Chapter 10

Heavy Metal Content in Bitter Leaf (*Vernonia amygdalina*) Grown Along Heavy Traffic Routes in Port Harcourt

Ogbonda G. Echem and L. G. Kabari

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/55604

1. Introduction

The herb known as bitter leaf *(Vernonia amygdalina)* is a shrub or small tree that can reach 23 feet in height when fully grown. Bitter leaf has a grey or brown coloured bark, which has a rough texture and is flaked. The herb is an indigenous African plant; which grows in most parts of sub-Saharan Africa. The East African country of Tanzania is traditionally linked to this plant and can be found growing wild along the edges of agricultural fields. It is a medicinal plant and fresh bitter leaf is of great importance in human diet because of the presence of vitamins and mineral salts (Sobukola et al., 2007).

It is a very important protective food and useful for the maintenance of health and prevention and treatment of various diseases. Some principal chemical constituents found in bitter leaf herb are a class of compounds called steroid glycosides- type vernonioside B1 – these chemical substances possess a potent anti-parasitic, anti-tumour, and bactericidal effect. The bitter leaf is mainly employed as an agent in treating schistsomiasis, which is a disease caused by parasitic worms. It is also useful in the treatment of diarrhoea and general physical malaise.

Remedies made from bitter leaf are used in treating 25 common ailments in sub- Saharan African, these include common problems such as fever, and different kinds of intestine complaints, as well as parasite-induced diseases like malaria. Bitter leaf also helps to cleanse such vital organs of the body like the liver and the kidney. Bitter leaf is also used in the treatment of skin infections such as ringworm, rashes and eczema. However, bitter leaf and other vegetables contain both essential and toxic metals over a wide range of concentrations (Radwan and Salama, 2006).

2. Heavy metal

This is a member of an ill-defined subset of an element that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanides and actinides. Many different definitions have been proposed - some based on density, some based on atomic number or atomic weight and some on chemical properties or toxicity (Purseglove, 1977)

The primary anthropogenic sources of heavy metals are point sources such as mines, foundries, smelters, coal-burning power plants, and other sources such as combustion of wastes, and vehicle emissions. Some investigations carried out have shown that heavy metal accumulation in vegetables may pose a direct threat to human health.

Vegetables ingest metals by absorbing them from contaminated soil as well from deposits on different parts of the vegetable exposed to the metal from polluted environments. Many heavy metals act as biological poisons even at parts per billion (ppb) levels.

The distribution of heavy metals (such as iron, copper, manganese, lead, chromium and zinc) in leaves, stems and roots of fluted pumpkin (*Telfeiria occidentalis*) were investigated at three different street roads in Cross River State of Nigeria (Edem et al., 2009). The streets were Afokang, Anantigha and Eneobong. The result showed that, the concentrations of Fe, Mn, Pb and Cr were highest in the leaves.

Also, Afokang Street with the heaviest vehicular traffic out of the three streets recorded the highest concentration of Pb in the leaves of the plants. This may be attributed to the high level of exhaust emissions from vehicles plying the road.

Ademoronti (1986) in his findings on a study carried out in Benin, Nigeria, showed that lead deposits on bark of trees were found to vary according to traffic volumes; areas of high traffic volume recorded higher concentrations of lead. Further studies have revealed that lead does not readily accumulate in the fruiting part of vegetables and crops (e.g., corn, beans, tomatoes, apples and berries); a higher concentration of lead is most likely to be found in leafy vegetables and on the surface of roots crops.

According to Ademoronti (1986), plants accumulate minerals essential for their growth from the environment and also accumulate metals such as cadmium (Cd) and chromium (Cr) which have no known direct benefit to the plants (Brook and Robinson 1989). From Ademoroti’s (1995) findings, cadmium is present in low concentrations in vegetable leaves, entering the human body through diet. The mechanism of trace metals’ movement within plants was investigated by Walsh (1971). He found that most metals become chelated by a relatively simple agent in xylem sap.

