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Heavy Metals In Edible Vegetables At Abandoned Solid Waste Dump Sites In Port Harcourt, Nigeria.

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ABSTRACT: *The concentrations of eight selected heavy metals, Pb, Cd, Cu, Ni, Cr, As, Hg, and Zn in seven consumable vegetables harvested at some dump sites and farm lands (as control) in Port Harcourt and its environs in Rivers State Nigeria were investigated. The soils in which they are grown were also analysed using Solaar Thermo Elemental Atomic Absorption Spectrometer (AAS) model SE 71906. The vegetables plants investigated were Bitter leaf (Vernonia Amgdylina, Pumpkin (Telfairia Occidentalis), Green Vegetable (Amaranthus hybridus), Okro plant (Abelmoschus esculentus L), Green Amaranths (Amaranthus viridis). The results obtained show that the concentration of heavy metals in the dumpsites were significantly higher ($P<0.05$) and varies from the results for the farmlands (control). Similarly there were more heavy metals in vegetables harvested at dumpsites than the control sites. Zn concentration in vegetables at both sites Zn (31.6 ± 0.23 - 68.04 ± 0.1 mg/kg) and Zn (10.36 ± 0.18 - 26.62 ± 0.26 mg/kg) respectively. Concentration of other metals followed the order, Ni> Cu>Cr>Pb>Cd >As. Concentrations of Pb, Cd, Cr in all the vegetables from the dumpsites were extremely higher than the WHO permissible standard limit. While the Ni, Cu were below permissible limit only in some vegetables. Hg concentration was minimal in dumpsite vegetables and was not detected in samples from the control sites. The significantly high level of heavy metal concentrations, above the World Health Organization (WHO) permissible limits, indicates bioaccumulation in the vegetables and subsequent bioavailability when consumed. This can pose great health risk to humans and animals through the food chain.*

Keywords: *Heavy metals, Dump sites, Edible vegetables, Bioaccumulation, AAS, food chain.*

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I. Introduction

Vegetables are consumed daily in households all over the world. They are widely used for culinary and dietary purposes. The quest to meet increasing demand for vegetables has made peasant farmers utilize any available land space like dump or solid waste disposal sites and road sides for the cultivation of vegetables. Most local farmers prefer dump or solid waste disposal sites believing that decaying materials contained therein would serve as natural manures to their plants. However, studies on soils around dump sites have revealed presence of high levels of heavy metals (Opaluwa *et al*., 2012; Ogundele *et al*., 2016). Over time these heavy metals may pose health hazard to humans and animals through the food chain.

Metallic elements are ubiquitous in the environment. Most of them are significant in nutrition either as essential components or for their toxicity. Heavy metals are released into the environment by various anthropogenic activities such as combustion, vehicular emission, industrial manufacturing process, domestic and municipal refuse and waste materials, etc. In recent years, there has been increased ecological and global public health concern associated with contamination by some of these metals.

The uptake of heavy metals by vegetables is a biological process occurring through the plants roots and membrane transport systems. Some of these heavy metals are chemically similar to regular nutrients and are taken up advertently causing bioaccumulation (Samuel *et al*., 2008).

The toxicity of heavy metals in soil on vegetables varies with the plant's characteristics and duration of contamination. Although heavy metal polluted sites can inhibit plant growth by metal absorption, some plant species have capacity to accumulate large amounts of heavy metals without stress (Kailas (2013).

The heavy metals in soil eventually get into plants and enter the food chain when the vegetables are consumed. The toxic effects of heavy metals in food have been widely reported. Divirikil (2006) reported accumulation of cadmium in the kidney and liver of animals from vegetable and plants consumed. The fundamental cause of Wilson disease is attributed to high contamination of copper in consumable products

(Bandmann *et al*., 2015). High level of lead is also considered poison to the system. Osu and Okereke 2015) reported that hazardous health effects and losses in agricultural yield can occur as a result of heavy metals pollution in soil and plants.

Based on the persistent nature and cumulative tendency as well as probability of potential toxic effects of heavy metals resulting from consumption of some edible plants, it is important to periodically analyze food material to evaluate the amount of these heavy metals present in order to monitor compliance with local, national and international standard threshold limit. This is particularly necessary for agricultural products from developing countries like Nigeria where scanty information on deleterious substances present in commonly consumed farm products is available.

Although several studies had been done to assess the negative effects of accumulation of heavy metals, the practices that contribute to toxic heavy metal accumulation in edible vegetables still persist. There is need for intermittent assessment to alert the inhabitants of likely danger. Consequently, this report presents data on the levels of some toxic heavy metals in the soil and commonly consumed vegetables cultivated in and around some abandoned solid waste dump sites in Port Harcourt, Nigeria.

II. Materials And Methods

STUDY AREA

Dump sites were (1) Eneka/Igwuruta dumpsite in ObioAkpor Local Government area, (2) Agip/Eagle Island dumpsite (3)Bundu water side from Port Harcourt Local Government Area.

