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Determinations of Some Heavy Metals and Elements in *Moringa oleifera* Leaves Cultivated in Gulani Town, North – Eastern Nigeria

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Abstract: This research study was conducted on the determinations of some heavy metals and elements in *Moringao leifera* leaves that were grown in Gulani town, North – Eastern Nigeria. Fresh plant part materials were sampled and prepared as the method described by Gwana, *et al.* [1]. The prepared sampled were analysed by using the Atomic Absorption Spectrophptometric techniques as described by Association of Official Analytical Chemists [2].The study revealed the presence of heavy metals and elements determined and their mean concentration levels were ranged from 0.17 to 89.0 µg / l; Ca (89.0 µg / l), Cd (0.26 µg / l), Cr (0.17 µg / l), K (6.5 µg / l), Mn (0.68 µg / l), Pb (not detected) and Zn (0.32 µg /). With regard to their percentage of concentration were ranged from 0.17 % to 91.8 %; Ca (91.8 %), Cd (0.27 %), Cr (0.17 %), K (6.7 %), Mn (0.68 %), Pb (0 %) and Zn (0.32 %) The magnitude of concentration levels of these elements detected in *M. oleifera* plant parts materials' in sequential order was Ca>K>Mn>Zn>Cd>Cr> Pb, the highest mean concentration was calcium (Ca), the least was chromium, lead was not detected. *M. oleifera* leaves cultivated in this area were rich in minerals, both macro and micro elements, did not exceed the standard recommended values for heavy metals, found health risks free, wholesome for consumption(in terms of the minerals determined)by human beings and animals. The results obtained support the works of Ibrahim and Jimoh [11], Qais, *et al.* [12]; Okoronko, *et al.* [15] amongst others. Studies need to be carried out in the studied area in order to determinethe other heavy meta ls and elements that are not involved in this study.

Keywords: Concentration; Consumption; Plant material; Macro and Micro element; *Moringa oleifera.*

1. Introduction

Miracle plant, drumstick or horse radish tree, (*Moringa oleifera*), is call *Zogale* in Hausa language and *Alam* in Kanuri language, used as vegetable and for medicinal purposes traditionally. It belongs to the monogenic family of shrub and tree is the most widely cultivated species of the genus *Moringa*, which is the only genus in the family Moringaceae. This rapidly growing, drought - resistant tree is native to the southern foothills of the Himalayas in north-western India and widely cultivated in tropical (including Nigeria) and subtropical areas where its young seed pods and leaves are used as vegetables, a perennial softwood tree with timber of low quality but which for centuries has been advocated for traditional medical and pharmaceutical industrial uses.

Moringa is derived from the Tamil word, Murungai [3, 4]. It is a fast - growing, deciduous tree and can reach a height of 10 to 12 m (32 - 40 Ft.) with a trunk diameter of 45cm (1.5 ft). The bark has a whitish - grey colour and is surrounded by thick cork. Young shoots have purplish or greenish-white, hairy bark. The tree has an open crown of

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drooping, fragile branches and the leaves build up feathery foliage of tripinnate leaves [5-7]. The flowers are fragrant and bisexual, surrounded by five unequal, thinly veined, yellowish-white petals and grow on slender airy stalks in Spreading or drooping later flower clusters which have length of 10 - 25cm [8-10].

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, form the major group of toxic pollutants among the other pollutants, as these metals temper the harmony of the ecosystem [13, 14].

Heavy metals such as copper, lead, etc, get into water from many sources, including industries, mines, natural soil, etc, become more concentrated as human and animals feed on plants and are consumed in turn by other animals [16-19]. High levels in the body can be immediately poisonous, or can result in long-term health problems similar to those caused by pesticides and herbicides. For example, cadmium in fertilizer derived from sewage sludge can be absorbed by crops. If these crops are eaten by humans in sufficient amounts, the metal can cause diarrhoea and, over time, liver and kidney damage [18, 20-22].

