Available online at http://www.sjbas.com.ng
Savanna Journal of Basic and Applied Sciences (June, 2022), 4(1): 17-26
P:ISSN 2705-3164 | E:ISSN 2695-2335

Assessment of Heavy Metals Content in Selected Vegetables from Irrigation Farms in Minna, Nigeria

*Abdulhamid, Z., [1]Agbaji, E. B., [2]Yakubu, M. and [3]Musah, M.
*Department of Integrated Science, Niger, State College of Education, Minna, Nigeria
[1]Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Crop Production, Ibrahim Badamasi Babangida University, Lapai, Nigeria
[3]Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Nigeria

ABSTRACT

Heavy metals pollution of the environment majorly by anthropogenic activities has been widely reported. This study was to assess the level of heavy metals in three staple vegetables commonly cultivated in Minna. The vegetables were *Amaranthus hybridus* (spinach), *Hibiscus esculentus* (Okra) and *Telfairia occidentalis* (fluted pumpkin leaves). These vegetables were collected from seven selected farms at Okada Road, Kpakungu, Dutsen kura, Keteren Gwari, Chanchaga, Mandela and Sauka ka huta areas of Minna. The samples were analyzed for the presence of six heavy metals (cadmium, copper, iron, manganese, nickel and zinc) using standard analytical methods which include digestion using nitric acid and analysis with atomic absorption spectrometry. Results of analyses showed *Amaranthus hybridus*: Cd (4.65-4.85 mg/kg); Cu (4.31-30.17 mg/kg); Fe (27.06-683.95 mg/kg); Mn (13.01-81.00 mg/kg); Ni (1.22-1.44 mg/kg); Zn (2.48-164.78 mg/kg), *Hibiscus esculentus*: Cu (11.22-19.90 mg/kg); Fe (114.71-189.86 mg/kg); Mn (33.26-103.61 mg/kg); Ni (1.24-1.54 mg/kg); Zn (38.81-97.95 mg/kg), *Telfairia occidentalis*: Cd (5.11-7.16 mg/kg); Cu (4.96-36.93 mg/kg); Fe (116.72-592.28 mg/kg); Mn (95.67-572.72 mg/kg); Ni (1.36-3.42 mg/kg); Zn (7.25-69.06 mg/kg) across the seven farms. Average concentration of the six metals in the different vegetables from all farms varied in the following order; Spinach: Fe>Zn>Mn>Cu>Cd>Ni; okra: Fe>Zn>Mn>Cu>Ni and fluted pumpkin leaves: Fe>Mn>Zn>Cu>Cd>Ni. The transfer factor (TF) for Cd (0.49 and 0.00), Fe (0.24 and 0.08) and Ni (0.07 and 0.08) in spinach and okra were low. Results obtained revealed the vegetables were safe for consumption.

Keywords: Heavy metals, *Amaranthus hybridus*, *Hibiscus esculentus*, *Telfairia occidentalis*, leaves

INTRODUCTION

The consumption of vegetables as food aids to provide vitamins, minerals and fibre to the body. Vegetables used as food include those used in making soups or served as integral parts of the main sources of a meal. Leafy vegetables occupy a very important place in the human diet, they also act as neutralizing agents for acidic substances formed during digestion (Yusuf, and Oluwole, 2009) but unfortunately constitute a group of foods which contributes to heavy metals ingestion (Akan *et al*., 2013). The bioaccumulation of heavy metals in vegetables is known to distort the composition of beneficial nutrients in them (Dosumu *et al*., 2005; Sarita *et al*., 2002). Accumulation of heavy metals in vegetables may depend on plant species as well as concentration of the heavy metal. It may also depend on the efficiency of different plants in absorbing metals, which is evaluated by either plant uptake or soil-to plant transfer factors of the metals (Brhane and Shiferaw, 2014).

Heavy metals are environmental pollutants and their presence in the atmosphere, soil, water and food chain can cause serious problems to living things (Mubofu, 2012). Pollution by heavy metals is of significant ecological and environmental concern. This is due to the fact that they are not easily biodegradable thereby precipitating far reaching effects on the biological system (Otitoju *et al*., 2012). Heavy metals enter plant, animal and human tissues via air inhalation, diet and manual handling. Motor vehicle emissions and dust from mining activities are among the major sources of airborne pollutants which include arsenic, cadmium, cobalt, nickel, lead, antimony, vanadium, zinc, platinum, palladium and rhodium (Balasubramanian *et al*., 2009). Water sources can be polluted by heavy metals as a result of leaching from industrial and consumer wastes; acid rain can exacerbate this process by releasing heavy metals trapped in soils (Worsztynowicz and Mill, 1995). Plants are exposed to heavy metals through the uptake of water; animals eat these plants; ingestion of plant and animal based foods is the largest sources of heavy metals in humans (Radojevic and Bashkin, 1999). Heavy metals can accumulate in organisms as they are hard to metabolize (Pezzarossa *et al*., 2011).

Heavy metals can bind to vital cellular components, such as structural proteins, enzymes, and nucleic acids, and interfere with their functioning (Landis *et al*., 2000). Symptoms and effects can vary according to the metal or metal-compound, and the dose involved. Broadly, long-term exposure to heavy metals can have carcinogenic, central and peripheral nervous system and circulatory effects. This calls for concern as the toxicological effects of the chemicals which humans and animals are exposed to daily are ever-increasing.

*Corresponding author. E-mail: zulaihatabdulhamid@gmail.com

In recent times, there have been reported cases of heavy metal poisoning and deaths from heavy metal poisoning related complications in Nigeria (Etonihu *et al.*, 2011). In addition, there has been increase in activities related to metal processing and haphazard disposal of wastes in major cities. This study assessed the level of heavy metals in three staple vegetables commonly cultivated in Minna, Nigeria. These vegetables are *Amaranthus hybridus* (spinach), *Hibiscus esculentus* (okra) and *Telfairia occidentalis* (fluted-pumpkin leaves, ugu).

MATERIALS AND METHODS

Sample Location

Seven farms were selected for this study. The farms were situated near dumpsites, mechanic workshops, car parks and along the town's main drainage system (Table 1).

