

Status of Toxic Metal Pollution of Soil in and around Araromi Metal Scrap Dumpsite, Akure, Ondo State

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Authors' contributions

This work was carried out in collaboration between both authors. Author IASO designed the study, wrote the protocol and wrote the first draft of the manuscript. Author FTF managed the literature searches, analyses of the study and performed the spectroscopy analysis. Authors IASO and FTF managed the experimental process and identified the metals. Both authors read and approved the final manuscript.

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ABSTRACT

Most problems of soil pollution are associated with large amount of heavy metals deposited on it through disposed waste. This study was carried out to assess heavy metals (Fe, Zn, Pb, Cu and Cd) in soil samples around metal scrap dumps at Araromi vicinities of Akure South Local Government, Ondo State, Nigeria, in order to assess the effects of the dumps on the soils. A total of thirty nine soil samples were taken for laboratory analysis. The soil samples were collected using hand driven stainless steel auger at various depths at the dumpsite, and at various horizontal distances away from the dumpsite including human settlements close to the dumpsite. The heavy metals in the waste soils samples was sequentially extracted and quantified, using atomic absorption spectrometry (AAS). The findings revealed that Iron, Lead, Cadmium and Copper with concentration of 611.7 mg/kg, 200.8 mg/kg, 4.9 mg/kg and 103 mg/kg respectively, all exceeded National Environmental Standards and Regulation Enforcement Agency (NESREA) acceptable limit

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and index of 2007, except Zinc 229.2 mg/kg The order was Fe>Zn>Pb>Cu>Cd for the study area. A consistent trend showing a decrease in the concentration of toxic metals was observed at increasing depths and distances from dumpsite, which suggest a discontinuation or mitigation of anthropogenic input on the environment.

Keywords: Heavy metal; dumpsite; scrap metals; vertical depths; horizontal distances.

1. INTRODUCTION

The management of solid wastes has been a major challenge in Nigeria. Solid wastes are frequently disposed along the streets, gutters, drainage channels, rivers, abandoned plots of land. Poor waste disposal has been linked to blockage of gutters and other drainage channels causing flood, poor aesthetics, release of foul odour and greenhouse gases, obstruction of traffic flow and pollution of surface and ground water [1,2]. The daily accumulation of heavy metals in our environment has intensified in recent years with population growth, industrialization and new technological developments. This phenomenon is of great concern because heavy metals constitute considerable hazards to human health due to their toxicity, accumulative tendencies and persistence in the environment with possibilities for environmental transformation into more toxic compounds.

Most of these heavy metals are essential for growth of organisms but are only required in low concentrations. Heavy metals occupy a special position in soil chemistry because they play very important physiological roles in nature. These trace elements have been proven to be dispensable for normal growth and reproduction of all higher plants [3]. They exert toxic effects when their concentrations are increased, and at this stage, they could be referred to, as toxic metals. The present distribution of metals in the soil can serve as an indication of time, history, and extent of pollutants discharged in the area. Public awareness on the dangers associated with heavy metals has been partly responsible for alerting governments on the need to protect the health of the communities by keeping constant watch on levels of toxic pollutants, taking steps to reduce them to acceptable levels and ensuring control of emission of pollutants into the environment by legislation. However, these objectives are not being actively pursued in many developing nations. Most problems of soil pollution are associated with large amount of heavy metals deposited on it through disposed waste. These metals which are not biodegradable are accumulated in living

organisms when released into the environment. Although trace quantities of certain heavy metals are essential to animals and plant growth, they are of considerable environmental concern due to their toxicity and cumulative behaviour [4]. The composition of these dumps varies from site and depends on the peculiarity of the neighbourhood. The heavy metal pollution of urban soils have been investigated in many cities of Western Europe such as London [5], Berlin [6] or Hamburg [7] indicating large amounts of anthropogenic inputs.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Araromi dumpsite, is situated in Akure South Local Government Area of Ondo state, and geographically located on Longitude 7° 27'11"N and Latitude 5°19'37"E. The geographical coordinates of the location was determined using a Garmin global positioning system (GPS) and entered into a geographical information system (GIS) for data processing. The area is the residence of a number of activities ranging from auto mechanic workshops, auto spare parts sales, used automobiles sales, butcher points, and eateries. The dumpsite studied is densely populated, with industrial, agricultural and economic activities on the increase.

