International Journal of Agricultural Research and Food Production
ISSN: 2536-7331 (Print): 2536-734x (Online)
Volume 7, Number 2, June 2022
http://www.casirmediapublishing.com

Solid Waste Characterization and Assessment of Heavy Metal Concentration in Soils and *Amaranthus Spp* in some Dumpsites in Uyo Metropolis, Akwa Ibom State

[1]Tommy, I. E., [2]Ndaeyo, N. U. & [3]Etuk, I. M.
[1]Department of Agricultural Science, University of Uyo, Uyo, Nigeria
[2]Department of Crop Science, University of Uyo, Uyo, Nigeria
[3]Department of Forestry and Wildlife, University of Uyo Uyo, Nigeria
Email: inibehe2013@gmail.com; drnundaeyo@yahoo.com; etukidongesit01@gmail.com

ABSTRACT
The study was conducted in Uyo metropolis, the capital city of Akwa Ibom State, Nigeria. Solid waste materials were collected and sorted to examined their characterized componentat each dumpsite.The concentration of some heavy metals (Cd,Pb, Ni,Fe, Zn, Cr, Cu, Mn and Co) on soils of some refuse dumpsites in Uyo metropolis and *Amaranthus spp* grown within the vicinity of the dumpsites were studied. Soil (0-30cm) and *Amaranthus spp* were sampled within the dumpsites at 5m interval and the control samples from University of Uyo permanent site farm. Soil and plant samples were analyzed using established methods and results indicated the following mean concentrations (mg kg^{1}) in dry season in the order: Iron (724.14)> Manganese (72.46) > Lead (35.11) > Zinc (30.76)> Cadmium (18.94)> Copper (17.73) > Chromium (12.46) > Nickel (5.30)> Cobalt (5.03). In the wet season, it was: Iron (1260.39) > Manganese (74.37) > Lead (35.06) >Zinc (32.92) >Cadmium (20.24)> Copper (19.31) > Chromium (13.80)> Cobalt (5.43)> Nickel (4.74). Plant sample in dry season indicated the following trend: Iron (307.5)> Manganese (58.14) > Zinc (32.22) > Copper (18.74)> Cadmium (1.29) > Lead (1.18) >Chromium (0.79)> Nickel (0.29) > Cobalt (0.04). In wet season, it was; Iron (325.24) > Manganese (61.70)> Zinc (35.71)> Copper (22.03) > Lead (1.40)> Cadmium (1.18)> Chromium (0.81)> Nickel (0.35)> Cobalt (0.07). Heavy metals were higher in soil than plant samples. Values in dumpsites in both soil and plant samples were higher than the control sampled. Though there was no clear trend in heavy metal concentrations at dumpsites but the highest concentration was obtained in Eka Street. Mean seasonal concentration values varied with season and were higher in wet season than dry season. Heavy metal values from soil and plant samples were higher than the safe standard recommended by WHO/FAO except for Cobalt. This implies that it is risky to consume vegetables grown on and around dumpsites since it can accumulate toxic metals. Awareness creation among consumers and ban of cultivation at dumpsite soils to forestall wastes related illness should be encouraged.
Keywords: Dumpsites, Solid Waste, Heavy Metals, Soil, *Amaranthus spp*

INTRODUCTION

Solid wastes constitute an environmental problem all over the nation. Waste management is one aspect that Nigeria has virtually made little or no significant impact, where attempts are made in this regard, poor and ineffective method is applied. These wastes are either burnt or disposed untreated by open dumpsite or land-fill in an open space without regards to the composition of the waste materials (Eja *et al.*, 2003). Thus, government consider solid waste management as an essential social services whose budgetary provision is made in line with population projections.
Akwa Ibom is one of the state in Nigerian that has its population growth, land use become increasingly complex, and the waste generated increases in variety and volume. In terms of the economic potentials of Akwa Ibom State, the expansion of the commercial activities of its urban centers have not only compounded the problems of waste generation and management, but also affected the social, economic, political and environmental settings of the urban areas. In the opinion of Onibokun and Kumuyi (2003), waste management due to the ever increasing production of refuse has become one of the worrying results of the rapid and anarchic urbanization of these centers. Currently, solid waste generation in Uyo metropolis of Akwa Ibom State has reached a mammoth proportion. The metropolis is characterized by heaps of garbage and rubbish dumps on the street corners, market places and drainages as a result of indiscriminate dumping of refuse (Ebong *et al.,* 2007).

Thus, the levels of heavy metals in both soil and plant grown within the metropolis are expected to be considerably high. Contamination of soil by heavy metals could be caused by many factors, such as metal enriched by parent material and anthropogenic sources. Heavy metals derived from anthropogenic inputs are present in soils in a more reactive form and could lead to a higher risk of toxicity compared to heavy metals derived from natural parent materials in soil which are generally immobilized in relatively inert forms (Baize, 1997). However, soil contamination by heavy metals and toxic elements due to enriched parent materials often occur in limited area and can easily be identified (Lisk, 1988). According to Ebong *et al.,* (2007) most abandoned waste dumpsites in Uyo metropolis have been used extensively as fertile soils for cultivating varieties of vegetables. Indeed, studies also revealed that, pollution of plants is of concern for two reasons: Firstly, pollutions may have direct or indirect phyto-toxicity impacts on the plants themselves;

