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Toxic Elements Levels in Water and Some Vegetable Crops Grown in Farms in Bade Local Government Area of Yobe State, Nigeria

A. Oyekanmi[1], F. Okibe[1] and W. P. Dauda[2*]

[1]Department of Chemistry, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria.
[2]Department of Agronomy, Faculty of Agriculture, Federal University, Gashua, Yobe State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author FO designed and supervised the study. Author AO performed the laboratory and statistical analysis and author WPD wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This study determined heavy metal concentrations in soil, water and some vegetables such as (Spinach (*Amaranth caudatus*), Lettuce (*Lactuca Sativa*) and Tomato (*Lycopersicon esculentum*)) which were freshly harvested within five various farms (Samaila Hardaway farm, Mohammed Koli farm, MainaBabi farm, Ngatau farm and Sani Chansa farm) at Jawa village in Bade Local Government Area of Yobe state, Nigeria which were digested and analyzed for heavy metals such as As, Cd, Ni, Pb, and Cr. The aforementioned heavy metal concentrations were determined using Micro Plasma Atomic Emission Spectrophotometer MP-AES model 4200 of Agilent. The result of the analysis shows that all the heavy metals were detected and exceeded the World Health Organization (WHO) permissible limit. The metals were of the sequence As > Pb > Cd > Ni > Cr in the descending order. The high level of these heavy metals, especially arsenic place the consumers of these vegetable crops grown within the study area at health risk like cancer, kidney failure with time unless an urgent step is taken by relevant agencies to address this issue.

**Corresponding author: E-mail: wadzanidauda@gmail.com;*

Keywords: Profiling; heavy metal; soil; water; vegetables; accumulation; contamination MP-AES.

1. INTRODUCTION

Heavy metal profiling refers to the process of viewing heavy metal deposition in soils, plants and water caused by human activities [1]. Heavy metals in soil, crops and water include some significant metals of biological toxicity such as Cadmium, Lead, Chromium, Arsenic, Nickel and many others [2,3] In recent years, with the development of Global economy, both type and content of heavy metals in soils, crops, and water caused by anthropogenic activities have gradually increased resulting in the deterioration of the environment [4,5,6]. Heavy metals are highly hazardous to the environment and organisms. It can be enriched through food chain. Once the soil suffers from heavy metal contamination, it is difficult to be remediated.

In the past, soil contamination was not considered as important as air and water pollution, because soil contamination was often wide in range and was difficult to control. Heavy metals profiling in soil, crops and water is thus paid more and more attention and becomes a topic interest as regards to environmental protection worldwide.

Recently, heavy metals pollution in the environment has increasingly gathered global interest. In this respect, contamination of vegetables with heavy metals has always been considered critical and challenging among the scientific community [7]. On the other hand, release and subsequent deposition of heavy metals in food product like fruits, vegetables etc. cannot be over-emphasized. Heavy metals are mobile and easily taken up by the plants in the environment [8]. Metals accumulation in vegetable may pose direct threat on human health [9]. Many diseases are caused by the inability of environment to support mineral needs of human, plants, and animals [10]. Heavy metals contamination may occur due to irrigation with contaminated water, addition of chemical fertilizer and metal-based pesticides, industrial emission and harvesting process, storage or sale. These metals, due to their toxicity have potential hazardous effect not only on plant but also on human health [11,12]. For instance, lead toxicity causes reduction of haemoglobin synthesis, kidney failure, and weaknesses of the joints, negative effect to the reproductive and cardiovascular systems and chronic damage to the central and peripheral nervous systems [13]. During the last decades, the increasing demand of the safety level of most vegetables have stimulated research regarding the risk associated with their consumption as a result of contamination by pesticides, heavy metals and/or toxin [14,15,10,16,17]. Vegetable most especially leafy vegetables accumulate higher amounts of heavy metals because they absorb these heavy metals in their leaves [18]. Food safety is a major concern at present. The increasing demand of food safety has accelerated research regarding the risk associated with food consumption contaminated by heavy metals [19,20]. Heavy metals in cultivated soils can be transfer to human through various exposure pathways causing adverse effects on human health [4]. Hence heavy metals determination in vegetables is therefore of importance. Constant monitoring programs for residues and contaminants contribute to the improvement of food safety.