Consumption of food crops contaminated with heavy metals is a major food chain route for human exposure [23-25].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 [3, 24, 26]. 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 [23, 27]. Many researchers have shown that some common vegetables are capable of accumulating high levels of metals from the soil [28, 29]. Certain species of these vegetables (e.g. cabbage) are hyper-accumulators of heavy metals into the edible tissues of plants [30].

Out of the one hundred and twelve (112) elements in nature, about eighty (80) are metals, most of which are found only in trace amounts in the biosphere and biological materials. Some metals or metal-like elements which do give rise to well organize toxic effects in man and his ecological associates [23, 31-33]. These elements include; arsenic, antimony, beryllium, cobalt, chromium, lead, manganese, nickel, e.t.c, [34, 35]. These metals have been known to be toxic to man for centuries, and their carcinogenic activities have also been reviewed by Meittinien [35]. Protection of environment is the most vital issue today; explosive population growth, rapid progress in science and technology, massive industrial organization and use of various chemicals in agriculture and most important, human activities are the factors threatening the very quality of life [36-38].Macro and micro element compounds found in plants such as vegetables and grains in small amounts, these compounds are not established nutrients, but significantly protect the development of lots of degenerative diseases [16, 18, 19].

The objectives of this research study are to determine some heavy metals and elements in horseradish tree leave (*M. oleifera*) cultivated in Gulani town, North – Eastern Nigeria. With the current highly need for food security, when this plant (*M. oleifera*) is been cultivated in large scale farming (as medicinal plants or Horticulture farming) a lot of products would be obtained from it, this is because every part of the plant materials are useful, the foods, herbal medicines and pharmaceutical industries that processing it and lot of income would be generated, which will increase the Gross Domestic Products and income at large.

2. Methodology

The method applied in the determinations of heavy metal in each plant materials samples after the Ashing and the digestion was by using the Atomic Absorption Spectrophptometric techniques as described by Association of Official Analytical Chemists [2]; Ashiq, *et al.* [23]; Gwana, *et al.* [1].

2.1. Materials

2.1.1 Reagents

6Molar hydrochloric acid (HCl), concentrated nitric acid (HNO_3), distilled water, deionised water, and AOAC Standard Reagents.

2.1.2. Apparatus

Plastic spatula, filter paper, hotplate, blast furnace, volumetric flasks, beakers, plastic and glass test tube crucible dish, hand gloves, analytical balance, atomic absorption spectrophotometer (AAS – Buck model 210 VGP), pistle and motor, and Plastic sieve.

2.2. Sampling

2.2.1. Samples Collection

The site of the farm is located at Gulani town, Yobe state of Nigeria. At early hours (06:30 AM) in the morning, fresh sample of the plant material (*M. oleifera* leaves) were obtained directly and randomly through carefully hand plucked from five locations of the farm within Gulani town, i.e. in north, south, west, east and central parts of garden farm. These plant materials were pooled together and packed in black polythene bags, labeled and transported to the Laboratory, College of Agriculture, Maiduguri, Nigeria.

2.2.2. Plant Sample Identification

The plant was identified as *Moringa oleifera* tree plant by Botanist, Shetima, U.K. of the Forestry department, Mohamet Lawan College of Agriculture, Maiduguri, Borno State of Nigeria. The age of the plants were estimated at about four years old and authenticated with reference to the herbarium sheets (Voucher number 12), kept at the Herbarium of the said Department of the same University.

2.2.3. Preparation of Sample Plant Materials

The plant parts materials obtained were prepared, standard operation procures (SOP) are absolutely being observed as described by Gwana, *et al.* [1].

The leaves were destalked and cut into pieces, washed with running tap water for several minutes, deionised water for few minutes and air - dried for three weeks at an average room temperature of 30 – 34^{o}C. Continuous turning of the plants materials were done to avert fungal growth for several days until the treated leaves dried completely, and then in hot air oven at 60 ± 5^{O}C for 48 hours and were kept away from high temperatures and direct sunlight to avoid denaturalizing the treated plant part material.