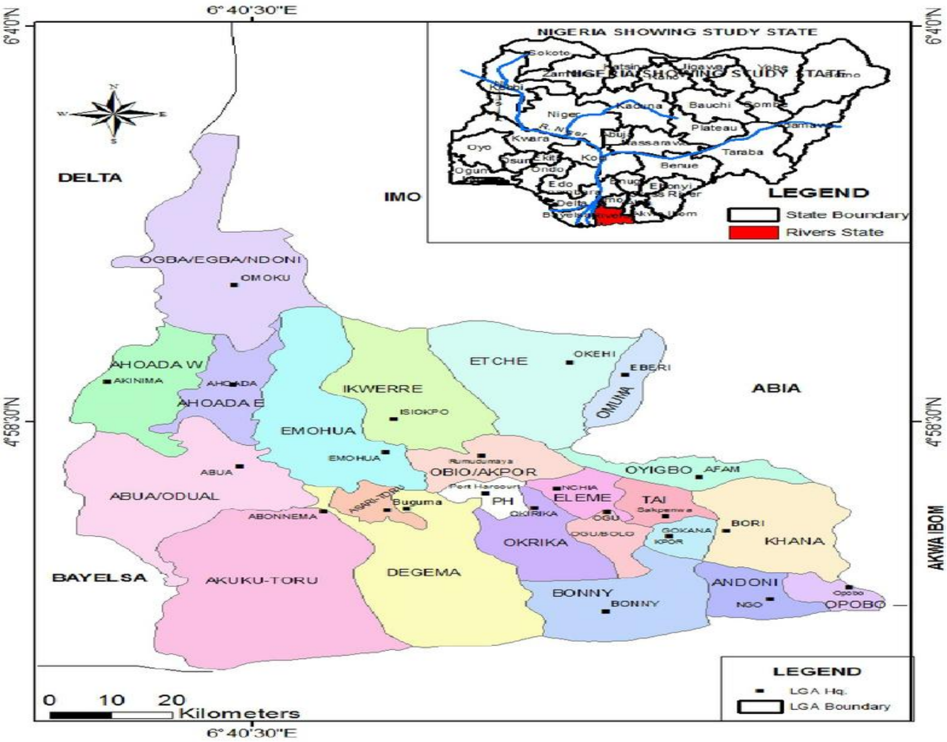

Fig 1. Map of study area

Control sites were (1) Norwan farmland in Tai local government Area (2) Ndele farmland in Emohua Local Government Area (3) Choba Farmland in Obio Akpor Local Government area.

III. Sample Collection And Processing

Soil samples.

Three top soil (0-20cm) samples were collected in triplicates from each of the three different abandoned dumpsites in Port Harcourt metropolis. The soil samples were obtained by drilling the soil using soil auger from the top soil to the depth of 20cm. Plastic hand trowel was used to scoop and transfer the drilled soil into well labeled polythene bags, after which they were conveyed to the laboratory for analysis. Same sampling procedure was also at the control sites. The soil samples were air-dried to constant weight, crushed with mortar and pestle and sieved with 2mm mesh sieve before storing in air tight containers prior to acid digestion for metals analysis.

Vegetable samples.

Two different edible vegetable plants from each dump site; Eagle Island (bitter leaf and water leaf); Eneka / Igwuruta (Pumpkin and Green vegetable), Bundu water side (Okro plant, Green Amaranthan and Scent leaf ; Scent leaf was chosen as the seventh vegetable because of its abundance in Bundu water side dump site). They were randomly harvested with a stainless steel knife and transferred to the laboratory in polythene bags. Vegetable samples of the same species were similarly collected from the control sites and transferred to the laboratory. At the laboratory, 250 – 300g of the edible portions of the vegetable samples were sorted, rinsed with distilled water to remove dust particles, chopped into small pieces using stainless steel knife and air-dried to constant weight. The dried samples were ground to fine powder using agate mortar and pestle and stored in air tight containers for further analysis. The vegetables were the most commonly cultivated and consumed in the environment.

DETERMINATION OF HEAVY METALS IN SOIL.

The soil heavy metal content was determined using standard methods (APHA, 1985) and described elsewhere (Orubite et al.,2015). Five grams of the ground and sieved sample was weighed into a digestion vessels placed in the fume cupboard, 3.0ml of concentrated HNO_3, 9.0ml of HCl and 25ml of distilled water were added to the sample. This solution was thoroughly mixed together and then transferred to the hot plate at the temperature of 105^0C. The solution heated until pale yellow clear solution was observed and the brown fume of HNO_3 ceased. The solution was then removed from the hot plate and allowed to cool before it was filtered through a 0.2mm Whatman filter paper into a 100 ml volumetric flask. The distilled water was used to rinse the funnel and the wall of the digestion beaker into the filtrate in the volumetric which was later made to the 100ml mark with distilled water, Aliquots of this filtrate was nebulized into the “SolaarThermo Elemental” Atomic Absorption Spectrometer (Model SE 71906) for heavy metal analyses

DETERMINATION OF HEAVY METALS IN VEGETABLES

Powdered samples of the vegetables, 2g, each were accurately weighed into the digestion vessel in flame hood, 5ml to concentrated $HN0_3$ was added and covered with ribbed watch glass and evaporated on a hot plate to the lowest volume possible (10 to 20ml). Thereafter 10ml each of concentration $HN0_3$ and $HClO_4$were added and the content of the beaker, evaporated gently on hot plate until white fume of $HClO_4$ just appeared. The appearance of a light coloured, clear solution indicated complete digestion. The solution was not allowed to dry during digestion. The beaker containing digestion sample was washed with deionised water and filtered. The filtrate was put into100ml volumetric flask cooled and diluted to mark and mix thoroughly. Portion of this solution was taken for required metals determination by aspirating it into the Solaar Thermo Elemental Atomic Absorption Spectrometer (AAS), model SE 71906 instrument.