2.2 Sample Collection

The soil samples were collected using hand driven stainless steel auger, into polythene bags, in triplicates. A total of 39 soil samples were taken to laboratory for analysis which were collected at various vertical depths (0 cm-12 cm) on the dumpsite and at various horizontal distances away from the dumpsite. The soils were air-dried at laboratory temperature (30±2°C) for 6 days, before being passed through 2 mm sieve to obtain the soil fraction used [8].

2.3 Sample Treatment

Soil samples were air - dried in a circulating air in the oven at 30°C to a constant weight and then

passed through a 2 mm sieve and stored in dry labelled plastic and taken to the laboratory for pre-treatment and analyses under frozen condition (4°C) to prevent any microbial activity [9].

2.4 Determination of Heavy Metals

2.4.1 Digestion of soil sample

Extraction of metals from soil sample were done using mixed acid digestion. About 1 g of the soil samples were weighed into a 100 mL conical flask and were moisten with double- distilled deionised water; 10 mL of aqua regia was introduced to the sample and the mixture heated to near dryness and allowed to cool. 5 mL of 6 M H₂SO₄ was added and the solution and 5 mL distilled water and allow to boil for 10 minutes. The solution was cooled and filtered into a 50 mL volumetric flasks using whatmann filter paper No 42. The filtrate obtained was made up to a known volume.

2.4.2 Analysis of digested soil sample for heavy metals

The Atomic absorption spectrophotometry (Buck scientific 210 VGP) instrument was calibrated using appropriate standards for various metals. The combustion gases were acetylene and air, the hollow cathode lamps for each metal were inserted to the equipment, the air-acetylene mixture was ignited and the flame conditions adjusted appropriately. The various sample treated were aspirated into the flame and the concentration of the metals were read out directly from the instruments in ppm (mg/L). The instrument readings were converted to mg/kg using the weight of the soil samples. The analysis was carried out based on standard operating procedures of [10].

2.5 Data Analysis

All data obtained were subjected to descriptive statistics using SPSS version 20 and Pearson Correlation analysis to examine relationship among analysed heavy metals.

3. RESULTS AND DISCUSSION

For the heavy metal analysis of soil sample collected, the concentrations of all metals studies decreased with increasing depth and horizontal distances in all sites. This indicates the soils studied had some heavy metal enrichment and surface soil or top soil which is the point of impact which bears metallic burden. Studies

have supported this findings that surface soil are better indicator of metallic burdens [11].

Iron concentration was highest (611.7 mg/kg) at the dumpsite surface. A sharp decrease was also observed between surface of the dumpsite and 0.3 m depth. The valued Iron declined from 611.7 mg/kg to 92.5 mg/kg (Figs. 1 and 2). The concentration of Iron also decreased with increasing horizontal distances from the scrap metal dump. Iron concentration at the surface soil of Araromi exceeded NESREA acceptable limit, this might be due to the fact that motor vehicle parts and scraps dumped at the site are mainly made of iron which corrodes fast when exposed to environmental conditions. High levels of iron obtained in this study can also be said to be due the fact that natural soils contain significant concentrations of iron as previously reported by [12].

The concentration of Lead at the surface of the dumpsite was 200.8 mg/kg (Fig. 3). It decreased to 3.1 mg/kg at the depth of 1.2 m. It also shows a decrease in the lead toxicity of the soil. At 20 meters away from the dumpsite, the value of lead also decline from soil surface to 1.2 meters. Similar trend were also observed at horizontal distances from the dumpsite as shown in Fig. 4.

