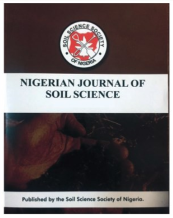
Anikwe, et al. NJSS 30 (3) 2020 62-69

Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com


NIGERIAN JOURNAL OF SOIL SCIENCE

Published by the Soil Science Society of Nigeria.

# Suitability of urban waste land use in relation to heavy metal and micronutrient influence on soil and green amaranth production in Southeast Nigeria

A.O Ezeifeka [1], V.I Ezeaku, [1], P.I. Ezeaku [2,1], M.A.N Anikwe[4]*., P.K Kefas[2] and K.I Ofem[3]

[1] *Department of Soil Science, University of Nigeria, Nsukka*
[2] *Department of Agronomy, Taraba State University, Jalingo*
[3] *Department of Soil Science, University of Calabar, Nigeria*
[4] *Department of Agronomy and Ecological Management, Enugu State University of Science and Technology, Enugu, Nigeria*

**ARTICLE INFO**

*Article history:*
*Received November July 10, 2020*
*Received in revised form August 5, 2020*
*Accepted September 13, 2020*
*Available online November 10, 2020*

***Keywords:***

Soil heavy metal
Toxicity
Urban waste
Green amaranth
southeast Nigeria

Corresponding Author's E-mail Address:

anikwema@yahoo.co.uk
Tel.: +234(0)8033387354

https://doi.org/10.36265 njss.2020.300308

ISSN– Online **2736-1411**

Print **2736-142X**

## ABSTRACT

An assessment of the impact of long term (>20 years) MSW disposal on soil properties and their suitability for crop productivity was carried out in Anambra and Enugu States of southeast Nigeria. Four dumpsites were selected (two in each state) and, 12 soil auger samples (2 sampling points at 3 depths and 2 repeated measures) each were collected at incremental depth intervals of 0-20, 20-30, and 30-40cm were collected at the dump sites and adjacent non-dumpsites situated 100 meters away from the dumpsites; The auger samples were used for the determination of Fe, B, Pb and Zn content of the soil. Forty *Amaranthus spinosus* biomass samples were collected from both dump and non-dumpsites in the four locations and also assayed for Fe, B, Pb, and Zn content. Results showed that the mean values of Fe concentration in the dumpsites are between 4.48 – 11.57 mg kg$^{-1}$ whereas B ranged from 1.19 – 6.73 mg kg$^{-1}$; Pb ranged from 0.36 – 2.19 mg kg$^{-1}$ and Zn averaged from 17.2 – 54.0 mg kg$^{-1}$. The values of these elements were higher than those of the corresponding non-dump sites by between 6-100 %. Pb and Zn with values of 2.0 and 0.06 mg kg$^{-1}$ respectively in the amaranth plants in the dumpsite soils were higher than the permissive limits for heavy metals in vegetables. Despite the toxicity variance of the elements in the dumpsites and non-dumpsite soils and vegetables, the calculated hazard quotient (ecological risks) values of these elements were less than unity (Q.H.Q < 1), suggesting that harmful effects are not likely to occur in the study areas. Public awareness creation of the dangers of plant cultivation in the unmanaged dumpsite, including health implication of heavy metal pollution and entry into the food chain as well as controlling sources of municipal wastes with appropriate legislations are recommended.

## 1.0. Introduction

Nigeria is urbanizing at an astounding pace, with the urban population growing at about 5.5 percent per annum (World Bank, 1995). Some of the apparent implications of the urban explosion are changes in land use with an increasing proportion being used for commercial and industrial purposes. Some of the environmental impacts of the land-use change include the brown agenda problems: air, soil and water pollution, loss of biodiversity, and infrastructure inadequacy (National Research Council, 1999).

Anambra and Enugu States in southeast Nigeria are characterized by infrastructure inadequacy, and this has made solid waste handling and disposal difficult. These wastes are in the form of garbages from households, markets, and small-scale industries, rarely incinerated or burnt in the open. Some authors (Nwaogu and Ogbuagu, 2017; Anikwe and Nwobodo, 2002) have reported that municipal solid wastes (MSW) are complex refuses to consist of various materials from our day-to-day consumed and discarded items with different properties. Some of the components are stable while others biodegrade as a result of biological and chemical processes. The amount and variety of these wastes drastically increase with both technology and population growth in any given area.

Municipal solid wastes (MSW) are sources of environmental pollution through the introduction of chemical substances above their threshold limit into the environment. Reports have shown that solid wastes introduce additional heavy metals into the surrounding soil and groundwater

(Aydinlp and Marnova, 2003; Elaigwe *et al*., 2007; Ideriah *et al.,* 2006). According to Oyedele *et al.* (2008) as well as Anikwe and Nwobodo (2002) the continuous accumulation of the municipal solid waste (MSW) over a long period usually twenty years and above (long term) is associated with heavy metals accumulation and can affect soil properties and productivity, and this is common in the urban centers where accelerated industrial, agricultural, and intensive economic activities prevail. This, therefore, poses a threat to humans as most edible crops are indiscriminate in their extraction of nutrients from the soil, thereby serving as a point of entry of heavy metals into the food chain.

