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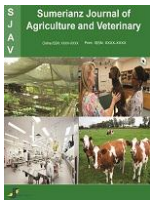

Original Article Open Access

Evaluations of Some Heavy Metals in Some Vegetables Cultivated in Two Villages in Damboa, Nigeria

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Abstract

With regard to food security and its hazards, and environmental impacts, this research study was carried out to determine the concentration of some heavy metals in some vegetables that are cultivated in some villages in Damboa, Nigeria. Fresh samples of spinach (*Amaranth caudatus*) and lettuce (*lactuca sativa*) were obtained from the farms in triplicates, in two villages, were placed each in polythene bags, labelled, transported to the Laboratory and were analysed by using Atomic Absorption Spectrophotometric techniques. The results obtained, revealed a variation in mean concentration of heavy metals analysed (Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn), were obtained in µg / L and %. Katchalla-Bulari village; lettuce ranged from -1.00 ± 0.06 to 1.07 ± 0.01 µg / L (- 38.5 to 41.2 %), the highest concentration level is Iron (Fe) and least is Lead (Pb), spinach ranged from -0.40 ± 0.06 to 1.33 ± 0.02 µg / L (- 8.9 to 29.6 %), the highest concentration level is Iron (Fe) and least is Lead (Pb), same as in lettuce. Nziddamari village; lettuce ranged from 0.08 ± 0.02 to 2.10 ± 0 and 2.10 ± 0.1 µg / L (1.1 to 29.5 %), the highest concentration level is Fe and Pb which have same value, and least is chromium (Cr). While in spinach it ranged from 0.10 ± 0.01 to 2.10 ± 0.1 µg / L (2.0 to 41.2 %), the highest is Fe and Pb being the least. The values were within the recommended values by WHO / FAO standard. Thus, the vegetable cultivated in these two villages, Damboa area were found to be wholesome and fit for consumption as at the time of this findings.

Keywords: *Amaranth caudatus*; Damboa; Heavy metals; Lactuca sativa; Mean concentration; Vegetable.

1. Introduction

Almost intensively cultured plant rightly comes under the domain of horticulture, primary effort is centred on the various traditional garden plants which falls under horticulture. The Horticulturist divides the edible garden plant into vegetables and fruits; considered vegetables as are those herbaceous plants of which some portion is eaten, either cooked or raw, and are the principal part of the day to day meal e.g. spinach (edible leaf), asparagus (edible stem), beet (edible root), cauliflower (edible flower), eggplant (edible fruit) and pea (edible seed). Fruit plants are most often perennial and are usually woody and are usually woody. On other hand, are plants from which a more or less succulent fruits or closely related structure is commonly eaten as a desert or snack. The cultivation of plants has been interesting and important sources of food and many biological and chemical (biochemical) substances [1, 2]. Food production contributes to sense of community and its livelihood [3-5]. It has educationally and skill development benefits for society, helping to nature cultural and horticultural knowledge of food production and usage. Urban and Peri – urban agriculture (UPA) is an alternative way of producing food within the cities. Food

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production can take place on rooftops and in backyard, community vegetable and fruit gardens and unused or public spaces [4].

For a proper livelihood and decent life living to be obtained, food hazards, food security and the protection of our environments and their management systems must firstly to be considered in all respects [5, 6]. Gwana, *et al.* [7], stated that the economic benefit derived from plants (rain fed or irrigated plant or crops) without recourse to the health implications has negative consequences on human livelihood and environmental quality. Gwana, *et al.* [7] and Sharma, *et al.* [8] stated that the protection of environment is the most vital issue today; most important human activities such as explosive population growth, rapid progress in engineering, science and technology, massive industrialisation and the major involvement of the use of various chemicals (e.g. herbicides and insecticides) in agriculture are the factors threatening the very quality of life.

On the other hand, consumption of vegetables and fruits as food offer rapid and least means of providing adequate vitamins supplies, minerals and fibres, and least plant proteins. Vegetables are used as food including those used in making soups or served as integral parts of the main sources of a meal [2, 6, 9]. Akan, *et al.* [10],. Plants are conveniently separated into those which are edible, those which serves as a source of drugs or spices, those that are of ornamental value, and so forth [11, 12] According to Oxford Learner's Dictionary, defined vegetable as a plant or part of a plant that is eaten; e.g. potatoes, beans and onion are all vegetable [13]. Green vegetable, e.g. lettuce, cabbage; Root vegetable, e.g. carrot; Leaf vegetable, e.g. spinach, sorrel, etc. Fruit was also defined as the part of a plant that consist of a stone, or pit or seeds and fresh, can be eaten as food and usually taste sweet, or a part of plant or tree that is formed after the flowers have died and in which seeds develop [11, 13].