The iron content of normal plant tissue varies with the plant species, but it is usually between the range of 20 - 200mg/kg dry matter (Walsh, 1971). The cobalt content of a normal plant is usually within the range of 0.01 – 1.00mg/kg dry matter (Walsh, 1971). Lead is toxic to crops at concentration range of 3 -20 ppm depending on the plant species; and to animals at a concentration of 1mg/day (Bowen, 1979). Zinc is an essential mineral involved in catalytic functions and is important for both man and plants health and growth (Jeffery, 1992). The zinc content of normal plants tissues varies according to plant species, but it is usually within the range of 5 – 300mg/kg dry matter (Walsh, 1971).

Generally vegetables appear to have the highest and lowest amount of heavy metals accumulated in their leaves and seed respectively e.g. beans, peppers, tomatoes, melons and peas show very low intake of heavy metals in their seed. Plant intake of heavy metals varies with soil P^H. A study by Echem (2010) on cassava cultivated on oil polluted soil showed that soil contaminated with heavy metals cause contamination of foodstuffs.

Heavy metals are associated with myriad adverse health effects, including allergic reaction, nephrotoxicity, and cancer. Humans are often exposed to heavy metals in various ways - mainly through the inhalation of metals in the workplace or polluted neighbourhoods, or through the ingestion of food that contains high levels of heavy metals or paint chips that contain lead Ifon, (1977).

The three heavy metals commonly cited as being of the greatest public health concern are cadmium, lead and mercury. There is no biological need for any of these three heavy metals. Exposure to cadmium can result in emphysema, renal failure, cardiovascular disease and perhaps cancer. The primary adverse health effect from exposure to lead is neurological impairment (particularly in children). Other adverse health effects associated with lead include sterility in males and nephrotoxicity.

Heavy metals have been reported to play positive and negative roles in human life (Slavesk et al., 1998; Divrikli et al., 2003; Dundar and Saglam, 2004). Some heavy metals like cadmium, lead and mercury are major contaminants of food supply and may be considered as very harmful to the environment since they do not biodegrade while others like iron, zinc and copper are essential for biochemical reactions in the body (Zaidi et al., 2005). Jarup (2003) and Sathawera et al., (2004) have reported that, most heavy metals are not biodegradable, have long biological half-lives and have the potential for accumulation in the different body organs leading to unwanted side effects. There is a strong link between micronutrient of plants, animals and humans, and the uptake and impact of contaminants in these organisms (Yuzbas, et al., 2003; Yaman et al., 2005).

Research findings by Divrikli et al. (2006) had shown that the concentration of essential elements in plants is conditional; it is affected by the characteristics of the soil and the ability of plants to selectively accumulate some metals. Sources of heavy metals for plants include rainfall in atmospheric polluted areas, heavy traffic as a result of high discharge of exhaust effluents- indiscriminate disposal of oil or fossil fuels by road side mechanics, - plant protection chemicals and fertilizers which could be absorbed through leaf blades (Kovacheva et al., 2000; Lozak et al., 2002; Sobukola et al., 2006).

The aim of this research is to ascertain the level of heavy metals ingested by bitter leaf grown along heavy traffic routes. It is a well established fact that diesel, gasoline, lubricants, vehicle parts such as carburettors among others, contain heavy metals. The routes chosen for this study record the highest traffic density for heavy duty vehicles, lorries, buses and cars in Rivers State; this is due to the presence of Onne Sea Port, Eleme and Port Harcourt Refineries, Eleme Petrochemicals among others on one hand, and the movement of goods and persons between Aba and Port Harcourt on the other. On these routes, it is common to see vehicles under- going various types of repairs, mechanic workshops and heavy exhaust emissions, and these invariably become the primary source of pollution to the road side soils. Symptoms associated with acute oral zinc dose are vascular shock, vomiting, diarrhoea, pancreatitis and damage of hepatic parenchyma. Consequently, crop plants growing on heavy metal contaminated medium can accumulate high concentrations of trace metals causing serious health risks to consumers.