As seen in most cases, soils in municipal waste dump sites are usually very fertile for the cultivation of a variety of fruits and leafy vegetables, and the soils are sometimes used as compost by farmers with little knowledge of the probable health hazards these heavy metal contents of such soils could cause when consumed through grown vegetables (Amusan *et al.,* 2005). Furthermore, waste in the form of garbage and waste from food processing plants are simply dumped and thus increasing air, soil and water problem, traffic congestion, which have direct and immediate implication for human management of urbanization

Municipal solid waste (MSW) exerts a positive influence on physical and chemical soil properties such as porosity, aggregate stability, water holding capacity, pH-buffering capacity, cation exchange capacity, and microbial population (Drozd, 2003; Goswami and Sharma, 2008). Furthermore, municipal solid wastes (MSW) improves the restoration of degraded soils and adds to the organic matter content of the soil when they decompose which eventually helps to improve the soil's physical and chemical properties and enhance biological activities.

There are concerns about potential public health hazards from the presence of pathogens and pollutants, such as trace metals and organic contaminants. According to Alloway (1996), toxicity sets in when the heavy metal and micronutrient contents in the soil exceed the natural background level. Continuous disposal of MSW in soils may increase heavy metal accumulation and impacts harmful effects on soil, crop, and human health (Amhakhian *et al*., 2003). They further noted that if organic waste is allowed to concentrate and is exposed to rain, its decomposition produces a noxious odor, thereby constituting a health hazards.

Green amaranth is a vegetable of national importance in terms of human and animal nutrition (rich in vitamins, minerals, and protein content of the leaf and seeds), diversifying the food basket and industrial use as ink (Amhakhian *et al*., 2003). However, it is a heavy bioaccumulator of heavy metals.

It has been observed that soil has traditionally been an essential medium for organic waste disposal. Mbagwu and Piccolo (1992) observed that soil differs in their response to organic waste, and it is essential to investigate more closely the influence of these organic and inorganic wastes on a range of physicochemical properties. It was noted that a better understanding of the behavior of elements in the soil-air-plant system seems to be particularly significant, especially at the time when environmental quality and food production are of significant concern (Voutsa *et al*., 1996). The study sought to i) assess the influence of municipal waste dumpsites on soil properties, particularly the level of heavy metals concentration, and their suitability for green amaranth (*Amaranthus spinosus)* production; ii) compare the number of heavy metals bio-accumulated by the green amaranths in the waste dumpsites with those grown in the surrounding environment, and iii) assess the ecological risks of the heavy metals in Enugu and the Anambra States of southeast Nigeria.

## 2.0. Materials and methods

### *2.1 Study site*

The study was carried out in 4 urban centers in Anambra and Enugu states of the Southeast zone of Nigeria. A reconnaissance survey of the study area was carried out and four municipal waste dump sites were selected in the two states. They are Obosi ($6^0$ 6.158' N and $6^0$17.975' E with an altitude of 44 m) and Onitsha ($6^0$8.631' N and $6^0$46.504' E with an altitude of 307m) in Anambra state as well as Nsukka ($6^0$ 51.131' N and $7^0$25.415' E with an altitude of 470m) and Ugwuaji ($7^0$ 32.967' N and $6^0$ 26.318' E with an altitude of 181m) in Enugu State. The coordinates were obtained with a handheld GPS. The study area is characterized by a pseudo-bimodal rainfall pattern from April to November. The total rainfall received within this period in the area was about 1700–2060 mm. The entire zone receives abundant insolation during the day. The maximum mean daily temperature is 27–31 $^0$C all through the year. Humidity is high, with the lowest levels during the dry season in May before the rainy season begins.

The soil of the Obosi and Onitsha site are typified by the coastal plain sands characteristics and are highly susceptible to erosion. Beneath the weak lateritic and acidic soils are unstable and poorly consolidated geologic rocks (World Bank Group 2016). The Nsukka soil is deep, porous, and red to brownish red, derived from sandy deposits of false-bedded sandstone. It has an isohyperthermic soil temperature regime and is classified as Typic Paleustult (Nwadialor, 1989). The soil of the Ugwuaji site is lateritic and is of sandy loam textural class. It has an isohyperthermic soil temperature regime and is classified as Typic Paleustult (Anikwe et al., 1999).

These sites are within each metropolis and have been used for more than 20 years for dumping municipal wastes. At each site (measuring between 3,000 to 7,000 m$^2$) more than 85 to 10 ton of unsorted municipal wastes mainly made up of household and industrial effluents including leaves and food remnants, paper, rags, plastic/ polyethylene, tins and metals, bottles, glasses, laboratory wastes and a variety of miscellaneous materials are dumped weekly in each site. . It was a common practice of urban dwellers to cultivate a variety of crops in parts of the temporarily abandoned sections of the dumps because of lush green vegetation found around those dumpsites (Anikwe and Nwobodo 2002). The temporarily abandoned parts of the four dumpsites currently cropped by urban farmers for between two and four years were used for this study. The sites were cultivated with different types of food crops (yams, cassava, groundnut, and leafy vegetables). Observation points were selected at each site using a free survey technique (observation points that are representative of the site are chosen by the surveyors based on personal judgment and experience (Mulla and McBratrey, 2000).

### *2.2 Soil Sample collection*

Observation points were selected at each site using a free survey technique (observation points that are representative of the site are chosen by the surveyors based on personal judgment and experience (Mulla and McBratrey, 2000). In the four location dumpsites, 12 soil samples (2 sampling points at 3 depths and 2 repeated measures) each were collected with an auger at incremental depth intervals of 0-20, 20-30, and 30-40cm; giving 48. The same number of auger soil samples was collected at the non-dumpsites situated 100 meters away from the dumpsites; giving a total of 96 for both dump and non-dump sites. Forty-eight (48) cylindrical core (volume = 98.2 $cm^3$) soil samples were collected at the same depth intervals in the dump and non-dumpsites of the four locations. Soil samples were air-dried, sieved using 2 mm mesh, and adequately labeled. The soil samples were subjected to routine physical and chemical analyses.

