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Research Article

Investigation of the Presence of Some Heavy Metals in Four Edible Vegetables, Bitter Leaf (*Vernonia amygdalina*), Scent Leaf (*Ocimum gratissimum*), Water Leaf (*Talinum triangulare*) and Fluted Pumpkin (*Telfairia occidentalis*) from a Cottage Farm in Port Harcourt

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Abstract: One of the sources of heavy metals contamination is atmospheric pollution from the use of fossil fuel, traffic density and dust. This research was carried out to investigate the presence of Cr, Mn, Ni, Co, Cu, Cd, Zn and Pb were investigated in four of the most commonly consumed vegetables in the Southern part of Nigeria. These vegetables are fluted pumpkin (*Telfairia occidentalis*), Bitter leaf (*Vernonia amygdalina*), Scent leaf (*Ocimum gratissimum*) and Water leaf (*Talinum triangulaire*). The metal analysis results showed the concentrations (mg/kg) as follows; Cr (1.50-10.25), Mn (9.75-62.75), Ni (15.75-19.25), Co (1.75-3.00), Cu (7.75-11.00), Cd (1.25-1.50), Zn (79.75-186.95) and Pb (6.25-8.00). The concentrations of the metals are in the order of Zn>Mn>Ni>Cu>Pb>Cr>Co>Cd. Water leaf has the highest concentration of the metals Zn, Mn, Ni, Co, Cr and Cd. Fluted pumpkin has the second highest concentration of Mn and the highest for Cu. The leaves under study reveal high concentrations of these heavy metals which were found to be above the FAO and WHO acceptable limits. These high values can be attributed firstly to atmospheric pollution as the cottage farm is a few meters away from a major highway and most of these metals are constituents of fossil fuel and machinery. Ni, Cd and Pb are classified as carcinogens. This therefore implies that the consumption of these vegetables will eventually lead to serious health problems in the organs and circulatory systems.

Keywords: Atmospheric pollution, carcinogens, fossil fuel, highway, metal analysis, toxicity

INTRODUCTION

Vegetables are important ingredient of human diet that contains essential nutrients and trace elements. Some of these vegetables are used in making our traditional soups or served as intergral parts of the main course of a meal. Bitter Leaf (*Vernonia amygdalina*) is a common and popular vegetable among the people of West Africa and is used in many delicacies in Nigeria, Ghana and Cameroon. It is also a common vegetable to Central East Africa. This plant plays important roles in the nutrition and traditional medicine (Hamowa, 1994) commonly used as antihelminthes, antipyretic, antitumors agents and for cough.

Scent leaf (*Ocimum gratissimum*) is a perennial plant which is widely distributed in the tropics of Africa and Asia. In Nigeria it is a widely used local plant used for both nutritional and therapentic purposes.

Water leaf (*Talinum triangulare*) is a herbaceous plant grown on a large scale by communities living in the Western and Southern parts of Nigeria. It has a narrow succulent foliage which makes it a very much desired vegetable in our traditional "vegetable soup". It helps in enzyme activities in the body and is used as a component of some herbal medicine preparation.

Fluted pumpkin (*Telfairia occidentalis*) is a creeping vegetable that produces luxuriant edible green leaves which are rich in iron and vitamins. It is a popular vegetable all over Nigeria and its high growth rate is preferred by farmers because of its quick returns. It is a rich source of vitamin A, C and K used in the treatment of anaemia and a raw material in pharmaceutical industries in the preparation of blood tonics.

Leafy vegetables occupy a very important place in the human diet, but unfortunately are sources of heavy metal accumulation (Abdulla and Chielnicka, 1990). Although some heavy metals such as Cu, Ni, Zn, Mn and Fe are essential in plant nutrition and enzymatic action, many of them do not play significant role in plant physiology.

Studies carried out by Al-Jassir *et al*. (2005) revealed that leafy vegetables accumulate higher metals concentration than others. Heavy metals such as Pb, Co, Zn, Cr, Fe, Ni and Cd were examined in selected fruits and vegetables sold in a local market in Egypt (Radwan

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and Salama, 2006) and the results showed high concentration of these metals.

