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Trace metals analysis of soil and edible plant leaves from abandoned municipal waste dumpsite in Owerri, Imo state, Nigeria

Ibe Francis Chizoruo[1], **Beniah Obinna Isiuku**[2] and **Enyoh Christian Ebere**[3]

[1,3]Group Research in Analytical Chemistry, Environment and Climate Change (GRACE&CC), Department of Chemistry, Imo State University, Owerri, Imo State, P.M.B 2000, Nigeria

[2]Department of Chemistry, Imo State University, Owerri, Imo State, P.M.B 2000, Nigeria

[1-3]Email address: francispavo@yahoo.com , obinnabisiuku@yahoo.com , cenyoh@gmail.com

ABSTRACT

Municipal refuse may increase heavy metal concentration in soil, even at low levels, and their resulting long-term cumulative health effects are among the leading health concerns all over the world. In this study, we investigated the concentration of heavy metals in soils and edible plant leaves grown in an abandoned dumpsite along Akachi road in Owerri municipality. The soil samples were collected at each plot using a soil Auger at the depth of 0-10 cm. Leaves of dominant edible plant species were selected and collected from each sample plot. The samples were dried in an oven with forced air at 40 °C, milled to fine powder, then digested with 10 ml concentrated HNO_3 and 5 ml concentrated $HClO_4$ and were analyzed for Cr, Cu, Fe, Mn, Al, and Zn, using an H183200 MultiParameter Bench Photometer. Result showed that metals in the sampled soils included (in order of quantity) Cr: 150-280 >Fe: 116.50-203 >Cu: 12.4-18.8 >Mn: 0-20 >Al: 0.08-0.16 >Zn: 0-1.4 mg kg^{-1} Dw. Moreover, levels of metals in the edible plant leaves are in the order of: Zn>Fe>Cu>Al>Mn>Cr. Zn content, in particular, was higher than FAO/WHO recommended limits. Still, application of Pollution Load Index and Ecological risk models showed that the area is unpolluted and safe for use. Daily Metal Intake estimates indicated that zinc is mostly consumed from the plant species. The trends in Transfer Factor for the heavy metal in vegetable samples studied were in order: Zn>Al>Cu>Mn>Fe>Cr. Therefore, abandoned solid waste dumpsites contained significant concentrations of heavy metals which are later absorbed and accumulated by plants growing it.