Consumption of food crops contaminated with heavy metals is a major food chain route for human exposure [2, 14, 15]. The distribution of heavy metals in plant body depends upon availability and concentration of heavy metals as well as particular plant species and its population [16, 17]. The heavy metals or trace elements play an important role in the metabolic pathways during the growth and development of plants, when available in required concentration [18]. Many researchers have shown that some common vegetables are capable of accumulating high levels of metals from the soil [12, 19]. Certain species of these vegetables (e.g. cabbage) are hyper-accumulators of heavy metals into the edible tissues of plants [20]. Out of the one hundred and twelve (112) elements in nature, about eighty (80) are metals, most of which are food only in trace amounts in the biosphere and biological materials. There are at least some twenty (20) metals or metal like elements which do give rise to well organised toxic effects in man and his ecological associates [14, 21]. These elements include; arsenic, antimony, beryllium, cobalt, chromium, lead, manganese, mercury, molybdenum, nickel and tin.

Among the different pollutants, heavy metals have received escalating attention due to their possible injuries effects to man, animals and plants as there are recorded to be cytotoxic, mutagenic, and carcinogenic. Heavy metals are conventionally defined as elements with metallic properties such as ductility, conductivity, stability and cat ions, legends specificity, etc. and atomic number greater than 20. The most common heavy metals contaminants are arsenic, cadmium, chromium, copper, mercury, lead, nickel, vanadium and zinc. Heavy metals form the major group of toxic pollutants among the other pollutants, as these metals temper the harmony of the ecosystem [14, 22, 23].

Despite the enormous potential need of vegetables and fleshy fruits and the bright prospects, production in Nigeria, there are challenges such as. Sanitised cultivation, Poor growth and harvesting techniques, lack of storage facilities, inadequate processing facilities, and improper packaging and pest's protection management procedures. These factors mentioned may lead to the contamination of the vegetables with the heavy metals. Hence, the necessity to carry out this research study becomes necessary. The objectives of this study are to determine some the heavy metals (Arsenic, cadmium, chromium, copper, iron, lead, nickel and zinc) in vegetable samples (Spinach and Lettuce), qualitatively and quantitatively, and which will be useful in revealing the concentration in vegetables consumed by human in Damboa Local Government Area of Borno State, Nigeria.

2. Methodology

2.1. Materials

All the materials and reagents used in the course of carrying out this analysis were of analytical grade standard from Laboratory Unit, AHP Department, MOLCA, Maiduguri and NAFDAC, Maiduguri, Nigeria.

2.2. Sample and Sampling

At early hours (06:30 am) in the morning, fresh samples of spinach (*Amaranth caudatus*) and lettuce (*lactuca sativa*) were obtained directly from the garden farms, from three locations each, in Katchalla – Bulari and Nziddamari villages, at Damboa Local Governments of Borno State, Nigeria. These were packed in polythene bags each, labelled and transported to the Laboratory, Department of Chemistry, University of Maiduguri, as described in the methods applied by Gwana, *et al.* [5] and Ashiq, *et al.* [14].

2.2.1 Sample Preparation

In the laboratory, the samples were unpacked and washed successively under tap water gently, acidified water, distilled water and doubled or repeated with distilled water gently. Moisture and water droplets were removed with aid of blotting papers. These samples were then dried, first at room temperature for several days and then in hot air oven at 60 ± 5 ^{O}C for 48 hours, as described by Ashiq, *et al.* [14]. Fresh and dried weights of the samples were determined, as described by Akan, *et al.* [10] and Gwana, *et al.* [2].

2.2.2. Ashing the Samples

Air dried plant materials (vegetables) were pulverized in to powder, transferred into crucible dish and put to muffle furnace, heated at 500 ^{O}C for 3 hours. It was then removed and allowed in a desiccator to cooled and dried, as described by Akan, *et al.* [10] and Gwana, *et al.* [2].

2.2.3. Digestion of the Samples

To a beaker 0.5 g of the ashed samples was transferred into 250 ml beaker each. 10 ml of 6M Hydrochloric acid (HCl) were also added to each and covered the beaker with watch glass and heat for 15 minutes, removed and cooled. 1ml of concentrated Nitric acid (HNO_3) was added and heated to evaporated to direness'' and dehydrated the Sillica.1 ml of 6M of HNO_3 was added again. 10 ml of distilled water was added and heated to redissolved, cooled filtered with Filter paper Whatman No 541 in to 100 ml volumetric flask up to the mark levelled. It was the transferred into polythene bottle for elements analysis, as described by AOAC [24].

2.3. Method of Sample Analysis

The method applied in the evaluations of some mineral composition of each plant materials samples after the Ashing and the digestion, was by Atomic Absorption Spectrophotometric (AAS) techniques as described by AOAC [24].

2.4. Data Analysis

Data obtained from this research study was subjected to statistical tools of analysis using graphical presentation mean for the measurement of central tendency, and standard deviations for measurement of dispersion and or discrepancy within the variables being obtained and its' significance, as described by Stroud and Booth [25].

3. Results

The results of the analysis on the determinations of heavy metals in vegetables (lettuce and spinach) that were obtained in microgram per litre (µg / L) and presented in percentage, from the two villages **(**Nziddamari and Katchalla Bulari villages) Damboa Local Government of Borno state, Nigeria, are as presented in the tables as follows: -

Table 1 present the mean concentration levels of some heavy metals determined in some types of vegetables (lettuce and spinach) that were sampled from Katchalla-Bulari village. From the results obtained, in lettuce concentration level ranged from -1.00 ± 0.06 to 1.07 ± 0.01 µg / L, the highest concentration level is Iron (Fe) and least is Lead (Pb), while in spinach it ranged from -0.40 ± 0.06 to 1.33 ± 0.02 µg / L, the highest concentration level is Iron (Fe) and least is Lead (Pb), same as in lettuce.

