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Assessment of Physicochemical Properties and Heavy Metals Contents in Selected Dumpsites in Afikpo, Afikpo North, Ebonyi State, Nigeria

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ABSTRACT

The physiochemical parameters and heavy metals contents in refuse waste soils of selected dumpsites in Afikpo, Afikpo North, Ebonyi State, Nigeria were investigated using standard analytical methods. The results showed no significant (P > 0.05) differences in the temperature and moisture contents of the samples in all the sites. However, the pH, electrical conductivity, total organic carbon, total organic matter, phosphate (PO_4^{3-}), sulphate (SO_4^{2-}), nitrogen and carbon to nitrogen ratio (C:N) varied significantly (P < 0.05) from one site to another and were always higher in the dumpsites compared to the control sites. The results also indicated that the mean values of Zn, Cu, Fe, Ni, Mn, and Pb varied significantly (P < 0.05) from one site to another and were always higher in the dumpsites compared to the control sites. In all cases, Mgbo dumpsite had the highest mean contents for all the metals followed by Amuro dumpsite, while Amaizu dumpsite had the least mean values for Cu, Ni and Mn only, Amaechara dumpsite had the least values for Zn, Fe and Pb only. These results showed anthropogenic input of heavy metals in the dumpsites and their ecological risks implications in biodiversity were discussed.

Key words: physicochemical parameters, heavy metals, Dumpsites, Afikpo

Introduction

Wastes are those things which its owner no longer wants at a given time and space and which has no current or perceive market value (Ogbonna, 2005). Wastes do not therefore apply to worthless substance or useless substances as one waste in an instance may become a feedstock or raw materials in another instance. Waste usually contains paper, food waste, metal scraps, glass, ceramics, ashes etc depending on their sources. Some of the components are biodegradable while others are not. Soil is a natural reservoir of metals whose concentrations are associated with several factors such as biological and biogechemical cycling, parent material and mineralogy, soil age, organic matter, soil pH, redox concentrations and microbial activities (Greenland and Hayes, 2000; Lee *et al*, 1997; Ma *et al*., 1997). Report has shown that the decomposition or oxidation of waste releases additional heavy metals into the surrounding soil and groundwater (Obasi *et al*., 2015:2013:2012; Agiratas *et al*., 1999, Nupe *et al*., 2008; Uba *et al*., 2008; Elaigwu *et al*., 2007). Heavy metals are metals and metalloid having atomic densities greater than $5g/cm^3$(Wild, 1993). Metals found in waste dumps exist in various forms either as the pure metal or alloyed with various other metals. Numerous reports have shown that the heavy metals which impair the quality of our environment come from various sources which could be generally categorized into urban industrial aerosols, liquid and solid wastes from animal and man, mining and industry and agricultural chemicals among others (Gerard, 1996; Garbarine *et al*., 1995).
Although some heavy metals (e.g. copper, selenium, zinc) are essential for metabolic purposes in flora and funna, at concentrations above their threshold limit, they become toxic to the biodiversity in the environment due bioaccumulation and biomagnifications (Lenntech, 2011; Raikwar *et al*., 2008). In Afikpo as in most semi-urban and rural area of developing nations, dumpsites are used as arable lands for cultivation of a variety of edible plants food stuffs. Therefore, a better understanding of the heavy metal load and their interactions in this environment is an important for the risk assessment (Obasi *et al*., 2015:2013; Sharma *et al*., 2004). Thus, this study is aimed to investigate the physicochemical properties and the heavy metal status in some dumpsites soil in Afikpo in order to extrapolate the human health and ecological risks associated with the refuse dumpsite.

Materials and Methods

Dumpsite description and sample collection: Soil samples were obtained from four dumpsites and one control site in Afikpo, Afikpo-North, Ebonyi State, Nigeria. The five locations include: Amaizu dumpsite (latitude 05^0, 45", 36" and longitude 07^0, 55", 12"), Mgbom dumpsite (latitude 05^0, 45", 22", and longitude 7^0 55", 22"), Amaechera dumpsite (Latitude 05 55", 18" and longitude 07^0 55" 22") and Amuro dumpsite (latitude 05^0 45", 14", and longitude 07^0 55", 22") and a control site which is a nearby farmland (latitude 05^0, 51", 45" and longitude 07^0, 05", 44"). Triplicate sample from each dumpsite and control site were collected seven meters within the vicinity of the sites and composite samples were made in the laboratory. The samples were air dried and sieved (using 2mm sieve) and then stored in Polythene bottles in desiccators at room temperature before further analysis.

