DETERMINATION AND ASSESSMENT OF HEAVY METAL UPTAKE BY PUMPKIN AND WATER LEAVES GROWN AT DUMPSITES IN OKRIKA, RIVERS STATE, NIGERIA

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ABSTRACT

This work was aimed at determining the heavy metals uptake by pumpkin and water leaf grown at dumpsites in Okrika, Rivers State Nigeria.. Soil samples and vegetable samples were collected from dumpsites located at Abam and Drupabo communities in Okrika, Rivers State, Nigeria. The soil samples and the vegetable samples were analyzed for the heavy metals using atomic absorption spectrometer (AAS). From the results obtained, the concentrations of heavy metals in the soil and vegetables were in the sequence: soil [Fe 1905.02 mg kg,) > Zn (56.2mg/kg) >Mn (47.02 mg/kg) >Ni (4.99 mg/kg) >Cu (4.22 mg/kg) >Cr (3.23 mg/kg) > Pb (1.31 mg/kg> Cd (0.86 mg/kg)] fluted pumpkin leaf [Fe (1562.21mg/kg) > Zn (47.97 mg/kg) > Mn (34.29 mg/kg) > Cu (8.37 mg/kg > Ni (5.92 mg/kg) Cr (4.52 mg/kg) > Pb (1.31 mg/kg) > Cd (0.39mg/kg)]; water leaf [Fe (708.08 mg/kg) > Zn (45.91 mg/kg) > Mn (34.18 mg/kg) > Ni (6.79 mg/kg) > Cu (6.67mg/kg)> Cr (3.75 mg/kg) > Pb (3.69 mg/kg) > Cd (0.58 mg/kg)]. The results obtained from this investigation have shown that soils are contaminated at dumpsites with heavy metals which could be transferable to vegetables grown on dumpsites. It is therefore recommended that efforts should be intensified to discourage the practice of cultivating on dumpsite soils.

Keywords: Heavy metals, Dumpsites, Vegetable leaves, PLI

1.1 INTRODUCTION

Vegetables form part our dietary consumption daily all over the world and they are used for culinary and dietary purposes. The quest to meet increasing demand for vegetables has made peasant farmers utilize any available land space like dump or solid waste disposal sites and road sides for the cultivation of veget able. Most local farmers prefer disposal compost sites believing that decaying materials serve as natural manures to their plants (Alam *et al., (201)*. However, studies on soils around dump sites have revealed the presence of high levels of heavy metals (Opaluwa *et al.,* 2012; Ogundele *et al.,* 2015). Over time these heavy metals may pose health hazard to humans and animals through the food chain (Okeke *et al.,* 2014).

Metallic elements are ubiquitous in the environment. Most of them are significant in nutrition either as essential components or for their toxicity. Heavy metals are released into the environment by various anthropogenic activities such as combustion, vehicular emission, industrial manufacturing process, domestic and municipal refuse and waste materials, etc. In recent years, there has been increased ecological and global public health concern associated with contamination by some of these metals (Okorosaye-Orubite and Igwe, 2017).

The uptake of heavy metals by vegetables is a biological process occurring through the plants roots and membrane transport system. Some of these heavy metals are chemically similar to regular nutrients and are taken up advertently causing bioaccumulation (Samuel *et al.,* 2018).

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

The heavy metals in soil eventually get into plants and enter the food chain when the vegetables are consumed. The toxic effects of heavy metals in food have been widely reported. Bandmann *et al.,* (2015) reported accumulation of cadmium in the kidney and liver of animals from vegetable and plants consumed. The fundamental cause of Wilson disease is attributed to high contamination of copper in consumable products. High level of lead is also considered poison to the system. Osu and Okereke (2015) reported that hazardous health effects and losses in agricultural yield can occur as a result of heavy metals pollution in soil and plants.

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

Although several studies have been done to assess the effects of accumulation of heavy metals in vegetables by Okorosaye-Orubite and Igwe (2017), Babayemi *et al.,* (2017), Nyodee and Miikue-Yobe (2015), Shuaibu*, ct al.,* (2013), Daniel and Sumaila (2016), the practices that contribute to toxic heavy metals accumulation in vegetables still persist. Notably, none of these studies examined the uptake of heavy metals by vegetables at dumpsites in Okrika communities. There is need for intermittent assessment to alert the inhabitants of likely danger. Therefore, this study determined the heavy metal uptake by pumpkin and water leaves grown at dumpsites in Okrika communities, Rivers State, Nigeria.