2.2.4. Pulverization of the Treated and Dried Plant Part Material

The reduced chopped leaves materials were pulverized reduced to fine powder using an electronic blender (Homogenizer). This was done in order to increase the surface area so that the Ashing process could easily taken place, i.e., to hasten the process, thus releasing the mineral element - constituents. The fine powdered plant material was then transferred in to sterilized brown plastic bottles, labeled, screwed - capped and stored in a dry – cool, and away from damp and direct sunlight (this is to avoid the denaturalizing the prepared plant material sample and its components) until when ready for Ashing.

2.2.5. Ashing the Samples

The treated, air dried plant parts materials were pulverized in to powder, transferred in to 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 Ashiq*, et al.* [23].

2.2.6. Digestion of the Samples

0.5g of the ashed samples was transferred into 250 ml beaker each. 10 ml of 6M Hydrochloric acid were also added to each and covered the beaker with watch glass and heated for 15 minutes, removed and cooled. 1ml of concentrated Nitric acid was added and heated to evaporate to dryness and dehydrated the Silica. 1ml of 6M of Hydrochloric acid was added again. 10ml of distilled water was added and heated to redissolved, cooled and filtered with filter paper Whatman No 541 into 100ml volumetric flask up to the mark leveled. It was then transferred in to polythene bottle for elements analysis, as described by Association of Official Analytical Chemists [2].

2.3. Method of Elements Analysis

The method applied in the determinations of some mineral composition of the sampled plant materials, after the Ashing and the digestion of the samples was by using the Atomic Absorption Spectrophptometric techniques as described by Association of Official Analytical Chemists [2].

2.4. Data Analysis

Data obtained from this research study were subjected to statistical tools of analysis using percentage, 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 [39].

3. Results

The results obtained from this study revealed that, some heavy metals and other elements were screened and evaluated in some plant parts materials (leaves) of *M. oleifera* of which were cultivated in Gulani town farm site. The concentration levels of seven (7) elements Ca, K, Cd, Cr, Mn, Pb and Zn in microgram per gram (µg/g) were determined and evaluated. The results were presented in mean concentration levels and standard deviations of each element in the plant part material concerned as presented in the tables as follows:

Table 1 showed the mean concentration levels of some heavy metals and elements determined in *M. oleifera* leaves. The results revealed that the mean concentration levels of the elements evaluated expressed in microgram per litre were ranged from 0.17 to 89µg / l; Ca had 89 µg / l which was the highest, Cd (0.26 µg / l), Cr (0.17 µg / l), K (6.5 µg / l), Mn (0.68 µg / l), Zn had the lowest value of 0.32 µg / land Pb was not detected. That is, lead (Pb) was not detected in the leaves of *M. oleifera* respectively.

Table 2 showed the mean percentage of some heavy metals and elements detected in *M. oleifera* leaves. The results revealed that the percentage of each heavy metal and elements, their percentage of concentration were ranged from 0.17 % to 91.8 %; Ca had the highest value of 91.8 %, Cd (0.27 %), Cr (0.18 %), K (6.7 %), Mn (0.7%), Pb (0 %) and Zn was the least in value with 0.33 %. Lead (Pb) was not detected. That is, lead (Pb) was not detected in leaves of *M. oleifera* obtained from Gulani town respectively.

Table-1. Mean Concentration Levels of Some Heavy Metals and Elements Determined in *M. oleifera* leaves.

Plant part (*M. oleifera*)	Mean Concentration of Metal in microgram per gram (µg / l)						
	Ca	Cd	Cr	K	Mn	Pb	Zn
Leaves	89.0 ± 0.58	0.26 ± 0.01	0.17 ± 0.01	6.5 ± 0.29	0.68 ± 0	nd	0.32 ± 0.01
*Safe limit (mg / l)	75.0	0.003	0.40	10.0	-	0.10	5.0

Keys: - = no known, nd = not detected.
*SOURCE: WHO / AOAC, safe limit, revision 2, section 973 – 42B (b).

Table-2. Percentage Concentration of Some Heavy Metals and Elements Determined in *M. oleifera* leaves.