3. Hypothesis

H_O: There is significant difference in the mean concentration of heavy metals in bitter leaf cultivated along heavy traffic route from the ones cultivated away from the routes.

H_A: There is no significant difference in the mean concentration of heavy metals in bitter leaf cultivated along heavy traffic routes from the ones cultivated away from the routes.

3.1. Materials and methods

The materials used for this study include among others bitter leaf, stainless steel knife, laboratory grinder, polythene bags, desiccator, analytical balance, platinum crucible, muffle furnace, hydrochloric acid, volumetric flask, distilled water and atomic absorption spectrophotometer.

3.2. Study area

The research was carried out in three different heavy traffic vehicular routes in Rivers State. These routes are: Eleme Junction – Aba Road, Eleme Junction – Akpajo Road and Akpajo – Refinery Junction. The control location was Kina Gbara Street in Bori, Khana Local Government Area.

3.3. Sample collection and preparation

The bitter leaf samples were obtained from the four stated locations. The bitter leaf were harvested from two different sites per location; and then put into separate polythene bags and labelled accordingly. They were then taken immediately to the laboratory for preparation and analysis.

The bitter leaf (*Vernonia amygdalina)* samples were washed with tap water and thoroughly rinsed with distilled water, then dried in an oven at 105°C. They were then pulverized to fine powder using a laboratory grinder. The fine powder was put into polythene bags and preserved in the desiccator. 3.0g of each sample was accurately weighed into clean platinum crucible and ashed at 450-500°C, then cooled to room temperature in the desiccator. The ash was dissolved in 5ml of 20% hydrochloric acid and the solution was carefully transferred into a 100ml volumetric flask. The solution was filtered using Whatman No 1 filter paper (Umoren and Onianwa, 2005) into a 50ml volumetric flask and made up to the mark with distilled deionised water. The samples were taken to the Shimadzu atomic absorption spectrophotometer (model 6650) for aspiration.

The determination of heavy metal (Fe, Zn, Cr, Pb and Cd) content of the sample solution was carried out in accordance with the procedure of the AOAC (1984) on dry samples.

4. Results and discussion

The results of the heavy metal analysis of the bitter leaf samples are shown in table 1.

Sample	Location	Fe	Pb	Cr	Cd	Zn
Bitter Leaf	PH-Aba Road	2.96	0.220	0.030	ND	0.890
Bitter leaf	Akpajo-Eleme Road	3.43	0.405	0.052	ND	1.08
Bitter leaf	Refinary-Akpajo Road	3.27	0.350	0.041	ND	1.12
Mean		3.22	0.325	0.042	ND	1.03
Bitter leaf	Kina Gbara Street	2.21	0.156	0.024	ND	0.84

ND = not detected.

Table 1. Concentration (mg/kg) of heavy metal in bitter leaf

The results in table 1 show that the concentrations (mg/kg) of the heavy metals fall within the following range: iron (Fe) is 2.21 to 3.43, lead (Pb) is 0.156 to 0.405, chromium (Cr) is 0.024 to 0.052, zinc (Zn) is 0.840 to 1.12, while Cadmium (Cd) was not detected in any of the locations.

