Assessment of Cd, Cu and Pb in Edible Vegetables Planted on Selected Dumpsites in Okene, North Central, Nigeria

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ABSTRACT

Cadmium, copper and lead were assessed in four edible vegetables (*Amaranthus spinosus, Ocimum gratissimum, Corchorus olitorius and Telfairia occidentalis*) planted on selected nine (9) dumpsites where waste materials are still being deposited all through the period of this research by the inhabitants of Okene metropolis. These dumpsites included Idoji (ID), Okene (OK), Ikuehi (IK), Oboroke (OB), Uhuoze (UH), Ozuri (OZ), Nagazi (NA), Kabba Junction (KJ), Obehira (AC) and a control site (CTR), were investigated by standard methods in the wet seasons of 2019-2021. The highest concentration of Cd across the dumpsites was recorded in *Amaranthus spinosus* planted at KJ (1.517 mg/kg) while Cd was below detection limit at all CTR sites. Cd concentrations were higher than the permissible limit of 0.02 mg/kg FAO/WHO. Highest Cu concentration across dumpsites was recorded in *Amaranthus spinosus* planted at UH (2.787 mg/kg) and all recorded Cu concentrations were lower than the 40 mg/kg permissible limit. The highest concentration of Pb across dumpsites was recorded in *Amaranthus spinosus* planted at a control site (2.147 mg/kg) while the lowest was Corchorus *olitorius* at Oboroke (0.005 mg/kg) site. With few exceptions, Pb levels in the four vegetables were above stipulated limit of 0.3 mg/kg. The varied results of Cd, Cu and Pb across selected vegetables and dumpsites were attributed to dumpsite compositions and generally indicate that there was serious threat of Cd and Pb accumulation to the immediate inhabitants of the dumpsites surroundings. Adequate solid waste disposal technique should be adopted by appropriate agencies to forestall Cd and Pb threat to Okene residents.

Keywords: Vegetables, heavy metals, pollution, dumpsite and Okene

INTRODUCTION

The fact that vegetables are a source of nutrients makes them a significant component of the human diet. According to Adefemi and Awokunmi [1], a vegetable contains protein, vitamins, iron, calcium, and other nutrients with significant health benefits.

Heavy metal contamination of food has become a problem for both producers and consumers. According to Adagunodo et al. [2], the main sources of heavy metals in vegetable crops are the growing media (soil, air, nutrient solutions), from which the roots or foliage absorb the heavy metals. Only after long-term consumption of contaminated vegetables can the harmful and negative effects of heavy metals become apparent. In order to prevent an excessive buildup of these heavy metals in the human food chain, routine monitoring of heavy metals in vegetables and other food products should be carried out [3].

Heavy metals can be absorbed and accumulated by vegetables at levels high enough to affect humans clinically and daily heavy metal intake estimates may easily predict the potential ingestion rate of a certain metal but do not account for the metal's potential metabolic ejection [4]. Dietary intake of food causes a long-term, low-level buildup of heavy metals in the body, and the negative effects do not manifest for several years after exposure [5].

The risk and health effects of metals in contaminated soils used for crop cultivation were studied by Ukpe and Chokor [6] and their study indicated that there is a higher risk of consumer exposure to heavy metals due to plant uptake of these toxic elements from contaminated soils, abandoned waste dumpsite soil, and any other form of polluted soil for agricultural uses. According to Chiroma et al. [7], either directly from polluted soil to vegetable plants, then from plants to animals, and finally up the food chain to humans, heavy metals are ingested by humans through their food.

It is worrisome that from available literature, research on heavy metals contamination of vegetables planted on dumpsites and consumed by the inhabitants of Okene metropolis has been very scanty, hence, the need for this research. The aim of this study is to analyse cadmium (Cd), copper (Cu) and lead (Pb) in vegetables planted on dumpsites of Okene, North Central Nigeria, with the objective to ascertain if the planted vegetables on the selected dumpsites contains mean concentrations of Cd, Cu, and Pb above the permissible limits by FAO/WHO. The analyses were carried out at the Chemistry Department laboratory of Federal University of Technology, Akure, Nigeria.