Keyword**:** Accumulation, Metal intake, Pollution indices, Risk, Zinc

1. INTRODUCTION

There have been increasing attentions in the last few decades in both developing and developed countries on the environmental problem of soil pollution associated with heavy metals (Wu *et. al*., 2014). This is assisted by the unorganized increasing urban expansion, industrial developments coupled with inadequate waste management, which causes significant alterations in the physical environment and increases accumulation of municipal waste. Soil which enables growing of plant (Enyoh *et al*., 2017) and human activities is mostly affected. Urban areas are known for high level of industrial activities which generate more pollutants (Tanee and Eshalomi-Mario, 2015). An example of such area is Owerri municipal, which serves as a connecting route to Port Harcourt, River State, Ontisha, Anambra State and Aba, Abia State. For this reason, the city has high exponential increase in human population and boost for commercial activities, which persistently creates significant volumes of waste on daily basis. The city lacks proper solid waste regulations and proper disposal facilities, for harmful waste. The poor management of waste or effluents could create a number of adverse environmental impacts as waste may be toxic or radioactive (Onibokun and Kumuyi, 1996; Wong *et al*., 2003; UNDP, 2006; Kimani, 2007; Verla *et al*., 2017a). Furthermore, explosion may occur as waste produce methane gas when organic materials are decomposing and also produce leachates, which pollute and ruin the aesthetic quality of the soil (Cointreau Levine, 1997; Oyelola *et al*., 2009). Studies have shown municipal refuse may increase heavy metal concentration in soil and underground water (Albores *et al*., 2000; Okoronkwo *et al*., 2005; 2006), even at low levels, and their resulting long-term cumulative health effects are among the leading health concerns all over the world (Oluyemi *et al*., 2008, Njoku and Ibe, 2009). However, abandoned waste dumpsites in southeastern Nigeria and other parts of the country have been used extensively as fertile grounds for cultivating vegetables and plant based foodstuff, though research has indicated that the vegetables are capable of accumulating high levels of heavy metals from contaminated and polluted soils (Garcia *et al*., 1981; Xiong, 1998; Obasi *et al*., 2013). In Owerri city, most abandoned landfill sites are currently used for crop cultivation, rearing livestock, as playground for children and as sites for unauthorized settlements. This practice is scientifically unacceptable in this era and as such, there is need for proper assessment of dumpsite waste soils to ensure environmental sustainability (Obasi *et al*., 2013). Though numerous studies have been reported on heavy metals from dumpsites soils and crops grown on them (Amusan *et al*., 2005; Okoronkwo *et al*., 2005; Ololade *et al*., 2007; Elaigwu et al., 2007; Ndukwu et al., 2008; Ebong et al., 2008; Goorah et al., 2009; Ayan *et al*., 2010; Obute *et al*., 2010; Charlse *et al*., 2011; Magaji, 2012; Obasi *et al*., 2012; Kanmani and Gandhimanti, 2013; Leah and Johny, 2014; Osei-Akoto *et al*., 2016). However, the need for this research is due to paucity of data as well as published works regarding the fate of trace metal in this abandoned waste dumpsite. Since people now live in this area and cultivate the land, this study will be built on these works by attempting to address part of this problem, by assessing the levels of heavy metals in the abandoned dumpsite located at Akachi road, Owerri municipal. This will involve determination of the concentration of these heavy metals in soil and edible plant leaves as well as subjecting them to index models for risk assessment. It is expected that results obtained from this study will widen our knowledge on the environmental risks associated with solid waste dumps in terms of heavy metal toxicity and the suitability of such site for plant cultivation. This will be of great benefit to the immediate community, the public and environmental health policy makers.

2. MATERIAL AND METHOD

2. 1. Study location

The study was conducted in Owerri municipal, which is one of the three Local Government areas that make up Owerri, the capital of Imo state in the Eastern part of Nigeria. According to 2006 population census of the Federal Republic of Nigeria, Owerri has a population of 401,873, (FRN, 2006) which must have increased tremendously over the past decade. Owerri Metropolis is located within latitudes 4°23'N - 7°15'N and longitudes 6°50' E and 7°25'E. The town is the capital of Imo State, having three big markets with a lot of commercial activities.

The location of the abandoned waste dump site is at Akachi road, Owerri, Imo state, Nigeria, as shown in **Fig. 1**. This area was specifically chosen for the study because the waste dump site has been abandoned for over ten years. Some of the municipal wastes dumped in this site are now buried in the soil. There have been a lot of activities in this area in the recent years owning to the construction of a bypass across the abandoned waste dump site which opened up the area. The opening up of this area resulted in construction of both residential and commercial buildings. This is in addition to farming and growing of edible crops due to a river that passed through the area, as shown in the legend (Fig. 1).