Eslami *et al*. (2007) in their investigation of heavy metal concentration in the roots of radish, leek, sweet basil and parsely discovered that some of them were contaminated with high levels of heavy metals beyond the levels given by FAO and WHO for human consumptions.

Risk of Cd and Pb ingestion to the population of the Uganda Capital located close to lake Victoria has been reported (Jolocan *et al*., 2010). Studies by Akan *et al*. (2009) on some samples of vegetables in an industrial area in Kano, Nigeria revealed high concentrations of the heavy metals in the leaves of the vegetables studied These concentrations were much higher than the WHO acceptable limits.

Echem and Kabari (2012) carried out studies on the heavy metal content in Bitter leaf (*Vernonia amygdalina*) grown along heavy traffic routes in Port Harcourt and their result showed that the use of pesticides, insecticides and heavy metals in industries has led to widespread environmental contamination. Some of these compounds are object of study on account of their toxicity and ubiquity. Moreover, they are known to remain stable in the aquatic environment (Samanta *et al*., 2005; Singh and Jaswant, 2006). Some common vegetables are capable of accumulating high levels of heavy metals from contaminated and polluted soils (Cobb *et al*., 2000; Benson and Ebong, 2005).

This research is aimed at investigating the presence and concentrations of some of the heavy metals on the edible vegetables from this farm which is proximate to a highway where there is a lot of vehicular traffic.

METHODOLOGY

The vegetable samples for bitter leaf (*Vernonia amygdalina*), scent leaf (*Ocimum gratissimum*), water leaf (*Talinum triangulare*) and fluted pumpkin (*Telfairia occidentalis*), were collected from the farm in triplicate, labeled and transported to the laboratory for subsequent digestion and analysis.

Since the method chosen for a particular analysis is dependent on the reason for the analysis, wet ashing is used in the preparation of the vegetable samples to avoid loss of some of the metals by high temperature (dry) ashing.

The samples were air dried in the open and then ground in a blender. From the powder, 2 g of each vegetable was weighed out and transferred into flasks.

A mixture of concentrated trioxonitrate (V) acid, HNO_3 and tetraoxochlorate (VII) acid, $HClO_4$ in the ratio (4:1) was added and brought to boil for 4hrs.After the samples were completely digested, they were allowed to cool, then filtered with Whatman filter paper and transferred into a 50 mL volumetric flask and made up to mark with deionized water.

The metal concentrations in these vegetable samples were determined using Buck Scientific Atomic Absorption Spectrpophotometer 205. The heavy metals analysed were Cr, Mn, Ni, Co, Cu, Cd, Zn and Pb.

RESULTS

The results for the various metal concentrations for bitter leaf (*Vernonia amygdalina*), Scent leaf (*Ocimum*

Table 1: Heavy metals concentration for the vegetable samples; Concentration (mg/kg)

	Cr	Mn	Ni	Co	Cu	Cd	Zn	Pb
Bitter leaf	2.25	37.25	15.75	2.25	8.00	1.50	90.50	6.25
Scent leaf	1.50	9.75	19.25	3.50	9.75	1.50	111.25	8.00
Water leaf	5.75	62.75	19.00	3.00	7.75	1.50	186.75	7.00
Fluted pumpkin	1.75	42.50	16.75	1.75	11.00	1.25	79.75	6.75
Min	1.50	9.75	15.75	1.75	7.75	1.25	79.75	6.25
Max	5.75	62.75	19.25	3.50	11.00	1.50	186.75	8.00
Median	2.00	39.88	17.88	2.63	8.88	1.50	100.88	6.88
Geometric mean	2.41	31.37	17.62	2.54	9.03	1.43	110.66	6.97
Arithmetic mean	2.81	38.06	17.69	2.63	9.13	1.44	117.06	7.00