Secondly, the plants may act as a vehicle for transferring pollutants in the food chain (Odukaya *et al.,* 2000). This constitutes dangerous health and environmental hazard because of the phyto-toxicity health implications to the humans and animals consuming such vegetables (Pillay *et al.,* 2003). Umoren *et al.* (2019) found higher concentrations of copper, lead and Nickel in cocoyam grown near a waste dumpsite in Uyo, with a higher concentration level above the critical limit of 0.2mgkg^{-1} by WHO/FAO. The consumption of vegetables irrigated with dye effluent could pose risks to human health, and about 50% effluent resulted in death of Amaranthus seedlings (Oguntade *et al.*, 2017). The concern about these heavy metals is that, they are not biodegradable and may therefore accumulate in the environment. Therefore, monitoring of heavy metal concentration on dumpsites can help in reducing the effects on plant and the risk on human through consumption of such vegetable grown around the dumpsites soils. The main aim of this study were to characterized the solid waste component and assess the levels of heavy metal Cd, Pb, Ni, Fe, Zn, Cr, Cu, Mn and Co concentration in soils and plant (*Amaranthus*spp) in some dumpsite in Uyo metropolis.

MATERIALS AND METHODS

Location of Study Area

The study was conducted in Uyo metropolis, the capital of Akwa Ibom State, Nigeria with a population of over 605,961 (TWG, 2007). It is situated between latitudes 7° 50'E and 8° 00' E, and Longitudes 4° 59' N and 5° 05'N (Fig. 1) at an altitude of 60.0m above sea level with a mean annual rainfall of 3000mm and temperature range between 27-34°C (AKSEPA, 1999). The waste dumpsites under study were: Old Stadium road; St. Luke Hospital, Anua; Ewet Housing Estate; Itam and Eka Street. The University of Uyo permanent site farm Use Offot, was served as control site.

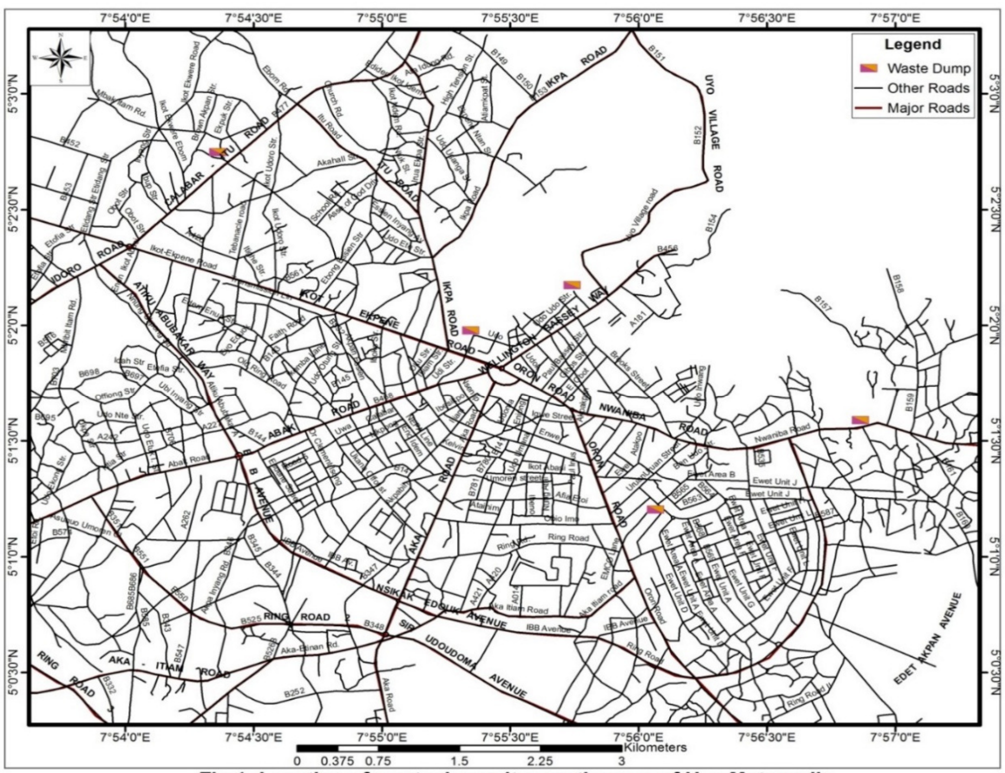

Fig.1: Location of waste dumpsites on the map of Uyo Metropolis

Study Design

A Randomized complete block design with five replications was used for this study. Five waste dumpsites were randomly selected to represent Uyo Metropolis as follows; Ikot Ekpuk

Itam, Ewet Housing Estate, Old Stadium Road and Eka Street. Farmland from University of Uyo located at Use Offot served as the control site. Within each site, soil was sampled in 5 replicates at 0-30cm depth. Soil and plant sampling were done once on the January and September, representing the dry and wet seasons, respectively.

Sample Collection and Preparation

Five sampling points were randomly made within each dumpsite from a marked out at5m interval to cover the total dumpsites area. The collection and sorting of the refuse/waste materials were performed with the help of refuse collectors at each dumpsite. The materials were laid in the open to eliminate moisture before dry weight was determined. The wastes were sorted into food and garden waste, bottles, plastics, glass, paper wastes and metals categories among others. The weighing was performed using a top load weighing balance capacity scale. Data obtained from this were extrapolated to cover the size (area) of each dumpsite. Composite soil samples (0-30cm depth) were collected at the dumpsites and *Amaranthus spp* leaves were also collected from farmland further away from the dumpsites. Soil sample was collected using Dutch auger and while knife was used to collect the *Amaranthus spp* leaves. Samples from soil and *Amaranthus spp* from waste dumpsites and control site were transferred into appropriate labeled polyethylene bags and taken to the laboratory for analysis.

