Research Article
Volume 10:1, 2021

Expert Opinion on Environmental Biology

Open Access

Availability and mobility of toxic metals across soil levels and surrounding of Gbogi scrap metal landfills in Akure

***F.T. Fadoju, I.A Simon-Oke, J.A Owoeye, O.O Olasoji**

Department of Biology, Federal University of Technology, Akure, Nigeria

Abstract

The study was carried out, to ascertain the effect of metal scraps on surrounding soils at Gbogi vicinities of Akure South Local Government, Ondo State, Nigeria. A total of thirty-nine soil samples were taken for laboratory analysis. The soil samples were collected at various depths at the dumpsite, and at various horizontal distances away from the dumpsite including human settlements close to the dumpsite, in order to find the concentration and mobility of toxic metal on human living habitat around 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, Copper and Zinc with concentration of 209mg/kg, 9.2mg/kg, 3.6mg/kg, 0.1mg/kg and 39.7mg/kg respectively. All concentrations did not exceed National Environmental Standards and Regulation Enforcement Agency (NESREA) acceptable limit and index of 2007. The order was Fe>Cu>Pb>Zn>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, however, the paper suggests a discontinuation or mitigation of anthropogenic input on the environment.

Key words: Toxic metal; dumpsite; scrap metals; vertical depths; horizontal distances.

INTRODUCTION

Presently, in most cities in Nigeria, scrap car dumpsites are located in and around human settlements, very close to motor mechanic workshops and fairly used motor spare parts markets (Uba et al., 2008). The absence of metals recycling systems in most cities in Nigeria have resulted to gradual accumulation of scrap motor parts as well as scrap motors (which can either be cars, lorries and motor cycles), which later become heaps, known as scrap car dumpsites (Ogundiran and Osinbanjo, 2008). The presence of used/worn-out scrap car parts and scrap motor vehicles at the dumpsites cause soil, underground water and surface water contamination. The pollutants are mainly toxic heavy metals such as Fe, Pb, Zn, Cu, and Cd. The sources include motor vehicle parts, scrap tyres/rubber. After corrosion these metals get leached into the environment causing serious pollution. Scrap cars pollution from heavy metals is a major environmental concern worldwide (Okoronkwo et al., 2006). The presence of heavy metals in high levels can endanger the ecosystem, plants and animals and cause severe health problems in humans, animals and plants (Amadi et al., 2012). 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. Assessing the problems caused by contaminated soils typically involves soil chemistry as well as laboratory and field studies to fully assess the extent and significance of any adverse environment effects (Osakwe et al., 2003).

Scrap metals are an important components of the municipal solid wastes (MSW) in Nigeria accounting for 1.8% (Olanrewaju and Ilemobide, 2009), 10.8% (Ayotamuno and Gobo, 2004) and 3 – 20% (Nabegu, 2010) of the Municipal solid waste (MSW) generated in South West, South East and North Western part of the country respectively. Through the activities of scavengers, useful materials are often recovered from MSW including metal scraps, wood, plastics (Nabegu, 2010; Adebola, 2006; Nzeadibe, 2009; Scheinberg, 2012; Medina, 2010; Umaru, 2010). Scrap metals are among the most important and most priced materials in MSW. Many important metals have been recovered and recycled including iron and steel, copper, brass, aluminum (Onwughara et al., 2010; Norgate et al., 2007). Recycling of scrap metals prevent air, water and soil pollution, saves energy and raw materials and reduce greenhouse gas emissions. Recycling also conserve space in landfill sites.

MATERIALS AND METHODS

Description of Study Area

Gbogi scrap metal dumpsite is situated in Akure South Local Government Area of Ondo State, and geographically located on Latitude 7o 251 2711N and Longitude 5o 1812711E. The geographical coordinates of these locations were 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 is densely populated, with industrial, agricultural and economic activities on the increase. These condemned metal scraps from mechanic workshops, welding and fabrication workshops, automobile crash sites, markets and homes remain on the dumpsites for a very long period of time for large accumulation to be achieved before they are evacuated and transported to the steel company for recycling after which further accumulation continues.

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. They were collected at various vertical depths on the dumpsite. Also collection of soil samples were carried out at various horizontal distances away from the dumpsite. The soils were air-dried at laboratory temperature (30 ± 2^{o}C) for 6 days, before being passed through 2mm sieve to obtain the soil fraction used (FAO, 2006)

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 (Page, 1982)

Determination of heavy metals

Digestion of soil sample

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

Analysis of digested soil sample for heavy metals

The Atomic absorption spectrophotometry 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-acytylene 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 APHA, 1992

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.

