DETERMINATION OF LEAD, CADMIUM AND CHROMIUM CONCENTRATIONS IN EDIBLE LEAFY VEGETABLES GROWN BY ROADSIDE SOILS IN MAKURDI TOWN

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Abstract— *The increased accumulation of trace metals on agricultural soils and edible plant parts has drawn the attention of the research community due to their toxic nature and cumulative effects.Vegetables are among the list of the most consumed perishable crops produced in Benue State.This study was aimed at determining Lead(Pb),Cadmium(Cd) and Chromium(Cr) concentrations in edible leafy vegetables namely; Bitterleaf(Vernonia amygdalina), Fluted Pumpkin(Telferia occidentalis) and Spinach(Spinaceae oleracea) grown by roadside soils in Makurdi town. Vegetable and soil samples were collected from roadsides of Wadata, Wurukum and Northbank areas of Makurdi, town. Direct reading Spectrophotometric methods were used to determine the concentrations (mg/kg) of trace metals (Lead, Cadmium and Chromium) in vegetable and soil samples. Mean concentrations of trace metals in soil samples was in the decreasing order of Lead (0.158)>Chromium (0.059)>Cadmium (0.009).Lower and upper range values of trace metal amounts in vegetable samples were recorded as Lead (0.460) (0.510), Cadmium (0.090) (0.140) and Chromium (0.030) (0.060) respectively. Lead and Cadmium concentrations in soil and vegetable samples were within FAO/WHO permissible limits while Chromium was above permissible limits. Trace metals accumulated more in fluted pumpkin than other vegetable samples under study.In an assessment to remove heavy metals in the vegetable edible prts under study,two washing methods were applied and results showed that the percentage reduction of trace metals in vegetable samples (Calculated as the percentage ratio of the difference between the unwashed and washed leaf metal concentrations to the unwashed leaf metal concentration) was higher (56%) in salt water washed (SW) vegetable samples compared to the warm water washed (WW) vegetable samples* (31%).*Chi-square was used to determine the statistical significance of the reduction of trace metals using the two washing methods, the study showed that there was no significant difference (P>0.05). High concentrations of trace metals were recorded in the unwashed to the washed vegetable samples. In conclusion, edible leafy vegetables grown by roadside soils in Makurdi town are prone to trace metal contamination; hence the need for routine mornitoring by relevant authorities of soil sites where vegetables are grown and washing them thoroughly with salt or warm water before consumption.*

Key words—Cadmium(Cd),Chromium(Cr),Edible leafy vegetables,Lead(Pb),Roadside soils,Salt water wash(SW),Warm water wash(WW).

1.0 INTRODUCTION

More than 90% of transportation in Nigeria is done via roads and more alarming is the concentration of these vehicles in cities.According to the Nationl Bureau of statistics,vehicle population in Nigeria as at the first quarter in 2017 is put at 11.46million. Road transport sector contributes to about 75% atmospheric emission of green house gases (Raji, 2017). The accumulation of trace metals in soils is largely dependent on the atmospheric deposits of gases from industrial and vehicular emssions which occur due to complete and incomplete combustion of leaded gasoline,other trace metal sources include, mining, smelting, sewage sludge disposal, application of pesticides and inorganic fertilizers, smoke and dust emissions of coal and gas fired power stations, laying of Lead sheets by roofers, Oil Leakage, surface run-off and the use of paints and other anti-rust agents (Akwaka and Sule, 2013; Zakir *et al*., 2014,John *et al*., 2012;Islam *et al*., 2016).

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This has posed a great challenge to our soil ecosystem and has altered some naturally occurring environmental processes such as microbial decomposition of organic matter in soils, self-purification of water bodies, atmospheric cleansing via precipitation and other interactions that takes place within the ecosphere (Quenea *et al*., 2009).

The uptake and bioaccumulation of trace metals in edible leafy vegetables are influenced by many factors such as climate, atmospheric depositions, road run-off, the nature of soils, the degree of maturity of plants at harvest and the concentrations of trace metals in soils (Xuedong *et al*., 2013, Adeniyi, 1996, De Nicola *et al*., 2008, Akwaka and Sule, 2013, Scott *et al.*, 1996 and Sobukola *et al*.,2010). Cultivation of areas near highways is also exposed to atmospheric pollution in the form of metal containing aerosols. These aerosols are deposited on soils, leaves and fruits and then absorbed. High accumulation of trace metals in edible leafy vegetables due to atmospheric depositions have been reported by a number of researchers.