Plant part (*M. oleifera*)	Mean Percentage Concentration of Metals and elements (%)						
	Ca	Cd	Cr	K	Mn	Pb	Zn
Leaves	89.0	0.26	0.17	6.5	0.68	nd	0.32
Percentage	91.8	0.27	0.18	6.71	0.7	0	0.33

Keys: % =percentage, - = no known, nd = not detected.

4. Discussion

Moringa oleifera, horseradish plant, was known as '*Zogale'* in Hausa language and '*Allam'* in Kanuri language. It is been used as vegetable and for medicinal purposes traditionally. The plant has been widely cultivated in tropical (including Nigeria) and subtropical areas where its young seed pods and leaves are used as vegetables, a perennial softwood tree with timber of low quality but which for centuries has been advocated for traditional medical and industrial uses. Both plant parts of *Moringa oleifera* tree are useful as vegetable food; it could be used as leafy vegetable, root vegetable, seed and fruit vegetable. Vegetables are source of minerals (essential elements, both macro and micro elements), vitamins, proteins, oil, carbohydrates, phytochemicals or phytonutrients which serves as nutrition and source of medicinal materials, e.g. antioxidants.

Due to the human activities, such as the global warming and contaminations by industrial wastes materials to the ecosystem environments may lead to excessive release of some metals to waters and soils, e.g. rivers, streams, etc, and as a result this may lead to bioaccumulation in edible plants. Plants absorb these metals through their root tissues, depending on of type of varieties of the plants, and some are specific to these metals. The distribution of heavy metals in plant body is been depending upon availability, pH and the concentration of heavy metals as well as particular plant species and its population. According to National Institution Occupational Safety and Health [25] and Awofolu [24] who stated that the consumption of food crops contaminated with heavy metals is a major food chain route for human exposure and may result to various health risk hazard.

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. Many researchers have shown that some common vegetables are capable of accumulating high levels of metals from the soil. Certain species of these vegetables are hyper-accumulators of heavy metals into the edible tissues of plants. When eaten by human and animals, are then transferred into their body systems, thereby, causing health risks or may cause unsafe and insecurity for foods. In addition to that, the distribution of heavy metals and essential elements (both the macro and the micro elements)in plant body depends upon availability, P^H and concentration of heavy metals as well as particular plant species and its population, which was proved in this study that, the *M. oleifera* plant parts (leaves) materials determined that was cultivated and sampled in Gulani town was found to contained no lead (a heavy metal), which was not detected and this was also reported by Ibrahim and Jimoh [11], Qais*, et al.* [12]; Okoronko*, et al.* [15]; Bhata [3] among others.

The determinations of some heavy metals and elements in *M. oleifera* plant parts (leaves) materials were restricted to those that are cultivated in Gulani town farm and the results obtained from the analysis revealed that concentration levels of the sampled leaves were ranged from 0.17 to 89 µg / l;

Calcium had 89 µg / l which was the highest in value of concentration, and potassium was with 6.5 µg / l was the least in concentration levels amongst the elements determined in this study, and found both not exceeding the recommended standard values of 75.0 mg / g for Calcium and 10.0mg / g for potassium by Association of Official Analytical Chemists [2]; European Union [40]; WHO / AOAC [41].

Amongst the heavy metals determined in this research study, manganese was detected and had the highest concentration value of 0.68 µg / l, seconded by Zinc with a concentration value of 0.32 µg / l, the followed by cadmium had the concentration value with 0.26 µg / l and the least was chromium with a value of 0.17 µg / l in concentration. Lead (Pb) was not detected. That is, Pb was not present in the leaves of *M. oleifera* leaves sampled in Gulani Town. With regard to their percentage of concentration values were 91.8 %, 0.27 %, 0.17 %, 6.7 %, 0.68 %), 0 % and 0.32 % for Ca, Cd, Cr, K, Mn, Pb and Zn. The magnitude of concentration levels of these heavy metals and elements detected in *M. oleifera* plant parts materials' in the sequential order was Ca > K > Mn > Zn > Cd > Cr > Pb, the highest was calcium and the least was lead.