Physiochemical analysis of samples: Soil pH was determined (1:2.5w/v) using digital pH meter according to the method described by Bates (1954), soil electrical conductivity was determined (1:2.5 w/v) using conductivity meter according to the method outlined by Godson *et al*. (2002), moisture content was determined by the method of Shrivastava and Banerjee (2004), total organic carbon and total organic matter were determined according to the method outlined by Osuji and Adesiyan (2005), Total nitrogen was determined by the Semi kjeldhal method (Yeomans and Bremmer, 1991), SO_4^{2-} was quantified by the turbidimetric method outlined by Butters and Chenery (1959) while PO_4^{3-} was determined by Braig No. I method (Olsen and Somners, 1982).

Heavy Metal Analysis of Sample

Soil samples were air dried, ground to fine dust, sieved to pass through a 2mm sieve one gram of the sieved soil sampled was weighed into a conical flask and digested with 10ml of 50% hydrochloric acid on a hot plate until 2-3ml of acid was left. The content was the filtered into a 50ml volumetric flask and rinse to make up to the mark with deionized water. The concentrations of heavy metals in all the samples were determined using the Perkin-Elmer atomic absorption spectrophotometer (model 403).

Result and Discussion

The results of physiochemical properties of the soil samples are shown in Table 1. The temperature of the waste dumps range from 28.7^0C – 29.2^0C with Amaechara and Amaizu dumpsite having the lowest and highest temperature values respectively. There was no significance difference ($P > 0.05$) in the temperature recorded in all the sites including that of the control site. Temperature directly affects the activities of the soil biota by determining the rates of physiological activity such as enzyme activity and indirectly by affecting physiochemical properties such as diffusion and solubility of nutrients, mineral weathering and evaporation rates (Tukura *et al*., 2007). The temperature range obtained in the sites of study is in line with the climatic dispositions of the area under study and fell within defined limits for optimum biological activities of soil microbial flora and fauna.

The results showed that the soil pH ranged from 6.91 in the control site to 7.41 Amaizu dumpsite. Generally, the results showed that the pH were higher in all the dumpsites compared to the control site and that the difference in these pH values from one dumpsite to the other were significant ($P < 0.05$). These results showed the varying ages of the dumpsites and probably the level of deposition of municipal waste and other organic substances in the dumpsites. The pH however is within the normal range favourng the growth of soil microbial flora and fauna and the availability of many nutrients for plant growth and maintenance (Arias *et al*., 2005).Thus, being a key player in soil microbial reactions, the measured pH values may well have implications on the availability and uptake of metals by plants and micro organisms.

The electrical conductivity of the waste soil was generally and significantly higher ($P < 0.05$) in the dumpsites compared to the control sites and ranged from 2.85μs/m in Amaizu to 4.00μs/m in Mgbom. Similar results were reported for some dumpsites at Zaria (Uba *et al*, 2008) and Enugu – Port Harcourt express way (Obasi *et al*., 2012). The high electrical conductivity values of the waste soils may be attributed to the presence of metal scraps which is one of the constituents of the refuse dumpsites and this implicates that there are more soluble salts in the soil (Arias *et al*., 2005; Karaca, 2004, Singer and Munns, 1999).

The moisture content of the samples were higher in all the sites and there were no significant difference ($P > 0.05$) in the values of the moisture content observed in all the sites. The high moisture content in the studied sites may be attributed to the climatic disposition in the study area. Similar results have been reported for different dumpsites in this region (Obasi *et al*., 2015: 2013: 2012; Goorah *et al*. 2009; Obute *et al*., 2010). Also, moisture content is directly related to the volume of pores in any given soil at any given suction and the high moisture content may also be attributed to the poor drainage of waste dumpsite (Talha *et al*., 1999; Howl *et al*., 1985). The level of organic matter in soils influence a number of soil chemical and physical processes and it is an important indicator of the soil as a rooting environment (Okalebo *et al*., 1993). The total organic carbon and total organic matter were significantly higher ($P < 0.05$) in all the dumpsites compared to the control sites and significantly ($P < 0.05$) varied from one dumpsites to another. The higher organic carbon in the studied dumpsites may support increase in activities of micro organism that decomposes organic residues, leading to accumulating of organic matter. The total nitrogen, PO_4^{3-} and SO_4^{2-} in the refuse waste soils were generally high. These show appreciable level of these nutrients in the soils and may partly account for the luxuriant growth of plants species observed in the study areas (Obute *et al.*, 2010; Okalebo *et al*., 1993; Ukpong *et al*., 2013).