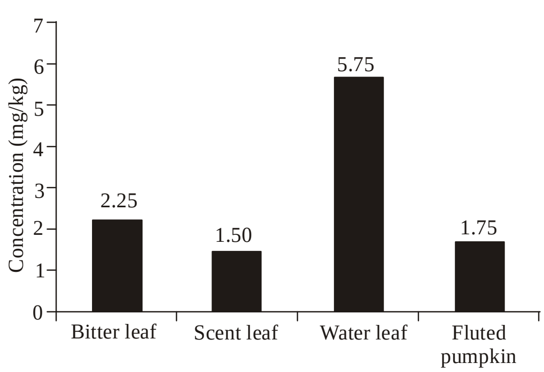

Fig. 1: Cr concentrations for the vegetable samples

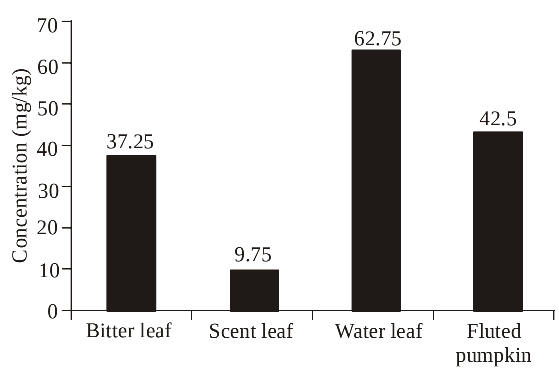

Fig. 2: Mn concentrations for the vegetable samples

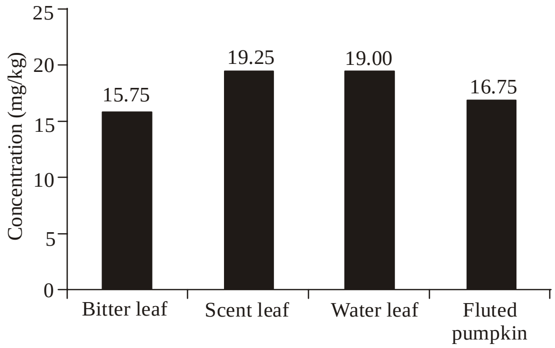

Fig. 3: Ni concentrations for the vegetable samples

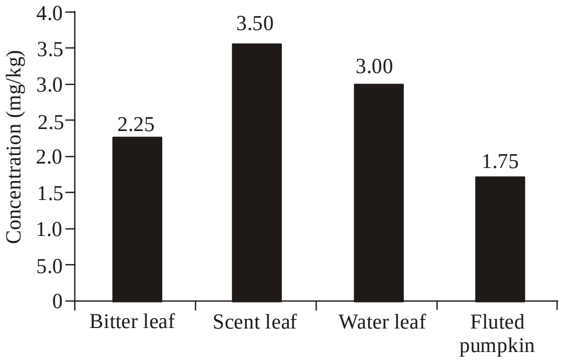

Fig. 4: Co concentrations for the vegetable samples

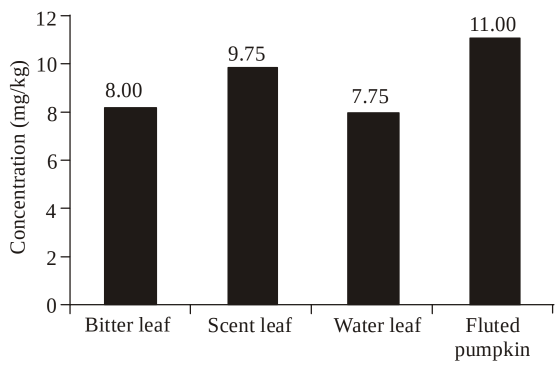

Fig. 5: Cu concentrations for the vegetable samples

gratissimum), water leaf (*Talinum triangulare*) and fluted pumpkin (*Telfairia occidentalis*) are presented as follows:

Bitter leaf-Cr (2.25 mg/kg), Mn (37.25mg/kg), Ni (15.75 mg/kg), Co (2.25 mg/kg), Cu (8.00 mg/kg), Cd (1.50 mg/kg), Zn (90.50 mg/kg) and Pb (8.00 mg/kg).