Table 2 present the mean concentration levels of some heavy metals determined in some vegetables sampled from Nziddamari village. From the results obtained, in lettuce concentration level ranged from 0.08 ± 0.02 to 2.10 ± 0 µg / L, the highest concentration level is Fe and Pb, and least is chromium (Cr). While in spinach it ranged from 0.10 ± 0.01 to 2.10 ± 0.1 µg / L, the highest concentration level is Iron Fe and least being Pb.

Table 3 present the percentage concentration levels of some heavy metals determined in two types of vegetables obtained from Katchalla-Bulari village in Damboa. From the results, obtained, in lettuce concentration level ranged from - 38.5 to 41.2 %, the highest concentration level is Fe, and least is Pb. While in spinach it ranged from - 8.9 to 29.6 %, the highest concentration level is Iron Fe and least being Pb same as in lettuce.

Table 4 Present the mean concentration levels of some heavy metals determined in some vegetables sample from Nziddamari village. From the results obtained, in lettuce concentration level ranged from 1.1 to 29.5 %, the highest concentration level is Fe and Pb, and least is chromium (Cr). While in spinach it ranged from 2.0 to 41.2 %, the highest concentration level is Iron Fe and least being Pb.

Figures 1 and 5 present the mean concentration levels in µg / L of some heavy metals determined in two vegetables obtained from Katchalla- Bulari village, Damboa.

Figures 2 and 6 present percentages (%) concentration levels of some heavy metals determined in vegetables obtained from Katchalla-Bulari, Damboa.

Figures 3 and 7 present Mean concentration in µg / L of some heavy metals determined in two vegetables obtained from Nziddamari village, Damboa.

Figures 4 and 8 present percentages (%) concentration levels of some heavy metals determined in vegetables obtained from Nziddamari, Damboa.

Table-1. Mean concentration levels of some heavy metals determined in two vegetables obtained from Katchalla-Bulari village, Damboa

Type of samples.	Mean concentration in microgram per litre (µg / L)							
	Cd.	Cr.	Cu.	Fe.	Mn.	Ni.	Pb.	Zn.
Lettuce	0.75 ± 0.01	0.11 ± 0.01	0.25 ± 0.01	1.07 ± 0.01	0.52 ± 0.01	0.50 ± 0.01	-1.00 ± 0.06	0.40 ± 0.01
Spinach	0.62 ± 0.01	0.13 ± 0.01	1.31 ± 0.01	1.33 ± 0.02	0.61 ± 0.01	0.50 ± 0.01	-0.40 ± 0.06	0.34 ± 0.01
Standard	0.01	1.30	10.0	1.30	3.0	-	2.50	5.0

Source: WHO / AOAC, revision 2, section 973 – 42B(b)

Table-2. Mean concentration of some heavy metals determined in two vegetables obtained from Nziddamari village, Damboa

Type of samples.	**Mean concentration in microgram per litre (µg / L)**							
	Cd.	Cr.	Cu.	Fe.	Mn.	Ni.	Pb.	Zn.
Lettuce	0.46 ± 0.07	0.08 ± 0.02	0.84 ± 0.01	2.10 ± 0	0.52 ± 0.01	0.3 ± 0.06	2.10 ± 0.1	0.71±0.01
Spinach	0.54 ± 0.01	0.13 ± 0.01	1.15 ± 0.01	2.10 ± 0.1	0.13 ± 0.01	0.4 ± 0.1	0.10 ± 0.01	0.54±0.01
Standard	0.01	1.30	10.0	1.30	3.0	-	2.50	5.0

Source: WHO / AOAC, revision 2, section 973 – 42B(b)

Table-3. Percentage concentration levels of some heavy metals determined in vegetables obtained from Katchalla-Bulari, village Damboa

Type of samples.	**Mean concentration in percentage (%).**							
	Cd.	Cr.	Cu.	Fe.	Mn.	Ni.	Pb.	Zn.
Lettuce	28.8	4.2	9.6	41.2	20.0	19.2	-38.5	15.4
Spinach	13.8	4.2	21.1	21.6	13.5	11.1	-8.9	7.6

Table-4. Percentage concentration levels of some heavy metals determined in vegetables obtained from Nziddamari village, Damboa

Type of samples.	**Mean concentration in microgram per litre (µg / L)**							
	Cd.	Cr.	Cu.	Fe.	Mn.	Ni.	Pb.	Zn.
Lettuce	6.5	1.1	11.8	29.5	7.3	4.3	29.5	10.0
Spinach	10.6	2.6	22.6	41.2	2.6	7.9	2.0	10.6

Figure-1. Mean concentration levels of some heavy metals determined in two vegetables obtained from Katchalla- Bulari village, Damboa