Table 1: Farms and their locations

Farm	Location
A	Okada road
B	Kpakungu
C	Dutsen kura
D	Kateren gwari
E	Chanchaga
F	Mandela
G	Sauka kahuta

Sample Collection

Three samples of spinach (*Amaranthus hybridus*) leaves, okra (*Hibiscus esculentus*) and fluted pumpkin (*Telfairia occidentalis*) leaves used for this study were obtained from each of the seven selected farms at different locations in Minna. Samples were taken in the morning in separate clean, ventilated polythene bags, properly identified and marked in a way that prevents inadvertent loss or confusion of labelling, then transported to the laboratory on the same day**.** The samples were dried, then ground and stored in polythene bags ready for analysis. All reagents used were analar grade.

Analysis of Heavy Metals

Each dried powdered sample (6 g) was weighed into dry crucibles in triplicates and ignited in a muffle furnace at 600 ^{o}C for three hours until greyish white ash was obtained. The samples were removed and cooled in a desiccator, 5 cm^3 of 1.0 moldm^{-3} HNO_3 was added and evaporated to dryness on a steam bath. They were then heated in a muffle furnace for about ten (10) minutes until greyish white ash was obtained. The samples were removed, cooled in a desiccator and 10 cm^3 of 1.0 moldm^3 HCl was added to each ash and filtered into 100 cm^3 volumetric flasks. Cadmium (Cd), Copper (Cu), Iron (Fe), manganese (Mn), Nickel (Ni) and Zinc (Fe) were determined using Atomic Absorption Spectrophotometer (AAS Model SP9) with standard air-acetylene flame (AOAC, 2006). Data obtained were analyzed using Microsoft Excel to plot. The relationship between heavy metal in farm soil and vegetable was identified using the Pearson correlation matrix.

RESULTS AND DISCUSSION

Concentrations of Cd, Cu, Fe, Mn, Ni and Zn in spinach (*Amaranthus hybridus*) leaves, okra (*Hibiscus esculentus*) and fluted pumpkin (*Telfairia occidentalis*) leaves are presented in Figures 1 – 9.

Concentration of each heavy metal in vegetables from all farms

Concentration of cadmium in the three vegetable samples from the seven farms is presented in Figure 1. Cadmium metal was not detected in vegetables obtained from farms A, B, C, E and G, but present samples from farm D and F. It can also be observed that only spinach and pumpkin leaves from farms D and F had some levels of the metal. The concentration range of the metal in farm D was 0.00465 to 0.00511 mg/g and that of farm F was 0.00485 to 0.00716 mg/g. The highest level (0.00716 mg/g) of the metal was recorded for pumpkin leaves in farm F while the lowest (0.00465 mg/g) was recorded for spinach in farm D.

The level of copper metal in the three vegetable samples obtained from farms A to G is presented in Figure 2. All samples contained levels of copper, with pumpkin leaves from farm B having the highest value of 0.03693 mg/g and the lowest value of 0.00496 mg/g recorded for pumpkin leaves in farm A. The levels of copper in spinach samples ranged from 0.00431 to 0.03017 mg/g, that of okra samples ranged from 0.0112 to 0.0199 mg/g and 0.00496 to 0.03693 mg/g for pumpkin leaves samples. The samples from the control farm A had lowest levels of Cu metal.

Figure 3 shows the level of iron in the three vegetable samples obtained from farms A to G. Iron was detected in all samples, with pumpkin leaves from farm D having the highest value of 0.78409 mg/g and the lowest value of 0.02706 mg/g recorded for spinach in farm A. The levels of iron in spinach samples ranged from 0.02706 to 0.68395 mg/g, that of okra samples ranged from 0.11471 to 0.18986 mg/g and 0.11672 to 0.78409 mg/g for pumpkin leaves samples**.** The result of the level of manganese in the three vegetable samples is presented in Figure 4. The highest level of manganese is recorded in pumpkin leaves samples from all farms with the exception of farm D. The level of manganese in all samples ranged from 0.01301 to 0.57272 mg/g. The concentration range in spinach samples was between 0.01301 to 0.08100 mg/g, that of okra samples is 0.03326 to 0.10361 mg/g and 0.09567 to 0.57272 mg/g for pumpkin leaves samples. The results obtained for nickel is shown in Figure 5. Nickel was detected in farm B and E only. Pumpkin leaves have the highest level of nickel in the two farms while spinach has the least. The level of nickel in all samples ranged from 0.00122 to 0.00342 mg/g. The concentration range in spinach samples was between 0.00122 to 0.00144 mg/g, that of okra samples is 0.00124 to 0.00154 mg/g and 0.00136 to 0.00342 mg/g for pumpkin leaves samples**.**

The result of the level of zinc in the three vegetable samples is presented in Figure 6. Zinc metal was detected in all samples with the highest level (0.16478 mg/g) recorded in spinach sample from farm C, and the lowest (0.01246 mg/g) recorded in spinach sample from farm A. The concentration range in spinach samples was between 0.01246 to 0.16478 mg/g, that of okra samples was 0.03881to 0.09795 mg/g and 0.01725 to 0.08546 mg/g for pumpkin leaves samples.

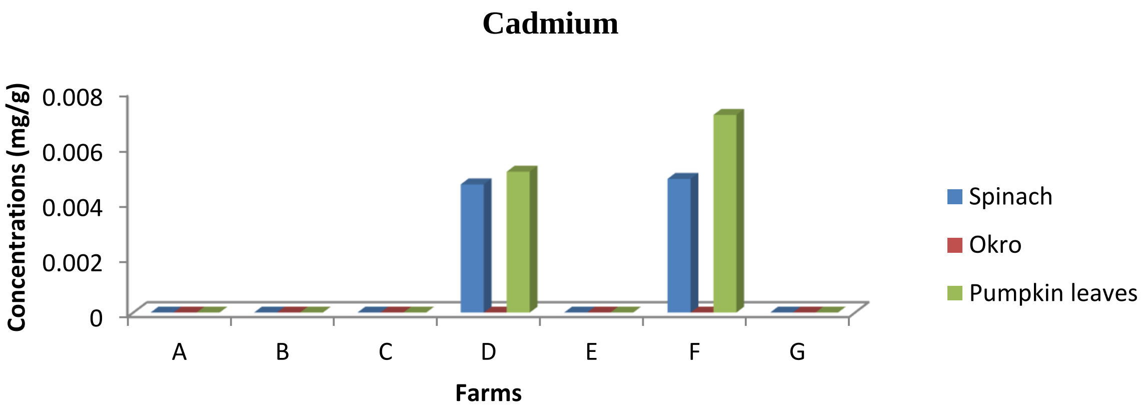

Figure 1: Concentrations in mg/g of cadmium metal in spinach, okra and pumpkin leaves samples from farms