STATISTICAL ANALYSIS

All determinations were done in triplicates and the results analyzed statistically using SPSS computer software. The results are expressed as Mean ± Standard Deviation (SD). ANOVA followed by multiple comparison two tailed t test was done.

IV. RESULTS AND DISCUSSION

Heavy metals in soil

Statistical analysis of the concentration of heavy metals in the soils (dump sites and control) is presented in Table 1.

Table 1:Heavy metals concentration from solid waste dump sites in Eagles island, Eneka and Bundu water side and control sites in Norwan, Ndele and Choba farmlands.(Mean ± SD, N=3). As compared with control, P < 0.05 (ANOVA followed by multiple comparison two tailed t test). Same superscript differs from each other significantly.

Samples	Pb	Cd	Cu	NI	Cr	As	Hg	Zn
Eagle Island -Agip	2.42 ± 0.14^{a}	12.44 ± 0.42a	27.49 ± 0.16^{a}	14.4 ± 0.25^{a}	17.48 ± 0.12^{a}	0.65 ± 0.04^{a}	0.64 ± 0.04^{a}	57.9 ± 0.32^{a}
Eneka/ Igwuruta	13.45 ± 0.19^{b}	9.49 ± 0.62b	19.42 ± 0.15^{b}	13.09 ± 0.38^{b}	10.69 ± 0.41^{b}	4.67 ± 0.37^{b}	1.08 ± 0.04^{b}	53.4 ± 0.85^{b}
Bundu water side	11.65 ± 0.21^{c}	6.34 ± 0.38c	23.31 ± 0.34^{c}	11.84 ± 0.87^{c}	8.05 ± 0.12^{c}	3.86 ± 0.85^{c}	0.63 ± 0.05^{c}	45.9 ± 0.27^{c}
Norwan farmland	$0.17\pm0.02^{a,b,c}$	$0.003\pm0.0006^{a,b,c}$	$1.95\pm0.08^{a,b,c}$	$1.14\pm0.05^{a,b,c}$	$0.38\pm0.05^{a,b,c}$	$0.007\pm0.001^{a,b,c}$	$0.00\pm0.00^{a,b,c}$	$6.25\pm0.14^{a,b,c}$
Ndele	0.29±0.	$0.00\pm0.00^{a, b,}$	1.64±0.09	0.82±0.08	0.29±0.35	0.00 ±	0.00±0.0	3.01±0.13

farmland	$03^{a,b,c}$	^{c}	^{a,b,c}	^{a,b,c}	^{a,b,c}	$0.00^{a,b,c}$	$0^{a,b,c}$	^{a,b,c}
Choba Farmland	0.19±0.03^{a,b,c}	0.003±0.0005^{a,b,c}	0.95±0.03^{a,b,c}	1.67±0.59^{a,b,c}	0.18±0.04^{a,b,c}	0.11 ± 0.03^{a,b,c}	0.00±0.00^{a,b,c}	2.27±0.11^{a,b,c}
WHO/MPL 1996 (mg/kg)	300	2.5	40.0	35.0	100	30	2.0	35

Table 1 shows that the concentration of heavy metals in the dumpsites were significantly higher (P<0.05) and varies from the results for the farmlands (control). Apart from Cadmium and Zinc all other metals were within the WHO permissible limit. Zinc recorded high concentrations in Eagle Island /Agip and Bundu water side and was within limit in Eneka /Igwuruta. The abundance of zinc in the dumpsites may have resulted from the disposing and dumping of galvanized materials, vehicles tyres, acid, dry cell battery parts, cosmetics and expired pharmaceutical waste products . All these, generate Zinc into the soil, during the decomposition and oxidation process, and eventual vegetable plants uptake. Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms. Soil Zn^{2+} dynamics depends on pH, soil organic matter and soil clay contents. Zinc can be adsorbed to particles of Fe, Mn and Al oxides, clays and organic fraction (Agbenin and Olojo 2004). In contaminated soils, Zn excess has been a major environmental concern. Its build up on surface soil has been enhanced by Zn fertilizers, sewage sludge and other pollution sources (Kabata-Pendias 2010). Dekor and Sarma, (2012) reported that contaminant concentration in the soil is related to the adsorption properties of soil matter which is largely influenced by phenolic group such as –OH. These groups may likely form organic complexes with the heavy metals and remain in the soil. Similar result was reported by Hang Zhou,*et al.,* (2016). In this study Eagle Island/Agip and Eneka/ Igwuruta are industrial dump sites and Bundu water side is a domestic dump sites. Higher concentrations of heavy metals were found at the industrial dump site than the domestic dump site. Kailas et al., (2013) reported similar report in their study.The concentration of Cd was also observed to be well above the WHO limits in these dump sites. Again Eagle Island/Agip (12.44 ± 0.42a) and Eneka/Igwuruta(9.49 ± 0.62) ranked highest concentration obviously for their industrial activities. Radwan and Salema, (2005), sited that Cd components were widely used in batteries, poly vinyl chloride (PVC) plastics and paint pigments and cigarettes packages. All other heavy metals were within the WHO permissible limits.
Hg was of very minimal concentration in all dumpsite and completely not detected in the control farmlands.

Concentration of heavy metals in vegetables.
The results of statistical analysis of concentration of heavy metals are presented in Table 2. Two vegetables collected from each dumpsite and control site were analyzed for heavy metals. The concentrations were compared to WHO/MPL standards.