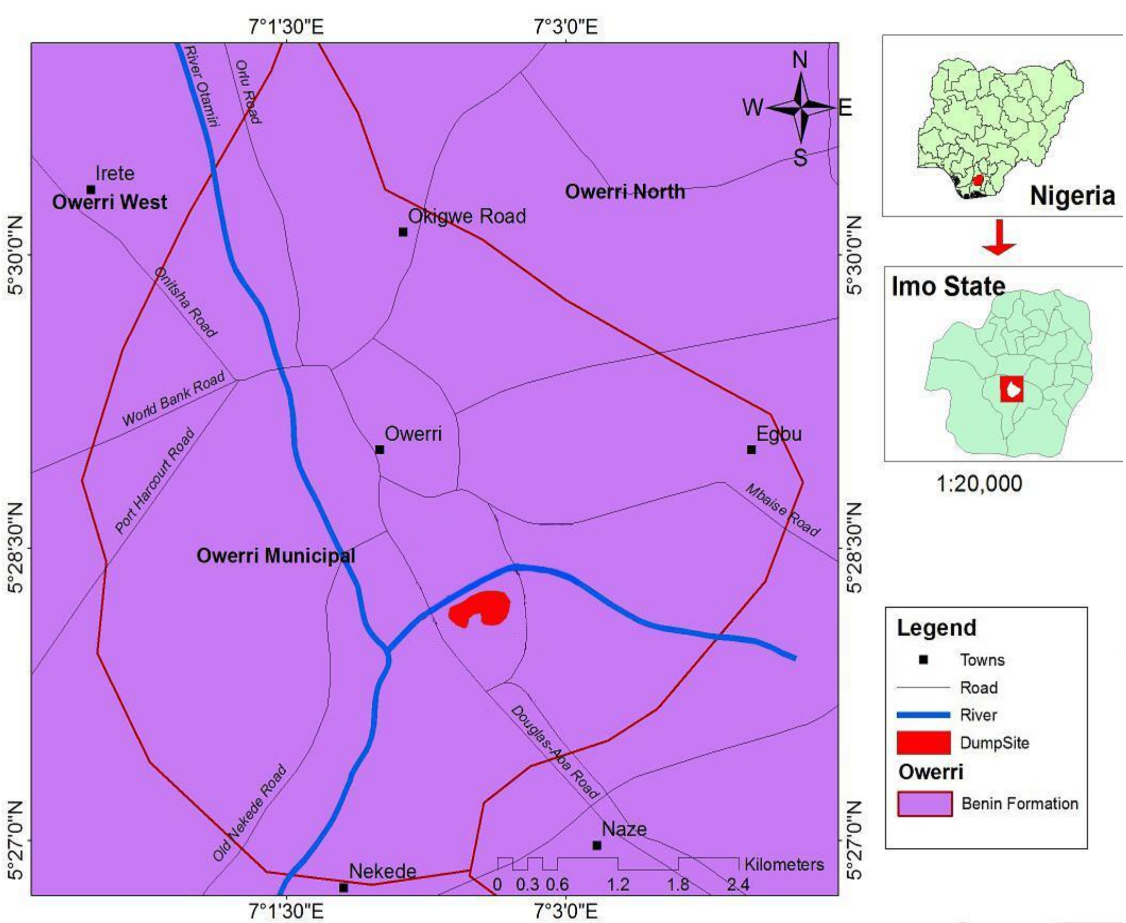

Figure 1. Map of Owerri showing sample location

2. 2. Sample collection and preparation

The sampling sites were spread objectively and the collections were done using a soil auger at 10 cm depth (top soil). At each site a “W” shaped line was drawn on a 2×2 m surface along which five samples were collected from each sample field area and mixed homogeneously to form one sample (Enyoh *et al*., 2017). The containers were washed with hot water and detergent and thoroughly rinsed in order to remove all contaminant.

The dominant plant species were collected using a knife from the abandoned site, washed in distill water to remove soil/dust particles. They were put in black polythene bags, tied and labeled with a masking tape and marker. Soil and plant samples were marked A to E to represent the same sample location. The soil and plant leaves were then transferred to the Imo State University Chemical Laboratory for analysis. The plant leave samples were dried in an oven with forced air at 40 °C, then they were milled to obtain fine powder and stored in a previously cleaned plastic bottle for heavy metals analysis. The samples were collected at five different points within the abandoned waste dump site at Akachi road. Coordinates of the sample collection points were referenced with GPS map 76, as presented in **Table 1**.