Sample Analysis

The soil samples were air-dried, ground and sieved through a 2.00mm mesh sieve. While the *Amaranthus spp* samples were dried in oven at 80°C for 24 hours, and were ground with blander to a powder form prior to analysis. 1g of each sample of soil and plant were weighed into a digestion flask, followed by addition of analytical grade acid (analar (R)), concentrated trioxonitrate (v) acid and per chloric acid, (HNO_3 and $HCLO_4$), in the ratio of 2:1, respectively (10ml and 5ml). The HNO_3 acid was added to the sample before $HCLO_4$ acid to avoid any explosive reaction of $HCLO_4$ with untreated organic materials. This was covered with watch glass. The flasks and the contents were placed in a standing position on an electric hot plate in a fume cupboard and gently heated to evaporate until 1-2m of the acid will be left (near dryness), the colour changes to white. This was allowed to cool before leaching the residue with 5ml of 20% HNO_3. The filtration was done using an acid filter paper (Whatman no. 1) finally made up to 50cm with de-ionized water. A blank determination that served as the control was also carried out with all the reagents used for digestion except that it contained no sample of interest. The aliquots were used for the determination of cadmium (Cd), lead (Pb), nickel (Ni), iron (Fe), zinc (zn), chromium (Cr), copper (Cu), manganese (Mn) and cobalt (Co) metals using a Unicam atomic absorption spectrophotometer (AAS) MODEL 939 (Udo *et al.*, 2019).

Statistical Analysis

Data collected were subjected to analysis of variance and means compared using least significant difference at $P< 0.05$ (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Characterization of Solid Waste Material

Examination of wastes at the dumpsites revealed that the principal component of refuse sites are food and garden waste, bottles, plastics, glass, paper wastes and metals categories among others. Solid wastes are not separated or sorted into biodegradable and non-biodegradable wastes by those who dump refuse as is the practice in developed countries. Table 2 shows

International Journal of Agricultural Research and Food Production
ISSN: 2536-7331 (Print): 2536-734x (Online)
Volume 7, Number 2, June 2022
http://www.casirmediapublishing.com

the percentage range of the refuse released by dwellers in the study area as follows; food and garden wastes (19 – 52%) has the highest percentage followed by metal (7– 25%), plastics (7 – 15%), bottles (6 – 23%), Paper waste (2 – 11%) and glass (2 – 8%). Results also indicated that the highest proportion of the refuse were in the following trend order at old stadium road (138kg)> Ikot Ekpuk Itam (60kg)> St. Luke Hospital (43kg)> Eka Street (29kg)> Ewet Housing Estate (25kg) (Table 1). The highest waste deposition was from the old stadium road site. This is probably because it is the former State Government approved dumpsite managed by State Ministry of Environment. This was followed by Ikot Ekpuk Itam, St. Luke Hospital, Eka Street and Ewet Housing Estate (Table 1).

Table1: Fraction of the Solid Waste Materials in Different Dumpsites of the Study Area

Refuses type	Weight per site (kg)					Mean	Percentage by weight (%)					Percentage mean
	1*	2**	3***	4****	5*****		1*	2**	3***	4****	5*****	
Food and Garden Wastes	10	15	50	8	30	22.6	40	52	36	19	50	39.4
Bottles	4	4	8	10	5	6.2	16	14	6	23	8	13.4
Plastics	3	2	20	4	7	7.2	12	7	15	9	12	11
Glass	2	1	7	1	5	3.2	8	4	5	2	8	5.4
Paper waste	1	2	15	2	1	4.2	4	7	11	5	2	5.8
Metals	3	2	20	15	4	8.8	12	7	15	35	7	15.2
Others	2	3	18	3	8	6.8	8	11	13	7	13	10.4
Total	**25**	**29**	**138**	**43**	**60**							

Dumpsites Location:

1) Ewet Housing Estate
2) Eka Street
3) Old Stadium Road
4) St. Luke Hospital, Anua

5) Ikot Ekpuk Itam

Table 2: Percentage Range of Solid Waste Material Released in the Study Area

Refuse type	Quantity %
Food and garden waste	19 - 52
Bottles	6 - 23
Plastics	7 - 15
Glass	2 - 8
Paper waste	2 - 11
Metals	7 - 35
Others	7 - 13

Heavy Metal Concentration in Soils and Plant (*Amaranthus* spp)

This study revealed that the concentration of the heavy metals in the dumpsites was significantly influenced by season as they were comparatively higher in wet season than dry season. The variation in concentration could be due to increased rate of waste/ refuse deposition during wet seasons, surface water runoff and leaching at dumpsites in the rainy season compared to dry season. This agrees with the view that the use of organic waste as a source of manure even on proper compositing by microorganism will still be risky because high proportion of organic carbon may have negative health implication to humans.

The high concentration of some of the heavy metals observed in some dumpsites may be due to downward migration of leachates, soil pH, cation exchange capacity as earlier observed by Sauvé *et al.,* (2000). Similarly, some heavy metal concentrations on some dumpsites soil and plant samples were low and this could be attributed to phyto extraction of some metals by natural vegetation within the dumpsite vicinity. The heavy metal concentrations of these wastes increased with volume reduction during decomposition of metal rich materials (Das *et al.*, 2002). This could be attributed to the high concentration of some metals in soil and plant samples that may have deposited through leaching compared to the control samples.