In this study, we will take a look at toxic elements level in soil, water and some selected vegetable crops grown in Bade local government area of Yobe state, we also hope to explore background, impact of heavy metals and provide a reference for local eco-environmental management. This study is catalyzed by the strong zeal to verify the elements level both of rural and urban farmland in Bade Local Government Area of Yobe state and to ascertain if eating vegetables from such area poses any health threat to the people of these communities. This study is also relevant since it has been reported that soil contamination may adversely affect human health when agricultural produce grown in such area is consumed. The aim of this study focuses on toxic elements level of soil, water and some crops grown in Bade local government of Yobe State, by taking a profile of elements level in water, soil and crops and determining the factors that contributes to the deposition of heavy metals in those area where these crops are grown. E.g. irrigation using groundwater, anthropogenic activities and application of metal-based manure, fertilizer and pesticide.

2. MATERIALS AND METHODS

2.1 Sample Collection

The samples analyzed in this study were collected at Jawa village north-east of bade local government area of Yobe state in September 2016. There are several small-scale farms of vegetables mainly, onion, pepper, tomatoes, lettuce, and spinach. The farms are located behind the houses at Jawa village. These vegetables are grown during dry season of the year and irrigated using groundwater. The used of pesticide is a common practice and as well as application of manure and fertilizer. Five samples of water, four samples of tomatoes, four samples of spinach and two samples of lettuce were collected randomly from five farms in Jawa village. The samples of vegetable and soil collected were dried some in the oven at 110ºC for 12 hours and others were air-dried to remove moisture content. The samples were milled with an electric blender before digestion [21,22].

2.2 Soil Digestion

1.0 g each of five different soil samples milled was weighed and added to the test-tubes. A concentrated nitric acid (HNO_3) of 7.5 mL and perchloric acid ($HClO_4$) of 2.5 mL (10 mL; aqua regia) was added to each test-tube containing different soil samples, the mixture was heated progressively under reflux for 72 hours. After cooling, the digest were passed through a pre-washed filter paper (Whatman filter paper), after which distilled water was added to the filtrate to make it up to 50 mL. The prepared samples were refrigerated in an acid-washed polythene bottles before analysis.

2.3 Water Digestion

The water samples in plastic containers were shaken thoroughly and a volume of 5 mL of each water samples was measured using a 20 mL measuring cylinder. These were poured into test-tubes and thereafter 7.5 mL concentrated nitric acid was added to the mixture and heated in an oven for 72 hours. After digested, the solution was filtered and the filtrate transferred to a 60 mL polythene bottles. The filtrate was made up to the required mark with distilled water before analysis [23,5].

2.4 Plant Digestion

1.0 g of well-homogenized plant samples was weighed into beakers and 10 mL of freshly prepared acid mixture of NHO_3 and HCl (1:3) was added. The beakers containing the samples were heated for 2 hours on a hot plate. The mixture was allowed to cool and then filtered through a Whatman filter paper into a 60 mL polythene bottle. The filtrate was diluted to 50 mL with distilled water before analysis [24].

2.5 Sample Analysis

The samples after digestion were analyzed using Micro Plasma Atomic Emission Spectrophotometer MP-AES model 4200 of Agilent, to determined heavy metals such as (Pb, Cr, Cd, Ni, and, As) in the Multi-user laboratory of Chemistry Department, Ahmadu Bello University (ABU), Zaria.

3. RESULTS AND DISCUSSION

Below are tables of result showing the level of elemental concentration in various samples obtained from Jawa village in Yobe State Nigeria.

3.1 Discussion

The result obtained revealed that all the metals analyzed were detected and there were variation in the values obtained in soil, water, and vegetable samples respectively. The metal concentrations obtained in aforementioned samples were presented in Tables 1, 2, 3, 4, and 5 respectively. The results of the analysis displayed in the various tables and figures, shows the concentrations of heavy metal in water, soil and vegetable samples from various farm site in Jawa village in Bade local government area of Yobe state.