Reports show that trace metals have been found in a variety of food stuffs such as dry or smoked fish, meat, spices, cocoa products and vegetables (Onianwa, 2005). Vegetables are an important component of daily diets. They contribute fibre, protein, vitamins and other nutrients that help reduce cancer risks, lower blood pressure and cholesterol levels, normalize digestion time, support retinal health and vision, fight free radicals and boost immune system (Doherty *et al*., 2011). Spinach (*Spinacia oleracea*), fluted pumpkin(*Telferia occidentalis*) and bitter leaf (*Vernonia amygdalina*)are used for both nutritional and medicinal purposes in Nigeria, often planted in home gardens or serve as fence for residences near highways which makes them prone to trace metal contamination via vehicular emissions or atmospheric depositions. The prolonged consumption of trace metals in food stuffs, most importantly vegetables, may lead to a wide range of adverse health effects such as upper gastrointestinal cancer, hypertension, reproductive toxicity, developmental effects and neurological disorders, some of which are irreversible (Atayese *et al*., 2009; WHO, 2000; Long *et al*., 2003).

1.1 Trace metals reduction in edible leafy vegetables by various washing methods

Some washing techniques have been used by various researchers to investigate the location of elements in foliage such as shaking the leaves with washing agent, immersing the sample in washing solution, mechanical cleanings etc. Also, various washing agents have been used to cleanse vegetables from dirts, debris and deposits, such as the singular use or combination of distilled water or tap water with chloroform or acetone hydrochloric acid, ammonium acetate solution, weak acid solution etc. Washing agent selection depends on the aim of the study, plant species, leaf structure and properties of accumulated elements (Ataabadi *et al*., 2012). Findings from other researchers show that unwashed vegetables samples contained high trace metals contamination levels compared to the washed samples (Ataabadi *et al*., 2012; Etem *et al*.,2013; Nazir *et al*.,2015).

1.2 Justification

Benue State is known for its high capacity for food production, and foremost on the list of perishable crops produced are edible leafy vegetables. There is therefore a great tendency for these vegetables to be contaminated with trace metals during production, transportation and marketing.

1.3 Aim

This study was aimed at determining the concentrations of Lead(Pb), Cadmium(Cd) and Chromium(Cr) in edible leafy vegetables cultivated by roadside soils in Makurdi town.

1.4 Objectives;

- To determine the concentrations of Lead, Cadmium and Chromium in edible leafy vegetables (Spinach, Fluted pumpkin and Bitterleaf).
- To ascertain the water removable fraction of trace metals using various treatment methods.

2.0 Materials and Methods

Sample site

Makurdi is the Capital of Benue State located in Central Nigeria. Its geographical coordinates are 7.44^0N and 8.32^0E with a population of over 500,000 people as at 2007(The world Gazetteer, 2007).Figure 1 below is a map of Makurdi showing the study location.

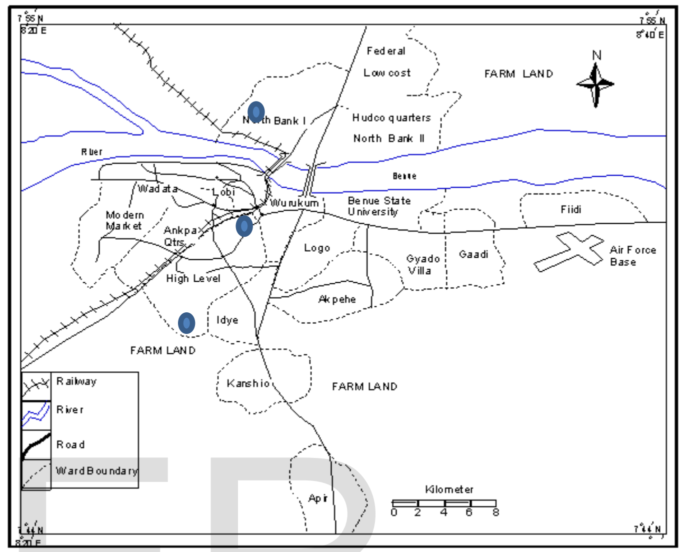

Fig.1: Map of Makurdi
Source: Federal Ministry of Land and Survey (2011).
: Sample collection sites

2.1 Sample collection

Soil samples and fresh mature vegetables samples (three months old) were collected from roadside farms of North bank, Wadata and Wurukum areas of Makurdi town for twenty one days at intervals of seven days during the morning hours (10-11am) of the day.

Similarly, a composite representation of vegetable and soil samples were collected from residential areas 15-20 meters away from roadside farms and used as control samples which will serve as a standard to which the contaminated samples will be compared with. These were then packaged in black polythene bags, labeled and transported to the laboratory.Figures 1-3 below shows the images of the vegetable samples that were collected.