M. oleifera cultivated in Gulani town were found to be rich in minerals, both macro and micro elements, and found fit wholesome for consumption (in terms of the minerals concerned) by both human beings and animals. It did not exceeded the standard recommended values for heavy metals, it is health risk free for consumption, which is in line with the work of Ibrahim and Jimoh [11], and also support the works of Qais*, et al.* [12]; Okoronko*, et al.* [15]

amongst others. Therefore, *M. oleifera* leaves that was cultivated in Gulani soil was found not contaminated with heavy metals and also found wholesome for consumption with health risks free in terms of the metals and elements determined.

5. Conclusion

The cultivation of economic plants became necessary in our surroundings ecosystem environment; The findings of the research studied plant parts materials of *M. oleifera* (leaves), the results revealed that, the mean range concentration levels of the metals and elements determined were from 0.17 to 89 µg /, which were within the normal, standard recommended values, and with these values that were obtained it has been signified that the soils in Gulani town were not contaminated with heavy metals. To confirm this statement, there is the need to carry out some research on heavy metals and elements on the soils in Gulani town, north –eastern Nigeria.

Foods production contributes many, it helps socially to sense of community, educational and skill development benefits for the society. Planting economical plants are helping to nature cultural, horticultural skill and knowledge of food production, storage and usage. All forms of vegetables are used as food and had a medicinal values, either cooked or raw are eaten, these could be vegetable plant parts such as roots, stems, leaves, fruits, seeds or both. Vegetables are source of minerals (essential elements), vitamins, proteins, oil, carbohydrates, phytochemicals which serves as nutrition and source of medicinal materials, e.g. antioxidants.

Due to the human activities, farming, contamination of the environments with wastes materials may lead to excessive release of some metals to waters and soils, e.g. streams, etc. The distribution of heavy metals and essential elements in plant body depends upon the particular plant species or variety and its population, availability, pH and concentration of heavy metals as well as. The consumption of food crops that were contaminated with heavy metals is the food chain route for human and animal's exposure and is the major bioaccumulation of these metals, which may exceed the standard safe limit. To control the bioaccumulation and free from health risks of these metals is through evaluations of our environment and it biodiversity.

6. Recommendation

Based on the findings of this research study; it is recommended that the planting of economical plants which have the nutritional and medicinal values became necessary in our surrounding environs, especially plants such as *M. oleifera* tree, which is rapidly growing, drought - resistant tree. It is also recommended that *M. oleifera* tree should be used as a demarcation plant in our farms, backyard farm gardens and to be plant in any piece of land where available and feasible, this is, in order to have enough access and available to the plant parts material for tremendous harvest of the plant part materials, for provision of quick and safe supply of its nutritional values and health benefits' as well as the Gross Domestic Products (GPD) and income at large.

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References

[1] Gwana, A. M., Bako, M. M., Bagudu, B. Y., Sadiq, A. B., and Abdullahi, M. M., 2014. "Determinations of phytochemical, vitamin, mineral and proximate compositions of varieties of watermelon seeds cultivated in Borno State, North – Eastern Nigeria." *International Journal of Nutrition and food Science,* vol. 3, pp. 238–245.

[2] Association of Official Analytical Chemists, A. O. A. C., 1990. *Official methods of analysis. Association of Official Analytical Chemists*. 15th ed. Gaithersburg, Washington D.C. USA: AOAC Press. pp. 71– 92.

[3] Bhata, S. C., 2002. *Environmental Chemistry*. New Delhi: CBS Publishers and Distribution. p. 442.

[4] Satish, S., Raghavendra, M. P., and Raveesha, K. A., 2008. "Evaluation of the antibacterialpotential of some plants against human pathogenic bacteria." *Advances in Biological Research,* vol. 2, pp. 44-48.

[5] Azuonwu, T. C., Odutayo, F. O. I., and Aina, D. A., 2016. "Antibacterial activities of moringa oleifera plant bark, leaf and seed extracts on abattoir waste water." *Acadamic Journal of Life Science,* vol. 2, pp. 1-4.