Table 1. Mean concentration and standard deviation of heavy metals (mg/L) in groundwater used for irrigation in Jawa village of Bade local Gov't area of Yobe State

Solution	As	Cd	Ni	Pb	Cr
SH	8.05±1.64	0.15±0.12	0.05±0.06	0.26±0.24	0.03±0.03
MK	8.51±0.38	0.22±0.01	0.01±0.01	0.10±0.07	0.03±0.01
MB	2.30±0.62	0.69±0.19	0.09±0.07	3.58±1.69	0.06±0.02
NG	2.59±0.41	0.42±0.02	0.03±0.02	0.47±0.24	0.04±0.02
SC	6.73±0.61	0.33±0.02	0.08±0.01	0.45±0.05	0.07±0.05
WHO	0.01	0.005	0.01	0.01	0.05

SH= Samaila Hardawa, MK= Mohammed Koli, MB= Maina Babi, NG=Ngatau, SC= Sani Chansa

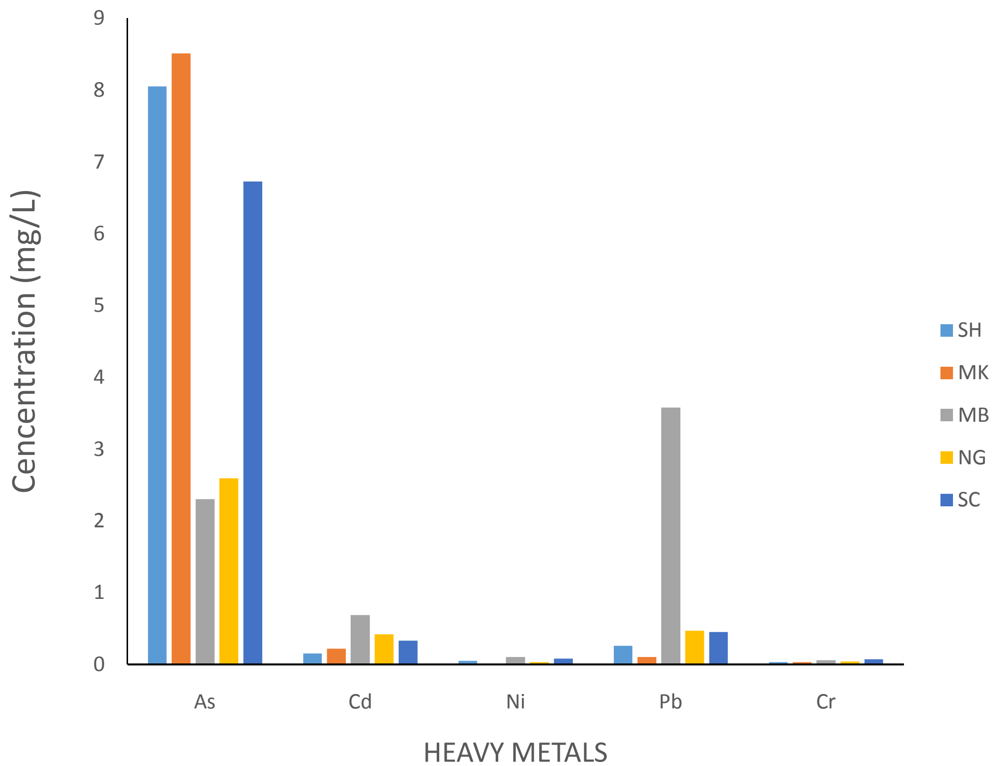

Fig. 1. Heavy metal concentrations in Groundwater used for irrigation in Jawa village of Bade local Gov't area of Yobe State

Table 2. Mean concentration and standard deviation of heavy metals (mg/L) in soils obtained from various farms in Jawa local government area of Yobe State

Solution	As	Cd	Ni	Pb	Cr
SH	22.34±10.95	0.97±0.04	4.85±0.40	2.71±0.99	13.42±1.25
MK	53.19±11.31	1.07±0.230	6.04±0.29	7.52±1.11	13.47±0.16
MB	35.31±18.29	1.39±0.09	1.75±0.10	10.61±1.92	11.19±0.50
NG	1748.66±19.12	1.30±0.32	3.25±0.42	2.21±1.13	9.89±0.76
SC	1525.24±11.12	19.42±1.45	20.45±0.72	14.05±2.47	17.59±1.39
WHO	4.5	0.15	2.6	0.15	0.12

SH= Samaila Hardawa, MK= Mohammed Koli, MB=Maina Babi, NG= Ngatau, SC= Sani Chansa

Table 3. Mean concentration and standard deviation of heavy metals (mg/L) in spinach harvested from various farms in Jawa village of Bade local Gov't area of Yobe State