Scent leaf-Cr (1.50 mg/kg), Mn (9.75 mg/kg), Ni (19.25 mg/kg), Co (3.50 mg/kg), Cu (9.75 mg/kg), Cd (1.50 mg/kg), Zn (111.25 mg/kg) and Pb (8.00 mg/kg).

Water leaf-Cr (5.75 mg/kg), Mn (62.75 mg/kg), Ni (19.00 mg/kg), Co (3.00 mg/kg), Cu (7.75 mg/kg), Cd (1.50 mg/kg), Zn (79.75 mg/kg) and Pb (7.00 mg/kg).

Fluted pumpkin-Cr (1.75 mg/kg), Mn (42.50 mg/kg), Ni (16.75 mg/kg), Co (1.75 mg/kg), Cu (11.00 mg/kg), Cd (1.25 mg/kg), Zn (79.75 mg/kg) and Pb (6.75 mg/kg).

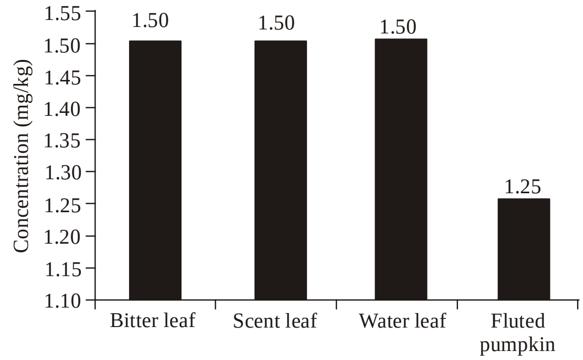

Fig. 6: Cd concentrations for the vegetable samples

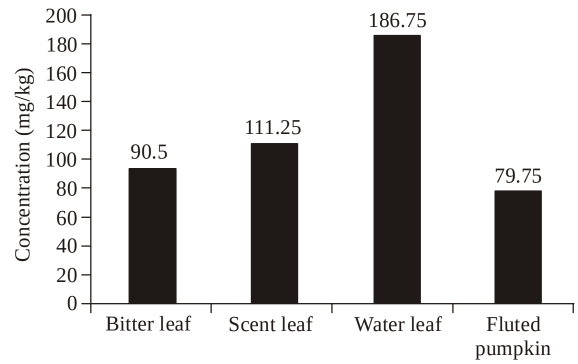

Fig. 7: Zn concentrations for the vegetable samples

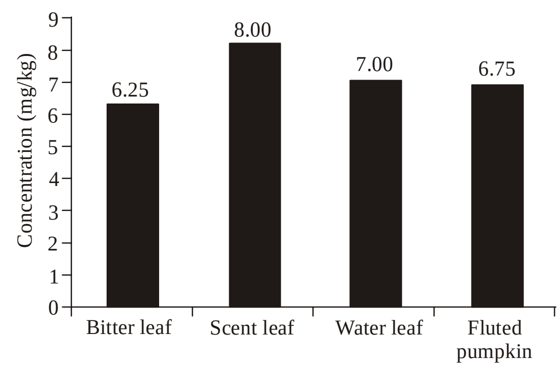

Fig. 8: Pb concentrations for the vegetable samples

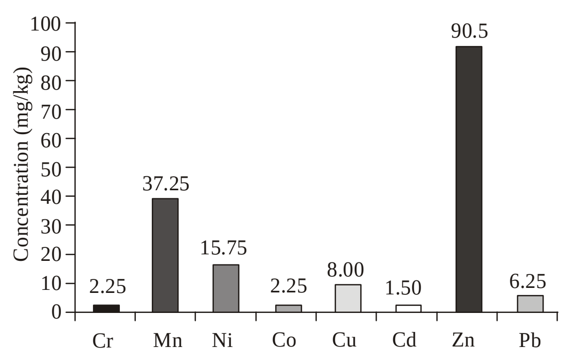

Fig. 9: Bitter leaf

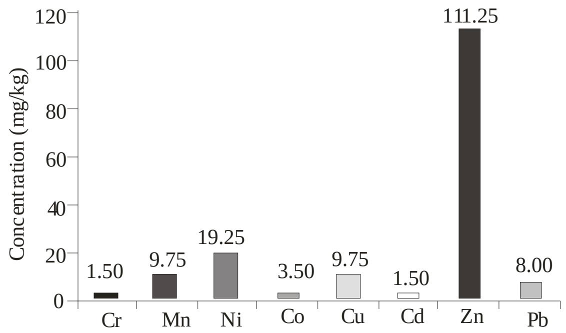