Table 2: Heavy metals concentration in common vegetables from solid waste dump sites in Eagles Island, Eneka/Igwuruta and Bundu water side and control sites in Norwan, Ndele and Choba farm lands. (Mean ± SD, N=3). As compared with control, P < 0.05 (ANOVA followed by multiple comparison two tailed t test). Same superscript varied significantly from each other.

Samples	Pb	Cd	Cu	NI	Cr	As	Hg	Zn
Bitter leaf Eagle Island	5.74 ± 0.33^{a}	1.82 ± 0.12^{a}	16.04±0.23^{a}	11.71±0.29^{a}	8.79±0.38^{a}	0.87 ± 0.04^{a}	0.002 ± 0.0001^{a}	48.59 ± 0.1a
Water leaf Eagle Island	3.42 ± 0.27^{b}	0.9 ± 0.11^{b}	13.61±0.18^{b}	9.19±0.54^{b}	12.5±0.16^{b}	1.08 ± 0.04^{b}	0.002±0.0001^{b}	59.93 ± 0.3^{b}
Pumpkin Eneka/Igwuruta	5.68 ± 0.26^{c}	1.64 ± 0.17^{c}	11.44±0.09^{c}	14.47±0.48^{c}	9.55 ±0.29^{c}	0.75 ± 0.1^{c}	0.00±0.00^{c}	68.04 ± 0.1^{c}
Green Vegetable Eneka/Igwuruta	6.09 ± 0.15^{d}	0.94 ± 0.1^{d}	7.71 ± 0.17^{d}	10.33±0.23^{d}	5.37 ± 0.4^{d}	1.15 ± 0.03^{d}	0.002±0.001^{d}	46.5 ± 1.24^{d}
Okro plant Bundu Water side	4.72 ± 0.19^{e}	0.43 ± 0.09^{e}	12.51±0.51^{e}	9.86±0.16^{e}	8.49±0.09^{e}	0.07 ± 0.01^{e}	0.00±0.00^{e}	39.6 ± 0.41^{e}
Green Amaranthan Bundu Water side	6.44 ± 0.08^{f}	0.49 ± 0.04^{f}	10.62±0.13^{f}	12.37±0.43^{f}	11.5±0.14^{f}	0.15 ± 0.006^{f}	0.002±0.001^{f}	31.6 ± 0.23^{f}
Scent leaf Bundu Water side	7.69 ± 0.45^{g}	1.1 ± 0.05^{g}	8.35 ± 0.17^{g}	8.56±0.5^{g}	7.49±0.33^{g}	0.14 ± 0.005^{g}	0.00 ± 0.00^{g}	41.75 ± 0.36^{g}
Bitter leaf control Norwan	0.29 ± 0.04 ^{a}	0.00 ± 0.00^{a}	1.37±0.05^{a}	0.14±0.02^{a}	0.25±0.04^{a}	0.005±0.004^{a}	0.00 ± 0.00^{a}	26.62 ± 0.26^{a}

Farmland								
Water leaf control Norwan Farmland	0.44 ± 0.03^{b}	0.00 ± 0.00^{b}	0.34±0.07^{b}	0.06 ± 0.02^{b}	0.38±0.06^{b}	0.00 ± 0.00^{b}	0.00 ± 0.00^{b}	14.63 ± 0.23^{b}
Pumpkin control Choba Farmland	0.34 ± 0.02^{c}	0.00 ± 0.00^{c}	1.21± 0.05^{c}	1.43±0.05^{c}	0.43 ± .08^{c}	0.002±0.001^{c}	0.00 ± 0.00^{c}	11.53 ± 0.07^{c}
Green veg. control Choba Farmland	1.06 ± 0.03^{d}	0.00 ± 0.00^{d}	0.89±0.03^{d}	0.00±0.00^{d}	1.19±0.03^{d}	0.001±0.001^{d}	0.00 ± 0.00^{d}	15.36 ± 0.07^{d}
Okro Plant control Ndele Farmland	0.24 ± 0.04^{e}	0.00 ± 0.00^{e}	0.37±0.05^{e}	0.13±0.015^{e}	0.25±0.05^{e}	0.00 ± 0.00^{e}	0.00 ± 0.00^{e}	12.59 ± 0.16^{e}
Green Amar. Control Ndele farm land	0.25 ± 0.03^{f}	0.00 ± 0.00^{f}	0.4 ±0.01^{f}	1.73 ± 0.05^{f}	0.00±0.00^{f}	0.00 ± 0.00^{f}	0.00 ± 0.00^{f}	10.36 ± 0.18^{f}
Scent leaf control Ndele farm land	1.04 ± 0.03^{g}	0.00 ± 0.00^{g}	0.00±0.00^{g}	0.63±0.02^{g}	0.36±0.04^{g}	0.00 ± 0.00^{g}	0.00 ± 0.00^{g}	16.16 ± 0.21^{g}
WHO/MPL 1996 (mg/kg)	0.3	0.2	10.0	10.0	1.3	0.10	0.03	55

Values are Mean ± SD, n =3. $P < 0.05$ for values with same superscript (differs from each other significantly).
The statistical analysis of results obtained is presented in table 1. The heavy metal levels in the vegetables from the dumpsites were significantly ($P<0.05$) higher than those from the regular farmland locations that served as control.