Table 1. Showing coordinates, elevation and description of sample area

SN	Sample site	Co-ordinate	Elevation (m)	Description of area
1	A	05°28’18.6” N 007°02’21.4” E	74	Along Akachi Road, in a residential building
2	B	05°27’57.0” N 007°02̕37.1’’E	77	Along Akachi Road, in a car wash
3	C	05°28’0.62” N 007°02’36.4” E	79	KenuJ 0^2 shopping mall
4	D	05°28’02.2” N 007°02̕23.5’’E	78	Njoku sawmill (a mini market)
5	E	05°28’21.8” N 007°02’27.3” E	67	Along Akachi Road, at car wash

2. 3. Determination of Al, Cr, Cu, Fe, Mn, and Zn

The soil and plant samples were digested with a mixture of nitric and perchloric acid. 2 g of powdered samples were accurately weighed into a beaker and then 10 ml of HNO_3 and 5 ml of $HClO_4$ were added, then it was allowed to stand for 24 hours. This was followed by filtration into a 100-ml volumetric flask and the filtrate was made up to mark, and used for analysis. The concentrations of metals were determined using Multiparameter Bench Photometer HI 83200 by HANNA Instruments (Duru *et al*., 2017).

2. 4. Analysis of potential ecological risk index

The Potential Ecological Risk Index (RI) was assessed according to (Hakanson, 1980; and Aktaruzzaman *et al.*, 2013) as the degree of heavy metal pollution in soil and according to the toxicity of metals and the response of the environment (Aktaruzzaman *et al*., 2013). RI could evaluate ecological risk caused by toxic metals comprehensively. The calculating methods of RI are listed below:

$$Pi = \frac{C_m}{C_o} \quad (1)$$

$$E_T = T_{ri} \times P_i \quad (2)$$

$$R_I = \sum ETi \quad (3)$$

where, *Pi* is the single metal pollution index; C_m is the concentration of metal in the samples; C_o is the reference value for the metal. The reference concentrations were taken as the target value (mg/kg) of the Department of Petroleum Resources. The values are: Fe = 38,000, Zn = 140, Cu = 36, Cr = 100, and Mn = 850 (DPR, 2002; Verla *et al*., 2017b). E_T is the monomial potential ecological risk factor; T_{ri} is the metal toxic response factor, according to Hakanson (1980). The values for each element are in the order: Zn = 1, Cr = 2, Cu = 5. R_I is the potential ecological risk caused by the overall contamination.

2. 5. Daily metals intakes estimate (DI_{metal})

The daily metals intakes were estimated by multiplying the concentration of metals in the edible plant leave with the recommended daily intake of at least 0.4 mg of vegetables (Sharma *et al*., 2008).

$$DI_{metal} = 0.4 \times C_{plant} \quad (4)$$

where C_{plant} is the concentration of metals in the plant samples, 0.4 is a factor recommended by experts (Sharma *et al*., 2008).

2. 6. Transfer factors (*TF*) of the heavy metals from soils to the edible plant leaves

The transfer coefficient was calculated by dividing the concentrations of heavy metals in vegetables by the total heavy metal concentration in the soil (Kachenko and Singh, 2006).

$$TF = \frac{C_{plant}}{C_{soil}} \quad (5)$$

where, C_{plant} = metal concentration in plant tissue, mg·kg^{-1} fresh weight, and C_{soil} = metal concentration in soil, mg·kg^{-1} dry weight (mg·kg^{-1} Dw).

3. RESULTS AND DISCUSSION

Heavy metal concentrations in the abandoned dumpsite soil samples collected are presented in **Table 2**. The metal concentration ranges were: Cr: 150-280; Cu: 12.4-18.8; Fe:

116.50-203; Mn: 0-20; Al: 0.08-0.16; Zn: 0-1.4 mg·kg^{-1} Dw. The mean values were: 264, 15.7, 169.3, 20, 0.12, 1.07, and standard deviations were: 113.93, 2.62, 36.42, 0, 0.03, and 0.31, respectively.

Table 2. Metal concentration in soil samples.