Fig. 10: Scent leaf

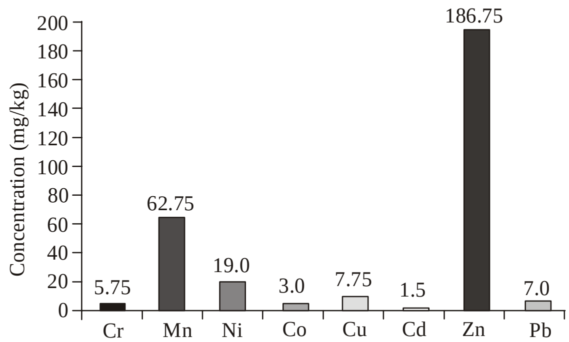

Fig. 11: Water leaf

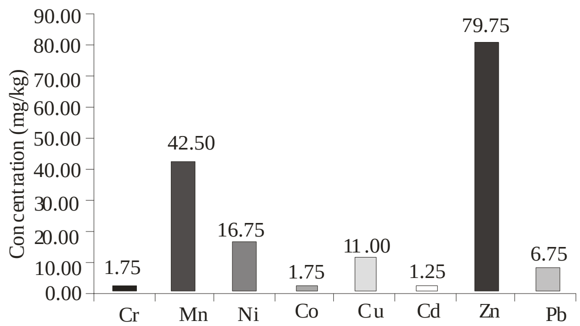

Fig. 12: Fluted pumpkin

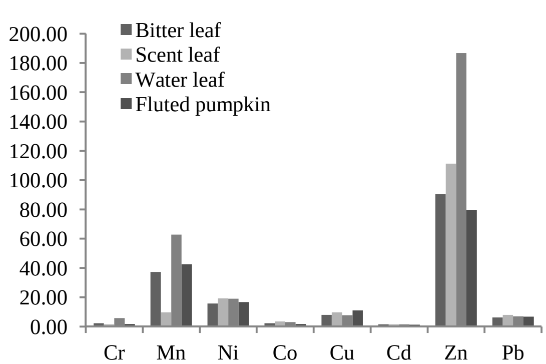

Fig. 13: Mean concentrations of the metals in the vegetable samples

Table 2: FAO Acceptable limits mg/kg (2005)

Cr	Mn	Ni	Co	Cu	Cd	Zn	Pb
0.08	2.00	0.20	1.10	0.20	0.01	5.00	0.01

Table 3: WHO Acceptable limits mg/kg (2005)

Cr	Mn	Ni	Co	Cu	Cd	Zn	Pb
0.85	0.30	0.14	2.00	0.02	0.10	5.00	0.01

These are summarized in Table 1 and presented in Fig. 1 to 8. The concentrations of all the metals for the four edible vegetables are presented in Fig. 9 to 12.

Table 2 and 3 show the acceptable limits for these metals by FAO/WHO (2005), respectively. The mean concentrations of all the eight metals analysed in the vegetable samples are presented in Fig. 13.

