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Determination of Minerals in Five Different Vegetables Collected from Two Different Markets in Ado-Ekiti, Nigeria

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Abstract

This study was conducted to ascertain the status of vegetables consumed within Ado-Ekiti, Nigeria. The concentrations of some metals (Zn, Cu, Mg, Fe, Pb and Cd) were determined in five (5) vegetable samples which were freshly bought from two different markets: Iwororko and Oja-oba markets in Ekiti State, Nigeria with a view to determining their suitability for consumption. The samples were subjected to analyses using standard analytical procedures. Each sample was chopped into small pieces and dried, the dried sample was weighed and digested using $HClO_4$ and HNO_3, the digested sample was cooled and filtered into 100 mL volumetric flask which was made up to the mark using deionized water. The concentration of metals in each sample was determined using Atomic Absorption Spectrophotometer (AAS Buck scientific 210 VGP). The following ranges of results were obtained from Iworoko sample: Ca (37.23 -102.21 mg/L); Mg (15.43 - 77.53 mg/L); Fe (1.73 - 3.97 mg/L); Cu (0.06 - 0.11 mg/L); and Zn (0.11 - 1.84 mg/L). While the results from Oja-oba were as follows: Ca (23.52 - 61.20 mg/L); Mg (7.53 - 17.98 mg/L); Fe (1.5 - 47.58 mg/L); Cu (0.07 - 4.93 mg/L); and Zn (0.15 - 0.74 mg/L). Cadmium and lead were not detected in all the samples. The levels of detected metals were compared with international standards set by FAO/WHO, it was observed that the obtained results were within the permissible limits of FAO/WHO, this indicated that all the vegetables samples analysed were suitable for consumption.

Keywords

Vegetables, Heavy Metals, Concentration, Environment, Accumulation, Anthropogenic, Pollution, Irrigation

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1. Introduction

Vegetables are important in human diet as they play a major role human development [1]. They are rich in proteins, carbohydrates, fibres, vitamins, and trace elements which are highly beneficial for the maintenance of human health and prevention of diverse diseases [2]. However, both essential and non-essential minerals are present in vegetables at varying concentrations since they are known to pick up minerals from the soil [3]. Accumulation of heavy metals persists in the environment since they are not biodegradable, having density of at least 5 g/cm^{-3} and atomic mass above 40 [4]. The availability of toxic metals such as lead (Pb), chromium (Cr), and cadmium (Cd) in soils is mostly governed by anthropogenic activities [5]. Heavy metals at elevated concentrations affect factors of growth in plant, such as photosynthesis, respiration, uptake of water and nutrients, which could invariably diminish plant production [6]. Recently, interference of heavy metals in vegetables has increased tremendously, and the health implication on the final consumers may not be palatable [7]. Increase in the levels of toxic metals in the environment is not too far from

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anthropogenic activities, environmental pollution from industries, using metal-loaded water for irrigation purposes, application of inorganic fertilizers, deposition through transport system, etc. [8, 9].

The pollution of vegetables and agricultural soils by heavy metals is part of the most feared ecological concerns around the world, food chain in the ecosystem has been the major pathway by which humans consume these toxic heavy metals [10]. Irrigation system using the municipal or industrial sewage is a common occurrence in many continents like Africa, Asia, and South America [11]. Assessment of trace metal accumulation on vegetables planted close to industrial environments has revealed high concentration of nickel, lead, and cadmium [12]. In line with this, the possibility and the risk of consuming heavy metal polluted vegetables or other crops grown in the vicinity of industrial layout pose a potential concern, health-wise. Increased consumption of heavy metal contaminated vegetables lead to the accumulation of such metals in the body which would invariably alter many biochemical activities going on in human body, resulting in cardiovascular problem, nervous system breakdown, kidney problems, bone defects, etc. [13]. Industrial revolution and increased urbanization have actually elevated the levels of heavy metals in urban centres across different cities in the developing countries [14]. However, based on the growing demand for different agricultural produce by consumers as a result of population explosion, the producers of agricultural crops have devised many practices of increasing their production. Most vegetables that are sold in the markets are brought by local producers, but there is paucity of information on the means of cultivation, harvesting, transportation, and storage [9]. Al-Jassir *et al.* [15] and Sharma *et al.* [16] submitted reports that there was increase in the concentration of vegetable crops sold in the market. Vegetables that are grown in heavy metal polluted environment tend to accumulate more concentration than the vegetables planted in non-thickly polluted environment, the metals are absorbed through the roots into the other parts of the plant [17]. Both the edible and non-edible parts of vegetables have the tendency to accumulate heavy metals, however, the absorption capacity of the vegetables vary from one to another, some have higher potential to absorb than others [18].