Metals (mg/kg)	Samples					Mean	SDV
	A	B	C	D	E		
Cr	210	230	450	150	280	264	113.93
Cu	17.3	16.3	18.8	13.7	12.4	15.7	2.62
Fe	203	202	116.50	152.00	173.00	169.3	36.42
Mn	ND	20	ND	20	20	20	0
Al	0.10	0.08	0.14	0.16	0.10	0.12	0.03
Zn	1.4	0.80	ND	ND	1.00	1.07	0.31

The concentrations of these elements obtained in this study were compared with values reported in literature. Chromium (Cr) concentration, recorded in the present study (264 mg/kg), is high when compared to values recorded in other studies, such as 21.51 mg· kg^{-1} in the soil of Ado Ekiti, Southwestern Nigeria (Aruleba and Ajayi, 2012). Li *et al.* (2001) recorded 54.88 mg·kg^{-1} in urban soil of Hongkong. 22.27 mg/kg was observed in abandoned dumpsite in Umuahia, Abia State, Southeastern Nigeria (Okoronkwo *et al.*, 2006). 4.55-33.46 mg/kg was recorded in the Region of DhakaAricha Highway, Savar, Bangladesh (Aktaruzzaman *et al.*, 2013). In a related study carried out in China, 159.3 mg·kg^{-1} was recorded in urban soils and roadside dust (Shi *et al.*, 2008), while Jiang *et al.* (2014) reported a mean value of 66.48 mg/kg in soils around coal gangue dump. The high level of chromium could be due to the nature of waste and persistent nature of the metal. The higher concentration values of chromium compounds could have been leached by rainwater and migrated through cracks in soil, asphalt roadways, and masonry walls, forming high-content chromium crystals on their surfaces (ATSDR, 2008). Chromium is carcinogenic, resulting in cancer of respiratory organs in workers exposed to chromium containing dust (Langard, 1980).

The investigation found lower concentration of Cu compared to that in the soil of Gazipur (55-65) mg·kg^{-1}, as reported by Habib *et al.* (2009) and soil around a coal gangue dump (22.72 mg/kg) reported by Jiang *et al.* (2014), though higher than mean values reported in soils of Bangladesh (9.92 mg/kg), as reported by Aktaruzzaman *et al.* (2013). In general, Cu concentrations in the investigated soil were unpolluted since it is below the maximum acceptable limit of 70-80 mg/kg set by Federal Environmental Protection Agency, FEPA (1997).

Higher mean values of Fe were recorded in the present study when compared with the report of Osakwe and Okolie, (2015), who observed a mean value of 142.93 mg·kg^{-1}. High concentrations of iron in soils, relative to other metals, have been reported in various studies (Dara, 1993; Ademoroti, 1996; Aluko and Oluwande, 2003) confirming that natural soils contain significant levels of iron. Furthermore, the value obtained in this study was far lower than value (12590.67 mg/kg) reported by Osei *et al.* (2016) in surface soils from abandoned waste sites in Ghana. Fe also was lower than the maximum acceptable limit of 400 mg/kg set by Federal Environmental Protection Agency, FEPA (1997). Lower levels of Mn and Zn were obtained in the investigated soil when compared to the mean values obtained by Chukwuocha *et al*. (2015) who reported 150.7 mg/kg and 268.67 mg/kg for Mn and Zn, respectively, in top soils of Owerri, Imo State, Nigeria. The concentrations of metal found in soil of the present study were considerably significant and were moderately too heavily polluted for Cr, Cu, Mn, and Fe, according to the soil quality guidelines for heavy metals in soil (Pekey, 2006). This observation suggests that dumping of waste materials might have influenced levels of these metals in the sites. Persons living or working in the vicinity of the sites may have been exposed through inhalation, ingestion, or skin contact with contaminated soils and dusts (ATSDR, 2008). On the other hand, Al and Zn in all the soil samples were unpolluted.

The degree of contamination is defined as the sum of all contamination factors. According to (Tomlinson *et al*., 1980; Mathias and Stephen, 2016), the following terminologies are used to describe the degree of contamination; $Pi<6$, low degree of contamination; $6 \le Pi < 12$, moderate degree of contamination; $12 \le Pi < 24$, considerable degree of contamination; $Pi \ge 24$, very high degree of contamination. In the present study, all sites were uncontaminated. The pollution load index is a potent tool in heavy metal pollution evaluation that provides a simple and comparative means for assessing the level of heavy metal pollution. The *PLI* represents the number of times by which the metal content in the soil exceeds the average natural background concentration, and gives a summative indication of the overall level of heavy metal toxicity in a particular sample (**Table 3**).