MATERIALS AND METHODS

Four edible vegetables, *Amaranthus spinosus*, *Ocimum gratissimum*, *Corchorus olitorius, and Telfairia occidentalis* grown on the selected dumpsites (ID, OK, CTR, IK, OB, UH, NA, OZ, KJ, and AC) as indicated in the sampling map of Okene metropolis (Figure 1) were gathered in three to five replicates between the wet season of 2019 -

2021, stored in labelled polythene sampling bags, transported to the Chemistry Laboratory of the Federal University of Technology Akure, Nigeria, washed with tap water to remove any kind of deposition, such as soil particles, and then ground into powder for making plant digests [8]. Vegetable samples weighing 1.0 g were broken down in 15 ml of *aqua regia* (HNO_3, HCl in a 3:1 ratio) at 100 ºC until the translucent solution materialized. Following pH 2 adjustments, the resulting sample solutions were filtered using Whatman No. 42 filter sheets, and 50 ml of the filtrate was kept at 40 °C. Each digest's volume was increased by adding distilled water to make it equal 50 ml and stored for further analysis. Concentrations of heavy metals were determined by an atomic absorption spectrophotometer (model AA320N) in accordance with the instrument's working conditions at the following wavelengths (nm) measurements of the metals Pb (217.0), Cd (228.8) and Cu (324.8) using an air-acetylene flame.

Health risk assessment

The potential health risks of heavy metal consumption through vegetables were assessed based on the daily intake of metal (DIM) [13] and hazard index (HI) [14]. The daily intake of metals (DIM) was calculated to averagely estimate the daily metal loading into the body system of a specified body weight of a consumer. This will inform the relative phyto-availability of metal. This does not take into cognizance the possible metabolic ejection of the metals but can easily tell the possible ingestion rate of a particular metal. The estimated daily intake of metal in this study was calculated based on the formula below:

$$\text{Estimated Daily Intake DIM)} = \frac{Cm * IR}{BW} \quad (1)$$

Where Cm = metal concentration in the vegetables (mg/kg dry weight); IR = ingestion rate, which is taken as 50 × 103 kg/day. This consumption rate was used in health-risk assessments and BW is the average body weight of an adult Nigerian, which is 60.7 kg [14].

Using [13] formula, the health index (HI) for Cu, Pb, and Cd associated with eating contaminated vegetables was determined. Where RfD is the oral reference dose