DISCUSSION

Heavy metals concentrations in the soil are associated with biological and geochemical cycles which are influenced by anthropogenic activities such as agricultural practices and waste disposal methods (Ndiokwere and Ezehe, 1990; Zauyah *et al*., 2004; Usman *et al*., 2002). Heavy metals contamination affects the nutritive values of agricultural products and erases the benefits required from consuming them. Cr, Cu, Ni and Zn are beneficial to man at lower and standard concentrations. Cr, Ni and Zn have been suggested as essential trace elements in nutrition. Their functions include regulation of apoptosis, activation of depressed immune system and as co factors for metaloenzymes (Gbaruko and Friday, 2007).

Cr (III) is an essential element required for normal sugar and fat metabolism. It is effective to the management of diabetes and it is a cofactor with insulin. Cr (III) and its compounds are not considered a health hazard, while the toxicity and carcinogenic properties of Cr (VI) have been known for a long time (Barceloux, 1999). High concentrations can be found in the liver, kidney, spleen and bones. Cr (VI) is not beneficial to man and it is the one most prevalent in the environment. The concentration range is 1.50 mg/kg (bitter leaf) to 5.75 mg/kg (water leaf). This is 72 times higher than the acceptable limit for FAO (0.08 mg/kg) which is presented in Table 2.

The acute toxicity of Cr (VI) is due to its strong oxidative properties. In the blood stream, it damages the kidneys, the liver and blood cells through, oxidation reactions. Haemolysis, renal and liver failure are the results of these damages (Dayan and Paine, 2001). Mn is an important element responsible for the function of the pituitary gland and promotes hepatorenal functions. However, it is capable of causing brain and nerve damage, forgetfulness and other health problems when present in high concentrations, as is seen in the result presented in Table 1. Scent leaf has the least concentration (9.75 mg/kg) and waterleaf the highest (62.75 mg/kg). The average value is 38.1 mg/kg which is very high.

Ni is involved in fat metabolism and acid in fat deposition (Goyer, 1995). It also plays some role in body function including enzyme functions and occurs naturally more in plants than in animal flesh. It activates some enzymes systems in trace amount but its toxicity at higher levels is more prominent (Divrikli *et al*., 2006). It functions as a biocatalyst required for body pigmentation in addition to iron, maintains a healthy central nervous system, prevents anaemia and interrelates with the function of Zn and Fe in the body (Akinyele and and Osibanjo, 1982). Some Ni metal dust and soluble compounds are believed to be carcinogenic (Kasprzak *et al*., 2003; Dunnick *et al*., 1995). The concentration range for Ni is 15.75 mg/kg (Bitter leaf) to 19.25 mg/kg (scent leaf) and an average of 17.69 mg/kg. The levels are 110 to 138 times higher than the WHO acceptable limits (Table 3). Cu is an essential authentic micronutrient which functions as a biocatalyst required for body pigmentation in addition to iron. It helps maintain a healthy central nervous system, prevents anaemia and interrelated with the functions of Zn and Fe in the body (Akinyele and and Osibanjo, 1982). High concentration of Cu may be linked to liver cancer and brain tumors (Ellis and Salt, 2003). Cu does not break down from the environment therefore it accumulates in plants. The average concentration of Cu found in the four vegetable samples is 9.13 mg/kg with a range of 7.75-11.00 mg/kg. The lowest concentration is recorded for water leaf and the highest is fluted pumpkin respectively.