Table 3. Individual pollution index or contamination factors for various metals studied.

Site	Individual Pollution Index						Degree	*PLI*	Comment
	Cr	Cu	Fe	Mn	Zn	∑Pi			
A	0.7	0.48	0.0053	-	0.01	1.20	Low	0.02	No pollution
B	0.77	0.45	0.0053	0.02	0.0057	1.25	Low	0.002	No pollution
C	1.5	0.52	0.003	-	-	2.02	Low	0.24	No pollution
D	0.5	0.38	0.004	0.02	-	0.90	Low	0.02	No pollution
E	0.93	0.34	0.0045	0.02	0.007	1.30	Low	0.002	No pollution

**PLI* = Pollution Load Index

The *PLI* value of > 1 is polluted, <1 indicates no pollution, whereas values of *PLI* = 1 indicate heavy metal loads close to the background level (Cabarera *et al*., 1999; Mathias and Stephen, 2016). Therefore, the five sample points could be considered unpolluted for the metals studied.

Table 4. Monomial potential ecological risk factors and potential ecological risk caused by the overall contamination for various metals studied.

Site	Cr	Cu	Fe	Mn	Zn	RI = ∑Pi
A	1.4	2.4	-	-	0.01	3.81
B	1.54	2.25	-	-	0.0057	3.89
C	3	2.6	-	-	-	5.6
D	1	1.9	-	-	-	2.9
E	1.86	1.7	-	-	0.007	3.57

The following terminologies are used to describe the ecological risk factor: $E_T i$ <40, low potential ecological risk; 40≤$E_T i$<80, moderate potential ecological risk; 80≤$E_T i$<160, considerable potential ecological risk; 160≤$E_T i$<320, high potential ecological risk; and $E_T i$≥320, very high ecological risk and the potential ecological risk index as given by Mathias and Stephen, (2016): RI<150, low ecological risk; 150≤RI<300, moderate ecological risk; and RI>600, very high ecological risk. As shown by **Table 4**, all sample sites have low potential ecological risk, as well as low ecological risk. These suggest that the study area is safe for use.

Table 5. Metal concentration in plant samples

Metals (mg/kg)	*Carica papaya* [1]	*Colocasia esculenta*	*Psidium guajava*	*Prinus dulcis*	*Carica papaya* [2]	Mean	SDV
Cr	0.015	0.07	0.085	0.1	0.15	0.08	0.05
Cu	3.0	3.55	4.25	4.00	4.20	3.80	0.53
Fe	16.40	1.05	3.25	3.85	10.20	6.95	6.28
Mn	0.5	ND	ND	1.50	1.50	1.17	0.57
Al	4.20	3	ND	5.00	1.05	3.32	1.72
Zn	225	75	75	100	150	125	63.74

*ND = Not Detected

Heavy metal concentrations in leafy vegetables of the edible plants grown on the abandoned dumpsite soil and their statistical analysis are presented in **Table 5**. Concentrations of heavy metal ranges were: Cr: 0.015-0.15; Cu: 3.0-4.25; Fe: 1.05-16.40; Mn: 0.5-3.1.50 mg·kg^{-1}; Al: 1.05-5.00, and Zn: 75-225, and order of heavy metals concentration in the vegetables samples were: Zn>Fe>Cu>Al>Mn>Cr.

Out of the six metals analyzed only, the standard levels for Zn (60 mg/kg), Cu (40 mg/kg), and Cr (2.3 mg/kg) were available for comparison obtained from FAO and WHO permissible levels for food, as reported by Charlse *et al*. (2011).

The Zn concentrations in the samples were high. *Carica Papaya* [1] recorded the highest value of 225 mg/kg while *Colocasia Esculenta* and *Psidium guajava* recorded the lowest (75 mg/kg). In general, the samples were all above the standard level of 60 mg/kg. These suggest that Zn is the most accumulated metal by plants grown in the area. Zn is an essential element in plants, but could become toxic and pose health issues when consumed in excess.