A total of 40 green amaranths (*Amaranthus spinosus*) biomass samples were collected from the four locations by random sampling. Ten (10) from each location (ten from the dumpsite and non-dumpsite, respectively). They were labelled correctly and oven-dried at 60 $^0$C, after which they were ground and subjected to assaying.

### *2.3 Analysis of Procedures*

Heavy metals content (Pb, Zn, Fe, and B) of both the soil and plant samples were analysed using the Atomic Absorption Spectrophotometer (AAS) as described in the method of Clayton and Tiller (1979). The samples were analysed in the research laboratory of the Department of Soil Science, University of Nigeria Nsukka. The values of the soil chemical properties obtained in the study were compared with the established critical limit of the soil element from various works of literature (Table 1).

### *2.3.1 Estimation of Hazard Quotient (HQ).*

The Hazard Quotient (HQ) was used to calculate the possible human health risks associated with the consumption of contaminated vegetables. The following equation for calculating human health risk (HQ) from the consumption of leafy vegetables [30]. HQ is the ratio between exposure and the reference oral dose (RFD). If the ratio is lower than one (1), means there will be no obvious risk.

HQ = ADDM/RFDM

Where;

ADDM = the average daily dose (mg, kg/d) of the metal

RFDM = the reference dose of the heavy metal (mg, kg/d)

RFDM = represent the maximum tolerable daily intake of metal with no adverse effect

### *2.3.2 Statistical analysis*

The data obtained from the physical and chemical analysis were subjected to a T-test using a statistical package for the social science software (SPSS, 2015) to determine the effect of dumpsites on the soil chemical properties.

## 3.0. Results and Discusion

Texturally, the dumpsite soils range from sandy to sandy loam and sandy to sandy clay loam in the non-dumpsite soils in the two states. It is important to note that although sandy loam texture has been recommended as being suitable for waste disposal sites, soils with greater than 70% sand are highly unsuitable for waste disposal because they are highly permeable and allow large quantities of leachates to pass through the soil (Loughry, 1973).

### *3.1 Concentrations of Micronutrients in Dump and Non-Dumpsite Soils*

The mean concentrations of Fe, B, Pb, and Zn in the dump and non-dumpsite soils are presented in Table 2. However, it is generally observed that there was a higher concentration of heavy metal in the dump soil compared to the control, and the concentration of these heavy metals declined with depth in both soils. Similar findings have been reported (Oluyemi *et al*., 2008; Ogundele *et al*., 2015).

The mean values of Fe concentration in the dumpsites are 11.57 mg $kg^{-1}$ (AN-Obosi), 9.71 mg $kg^{-1}$ (AN-Onitsha), 10.82 mg $kg^{-1}$ (EN-Nsukka), and 4.48 mg $kg^{-1}$ (EN-Ugwuaji). In comparison, the mean values for Fe concentration in the non-dumpsites were 7.39 mg $kg^{-1}$ (AN-Obosi), 3.17 mg $kg^{-1}$ (AN-Onitsha), 4.67 mg $kg^{-1}$ (EN-Nsukka), and 2.59 mg $kg^{-1}$ (EN-Ugwuaji). These values for non-dump sites were relatively lower than the corresponding dumpsites by 36, 67, 57, and 42 % respectively. This could be a result of the dumping of municipal solid wastes containing high levels of iron such as construction rods, discarded car parts, etc. Meanwhile, the mean values of Fe concentration in the four locations are less than the critical concentrations in soils (Table 1). Although total Fe is generally high in the soil, the magnitude of its available fraction is generally very low and is governed by the very low solubility of Fe oxides. Plant, microbes, and Fe oxides coexist in soils, and their close association provides ample opportunities for mutual interactions with an impact on mineral weathering of primary Fe minerals and on the availability of this nutrient for microbe and plant growth (Colombo et al. 2014).

The mean values of Boron (B) concentration in the dumpsites are 6.54 mg $kg^{-1}$ (AN-Obosi), 6.73 mg $kg^{-1}$ (AN-Onitsha), 1.57 mg $kg^{-1}$ (EN-Nsukka), and 1.19 mg $kg^{-1}$ (EN-Ugwuaji) ( Table 2). In comparison, the mean values for B concentration in the non-dumpsites with values viz. 4.75 mg $kg^{-1}$ (AN-Obosi), 6.34 mg $kg^{-1}$ (AN-Onitsha), 0.91 mg $kg^{-1}$ (EN-Nsukka), and 0.98 mg $kg^{-1}$ EN-Ugwuaji) were relatively lower than the corresponding site by 33, 6, 42, and 18 % respectively. Generally, B concentration in the dumpsites (1.19 to 7.75 mg $kg^{-1}$) is higher relative to those of the non-dumpsites (0.56 to 5.94 mg $kg^{-1}$) across the four locations. The B status of arable soils has been extensively investigated throughout the world. The total B content in surface soils range from 1 to 467 mg $kg^{-1}$, and its average content ranges from 9 to 85 mg $kg^{-1}$ (Kabata-Pendias and Pendias 1984). This implies that dumping of municipal wastes added between 6-33 % more B to the soil to improve its productivity, although the B content within the dump and non-dump soils were still below the normal range in soils (Table 1). It should be pointed out, however, that although B is a rather deficient micronutrient in most soils, some soils overfertilized with B may contain hazardous amounts of this element. Some sewage sludges and fly-ash may also be significant sources of B contamination of soils. B-rich soils are known to cause B toxicity in the field, as well as decreased crop yields in different regions of the world. For example, in sewage wastewaters, up to 40% of B is from a detergent source. The amelioration of high-B soils is very difficult (Kabata-Pendias and Pendias 1984).