At the dump sites, the trend for the concentration of the metals in most of the vegetables was Zn>Cu>Ni>Cr>Pb>Cd>As>Hg. Hg was not detected in Pumpkin, Okro and Scent leaf vegetables. This may be as a result of difference in plants uptake of the metals from the contaminated dumpsites. The rate of the metal uptake by the vegetable plants could have been affected by factors such as plant age, species soil pH, soil nature and climate and this in turn affected the contents of the metals uptake by these plants. (Alloway and Ayren , 1997, Audu and Lawal, 2006). Concentration of Pb (3.42 ± 0.27 - 7.69 ± 0.45) in the vegetable plants grown on dumpsites went beyond the allowable limit of WHO (0.3mg/kg). Cadmium values reported ranged from 0.43±0.09 to 1.82±0.12mg/kg. Its highest level was recorded in bitter leaf and pumpkin vegetables, while the lowest values were recorded in Green Amaranthan and okro plants. The concentration of Cd in all the vegetables were above those obtained for vegetables from the control sites and levels recommended by WHO for metals in foods and vegetables. (Parveen, et al. 2003 and Karavoltsos, et al; 2002) previously reported such high levels of Cd in banana and watermelon respectively. As shown in table 2, the concentration of Cu in all the vegetables from dump sites varied between 7.71 ± 0.17 to 16.04±0.23 mg/kg with the industrial dumpsites registering the highest levels. Green vegetable had the lowest and bitter leaf accumulated the highest amount of Cu. The results reported here were observed to be lower when compared with other published results (Radwan and Salema 2006, and Parveen et al. 2003) for some vegetables. Divrikli et al., (2006) earlier, reporting on Cu concentration in Indian Basil , opined that the ubiquitous nature of Cu was due to its extensive uses in industrial applications, domestic items, and electrical wiring, water and fabric treatments as well as in herbicides and fungicides which were commonly found materials at dumpsites. All the estimated Cu values were higher than the levels recommended by WHO (10.0mg/kg) for heavy metal in consumable vegetable plants except in Green vegetables and Scent leaf where their values were below the permissible limit. Control farm lands appear safer for the vegetable in respect of Cu concentration ranging from 0.00±0.00 to 1.37±0.05 mg/kg. The concentration of Ni in all vegetables at dump site varied between 7.49±0.33 to 14.47±0.48 mg/kg and 0.00±0.00 to 1.43±0.05 at the control sites. Ni occurs naturally more in plants than in animals. Its lowest level was observed in waterleaf and its highest was recorded in pumpkin vegetable plants. Ni is absorbed easily and quickly by plants from the airborne particles emitted from vehicle brakes and wears from the tyres. The level of Ni in the vegetables from the dumpsites indicated concentrations above the WHO permissible limit (10.0 mg/kg) except water leaf and Okro plants which were below this recommended limit. The concentration of Chromium in vegetables from dumpsites was between 5.37 ± 0.4 – 12.5±0.16 mg/kg. This concentration is high when compared to the WHO permissible limit of 1.30 mg/kg. Its highest concentration was recorded in Water leaf from Eagle

Island dumpsite (12.5±0.16 mg/kg) and lowest was reported in Green vegetable from Eneka/ Igwuruta dumpsite (5.37± 0.4). The control sites had much lower concentrations (0.00±0.00 0.43 ± .08). The concentration of As obtained was from 1.142- 0.03mg/kg. In some of the vegetables, concentration of As was higher than the permissible level (0.1mg/kg). Its highest and lowest concentrations were recorded in Green vegetable (1.15 ± 0.03mg/kg mg/kg) and Scent leaf (0.07 ± 0.01mg/kg) respectively from the dump sites. Arsenic is used as alloys in electronic as semi conductors, as paint formicating and glass colouration, oil paints etc . When these materials are dumped as waste they decompose and are released into the soil and eventual uptake by plants. As is also largely present in the atmosphere and finds its way into the soil during the rainy season principally in form of As_2S_2 as mineral salts. This result is in tandem with the study of Opaluwa et al., (2012), where similar values were obtained for okro and Roselle plants. All the As results recorded were above those in the control samples.

Extreme low level of Hg was observed in all the analyzed vegetables but absent in Pumpkin, Okro and Scent leaf. All the values reported were higher than the controls (farmland sites). Hg accumulates in soils when components that contain Hg are disposed off at dumpsites and eventually released as toxic compound into soil during oxidation process. Such mercury containing elements include nasal spray, paper coating, acids, lubricating oil, wiring devices, instrumentation parts with some house hold detergents and cleaners, Karavoltsos *et al*; (2002). All the reported concentrations in the vegetables were below the WHO permissible limit of (0.03mg/kg). Zn concentration in the vegetable plants varied between 31.6 ± 0.23 – 68.04 ± 0.1 mg/kg for the dump site and (11.53 ± 0.07 -26.62 ± 0.26) for the control farmlands as recorded in Table 2. All the ventured vegetables from dumpsites exhibited higher concentration as compared to the control. Highest concentration was found in Pumpkin from Eneka /Igwuruta (68.04 ± 0.1mg/kg) and Water leaf (59.93 ± 0.3 mg/kg), Eagle Island dumpsites. Neha et al (2016) opined that high concentration of Zn in the vegetables may be attributed to the plant species' ability to tolerate the metal toxicity of the soil and also direct exposure of the roots of the vegetables to the contaminated spot. Hart et al., 2005 observed that Pumpkin leaves and okra contained the highest levels of the metal Zinc, followed by waterleaf.

Variation of heavy metal accumulation in vegetables .

Metal up take by plants is a function of factors such as plant age , soil type, soil pH, cation exchange capacity, organic matter content other and environmental conditions (Myung 2008). The variation of uptake by the vegetables in dumpsite and control farmlands is presented in fig. 1 and 2 below.