2.0 Materials and Methods

2.1 Samples Collection

The study considered two sample location points. The location of the study is Abam community which has on longitude $7^0\ 6^1\ 54.359^{11}$ E and latitude $4^0\ 46^1\ 20.368^{11}$ N while Orupaba lies on longitude $7^0\ 7^1\ 58.248^{11}$ E and latitude $4^0\ 47^1\ 27.845^{11}$ N. Soil samples were collected at 0 – 15cm dept with the aid of stainless steel auger. Soil samples and vegetable samples (water leaves and pumpkin leaves) were collected from the vicinities of dumpsites each located at Abam and Orupaba communities in Okrika to produce composite samples. The control composite samples were collected outside the dumpsites of the study areas at a location point with longitude of $7^0\ 9^1\ 35.031^{11}$ E and latitude $4^0\ 45^1\ 34.051^{11}$ N.

2.2 Preparation of Soil Samples for Laboratory Analysis

After sampling, the soil samples were taken to laboratory in well labelled polythene bags. The soil samples were air dried for 48 hours. After drying, soil samples were mechanically crushed using pestle and mortar and passing through a sieve to collect fine particles according to Pal *et al.,* (2017) method. The fine particles were stored for analysis while all the coarse soil particles were discarded (Harrison *et al.,* 2018). Exactly two (2.0) gms of the sieved soil were weighed into a digestion flask and 10ml of perchloric acid and 20ml HNO_3 were added (Ehabhi *et al.,* 2020). The samples were digested using hot plate and sand bath until the colour of the digest changed to white desiccate.

The sample was cooled and 50ml of distilled water was added to the digestion flask, which was filtered using a whiteman filter paper into a clean volumetric flask. The resulting solutions were stored for the analysis of heavy metals; Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pd), Nickel (Ni), Zinc (Zn), Manganese (Mn) and Iron (Fe), using atomic absorption spectrometer (AAS) (Mahmood and Malik, 2014).

2.3 Preparation of Vegetable Samples for Laboratory Analysis

The vegetable leaves were washed in water to remove soil, dirt, and were air dried to remove the moisture. The samples were then oven-dried using Galenkamp oven at a temperature 65^0C for about 72 hours to a constant weight. These were pulverized to fine powder using a laboratory pestle and mortar (Mbong *et al.,* 2014). According to Harrison *et al.,* (2018), five grams (5 grams) of each sample were weighed into clean platinum crucible and ashed at 450 – 500^0C, then cooled to ambient temperature in a desicator. The ash samples were dissolved in 25ml of nitric acid in the digestion tubes and set at a temperature of 95^0C for two hours, cooled and filtered (Ogbuchi *et al.,* 2010). The resulting digests were then taken for the determination of the heavy metal Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Nickel (Ni) and Zinc (Zn) concentrations using atomic absorption spectrophotometer (AAS).

2.4 DATA ANALYSIS

2.4.1 Pollution Load Index

The degree of soil pollution for each metal was measured using the Pollution Load Index (PLI) technique depending on soil metal concentrations. The following modified equation adopted by Ali *et al.,* (2013) was used in the calculation.

$$PLI = \frac{Csoil\ (sample)}{C(reference)} \qquad (1)$$

Where C (sample) is the heavy metal concentration in the sample and the C (reference) is the value of WHO permissible level. The PLI value of each heavy metal is classified as low contamination (PLI < 1), moderate contamination (1 < PLI < 2) or high contamination (PLI > 3) (Ali *et al.*, 2013).

2.4.2 ACCUMULATION FACTOR (AF)

Plants are divided into three categories i.e. accumulator, excluder and indicator (Pal *et al.,* (2017), based on the value of AF calculated. The formula adopted by them is used for this calculation.

Accumulation Factor (AF) =

$$\frac{Metal\ conc.in\ Aerial\ parts\ of\ plant}{Metal\ conc.in\ soil} \qquad (2)$$

From the calculated value of AF, when AF > 1 = accumulator plants; AF < 1 = excluder plant and AF = 1 indicates indicator plants.

2.4.3 STATISTICAL ANALYSIS

The data were statistically analysed using Analysis of Variance (ANOVA) to detect any significant difference between the soil sample means of different sampling locations of the study area. Omega squared (W2) by Huck (2012) was used to determine whether the various heavy metals interact significantly with each other, with the equation as;

$$W^2 = \frac{SSbetween}{SSbetween + SSwithin} \quad (3)$$

Where:

w^2 = Omega squared
SSbetween =
Between sample means
SSwithin = Within Sample means

Huck (2012) described the levels of interaction based on the calculated value of w^2 as shown in Table 1.