Solution	As	Cd	Ni	Pb	Cr
SH	973.09±42.64	17.46±3.43	2.21±2.03	8.50±2.35	0.69±0.59
MB	1416.36±18.13	17.43±3.22	4.59±1.28	7.75±5.44	2.48±1.45
NG	1173.64±87.91	19.11±0.69	3.76±0.55	14.36±1.35	3.97±2.16
SC	1311.90±101.58	17.92±0.66	4.05±0.55	8.64±2.68	1.47±1.58
WHO	0.4	0.03	0.8	0.3	0.12

SH= Samaila Hardawa, MB= Maina Babi, NG=Ngatau, SC= Sani Chansa

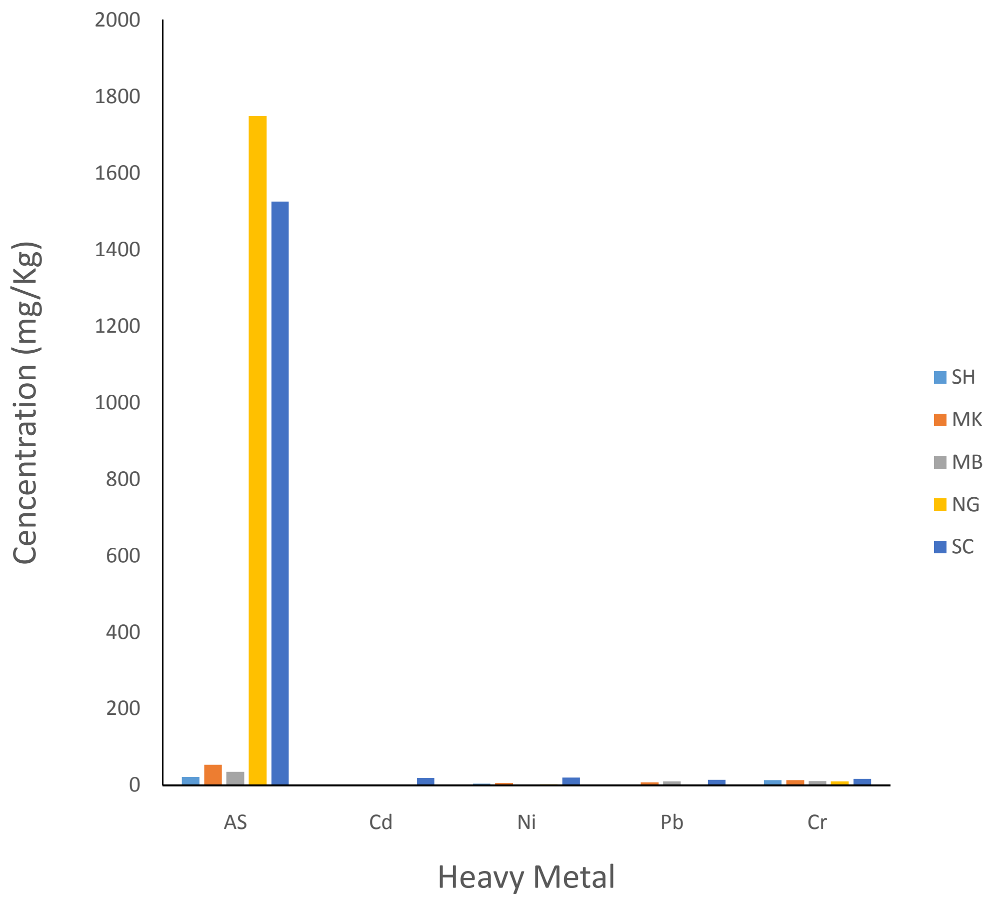

Fig. 2. Heavy metal concentrations in soils obtained from various farms in Jawa Local Government area of Yobe State

Table 4. Mean concentration and standard deviation of heavy metals (mg/L) in Tomato harvested from various farms in Jawa village of Bade local Gov't area of Yobe State

Solution	As	Cd	Ni	Pb	Cr
Mk	903.77±3.25	13.95±1.05	1.23±0.06	13.97±0.13	4.63±0.05
MB	919.76±2.79	13.95±0.24	0.92±0.05	14.27±0.03	4.66±0.10
NG	965.07±98.80	10.12±1.79	9.37±3.34	24.63±6.54	0.91±1.29
SC	967.87±51.12	15.40±0.69	2.03±0.70	12.17±5.37	5.05±0.01
WHO	0.4	0.03	0.8	0.76	0.12