The heavy metals contents of the studied sites are shown in Figures 1and 2. The results showed that metals in the dumpsites were generally significantly higher ($P < 0.05$) compared to the control sites for all the sites studied. For all the sites studied, Mgbo dumpsite has the highest level of all the metals studied, Amaechara dumpsite has the lowest level of Zn, Fe and Pb while Amaizu dumpsite has the lowest Cu, Ni and Mn. The level of zinc (Zn) in the studied dumpsites (Figiure 1) which ranged from 128.55 to 161.43 mg/kg fell below the permissible limits of 300mgkg^{-1} for agricultural lands set by USEPA (1986) and CEC (1986). Although, Zc is a micro-element which a essential in plants and animals nutrition but only in minute quantities as constituent of a plant necessary for their growth and development(Lieberman and Bruning, 2008), the level of Zn in these dumpsites might in the long run cause ecological and health risks.

The results (Figure 1) of Cu indicated that the metals concentrations in all the refuse dumpsites studied were all below the toxic limit of 250mgkg^{-1} set by USEPA (1986) and CEC (1986) for agricultural lands. This could be attributed to the fact that anthropogenic input of the metal is very low due to the location of the dumpsites in the rural area.

Results obtained for Fe content in these dumpsites (Figure 1) compared favourably with those reported by others (Ogbonna *et al*., 2009; Uwah *et al*., 2009; Uba *et al*., 2008; Elaigwu *et al.*, 2007) and are within the permissible range for agricultural lands.

The results of the Nickel (Ni) contents in the studied refuse dumpsites (Figure 2) showed that all the dumpsites fall below the permissible limit of 150mgkg^{-1} for residential and agricultural lands (CCME, 1991).

The results of the manganese obtained from this study (Figure 2) showed that the concentrations of Mn in all the dumpsite samples were within the tolerable limits (100-300mgkg^{-1}) set by USEPA (1986) for agricultural lands. Similar results were observed by Uba *et al*. (2008) and Albores *et al*. (2000) among others. The study recorded that all the dumpsites contained lead (Pb) concentrations within the USEPA (1986) allowed limits of 30-300mgkg^{-1}(Figure 2). Similar results were reported by Uba *et al*. (2008) and Obasi *et al*. (2015).

The enrichment of soil with manganese and lead may be attributed to the various human activities going on in the area. Although these metals were still within the permissible limits, their concentrations showed anthropogenic inputs (Odero *et al.*, 2000).

Conclusion

The findings of this study revealed that waste alter the mean value of physicochemical parameters and may improve the fertility of the soils to support increased biodiversity. Also, the study revealed anthropogenic input of high level of metals in dumpsites. Although, it was observed that the metals were still within the permissible limits, the results revealed possible ecological and health risks in the long run.

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(Tables & Figures)

Table I: Phsico-chemical parameters of waste soils identified in studied dumpsites

Sample	Temp. (^{0}C)	pH	EC (μs/m)	Moisture (%)	TOC (%)	TOM (%)	PO_4 (mg/kg)	SO_4 (mg/kg)	N (%)	C:N
Amaizu dumpsite	29.2^a ±1.02	7.41^e ±0.07	2.85^b ±0.33	87.95^a ±1.12	3.96^d ±0.91	6.83^d ±0.07	8.38^b ±0.16	29.73^c ±0.15	0.36^c ±0.05	11.00
Amuro Dumpsite	28.8^a ±0.05	7.16^c ±0.11	3.92^c ±0.04	88.15^a ±0.22	4.40^e ±0.21	7.59^e ±0.13	12.88^d ±0.31	49.39^e ±0.21	0.29^b ±0.11	15.17
Amechara Dumpsite	28.7^a ±0.72	7.32^d ±0.55	2.90^b ±0.07	87.98^a ±0.13	3.60^c ±0.08	6.21^c ±0.16	15.00^e ±0.42	37.28^d ±0.55	0.38^c ±0.08	9.47
Mgbom dumpsite	29.0^a ±0.22	7.05^b ±0.17	4.00^d ±0.02	87.96^a ±0.24	3.29^b ±0.53	5.67^b ±0.11	11.50^c ±0.24	26.20^b ±0.14	0.27^b ±0.03	12.19
Control Soil	28.9^a ±0.13	6.91^a ±0.08	1.37^a ±0.03	88.10^a ±1.01	1.30^a ±0.12	2.24^a ±0.25	8.13^a ±0.22	15.17^a ±1.03	0.20^a ±0.02	6.5