Since vegetables are known to contain important nutrients that are needed by the body, most especially the fibre content which aids digestion of food. Going by the increased demand for vegetables across the word, and considering different farming practices used by vegetable producers, there is the need to ascertain the loads of toxic metals in the vegetables, so as to ensure the safety of the consumers. Therefore, this study is aimed at evaluating the levels of metal contents in vegetables obtained from Iworoko and Oja Oba markets, Ado Ekiti, Nigeria.

2. Materials and Methods

2.1. Materials

Green leaf vegetable samples were purchased from Iworoko Ekiti and Oja Oba (in Ado Ekiti) markets, Ekiti State, Nigeria. The samples were immediately certified at the Department of Plant Science and Biotechnology, Ekiti State University, Ado- Ekiti, Nigeria.

Table 1. Description of vegetable samples.

Sample	Botanical name	English name	Yoruba name
A	*Corchorus olitorius*	Nalta jute	Ewedu
B	*Amaranthus hybridus*	Green amaranth	Tete
C	*Vernonia amygdalina*	Bitter leaf	Ewuro
D	*Talinum triangulae*	Water leaf	Gure
E	*Telfairia occidentalis*	Fluted umpkin	Ugu

The samples were washed thoroughly with deionised water to remove soil, dirt, and other visible debris. The samples were put in already leached (with 10% HNO_3) and washed polythene bags, and kept in a laboratory prior to analysis.

2.2. Methodology

The vegetable samples were air-dried by spreading it in the laboratory for a few weeks; the samples were reduced to smaller particles using mortar and pestle. 0.5 g of the dried leaf samples were weighed and transferred into a conical flask. The sample was digested by adding 3 mL of $HClO_4$ and 5 mL of HNO_3, and then heated for 1h, the sample was removed, cooled and filtered using Whatman Filter paper into 100 mL volumetric flask, and made to the mark using deionized water. Same procedure was performed on the stems and roots of all the 5 vegetable samples. The metal contents were analysed using Atomic Absorption Spectroscopy (Buck Scientific 219 VGP).

3. Results and Discussion

Tables 2 to 6 show the concentrations of some metals analysed in the vegetable samples that were obtained from the two different locations. Table 2 shows the concentration of heavy metals in five different vegetable leaves in Iworoko market. The availability of heavy metals (mg/L) in the samples are in the following ranges: Ca (37.23 - 137.15 mg/kg); Mg (15.43 – 77.53 mg/kg); Fe (1.72 – 3.97 mg/kg); Cu (0.06 – 0.17 mg/kg); Zn (0.11 – 1.84 mg/kg); Cd and Pb were not detected.

Table 2. Metal concentrations in the leaves of vegetable samples from Iworoko.

Sample	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
A	37.23	15.43	2.42	0.11	1.84	ND	ND
B	48.38	29.53	1.73	0.06	0.11	ND	ND
C	137.15	23.51	3.45	0.17	0.48	ND	ND
D	102.21	77.53	3.97	0.08	0.15	ND	ND
E	80.63	21.52	2.21	0.08	0.29	ND	ND
WHO (2001)	-	-	4.0	2.0	1.5-2.0	0.2	0.5

A (Corchorus olitorius); B (Amaranthushybridus); C (Vernonia amygdalina); D (Talinum triangulare); E (Telfairia occidentalis); ND (Not Detected)