$$HI = \frac{DIM}{RfD} \quad (2)$$

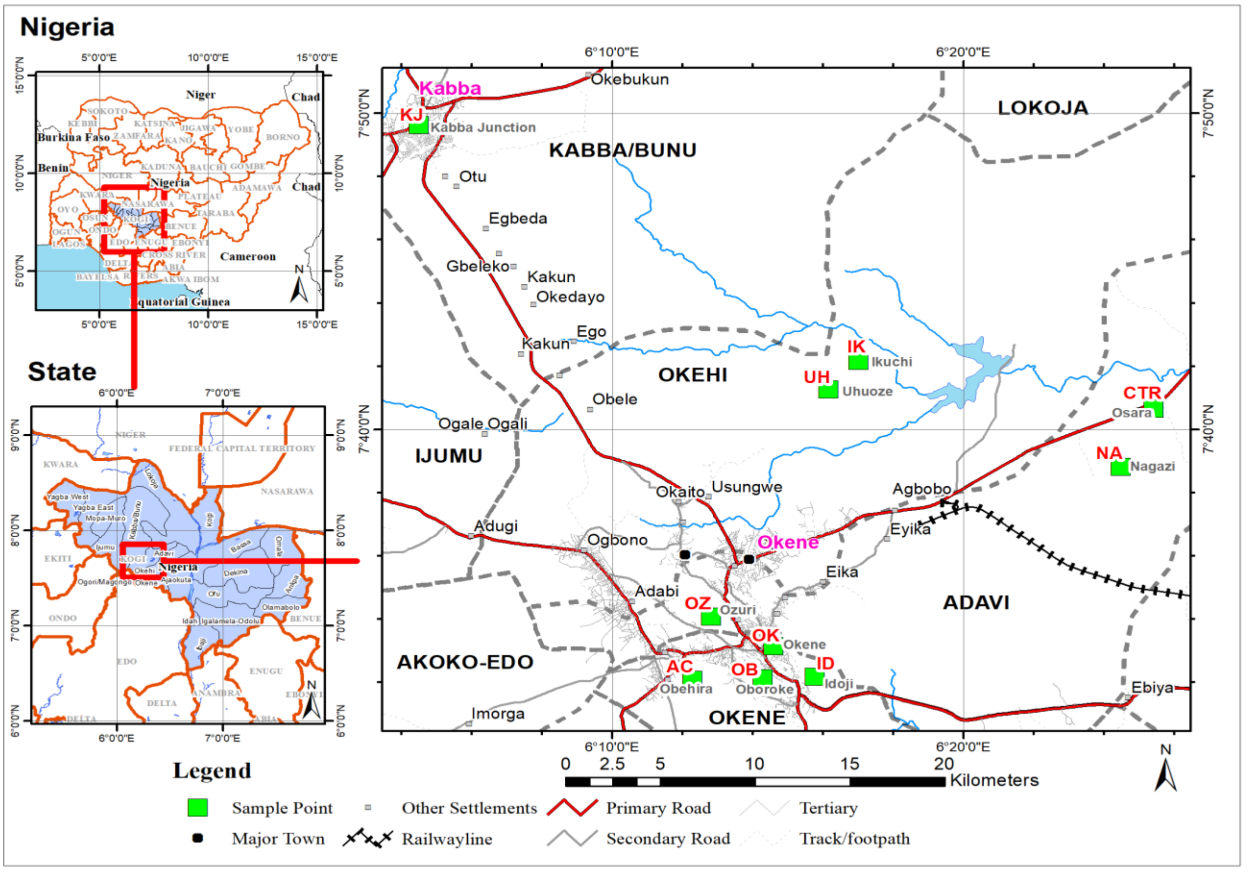

Figure 1: Okene metropolis map showing sampling points

Data Analysis

Statistical analysis was carried out using SPSS Package 20.0

RESULTS AND DISCUSSION

Cadmium Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

The highest concentration of Cd across dumpsites and selected edible vegetables was recorded in *Amaranthus spinosus* planted at KJ (1.517 mg/kg) while the CTR site which is a flat land with no dumping activities taken place on it and about 4 km from the Nagazi Dumpsite (NA) which is closest to it showed Below Detection Limit (BDL) for Cd (Table 1).The mean Cd concentrations in *Amaranthus spinosus* for the selected dumpsites and control in the descending was KJ>ID>AC>OB>NA>IK>OZ>OK>UH>CTR; ID>AC>KJ>OB>IK>NA> OZ>OK >UH>CTR for *Ocimum gratissimum;* ID>AC>OB>KJ>IK>NA>OZ>OK>UH>CTR for *Corchorus olitorius* and KJ>ID>AC>OB>NA>IK>OZ>OK>UH>CTR for *Telfairia occidentalis* (Table 1). The Cd concentrations were higher than the permissible limit of 0.02 mg/kg [12]. The mean concentrations obtained for Cd in selected vegetables is higher than those reported by other researchers [13, 14] and lower than values obtained for edibles planted on dumpsites by [15]. Therefore, those who ingest the vegetables investigated in this study over a long period of time could risk developing cadmium-related health issues like kidney damage, chest pain, frothy blood sputum, and bone defects. One-way analysis of variance (ANOVA) found a significant difference in the concentrations of Cd in selected vegetables across the dumpsites when the findings were subjected to statistical analysis, with a P value of 0.05 (Table 2). Also, there was a statistically significant difference in the mean concentration of Cd in at least two of the chosen vegetables ($F(3, 36) = [0.721]$, $P = 0.546$) (Table 2).