Specifically, there was significant difference (P< 0.05) in Iron concentration among the dumpsites. Eka Street dumpsite had the highest values (994.28 mg kg^{-1}), followed by Ikot Ekpuk Itam dumpsite (787.92 mg kg^{-1}) while Ewet Housing Estate dumpsite had the least value (525.28 mg kg^{-1}) during dry season (Table 3). In wet season, the highest values were recorded in Ewet Housing dumpsites (1575.85mgkg^{-1}) followed by Eka Street (1425.00mgkg^{-1}) while Ikot Ekpuk (991.10mgkg^{-1}) had the lowest values (Table 4). The concentration of Fe in the soil and plant samples at dumpsite during dry and wet season were higher than the recommended value (5.00 mg kg^{-1}) of WHO/FAO (1996) Standards or critical limits. Therefore, the high Iron level calls for concern as it has health implications such as capability to cause vomiting, upper abdominal pain, diarrhea, dizziness, shock, diseases of kidney, liver and lungs to the consumers and those living with their vicinities (Ebong *et al.*, 2007).

The concentrations of Iron were significantly higher in wet season than dry season, and among different dumpsites. The level of Iron from the control soil and plant samples also varied during dry and wet seasons. The comparison of the concentration between dumpsites and control showed that the waste dumps contributed to the increase concentration of Iron in dumpsites.
Lead concentration was significantly higher (P< 0.05) in Ikot Ekpuk Itam (41.38mgkg^{-1}) dumpsite, followed by Eka Street (38.49mgkg^{-1}) while St Luke's Hospital, Anua (35.09mgkg^{-1}) recorded the lowest value concentration during dry season (Table 3). In wet season the highest values were recorded in Eka Street

(42.00mgkg^{-1}) followed by Ikot Ekpuk Itam (39.81mgkg^{-1}) while St. Luke's Hospital Anua (24.20mgkg^{-1}) had the lowest values (Table 4). Lead concentration in the soil and plant samples during dry and wet seasons were significantly higher than the recommended WHO/FAO (1996) Standard (0.30 mg kg^{-1}). However, the concentration of Lead in the control soil samples and plant showed an increased value with no particular trend but varied between seasons. The slight differences in the level of Lead in soil and plants in dry season compared to that of the wet season indicated the influence of the waste dumpsites and the high contents observed in some study areas. This supports the fact that Lead is specifically prone to accumulating in surface horizon of soils because of its low water solubility within certain pH range resulting in a very low mobility (Curtis and Smith, 2002). The presence of Lead suggests that materials such as spent batteries, tin, can and petroleum wastes might have been dumped at the site. This has health implications as neurological problems; especially in children as this have been identified as the principal concern for chronic lead exposure (Goyer and Clarkson, 2001).

Cadmium was significantly different ($P < 0.05$) among the dumpsites with St Luke's Hospital site having the higher concentration followed by Old Stadium Road site while Eka Street recorded the least concentration value. The cadmium concentration in the soil and plant samples during dry and wet seasons were found to be far higher than the WHO/FAO (1996) recommended values (critical limits) of 0.20 mg kg^{-1}. Though the values for control and plant samples were within the recommended ranged, the level of concentration at the dumpsites is rather very alarming, and farmers should be banned by the metropolitan authorities and the environmental protection agency from using waste dumpsites in the metropolis for vegetables cultivation. However, the high concentration in soil samples on

International Journal of Agricultural Research and Food Production
ISSN: 2536-7331 (Print): 2536-734x (Online)
Volume 7, Number 2, June 2022
http://www.casirmediapublishing.com

dumpsites during dry and wet season compared to the control soil samples is attributed to the biodegradation of waste materials rich in metal at the dumpsite (Das *et al.*, 2002). The decreasing trend on plant sample and its low concentration level for cadmium recorded in this study could be attributed to the metal being non-essential element for plant growth and metabolism (Shauibu and Ayodele, 2002), phyto toxicity can occur above the range of 0.10 -12.20 mg kg^{-1}. Indeed, the range of cadmium in plant recorded in this study is higher than 1.13 – 1.67 mg kg^{-1} reported by Udosen *et al.*,(2006) and Yusuf *et al.*, (2003), respectively and this may cause phyto toxicity.

Chromium concentration was higher in Old Stadium Road (16.20 mg kg^{-1}) followed by Eka Street (14.90 mg kg^{-1}) while Ikot Ekpuk Itam (8.16 mg kg^{-1}) had the least concentration value. Contents of Chromium ranged were found to be above the WHO/FAO (1996) recommended values of 0.02 mg kg^{-1}. The values were generally high when compared with the control soil and plant samples. This shows an influence of the waste dumped on the soil of the study area. However, phyto toxicity levels of Chromium in most plants seem to limit its accumulation in the food chain. Therefore, most plants have low Chromium concentrations, even when grown on Chromium rich soils, as food chain is well protected against Cr toxicity (Yadav *et al.*, 2005). Nickel concentration value were significantly difference ($P< 0.05$) with highest value recorded in Ikot Ekpuk Itam (7.88 mg kg^{-1}) dumpsite, followed by St. Luke's Hospital, Anua (7.01 mg kg^{-1}), while the least value were recorded in Ewet Housing Estate and Old Stadium Road (3.70 mg kg^{-1}) dumpsites. Ranges obtained for Nickel in soil and plant from dumpsites during dry and wet season were within the recommended limits (0.20 mg kg^{-1}) of WHO/FAO (1996), except for one (DPS2) site in plant sample that was slightly higher. Though, the ranged value is low, but continuous accumulation of

Nickel at dumpsites will eventually accumulate more toxic metal by plants grown on such soils. In comparison, the range of Nickel obtained is lower than 7.92 -19.12 mg kg^{-1} reported by Alegria *et al.,* (1991), and 11.05-20.55 mg kg^{-1} reported by Ebong *et al.,* (2007). Although the plant sample value of Ni in this study is higher than the values reported by Ebong *et al.,* (2007), it is however in conformity with 1.33 mg kg^{-1} recorded by Yusuf *et al.* (2003). The concentration of Nickel metal in dumpsite soil and plant was significantly higher than the corresponding concentration in the control samples. The high levels of Nickel in the dumpsite soils and plants could be attributed to huge amounts of waste products disposed of at the dumpsites.