The results show that the concentration of Ca in the leaves was higher when compared to other metals, however, the highest concentration of Ca was found in *Vernania amydalina* (bitter leaf). *Talinium triangulare* (water leaf) had the highest amount of Mg. Cd and Pb were not detected in all the vegetable samples obtained from Iworoko market. As presented in Table 2, highest concentration of Zn was found in *Corchorus olitorius* (Nalta jute) followed by *Vernonia amygdalina* (bitter leaf). The lowest concentration of Zn was detected in *Amarathus hybridus* (Green amaranth). The levels of Cu in the five samples ranged from 0.06 – 0.17 mg/kg, Cu, as an essential element for humans has a tolerable upper intake level of 5 mg per day, an adequate intake of 1.6 mg per day for men and 1.3 mg per day for women [19, 20].

Table 3. Metal concentrations in the stems of vegetable samples from Iworoko.

Sample	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
A	73.48	33.11	5.53	0.45	0.29	ND	ND
B	60.42	30.56	2.01	0.11	0.13	ND	ND
C	74.89	12.13	3.1	1.58	0.34	ND	ND
D	18.35	13.20	5.02	0.26	0.15	ND	ND
E	19.49	7.25	1.46	0.10	0.16	ND	ND
WHO (2001	-	-	4.0	2.0	1.5-2.0	0.2	0.5

A (Corchorus olitorius); B (Amaranthus hybridus); C (Vernonia amygdalina); D (Talinumtriangulare); E (Telfairia occidentalis); ND (Not Detected)

Table 3 shows the levels of metals detected in vegetable stems from Iworoko Ekiti Market. The concentrations of Ca were high in all the samples; however, *Vernonia amygdalina* had the highest concentration of Ca among the stems followed by *Corchorus olitorius* (Nalta jute). *Vernonia amygdalina* had the highest concentration of Mg in stem. For Zn, a tolerable upper intake level of 25 mg per day, and a population reference intake range from 7.5 to 12.7 mg per day in women, and from 9.4 to 16.3 mg per day in men, both in adults, have been established [21, 22]. Cd and Pb were not detected in all the stem samples. All the metal concentrations in the samples were within the permissible limits stipulated by WHO [23].

Table 4. Metal concentrations in the roots of vegetable samples from Iworoko.

Sample	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
A	23.52	7.53	47.58	2.21	0.17	ND	ND
B	33.21	17.98	64.8	0.16	0.33	ND	ND
C	61.20	12.65	26.83	1.39	0.74	ND	ND
D	40.25	16.34	1.52	0.07	0.15	ND	ND
E	44.38	10.84	21.37	4.93	0.25	ND	ND

A (Corchorus olitorius); B (Amaranthus hybridus); C (Vernonia amygdalina); D (Talinum triangulare); E (Telfairia occidentalis); ND (Not Detected)

Table 4 shows the levels of metals detected in the root of the vegetables collected from Iworoko Ekiti market. *Vernonia amygdalina* had the highest concentration of calcium among all the vegetable samples under investigation. *Corchorus olitorius* had the highest concentrations of Fe when compared to other samples. Mg, Cu, and Zn were also detected in the samples and were all within the range stipulated by WHO [23]. However, Cd and Pb were not detected in all the root samples.

Table 5. Concentration of metals in the vegetable leaves obtained from Oja Oba.

Sample	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
A	27.52	9.47	1.94	0.08	0.26	ND	ND
B	27.86	50.14	2.13	0.07	0.37	ND	ND
C	155.26	29.58	5.75	0.17	0.68	ND	ND
D	56.73	60.21	1.56	0.63	0.33	ND	ND
E	30.25	12.78	1.97	0.08	0.24	ND	ND

A (Corchorus olitorius); B (Amaranthushybridus); C (Vernonia amygdalina); D (Talinumtriangulare); E (*Telfairiaoccidentalis*); ND (Not Detected)