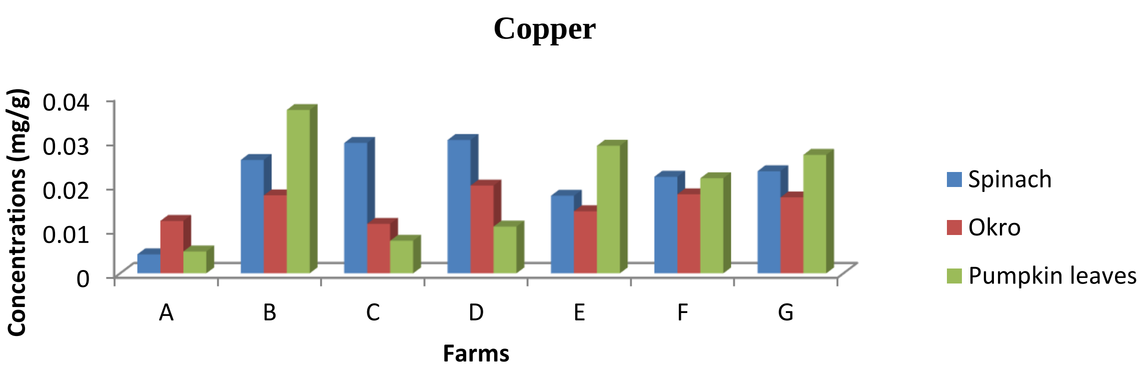

Figure 2: Concentrations in mg/g of copper metal in spinach, okra and pumpkin leaves samples from farms

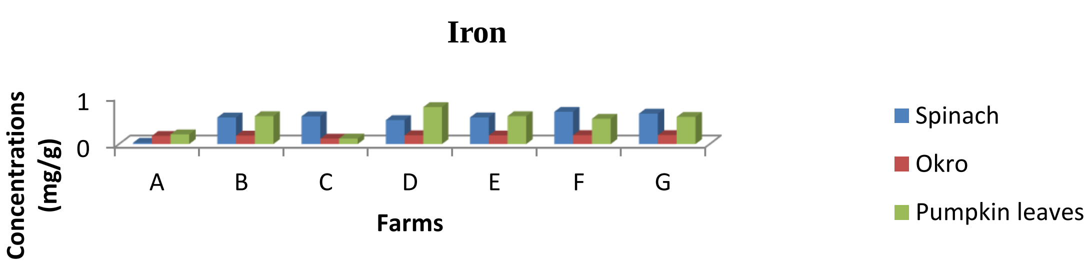

Figure 3: Concentrations in mg/g of iron metal in spinach, okra and pumpkin leaves samples from farms

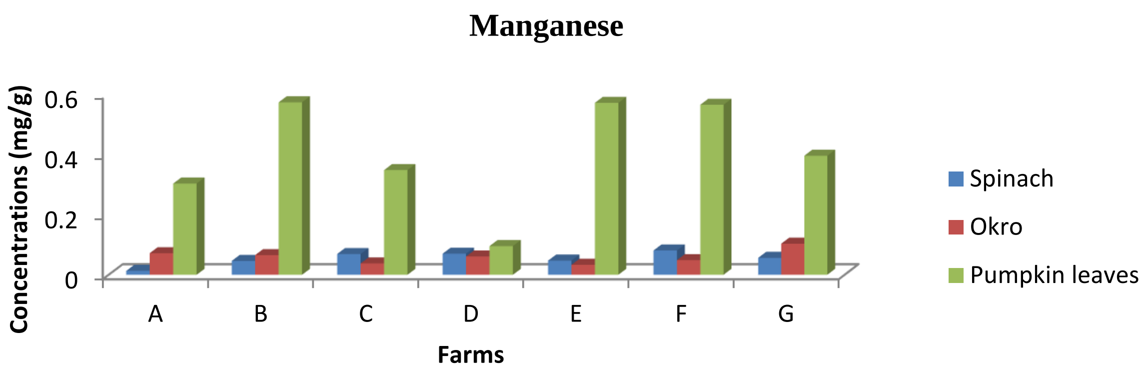

Figure 4: Concentrations in mg/g of manganese in spinach, okra and pumpkin leaves samples from farms

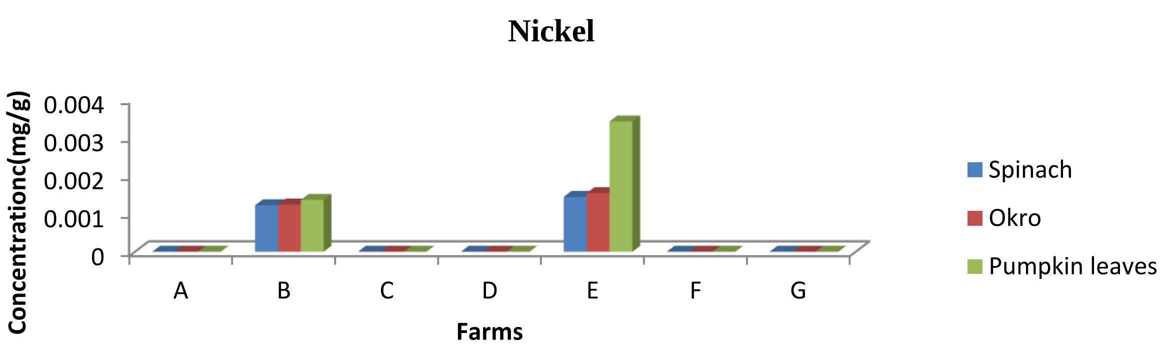

Figure 5: Concentrations in mg/g of nickel in spinach, okra and pumpkin leaves samples from farms