- Values are mean of three (n=3) replicates ± standard deviation .
- Temp. = Temperature, EC = Electrical Conductivity, TOC = Total Organic Carbon, TOM = Total Organic Matter
- Figures followed by the same alphabets along the column are not significantly different at P < 0.05 using Ducan Multiple Range Test (DMRT)

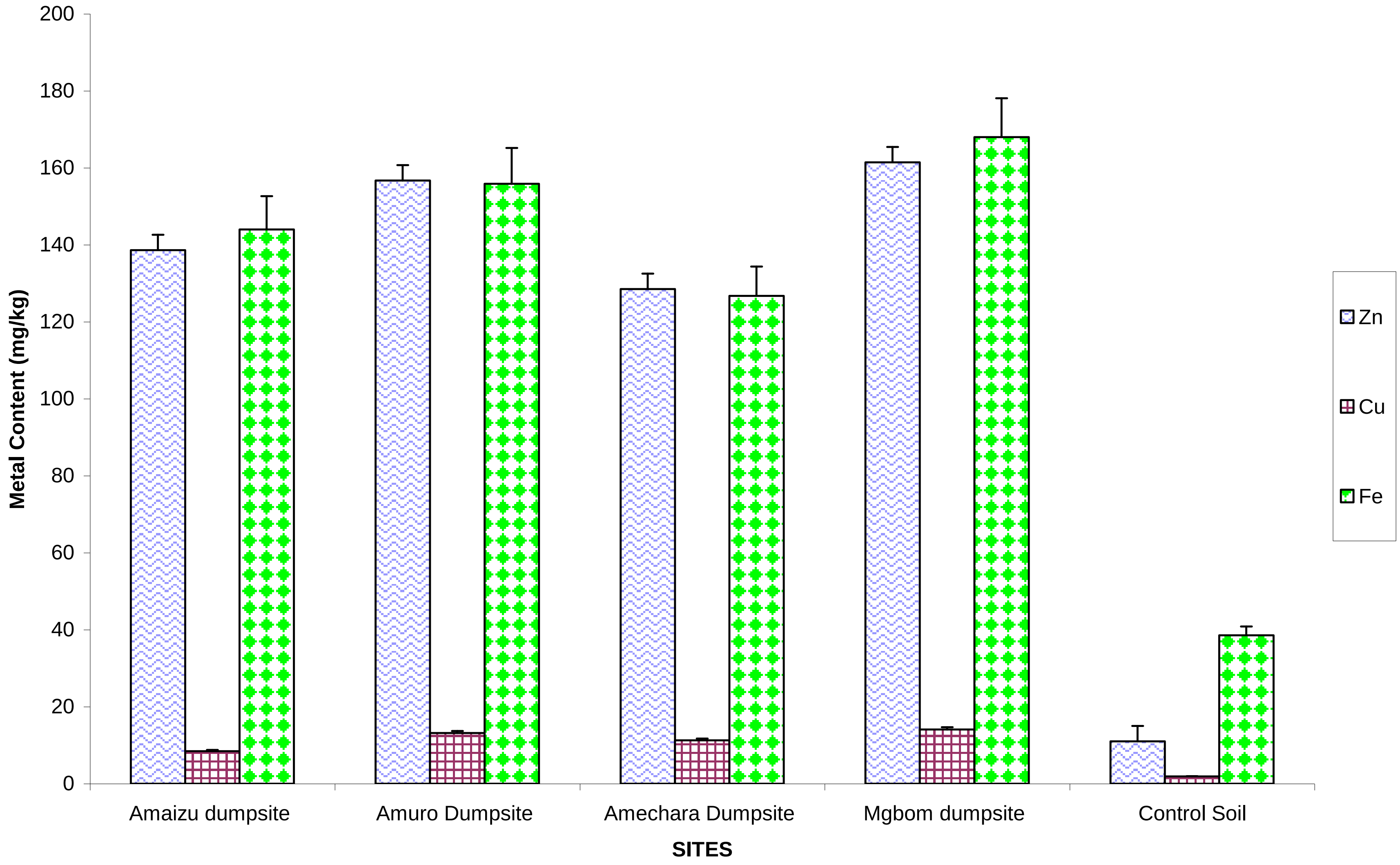

FIGURE 1: Zn, Cu and Fe contents in mg/kg (dry weight) of the soil samples in the various sites