MK= Mohammed Koli, MB= Maina Babi, NG=Ngatau, SC= Sani Chansa

Table 5. Mean concentration and standard deviation of heavy metals (mg/L) in lettuce harvested from various farms in Jawa village of Bade local Gov't area of Yobe State

Solution	As	Cd	Ni	Pb	Cr
SC	770.94±9.25	12.98±0.38	0.14±0.058	4.89±0.17	5.44±0.05
MK	790.65±6.95	12.08±0.30	3.82±0.14	6.52±0.13	9.28±0.28
WHO	0.4	0.02	0.8	0.3	0.12

MK= Mohammed Koli, SC= Sani Chansa

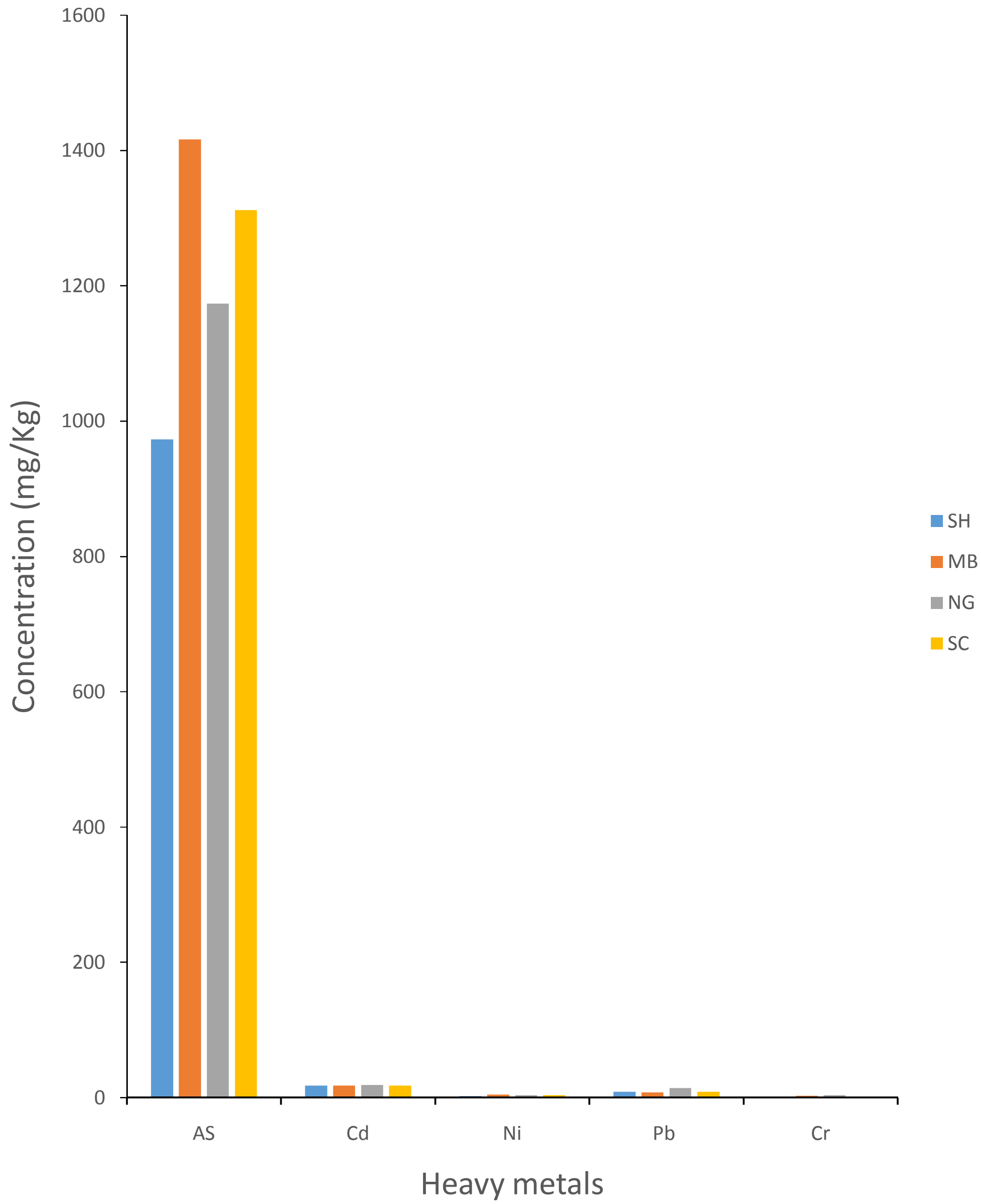

Fig. 3. Heavy metal concentrations in spinach harvested from various farms in Jawa village of Bade local Gov't area of Yobe State