There was significant difference ($P < 0.05$) of Copper concentration among the dumpsite with higher concentration recorded in Ikot Ekpuk Itam (22.87 mg kg^{-1}), followed by St. Luke's Hospital (19.10 mg kg^{-1}) while Eka Street recorded the least concentrated value of 10.40 mg kg^{-1}. Copper concentrations in the soil and plant during dry and wet season were higher than the recommended WHO/FAO (1996) maximum safe level of 0.20 mg kg^{-1}. The levels of Copper obtained were low compared to that of the control soil and plant samples. Though copper is known to occur naturally in soils as plant micro-nutrients, because they are essential elements for plants and animals, but when present in high quantity they may become toxic to plant and animals. In addition, copper salts though poisonous, yet is an essential element in human metabolism, having a powerful emetic action (Udosen *et al.*, 1990). However, when ingested in large dose by human could result in severe diarrhea, intestinal cramps, hepatic and renal damage exposure (Goyer and Clarkson, 2001).

Zinc concentrations were significantly difference ($P < 0.05$) among dumpsite. Ikot Ekpuk Itam (40.33 mg kg^{-1}) recorded the highest value, followed by St. Luke's Hospital (37.11 mg kg^{-1}) while Ewet Housing Estate had the least concentrated value of 20.85 mg kg^{-1}. Zinc is also known to occur naturally in soils as plant micronutrients, though it is an essential element for plants and animals, but when present in high levels, it may become toxic to human health. The levels of Zinc in the soil and plant sample during dry and wet season exceeded the safe limits (2.0 mg kg^{-1}) of WHO/FAO (1996) Standards. According to CDPM (1995), the maximum level of zinc tolerance for human health is 20 mg kg^{-1}. Therefore, the acute exposure of zinc can cause tachycardia, vascular shock, dyspeptic nausea, vomiting, pancreatic disorder, diarrhea and damage of hepatic parenchyma (Salgueiro *et al.,* 2000). In comparison, Zinc concentrations obtained from soil sample to that of the control soil suggested a significant contribution of wastes accumulation to Zinc metal pollution of the soil. The high values in the control plant sample may be attributed to the significant influence of the rate of metal uptake by plant species, plant age and plant part. However, the high level of this metal in control site may be attributed to the soil and environmental conditions of the study area, where deposition of metals are enhanced through erosion and surface runoff.

There was significant difference ($P < 0.05$) in manganese concentration among dumpsites. The highest value concentration was recorded in Ikot Ekpuk Itam (79.10 mg kg^{-1}), followed by St. Luke's Hospital, Anua (78.10 mg kg^{-1}), while Old Stadium Road recorded the lowest concentration value of 63.93 mg kg^{-1}. Manganese concentrations recorded in soil and plant samples during dry and wet season were extremely higher than the recommended values (0.40 mg kg^{-1}) of WHO/FAO (1996) standards. However, comparing the value from control soil and plant samples for both dry and wet season, there is no difference recorded. This could be attributed to the importance of the metal in proper functioning of the biological system and the importance of manganese in plant growth and abundance of the metal in the soils, (Oguntude, *et al., 2017*). Manganese is one out of three toxic essential trace elements, necessary for humans to survives, but when present in excess concentrations in a human body becomes toxic.

There was significant difference ($P< 0.05$) in Cobalt concentration among dumpsites. The values were higher in St. Luke's Hospital, Anua (7.89 mg kg^{-1}), followed by Ikot Ekpuk Itam (6.03 mg kg^{-1}) while Eka Street (1.87 mg kg^{-1}) recorded the least value concentration. The concentration of cobalt was found to be well below the WHO/FAO (1996) recommended values of 2.5 mg kg^{-1}.Though it intake may not pose a major health challenge, it could however constitute possible health hazards to humans with accumulatively taken over a period of time. The high concentration obtained at the dumpsite soil samples compared to control sample indicated the influence of the waste accumulation of the site. However, cobalt and manganese are closely associated in soils because they have similar chemical properties. Therefore, the solubility and availability of Cobalt in plant is influenced greatly by the activity of the Manganese oxides and the reactions which affect Manganese and its oxidation reaction oxidizes organic moieties, which some are phyto toxicity (Yadav *et al.,* 2005).