Table 1. Different levels of interactive relationship

Value of Mega squared (w^2)	**Level of interactive relationship**
0.01 – 0.05	Small interactive relationship
0.06 – 13	Medium interactive relationship
$\geq$ 14	Large interactive relationship

Source: Huck (2012)

The coefficient of correlation is determined to reveal the nature of correlation of heavy metal levels in the soil and vegetable samples.

3.0 RESULTS AND DISCUSSION

The Results for the Analysis are presented in Tables 2-4

3.1 Mean concentration of heavy metals in soil and vegetable samples

From Table 2, the heavy metals (Cu, Zn, Mn, Cr, and Fe) concentrations from dumpsite A are higher than those of dumpsite B except for Cadmium (Cd), Nickel (Ni) and Lead (Pb) Iron has the highest levels of concentrations (2070.77 mg/kg; 1739.26 mg/kg) in both dumpsites while cadmium has the least levels of concentrations (0.83 mg/kg; 0.88 mg/kg) in both dumpsites. The mean values for all the metals are below WHO permissible level except for Zinc (Zn) which is above the WHO limit. The high concentration of Zn in the soil may be as a result of the waters containing too much of Zinc materials. Although these heavy metal concentration falls below the critical permissible concentration level, their persistence in the soils of the dumpsite may lead to increase uptake by plants. The Pollution Load Index (PLI) values for Ni, Cu, Mn, Cr, Cd, and Pb are < 1 in dumpsite A, indicating low contamination of the metals in the dumpsite, but Zn has a value > 3 which shows high contamination in the soil. In dumpsite B, the PLI values for Cu, Mn, Cr, Fe, Cd, and Pb are < 1 indicating low contamination while Ni has a PLI value> 1 but < 2 which indicate a moderate contamination but Zn has a PLI value > 3 which indicate high contamination.

The resul1 for the analysis are presented in Table 2

Table 2. Heavy Metal Concentration in Dumpsite Contaminated soil

S/N	Heavy Metals	Control (mg/kg)	Dumpsite A (Mg/Kg) (Abam)	Dumpsite B (mg/kg) (Orupabo)	Mean value $\pm$ STD	PLI Value Dumpsite A (Abam)	PLI Value Dumpsite B (Orupabo)	WHO Permissible Value
1.	Nickel (Ni)	0.35	4.32	5.66	4.99 $\pm$ 0.75	0.86	1.13	5.00
2.	Copper (Cu)	2.49	4.87	3.57	4.22 $\pm$ 0.92	0.49	0.36	10.00
3.	Zinc (Zn)	11.20	56.40	56.02	56.21 $\pm$ 0.99	5.64	5.60	10.00
4.	Manganese (Mn)	12.31	66.26	27.78	47.02 $\pm$ 27.21	0.09	0.04	760.00
5.	Chromium (Cr)	1.83	3.26	3.19	3.23 $\pm$ 0.05	0.65	0.64	5.00
6.	Iron (Fe)	1,376.39	2,070.77	1,739.26	1,905.02 $\pm$ 234.41	0.10	0.09	20,000.00
7.	Cadmium (Cd)	0.14	0.83	0.88	0.86 $\pm$ 0.04	0.86	0.88	1.00
8.	Lead (Pb)	0.36	1.02	1.59	1.31 $\pm$ 0.40	0.20	0.32	5.00

Table 3. Heavy metal concentrations of fluted pumpkin in dumpsites

S/N	Heavy Metals	Control (mg/kg)	Fluted pumpkin leaves from dumpsite A (mg/kg)	Fluted pumpkin leaves from dumpsite B (mg/kg)	Mean value	AF Value Dumpsite A	AF Value Dumpsite B	WHO Permissible Value (mg/kg)
1.	Nickel (Ni)	4.67	6.18	5.66	5.92	1.43	1.00	0.30
2.	Copper (Cu)	2.36	13.16	3.57	8.37	2.70	1.00	40.00
3.	Zinc (Zn)	27.25	48.54	47.97	48.26	0.86	0.86	73.00
4.	Manganese (Mn)	17.64	43.39	25.18	34.29	0.65	0.91	2.20
5.	Chromium (Cr)	2.52	5.85	3.19	4.52	1.79	1.00	2.30
6.	Iron (Fe)	431.81	1,727.97	1,396.45	1562.21	0.83	0.80	425.00
7.	Cadmium (Cd)	0.27	0.36	0.41	0.39	0.43	0.47	0.20
8.	Lead (Pb)	1.01	1.02	1.590	1.31	1.00	1.00	0.30