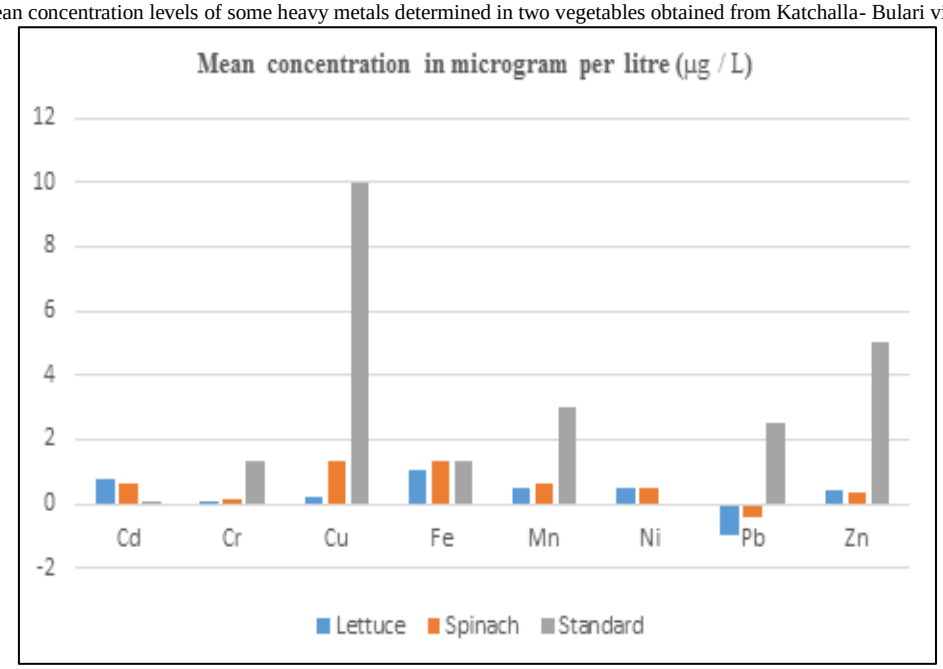


Figure-2. Percentage concentration levels of some heavy metals determined in vegetables obtained from Katchalla-Bulari, Damboa

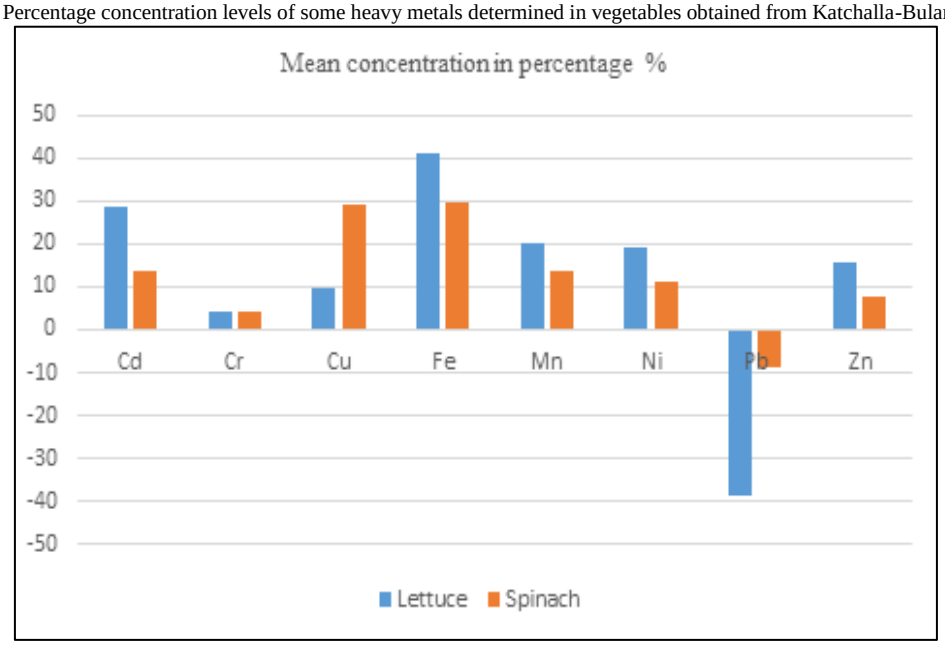


Figure-3. Mean concentration of some heavy metals determined in two vegetables obtained from Nziddamari village, Damboa