Lead concentration at Araromi dumpsite exceeded NESREA maximum acceptable limit [13]. The levels obtained for this specific metal was higher than those reported by [14] and [15]. It has been reported that Lead is much more soluble under acidic (low pH) conditions than at neutral or alkaline (high pH) conditions and the adsorption usually increases with increasing pH and decreasing ionic strength [16]. The trend of mobility of lead across soil depth at the dumpsite could be because metallic lead is only stable in a very low redox potential condition [17].

The concentration of zinc varied from 5.0 mg/kg – 22.9.2 mg/kg for Araromi soils (Fig 5). The values obtained are relatively higher than the levels reported by [18,19] Kaur and [20], studies carried out in Delta state and India respectively. The concentration of zinc was significantly high at the surface of the dumpsite, and the value decreased to 5 mg/kg across the soil profile. This implies that soil toxicity decreased with depth [21]. The values recorded were however above maximum acceptable limit of NESREA [13]. High concentration of zinc at the surface of the dumpsite might have been as a result of increasing corroded zinc plated materials, from

metal scraps dumped zinc is also a constituent of paints in form of zinc oxide, so the infiltration to soil could be as a result of the activities of spray painter and also vehicle body paints, crude oil

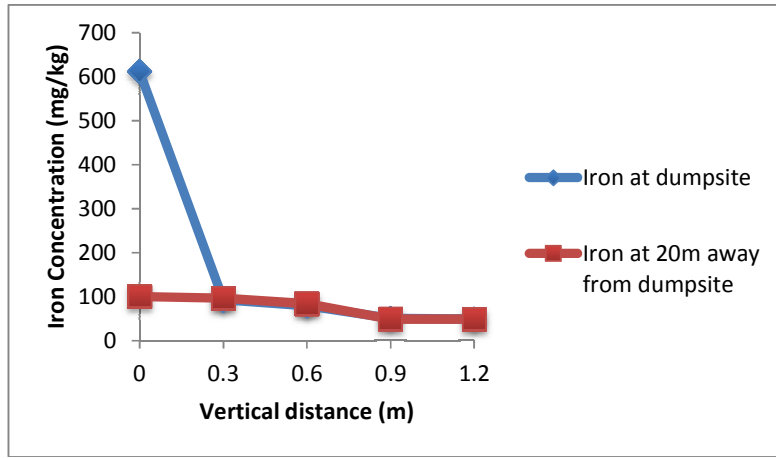


Fig. 1. Mobility of Iron showing different concentrations at depths of Araromi dumpsite and 20 meters away

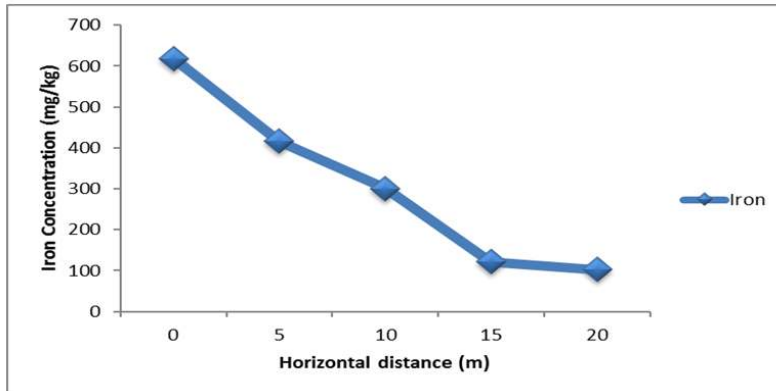


Fig. 2. Mobility of Iron showing different concentrations at distances away from Araromi dumpsite

