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SEASONAL INVESTIGATION OF HEAVY METAL CONCENTRATIONS IN VEGETABLES FROM OLUKU DUMPSITE AND A FARM LAND IN EDO STATE, NIGERIA.

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ABSTRACT

Without a doubt, plants take up toxic substances such as heavy metals which are transferred along the food chain. These constrain should not be overlooked due to the importance of vegetables in the human diet, hence this study was aimed to determine the heavy metal concentrations in green leafy vegetables from Oluku dumpsite and a nearby farm during the dry season (2020) and the rainy season (2021). In this study, samples (green leaves, water leaves, bitter leaves and fluted pumpkin leaves) were randomly collected and analyzed using the dry ashing method and atomic absorption spectrophotometry method. Results obtained showed that chromium and manganese concentrations were above the permissible limits set by FAO/WHO guideline values in all the samples, except bitter leaves which were within the FAO/WHO safe limit. The other heavy metals (mercury, lead, cobalt, cadmium and copper) analyzed were below the detectable limit of the atomic absorption spectrophotometer used. This study revealed that dumpsites and lands close to the dumpsite should not be used in the cultivation of vegetables because green leaves, water leaves and pumpkin leaves bioaccumulated chromium and manganese above the FAO/WHO safe limit for consumption.

Keywords: *Atomic absorption spectrophotometry method, Dry ashing method, Dry season, Heavy metals, Rainy season, Vegetables*

INTRODUCTION

Heavy metals are elements characterized by high atomic mass and high density of at least 5 gcm^3. They constitute an ill-defined group of organic chemicals that exhibit metallic properties including transition metals, metalloids, lanthanides, actinides, with five times the specific gravity of water (Sharma *et al*., 2014). Heavy metal is not toxic in itself, rather it is toxic when its concentration in plants and animals reaches a certain level. Studies have shown that cobalt, copper, iron, manganese, molybdenum, nickel and zinc only become harmful when their internal concentration reaches a certain level (Klaus, 2010). On the other hand, many of them, e.g., mercury, cadmium, arsenic, chromium, thallium, lead, etc. exert toxic effects at low concentrations (Peratta-Videa, 2009).

Soils contaminated with heavy metals have become one of the major environmental problems around the world (Gratao *et al*., 2015). One of the key sources of environmental contamination is improper solid waste management (Kimani, 2007). Uncontrolled disposal of solid waste generates serious heavy metals pollution occurring in the water, soil and plants (Vongdala *et al*., 2019). In developing countries open dumping of solid wastes in uncontrolled sites, open burning of waste fractions and the mismanagement of the leachate produced in final disposal sites are the main issues (Modak *et al*., 2015). For example in Abuja, the capital city of Nigeria, more than 250,000 tons of waste were generated per year in 2010, these waste were either dumped in open dumps, buried, or burnt. Leachate from the buried wastes flowed to the surface, especially during rainy seasons (Aderoju *et al*., 2018). Heavy metals contaminate farmland other than dumpsites through the application of fertilizers (Wei *et al*., 2020), pesticides (Alengebawy *et al*., 2021), bio-solids and manures (Li *et al*., 2019), wastewater (Bjuhr, 2007; Geoffrey *et al*., 2020).

Vegetables are an important part of the human diet because they contain nutrients such as proteins, vitamins and minerals with significant health benefits (Arif *et al*., 2016). There is an inherent tendency of plants to take up toxic substances including heavy metals that are subsequently transferred along the food chain (Singh *et al*., 2010). As a result, heavy metal contamination in vegetables should not be overlooked, as vegetables are important components of the human diet. One of the most critical aspects of food quality assurance is heavy metal contamination of food items (Khan *et al*., 2008). Heavy metals are primarily found in vegetable crops' growth media (soil, air and nutrients solutions), where they are absorbed by the roots or foliage (Page and Feller, 2015). The toxic and detrimental imparts of heavy metals become apparent only when long-term consumption of contaminated vegetables occurs. Regular monitoring of heavy metals in vegetables should be performed to prevent excessive build-up of these heavy metals in the human food chain (Khanna and Khanna, 2011).