International Journal of Agricultural Research and Food Production
ISSN: 2536-7331 (Print): 2536-734x (Online)
Volume 7, Number 2, June 2022
http://www.casirmediapublishing.com

Table 3: Concentrations of Heavy Metals in Soils Sample on Dumpsites and Control Site during Dry Season in the Study Area

Heavy Metals (mg kg^{-1})	DSS 1	DSS 2	DSS 3	DSS 4	DSS 5	Control	Mean for Location	LSD (P< 0.05)	CV (%)
Fe	525.28	994.28	600.32	712.88	787.92	412.72	724.14	72.51	25
Pb	33.15	38.49	35.09	27.44	41.38	2.10	35.11	5.35	15
Cd	16.33	14.30	22.08	25.99	15.99	2.40	18.44	2.30	26
Cr	13.10	14.90	16.20	9.96	8.16	2 . 0	12.46	1.35	27
Ni	3.70	4.20	3.70	7.01	7.88	1.30	5.30	1.05	38
Cu	18.30	10.40	18.00	19.10	22.87	40.13	17.73	3.74	26
Zn	20.85	26.66	28.86	37.11	40.33	38.04	30.76	2.23	26
Mn	68.18	63.93	73.00	78.10	79.10	88.26	72.46	4.26	9
Co	5.86	1.87	3.48	7.89	6.03	1.80	5.03	2.35	47
Mean for all Metals	78.3	133.2	88.97	94.9	112.2	65.4			
LSD (P< 0.05)	17.24	10.81	12.03	7.11	7.01	21.75			
CV (%)	215	2 4	217	246	227	204			

DSS (Dumpsite Soil Sample 1): C - line Ewet Housing Estate
DSS (Dumpsite Soil Sample 2): Eka Street
DSS (Dumpsite Soil Sample 3): Old Stadium Road
DSS (Dumpsite Soil Sample 4): St. Luke Hospital Anua
DSS (Dumpsite Soil Sample 5): Ikot Ekpuk Itam
LSD (Least Significance Difference)
CV (Coefficient of Variation)

Table 4: Concentrations of Heavy Metals in Soils Sample on Dumpsites and Control Site during Wet Season in the Study Area

Heavy Metals (mg kg^{-1})	DSS 1	DSS 2	DSS 3	DSS 4	DSS 5	Control	Mean for Location	LSD (P< 0.05)	CV (%)
Fe	1575.85	1425.00	1100.32	1210.0	991.10	660.00	1260.39	71.33	19
Pb	36.18	42.00	33.11	24.20	39.81	3.16	35.06	5.42	20
Cd	18.20	16.21	20.55	28.14	18.12	3.13	20.24	2.19	23
Cr	16.55	16.55	18.12	10.41	7.39	2.33	13.80	3.02	34
Ni	4.70	2.05	2.05	6.76	8.13	1.77	4.74	1.37	58
Cu	18.95	12.66	20.15	17.14	27.65	46.20	19.31	5.92	28
Zn	28.33	30.12	27.01	40.80	38.33	4.30	32.92	5.40	19
Mn	70.12	71.05	69.11	76.44	85.12	79.93	74.37	2.19	9
Co	6.65	2.48	4.33	8.14	5.56	0.96	5.43	2.18	40
Mean for all Metals	197.3	179.8	143.8	158.0	135.7	89.1			
LSD (P< 0.05)	7.84	11.77	7.01	7.81	10.57	30.13			
CV (%)	262	260	250	250	237	242			

DSS (Dumpsite Soil Sample 1): C-line Ewet Housing Estate

DSS (Dumpsite Soil Sample 2): Eka Street

DSS (Dumpsite Soil Sample 3): Old Stadium Road

DSS (Dumpsite Soil Sample 4): St. Luke Hospital Anua

DSS (Dumpsite Soil Sample 5): Ikot Ekpuk Itam

LSD (Least Significance Difference)

CV (Coefficient of Variation)

International Journal of Agricultural Research and Food Production
ISSN: 2536-7331 (Print): 2536-734x (Online)
Volume 7, Number 2, June 2022
http://www.casirmediapublishing.com

Table 5: Concentration of Heavy Metals in Plant Samples on Dumpsites and Control Sites during Dry Season in the Study Area

Heavy Metals (mg kg^{-1})	DPS 1	DPS 2	DPS 3	DPS 4	DPS 5	Control	Mean for Location	LSD (P< 0.05)	CV (%)
Fe	300.16	300.16	333.0	304.2	300.0	225.12	307.50	72.88	5
Pb	1.02	1.00	1.20	1.30	1.40	0.10	1.18	0.4	14
Cd	1.00	1.98	1.20	1.16	1.10	0.18	1.29	0.87	30
Cr	0.37	1.88	0.66	0.48	0.55	0.09	0.79	1.20	79
Ni	0.11	1.10	0.11	0.06	0.07	0.07	0.29	0.88	166
Cu	16.00	29.10	19.28	14.10	15.20	31.17	18.74	3.07	33
Zn	46.63	33.33	28.99	25.00	27.16	48.86	32.22	3.22	27
Mn	57.80	77.91	53.00	48.99	53.00	67.84	58.14	10.19	29
Co	0.05	0.04	0.06	0.03	0.03	0.002	0.04	0.02	75
Mean for all Metals	47.0	49.6	48.6	43.9	44.3	41.5			
LSD (P< 0.05)	11.08	5.42	8.31	10.72	11.05	16.45			
CV (%)	208	197	223	226	220	177			

DPS (Dumpsite Plant Sample 1): C – Line, Ewet Housing Estate
DPS (Dumpsite Plant Sample2): Eka Street
DPS (Dumpsite Plant Sample3): Old Stadium Road
DPS (Dumpsite Plant Sample4): St. Luke Hospital Anua
DPS (Dumpsite Plant Sample 5): Ikot Ekpuk Itam
LSD (Least Significance Difference)
CV (Coefficient of Variation)

Table 6: Concentration of Heavy Metals in Plant Samples on Dumpsites and Control Sites during Wet Season in the Study Area

