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Assessment of Zn Bioavailability in Dumpsites of Kaduna Metropolis, Nigeria

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Abstract

The objective of this research was to investigate the chemical fractionation, mobility and bioavailability of Zn in refuse waste soils of some dumpsites in Kaduna metropolis. The metal in the waste soil samples was sequentially extracted and measured using atomic absorption spectrometry, while the total concentration of the metal was determined using Energy Dispersive X-Ray Fluorescence (EDXRF) techniques. The soil pH was also determined. The results showed that Kurmin Mashi (KM) had the highest total concentration of Zn. From the ANOVA (P=0.005<0.05) it was established that there is a significant difference in the total Zn concentrations across the three locations. From the results it was also found out that the metal was distributed between oxide, carbonate and carbonate/organically bound fractions and that EDTA extracted the highest Zn concentration across the dumpsites. Similarly, the ANOVA (p=0.000<0.05) indicated a significant difference in the Zn extracted by the three extraction media.

Keywords: zinc, bioavailability, dumpsites, Kaduna metropolis.

Introduction

Zinc contamination in soils and vegetation is derived from several anthropogenic activities[1]. Soils are the receptacles for metals released from industrial activities, municipal waste sludge, urban composts, road traffics, atmospheric deposits and agro-chemicals[2]. Heavy metals are persistent in the environment and are non-biodegradable thus readily accumulate to toxic levels[3]. The heavy metal content alone does not provide predictive insights on the bioavailability, mobility and fate of heavy metal contaminants[4]. It is the chemical form or specie of the heavy metals that is a factor in assessing their impacts on the environment because it is their chemical forms that control its bioavailability or mobility[5].

The approach to soil speciation is to separate the soil into different chemical reagent or solvent fractions and analyse in each fraction the amount of elements combined or associated with each fraction or phase[6].

Research on nutrient intake have shown that low dietary Zn pose a potential nutritional problem[7]. Therefore, the accurate Zn determination in food and soil is very important.

This study reports Zn concentrations in dumpsites samples of Kaduna metropolis by flame atomic absorption spectrometry (FAAS) and Energy Dispersive X-ray Fluorescence (EDXRF).

Material and Methods

A flame atomic absorption spectrophotometer model 8010 Young Lin and Energy Dispersive X-ray Fluorescence spectrometer model minipal 4 were used in the Zn determination. In the extraction procedures, 1.0M oxalic acid, 0.05M Na□EDTA and 1.0M acetic were used.

Preparation of samples: The research covered three sites in Kaduna, Nigeria. The sites are: Kurmin Mashi (KM), Narayi (NY) and Tudun Wada (TW). The dumpsites are situated around residential areas within metropolis. The samples were collected during the rainy season in September and October, 2011. The soil samples from the dumpsites were collected from different areas enumerated (figure 1). Triplicate sample from each dumpsite were collected and composite samples were made in the laboratory. The samples were air dried and sieved using 2mm sieve.

Digestion and extraction of soil: Soil extracts from the dumpsite were obtained by shaking separately 5g of soil samples with 10cm³ of 0.05M Na□EDTA (for carbonate and organically bound phases) 1.0M of oxalic acid (for oxide phase) and 1.0M acetic acid (for carbonate phase) occasionally on a hot plate. Four (4)cm³ of 1.5M HNO□ was added to the residue and centrifuged. The digest was diluted to 60cm³ with distilled water. The clear digest was analysed for Zn using FAAS model 8010 Young Lin. A blank digest was carried out in the same way.

Total Metal Concentration: In determining the total metal concentration in the various dumpsites, 5g of fresh samples from each site were air dried and pulverized. These were analysed using the EDXRF spectrometer model minipal 4.

Results and Discussion

Total Zinc content in the dumpsites: The total Zinc content in the dumpsites varied from one location to another. The results are shown in table-1.

From the results, Kurmin Mashi (KM) dumpsite had the highest concentrations of Zn. Generally, the concentration of Zn in the three dumpsites studied were very high and above the allowable limits of 300mg/kg[8]. Similar findings were reported by other investigators[9-14]. From the ANOVA (P=0.005<0.05), there is a significant difference in the total zinc concentrations across the three locations.

Zinc Speciation: The distribution of zinc in the dumpsites varied from one location to another. It existed in oxide, carbonate and carbonate/organically bound fraction. The zinc content bound to carbonate/organically bound fraction is highest in KM and TW hence Zn is said to be organically bound species in these dumpsites and therefore bioavailable and mobile in these locations. This is in agreement with investigations carried out by other authors in similar situations[6, 15-16].

The pH of the dumpsites from two of the locations (KM and NY) is acidic, while the pH value from TW dumpsite appeared alkaline. This could be attributed to the presence of metal scraps, waste materials in the dumpsites and other anthropogenic activities taking place around the dumpsites[11]. EDTA extracted the highest concentration of Zinc from the dumpsites[6] as depicted in figure-2.