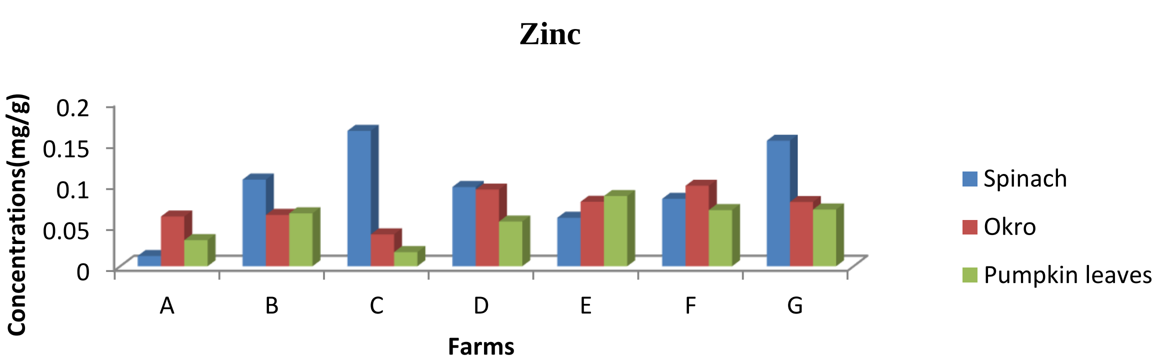

Figure 6: Concentrations in mg/g of zinc metal in spinach, okra and pumpkin leaves samples from farms

Level of heavy metals in each vegetable from all farms

The levels of all the metals in spinach samples from all farms analyzed are shown in Figure 7. The figure reveals that Fe had the highest concentration in all the spinach samples from all farms. This was followed by Zn in farm B, C, D, E and G while Zn and Mn were about the same concentration in farm F: 0.082mg/g and 0.081mg/g respectively, Cu was at a low level in all farms. The levels of Ni and Cd were negligible in all spinach samples. The general trend of the metals in spinach samples revealed that: Fe>Zn>Mn>Cu>Cd>Ni.

Figure 8 gives the levels of heavy metals in okra samples from all the farms. All the okra samples had higher concentrations of Fe. In farm A, B and G, Mn was the second highest while Zn was second highest in farm D, E and F. Concentration of Zn and Mn are almost the same in farm C. Okra samples from all farms had some levels of Cu. Cd was not detected in any of the okra samples while Ni was detected in two farms at very low levels of 0.00124 mg/g in farm B and 0.00154 mg/g in farm E. The general trend of the metals in okra samples showed that: Fe>Zn>Mn>Cu>Ni.

The levels of the heavy metals determined in all fluted pumpkin leaves from farms are shown in Figure 9. The result revealed that Mn and Fe were the most abundant metals in this vegetable from all farms. Zn was at a lower concentration followed by Cu while Ni and Cd were in lower concentrations in few samples. Fluted pumpkin had the highest average concentration of Mn (0.408mg/g) compared to spinach (0.055mg/g) and okra (0.060mg/g). The general trend of the metals in fluted pumpkin samples showed that: Fe>Mn>Zn>Cu>Cd>Ni.

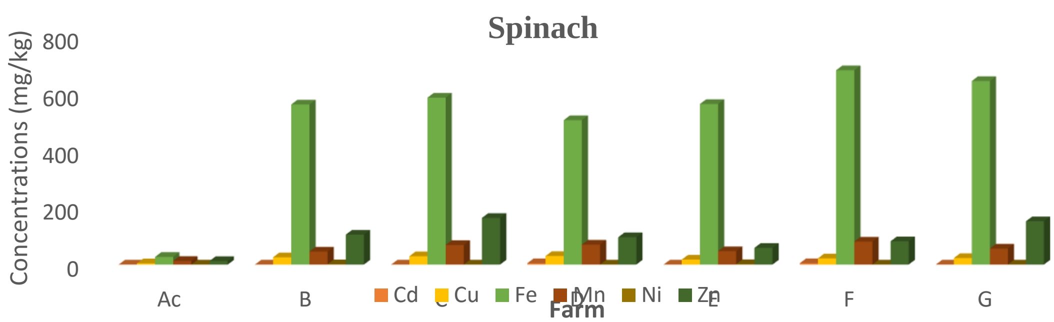

Figure 7: Concentrations of heavy metals (mg/kg) in spinach samples from all farms