Vegetables can take up and accumulate heavy metals in quantities high enough to cause clinical problems to humans (Toth *et al.*, 2016). Heavy metals are persistent in the environment and are subject to bioaccumulation in food chains. They are easily accumulated in edible parts of leafy vegetables as compared to grain or fruit crops (Mapanda *et al*., 2005). Therefore this study was aimed to ascertain t Vegetables can take up and accumulate heavy metals in quantities high enough to cause clinical problems in humans (Toth *et al*., 2016). Heavy metals are persistent in the environment and are subject to bioaccumulation in food chains. They are easily accumulated in edible parts of leafy vegetables as compared to grain or fruit crops (Mapanda *et al*., 2005). Therefore this study was aimed to ascertain the level of heavy metals contamination across the wet and dry seasons in green leafy vegetables; Water leaves (*Talinum triangulare*), Green leaves (*Amaranthus hybridus*), Fluted pumpkin leaves (*Telfairia occidentalis*) and Bitter leaves (*Vernonia amygdalina*), cultivated in a dumpsite and farmland close to the dumpsite.

The level of heavy metals contamination across the wet and dry seasons in green leafy vegetables; Water leaves (*Talinum triangulare*), Green leaves (*Amaranthus hybridus*), Fluted pumpkin leaves (*Telfairia occidentalis*) and Bitter leaves (*Vernonia amygdalina*), cultivated in a dumpsite and a farmland close to the dumpsite.

METHODOLOGY

STUDY AREA

This study was conducted on the Oluku waste dumpsite (Latitude 6.2298 0N and Longitude 5.5407 0E) near Benin in Ovia North East Local Government Area of Edo State, Nigeria.

SAMPLE COLLECTION

Vegetable samples of water leaves (*Talinum triangulare*), Green leaves (*Amaranthus hybridus*), Fluted pumpkin leaves (*Telfairia occidentalis*) and bitter leaves (*Vernonia amygdalina*) were randomly collected from Oluku waste dumpsite and a nearby vegetable farm in Benin, Edo State, Nigeria. Samples were collected with a clean stainless knife into a clean dry labelled polythene bag for each vegetable. Three samples of each vegetable were collected during the dry season and subsequently in the rainy season and were sent immediately to the Mycofarms laboratory at Isihor, Benin for analyses.

SAMPLE PREPARATION

The dry ashing method of Gul and Safdar (2009) was used to prepare the vegetable samples in which they were washed with tap water and de-Ionized water to remove air pollutants, followed by oven drying at 105^0C for 8h to remove moisture. The dried samples were pulverized, using pestle and mortar, and then sieved through a 0.5 mm mesh size sieve to obtain a uniform particle size. Each vegetable sample was labelled and stored in a dry plastic container pre-cleaned with concentrated nitric acid to prevent heavy metal contamination prior to analysis with Atomic Absorption Spectrophotometer (AAS).

One gram of each vegetable sample was weighed into a crucible and ashed in a muffle furnace at 500^oC for 3hours. The ashed samples were energized the next day by gently warming on an electric plate. Each sample was then dissolved in 20% HCl and filtered using Whatman No1 filter paper into a 1000ml volumetric flask and made up to the mark. The concentration of the elements of interest (Hg, Pb, Cr, Co, Cd, Mn and Cu) were determined under standard conditions for each element using standard stock solution. The sample solutions were diluted to bring the concentration of the element into a suitable range for analysis. The heavy metal contents were analyzed by Atomic Absorption Spectrophotometer (Solar 969 Univan series) using the Hill and Fisher method (2017).

DATA ANALYSIS

Data obtained were analyzed using Microsoft excel and results were expressed as mean ± standard deviation.

RESULTS AND DISCUSSION

Table 1 shows the concentrations (mg/kg) of mercury (Hg), lead (Pb), cobalt (Co), chromium (Cr), cadmium (Cd), manganese (Mn)and copper (Cu) in water leaves (*Talinum triangulare*) and Green leaves (*Amaranthus hybridus*) obtained from vegetables planted in a dumpsite. The concentrations of Hg, Pb, Co, Cd and Cu were not detected in the vegetable samples. Similar results were obtained for pumpkin leaves (*Telfairia occidentalis*) and bitter leaves (*Vernonia amygdalina*) from a farm land in Table 2, all in Benin. The fact that these heavy metals were not detected does not really mean they were not present in the vegetable samples but were found below the detection limit of the Atomic Absorption Spectrophotometer used in this study. In general, the concentrations of Cr and Mn which were detected were very high in the dry seasons when compared with the rainy season, these results are in agreement with that of Oluyemi *et al*. (2008) which also observed higher levels of heavy metals in crops during the dry seasons. The concentrations of heavy metals detected in all the vegetable samples were in the order: Mn > Cr.