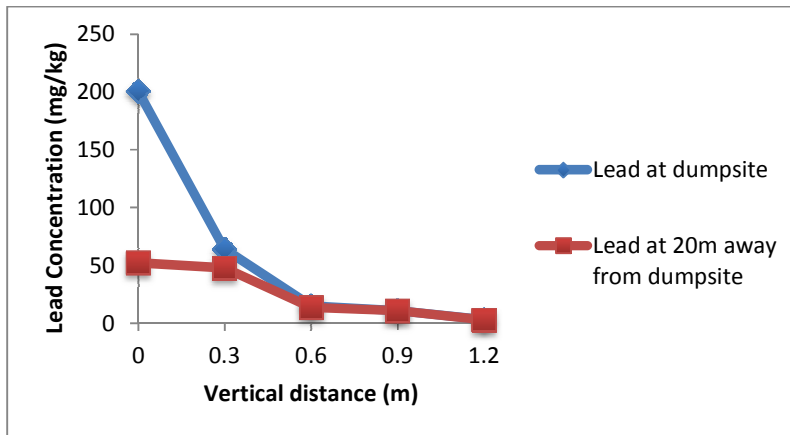


Fig. 3. Mobility of Lead showing different concentrations at depths of Araromi dumpsite and 20 meters away

tyre and automobile exhaust inclusive [22]. Biologically, it exerts negative impact on the activity of microorganisms and earthworms by interrupting soil activity, thus retarding breakdown of organic matter [23,24].

Cadmium recorded the lowest concentration on the surface of the dumpsite as revealed in Fig. 7. It showed a sharp decrease from the surface (4.9 mg/kg) to concentration at 0.3 m (2.1 mg/kg). Steady decline can be observed between depth 0.3 m-1.2 m which shows little or no leaching or run off processes. Fig. 8 revealed that concentration of cadmium at increasing distance

was 4.9 mg/kg and it decreased as the distance increases.

Concentration of Copper in soil surface of Araromi metal scrap dumpsite was 103.7 mg/kg and value decreased significantly to 2.3 mg/kg at a depth of 1.2 m as shown in Fig. 9. In the variation of Copper concentration with vertical depth at 20 meters away from the dumpsite, similar trends was observed as a constant value was maintained within soil profile (Fig. 9). The concentration of copper also decreased with horizontal distance from the dumpsite as shown in Fig. 10.

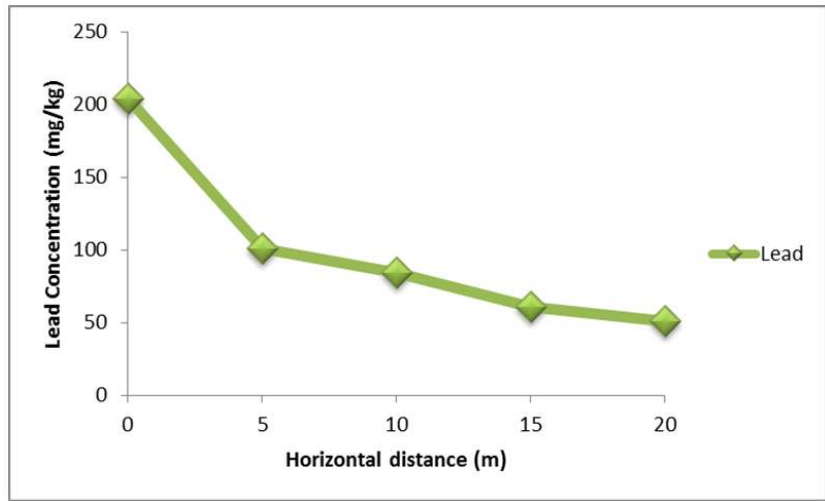


Fig. 4. Mobility of lead showing different concentrations at distances away from Araromi dumpsite