Fig. 1: Fluted Pumpkin (*Telferia occidentalis*)

Fig.2: Spinach (*Spinacia olerecea*).

Fig. 3: Bitterleaf (*Vernonia amygdalina*).

2.2 Sample preparation

Using an electronic weighing machine, 0.6 kilograms each of spinach (*Spinacia oleracea*), fluted pumpkin (*Telferia occidentalis*) and bitter leaf (*Vernonia amygdalina*) were separated into three portions of 0.2kg(this stipulated quantity was such that all edible parts of the vegetable samples were included during the sample preparation process). Two of the three portions were to be subjected to different water washing techniques designated as warm water washed (WW) and salt water washed (SW) samples. While the other portion (0.2kg) of the vegetable samples was left unwashed (UW) to compare the difference in trace metal concentrations of the washed and unwashed samples. These were further chopped into small sizes using a kitchen knife and put in three separate plastic bowls labeled WW, SW and UW respectively. Vegetables in bowls labeled WW was washed in a liter of warm water at 40^0C for five minutes, while vegetables in bowls labeled SW was washed with one liter of tap water containing 0.017kg common salt (a fine-ground, refined and crystallized rock salt with nearly pure 95% or greater Sodium Chloride) for five minutes. The portion of vegetables (0.2kg) in bowls labeled UW was left unwashed.

Soil samples were air dried at room temperature for 12 days, grounded and filtered through a 2mm mesh sieve to obtain fine particles (Omoni *et al*., 2015).Vegetable samples were oven dried for 48 hours(until they were crispy) at 70^oC, pulverized and filtered using a 2mm mesh sieve to obtain fine particles(Islam *et al*.,2016). All vegetable and soil samples collected from the control sites were also subjected to similar treatments stated above.

2.3 Trace Metal analysis

Trace metals concentration in vegetable and soil samples were analysed using methods described by Awofolu(2005) and Abdullahi *et al.*(2007). Thus 0.5g each of dried vegetable or soil samples was weighed into a 5ml beaker. Five milligrams of concentrated nitric acid and 2mls of perchloric acid were added to digest the mixture.

The Direct reading Spectrophotometer (HACH, 2000,USA model) was used to determine the concentrations of trace metals (Pb, Cd and Cr) in the solutions.

3.0 Results and Discussion

Table 1 below shows trace metal concentrations of vegetable and soil samples collected from both treatment and control sites. The treatment sites samples were collected from roadsides of Wadata, Wurukum and Northbank areas of Makurdi, while control site samples were collected 15-20 meters away from roadside farms. Results showed that the treatment sites had more concentrations of trace metals compared to those from the control sites. This supports the findings of Oluwale *et al.* (2013) in Lagos who reported low mean concentrations of Copper(Cu) in control site(LASU Campus, 1.1392 ± 0.353) compared to treatment sites(LASU Iyana Iba road, 1.2215 ± 0.502 and Iyana Iba Market, 1.5368 ± 0.429) in their study. Hence, high levels of trace metals in vegetable samples from the treatment sites may probably be attributed to pollutants in irrigation water, farm soil or due to pollution from the highways traffic Qui et al. (2000) as cited in Oluwale *et al*. (2013).

Table 1: Trace Metal Concentrations (mg/kg) in Vegetable and Soil Samples from Treatment and Control Sites.

T.M.	Fluted Pumpkin		Spinach		Bitterleaf		Soil sample	
	Trt.	Cnt.	Trt.	Cnt.	Trt.	Cnt.	Trt.	Cnt.
Pb	0.140	0.110	0.120	0.090	0.090	0.070	0.158	0.120
Cd	0.060	0.040	0.040	0.030	0.030	0.020	0.009	0.007
Cr	0.510	0.480	0.490	0.450	0.460	0.430	0.059	0.055

Key:Trt.(Treatment), Cnt.(Control), T.M.(Trace metal)

Furthermore, the mean values of trace metal concentrations in washed (Warm and salt water) and unwashed vegetable samples are shown in Table 2 below,

Table 2 :Mean Values of Trace Metal Concentrations in washed(warm and salt water) and unwashed vegetable samples from treatment sites

Vegetable	Trace metal	UW	WW	SW	Safe Limits
Fluted Pumpkin	Pb	0.140	0.100	0.080	0.300
	Cd	0.060	0.040	0.003	0.200
	Cr	0.510	0.370	0.340	0.200
Spinach	Pb	0.120	0.070	0.050	0.300
	Cd	0.040	0.030	0.002	0.200
	Cr	0.490	0.340	0.310	0.200
Bitterleaf	Pb	0.090	0.050	0.040	0.300
	Cd	0.030	0.020	0.002	0.200
	Cr	0.460	0.031	0.0310	0.200

Key: Unwashed (UW), Warm Water Washed (WW), Salt Water Washed(SW).
Safe Limits:FAO/WHO, Codex Alimentarius Commission(2001).