The mean values of Lead (Pb) concentration in the dumpsites are 2.19 mg $kg^{-1}$ (AN-Obosi), 0.60 mg $kg^{-1}$ (AN-Onitsha), 1.02 mg $kg^{-1}$ (EN-Nsukka) and 0.36 mg $kg^{-1}$ (EN-Ugwuaji) ( Table 2). In comparison, the mean values for Pb concentration in the non-dumpsites with values viz. 0.86 mg $kg^{-1}$ (AN-Obosi), 0.06 mg $kg^{-1}$ (AN-Onitsha), 0.02 mg $kg^{-1}$ (EN-Nsukka) and 0.04 mg $kg^{-1}$ EN-Ugwuaji) were relatively lower than the corresponding site by 61, 90, 98 and 88 % respectively. Generally, Pb concentration in the dumpsites (0.36 to 2.19 mg kg$^{-1}$) is higher relative to those of the non-dumpsites (0.02 to 0.86 mg kg$^{-1}$) across the four locations. As pointed by Kabata-Pendias (1984) natural Pb content of the soil is inherited from parent rocks. However, due to widespread Pb pollution, most soils are likely to be enriched in this metal, especially in the top horizon. There is much data available in the literature on soil Pb, but sometimes it is difficult to separate the data for background Pb levels in soils from those of anthropogenically influenced amounts in surface soils. The mean values for soil types range from 10 to 67 mg kg$^{-1}$ and average 32 mg kg$^{-1}$. High Pb levels (above 100 mg kg$^{-1}$) may reflect the impact of pollution. Davies (1977) stated that an upper limit for the Pb content of a normal soil could be established as 70 mg kg$^{-1}$. The Pb load values from the dumpsite soils were found to be higher than that from non-dump sites values because refuse dumps receive considerable waste proportions of unsorted materials including cloths, glass, and bottles, newspapers, paints, batteries, industrial dust, ash, tires, metal cans and containers, medical waste, abandoned vehicles and insulations which are known to be sources of metals (Anikwe and Nwobodo 2002; Woodbury 2005). Umoh and Etim (2013) found that soils from dumpsites within Ikot-Ekpene in Akwa-Ibom State, Nigeria also had a high concentration of Pb in the dumpsite soils relative to those of the non-dumpsite soils and linked its sources to automobile exhaust fumes as well as dry cell batteries, runoff of wastes and atmospheric depositions owing to the proximity of the sites to high vehicular emissions.

The mean values of Zinc (Zn) concentration in the dumpsites are 54.0 mg kg$^{-1}$ (AN-Obosi), 17.80 mg kg$^{-1}$ (AN-Onitsha), 17.2 mg kg$^{-1}$ (EN-Nsukka), and 18.46 mg kg$^{-1}$ (EN-Ugwuaji) ( Table 2). In comparison, the mean values for Zn concentration in the non-dumpsites with values viz. 0.00 mg kg$^{-1}$ (AN-Obosi), 9.60 mg kg$^{-1}$ (AN-Onitsha), 12.5 mg kg$^{-1}$ (EN-Nsukka), and 8.06 mg kg$^{-1}$ EN -Ugwuaji) were relatively lower than the corresponding site by 100, 46, 27, and 56 % respectively. Generally, Zn concentration in the dumpsites (17.2 to 62.60 mg kg$^{-1}$) is higher relative to those of the non-dumpsites (0.00 to 12.5 mg kg$^{-1}$) across the four locations. The solubilization of Zn minerals during weathering produces mobile Zn$^{2}$, especially in acid, oxidizing environments. Zn is, however, also easily adsorbed by mineral and organic components and thus, in most soil types, its accumulation in the surface horizons is observed. Mean total Zn contents in surface soils range from 17 to 125 mg kg$^{-1}$. Thus, these values may be considered as background Zn contents (Kabata-Pendias 1984). The mean values of Zn concentrations are less than the critical limits set for Zn in soils (Table 1). Zinc constitutes an essential element (micronutrient), but it is toxic to crop plants especially vegetables at the level of 300 mg kg$^{-1}$ in the soil (Abreu *et al.,* 1998; Anikwe and Nwobodo, 2002).

Generally, the result of the mean concentration of heavy metals and micronutrients studied (Fe, B, Pb, and Zn) in the four locations shows that higher concentrations are obtained in the dump soil when compared to the control. This implies that repeated disposal of urban wastes may increase the heavy metal load of the affected soil. It further suggests that most vegetable and arable plants may get these heavy metals by interception and mass flow. At the same time, tree crops may suffer deficiency due to inadequacy to the deeper horizon. These observations accord Mbah, and Ezeaku (2010) report that topsoils are better indicators of a heavy metal burden than subsoils. It is also observed that the dumpsites in Anambra state (AN-obosi and AN-Onitsha) contain higher amounts of Fe, B, Pb, and Zn relative to those in Enugu state (EN-Nsukka and EN-Ugwuaji). This can be attributed to the fact that a higher population density exists in Anambra state when compared to Enugu state and could have affected the amount and type of municipal wastes high in these heavy metals generated. Heavy metals and micronutrients in these dumpsites at Anambra and Enugu states are present in the soil in the following decreasing order Zn > Fe > B > Pb.