RESULTS AND DISCUSSION

From the soil samples collected and analysed, the concentrations of all metals studies decreased with increasing depth and horizontal distances in all sites. The findings suggest that the soils studied had some heavy metal enrichment and surface soil or top soil which is point of impact bears metallic burden. It also indicates that surface soil are better indicator of metallic burdens. (Nyangababo and Hamuya, 1986).

Iron (Fe) concentration was highest (209.4mg/kg) at the dumpsite surface (Fig. 1a). 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. The concentration of Iron (Fe) also decreased with increasing horizontal distances from the scrap metal dump. Iron concentration at the surface soil of Gbogi were below NESREA acceptable limit. 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 Aluko and Olawande, (2003) and (Aderinola, et al., 2009 and Nwajei, et al.,2000). Fig 1b shows the variations of Iron concentration with horizontal distance from the landfill. The concentration decreased with increased horizontal distance from dumpsite.

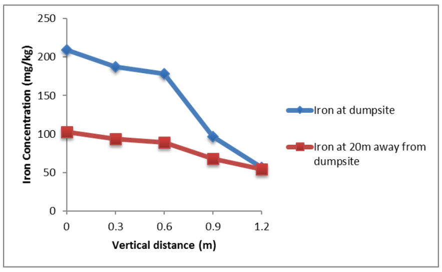

Fig 1a: Mobility of Iron showing different Concentrations at depths of Gbogi dumpsite and 20 meters away

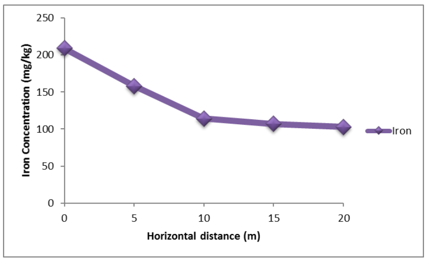

Fig 1b: Mobility of Iron showing different concentrations at distances away from Gbogi dumpsite.

Concentration of copper in soil surface of Gbogi metal scrap dumpsite was 39.7m/kg and value decreased significantly to 9.6mg/kg at a depth of 1.2m as shown in fig. 2a. The range of concentration reported by Awokunmi et al., 2010. This could have been as a result of corrosion and leaching of copper metals from the scrap vehicle parts at the dumpsite. In the variation of copper (Cu) concentration with vertical depth at 20 meters away from the dumpsite, similar trends were observed as a constant value was maintained within soil profile. It also indicates that soil toxicity decreases with depth, because copper mobility is low. The concentration of copper also decreased with horizontal distance from the dumpsite as shown in figure 2b.

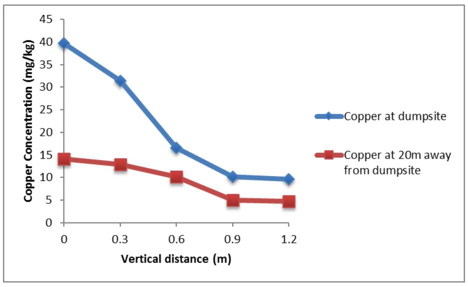

Fig 2a: Mobility of Copper showing different Concentrations at depths of Gbogi dumpsite and 20 meters away

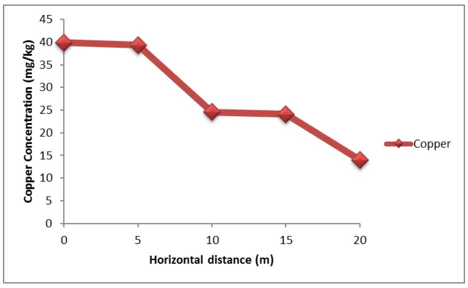

Fig 2b: Mobility of Copper showing different concentrations at distances away from Gbogi dumpsite.

Lead(Pb) at the surface of the dumpsite was 9.7mg/kg and it decreased to 4.4mg/kg at a depth of 1.2m- A very low concentration from what was reported by Akpoveta, et al., 2010. Between 0.3m to 0.6m, concentration of lead was stead of (Fig 3a). Lead concentration at Gbogi scrap dumpsite were below NESREA maximum acceptable limit. At increasing distances, lead toxicity also decreased with increasing distance and showed constant concentration at distance 15m to 20m (Fig 3b).

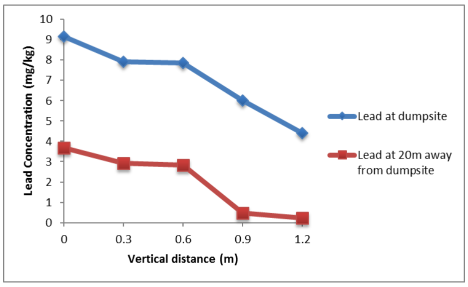

Fig 3a: Mobility of Lead showing different Concentrations at depths of Gbogi dumpsite and 20 meters away.