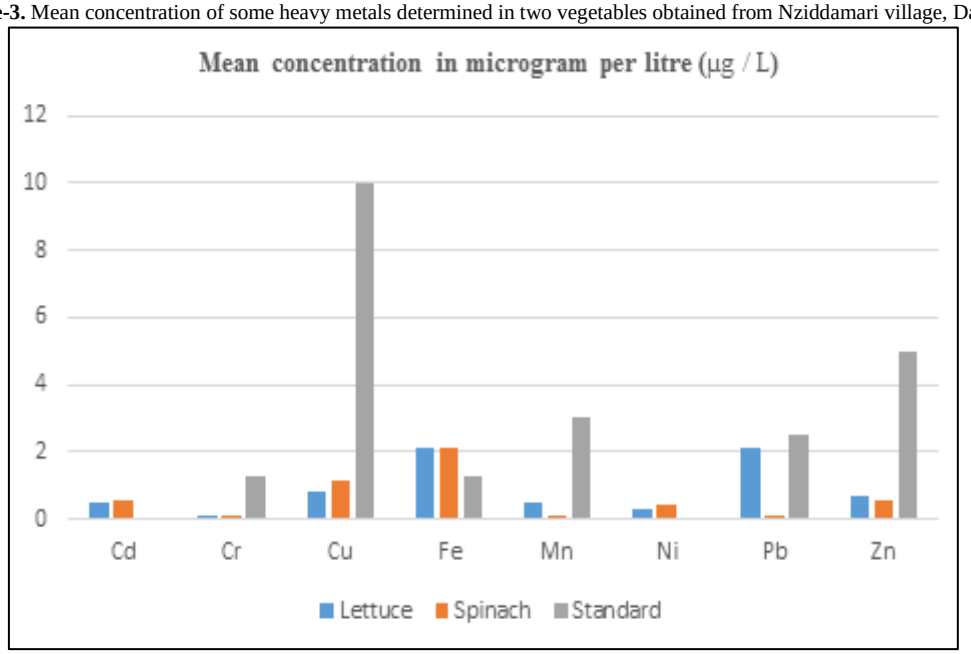


Figure-4. Percentage concentration levels of some heavy metals determined in vegetables obtained from Nziddamari, Damboa

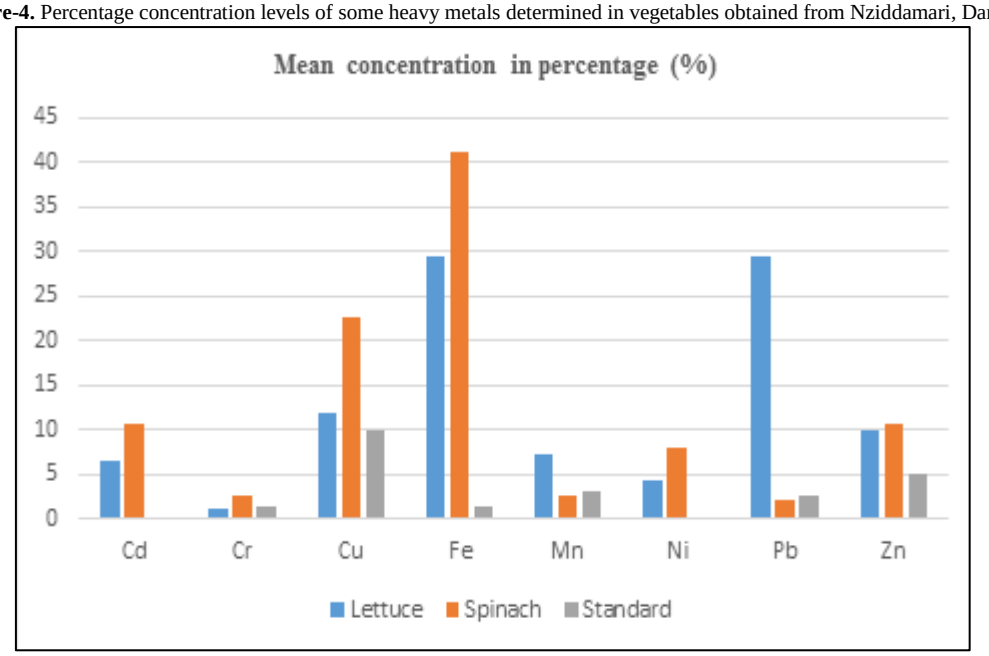


Figure-5. Mean concentration levels of some heavy metals determined in two vegetables obtained from Katchalla Bulari village, Damboa