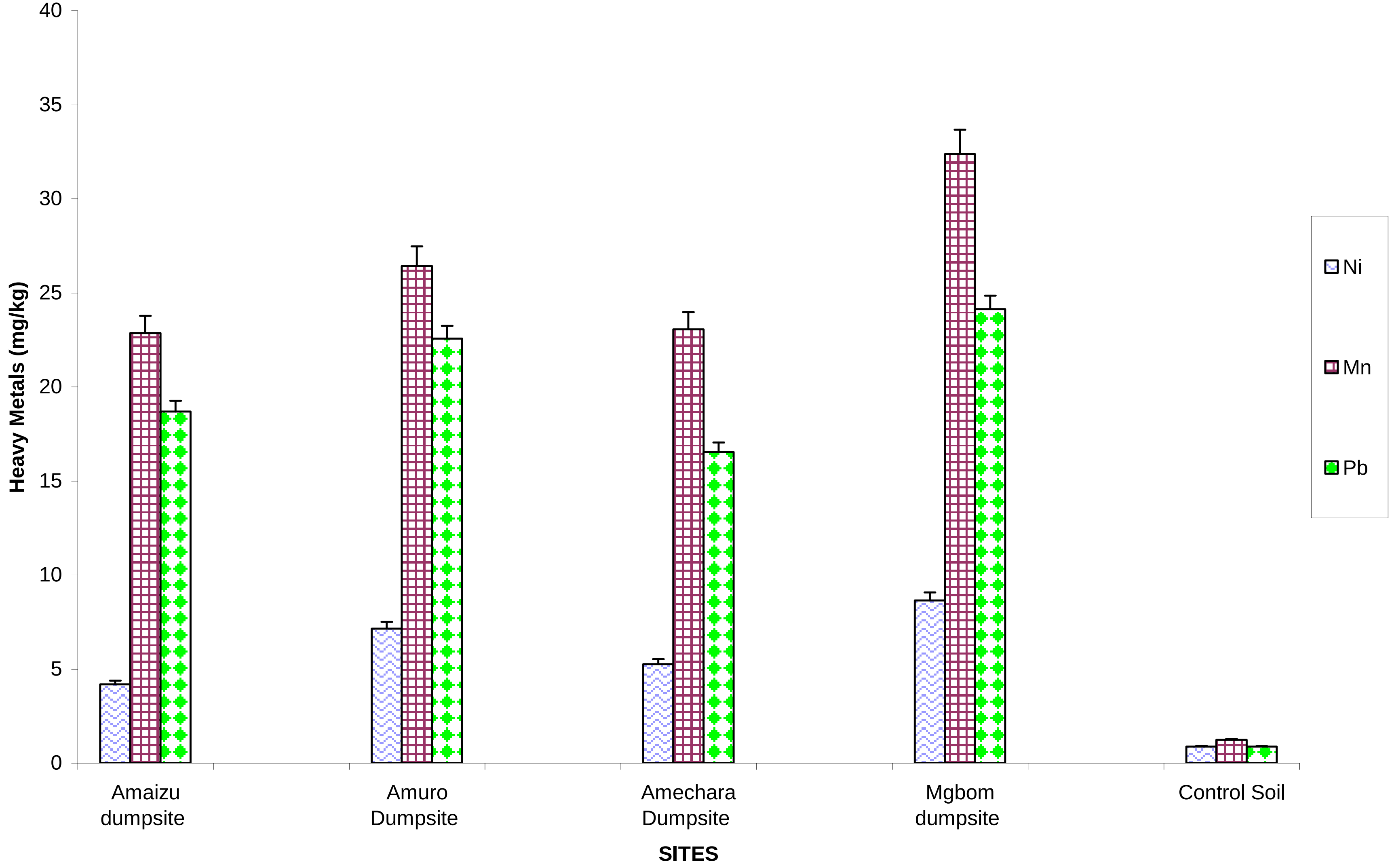

FIGURE 2: Ni, Mn and Pb contents in mg/kg (dry weight) of the soil samples in the various sites