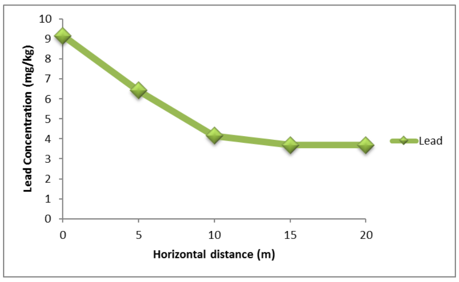

Fig 3b: Mobility of Lead showing different concentrations at distances away from Gbogi dumpsite

Toxicity associated with Zinc in soil shows a concentration 3.6mg/kg at surface of metal scrap site which decreased to 1.2mg/kg at 1.2m. At vertical depth away from dumpsite at 20m, concentration of zinc was 3.7mg/kg also decreased to 1.2mg/kg at 1.2m, revealing similar trend within soil profile

(Fig. 4a). The values recorded were however below maximum acceptable limit of NESREA (NESREA, 2007). The availability of zinc in the soil could be as a result of 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 tyre and automobile exhaust inclusive (Adriano, 2001).

Fig. 4b shows the variation of zinc concentration with horizontal distance from the dumpsite. The values of Zinc also decreased as the distances increases away from the dumpsite.

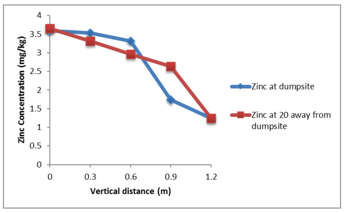

Fig 4a: Mobility of Zinc showing different Concentrations at depths of Gbogi dumpsite and 20 meters away

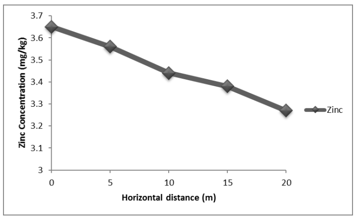

Fig 4b: Mobility of Zinc showing different concentrations at distances away from Gbogi dumpsite.

The concentration of cadmium (Cd) was 0.14mg/kg at the surface of the dumpsite. This value was the lowest concentration of heavy metals observed in the soil profile (Fig 5a). The concentration decreased to 0.07mg/kg at 1.2m. At vertical depth away from the dumpsite, similar or constant values of 0.01mg/kg was observed. It shows little or no leaching or run off processes.

The concentration of cadmium also decreased with horizontal distance from the dumpsite as shown fig. 5b.

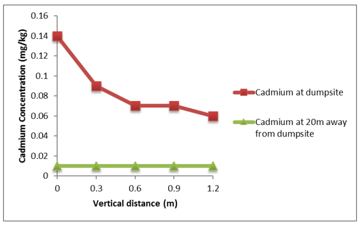

Fig 5a: Mobility of Cadmium showing different Concentrations at depths of Gbogi dumpsite and 20 meters away.

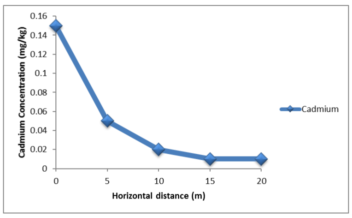

Fig 5b: Mobility of Cadmium showing different concentrations at distances away from Gbogi dumpsite

CONCLUSION

Toxic metals such as Fe (Iron), Copper (Cu), Lead (Pb), Zinc (Zn) and Cadmium (Cd) was present in Gbogi metal scrap soils. The concentrations of the observed metals was below NESREA limit for metal concentration in soil. It was observed that for all toxic metals, the concentration was highest at the surface, Iron (Fe) had the highest concentration with 209.4mg/kg. The order was Fe>Cu>Pb>Zn>Cd for Gbogi metal scrap dumpsite. Metal concentrations of the soils decreased with increasing vertical depth and increased horizontal distance from the dumpsite. Although, the concentration at the time of research seems low, continual use of the dumpsite should be discouraged due to foreseeable metal burden. The sorting or separation and recycling is advised. Accumulation of heavy metals in any soil is of concern due to health and Biosafety issues.

Mitigating the infiltration of metal leachate of scrap metal yards into soil and putting into consideration geology of the locality, prevalent climatic condition, type of waste generated and nature of settlement, a well-designed sanitary landfill should be encouraged. Legislative measures should also be considered in regulation of waste management.

For the purpose of soil protection and prevention of further soil pollution, the following constructive designs can be implored:

Area for temporary scrap storage should be built from solid material, fully sealed or enclosed roofed surface, protected from rainfall.

Floor of the storage or temporary landfill should be leak-tight and resistant to effects of stored or dumped scrap metals and polluted ingredients present in them.

Storage or temporary landfill should be equipped to avoid emission of dust, noise, smell and other emissions in the environment.

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