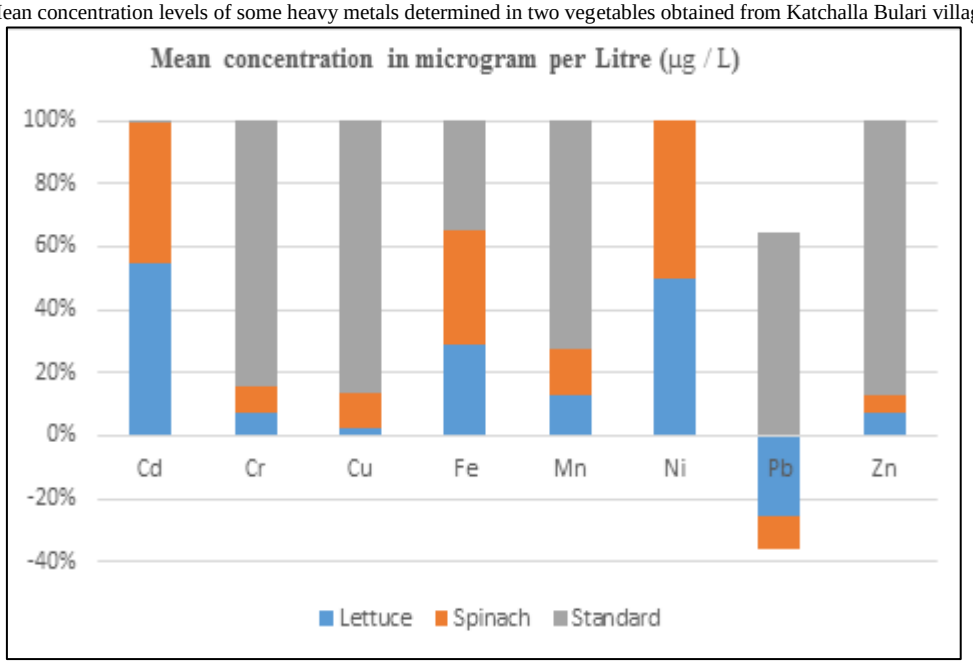


Figure-6. Percentage concentration levels of some heavy metals determined in vegetables obtained from Katchalla-Bulari, Damboa

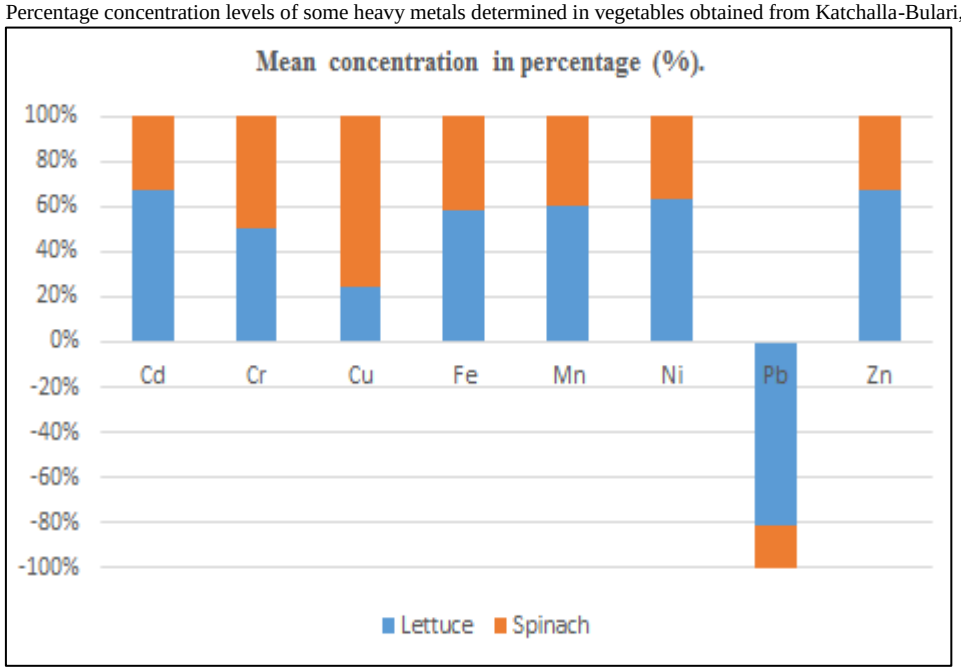


Figure-7. Mean concentration of some heavy metals determined in two vegetables obtained from Nziddamari village, Damboa