From the ANOVA (P=0.000<0.05) there is a significant difference in the Zn extracted by the three extraction media. From the Duncan multiple range test, it was established that the dumpsite from NY had the highest concentration of Zinc followed by KM and TW as shown in figure-3.

Table-1
Results of Zinc concentration in the dumpsites across the sample locations, The results are mean values (mg/kg) ± standard deviation n = 3

Sample Site	pH	EDTA 0.05M	Oxalic acid (1,OM)	Acetic Acid (1.0M)	Total Zn concentration (mg/kg)
KM	5.13	25.60 ± 0.069	15.00 ± 0.120	1.56 ± 0.120	5,403.33 ± 1,606.53
NY	5.23	15.16 ± 0.069	31.52 ± 0.069	0.20 ± 0.069	2,820.00 ± 541.48
TW	8.37	7.20 ± 0.120	1.00 ± 0.069	0.00	1,090.00 ± 268.89

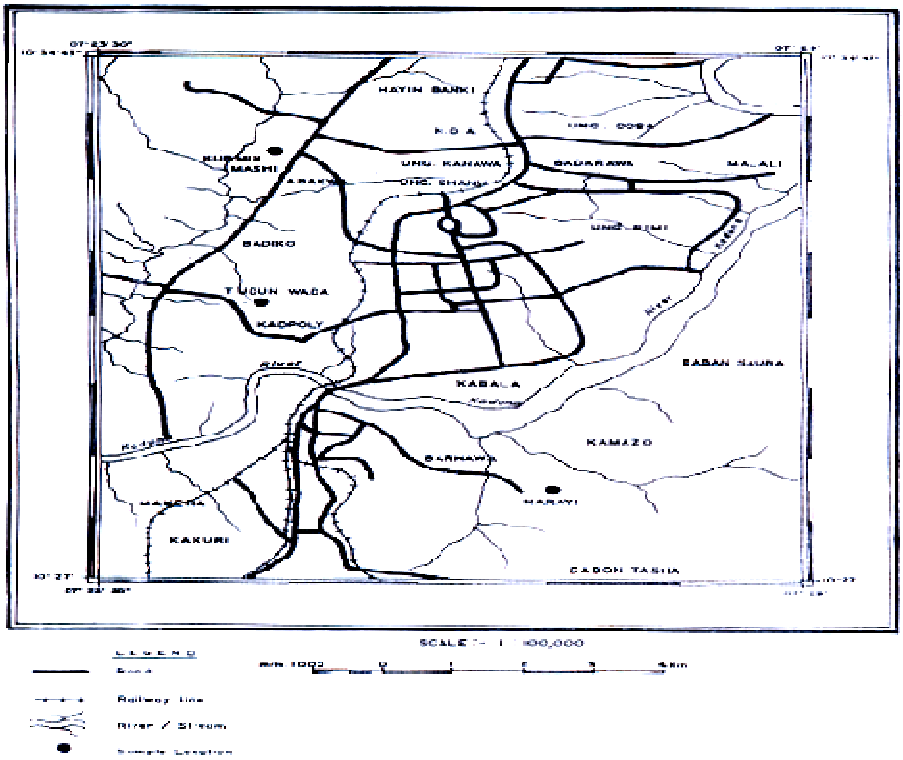

Figure-1
Map of Kaduna Metropolis showing sampling sites

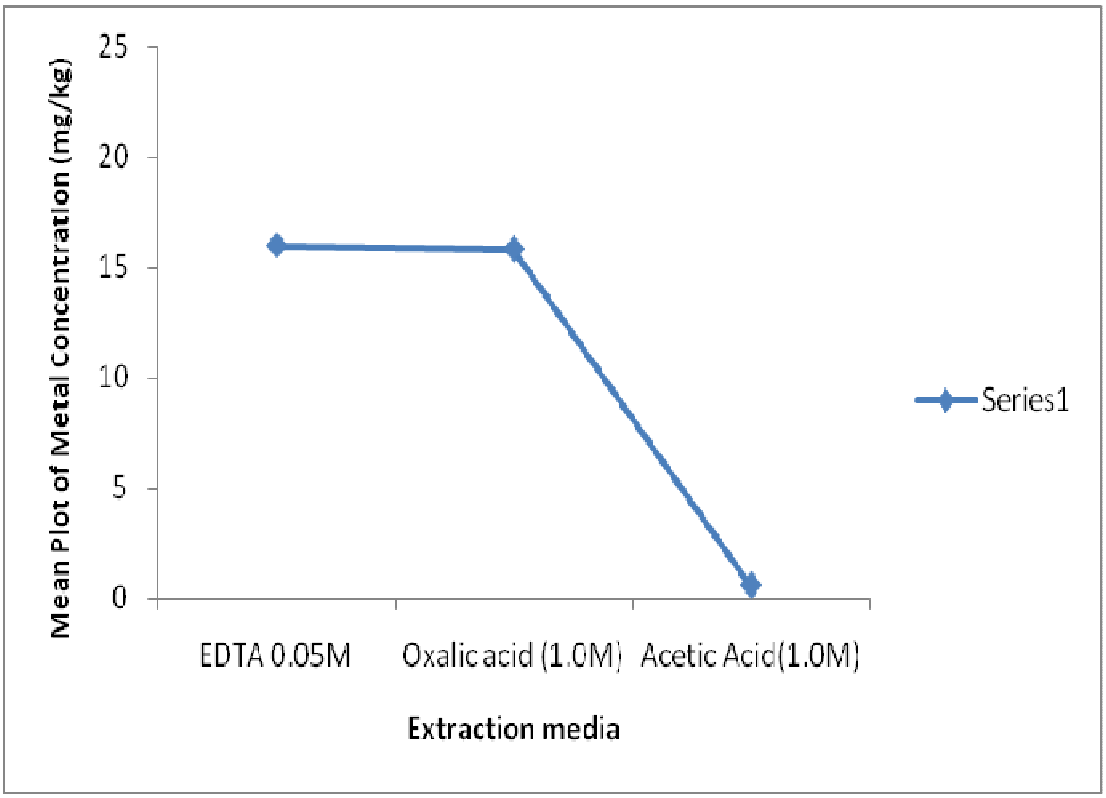