[6] Caceres, A., Cabrera, O., Morales, O., Mollinedo, P., and Mendia, P., 1991. "Preliminary screening for antimicrobial activity." *Journal of Ethanopharmacology,* vol. 33, pp. 212-216.

[7] Chuang, P., Lee, C., Chou, J., Murugan, M., Shief, B., and Chen, H., 2007. "Antifungalactivity of crude extracts and essential oil of moringa oleifera lam." *Bioresources Technology,* vol. 98, pp. 232-236.

[8] El-Mahmood, A., 2009. "Antibacterial activity of crude extracts of euphorbia hirtaagainst some bacteria associated with enteric infections." *Journal of Medicinal Plant Research,* vol. 3, pp. 498-505.

[9] Rahman, M. M., Sheikh, M. M., Shamima, A. S., Islam, M. S., A., R., and Alam, M. F., 2009. "Antibacterial activity of leaf juice and extracts of moringa oleifera lam against some human pathogenic bacteria." *Journal of Natural Sciences,* vol. 8, p. 219.

[10] Sabale, V., Patel, V., Paranjape, A., Arya, C., Sakarkar, S. N., and Sabale, P. M., 2008. "Moringaoleifera (Drumstick): An overview." *Pharmacognosy*, vol. 2, pp. 7-13.

[11] Ibrahim, G. and Jimoh, W. L. O., 2015. "Evaluation of heavy metal and macro – elements in irrigated vegetables from challawa – Yandanko and Kano River Basin Project, Kano." *International Journal of Scientific Research and Engineering Studies*, vol. 2,

[12] Qais, A. N., Mohammed Mukarem, Mosa Alwah, and Mukhtar Atef, 2013. "Survey of some heavy metals in yemeni vegetables." *Merit Research Journal of Food Science and Technology*, vol. 1, pp. 036-042.

[13] Bryce - Smith, D., 1971. "Lead pollution: A growing hazard to public health chemistry in Britain." vol. 7, pp. 54-56.

[14] Jayedev, E. and Puttah, T., 2013. "Assessment of heavy metals uptake in leafy vegetables grown on long term waste water irrigated soil across vrishabhavathi River, Bangalore, Karnataka." *Journal of Environmental Science, Toxicology and Food Technology*, vol. 7, pp. 52-55.

[15] Okoronko, N., Igwe, J. C., and Onwuchelcua, E. C., 2005. "Risk and health implication of polluted soil for crop production." *American Journal of Biotechnology*, vol. 4, pp. 1521-1524.

[16] Ajayi, A. O., 2008. "Antimicrobial Nature and use of some Medicinal Plants in Nigeria." *African Journal of Biotechnology*, vol. 7, pp. 595-599.

[17] Alloway, B. J. and Ayres, D. C., 1997. "Chemistry principal for environment pollution." *Blackie Academic and Professional*, pp. 190–221.

[18] Auwal, M. S., Gwana, M. A., Isma'ila, A. M., Bagudu, B. Y., Shu'ibu, A., and Hambagda, A., 2012. "Phytochemicals properties and in vitro antibacterial activity of aqueous extract of jatropha caucus root bark." *Journal of Laboratory Science*, vol. 1, pp. 1-6.

[19] Tease, G. E. and Evans, W. C., 1989. *A textbook of phamacognosy*. 13th ed. London: Bailliere –Tyndall Ltd.

[20] John, H., 2008. "Microsoft ® Encarta" ® 2008 [DVD], Remond, WA: Microsoft Corporation, © 1997 - 2007."

[21] Lide, D. R., 2006. *CRC, In: Handbook of Chemistry and Physics*. 87th ed.: Boca Raton, FL- CRC Press. pp. 21-29.

[22] Muhammad Farooq, Farooq Anwar, and Umer Rashid, 2008. "Appraisal of heavy metal contents in different vegetables grown in the vicinity of an industrial area." *Pak Journal Botany*, vol. 40, pp. 2099-2106.