### *3.2 Influence of the micronutrients on Green Amaranth (Amaranthus spinosus)*

Table 3 presents the results of the mean values of the micronutrients in the dump and non-dumpsite vegetables (*Amaranthus spinosus*). The influence of the heavy metals on the plants is variable and accords to earlier reports (Oyedele *et al*., 2008).

Generally, Fe concentration in the Amaranths at the four location dumpsites is generally higher (2.105 to 2.274 mg kg$^{-1}$) than those of non-dumpsites (1.432 to 1.919 mg kg$^{-1}$). The mean values of Fe concentration in the four locations are less than the critical concentrations for plants (Table 4), suggesting that Fe concentration is non-limiting to crop production in the study areas. The mean values of B concentration in the four location's dump and non-dumpsite vary, as shown in Table 5. Generally, B concentration at the dumpsites (3.162 to 4.751 mg kg$^{-1}$) is higher than those of the non-dumpsites (0.783 to 3.162 mg kg$^{-1}$). The mean values of B concentration in the four locations are less than the critical concentrations for plants (Table 4).The mean concentration values for Pb are also shown in Table 5. Generally, Pb concentration at the dumpsites (8.05 to 14.482 mg kg$^{-1}$) is higher than those of the non-dumpsites (0.805 to 1.609 mg kg$^{-1}$). The mean concentration of Pb concentration in the vegetable samples from the dumpsites (8.05 to 14.482 mg kg$^{-1)}$ exceeded the permissible limit for plants. In comparison, those of the non-dumpsites (0.805 to 1.850 mg kg$^{-1}$) are lower than the critical limit for plants (Table 4). Lead is usually released into the air during the burning of oil or waste, and it is removed from the air by rain and by particles falling to land or into surface water. Once lead falls onto the soil, it sticks firmly to soil particles and remains in the upper layer of soil and can be accumulated by vegetables grown on such contaminated soils (ATSDR, 2007). The high concentration depicts the dumpsites that are highly polluted which could be a result of the fuel combustion and vehicular emissions in the dumpsite areas and also due in no small amount of toxic properties which is usually a component of discarded electronic devices, tires and lead-acid battery from car batteries. The high concentration of Pb indicates that there is a likelihood of suffering from diseases associated with the consumption of vegetables containing elevated levels of Pb (Gupta *et al.,* 2013; Mba *et al.*, 2008).

The Zn concentration in both dump and non-dumpsites varies, as shown in Table5. Generally, Zn concentration at the four location dumpsites is generally higher (0.732 to 1.101 mg kg$^{-1}$) than those of non-dumpsites (0.103 to 0.524 mg kg$^{-1}$). The mean values of Zn concentration in the four locations dumpsites are higher than the permissive limit for plants (Table 4) while those of the non-dumpsites are less than the critical limit of Zn in plants (Table 4). Almost all the vegetables in the dumpsite exhibited very high Zn concentration relative to the non-dumpsites. The high concentration of Zn in the dumpsites may be a result of the type of municipal wastes containing a high amount of zinc being dumped on the sites. The sequence of the heavy metal and micronutrient concentration in the sampled vegetables (*Amaranthus spinosus*) is in the decreasing order Pb > Zn >B > Fe in terms of toxicity level.

### *3.3 Effect of Municipal Waste Dumpsites on Soil Heavy Metal and Micronutrient concentration*

The effect of municipal wastes on soil heavy metal and micronutrient concentrations are shown in Table 4. The concentration of Fe in the soil as affected by the municipal solid wastes is significant ($p<0.05$). The increased amount of Fe in dumpsite soils could be a result of the kind of dumps generated in the site. Metallic waste products will accelerate iron contents in the soil when they rust. The result also shows that the municipal wastes affect the concentration of boron (B) which is significant ($p<0.05$). Also, a significant ($p<0.05$) effect of municipal solid wastes dumpsites on the concentration of lead (Pb) is observed. Significantly, Pb is higher in the dumpsites compared to the non-dumpsites. These results synchronize with an earlier report (Adelekan and Alawode, 2011).

### *3.4 Hazard Quotients (Ecological Risk) of the Heavy Metals and Micronutrients of both Dump and Non-Dumpsites*

Table 5 shows the ecological risks as shown by the hazard quotients (H.Q.) of the heavy metals and micronutrients of both the dump and non-dumpsites in the two states. The hazard quotient (H.Q.) for Fe concentration in the four location dumpsites are AN-Obosi (0.002), AN-Onitsha (0.002), EN-Nsukka (0.002), and EN-Ugwuaji (0.001). Fe concentration across the four non-dumpsites has a Q.H.Q value of 0.001. The Q.H.Q. Fe in both dumps and non-dumpsites is lower than unity (< 1). According to the ratings by Ezeaku and Egbemba (2014),. Q.H.Q.< 1 suggests that a harmful effect is not likely. Q.H.Q. values recorded for B in both dump and non-dumpsites vary across the four locations in the two states (Table 5). .Q.H.Q. values for the four location dumpsites are AN-obosi (0.554), AN-Onitsha (0.673), EN-Nsukka (0.157), and EN-Ugwuaji (0.119) while .Q.H.Q. values for the non-dumpsites are AN-Obosi (0.435), AN-Onitsha (0.634), EN-Nsukka (0.168), and EN-Ugwuaji (0.137). .Q.H.Q. B in both dumps and non-dumpsites is lower than unity (H.Q. <1). .Q.H.Q. values for Pb also vary in the four locations (Table 5). The .Q.H.Q. values recorded for Pb range from 0.003 to 0.026 (H.Q. <1) in the dumpsites and range from 0.00004 to 0.14 (H.Q. <1) in the non-dumpsites. The .Q.H.Q. Pb in both dump and non-dumpsite is lower than unity (H.Q. <1) across the four locations. This means that Pb concentration in the four locations is low for a toxicity threat (Ezeaku and Egbema, 2014). .Q.H.Q. Zn values range from 0.06 to 0.18 in the dumpsites and 0.0 to 0.127 in the non-dumpsites (Table 5). The .Q.H.Q. values for Zn in both dump and non-dumpsite are less than unity (H.Q. <1) and follow the similar situation of non-likely occurrence of harmful effects on the soils (Ezeaku and Egbemba, 2014).