In the analyzed samples, Cu levels ranged from 3.0-4.25 mg·kg^{-1}, which is very low when compared to FAO/WHO permissible level for food. However, the concentration of Cu recorded (0.25-3.52) mg·kg^{-1} in the present study is higher than the mean concentration of Cu (2.00±1.174) mg·kg^{-1} observed by Aktaruzzaman *et al*. (2013). Alam *et al.* (2003) reported the mean Cu concentrations of 15.5mg·kg^{-1} and 8.51 mg·kg^{-1} in leafy and non-leafy vegetables, respectively, from Samata village, Jessor, which is higher than the present findings. Higher mean concentration of Cu (22.19-76.50) mg·kg^{-1} was reported in leafy vegetable species from Turkey (Demirezen and Aksoy, 2006). The mean levels of Cr in vegetables in the present study were significantly lower than FAO/WHO limit values. It was observed that lower concentrations of Cr were recorded in the present study, when compared with other studies. Gupta *et al.* (2008) recorded mean concentration of (34.83-96.30 mg·kg^{-1}) Cr in West Bengal, India. Sharma *et al*. (2007) observed mean Cr levels of (5.37-27.83 mg·kg^{-1}) in Varanasi, India, while Charlse *et al*. (2011) recorded values ranging from 1.15-29.29 mg/kg in vegetables grown in the vicinity of the closed dumpsite, which were all higher than the result of the present study. The low concentration of Cr in the area could be due to leaching capabilities of the metal to deeper part of the soil (Banks *et al*., 2006).

Table 6. Daily metal intakes estimates for participant in the area

Plant samples	Metals						Mean	SDV
	Cr	Cu	Fe	Mn	Al	Zn		
UL (mg/day)	N/A	10	8-18	11	N/A	40		
Carica Papaya [1]	0.006	1.2	6.56	0.2	1.68	90	16.61	36.03
ColocasiaEsculenta	0.028	1.42	0.42	-	1.2	30	6.61	13.086
Psidiumguajava	0.034	1.7	1.3	-	-	30	25.36	16.23
Prinusdulcis	0.04	1.6	1.54	0.6	2	40	7.63	12.44
Carica Papaya [2]	0.06	1.68	4.08	0.6	0.42	60	11.14	11.18

High concentration of Fe was recorded in the leaves of edible plants grown in the abandoned. The levels of Fe in plants were significant. However, there was no significant difference in concentration of Fe in plants of the same species. *Carica papaya* [1] recorded the highest Fe level in the study, while *Colocasia esculenta* recorded the lowest (Table 4). High levels of Fe have been reported in plants grown in abandoned solid waste dumpsites in Port Harcourt, Nigeria (Tanee *et al*., 2015). The level of Mn recorded in the present study ranged from 0.5 mg/kg in *Carica papaya* [1] to 1.50 mg/kg in both *Prinus dulcis* and *Carica papaya* [2], with mean value of 1.17 mg/kg. Mn was not detected in *Colocasia esculenta* and *Psidium guajava*. In the case of Al, the values recorded are as follows: 1.50 mg/kg in *Carica papaya* [2] to 5 mg/kg in *Prinus dulcis*, with mean value of 3.32 mg/kg.

Table 6 presents the daily metal intakes estimates for participant in the area**.** This study estimated the approximate daily metal intake for the participants living in the study area. Experts have recommended a daily intake of at least 0.4 mg of vegetables (Sharma *et al*., 2008). The daily metals intakes estimate of the metals (Al, Cr, Cu, Fe, Mn, and Zn) from each vegetable in this study were calculated as stated in the methodology, and results shown in Table 6. The DI_{metal} were compared with the upper tolerable daily intakes for the metals (UL) (Garcia-Rico *et al*., 2007). In general, Zn recorded high intake estimates for the various metals in the edible plant leave samples. Zinc is required by protein kinases that participate in signal transduction processes and as a stimulator of transducting factors responsible for regulating gene expression (ATSDR, 2005). Zinc plays an important role in the immune system and is an antioxidant *in vivo* (Michael *et al*., 2009; Strachan, 2010). Deficiency of zinc in human body can result in growth retardation, neuropsychiatric disturbances, dermatitis, alopecia, diarrhoea, increased susceptibility to infections, and loss of appetite (Demirezen and Aksoy, 2006; Michael *et al*., 2009). Ranking in the descending order of Zn daily intake for the various samples studied is as follows: *Carica papaya* [1] >*Carica papaya* [2] >*Prinus dulcis* > *Colocasia esculenta* >*Psidium guajava.*