The Bioconcentration Factor (BCF), DIM and HI of Cd for the four edible vegetables across dumpsites are presented in Table 3. Hazard index (HI) values of Cd across dumpsites and selected vegetable studied ranged from 0 (OK, CTR, UH and OZ) to 0.013 (UH), 0 (OK, CTR, UH and OZ) to 0.004 (ID), 0 (OK, CTR, UH and OZ) to 0.004 (ID), 0 (OK, CTR, UH and OZ) to 0.008 (KJ) for *Amaranthus spinosus*, *Ocimum gratissimum, Corchorus olitorius and Telfairia occidentalis* respectively (Table 3). Hence, no immediate short term danger of Cd since $HI < 1$.

Table 4 shows mean Cd concentration in the four selected edible vegetable which ranges from 0.314 ± 0.487 mg/kg (*Amaranthus Spinosus*) to 0.142 ± 0.143 mg/kg (*Corchorus olitorius*). It may be concluded that there is a substantial variation in the distribution of Cd in the species of vegetables selected. Additionally, the post hoc (Table 5) was used to determine which species' means were substantially different from those of other species and to test for equality among the mean Cd concentrations in the selected vegetable species. Table 5 shows the significant values between the selected vegetables were more than 0.500 (95 % confidence level) indicating that there was no significant difference in the Cd concentrations of the selected vegetable species.

Table 1: Mean Cadmium (Cd) Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

Samples/Dumpsites	*Amaranthus spinosus*	*Ocimum gratissimum*	*Corchorus olitorus*	*Telfairia occidentalis*
ID	0.808±0.002	0.500±0.014	0.480±0.017	0.508±0.021
OK	0.036±0.001	0.034±0.002	0.036±0.013	0.034±0.003
CTR	BDL	BDL	BDL	BDL
IK	0.131±0.010	0.120±0.011	0.130±0.010	0.111±0.017
OB	0.206±0.005	0.180±0.011	0.204±0.012	0.187±0.016
UH	0.015±0.001	0.013±0.001	0.013±0.002	0.009±0.018
NA	0.145±0.012	0.100±0.002	0.113±0.006	0.134±0.004
OZ	0.053±0.004	0.053±0.001	0.040±0.002	0.043±0.007
KJ	1.517±0.002	0.210±0.016	0.183±0.004	0.957±0.123
AC	0.224±0.006	0.220±0.012	0.220±0.002	0.212±0.036

Table 2: ANOVA Analysis for Cadmium in Selected Vegetables of Okene Metropolis

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	0.198	3	0.066	0.721	0.546
Within Groups	3.296	36	0.092		
Total	3.494	39			

Table 3: Daily Intake of Metal (DIM), Bioconcentration Factor (BCF) and Hazard Index(HI) of Cd in Selected Vegetables

Samples	*Amaranthus spinosus*			*Ocimum gratissimum*			*Corchorus olitorius*			*Telfairia occidentalis*	
Dumpsites	DIM	HI	BCF	DIM	HI	BCF	DIM	HI	BCF	DIM	HI
ID	0	0.007	0.234	0	0.004	0.224	0	0.004	0.237	0	0.004
OK	0	0	0.032	0	0	0.034	0	0	0.032	0	0
CTR	0	0	0	0	0	0	0	0	0	0	0
IK	0	0.001	0.087	0	0.001	0.095	0	0.001	0.081	0	0.001
OB	0	0.002	0.099	0	0.001	0.112	0	0.002	0.103	0	0.002
UH	0	0	0.006	0	0	0.006	0	0	0.004	0	0
NA	0	0.001	0.037	0	0.001	0.042	0	0.001	0.050	0	0.001
OZ	0	0	0.059	0	0	0.044	0	0	0.048	0	0
KJ	0	0.013	0.069	0	0.002	0.060	0	0.002	0.313	0	0.008
AC	0	0.002	0.090	0	0.002	0.090	0	0.002	0.087	0	0.002

Table 4: Mean Cadmium (Cd) Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Amaranthus spinosus		10	0.314	0.4838	0.153	-0.033	0.660	0	1.52
Ocimum gratissimum		10	0.143	0.149	0.047	0.037	0.249	0	0.50
Corchorus olitorius		10	0.142	0.144	0.045	0.039	0.245	0	0.48
Telfairia occidentalis		10	0.220	0.299	0.095	0.006	0.434	0	0.96
Total		40	0.205	0.299	0.047	0.109	0.300	0	1.52
Model	Fixed Effects			0.303	0.048	0.107	0.302		
	Random Effects				0.048a	0.052a	0.357a		

a Warning: Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.