Table 5 shows the concentrations of metals in vegetables leaves obtained from Oja Oba, Ado Ekiti market. The concentrations (mg/L) were in the following ranges: Ca (27.52 – 155.26 mg/kg); Mg (9.47 – 60.21 mg/kg); Fe (1.94 – 5.75 mg/kg); Cu (0.07 – 0.63 mg/kg); Zn (0.24 – 0.68 mg/kg). The concentrations of minerals in this study were within the permissible limits of WHO [23]. Bambara *et al.* [24] submitted similar report, that low concentration of Zn was observed in a study carried out on vegetables collected from selected farms of Loumbila and Paspanga, Burkina Faso. In this study, Cd and Pb were not detected in any of the samples. Cd has a tolerable weekly intake (TWI) of 2.5 µg kg^{-1} as established by EFSA [25, 26]. EFSA [25] estimated the mean dietary exposure to Cd in the adult population to be between 1.9 and 3.0 µg kg^{-1} per week. *Vernonia amygdalina* had the highest concentration of Ca, while *Talinium triangulare* had the highest concentration of Mg. Fe, Cu, and Zn were also detected, while Pb and Cd were below detection limits in all the leaves.

Table 6. Concentrations of metals in the stems of vegetables from Oja Oba Ado.

Sample	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
A	22.36	13.03	1.74	0.07	0.14	ND	ND
B	27.53	5.69	1.63	0.12	0.17	ND	ND
C	88.49	9.34	1.81	0.57	0.20	ND	ND
D	26.87	14.02	2.12	0.08	0.21	ND	ND
E	56.12	21.24	1.97	0.14	0.37	ND	ND

A (Corchorus olitorius); B (Amaranthus hybridus); C (Vernonia amygdalina); D (Talinum triangulare); E (Telfairia occidentalis); ND (Not Detected)

Table 6 shows the concentrations of metals in the vegetable stems obtained from Oja Oba, Ado Ekiti market. *Telfairia occidental* (fluted pumpkin) has the highest concentration of Mg. *Vernonia amygdalina* had the highest concentration of Ca as presented in Table 6. Cu, Zn, and Fe were detected in varying amounts, but were within the confines of WHO [23] permissible limits. Cd and Pb were below detection limits in the stem samples. Bagdatlioglu *et al.* [27] reported that the levels of metals in leafy vegetables studied were not outside the safety levels for consumption

Table 7. Concentration of metals in the vegetable roots obtained from Oja Oba.

Sample	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
A	35.47	12.96	5.23	0.33	0.23	ND	ND
B	46.83	35.27	46.78	2.11	0.28	ND	ND
C	21.02	11.53	2.10	0.12	0.15	ND	ND
D	84.76	43.59	66.58	3.78	0.87	ND	ND
E	32.45	12.48	4.10	0.47	0.23	ND	ND

A (Corchorus olitorius); B (Amaranthus hybridus); C (Vernonia amygdalina); D (Talinum triangulare); E (Telfairia occidentalis); ND (Not Detected)

Table 7 shows the concentrations of heavy metals in the vegetable roots obtained from Oja Oba, Ado Ekiti market. *Talinium triangulare* has the highest concentration of Ca (84.76 mg/L), the concentration of Mg (35.27 mg/L) was highest in *Amaranthus hybridus.* Fe, Cu, and Zn were detected and were within the permissible limits of WHO. *Vernona amygdalina* had the lowest concentrations of all the metals as shown in Table 7. Pb and Cd were not detected in all the root samples. Gezahegn *et al.* [2] reported that heavy metals in the soil could be transferred into the vegetables planted on that particular soil, many anthropogenic activities such as fertilizer and manure application could deposit heavy metals into the soil.

Chary *et al.* [28] reported that vegetables such as spinach, pumpkin, gourd, etc. have different potential and tendency to pick up metals from polluted soils. Leafy vegetables such as spinach demonstrate high affinity to absorb higher levels of Cr, Mn, and Fe. The higher potential to pick up heavy metal could be due to the high rate of absorption of leafy vegetables having a wide surface area.

4. Conclusion

Cd and Pb were not detected in all the samples. The non-availability of the toxic metals (Pb and Cd) in the vegetables is a major advantage to the consumers which live primarily on them. The concentrations of detectable metals in the leafy vegetables were within the permissible limits recommended by WHO. Therefore, the consumption of the vegetables is healthy to humans.

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