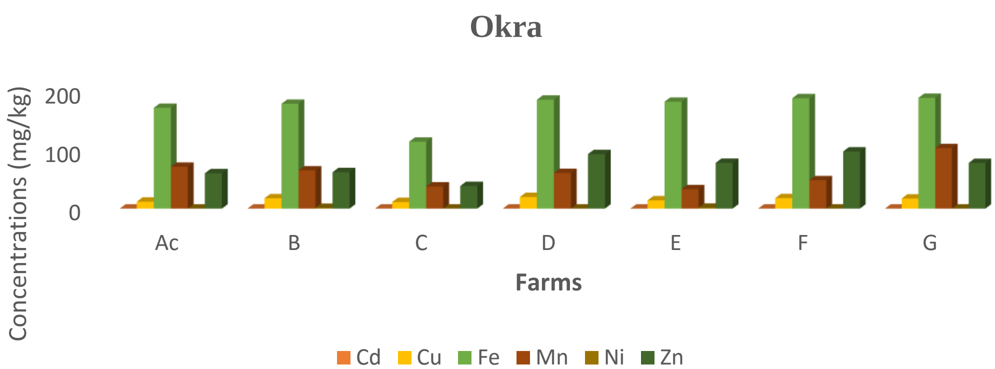

Figure 8: Concentrations of heavy metals (mg/kg) in okra samples from all farms

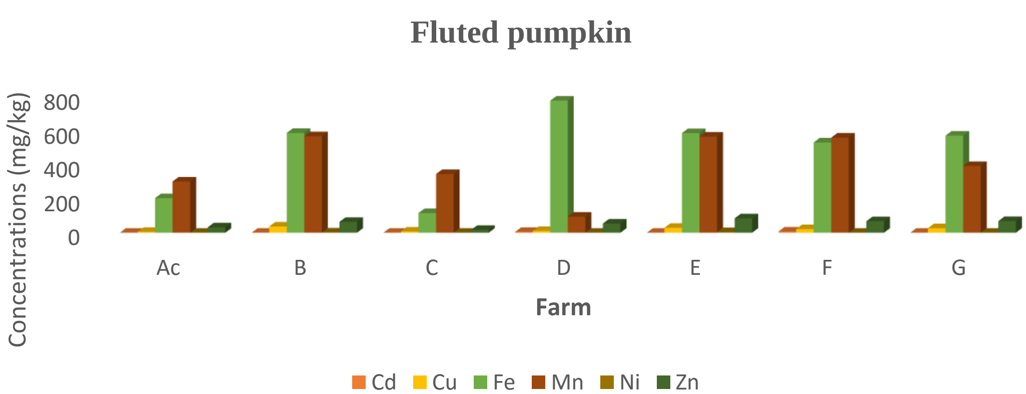

Figure 9: Concentrations of heavy metals (mg/kg) in fluted pumpkin leaves from all farms

Cadmium

Cd was obtained in only spinach and fluted pumpkin leaves of farm D and F, dumpsites near the two farms may contain used electronic parts due to activities of electronic repairs shops around the area. The burning of the dumpsites may also be associated to the level of Cd in the samples. None of the okra samples gave a positive result for Cd. This may be due to the fact that green leafy vegetables have more ability to absorb metals deposited on plant surfaces exposed to polluted environments than fruits and stems (Thilini *et al.*, 2014; Štofejová *et al*., 2021). The result also resembles values recorded for a similar study on heavy metals in Srilanka vegetables where Cd exceeded the FAO/WHO limit (Thilini *et al.,* 2014).

This study gave a range of (4.65 – 4.85 mg/kg) for Cd in spinach and 5.11 -7.16 mg/kg for fluted pumpkin leaves. These were the only two samples that showed presence of Cd and they are all above the FAO maximum permissible limits (FAO, 2002) of 0.20 mg/kg. These results differ from that obtained for vegetables from Paiko town in Niger state by Sumaila (2014) in which Cd was below detection limits in all the samples but similar to a study conducted on Kaduna vegetables where Cd exceeded the permissible limit (Jacob and Kakulu, 2012). The value of 0.090 mg/kg was reported for fluted pumpkin from selected farms in Lagos by Sobukola *et al.* (2010), which is much lower than the value obtained for the same vegetable in this study. The mean values of Cd from all farms were 4.75 mg/kg and 6.14 mg/kg for spinach and fluted pumpkin leaves respectively. A large share of general cadmium pollution is caused by dumping and incinerating cadmium-polluted waste (Jarup, 2003) these activities may be present around the two farms.

Copper

The Cu range were 4.31- 30.17 mg/kg for spinach, 11.22 – 19.90 mg/kg for okra and (4.96 – 36.93 mg/kg) for fluted pumpkin leaves. None of the samples exceed 40 mg/kg which is the FAO/WHO maximum permissible limits (FAO, 2002) for Cu in vegetables. On the other hand, these values are a bit higher than (4.09 – 15.81 mg/kg) recorded for Paiko vegetables (Sumaila, 2014). Elbagermi *et al.* (2012) also gave a value of 5.32 mg/kg for spinach from Misurata, Libya which is similar to some spinach samples in this study. The average levels obtained for Cu in samples from all farms were spinach (21.76 mg/kg), okra (30.97 mg/kg) and fluted pumpkin (19.59 mg/kg). Adah *et al*., (2013) reported 0.251 mg/kg and 0.0803 mg/kg for fluted pumpkin and spinach samples from bank of river Benue. In another research conducted in Colombo, Srilanka, 7.05 – 18.44 mg/kg was obtained for Cu metal in vegetables of that area (Thilini *et al.*, 2014), this value is similar to some samples in this study.

Iron

All the spinach samples except those of the control farm contained Fe above the FAO/WHO limits (Ogundele *et al.*, 2015) of 450 mg/kg, all the okra samples exceeded the permissible limits while 72% of fluted pumpkin leaves also exceeded the permissible limits. The concentration of Fe in the soil, its absorption capacity by the different vegetables may cause the differences in the contents (Mobofu, 2012). This result is however lower than 148.33 – 840.50 mg/kg recorded by Sumaila (2014). The values for Fe also differ from 0. 260 mg/kg average recorded for wild jute, tossa jute and kenaf from Katsina market (Shuaibu *et al*., 2013). The mean values for Fe in spinach, okra and fluted pumpkin leaves from all farms were: 512.0 mg/kg, 173.7 mg/kg and 486.0 mg/kg respectively, showing that spinach samples had the highest Fe content followed by fluted pumpkin while okra was the least. Okra, a fruit vegetable is expected to contain lower levels of heavy metals compared to leafy vegetables (Thilini *et al.*, 2014). The control farm (A) also contained higher level of Fe compared to other metals. This may be due to the fact that Fe usually has relatively high natural concentrations and is therefore not expected to be substantially enriched from anthropogenic sources.

Manganese

Mn had a range of 13.01 -81.00 mg/kg for spinach, 33.26 – 103.6 1mg/kg for okra and 95.67 – 572.72 mg/kg) for fluted pumpkin leaves which was higher than the 0.23 – 3.43 mg/kg recorded for Mn in spinach and lettuce from Biu, Borno state (Akan *et al.*, 2013). The difference between values from Biu and those of Minna could be geographical. All the spinach and okra samples contained Mn values below the FAO/WHO permissible limit of 500 mg/kg, while 43% of fluted pumpkin leaves exceeded the permissible limit. This pattern was also observed in a study on heavy metals in vegetables from Uyo where the fluted pumpkin had higher values than other vegetables (Otitoju *et al.*, 2012). Computing the average concentration of Mn from all farms gave 54.74 mg/kg, 60.25 mg/kg, 407 mg/kg for spinach, okra and fluted pumpkin leaves respectively.