Table 5: Multiple Comparisons Post-hoc Test for Cadmium (Cd) in Selected Vegetables of Okene Metropolis

(I) id	(J) id	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
	Ocimum gratissimum	0.171	0.135	0.594	-0.194	0.535
Amaranthus spinosus	*Corchorus olitorius*	0.172	0.135	0.589	-0.193	0.536
	Telfairia occidentalis	0.094	0.135	0.898	-0.270	0.458
	Amaranthus spinosus	-0.171	0.135	0.594	-0.535	0.194
Ocimum gratissimum	*Corchorus olitorius*	0.001	0.135	1.000	-0.363	0.366
	Telfairia occidentalis	-0.077	0.135	0.942	-0.441	0.288
	Amaranthus spinosus	-0.172	0.135	0.589	-0.536	0.193
Corchorus olitorius	*Ocimum gratissimum*	-0.001	0.135	1.000	-0.366	0.363
	Telfairia occidentalis	-0.078	0.135	0.939	-0.442	0.287
	Amaranthus spinosus	-0.094	0.135	0.898	-0.458	0.270
Telfairia occidentalis	*Ocimum gratissimum*	0.077	0.135	0.942	-0.288	0.441
	Corchorus olitorius	0.078	0.135	0.939	-0.287	0.442

Mean Cu Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

The highest concentration of Cu across dumpsites and selected vegetables was recorded in *Amaranthus spinosus* planted at UH (2.787 mg/kg) as shown on Table 6, while Cu concentration was BDL for vegetable planted on the control site. This result is lower than those obtained in a similar research by other researchers [15-17]. The mean Cu concentrations for *Amaranthus spinosus* for the selected dumpsites and control in descending order was UH>OB>KJ>OZ>IK>AC>NA>ID>OK>CTR; OB>UH>KJ>OZ>IK>AC>NA>ID>OK>CTR for *Ocimum gratissimum;* OB>UH>KJ>IK>AC>NA>ID>OK>OZ>CTR for *Corchorus olitorius and* OB>UH>KJ>OZ>IK>AC>ID=OB=NA>CTR for *Telfairia occidentalis* (Table 6). The analysis of variance (Table 7) revealed a difference in this metal's concentrations across the dumpsites and vegetables that was statistically significant (P 0.05). Also, There was a statistically significant difference in the mean concentration of Cu in at least two of the chosen vegetables (F (3, 36) = [0.224], P = 0.879) (Table 7) .

The four vegetables' copper levels were under the 40 mg/kg permissible limit set by FAO/WHO [12]. HI for Cu were estimated to be zero for ID, OK, NA and AC for all the four selected vegetables with the exceptions of CTR, IK, OB, UH, OZ, KJ that recorded values of DIM and HI values less that unity for *Amaranthus spinosus, Ocimum gratissimum, Corchorus olitorius and Telfairia occidentalis* respectively (Table 8). As a result, those who consume these veggies may not get health issues including renal dysfunction, chest pain, frothy blood sputum, bone defects, etc. that are linked to copper exposure. This implies that for the four vegetables' Cu concentrations are suitable for human consumption. Table 9 shows mean Cu concentration in the four selected edible vegetable which ranged from 0.314 ± 0.487 (*Amaranthus spinosus*) to 0.142 ± 0.143 mg/kg (*Corchorus olitorius*). It may be concluded that there is a substantial variation in the distribution of Cu in the species of vegetables selected. Additionally, the post hoc (Table 10) was used to determine which species' means were substantially different from those of other species and to test for equality among the mean Cu concentrations in the selected vegetable species.