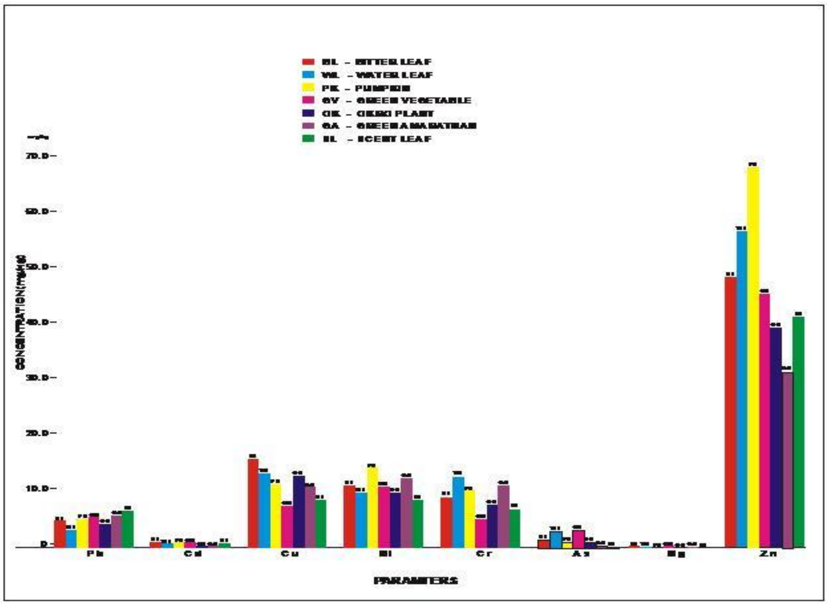

Fig.2.Heavy metals for consumable vegetables (dumpsites)

All the vegetables from the dumpsites had Zn, Cu, Ni, Cr and Pb in appreciable quantities as shown in fig.2. The accumulation of Zn in the vegetables follow the trend PK>WL>BL>GV>SL>OK>GA. Pumpkin leaf is shown to accumulate more Zn that other vegetables. Similar observation was reported by Othman (2001,) while investigating heavy metal in vegetables from Tanzania and Orubite et al.,2015. Plants species generally tend to accumulate high concentration of Zinc (Renileds et al., 2014). Nevertheless, higher concentrations of

Zinc can be toxic to both the plants and organisms. Copper (Cu) concentration in the vegetables follow the order of BL>WL>OK>GA>SL>PK>GV. Obviously Bitter leaf accumulated more Copper than others. Except in Green vegetables (Eneka/ Igwuruta) and Scent leaf (Bundu water side) , other vegetables contain amounts above the WHO permissible limit of 10.0mg/kg. The high contamination level of Copper in the vegetables can lead to chronic anemia. Its toxicity is a fundamental cause of Wilson's disease. For Ni the order was PK>GA>BL>GV>OK>WL>SL. Pumpkin also took the lead accumulating more Ni than all other vegetables. Apart from Water leaf (Eagle Island), Okro plant and Scent leaf (Bundu water side) all other vegetables had concentrations above the permissible limit of 10 mg/kg. Ni plays important role in enzyme functions and is toxic at higher levels. Accumulation of Cr was WL>GA>PK>BL>OK>SL>GV. Water leaf had higher concentration than others while Green Vegetable accumulated the least. In all the vegetables Cr levels were above the WHO permissible limit of 1.30mg/kg. Cr exists in various oxidation states such as Cr (0) , Cr (III) and Cr (VI), Cr toxicity in plants depends on its valence state. Cr (VI) is highly mobile and toxic while Cr (III) is less mobile and less toxic (Oliveira 2012).This work however did not examine the form in which Cr was absorbed by the vegetables but suffice to say that Cr concentration above the WHO limit can lead to bioaccumulation in the food chain and become harmful to consumers. In like manner, the vegetables had Pb concentration in the order, SL>GA>GV>PK>BL>OK>WL. All vegetables had Pb concentrations above the permissible limits. Pb is major pollutant in both terrestrial and aquatic environments. Apart from natural weathering the major source of Pb pollution is from exhaust fumes from automobiles, chimneys of factories using Pb ,effluents from storage battery industries and other related sources (Eick et al 1999). Pb accumulation in the body is known to cause serious health hazard. Despite regulatory efforts to reduce Pb concentration in the environment it continues to be one of the hazardous heavy metals in the environment. All vegetables in the dump sites had significantly low concentrations of Cd, and Hg as shown in fig. 1 and were below WHO permissible limits (0.2mg/kg). The concentration of Cd in the vegetables followed the order, BL>PK>SL>GV>WL>GA>OK, Bitter leaf having the highest value. Cadmium is a non-essential element in foods and vegetables plants. It accumulates principally in the kidney and liver (Divrikil et al; 2006). Various sources of environmental contamination have been implicated for its presence in foods (Adriano, 1984, Audu et al., 2006). The low levels of cadmium reported here may constitute health implication due to bioaccumulation. Most of the vegetables absorbed As from the dumpsite and accumulated same well above the permissible limit of 0.1 mg/kg except Scent leaf and Okro from Bundu water side which had concentrations below the permissible limits. The order was GV>>GA>WL>BL>PK>OK>SL. Bhupendra et al. (2014), reported concentration of As in some common vegetables in Yamuna flood plains, New Delhi. The range of As concentration according to their work varied from 0.6 to 2.52mg/kg which were well above WHO limit. The presence of As could pose serious health to consumers of these vegetables. All vegetables in the dumpsite accumulated very low and insignificant levels of Hg. PK, OK and SL did not accumulate detectable amounts of Hg while GV,> BL> WL> GA had Hg in that order.