Co is an intergral component of the vitamin B_{12} molecule. It is required in the manufacture of red blood cells and in preventing anaemia. An excessive intake of cobalt may cause the overproduction of red blood cells. Though Co is an essential element in minute quantities at higher levels of exposure it shows mutagenic and carcinogenic effects similar to Ni. The concentration range for these vegetable samples is from 1.75-3.50 mg/kg in fluted pumpkin and scent leaf, respectively. The average concentration is 2.63 mg/kg. Cd is a non-essential element and very actually displaces Zn in some of its important enzymatic and organ functions. Thus the Zn-Cd ratio is very important as Cd toxicity and storage are greatly increased with Zn deficiency. It accumulates principally in the kidneys and liver (Divrikli *et al*., 2006). Cd and several Cd compounds are known carcinogens and can induce many types of cancer. (Saplakogelu and Iscan, 1997) have reported that long-term intake of Cd caused renal, prostrate and ovarian cancers. Long period of exposure may lead to kidney failure and permanent lung damage (Cobb *et al*., 2000). The results revealed that bitter leaf, scent leaf and waterleaf had Cd concentrations of 1.50 mg/kg while fluted pumpkin had 1.25 mg/kg. These levels are 15 to 12.5 times higher than the WHO acceptable limits (Table 3). The results are higher than that obtained in other published work (Oti Wilberforce and Nwabue, 2013; Echem and Kabari, 2012; Otitoju *et al*., 2012). Zinc is one of the important metals needed by the body for normal growth and development of the sexual organs. It stimulates the activity of vitamin formation of red and white corpuscles (Claude and Paule, 1979). Zinc facilitates the process of wound healing. High levels of Zn can lead to urinary tract infection, kidney stones and even kidney failure.

Concentrations of Zn in the vegetable samples are outrageously high (79.75-186.75 mg/kg). The lowest being recorded for fluted pumpkin and the highest for waterleaf. Bitter leaf and scentleaf recorded 90.50 mg/kg and 111.25 mg/kg, respectively. These high concentrations are similar to the observed results by Odukoya *et al*. (2000). They attributed the source of Zn to domestic refuse, construction materials, motor vehicle emmisions and motor vehicle wear. Large quantities of Zn may cause anaemia, nervous system disorders, damage to the pancreas and low levels of "good" cholesterol. Pb is toxic to the body and is not required even in the smallest quantity. It accumulates in the bones and teeth causing weakness in the wrist and joints leading to brittle bones. It affects the central nervous system, kidney and liver. The concentration of Pb in the four vegetables studied is 6.25 to 8.00 mg/kg (bitterleaf and scentleaf, respectively) which is higher them that reported by Echem and Kabari (2012) and Oti Wilberforce and Nwabue (2013). Waterleaf had a concentration of 7.00 mg/kg and fluted pumpkin, a concentration of 6.75 mg/kg.

Figure 9 shows concentrations of these metals in bitterleaf (*Vernonia amygdalina*) in the order of Zn>Mn>Ni>Cu>Pb>Cr = Co>Cd. Figure 10 shows the metal concentrations for scent leaf (*Ocimum gratissimum*) in the order of Zn>Ni>Mn = Cu>Pb>Co>Cr = Cd. Concentrations of the metals in waterleaf (*Talinum triangulare*) are presented in Fig. 11 and are in the order of Zn>Mn>Ni>Cu>Pb>Cr>Co>Cd. Results for fluted pumpkin (*Telfairia occidentalis*) are presented in Fig. 12 and the metal concentrations are in the order of Zn>Mn>Ni>Cu>Pb>Cr = Co>Cd. Water leaf has the highest concentration of the metals Zn, Mn, Ni, Co, Cr and Cd followed by scent leaf. Fluted pumpkin ranks second in the concentrations of Mn and the highest for Cu.

CONCLUSION

The results obtained for the four vegetables under study for the eight heavy metals show that they are all above the FAO and WHO acceptable limits. This therefore implies that the consumption of these vegetables is risky as this will lead to a lot of health problems. As regular consumption of these vegetable will expose the consumers to heavy metal toxicity as the years go by. The high levels recorded for Zn may be as a result of improper disposal of roofing sheets Zn containing wastes and vehicular emissions.

RECOMMENDATIONS

It is recommended that the government set up agencies to embark on sensitization campaign to create awareness on the siting of farms close to high traffic roadways as most of these heavy metals are as a result of fossil fuel combustions. Indiscriminate dumping and discharge of wastes should be curbed. Cd and Ni have been reported to come from the Cd-Ni batteries. Buses and diesel driven vehicles emit significant amount of Cd to the environment and this can spread through the air.

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