[23] Ashiq, H. L., Eugenia, P. L., Sasya, T., Ganie, S. A., Mohammed, S. W., Ani, K., Sajad, H. W., and Fayaz, A. W., 2013. "Accumulation of heavy metals on soil and vegetable crops grown on sewage and tube well water irrigation." *Academic Journals*, vol. 8, pp. 2187-2193.

[24] Awofolu, O. D. R. A., 2005. "Survey of trace metals in vegetables, soil and lower animal along some selected major roads in metropolitan, Lagos." *Environmental Monitoring and Assessment*, vol. 105, pp. 431-447.

[25] National Institution Occupational Safety and Health, 1976. *NIOSH criteria for recommended standard occupational exposure to cadmium*. H.E.W. Publication Co. (NIOSH), pp. 76 – 192.

[26] Akan, J. C., Kolo, B. G., Yikala, B. S., and Ogugbuaja, V. O., 2012. "Determinations of some heavy metal in vegetable samples from biu local government area, Borno State, North – Eastern Nigeria." *International Journal of Environmental Monitoring and Analysis*, vol. 1, pp. 40-46.

[27] Nirmal Kumar, J. I., Hiren Soni, and Rita, N. K., 1997. "Characterization of metals in vegetables using inductive coupled plasma." *Journal of Applied Science, Environmental and Management*, vol. 11, pp. 75-79.

[28] Cobb, G. P., Sands, K., Waters, M., Wixson, B. G., and Dorward-King, E. L., 2000. "Accumulation of metals by garden vegetables." *Journal of Environmental Quality*, vol. 29, pp. 934-939.

[29] Huges, M. K., Lepp, W. W., and Philips, D. A., 1980. "Industrial heavy metal pollution and terrestrial ecosystem." *Advance Ecological Research*, vol. 11, pp. 217-227.

[30] Xiong, Z. T., 1998. "Lead uptake and effects on seed germination and plant growth in a lead (pb) hyper accumulator brassica pekinensis rupr." *Bulleting of Environmental Contamination and Toxicology*, vol. 60, pp. 285–291.

[31] Bunce, N. J., 1990. *Environmental Chemistry*. Winnipeg, Canada: Winners Publishing Ltd. pp. 206-247.

[32] Csuros, M. and Csuros, C., 2002. *Environmental sampling and analysis for metals*. New York: Lewis Publisher, CRC Press. pp. 237–238.

[33] Watt, J., Thornton, I., and Cotter, H. J., 1994. "Physical evidence suggesting the transfer of soil lead (pb) into young children via hand to mouth activity." *Appl. Geochem.*, vol. 15, pp. 269–272.

[34] Fischbein, A., 1992. "Occupation and environmental lead exposure In: Environment and Occupation Medicine", Ron, WW (ed), Little Brown.

[35] Meittinien, J. K., 1975. *The accumulation and excretion of heavy metals in aquatic environment*. Peter A. (ed) Krenkal Perganon Press, p. 155.

[36] Sharma, B. C., Mishra, A. K., and Bhattacharya, K. G., 2000. "Metal in drinking water in a predominantly rural area." *Indian Journal Environmental Protection*, vol. 21, pp. 315–322.

[37] Wikipedia, 2008. "Metal toxicity, In: Free Encyclopedia, Dartmouth Toxic Metal Research – Toxic Metals."
[38] Wikipedia, 2008. "Metal Toxicity, In: Announcement: Response to the Advisory Committee on Childhood Lead Poisoning Prevention Report, Low Level Lead Exposure Harms Children": A Reviewed Call for Primary Prevention. CDC.
[39] Stroud, K. A. and Booth, D. J., 2001. *Statistical package, in: Engineering mathematics*. 5th ed. London: Palgrave. GB. pp. 1130–1139.
[40] European Union, 2006. "Commission regulation (EU) No. 1881/2006." *European Journal of Public Health,* vol. 2, pp. 40–44.
[41] WHO / AOAC, 2007. Safe Limit, 2nd revision, section 973 – 42B (b).