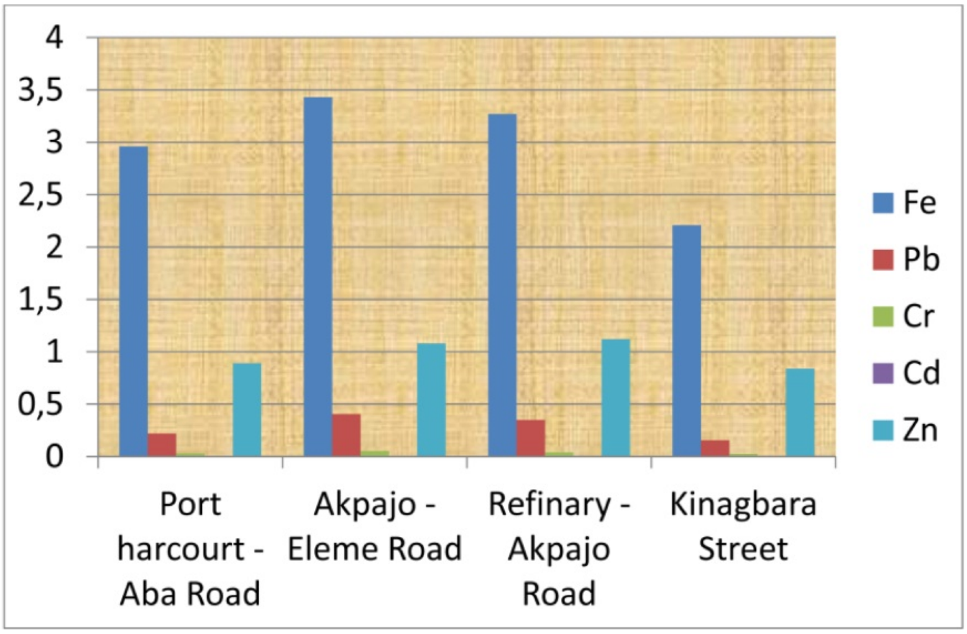

Figure 1. Bar Chart for the concentration of heavy metals

The order of concentration of each heavy metal in the bitter leaf harvested from all the studied locations is: iron (Fe) in bitter leaf harvested along Akpajo - Eleme Junction Road soil > Refinery - Akpajo Junction Road soil > Port Harcourt – Aba Road soil > Kina Gbara Street soil (Bori); lead (Pb) in bitter leaf harvested along Akpajo Road soil – Eleme Junction Road soil > Refinery – Akpajo Junction Road soil > Port Harcourt – Aba Road soil > Kina Gbara street soil (Bori); chromium (Cr) in bitter leaf harvested along Akpajo-Eleme Junction Road soil > Refinery – Akpajo Junction Road soil > Port Harcourt Aba Road soil > Kina Gbara street(Bori).

Zinc (Zn) in Refinery – Akpajo Junction Road soil > Akpajo – Eleme Junction Road soil > Port Harcourt – Aba Road soil > Kina Gbara street soil (Bori). The results further reveal that; the high concentration of iron (Fe), lead (Pb), chromium (Cr) and Zinc (Zn) found in the leaves of the bitter leaf may be due to the high levels of exhaust emission from the vehicles plying these roads, (Edem et al., 2009).This view is further supported by the relative lower concentrations of the heavy metals found in the control sample collected in Bori. The level of concentration of Fe in the control sample in addition to the low concentration of toxic heavy metals makes it suitable for human consumption (Ifon, 1977). The high concentration of iron in bitter leaf might be attributed to the nature of the soil and sometimes by the presence of some bacterial that depends on Fe^{2+} for source of energy.

The results of the study indicate that the bitter leaf harvested along Akpajo – Eleme Junction Road had the highest concentration of iron (Fe), lead (Pb) and chromium (Cr), compared to the one from Bori (control), while Refinery-Akpajo Junction Road had the second highest concentration of iron (Fe) lead (Pb) and chromium (Cr). The highest concentration of zinc (Zn) was also recorded along this route.

The findings of this study agree with the results of Edem et al. (2009) on levels of heavy metals in pumpkin leaves harvested in streets with heavy vehicular traffic in Cross River State and the report on the investigation of the deposit of lead on the bark of trees planted in areas of high traffic volume in Benin carried out by Ademoronti (1986).

The mean concentration of Pb (0.325) and Cr (0.041) in the sampled bitter leaf were above the WHO tolerable limit of 0.005 – 0.1 and 0.005 – 0.01 respectively. The bioaccumulation of these heavy metals has adverse health implications to man, especially in children and pregnant women (Dupler, 2001).