The mean concentration of Cr in Green leaves, Water leaves, Bitter leaves and pumpkin leaves during the dry season were 18.94, 115.94, 0.40 and 125.36 mg/kg respectively, these values were all higher than the FAO/WHO (2001) permissible limits of 1.3mg/kg of Cr in vegetables except that of bitter leaves which was within the FAO/WHO permissible limit. The values of Cr in these vegetables during the rainy seasons were 15.99, 113.48, 0.24 and 112.69 mg/kg respectively. Although these values in the rainy season were lower than that of the dry season, they were all higher than that of FAO/WHO (2001) permissible limits with the exception of bitter leaves which was within the permissible limits. The reasons for the high concentration of Chromium in green leaves, water leaves and pumpkin leaves can be attributed to the fact that its distribution and translocation in plants depends upon the plants species, the oxidation state of Chromium and also its concentration in the growth medium (Shahid *et al*., 2017). The United States Environmental Protection Agency (USEPA) listed Cr among the (14) most dangerous substances that can cause serious health issues in living organisms (EPA, 2000). Excessive Cr had been observed to reduce the uptake of essential minerals like iron, magnesium, phosphorus and calcium by making the sorption sites and forming Insoluble complexes (kabata-pendias and Szieke, 2015).

The mean concentration of manganese (Mn) in Green leaves, Water leaves, Bitter leaves and Pumpkin leaves during the dry seasons were 814.67, 844.90, 2.30 and 825.91 mg/kg respectively. These values were all above the FAO/WHO (2001) permissible limit of 500mg/kg except that of bitter leaves which was within the permissible limit. During the rainy season the values of 734.03, 813.23, 1.66 and 639.95 mg/kg were obtained, although lower than the dry season values. They were still higher than that of FAO/WHO (2001) permissible limit with only bitter leaves sample having a value within the safe limit. The high level of manganese in these vegetables could be as a result of high level of manganese in the soil which were bio accumulated by the vegetables (Khan et al., 2018). Researchers such as Sharma *et al*. (2006) and Yan *et al*. (2020) suggested that uptake of metals by plants is proportional to the compositional contents and bioavailability. According to Unver *et al*. (2015) by passing across the boundary of soil and root heavy metals increase in concentration in the crops.

High concentration of Mn is known to have hazardous effects on lungs and brains of humans (O'Neal and Zhang, 2015).

The low values of Mn in bitter leaves are in agreement with the report of Zafar *et al*. (2019) who also obtained low values of Mn in vegetables. From the results obtained it can be seen that bitter leaves did not bio accumulate chromium or manganese which suggests that the bitter leaves plant has a mechanism of detoxifying chromium and manganese after absorption from the soil in which it is growing.

CONCLUSION

Furthermore, the study indicated that the concentration of chromium and manganese found in the vegetables (Green leaves, Water leaves and Pumpkin leaves) from both the dumpsite and the farm land were above the FAO/WHO (2001) safe limit for consumption, while in bitter leaves the concentration of chromium and manganese were within the safe limit of the FAO/WHO (2001). Based on the ability of green leaves, water leaves and pumpkin leaves to bioaccumulate Cr and Mn in their leaves, they can be applied in phytoremediation of polluted soils. In addition, dumpsites and lands close to dumpsites should not be used in the cultivation of crops.

CONFLICT OF INTEREST

"The author declare that she has no conflicting interest"

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TABLES

Table 1: Bioaccumulation of heavy metals (mg/kg) in vegetable samples during the dry and rainy seasons in a dumpsite.

Heavy Metals	Green leaves		Water leaves		FAO/WHO (2001) permissible limits
	Dry season	Rainy season	Dry season	Rainy season	
Hg	ND	ND	ND	ND	0.5
Pb	ND	ND	ND	ND	2.0
Cr	18.94 ± 1.22	15.99 ± 0.64	115.98 ± 1.08	113.48 ± 2.80	1.3
Co	ND	ND	ND	ND	50
Cd	ND	ND	ND	ND	0.02
Mn	814.67 ± 2.38	734.03 ± 83/30	844.90 ± 1.48	813.23 ± 4.62	500

Table 2: Bioaccumulation of heavy metals (mg/kg) in vegetable samples during dry and rainy seasons in a vegetable farm

Heavy metals	Bitter leaves		Pumpkin leaves		FAO/WHO (2001) permissible limits
	Dry season	Rainy season	Dry season	Rainy season	
Hg	ND	ND	ND	ND	0.5
Pb	ND	ND	ND	ND	2.0
Cr	0.40 ± 0.03	0.24 ± 0.02	125.36 ± 2.35	122.96 ± 1.97	1.3
Co	ND	ND	ND	ND	50
Cd	ND	ND	ND	ND	0.02
Mn	2.30 ± 0.08	1.66 ± 0.22	825.91 ± 4.93	639.95 ± 1.17	500
Cu	ND	ND	ND	ND	10

ND = Not detected

Results are means ± Standard deviations of three replicates per sample in mg/kg