Generally, H.Q.s for the individual soil samples in both the dump and non-dumpsite across the four locations in the two states are below unity (H.Q. <1) for Fe, B, Pb, and Zn (Table 5). When .Q.H.Q. is < 1, there is no obvious risk from the substance over a lifetime of exposure (Gupta *et al.,* 2013; Ezeaku and Egbemba, 2014). The sequence of the heavy metal and micronutrient concentration in the sampled soils is in this decreasing order B > Zn> Pb> Fe.

## 4.0 Conclusion and recommendation

Results obtained from this study indicated that continuous (long-term) dumping of municipal wastes affected soil micronutrients and its suitability for crop production. The concentration of heavy metals and micronutrients assessed (Fe, B, Pb, Zn) were found to be below the critical limit guidelines for heavy metals toxicity in soils. They were found in the following decreasing order: Zn>Fe>B>Pb. The hazard quotient (ecological risks) values of Fe, B, Pb, Zn in the dumpsites, and non-dumpsites were less than unity (H.Q. <1), suggesting that harmful effects are not likely to occur.

The result of the concentration of these heavy metals and micronutrients contained in the vegetable samples showed that the vegetables at the dumpsites had a higher concentration of these heavy metals and micronutrients relative to those of the non-dumpsites, implying higher bio-accumulation of these heavy metals and micronutrients by the vegetables in the dumpsites relative to those on the non-dumpsites. Pb and Zn were found to be higher than the permissive limits for heavy metals in vegetables (2 mg kg$^{-1}$ and 0.06 mg kg$^{-1}$ respectively), while Fe and B were below the critical limits (20 mg kg$^{-1}$ and 5 mg kg$^{-1}$) set by FAO/WHO. The heavy metals and micronutrients in the vegetables were in the following decreasing order: Pb > Zn > B > Fe in terms of toxicity level. This implies that there is a high risk of phytotoxicity in plants especially edible hyper-accumulator plants such as leafy green amaranth *(Amaranthus spinosus*) vegetables that are found growing wildly or cultivated by farmers on these dumpsites for urban consumption. Therefore, the dumpsite soils are highly fertile but are not currently fit for crop productivity because of the high risk of heavy metal (Pb>Zn>B>Fe) bio-accumulation by the green amaranths.

To optimally manage these sites for future agricultural use/crop productivity and to reduce the concentration of harmful/toxic substances on the dumpsites, controlling the source of these municipal wastes should be regularly done through appropriate legislative and regulatory frameworks such as safe methods to handle urban wastes. There is an urgent need to create public awareness on heavy metal pollution and the dangers of plant cultivation within unmanaged dumpsite areas to farmers and urban consumers by governments, NGOs, and relevant environmental institutions and agencies. This will enable them to adopt the best practices for the cultivation of plants.

Food and health agencies like NAFDAC and Standard Organization of Nigeria (SON) should be charged with the responsibilities of making available threshold limits (minimum and maximum permissible) for contaminants in soils, foods, and vegetables to avoid entry of contaminants into the food chains. Soil testing is very significant in this direction. Soil test kits should be made available to farmers so that before cultivation, farmers would know the pollutant levels of the heavy metals and micronutrients. If the concentrations are high above the permissible limits, then such sites are not put into use. The agency should test food, especially vegetables produced and marketed for public consumption to avoid causing public health hazards.

Table 1: Concentration ranges of metals in soils and plants and critical concentrations in plants (mg/kg)

| Elements | Normal range in soils ($mg\ kg^{-1}$) | Critical soil concentration ($mg\ kg^{-1}$) | Normal range in plants ($mg\ kg^{-1}$)* | Critical plant concentration ($mg\ kg^{-1}$) * |
|---|---|---|---|---|
| Zinc (Zn) | 1-50 | 300 | - | 0.60 |
| Lead (Pb) | 2-30 | >85 | 0.2-2 | >2 |
| Iron (Fe) | 40-500 | 5000 | 20 | >20 |
| Boron (Bo) | - | 10 | - | 5 |

**Source: (**Bowen, 1979; Kabata – Pendias and Pendias, 1984; WHO*)

Table 2: Mean values of the heavy metal and micronutrients in the Anambra and Enugu dumpsite soils