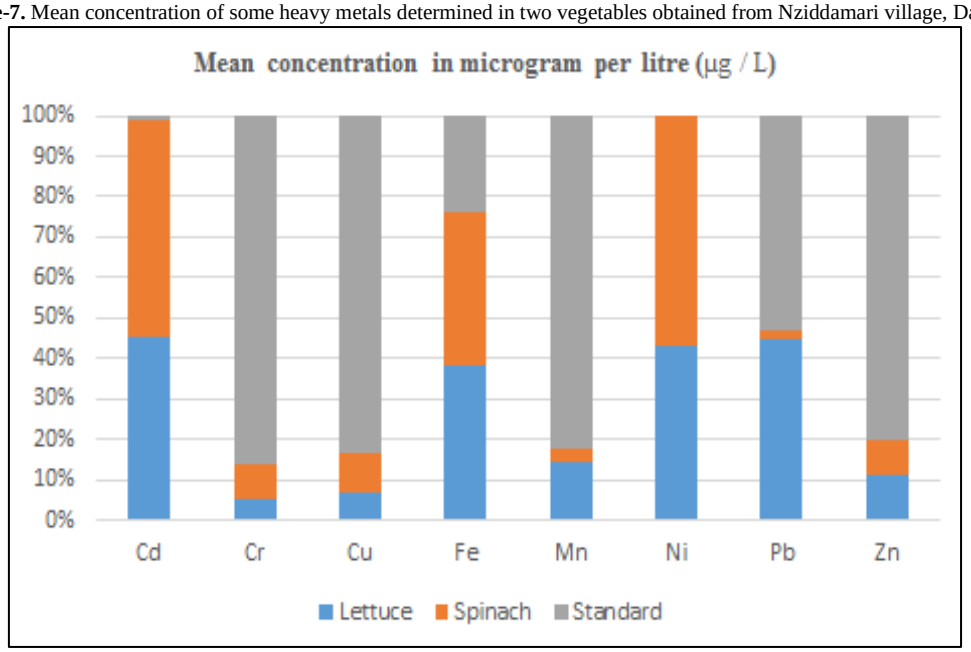
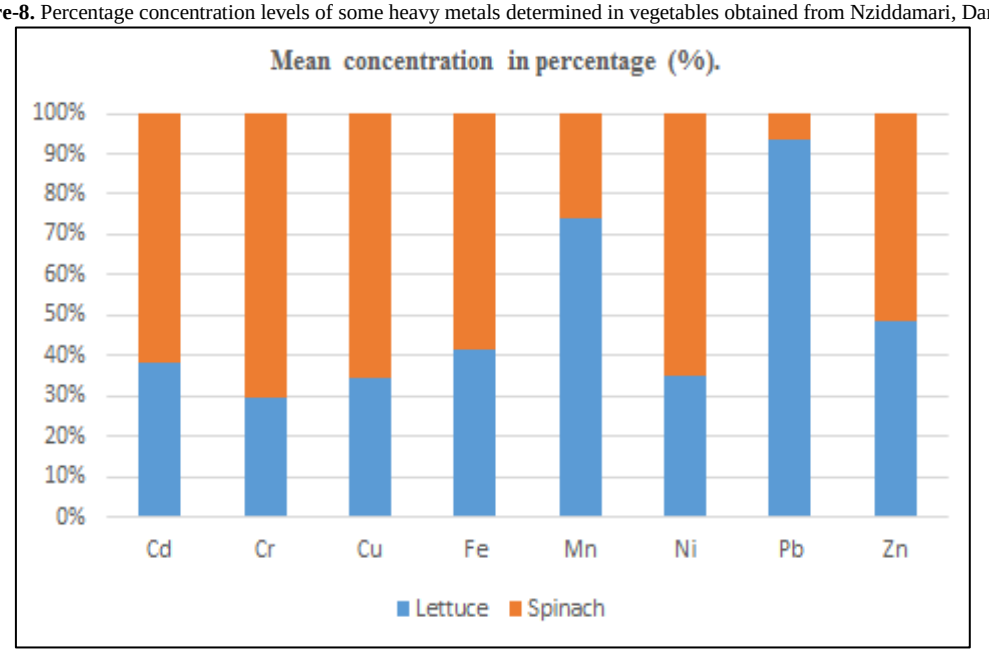


Figure-8. Percentage concentration levels of some heavy metals determined in vegetables obtained from Nziddamari, Damboa



4. Discussion

The persistent environmental contaminants may be deposited on the surfaces and then absorbed into the tissues of the plants, by absorbing the deposits on the parts of the plants which exposed to the air from polluted environment as well as from contaminated soils. Plants are separated into that which are edible, serves as a source of foods, drugs or spices, those that are of ornamental values, and so forth. Intensively cultured plants are under the domain of horticulture, efforts are centred about the various farm plants. Vegetable plants are used as food including those are used in making soups or eaten fresh, raw or served as parts of the main sources of meal. The consumption of vegetables (and fruits) as food offer rapid and least means of providing adequate some percentage vitamins, minerals, phytochemicals, plant proteins, fats and oils, sugars and fibres supplies. Amongst the minerals includes; macro and micro minerals (elements). Their distribution in plant body depends upon availability and concentration, as well as particular plant species and its population. Metals or trace elements play an important role in the metabolic pathways during the growth and development of plants, when available in required concentration levels in soils. Heavy metals contamination in vegetables cannot be underestimated as these food stuffs are important components of human diet, and heavy metal or trace elements contamination of food items is one of the most important aspects of food security and quality assurance.

In this research study, vegetables sampled were obtained from four different farms; in two villages (Katchalla-Bulari and Nziddamari), in Damboa, Nigeria. The samples were analysed to determine some heavy metals such as cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), Manganese (Mn), nickel Ni), lead (Pb) and zinc (Zn), qualitatively and quantitatively and sequential concentration levels of their magnitude in descending order were revealed in the findings. This research study supports the works of most authors, especially Akan, *et al.* [10]; Ashiq, *et al.* [14]; and Halima, *et al.* [6].

The two (2) vegetable samples that were cultivated and obtained from Katchalla Bulari village were determined, the results revealed that, lettuce contained moderate amounts of the heavy metals at concentration levels ranged from -1.0 µg / L (-38.5 %) to 1.1 µg / L (41.2 %). It's very rich iron, cadmium, manganese and nickel. Their mean concentration levels were; for Cd (0.75 µg / l), Cr (0.11 µg / l), Cu (0.25 µg / l), Fe (1.07 µg / l), Mn (0.52 µg / l), Ni (0.50 µg / l), Pb (-1.00 µg / l) and Zn (0.40 µg / l). It contained more amounts of zinc, copper and chromium concentration levels, and with a negative value of lead. Sequentially, their magnitude in descending order were as follow; Fe > Cd > Mn > Ni > Zn > Cu > Cr > Pb.