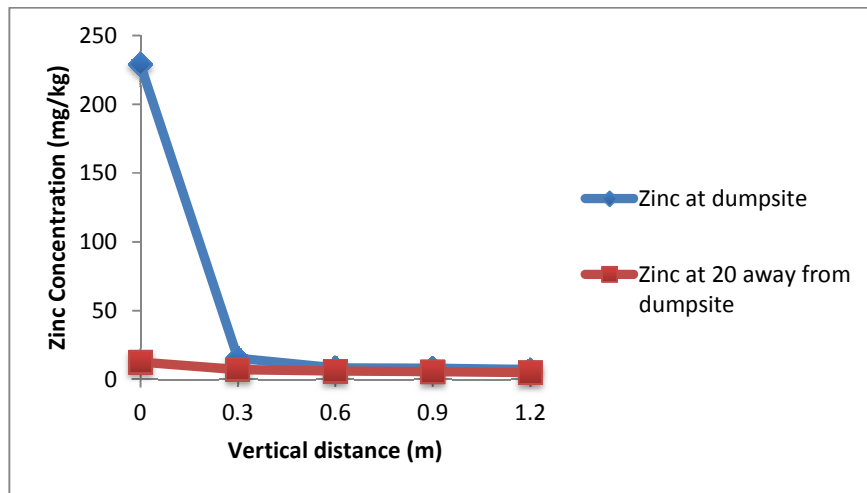


Fig. 5. Mobility of Zinc showing different concentrations at depths of Araromi dumpsite and 20 meters away

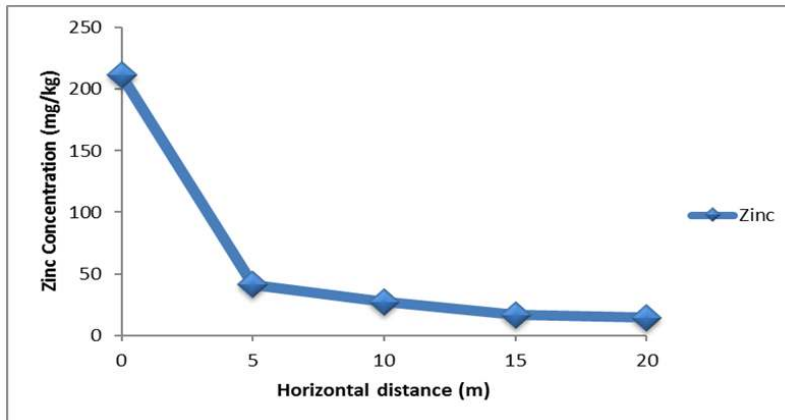


Fig. 6. Mobility of zinc showing different concentrations at distances away from Araromi dumpsite

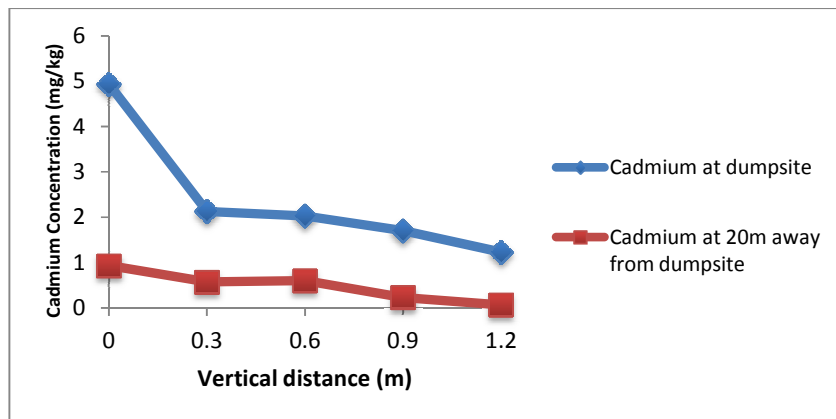


Fig. 7. Mobility of cadmium showing different concentrations at depths of Araromi dumpsite and 20 meters away

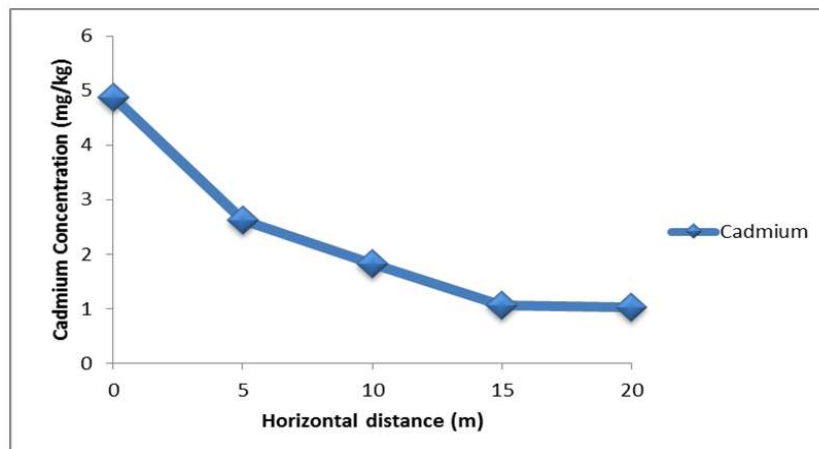


Fig. 8. Mobility of cadmium showing different concentrations at distances away from Araromi dumpsite