The variation of heavy metal accumulation of vegetables from the farmlands (control), is shown in fig. 3

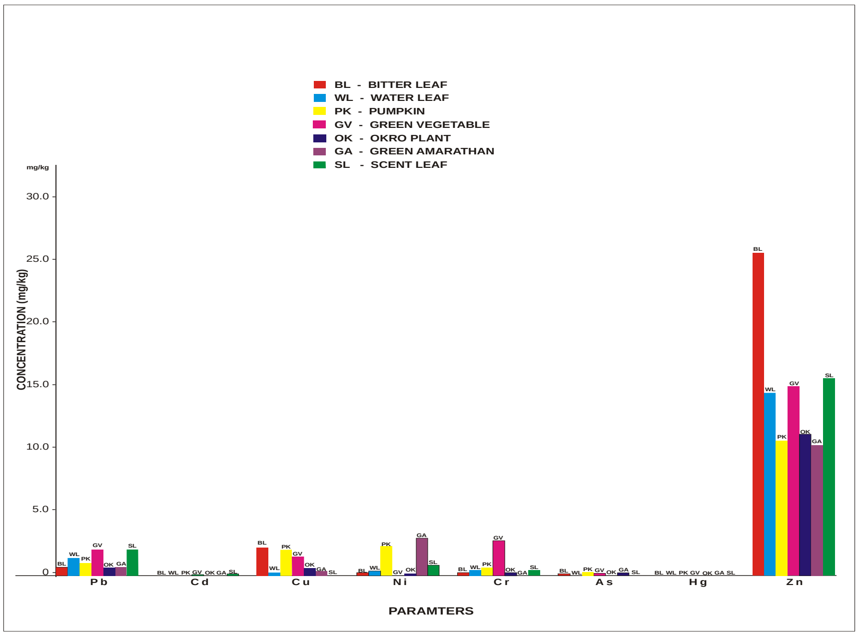

Fig. 2 Heavy metals for consumable vegetables (control farmlands)

The accumulation of heavy metals by the vegetables from the farmlands followed slightly different order from their counterparts at the dump sites. Although Zinc was the most accumulated heavy metal just as in the dump sites, its highest concentration was in BL rather than PK from the dumpsites. The order of Zn concentration therefore followed the sequence, BL>SL>GV>WL>PK>OK>GA. This work did not investigate the effect of soil characteristics on the absorption of the heavy metals by the different vegetables. However it is obvious from fig.2 that the soil type of the farmlands favoured the order above. Vegetables here had heavy metal concentrations lower than those from the dumpsites and were all below WHO permissible limits. The order of accumulation of Pb was GV>SL>WL>PK>BL>GA>OK. Cd was below detection in all the vegetables. Although Bitter leaf had the highest concentration of Cu, just as in the dumpsites, the sequence differed slightly as BL>WL>PK>GV>OK>GA>SL. Green Amarantha accumulated more Ni as against Pumpkin from the the dump sites. Mohammed and Khamis (2012) reported that Amaranth had significant ($P < 0.05$) higher concentrations of Zn, Fe, Cr and Mn than cabbage. The vegetables followed the order, GA>PK>SL>WL>BL>OK>GV. Chromium (Cr) concentration was far more in Green Amaranthan than in the other vegetables. Its concentration in the vegetables is presented as, GV>PK>SL>WL>OK>BL>GA not same with vegetables from the dumpsites. The vegetables accumulated extreme low concentrations of As in the order, PK>GA>GV>BL>WL, GA,SL. The vegetables from control farms did not contain Hg at all.

The variations of the heavy metal concentration at the different soils (dump site and farmland) are presented in fig. 4 and 5.