Nickel

The results showed that Ni was detected in the samples of only farms B and E and was below detection limit in other farms. Ni usually takes long time for it to be removed from air to other parts of the environment and often leaches down to adjacent groundwater (Wuana and Okieimen, 2011). Ni gave a range of 1.22 – 1.44 mg/kg for spinach, 1.24 – 1.54 mg/kg for okra and 1.36 – 3.42 mg/kg for fluted pumpkin leaves which are similar to 0.25 – 3.54 mg/kg reported by Akan *et al.* (2013). Only 16% of fluted pumpkin leaves exceed the FAO/WHO limit of 1.5mg/kg. The mean level of Ni in spinach, okra and fluted pumpkin leaves from all farms was 1.33 mg/kg, 1.39 mg/kg and 2.39 mg/kg respectively. These values are different from those reported by Adah *et al*. (2013) in a study to determine heavy metals in soil and vegetable samples from bank of river Benue where an average of 0.2047 mg/kg was obtained for Ni in fluted pumpkin and 0.0714 mg/kg for spinach. The difference may arise from geographical factors.

Zinc

Zn levels of 2.48 -164.78 mg/kg for spinach, 38.81 – 97.95 mg/kg for okra and 7.25 – 69.06 mg/kg for fluted pumpkin leaves exceeded the FAO/WHO permissible limit of 60 mg/kg. The average concentration of Zn in spinach, okra and fluted pumpkin leaves from all farms was 91.15 mg/kg, 72.80 mg/kg and 55.80 mg/kg respectively. These values are higher than 0.67 – 18.89 mg/kg reported by Lawal and Audu (2011) for Zn in spinach, okra, onions and tomatoes from vegetable farms in Kano. High levels of heavy metals in some of the vegetables might be closely related to the pollutants from irrigation water or from soil (Mubofu, 2012). This may be due to the fact that mineral uptake from soil; bioaccumulation and aerial deposition on the leaves all contribute to the mineral levels in the vegetables (Otitoju *et al*., 2012; Fosu-Mensah *et al.,* 2018). The high levels observed in the vegetables may also be because most of the farms are located near the source of contamination like tyre wear, motor oil, grease, brake emissions, corrosion of galvanized parts, fuel burning, and batteries e.t.c. Generally, the results showed that pumpkin leaves contain higher levels of heavy metals followed by spinach and then okra. This agrees with a report by Van Herk (2012) that in vegetable organs the concentrations of heavy metals are in the order of leaf> stem> root> tuber> bulb> fruit> seed.

The level of the heavy metals in each vegetable from all farms is presented in Figures 7 to 9. The figures showed that all the vegetables contain high concentration of Fe while Mn was also in high abundance in pumpkin leaves. Figure 8 revealed that okra samples from all farms had varying levels of Cu.

The average concentration of all six metals in the different vegetables from all farms varied according to the following trend, Spinach: Fe>Zn>Mn>Cu>Cd>Ni; okra: Fe>Zn>Mn>Cu>Ni and fluted pumpkin leaves: Fe>Mn>Zn>Cu>Cd>Ni. This showed that there is a relationship between the level of metals in the soil samples and in the vegetables. Fe had the highest concentration in the soil and it was also the highest in each vegetable. Ni had the least level in most of the farm soil samples and it also had the lowest concentration in all the vegetables considering that Cd was detected in two farms only.

The mean level of each metal from all farms also gave the following trend: (Cd) F>D; (Cu) B>G>F>D>E>C>A; (Fe) D>G>F>E>B>C>A; (Mn) B>F>E>G>C>A>D; (Ni) E>B; (Zn) G>F>D>B>E>C>A. From this trend it can be said that farm A, the control has the lowest levels of all metals as observed for the levels of metals in soil samples from the same farms.

Soil- Plant Transfer Factors

The concentrations of heavy metals in soil used for evaluation of transfer factors and correlation of heavy metals levels in vegetables with soil were presented in Abdulhamid *et al*. (2015). Results of soil- plant transfer factors are shown in Table 1. The transfer factor (TF) was obtained by dividing the heavy metal concentration in the plants over its concentration in soil. Table 1 revealed that Mn had the highest transfer factor of 1.35 in pumpkin leaves. For spinach samples Cu had the highest transfer factor of 1.26 while Ni had the lowest with a value of 0.07. The highest transfer factor in okra was for Zn (1.20) and the lowest was for Cd (0.00).

Table 1: Mean Soil-Plant Transfer Factor (TF) for Vegetables

Vegetable	Cd	Cu	Fe	Mn	Ni	Zn
Spinach	0.49	1.26	0.24	0.20	0.07	1.24
Okra	0.00	0.99	0.08	0.22	0.08	1.20
Fluted pumpkin	0.55	1.13	0.24	1.35	0.14	0.86
Average	0.35	1.13	0.19	0.59	0.10	1.10

Transfer factor expresses the bioavailability of a metal at a particular position on species of plant. Higher transfer coefficients reflect high soil contents or greater potentials of plants to absorb metals and bio-accumulate into tissues (Abah *et al*., 2012). However, low transfer coefficients have been reported to indicate strong sorption of the metals to soil colloids (Kachenko and Singh, 2006).

The soil-plant transfer factor (TF) differed between the vegetables types and sampling farms as shown in Table 1. TF > 1, indicate that the plant species is a hyper accumulator of the metal (Baker and Brooks, 1989). The Table revealed highest absorption and bio-accumulation of Zn and Cu in spinach, Mn and Cu by fluted pumpkin leaves (TF > 1). Zn also gave high transfer factors (TF > 1) in okra. The accumulation of heavy metals by vegetables may depend on plant species as well as the efficiency of different plants in absorbing metals (Brhane and Shiferaw, 2014). Lowest TFs were observed for Ni in spinach, okra and pumpkin leaves. TFs results also showed no absorption of Cd in okra & low absorption (TF < 1) of Fe/Ni in okra. Low TFs (TF <1) indicate strong sorption of heavy metals to soil colloids (Kachenko and Singh, 2006). This may be due to the high organic matter content recorded that chelate with positive ions making them unavailable to plants. The transfer factors also differed in the sampling farms for the same vegetable. This could be due to differences in soil properties (Jacob and Kakulu, 2012).