Cu, Fe, and Mn were below the upper tolerable daily intakes for the metals (UL) of 10, 8-18, and 11 mg/day, respectively. However, values obtained for Mn in this study were similar to the values reported in literature for vegetables by Harmanescu *et al*. (2011) and Uwah *et al*. (2011). Copper levels were very low. Lower copper uptake in human consumption can cause a number of symptoms which include growth retardation, skin ailments, and gastrointestinal disorder (ATSDR, 2004). Copper deficiency also exerts an effect on iodine metabolism resulting in hypothyroidism in animal (Michael *et al*., 2009).

Table 7. Transfer factor of heavy metal from soils to the leaves of the edible plants

Samples	**Transfer factor**					
	Cr	Cu	Fe	Mn	Al	Zn
A	7.14×10^{-5}	0.17	0.08	-	42	160.71
B	3.04×10^{-4}	0.22	5.20×10^{-5}	-	37.5	93.75
C	0.88×10^{-4}	0.23	0.03	-	-	-

D	6.67×10^{-4}	0.29	0.03	0.08	31.25	-
E	5.36×10^{-4}	0.34	0.06	0.08	10.5	150
Mean	<0.000	0.25	0.05	0.08	30.31	134.82

Table 7 displays the Transfer factor of heavy metal from soils to the leaves of the edible plants. Transfer factor (*TF*) is the ratio of the concentration of heavy metal in a plant to the concentration of heavy metal in soil. It signifies the amount of heavy metals in the soil that were accumulated in the plant leaves or vegetables (Harrison and Chirgawi, 1989; Smith *et al*., 1996). This was calculated to understand the extent of risk and hazard associated due to ingestion consequent upon heavy metal accumulation in edible portion of vegetables. Hence, soil-to-plant transfer is one of the key components of human exposure to metals through food chain. The transfer factors for each heavy metal were computed based on the method described by Harrison and Chirgawi, (1989). In the present study, the Transfer factor of different heavy metals from soil to vegetable is presented in Table 5. The *TF* value ranges were: Cr: 7.14×10^{-5} in site A, to 6.67×10^{-4} in site D, Cu: 0.17 in site A, to 0.34 in site E, Fe: 5.20×10^{-5} in site B, to 0.08 in A, Mn: 0.08 in both, site D and E, respectively, Al: 10.5 in site E, to 42 in site A, and Zn 93.75 in site B, to 160.71 in site A, and the trend of *TF* for heavy metals in vegetable samples studied were in the order: Zn>Al>Cu>Mn>Fe>Cr. The physicochemical properties of soil and vegetables could influence the transfer or mobility of metals from soil to plant, and is altered by innumerable environmental and human factors (Aktaruzzaman *et al*., 2013). The highest mean *TF* values, 134.82 and 30.31, were for Zn and Al, respectively. However, zinc was more significant than that of aluminium.

4. CONCLUSION

The current status of heavy metals contaminations in the abandoned municipal waste dumpsite in Owerri has been investigated. Levels of metals in the soil samples of the study areas were considerably significant. Assessment based on contamination factor, pollution load index, and potential ecological risk indexes revealed that the sites are unpolluted with these metals, indicating that the soils are safe for use. Levels of metals in the edible plant leaves are in the order of: Zn>Fe>Cu>Al>Mn>Cr. Zn in particular was higher than FAO/WHO recommended limit. On the daily basis, high intake of Zn will be obtained in *Carica Papaya* [1] and [2]. Zn and Al were most transferred from soil to the plant. Therefore, abandoned solid waste dumpsites which contain significant concentrations of heavy metals are later absorbed and accumulated by plants growing on such sites.

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