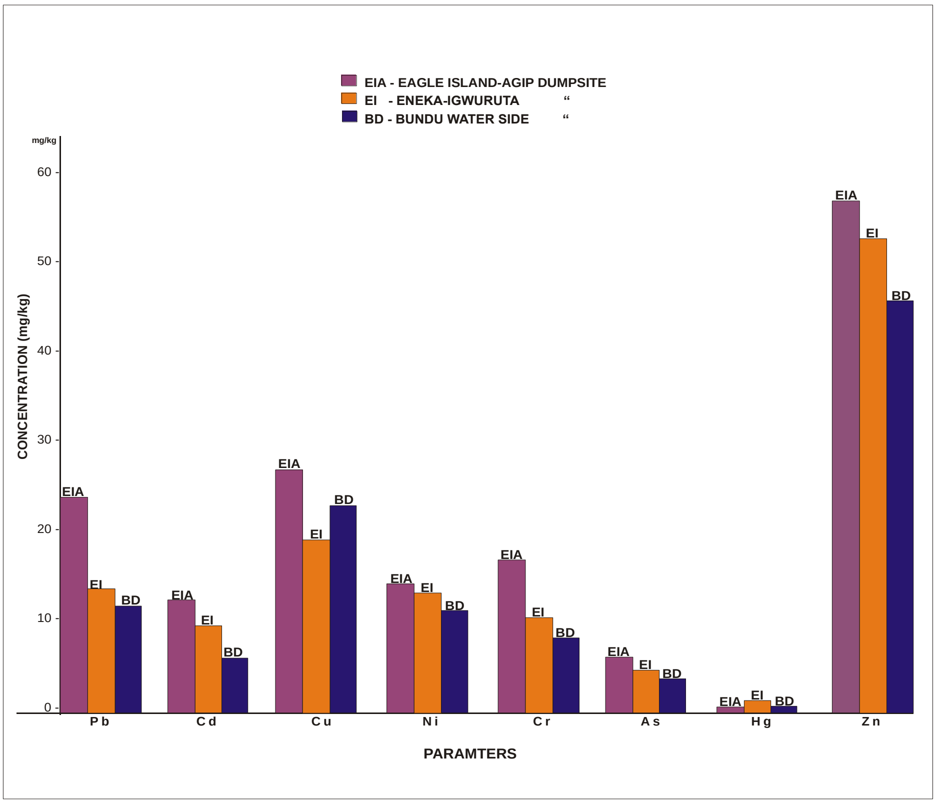

Fig. 4. Variation of heavy metal concentrations at dump sites.

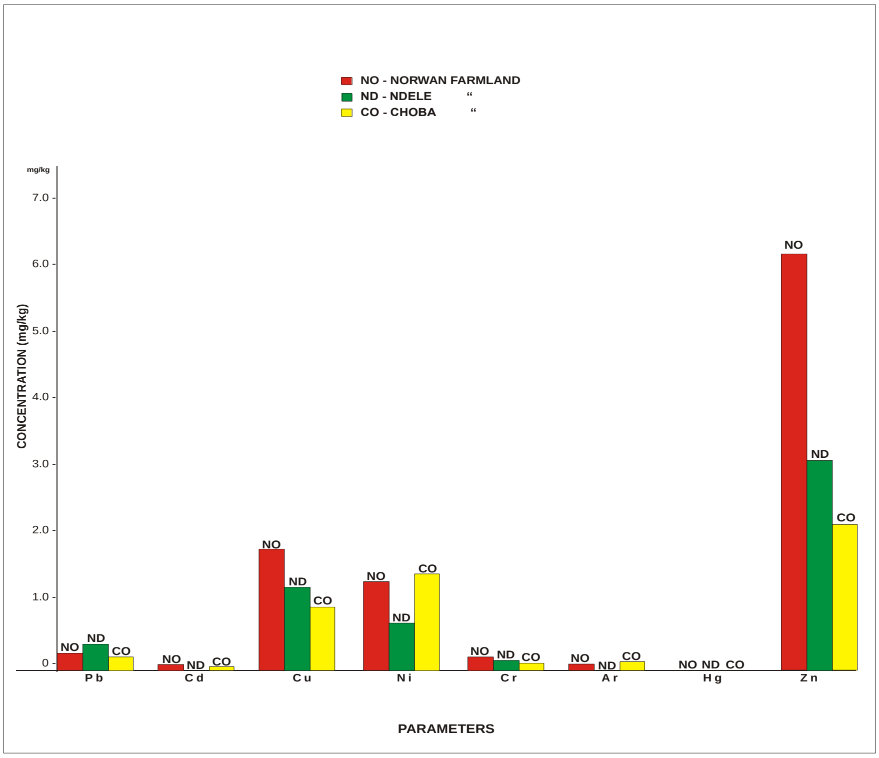

Fig. 5. Variation of heavy metal concentrations at control farmlands.

The dump sites are shown to have more heavy metal content than the control farmlands. The level of metal contamination of the dumpsites followed the order EIA>EI>BD for most of the metals except Cu which was , EIA>EI>BD. There was more Hg in EI than EIA and BD. EIA and EI are industrial dumpsites while BD is a domestic dump site.

Fig. 5 emphasizes that the farmlands contain comparatively lower concentrations of the heavy metals. Much lower than the WHO permissible limits and are therefore safer for cultivating less contaminated vegetables for healthy consumption.

V. Conclusion

The soils in the three dumpsites (Eagle Island/Agip , Eneka / Igwuruta and Bundu water side) studied were found to contain high concentrations of the eight heavy metals most of which were above the WHO standard recommended for each metal in soils. Eagle Island/Agip , Eneka / Igwuruta dumpsites identified as industrial waste dump had higher levels of heavy metals than Bundu water side a domestic waste dump . The nature of the wastes dumped at these sites probably was responsible for this difference. These dumpsites are therefore not recommended for cultivating vegetables. Comparatively the soils of the control farmlands had minimal levels of the eight heavy metals well below the WHO permissible limits for soils.

Vegetables grown at the three dumpsites all accumulated the investigated heavy metals to concentrations above the permissible limits for food and vegetable plants. Vegetables from the industrial dump sites had higher heavy metal levels than their counterparts from the domestic dump site for obvious reasons. The absorption and subsequent accumulation of the heavy metals by vegetables was governed by plant species, age of plant, soil type and other environmental conditions. This is evident in the different orders depicting the variation of metal accumulation in each vegetable. Vegetables from control farmland were obviously less contaminated by the heavy metals as their concentrations were within the WHO permissible limits. The results of this study, depicts that metals toxicity is imminent among the dwellers of these areas, alongside the ardent consumer of these heavy metals contaminated vegetables plants grown within the vicinity of the dumpsites. This raises the need for the public awareness about the accompanied dangerous health hazards. On the other side, the dumpsites soil that were highly contaminated should be discouraged from farming activities, while the habit of post-cultivating in the abandoned dump sites should be discouraged. Vegetables harvested from such environment are unfit and unsafe for both humans and animals consumption due to heavy metals bio-accumulation and bio-magnification syndrome.

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