The TF values showed that the order of uptake of metals by vegetables is Cu > Zn > Mn > Cd > Fe > Ni. Cu had the highest TF in all the vegetables while fluted pumpkin leaves generally had the highest TF for all metals followed by spinach, then okra had the lowest. This may be attributed to fact that leafy vegetables have higher transpiration rate to sustain the growth and moisture content of plants (Lato *et al*., 2012).

Correlation of Heavy Metals Levels in Vegetables with Soil

Results of correlation coefficients between the vegetables and soil samples are presented in Tables 2, 3 and 4 at $p \leq 0.05$. A correlation matrix was computed for the investigated heavy metals so as to determine their interrelationship with each other. From results presented in Tables 2, 3 and 4, a significant positive correlation was obtained for some of the elements at 0.05 significant level. This strong positive correlation shows that the metals in the soil and those in the vegetables are closely associated, thus suggesting their common origin. There was also a negative correlation between some metals in the soil and in the vegetables although not significant.

Table 2: Correlation Coefficients between the Heavy Metals in Farm Soils and Spinach

Parameter	Cadmium	Copper	Iron	Manganese	Nickel	Zinc
Cadmium	1					
Copper	0.323	1				
Iron	0.266	0.784	1			
Manganese	0.641	0.818	0.845	1		
Nickel	-0.398	-0.035	0.163	-0.244	1	
Zinc	-0.091	0.811	0.708	0.623	-0.205	1

Table 3: Correlation Coefficients between the Heavy Metals in Farm Soils and Okra

Parameter	Cadmium	Copper	Iron	Manganese	Nickel	Zinc
Cadmium	1					
Copper	0.000	1				
Iron	0.000	0.711	1			
Manganese	0.000	0.319	0.421	1		
Nickel	0.000	-0.003	0.201	-0.368	1	
Zinc	0.000	0.783	0.837	0.129	-0.050	1

Table 4: Correlation Coefficients between the Heavy Metals in Farm Soils and Fluted pumpkin

Parameter	Cadmium	Copper	Iron	Manganese	Nickel	Zinc
Cadmium	1					
Copper	-0.143	1				
Iron	0.433	0.550	1			
Manganese	-0.144	0.742	-0.003	1		
Nickel	-0.350	0.580	0.272	0.560	1	
Zinc	0.191	0.800	0.787	0.525	0.609	1

Table 2 gave the correlation of metal levels in spinach and soil. The result indicate a significant positive correlation for Fe:Cu, Mn:Cd, Mn:Cu, Mn:Fe, Zn:Cu, Zn:Fe and Zn:Mn, showing a strong Zn:Cd and Zn:Ni indicating an inverse relationship between the pair. Table 3 show the correlation of metal levels in okra and soil indicating high positive correlation between the following pair of metals: Fe:Cu, Zn:Cu and Zn:Fe. A low positive correlation existed between Mn:Cu, Mn:Fe and Ni: Fe showing a moderate relationship between the metals. Ni:Cu, Ni:Mn and Zn: Ni gave a negative correlation indicating an in inverse relationship. The Correlation of heavy metal levels in fluted pumpkin with soil shown in Table 4 indicate a strong positive correlation between Mn:Cu, Zn:Cu, Zn:Fe, and

Zn:Ni. A moderate positive correlation was observed between Fe:Cu, Ni:Cu, Ni:Mn and Zn: Mn. Also, Mn: Cd, Mn:Fe, Ni:Cd and Cu:Cd gave a negative correlation.

CONCLUSION

The presence of manganese, copper, iron and zinc in spinach (*Amaranthus hybridus*) leaves, okra (*Hibiscus esculentus*) and fluted pumpkin (*Telfairia occidentalis*) leaves studied suggests that pollution of these vegetables is a result of human activities such as indiscriminate dumping of refuse, exhaust fumes from vehicles and machinery, irrigating farms with contaminated water etc. The absence of Cadmium and Nickel in most samples suggests that activities producing these two metals in the study area are low. Continuous pollution of the environment could lead to cumulative effects that might expose people to health risks.

REFERENCES

Abah, J., Abdurahaman, F. I., Ndahi, N. P. and Ogugbuaja, V. O. (2012). Effects of inorganic fertilizers and herbicides on levels of some heavy metals in soils and grains of rice grown in selected areas of Benue State, Nigeria. *International Journal of Applied Research and Technology.*, 1: 160-166.

Abdulhamid, Z. Agbaji, E.B., Gimba, C.E. and Agbaji, A. S. (2015). Physicochemical parameters and heavy metals content of soil samples from farms in Minna. *International Letters of Chemistry, Physics and Astronomy,* 58,154-163.

Adah , C.A., Abah, J. Ubwa, S.T. and Ekele, S. (2013). Soil availability and uptake of some heavy metals by three staple vegetables commonly cultivated along the south bank of river Benue, Makurdi, Nigeria. *International Journal of Environment and Bioenergy*, 8(2): 56-67.

Akan, J. C., Kolo, B. G., Yikala, B. S. and Ogugbuaja, V. O. (2013). Determination of some heavy metals in vegetable samples from Biu Local Government Area, Borno State, North Eastern Nigeria. *International Journal of Environmental Monitoring and Analysis.* 1(2): 40-46. doi: 10.11648/j.ijema.20130102.11.

AOAC (2006). Official methods of association of official analytical chemist, association of official analytical chemists inc. Alington, Washington DC., USA.

Balasubramanian, R., He, J. and Wang, L. K. (2009). Control, Management, and Treatment of Metal Emissions from Motor Vehicles in LK Wang, JP Chen, Y Hung & NK. P.476.

Baker, A.J.M. and Brooks, R. R. (1989). Terrestrial higher plants which hyperaccumulate metallic elements: A review of their distribution, ecology and phytochemistry. *Biorecovery*, 1, 81-126.

Brhane, G. and Shiferaw, T. (2014). Assessment of levels of lead, cadmium, copper and zinc contamination in selected edible vegetables. *International Journal of Innovation and Applied Studies* 7(1): 78-86. Retrieved from http://www.ijias.issr-journals.org/

Dosumu, O. O., Abdus-Salam, N., Oguntoye, S. and Adekola, F. A. (2005).Trace metals bio-accumulation by some Nigerian vegetables. *Centrepoint* (*Science Edition*), 13(1): 23-32.