Heavy Metals (mg kg^{-1})	DPS 1	DPS 2	DPS 3	DPS 4	DPS 5	Control	Mean for Location	LSD (P< 0.05)	C V (%)
Fe	330.0	351.11	309.09	311.00	325.00	238.00	325.24	13.92	5
Pb	1.40	0.40	1.07	1.11	2.00	0.46	1.40	0.32	26
Cd	0.70	2.4	0.80	1.10	0.90	0.20	1.18	0.21	59
Cr	0.44	2.0	0.58	0.52	0.50	0.10	0.81	0.13	83
Ni	0.16	1.30	0.12	0.09	0.10	0.05	0.35	0.14	157
Cu	15.41	40.13	20.11	16.2	18.30	33.09	22.03	5.11	47
Zn	56.12	38.04	30.11	26.20	28.10	52.24	35.71	5.14	34
Mn	60.24	88.26	58.0	52.0	50.0	86.63	61.7	6.01	25
Co	0.09	0.06	0.07	0.06	0.05	0.03	0.07	0.02	357
Mean for all Metals	51.6	58.3	46.7	45.4	47.2	45.6			
LSD (P< 0.05)	39.14	45.12	9.12	6.13	9.14	17.86			
C V (%)	208	195	215	224	232	172			

DPS (Dumpsite Plant Sample 1): C – Line, Ewet Housing Estate
DPS (Dumpsite Plant Sample2): Eka Street
DPS (Dumpsite Plant Sample3): Old Stadium Road
DPS (Dumpsite Plant Sample4): St. Luke Hospital Anua
DPS (Dumpsite Plant Sample 5): Ikot Ekpuk Itam
LSD (Least Significance Difference)
CV (Coefficient of Variation)

Mean Seasonal Concentration and Variation of Metals in Soil and Plant *(Amaranthus spp)*

Table 7 shows that the mean seasonal concentration of Fe, Cd, Cr, Cu, Zn, Mn, and Co were higher in concentration during wet season than dry season and these could be due to surface water runoff and reaching at the dumpsites in rainy season compared to dry season, while plant samples had a higher concentrated value during wet season than dry season in all the heavy metals except Cadmium.

However, the mean values for variation of Heavy Metals were comparatively higher in soil than plant except for Copper and Zinc and these may be attributed to the significant influence of the rate of metal uptake by plant species, plant ageand plant part. Considering the heavy metal concentration in each dumpsite Ikot Ekpuk Itam had the most and is prone to heavy metal risk to human consumption.

Table 7: Mean Seasonal Concentration and the Variation of Metals in Soil and Plant in the Study Area (mg kg^{-1})

Heavy Metals	Soil		Mean	Plant		
	Dry Season	Wet Season		Dry Season	Wet Season	Mean
Fe	724.4	1260.39	992.2	307.50	325.24	316.4
Pb	35.11	35.06	35.1	1.18	1.40	1.3
Cd	18.94	20.24	19.6	1.29	1.18	1.2
Cr	12.46	13.80	13.13	0.79	0.81	0.8
Ni	5.30	4.74	5.00	0.29	0.35	0.3
Cu	17.73	19.31	18.5	18.74	22.03	20.4
Zn	30.76	32.92	31.8	32.22	35.71	34.0
Mn	72.46	74.37	73.4	58.14	61.7	59.9
Co	5.03	5.43	5.2	0.04	0.07	0.06
Mean	102.4	162.9		46.7	49.8	
T-Test (P< 0.05)	*	*	**	*	*	**

* Indicate significant difference between heavy metal concentration in dry and wet season of soil and plant samples.

** Indicates significant difference in heavy metal concentration in the overall means of soil and plant samples.

CONCLUSION AND RECOMMENDATIONS

Examination of wastes at the dumpsites revealed that the principal component of refuse sites are food and garden waste, bottles, plastics, glass, paper wastes and metals categories among others. Solid wastes are not separated or sorted into biodegradable and non-biodegradable wastes by those who dump refuse as is the practice in developed countries. However, waste component characterization shows that food and garden waste has the highest percentage followed by metal and plastics while broken glass, bottle amount was at par with paper wastes. Study also concluded that soil and plants (*Amaranthus spp)* had higher concentration of (Cd, Pb, Ni, Fe, Zn, Cr, Cu, Mn and Co) heavy metals than the control soil during the wet and dry seasons. Therefore, vegetable plants grown on dumpsites soils can accumulate more of the toxic metals than plants grown on the normal agricultural soils. Generally, the concentrations for all the metals in soil were higher than those in *Amaranthus spp* samples. This was because soil has been described as reservoir of pollutants where they concentrate according to the level of pollution. Indeed, Government efforts, NGO's, Private individuals Donor agencies should intensify their efforts to discourage the practice of cultivating at dumpsite soils and proper education and legislations on the handling of wastes in the society should be enforce to forestall wastes related problems along the food chain.

REFERENCES

AKSEPA (1999). World Bank Operation Manual. Akwa Ibom State WB Community-Based Development Project, Impact Assessment 111.

Alegria, A. R., Barbera, R., Boluda, R., Errecalde, F., Farre, R. and Lagarda, M. I. (1991). Environmental Cadmium, Lead and Nickel Contamination: Possible Relationship between Soil and Vegetable Content. *Journal of Analytical Chemistry,* 33(9): 654-657.

Baize, D. (1997). *Total Content of Trace Element in Soils*. France: Inra Paris. p 409.

CDPM, (1995). Thresholds for Food Hygiene Beijing: China Standard Press

Curtis, L. R. and Smith, B. W. (2002). Heavy Metals in Fertilizers: Considerations for Setting Regulations in Oregon. *Oregon Fertilizer Guide*. 17. p.