From Table 3, the heavy metals (Ni, Cu, Zn, Mn, Cr and Fe) concentrations in fluted pumpkin grown in dumpsite A are higher than those grown in dumpsite B except for Cadmium (Cd) and Lead (Pb), Iron has the highest level of concentration (1727.97 mg/kg; 1396.45mg/kg) in the fluted pumpkin leaves while cadmium had the least level of concentration (0.36 mg/kg; 0.41 mg/kg). The mean values of these metals (Cu and Zn) are below WHO permissible level except for Ni, Mn, Cr, Fe, Cd and Pb which were above the WHO permissible limit. The AF values of Zn, Mn, Fe and Cd in dumpsite A are < 1 indicating that it is an excluder plant but Ni, Cu, and Cr are > 1 which shows it is an accumulator plant while Pb is = 1 showing it is an indicator plant: In dumpsite B, the AF values for Zn, Mn, Fe, and Cd are <1 which shows it is an excluder plant while the values for Ni, Cu, Cr, and Pb are = 1 which shows it is an indicator plant.

Table 4. Heavy metal concentrations of water leaf in dumpsites

S/N	Heavy Metals	Control (mg/kg)	Waterleaf from dumpsite A (mg/kg) (Abam)	Waterleaf from dumpsite B (mg/kg) (Orupabo)	Mean value	AF Value Dumpsite A (Abam)	AF Value Dumpsite B (Orupabo)	WHO Permissible Value (mg/kg)
1.	Nickel (Ni)	4.01	4.32	9.26	6.79	1.00	1.64	0.10
2.	Copper (Cu)	3.78	4.87	8.46	6.67	1.00	2.37	40.00
3.	Zinc (Zn)	14.49	46.00	45.82	45.91	0.82	0.82	73.00
4.	Manganese (Mn)	12.78	46.53	21.83	34.18	0.70	0.79	2.20
5.	Chromium (Cr)	2.784	3.26	4.32	3.75	1.00	1.33	2.30
6.	Iron (Fe)	298.48	875.14	541.01	708.08	0.42	0.31	425.00
7.	Cadmium (Cd)	0.50	0.52	0.64	0.58	0.63	0.73	0.20
8.	Lead (Pb)	2.81	3.34	4.04	3.69	3.27	2.54	0.30

From Table 4, the heavy metals (Ni, Cu, Cr, Cd, and Pb) concentrations in the waterleaf grown in dumpsite B are higher than those grown in dumpsite A except for the metals Zinc (Zn), Manganese (Mn) and Iron (Fe). Iron has the highest level of concentrations in the waterleaf samples while cadmium has the least level of concentrations. The mean values of the heavy metals Cu and Zn are below WHO permissible limit while the mean values of Ni, Cr, Fe, Pb, Cd and Mn are above WHO value. The accumulation factor (AF) values of Zn Mn, Fe and Cd in dumpsite A are < 1 showing it is an excluder plant while the values for Ni, Cu, and Cr are = 1 which shows it is an indicator plant' but the value for Pb, > 1 which shows that it is an accumulator plant. In dumpsite B, the AF values for Zn, Mn, Fe and Cd are <1 showing that it is an excluder plant but the values for Ni, Cu, Cr, and Pb are> 1 showing that it is an accu m ulator plant.

It is also observed from the result that the means values of the heavy metals (Cu, Zn, Mn, Cr and Fe) in fluted pumpkin are higher than those in waterleaf while the level of Ni, Cd and Pb are highest in waterleaf than the fluted pumpkin. The level of the metals in the plant were generally lower than those of the soils. It has been reported that high soil pH can stabilize soil toxic elements resulting in decreased leaching effects of the soils toxic elements (Li and Yang, 2018). This may explain the low absorbability of the elements from the soil solution and translocation into plant tissues. All heavy metals investigated in the dumpsites and vegetables have their concentrations above the values of the control.

3.2 STATISTICAL ANALYSIS OF RESULTS

The results of the statistical analysis of the parameters using ANOVA are presented in Tables 5-7.

The results indicated that F- calculated value of 0.03 < F-critical value of 4.60, [F (1, 14) = 4.60, P < 0.05)]; F-calculated value of 0.12 < F-critical value of 4.60, [F (1, 14) = 4.60, P < 0.05; F - calculated of 0.25 < F-critical value of 4.60 [F{1, 14)= 4.60, P < 0.05)] for Table 5, Table 6 and Table 7 respectively.