Elbagermi, M.A., Edwards, H.G.M. and Alajtal, A.I. (2012). Monitoring of heavy metal content in fruits and vegetables collected from populated and market sites in the Misurata area of Libya. *International Scholarly Research Network*, 10, 1-5.

Epstein, E. (2002). *Land Application of Sewage Sludge and Biosolids.* CRC press. http://books.google.com/books?isbn=1420032119.

Etonihu, A. C., Aminu, B. A., Ambo, A. I. and Etonihu, K. I. (2011). Iodine Content and Pesticide Residues of Some Nigerian Food Grains. *Continental Journal of Agricultural Science* 5 (1): 26 – 32.

Food and Agriculture Organization of the United Nations. (2002). International Code of Conduct on the Distribution and Use of Pesticides. http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/Code/Download/code.pdf.

Fosu-Mensa, B.Y., Ofori, A., Ofosuhene, M., Ofori-Attah, E., Nunoo, F.K.E., Darko, G., Gordon, C., Turffour, I., Arhinful, K., Nyarko, A.K. and Appiah-Opong, R. (2018). Assessment of Heavy Metal Contamination and Distribution in Surface Soils and Plants along the West Coast of Ghana. *West African Journal of Applied Ecology*, 26,67-178

Jacob, J.O. and Kakulu, S.E. (2012). Assessment of heavy metal bioaccumulation in spinach, jute mallow and tomato in farms within Kaduna Metropolis, Nigeria. *American Journal of Chemistry,* 2(1): 13-16. doi: 10.5923/j.chemistry.20120201.04

Jarup, L. (2003). Hazards of heavy metal contamination. *British Medical Bulletin*, 68: 167-182.

Kachenko, A. G. and Singh, B. (2006). Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. *Water Air Soil Pollution,* 169: 101-123.

Landis, W.G., Sofield, R.M. and Yu M-H (2000). *Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes*, 4th ed., CRC Press, Boca Raton, Florida, pp. 269.

Lato, A., Radalov, I., Berbecca, A., Lato, K. and Crista, F. (2012). The transfer factor of metals in soil-plants system. *Research Journal of Agriculture and Science.* 44, 67-72.

Lawal, A.O and Audu, A.A. (2011). Analysis of heavy metals found in vegetables from some cultivated irrigated gardens in the Kano Metropolis, *Nigeria. Journal of Environmental Chemistry and Ecotoxicology*, 3(6): 142-148.

Mubofu, E.B. (2012). Heavy Metal content in some commonly consumed vegetables from Kariakoo market, Dares Salaam, Tanzania. *Tanzania Journal of Science.* 38(3): 1-8.

Ogundele, D.T., Adio, A.A. and Oludele, O.E. (2015). Heavy Metal Concentrations in Plants and Soil along Heavy Traffic Roads in North Central Nigeria. *Journal of Environmental & Analytical Toxicology*, 5(6):1-5

Otitoju, I.O., Akpanabiatu, M.I., Otitoju, G.T.O., Ndem, J.I., Uwah, A.F., Akpanyung, E.O. and Ekanem, J.T. (2012). Heavy metal contamination of green leafy vegetable gardens in Itam road construction site in Uyo, Nigeria. *Research Journal of Environmental and Earth Sciences*, 4(4): 371-375.

Pezzarossa, B., Gorini, F. and Petruzelli, G. (2011). Heavy metal and selenium distribution and bioavailability in contaminated sites: A tool for phytoremediation, P 94. In H.M. Selim, *Dynamics and Bioavailabiliy of Heavy Metals in the Rootzone*, CRC Press, Boca Raton, Florida, pp. 93–128.

Radojevic, M. and Bashkin, V.N. (1999). *Practical Environmental Analysis,* Royal Society of Chemistry, Cambridge, pp. 406.

Sarita, S., Rohit, S. and Shraddha, S. (2002). Comparative studies of accumulation of Cr from metal solution and tannery effluent under repeated metal exposure by aquatic plants: Its toxic effects. Environment Monitoring and Assessment, 80(1):17-31.

Shuaibu, l. K., Yahaya, M. and Abdullahi, U. K. (2013). Heavy metal levels in selected green leafy vegetables obtained from Katsina central market, Katsina, northwestern Nigeria. *African Journal of Pure and Applied Chemistry.* 7(5):179-183. doi: 10.5897/AJPAC2013.0499.

Sobukola, O.P., Adeniran, O.M., Odedairo, A.A., and Kajihausa, O.E. (2010). Heavy metal levels of some fruits and leafy vegetables from selected markets in Lagos, Nigeria. *African Journal of Food Science*, 4(2): 389-393.

Štofejová, L., Fazekaš, J. and Fazekašová, D. (2021). Analysis of Heavy Metal Content in Soil and Plants in the Dumping Ground of Magnesite Mining Factory Jelšava-Lubeník (Slovakia). *Sustainability*, 13,1-13

Sumaila, A. (2014). *Assessment of some heavy metals in selected vegetables and soils obtained from farm sites in Paiko, Niger State, Nigeria*. MTech. Dissertations, Federal University of Technology Minna.

Thilini, K., Jagath, W. and Anil, G. (2014). Heavy metal contamination in green leafy vegetables collected from selected market sites of Piliyandala area, Colombo district, Sri Lanka. *American Journal of Food Science and Technology*, 2(5): 139-144. doi: 10.12691/ajfst-2-5-1.

Van Herk, A. (2012). Physicochemical parameters in soil and vegetable samples from Gongulon agricultural site, Maiduguri, Borno State, Nigeria. *International Journal of Chemistry*, 1: 21-36.

Worsztynowicz, A. and Mill, W. (1995). *Potential Ecological Risk due to Acidification of Heavy Industrialized Areas - The Upper Silesia Case*. Pp. 361.

Wuana, R.A**.** and Okieimen, F.E. (2011). *Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation*. Retrieved from http://dx.doi.org/10.5402/2011/402647.

Yusuf, K.A. and Oluwole, S.O. (2009). Heavy metal (Cu, Zn, Pb) contamination of vegetables in urban city: A case study in lagos. *Research Journal of Environmental Science*, 30, 292-298. Doi 10.3923/rjes.2009.292.298.