Results in the above table show that the unwashed vegetable samples had higher trace metals concentration compared to the washed vegetable samples.

Findings in this study also showed that Lead (Pb) and Cadmium (Cd) with the exception of Chromium (Cr) were within FAO/WHO (2001) permissible limits. This agrees with the reports of Islam *et al.* (2016) in Bangledesh who reported Chromium (Cr) to have the strongest capacity of accumulation from soil to vegetables among other three elements(Ni,Pb and Cd).

However, Habib *et al*. (2012) recorded higher concentrations of Nickel compared to Lead and Cadmium on roadside soils and vegetables in Gazipur, Bangledesh. From these views, one may conclude that certain trace metals other than Lead (Pb) could accumulate more on roadside soils and vegetable samples. This may be attributed to the increased amounts of some trace metals in soils and the type of activities that takes place within the area of the sample location.

The magnitude of the accumulation of trace metals in vegetable samples was in the order of Fluted pumpkin> Spinach> bitter leaf. Higher concentration of trace metals observed in Fluted pumpkin compared to other vegetable samples is contrary to the findings of Aboho *et al.* (2010) who recorded high trace metal accumulation in Spinach than Fluted pumpkin. This could be due to the differences in the study location, the plant's morpho-physiology, leaf surface area exposure, absorbance rate, the excessive dumping of solid wastes on farmlands and the availability of these metals on the Earth Crust (Onianwa, 2005; Singh and Kumar, 2006).

The percentage reduction of trace metals in vegetable samples (Calculated as the percentage ratio of the difference between the unwashed and washed leaf metal concentrations to the unwashed leaf metal concentration) was higher (56%) in salt water washed (SW) vegetable samples compared to the warm water washed (WW) vegetable samples (31%).Although, there have been limited information on washing of edible leafy vegetables with water containing common salt for removal of trace metals , this study recorded high reduction rates of trace metals using this treatment method.

The trace metal reduction rates (31%) observed in this study using warm water to wash edible leafy vegetable samples supports the findings of Kharwade *et al*.(2014) who reported 23% reduction. He also noted that washing vegetables with warm water twice or three times reduces trace metals by 53-55 percent. However, some trace metals such as Cadmium and Chromium persists even after washing. Akwaka and Sule (2013) reported that Chromium cannot be removed by water washing; this may be accountable for the irremovable fraction of trace metals in vegetable samples observed in this study.

Results also show that there was no significant difference ($p>0.05$) in the comparative study showing the reduction of trace metals in vegetable samples using various water washing methods as shown in table 3 below.

Table 3: Results showing the statistical significance of water washing methods applied on vegetable samples

Vegetable	Treatment WW	SW	Total
Fluted pumpkin	1.420	1.175	2.595
Spinach	1.220	1.024	2.244
Bitterleaf	1.110	1.103	2.213
Total	3.750	3.299	7.032

X^2_{cal} = 0.017, df=6,p>0.05 no significant difference

Conclusion

In summary, roadside vegetable and soil samples are prone to trace metal contamination via vehicular emissions, atmospheric deposits, surface run-off and other industrial and domestic activities.

Findings from this study revealed that Lead (Pb) and Cadmium (Cd) concentrations in edible leafy vegetables and soil samples were within FAO/WHO(2001) permissible limits. However Chromium (Cr) concentration was above FAO/WHO permissible limits. Aside carcinogenic effects, Chromium could also have systemic, immunological, neurological, reproductive, and developmental and genotoxic effects which may equally lead to the death of the victim (Jacques, 2004).The U.S Environmental Protection Agency have listed Chromium as one of 129 priority pollutants and a potential harmful environmental contaminant due to its hazardous nature and toxicity.

A significant percentage reduction of trace metals in vegetables when washed with salt water was observed in this study. Therefore, the authors recommend that consumers should be enlightened on the need to wash their vegetables with warm or table salt water before consumption. Furthermore, there is the need for routine monitoring of soils where edible leafy vegetables are grown.

ACKNOWLEDGMENT

Author Donatus, Faith N. wish to acknowledge Prof.(Mrs) Amuta,E.U. and Prof. Imandeh, G.N. of the Department of Biological Sciences, Federal University of Agriculture, Makurdi, Benue State, Nigeria, for their immense contributions towards the success of the

completion of this research.

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