Table 5. Summary of ANOVA of heavy metal mean concentrations between pumpkin leaf from locations A and B.

Sources of Variation	SS	df	MS	F-Ratio	P	Omega (W^2) Squared
Between sample means ($SS_{between}$)	8210.62	1	8210.62	0-03	0.05	0.002
Within sample means (SS_{within})	4241960.47	14	302997.18		F(1.14) = 4.60	
Total	4250171.09	15				

SS = sum of squares; df= degree of freedom; MS = means square

Table 6. Summary of ANOVA of heavy metal mean concentration between water leaf from locations A and B

Sources of Variation	SS	df	MS	F-Ratio	P	Omega Squared (W^2)
Between sample means ($SS_{between}$)	7599.14	1	7500.14	0.12	0.05	0.008
Within sample means (SS_{within})	894199.03	14	63571.36		F(1,14) = 4.60	
Total	901798.07	15				

SS = sum of squares; df= degree of freedom; MS = means square

Table 7. Summary of ANOVA of heavy metal mean concentration between pumpkin and water leaves

Sources of Variation	SS	df	MS	F-Ratio	P	Omega Squared (W^2)
Between sample means ($SS_{between}$)	45754.28	1	45754.28	0.25	0.05	0.02
Within sample means (SS_{within})	2520294.98	14	180021.07		F(1,14) = 4.60	
Total	2566048.26	15				

SS = sum of squares; df= degree of freedom; MS = means square

These results indicated that there are no significant differences between the sample mean values of the pumpkin leaves, water leaves from different dumpsites. The results suggest that, though the pumpkin and water leaves could be obtained from different dumpsites, the source of anthropogenic pollution could be of the same origin. To ascertain whether the heavy metals interact significantly with each other to bring about pollution of the vegetables in the studied sites, Omega squared (W^2) is calculated and the values are presented in Tables 5-7. The calculated values of Omega square (W^2) are 0.002, 0.008 and 0.02 which are lower than 0.14. This revealed lower interactive relationship among the heavy metals to bring about pollution of the vegetables grown at dumpsites.

The coefficient of correlation (r) is calculated to reveal the nature of relationship between the levels of heavy metals in soil, pumpkin and water leaves. The calculated value for coefficient of correlation (r) is 0.99 for both situations. The coefficient of correlation (r) of 0.99 revealed that there is a positive relationship between the levels of heavy metals in soil and the heavy metal concentrations in pumpkin leaves as well as water leaves.

4 CONCLUSION

The findings of the study revealed that the soils and vegetables of the dumpsites actually contained heavy metals. However, the heavy metal concentrations are below the permissible limits by WHO standard except Fe in the soil samples and the mean concentrations of Mn, Ni, Cr, Fe, Cd and Pb in vegetable samples, exceeded the WHO standard except Zn and Cu. The concentrations of heavy metals in the soil and vegetable samples are in the sequence: soil [Fe (1905.02 mg/kg) > Zn (56.21 mg/kg) > Mn (47.02 mg/kg) > Ni (4.99 mg/kg) > Cu (4.22 mg/kg) > Cr (3.23 mg/kg > Pb (1.31 mg/kg) > Cd (0.86 mg/kg)]. Pumpkin leaf samples (Fe (1 562.20 mg/kg) > Zn 48.26 mg/kg) > Mn (34.29 mg/kg) > Cu (8.37 mg/kg) > Ni (5.92 mg/kg) > Cr (4.52 mg/kg) > Pb (1.31 mg/kg) > Cd (0.39 mg/kg)]. Water leaf samples (Fe (708.08 mg/kg) > Zn (45.82 mg/kg) > Mn (34.18 mg/kg) > Ni (6.79 mg/kg) > Cu (6.67 mg/kg) > Cr (3.75 mg/kg) > Pb (3.69 mg/kg) > Cd (0.58 mg/kg)].

The Pollution Load Index (PLI) values whether less than 1 or greater than 1 indicated that the soil samples of the studied sites are polluted with heavy metals.

The coefficient of correlation (r) value of 0.99 indicated a positive correlation between pollution of soils at dumpsites and the heavy metal contamination of vegetables grown on these sites.

The results obtained from the study have shown that soils at dumpsites are contaminated with heavy metals, which are transferable to vegetables grown on them. Therefore, efforts should be intensified to discourage the practice of cultivating vegetables (crops) on dumpsites. This could be done by proper public enlightenment and awareness campaign on dangers of cultivation of crops on dumpsites

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