Also in spinach, it revealed that, the mean concentration levels of the metals ranges from -0.4 µg / L (8.9%) to 1.3 µg / L (29.6%). It contained moderate amounts of iron, copper, cadmium, manganese and nickel. It had lesser amounts of zinc and chromium, with a negative value of lead concentration levels respectively. This results obtained support the works of Garba abd Jimoh, (201). Their mean concentration levels were; for Cd (0.62 µg / l), Cr (0.13 µg / l), Cu (1.31 µg / l), Fe (1.33 µg / l), Mn (0.61 µg / l), Ni (0.50 µg / l), Pb (-0.40 µg / l) and Zn (0.34 µg / l). And when these value are arranged sequentially, in descending order of magnitude of mean concentration levels of the chemicals obtained were Fe > Cu > Cd > Mn > Ni > Zn^{-} > Cr > Pb respectively.

It was observed that in this research study, the vegetables from Katchalla Bulari village; both the 2 vegetables (lettuce and spinach) had more concentration levels of cadmium and chromium, with negative value of lead. Spinach contained moderate amounts of copper. Lettuce and spinach had more iron concentration levels in them. The 2 vegetables sampled had lesser concentration levels of the nickel. Spinach had moderate amounts of zinc concentration levels. Finally, lettuce had lesser amounts of chromium, copper and zinc concentration levels. This finding is in conformity with the works of Akan, *et al.* [10].

Out of the 2 samples obtained from Nziddamari village, the results of the analysis revealed that, in lettuce, the mean concentration levels of the metals ranges from 0.1 µg / L (1.1%) to 2.1 µg / L (29.5%). It contained iron and lead at higher concentration, copper and zinc at more concentration levels. It had manganese and cadmium at lower levels of concentration, and, nickel and chromium at least concentration levels only. Cd (0.46 µg / l), Cr (0.08 µg / l), Cu (0.84 µg / l), Fe (2.10 µg / l), Mn (0.52 µg / l), Ni (0.3 µg / l), Pb (2.10 µg / l) and Zn (0.71 µg / l). Sequential magnitude in descending order were as follow; Fe and Pb > Cu > Zn > Mn > Cd > Ni > Cr respectively.

The analysis also revealed that, ranges of heavy metal concentration levels in the spinach sampled were at 0.1 µg / L (2.0%) to 2.1 µg / L (42.1%). These means that, it contained moderate amount of iron and copper concentration levels, it had more zinc and cadmium, and lesser amount of nickel, chromium and manganese, and lead in recommended values. It was observed that, spinach had more amount of copper. Cd (0.54 µg / l), Cr (0.13 µg / l), Cu (1.15 µg / l), Fe (2.10 µg / l), Mn (0.13 µg / l), Ni (0.4 µg / l), Pb (0.10 µg / l) and Zn (0.54 µg / l). When these values are arranged sequentially, in descending order of magnitude of mean concentration levels of the chemicals obtained were Fe > Cu > Cd and Zn > Cr and Mn > Pb > Ni respectively

Lettuce contained more concentration of lead, lettuce and spinach had adequate concentration of zinc. The two vegetables from this area had lesser concentration of chromium, manganese and nickel, while lettuce had high concentration of lead and spinach had lower amount of lead concentration levels. These makes the two vegetables in this area were rich both macro and micro elemental nutrients. Conclusively, vegetables sampled, cultivated in these areas were analysed and found that, they are rich in minerals nutrients, both macro and micro elements which are used by both plants animal metabolism. That means, they are good and healthy for consumption by human beings. This is because they did not exceed the standard recommended values for consumption. That is, they were found wholesome.

5. Conclusion

Heavy metals are non-biodegradable and persistent environmental contaminants which may be deposited on the surfaces and then absorbed into the tissues of the vegetables plants, by absorbing them from deposits on the parts of the plants exposed to the air from polluted environment as well as from contaminated soils. In this research study, vegetables sampled were obtained from 2 different farms in Katchalla-Bulari and Nziddamari, in Damboa. These were analysed to determine some heavy metals as described by AOAC [24], some Researchers works are being cited and standard operation procedures were observed and followed. The results revealed that, there are enough of the eight elements being analysed (comprises of micro elements), that vegetables from this area had higher concentration levels of the metals; cadmium, chromium, copper, Iron, manganese, nickel, lead and zinc.

In another observation, the two vegetables, lettuce and spinach that were obtained from the said villages, all contained higher amount of iron concentration level, and lettuce contained higher amount of cadmium, and lettuce contained no amount of copper. Both the vegetables obtained from the village contained lesser amount chromium, manganese, nickel and zinc. These make the vegetables obtained from these villages are safe for consumption. It is very rich minerals content, i.e. found that, they are rich in minerals nutrients (micro elements) which are used by both plants animal metabolism. That means, they are good and healthy for consumption by human beings. This is because, they did not exceed the standard recommended values for consumption and they are found wholesome.

Recommendations

The following recommendations are; studies need to be carried out on heavy metals in vegetables and fruits in the study areas, in order to ascertain and determine the other heavy metals that are not involved this study. The uses of these vegetables (lettuce and spinach) from this area are found fit and wholesome for consumption, as at the time the study.

Acknowledgement

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