| **Location** | **Soil Depth (cm)** | **Fe ($mg\ kg^{-1}$)** | | **B ($mg\ kg^{-1}$)** | | **Pb ($mg\ kg^{-1}$)** | | **Zn ($mg\ kg^{-1}$)** | |
|---|---|---|---|---|---|---|---|---|---|
| | | Dump site | Non Dump site | Dump site | Non Dump site | Dump site | Non Dump site | Dump site | Non Dump site |
| AN- Obosi | 0-20 | 12.32 | 6.16 | 7.75 | 4.75 | 1.85 | 0.83 | 50.8 | Trace |
| | 20-30 | 15.12 | 8.96 | 5.94 | 4.75 | 2.45 | 1.06 | 48.60 | Trace |
| | 30-40 | 7.28 | 7.04 | 5.94 | 3.56 | 2.27 | 0.69 | 62.60 | Trace |
| AN- Onitsha | 0-20 | 10.08 | 5.60 | 5.94 | 5.94 | 1.34 | 0.19 | 20.40 | 10.20 |
| | 20-30 | 12.32 | Trace | 7.13 | 7.13 | 0.16 | Trace | 17.60 | 9.00 |
| | 30-40 | 6.72 | 3.92 | 7.13 | 5.94 | 0.05 | Trace | 15.40 | 9.80 |
| EN- Nsukka | 0-20 | 24.64 | 6.72 | 1.19 | Trace | 1.17 | 0.05 | 20.60 | 17.20 |
| | 20-30 | 4.48 | 5.60 | 2.34 | 1.19 | 0.88 | 0.03 | 13.40 | 13.20 |
| | 30-40 | 3.36 | 1.68 | 1.19 | 1.56 | 1.17 | Trace | 17.60 | 7.20 |
| EN- Ugwuaji | 0-20 | 5.60 | 3.92 | 1.19 | 1.19 | 0.48 | 0.03 | 32.00 | 8.60 |
| | 20-30 | 4.48 | 1.68 | 1.19 | 1.19 | 0.08 | Trace | 14.00 | 12.6 |
| | 30-40 | 3.36 | 2.24 | 1.19 | 3.56 | 0.11 | 0.08 | 9.40 | 3.00 |

Table 3: Mean values of the micronutrients in the vegetables

| **Location** | **Sampling point** | **Fe** | **B** $mg\ kg^{-1}$ | **Pb** | **Zn** |
|---|---|---|---|---|---|
| AN-Obosi | Dump | 2.208 | 3.162 | 14.482 | 1.101 |
| AN-Obosi | Non-dump | 1.919 | 1.583 | 1.850 | 0.502 |
| AN-Onitsha | Dump | 2.274 | 4.751 | 12.229 | 0.865 |
| AN-Onitsha | Non-dump | 1.654 | 3.162 | 0.805 | 0.253 |
| EN-Nsukka | Dump | 2.251 | 3.162 | 10.459 | 1.132 |
| EN-Nsukka | Non-dump | 1.432 | 0.783 | 0.805 | 0.103 |
| EN-Ugwuaji | Dump | 2.105 | 4.751 | 8.045 | 0.732 |
| EN-Ugwuaji | Non-dump | 1.919 | 2.374 | 1.609 | 0.524 |

Note: **Fe**-iron, **B**-boron, **Pb**-lead, **Zn**-zinc, **AN**: Anambra **EN**: Enugu

Table 4: Effect of Municipal Waste Dumpsites on Soil Heavy Metal and Micronutrient concentration

| **Location** | **Fe** | **B** $mg\ kg^{-1}$ | **Pb** | **Zn** |
|---|---|---|---|---|
| Non-dumpsite | 4.46 ± 2.38 | 3.56 ± 2.06 | 0.33 ± 0.71 | 8.25 ± 3.02 |
| Dumpsite | 9.15 ± 6.25 | 3.66 ± 6.25 | 0.75 ± 0.67 | 26.87 ± 17.54 |
| LSD (0.05) | 0.02* | 0.03* | 0.00* | Ns |

Note: **Fe**-iron, **B**-boron, **Pb**-lead, **Zn**-zinc, ± = Mean and standard deviation, * = significant at 0.05 probability level, **ns**= non-significant

Table 5: Hazard Quotients of the Heavy Metals in the soil samples

| **Location** | **Sampling point** | **Iron (Fe)** | **Boron (B)** | **Lead (Pb)** | **Zinc (Zn)** |
|---|---|---|---|---|---|
| **AN- Obosi** | Dump | 0.002 (NHF) | 0.554 (NHF) | 0.014 (NHF) | 0.18 (NHF) |
| **AN-Obosi** | Non-dump | 0.001 (NHF) | 0.435 (NHF) | 0.014 (NHF) | 0 (NHF) |
| **AN-Onitsha** | Dump | 0.002(NHF) | 0.673 (NHF) | 0.006 (NHF) | 0.06 (NHF) |
| **AN-Onitsha** | Non-dump | 0.001 (NHF) | 0.634 (NHF) | 0.002 (NHF) | 0.03 (NHF) |
| **EN-Nsukka** | Dump | 0.002 (NHF) | 0.157 (NHF) | 0.026 (NHF) | 0.06 (NHF) |
| **EN-Nsukka** | Non-dump | 0.001 (NHF) | 0.168 (NHF) | 0.00004 (NHF) | 0.04 (NHF) |
| **EN-Ugwuaji** | Dump | 0.001 (NHF) | 0.119 (NHF) | 0.003 (NHF) | 0.06 (NHF) |
| **EN-Ugwuaji** | Non-dump | 0.001 (NHF) | 0.137 (NHF) | 0.001 (NHF) | 0.127 (NHF) |

Note: **AN**-Anambra, **EN**-Enugu, **NHF**- not harmful

## Reference

Abreu, J. M. F.; Bruno-Soares, A. M., (1998). Chemical composition, organic matter digestibility, and gas production of nine legume grains. Anim. Feed Sci. Technol., 70 (1-2): 49-57

Adelekan, B. A., and Alawode, A.O (2011).Contributions of municipal refuse dump to heavy metals concentrations in soil profile and groundwater in Ibadan Nigeria. Journal of Applied Biological Science., 40: 2727-2737

Alloway, B.J., (1996). Heavy Metal in Soils. London: John Wiley and Sons Incorporated, pp.149-159