Das, K. C., Smith, M. C., Gattric, D. K. and Hale-Boothe, D. D. (2002). Stability and Quality of Municipal Waste from a Landfill Aerobie Bioreduction Process. *Advance Environmental Research*, 6:401-409.

Ebong, G. A., Etuk, H. S. and Johnson, A. S. (2007). Heavy Metals Accumulation by *Talinum Triangulare* grown on Waste Dumpsite in Uyo Metropolis, Akwa Ibom state , Nigeria. *Journal of Applied Sciences. ISSN* 1812-5684.

Eja, M. E., Ogri, O. R. and Arikpo, G. E. (2003). Bioconcentration of Heavy Metals in Surface Sediments from the Great Kwa River Estuary. Calabar South – Eastern Nigerian. *Journal of Nigerian Environmental Society* 1:247-256.

Gomez, R. A. and A. A. Gomez (1984). *Statistical Procedures for Agricultural Research*. New York:USA, John Willey and Sons. p. 680.

Goyer, R. A. and Clarkson, T. W. (2001). Toxic Effects of Metals In:*Cassarell and Doullis Toxicology: The Basic Science of poisons* (6th Ed.). (O. D. Klaassen, Ed.). New York: McGraw-Hill, p.32.

Lisk, D. J. (1988). Environmental Implication of Incineration of Municipal Solid Waste and Ash Disposal. *Science of the Total Environment*. 74: 39-66

Odukoya, O. O., Bamgbose, O. and Arowolo, T. A. (2000). Heavy Metals in Top Soils of Abeokuta Dumpsites. *Journal of Pure and Applied Sciences*. 6(4): 651-653.

Oguntude, O. A., Adetunji, M. T. and Azeez, J. O. (2017). Heavy metal accumulation in soil and subsequent uptake by

Amaranthus (AmaranthusCrucutus (L) Irrigated with dye industrial effluent. *Nigerian Journal of Soil Science*. 27:35 – 38.

Onibokun, A. G. and Kumuyi, A. J. (2003). Governance and Waste Management in Africa. In: (Chinda, L., Ed.) *Managing the Monster, Urban Waste and Governance in Africa.* Canada: *CRDi*, p. 243.

Pillay, A. E., Williams, J. R., Al-Lawati, M. O., Al-Haddabi, S. M. H., Al-Hamdi, M. H., and Al-Hamdi, A. (2003). Risk Assessment of Chromium, Arsenic in Deed Palm Leaves Used as Livestock Feed. *Environmental International*, 29: 541-542.

Salgueiro, M., Zubillaga, J., Lysionek, M., Sarabia, A., Caro, M. T. and Paoli, R. (2000). *Zinc as an Essential Micronutrients. A* Review on Nutritional Research, 20: 737-755

Sauve, S., Henderson, W. and Allen, H. E. (2000). Solid-Solution Portioning of Metals in Contaminated Soils: Dependence on pH, Total Metal Burden, and Organic Matters. *Environmental Science and Technology*, 34:1125-1131.

Shauibu, U. O. and J. T. Ayodele, (2002). Bioaccumulation of Four Heavy Metals in leaves of *Calostropis procera. Journal of Chemical Society of Nigeria*, 27:26-27.

TWG (2007). Current Population Figures for Cities, Towns and Administrative Divisions of the World. *http://www.world-gazetter.com/home.htm,* accessed 26th February, 2007.

Udoh, E. J., Ibia, O. T., Ogunwale, J. A., Ano, A. O., & Esu, I. E. (2009). *Manual of soil, plant and water analysis.* Sibon Book Ltd.

Udosen, E. D., Benson, N. U., Essien, J. P. and G. A. Ebong, (2006). Relation between Aqua-regia Extractable Heavy Metals in Soil and *Manihot utilissima* within a Municipal Dumpsite. *International* Journal*of Soil Science*, 1:27-32.

Udosen, E. D., Udoessien, E. I. and Ibok, U. J. (1990). Evaluation of Some Metals in the Industrial Wastes from a Paint

Industry and their Environmental Pollution Implications. *Nigeria Journal of Technological Researchers*, 2(1):71-77.

Ukpong, E. C. Antigha. R. E. Moses, E. O. (2013). Assessment of Heavy metals content in soils and plants around waste dumpsites in Uyo Metropolis, AkwaIbom State. The *International Journal of Engineering and Science* (IJES) II volume/2/issue/7/pages/75-86/2013/IS5N (e): 2319-1813 ISSN(P): 2319-1805.

Umoren, A. S., Effiong, G. S. and Udosen, C. J. (2019). Assessment of copper, lead and nickel contamination in soils and cocoyam (*Xanthosoma sagittifolia*) grown near waste dumpsites in the outskirt of Uyo metropolis, Akwa Ibom State. Proceedings of 43rd annual conference of the soil science society of Nigeria. pp: 444 – 45.

WHO /FAO (1996). Report of 33rd Meeting of Joint WHO/FAO Expert Committee on food additives. *Toxicological Evaluation of certain foods additives and contaminants.* No. 24, International program on chemical safety, WHO, Geneva.

Yadav, S., Shukla, O. P, and Rai, U. N. (2005). Chromium Pollution and Bioremediation, *Environmental News*, 2(1): 34-48.

Yusuf, A. A., T. A. Arowol and O. Bamgbose, (2003). Cadmium, Copper and Nickel levels in Vegetables from Industrial and Residential Areas of Lagos City, Nigeria. *Food Chemistry Toxicology*, 41: 375-378.