Figure-2
Mean plot of zinc concentration in the extraction media

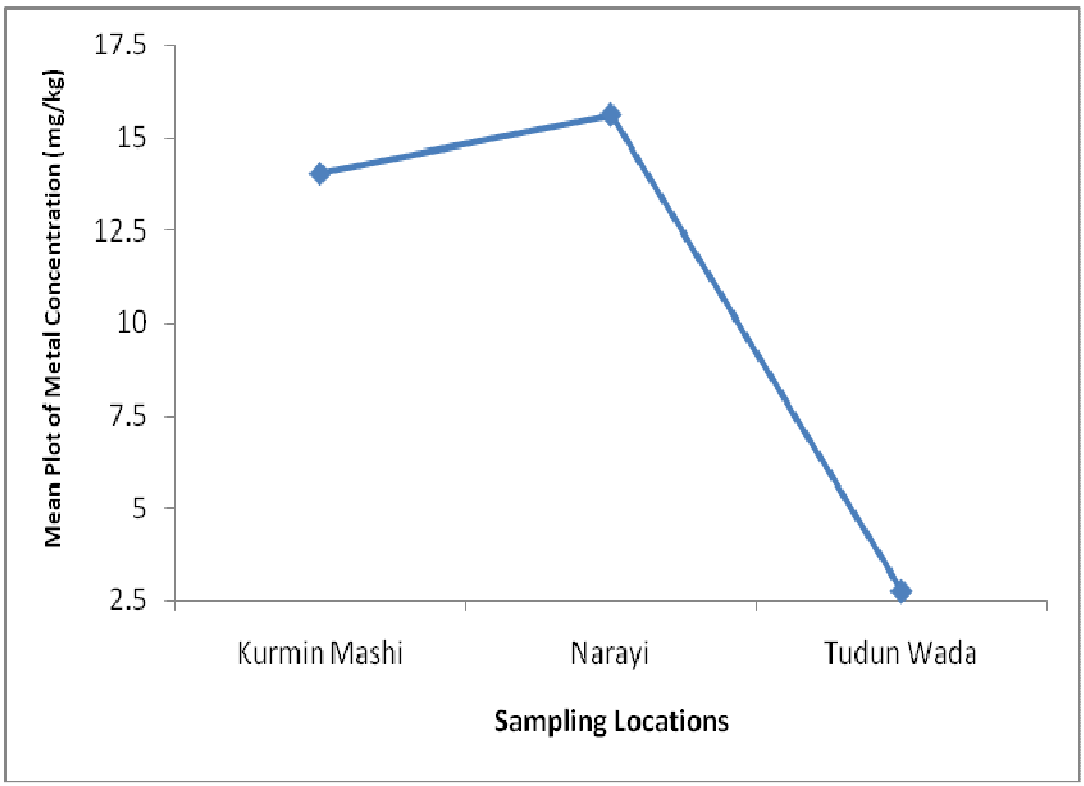

Figure-3
Mean plot of zinc concentration across the locations

Conclusion

In the present study, the level of Zn in the soil collected from the different dumpsites was found out to be very high, hence giving rise to the pollution of the areas considered. The contamination of the soil by the metal can be traced to the indiscriminate dumping of inorganic waste materials at the dumpsites. The continuous contamination of the soil by Zn and its detrimental effect on the residents of these areas begs for concerted efforts towards effective and adequate management of solid waste. The level of heavy metals can be reasonably reduced if soil wastes are sorted and the inorganic parts are recycled.

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