Amhakhian, S.G, Ezeaku, P.I, and J.A. Olimah (2003). Effects of heavy metal on Amaranthus grown on a municipal waste disposal site at Anyigba, Kogi State, Nigeria. Proceedings of the 28th Annual Conference of the Soil Science Soc., Nigeria p.208-211

Amusan, A. A., Ige D.V., and Olawale R. (2005). Characteristics of Soil and Crop uptake of metals in municipal waste dumpsites in Nigeria. J. Hum. Ecol. Kamla Rja 1 (2): 167- 171

Anikwe, M. A. N., and Nwobodo, K. C. A. (2002). Long term effect of municipal waste disposal on soil properties and productivity of sites used for urban agriculture in Abakaliki, Nigeria https://doi.org/10.1016/S0960-8524(01)00154-7

ATSDR (2007). Toxicology profile for lead. Atlanta, Georgia, United States. .S.U.S. Department of Health and Human Services. Agency for Toxic Substances and Disease Registry

Aydinlp C and Marinova S (2003). Distribution and forms of heavy metals in some agricultural soils. Poland. J Environ Studies, 12(5):629–633

Bowen, H. J. M. (1979). Environmental Chemistry of Elements. Academic Press London

Colombo, C., Palumbo, G., He, J. Z., Pinton, R., & Cesco, S. (2014). Review of iron availability in soil: interaction of Fe minerals, plants, and microbes. Journal of soils and sediments, 14(3), 538-548.

Drozd, J. (2003). The risk and benefits associated with utilizing composts from municipal solid waste (MSW) in Agriculture. p. 211-226. In Lynch, J.M., J.S. Schepers, and I. Unver (eds.) Innovative soil-plant systems for sustainable agricultural practices. Organization for Economic Co-operation and Development (OECD), Paris, France.

Elaigwu, S.E., Ajibola, V.O., and Folaranmi, F.M. (2007). Studies on the impact of a municipal waste dump on surrounding soil and air quality of two cities in northern Nigeria. Journal of Applied Sciences, 7(3): 421-425.

Ezeaku, P. I. and Egbemba, B.O. (2014). The yield of maize (Manoma spp.) is affected by automobile oil waste and compost manure. African Journal of Biotechnology, 13(11): 1250-1256

Goswami, U., and Sharma, H. P. (2008). Study of the impact of municipal solid waste dumping on soil quality in Guwahati city. Pollution Research 27(2): 327-330.

Gupta V. Jena, S. Jena, Neda Davic, Natalija Matic, D. Radojevic, J. S. Solanki (2013). Assessment of heavy metal contents of green leafy vegetable.Croatia. Journal of Food Science and Technology 5(2):53-60

Ideriah, T.J.K., Omuaru, V.O.T., Adiukwu, P.U., (2006). Soil quality around a solid waste dumpsite in Port Harcourt. African journal of Ecology, 44(3):388-394

Kabata – Pendias, A. and Pendias H. (1984). Trace element in soil and plants. C. R. K. Press Boca
Raton, FL. pp 9

Loughry FG (1973). The Use of Soil Science in Sanitary Landfill Selection and Management. Geoderma 10:131-139

Mbah, C.N, and P.I. Ezeaku (2010). Physico-chemical characterization of farmland affected by automobile wastes in relation to heavy metal. Nature and Science 8 (2): 1-7

Mbagwu, J.S.C.and A. Piccolo (1992). Some physical properties of structural aggregates separated from organic waste amended soils. Biological Wastes 3: 107-121

National Research Council (1999). Human dimensions of global environmental change. Resource pathway for the next decade. National Academy Press, Washington D.C

Nwaogu, C., and Ogbuagu, D. H. (2017). Assessment of the impacts of municipal solid waste dumps on soils and plants. https://doi.org/10.10 80/02757540.2017.1337101

Ogundele D.T, Adio, Abdulrasheed, and Oludele O.E (2015). Heavy Metal Concentrations in Plants and Soils along Heavy Traffic Roads in North Central Nigeria. Journal of Environmental and Analytical Toxicology. Doi: 05 10.4172/2161-0525.1000334

Oluyemi, E.A., Feuyit, G., Oyekunle, J.A.O., and Ogunfowokan, A.O. (2008). Seasonal variations in heavy metal concentrations in soil and some selected crops at a landfill in Nigeria. African Journal of Environmental Science and Technology, 2(5): 89-96

Oyedele, D. J., Gasu, M. B., and Awotoye, O. O. (2008) Changes in soil properties and plant uptake of heavy metals on selected municipal solid waste dumpsites in Nigeria. African Journal of Environmental Science and Technology, .3(5):.107-115

Uba, S., Uzairu, A., Harrison, G. F. S., Balarabe, M. L., and Okunola, O. J. (2008). Assessment of Heavy Metals Bioavailability in Dumpsites in Zaria. African Journal of Biotechnology, 7:22-130

Umoh S.D and Etim E.E (2013). Determination of heavy metals contents from dumpsites within Ikot Ekpene, Akwa Ibom State, Nigeria. Int. J. Eng. Sci. 2(2):123-129

Voutsa, D., Grinmanins, A and Samara, C (1996). Trace elements in vegetable grown in an industrial area in relation to soil and air particulate matter. Envtal. Pollution 94: 325-335

World Bank (1995). Restoring urban Nigeria. A strategy for restoring urban infrastructure and services in Nigeria. Prepared by World Bank with Nigerian Collaboration

World Bank Group (2016) Final report for environmental and social management plan (ESMP) Ugamua, Obosi gully erosion site, Idemili North LGA Anambra State. Nigeria