Table 6: Mean Copper Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

Samples/Dumpsites	*Amaranthus Spinosus*	*Ocimum gratissimum*	*Corchorus Olitorus*	*Telfairia occidentalis*
ID	0.005±0.002	0.003±0.001	0.005±0.002	0.003±0.001
OK	0.002±0.001	0.003±0.002	0.003±0.001	0.003±0.002
CTR	BDL	BDL	BDL	BDL
IK	0.028±0.005	0.016±0.006	0.015±0.008	0.020±0.002
OB	2.457±0.216	2.000±0.106	2.107±0.311	2.111±0.216
UH	2.787±0.187	1.947±0.111	0.879±0.212	1.787±0.123
NA	0.008±0.003	0.006±0.002	0.007±0.003	0.003±0.001
OZ	0.044±0.011	0.037±0.010	0.002±0.001	0.047±0.009
KJ	1.851±0.024	1.340±0.725	0.867±0.211	1.211±0.101
AC	0.015±0.009	0.01±0.001	0.01±0.001	0.017±0.005

Table 7: ANOVA Analysis for Copper (Cu) in Selected Vegetables of Okene Metropolis

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.553	3	.184	.224	.879
Within Groups	29.627	36	.823		
Total	30.180	39			

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Table 8: Daily intake of metal (DIM), Bioconcentration factor(BCF) and health index(HI) of Cu in selected vegetables

Samples	*Amaranthaceae spinacia*			*Ocimum gratissimum*			*Corchorus olitorus*			*Telfairia occidentails*		
Dumpsites	BCF	DIM	HI	BCF	DIM	HI	BCF	DIM	HI	BCF	DIM	HI
ID	0.001	0	0	0	0	0	0.001	0	0	0	0	0
OK	0	0	0	0	0	0	0.001	0	0	0	0	0
CTR	0	0	0	0	0	0	0	0	0	0	0	0
IK	0.004	0	0	0.002	0	0	0.002	0	0	0.003	0	0
OB	0.035	0	0.005	0.028	0	0.004	0.030	0	0.004	0.03	0	0.004
UH	0.073	0	0.006	0.051	0	0.004	0.023	0	0.002	0.046	0	0.004
NA		0	0	0	0	0	0	0	0	0	0	0
OZ	0.033	0	0	0.028	0	0	0.002	0	0	0.036	0	0
KJ	0.097	0	0.004	0.070	0	0.003	0.045	0	0.002	0.063	0	0.003
AC	0	0	0	0	0	0	0	0	0	0	0	0

Table 9: Mean Copper (Cu) Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Amaranthus spinosus		10	0.720	1.157	0.366	-0.108	1.548	0	2.787
Ocimumgratissimum		10	0.536	0.864	0.273	-0.082	1.154	0	2.000
Corchorus olitorius		10	0.390	0.703	0.222	-0.113	0.892	0	2.107
Telfairia occidentalis		10	0.520	0.844	0.267	-0.084	1.124	0	2.111
Total		40	0.541	0.880	0.139	0.260	0.823	0	2.787
Model	Fixed Effects			0.907	0.143	0.2521	0.832		
	Random Effects				0.143a	.0849a	0.998a		

a Warning: Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.

Table 10: Multiple Comparisons Post-hoc Test for Copper (Cu) in Selected Vegetables of Okene Metropolis

(I) id	(J) id	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Amaranthus spinosus	*Ocimum gratissimum*	0.184	0.406	0.969	-0.909	1.276
	Corchorus olitorius	0.330	0.406	0.847	-0.762	1.423
	Telfairia occidentalis	0.200	0.406	0.96	-0.893	1.292
Ocimum gratissimum	*Amaranthus spinosus*	-0.184	0.406	0.969	-1.276	0.909
	Corchorus olitorius	0.147	0.406	0.984	-0.946	1.239
	Telfairia occidentalis	0.016	0.406	1.000	-1.077	1.109
Corchorus olitorius	*Amaranthus spinosus*	-0.330	0.406	0.847	-1.423	0.762
	Ocimum gratissimum	-0.147	0.406	0.984	-1.239	0.946
	Telfairia occidentalis	-0.131	0.406	0.988	-1.223	0.962
Telfairia occidentalis	*Amaranthus spinosus*	-0.200	0.406	0.960	-1.292	0.893
	Ocimum gratissimum	-0.016	0.406	1.000	-1.109	1.077
	Corchorus olitorius	0.131	0.406	0.988	-0.962	1.223