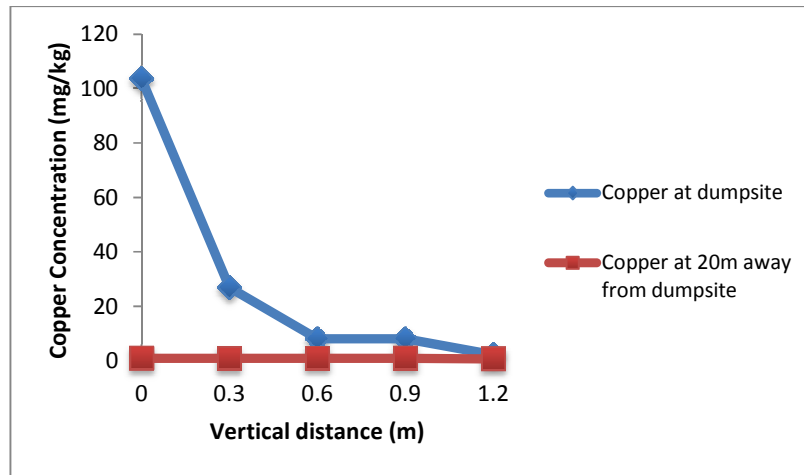


Fig. 9. Mobility of copper showing different concentrations at depths of Araromi dumpsite and 20 meters away

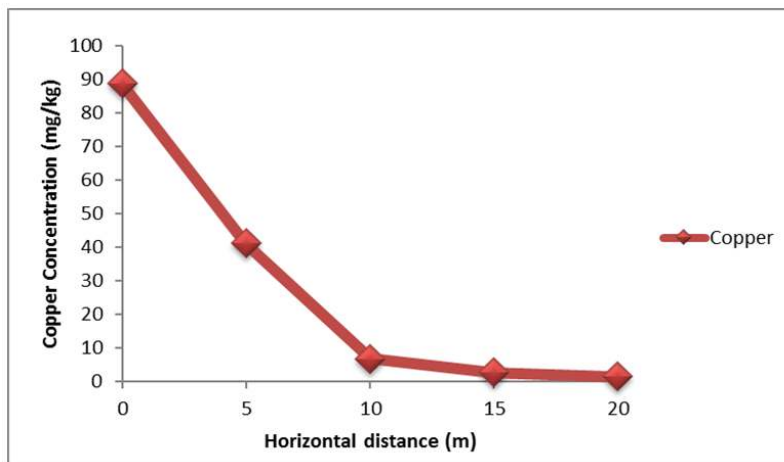


Fig. 10. Mobility of copper showing different concentrations at distances away from Araromi dumpsite

4. CONCLUSION

The soil in and around Araromi metal scrap dumpsite was contaminated with toxic metals such as Iron, Lead, Zinc and Copper. At Araromi dumpsite, toxic metals such as Fe, Pb, and Cd exceeded NESREA limit for metal concentration in soil. It was observed that for all toxic metals, the concentration were highest at the surface, Iron had the highest concentration with 611.7 mg/kg for Araromi. The order was Fe>Zn>Pb>Cu>Cd for Araromi metal scrap dumpsite. Metal concentrations of the soils decreased with increasing vertical depth and increased horizontal distance from the dumpsite.

Therefore, the use of the dumpsite should be discontinued due to metal burden. The separation and recycling of wastes should be encouraged as well. Geophagy and food chain or feeding level interaction must be avoided since the scrap metal dumpsite are around residential areas and use of manure from the dumpsite for agricultural purposes should be barred as plants and vegetables can easily absorb them.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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