 35.7 – 635.31 mg/kg reported Ukpung *et al.*, (2013) with a range of (3.00 – 117.50 mg/kg) and Adelekan and Alawode (2011) (45.00 – 624.50 mg/kg). On the other hand, the concentrations of Pb reported in this study were higher than those reported by Opaluwa *et al.*, (2012) with range 0.90 – 4.20 mg/kg. Pb levels should be cautiously minimized to prevent health hazard on man and the entire environment. (ATSDR, 2007).

The mean values of cadmium (0.067 ± 0.001 to 0.087 ± 0.000) obtained for the dumpsite soils studied were lower than those reported by

Awokunmi *et al.*, (2010) with 219 – 330 mg/kg. The obvious concentration of cadmium in the study areas could be likened to the location of the dumpsite and the nature of the waste being dumped. Human activities can also contribute to increased Cd level as a result of urban-industrial activity or agricultural practices (Mico *et al.*, 2006). Cadmium concentrations in the soils were above the standard limits (0.01 mg/kg) set by Federal Environmental Protection Agency (FEPA) 1991. Cd would be released into the environment only under very harsh conditions. Association of Cd in the residual fraction does not generally constitute an environmental risk. This is due to the stable nature of the compound and the fact that the metals are bounded firmly within a mineral lattice that restricts the bioavailability of this metal.

Chromium (Cr). The mean concentration of chromium in soil ranged from 1.433 ± 0.001 ppm to 1.683 ± 0.001 ppm in all the dumpsites (Table 4). Values at A1 (1.433 ± 0.001 ppm) and B2 (1.494 ± 0.001 ppm) were found to be lower than their reference locations. The values of Cr obtained in this study were lower than the 900–2000mg/kg reported by Adefemi and Awokunmi (2009) in dumpsites within Ado-Ekiti town in South West Nigeria. The elevated concentrations were ascribed to deposited waste which contained high concentrations of Cr. Similarly, low levels of chromium have been observed in surface soils under waste dumps in Onitsha, Nigeria (Nwajei and Iwegbue, 2007) and soils around foam manufacturing industry (Oviasogie *et al.*, 2007). The values of Cr obtained in this study are below the allowable limits of Cr for some countries; 150mg/kg in France; 100mg/kg in Austria and Spain; 60mg/kg in Germany and Sweden; and 30mg/kg in Denmark and the Netherlands (Pam *et al.*, 2013). Therefore, most of the values obtained in this study conform to acceptable limits.

The mean concentration of nickel at all locations ranged from 2.082 ± 0.000 ppm to 2.580 ± 0.000 ppm. The concentration range



reported in this study was lower than the concentration range reported by Adelekan and Alawode (2011) being 4.35 – 49.80 mg/kg, and the range (1.50 – 54.80 mg/kg) reported by Ukpung *et al.*, (2013), Opaluwa *et al.*, (2012), (7.10 – 14.90 mg/kg) reported by Akpofure (2012). Nickel concentration in the refuse soils were generally above the standard limits (0.1 mg/kg) set by Federal Environmental Protection Agency (FEPA) 1991, thus implying that the soil was contaminated with Ni. Global input of nickel to the human environment is from natural and anthropogenic sources including emissions from fossil fuel consumption, industrial production, use and disposal of nickel compounds and its alloys (Kasprzak *et al.*, 2003).

Conclusion and Recommendation

The result of this study revealed the presence of Chromium, Copper, Cadmium, Lead and Nickel in the dumpsites soil at an appreciable level. However, the present concentrations of the heavy metals were generally lower than their respective guideline values for the protection of human and environmental health.

This study has demonstrated the potential accumulation of heavy metals in the soils of the studied dumpsites. Thus, sorting and recycling of wastes especially electronic and metallic wastes should be intensified to reduce the levels of these toxic metals in these dumpsites. Therefore, we recommend that further research is carried out on the compositions of the waste materials to identify those that are potential sources of heavy metals contamination of soil and suggest appropriate disposal methods.

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