The high concentration of Fe reported in this study is in conformity with that published by Hart et al. (2005) on concentrations of trace metals (Pb, Fe, Cu and Zn) in crops harvested in some oil prospecting locations in Rivers State. The likely reason given for this high value of iron is the participation of green vegetables in the synthesis of ferrodoxin. However, the mean concentration of Fe (3.22) falls within the acceptable range (1.0 – 4.0mg/100g) as published by Platt (1980). The mean concentration of Zn (1.03) is also within the acceptable limit. However, from WHO (1984) report, excessive intake of Fe and Zn is capable of causing vomiting, dehydration, electrolytic imbalance and lack of muscular co-ordination.

By using chi-square x^2 , i.e.,

The expected value,

Where VT = Vertical Total
HT = Horizontal Total
GT = Ground Total.

Sample ID	Fe	Pb	Cr	Zn	Total
B. leaf (Ph Aba Road	2.96 (2.860)	0.220 (0.289)	0.030 (0.036)	0.890 (0.915)	4.10
B" Akpajo Etc.	3.43 (3.465)	0.405 (0.350)	0.052 (0.044)	1.08 (0.582)	4.967
B" Refinery and Akpajo Road	3.27 (3.335)	0.350 (0.337)	0.041 (0.042)	1.12 (1.067)	4.781
Total	**9.66**	**0.975**	**0.123**	**3.09**	**13.848**

, ,

, =0.350,

, ,

, ,

To find the chi-square,

=

.

= 0.0035 + 0.0004 + 0.0013 + 0.0165 + 0.0086 + 0.0005 + 0.001+ 0.0015 + 0.0000 + 0.0007 + 0.4261 + 0.0026

X^2 = 0.4601.

At 1% significant level i.e., 0.01

1 – 0.01 = 0.99

d.f = (n-1) (m-1) = (3–1) (4–1)

= (2) (3) = 6

Degree of freedom = d.f = 6

X^2 0.99, 6 = 0.872

Decision: since X^2 = 0.4601 is less than the critical value – 0.872, the null hypothesis (HO) is accepted and the alternative hypothesis (HI); is rejected.

Therefore, there is significant difference between B leaf (Bori) control and X^2 = 0.4601 at 1% significant level.

5. Conclusion

This study has shown that the mean concentration of heavy metals in bitter leaf harvested along heavy traffic route soil is significant compared with the one harvested away from these routes. The observed common practice of cultivating vegetables in the soil along heavy traffic routes in Port Harcourt will in the long run endanger consumers' health since the ingested heavy metals bioaccumulates in the human body. Consequently, there is a need for all the relevant government and non- governmental agencies to bring this to the knowledge of the general public.

Author details

Ogbonda G. Echem
Department of Science Laboratory Technology, Rivers State Polytechnic, Bori, Nigeria

L. G. Kabari
Department of Science Laboratory Technology, Rivers State Polytechnic, Bori, Nigeria
Member, IEEE, Department of Computer Science Rivers State Polytechnic, Bori, Nigeria

6. References

Ademoroti, C.M.A. (1996). Environmental Chemistry and Toxi Ecology, Folulex Press Ltd. Ibadan

Ademoroti, C.M.A. (1986). Environmental Chemistry and Toxi Ecology, Folulex Press Ltd. Ibadan

AOAC (1984). Official methods of analysis of the Association of Official Agricultural Chemists -12 Edn, AOAC, Washington, DC.

Bowen, H.J.M. (1979). Environmental Chemistry of Element Acad Press Inc Ltd, London pp.213-273.

Brooks, R.R. and Robinson, B.H. (1998). Aquatic Phytoremediation by Accumulator Plants CAB International, Wallingford pp.203-226.