Mean lead Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

The highest concentration of Pb across dumpsite and vegetables was recorded by *Amaranthus spinosus* planted at the IK dumpsite (1.540 mg/kg) while the lowest was at *Corchorus olitorius* OB (0.005) dumpsite. The mean Pb concentrations for *Amaranthus spinosus* for the selected dumpsites and control in descending order was IK>UH>KJ>OB>AC>OK>ID>OZ>NA (Table 11), IK>CTR>KJ>OB>ID>AC>OK>UH>OZ>NA for *Ocimum gratissimum;* IK>UH>KJ>AC>OK>ID>OZ>NA>OB for *Corchorus olitorius* and IK>UH>KJ>OB>AC>OK>OZ>ID>NA for *Telfairia occidentalis* with a few exceptions, Pb levels in the four vegetables were over (Table 11) stipulated limit of 0.3 mg/kg [12]. Results obtained in this studies were lower than those reported by other researchers [18, 20] but higher than the value reported by Ilori et al [19] in similar studies. This suggests that the four vegetables contain hazardous levels of Pb if eaten. The results of the analysis of variance showed that there was, at P 0.05, a significant variation in the concentrations of this metal among the sites and vegetables (Table 12). According to a one-way ANOVA, the average Pb concentration in at least two of the chosen vegetables varied statistically significantly (F (3, 36) = [0.127], P = 0.943. It can be deduced that there is a significant difference in the distribution of Pb in the species of vegetables chosen (Table 12). The values of HI for Pb ranged from 0.001 (NA, OZ) to 0.032 (IK) for *Amaranthus spinosus*, 0.001 (OZ) to 0.031 (IK) for *Ocimum gratissimum*, *0.001* (OZ) to 0.031 (IK) for *Corchorus olitorius* and 0.001 (OZ) to 0.029 (IK) for *Telfairia occidentalis* (Table 13). The mean Pb concentration in the four selected vegetables ranges from 0.665 ± 0.723 (*Amaranthus Spinosus* and *Ocimum gratissimum*) to 0.501 ± 0.567 (*Corchorus olitorius*). However, the mean Pb concentration ranges among the four selected vegetables as follows *Amaranthus spinosus = Ocimum gratissimum > Telfeiria occidentalis*> *Corchorus olitorius* (Table 14). Additionally, the post hoc (Table 15), which shows which species' means are substantially different from other species, was employed to test for equality among the mean Pb concentrations in the chosen vegetable species. The significant values between the selected vegetables were more than 0.500 (95 % confidence level) indicating that there was no significant difference in the Pb concentrations of the selected vegetable species.

Table 11: Mean Pb Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

Samples/Dumpsites	*Amaranthus spinosus*	*Ocimum gratissimum*	*Corchorus Olitorius*	*Telfairia occidentalis*
ID	0.093±0.067	0.290±0.113	0.173±0.101	0.045±0.014
OK	0.213±0.089	0.200±0.098	0.187±0.076	0.211±0.0103
CTR	2.147±0.112	1.312±0.076	1.380±0.082	2.213±0.175
IK	1.540±0.157	1.520±0.116	1.520±0.043	1.412±0.151
OB	0.438±0.143	0.438±0.154	0.005±0.003	0.406±0.119
UH	1.140±0.123	0.086±0.017	0.864±0.212	1.130±0.098
NA	0.035±0.004	0.022±0.013	0.022±0.017	0.023±0.002
OZ	0.063±0.009	0.042±0.021	0.052±0.015	0.054±0.009
KJ	0.733±0.126	0.513±0.100	0.563±0.123	0.533±0.117
AC	0.248±0.111	0.250±0.122	0.247±0.103	0.261±0.113

Table 12: ANOVA Analysis for Lead in Selected Vegetables of Okene Metropolis

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.181	3	.060	.127	.943
Within Groups	17.092	36	.475		
Total	17.274	39			

Table 13: Daily Intake of Metal (DIM), Bioconcentration Factor (BCF) and Health Index (HI) of Pb in Selected Vegetables