Divrikli U., Saracoglu S., Soylak M., Elci L. (2003). Determination of trace heavy metal contents of green vegetable samples from Kayseri-Turkey by flame atomic absorption spectrometry. Fresenius Environ. Bull 12:1123-1125

Dupler, D. (2001). Heavy metals poisoning. Gale Encyclopedia of alternative medicine, Farmington Hills, pp. 23-26

Dundar M.S., and Saglam H.B. (2004). Determination of cadmium and vanadium in tea varieties and their infusions in comparison with infusion processes. Trace Ele. Elect 21:60-63

Edem C.A., Dosunmu I., Miranda I. and Bassey F., (2009). Distribution of heavy metals in leaves, stems and roots of fluted pumpkin (*Telfeira occidentalis)* Pak J. Nutrit, 8:222-224.

Hart A.D., Oboh C.A., Barimalaa I.S. and Sokari T.G. (2005). Concentrations of trace metals (lead, iron, copper and zinc) in crops harvested in some oil prospecting locations in Rivers State, Nigeria. African Journal of Floor and Nutritional Sciences Volume 5 no. 2

Ifon, E.T. (1977). The nutrient composition of some Nigerian leafy green vegetables and physiological availability of their iron content. Ph.D thesis, Department of Biochemistry University of Ibadan, Nigeria.

Jarup L. (2003) Hazards of heavy metals contamination. Br. Med. Bull 68:167-182

Jeffery, P.K. (1992). Environmental toxicology, Edward Arnold Ltd. London. 68-78.

Kovacheva P., Djingova R., Kuleff I. (2000). On the representative sampling of plants for multi-element analysis. Phyto. Bal. 6:91-102

Lozak A., Sotyk K., Ostapezuk P., Fijalek Z. (2002). Determination of selected trace elements in herbs and their infusions. Sci. Total Environ. 289:33-40.

Platt B.S. (1980). Tables of Representative Values of Foods Commonly Used in Tropical Countries. Medical Research Council. Special Report Series. No 302 (Revised Edition of SRS 253) London: Her Majesty's Stationery Office.

Purseglove J.W. (1977). Tropical crops dicotyledons (Volumes I and 2 combine). Longman, London.

Radwan M.A, and Salama A.K. (2006). Market basket survey for some heavy metals in Egyptian fruits and vegetables. Food Chem. Toxicol 44:1273 - 1278.

Sathawera N.G., Parikish D. J., Agrwal Y.K. (2004). Essentials heavy metal in environmental samples from western Indian. Bull Environ Cont. Toxical. 73:756 -761.

Slavesk R., Spirevska I., Stafilov T., Ristor T.(1998). The content of trace metals in some herbal teas and their aqueous extracts. Acta.Pharm. 48:201-2009.

Sobukola O. P., Dairo O. U. (2007). Modeling drying kinetics of fever leaves *(Ocimum viride*) in a convective hot air dryer Niger Food J. 25(1):145-153.

Sobukola O. P., Dairo O.U., Sanni L.O, Odunewu A. V., Fafiolu B.O. (2006). Thin layer drying process of some leafy vegetables under open sun. Food Sci. Technol. Int. 13(1):35-40

Umoren, I. U., and Onianwa, P.C.(2005). Concentration and distribution of some heavy metals in urban soil of Ibadan, Nigeria. Park J. Ind. Res., 48:397 – 401.

Walsh, L.M. (1971). Instrumental method of analysis of soil and plant tissues. Soil Science Society of America, Inc. Madison Wisconsin, USA. 26-30.

WHO (1984). Guideline for Drinking Water Quality. Health Criteria and Supporting Information 2: 63-315.

Yaman M., Okumus, N., Bakirdere, S., Akdeniz I. (2005) . Zinc Speciation in soil and relation with its concentration in fruits, Asian J. Chem. 17:66 -72.

Yuzbas N., Sezgin E., Yildirim M. Yildirim Z, (2003). Survey of lead, cadmium, iron, copper and Zinc in kasar cheese. Food Add. Cont. 20: 464-469.

Zaidi M. I., Asrar A., Mansoor A., Faroogui M.A. (2005) . The heavy metal concentration along roadsides of Quetta and its effects on public health J. Appl. Sci.5(4): 708-711.