Samples	*Amaranthus spinosus*			*Ocimum gratissimum*			*Corchorus olitorius*			*Telfairia occidentalis*		
Dumpsites	BCF	DIM	HI	BCF	DIM	HI	BCF	DIM	HI	BCF	DIM	HI
ID	0.081	0	0.002	0.253	0	0.006	0.151	0	0.004	0.039	0	0.001
OK	0.170	0	0.004	0.160	0	0.004	0.150	0	0.004	0.169	0	0.004
CTR	1.883	0	0.044	1.151	0	0.027	1.211	0	0.029	1.941	0	0.046
IK	0.242	0	0.032	0.239	0	0.031	0.239	0	0.031	0.222	0	0.029
OB	0.127	0	0.009	0.127	0	0.009	0.001	0	0	0.117	0	0.008
UH	0.240	0	0.024	0.018	0	0.002	0.182	0	0.018	0.238	0	0.023
NA	0.024	0	0.001	0.015	0	0	0.015	0	0	0.016	0	0
OZ	0.033	0	0.001	0.022	0	0.001	0.027	0	0.001	0.028	0	0.001
KJ	0.299	0	0.015	0.209	0	0.011	0.230	0	0.012	0.217	0	0.011
AC	0.078	0	0.005	0.078	0	0.005	0.077	0	0.005	0.082	0	0.005

Table 14: Mean Lead (Pb) Concentrations (mg/kg) in Selected Vegetables of Okene Metropolis

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Amaranthus spinosus		10	0.665	0.723	0.229	0.148	1.182	0.035	2.147
Ocimumgratissimum		10	0.665	0.723	0.229	0.148	1.182	0.035	2.147
Corchorus olitorius		10	0.501	0.567	0.179	0.096	0.907	0.005	1.520
Telfairia occidentalis		10	0.629	0.729	0.230	0.107	1.150	0.023	2.213
Total		40	0.615	0.666	0.105	0.402	0.828	0.005	2.213
Model	Fixed Effects			0.689	0.109	0.394	0.836		
	Random Effects				0.1089a	0.268a	.9617a		

a Warning: Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.

Table 15: Multiple Comparisons Post-hoc Test for Lead (Pb) in Selected Vegetables of Okene Metropolis

(I) id	(J) id	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Amaranthus spinosus	*Ocimum gratissimum*	0	0.308	1.000	-0.830	0.830
	Corchorus olitorius	0.164	0.308	0.951	-0.666	0.994
	Telfairia occidentalis	0.036	0.308	0.999	-0.794	0.866
Ocimum gratissimum	*Amaranthus spinosus*	0	0.308	1.000	-0.830	0.830
	Corchorus olitorius	0.164	0.308	0.951	-0.666	0.994
	Telfairia occidentalis	0.036	0.308	0.999	-0.794	0.866
Corchorus olitorius	*Amaranthus spinosus*	-0.164	0.308	0.951	-0.994	0.666
	Ocimum gratissimum	-0.164	0.308	0.951	-0.994	0.666
	Telfairia occidentalis	-0.128	0.308	0.976	-0.957	0.702
Telfairia occidentalis	*Amaranthus spinosus*	-0.036	0.308	0.999	-0.866	0.794
	Ocimum gratissimum	-0.036	0.308	0.999	-0.866	0.794
	Corchorus olitorius	0.128	0.308	0.976	-0.702	0.957

CONCLUSION

The levels of Cd, Cu and Pb in four edible vegetable samples planted on nine selected dumpsites of Okene metropolis Kogi State, Nigeria, were investigated with AAS. Based on the results obtained, the vegetable samples of all the selected dumpsites have Pb and Cd levels above the maximum permissible limits, while Cu levels obtained in all the vegetable samples were below maximum permissible limits. One-way ANOVA at 95% confidence level revealed significant variations between the elements' concentrations in the vegetables. It is therefore, recommended that periodic dumpsite evaluation and treatment to help rid dumpsites of the contamination should be considered and the various environmental agencies in Kogi State should provide dumpsite treatment standard to help remedy the situation.

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