3.2 Arsenic

Table 1, Fig. 1 shows the arsenic concentration in water sample in various farm sites in Jawa village of Bade local government area of Yobe state. The arsenic concentration ranged from (2.30-851) mg/kg, which was higher than the permissible value (0.01 mg/L) laid down by the World Health Organization [25]. [26,27], reported a mean value of arsenic to be (0.02-0.5)mg/L in Zaria city of Kaduna state. [28] also reported high level of arsenic concentration of 0.8 mg/L in Kutama and 0.77 mg/L in Getso, Gwarzo local government area of Kano state. [29,30] In contrast reported arsenic concentration ranged below detection limit to 0.12 mg/L. [31], reported arsenic concentration that ranged from 0.010-0.090 mg/L.

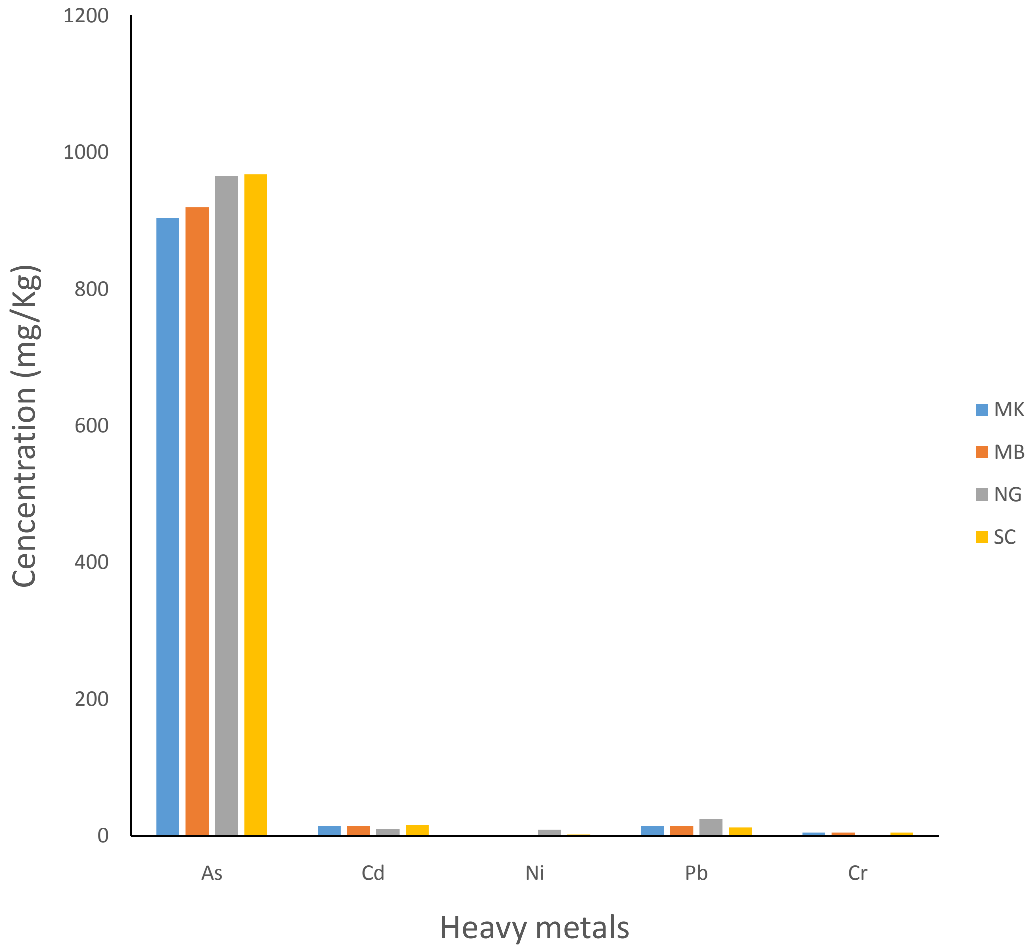

Fig. 4. Heavy metal concentrations in tomatoes harvested from various farms in Jawa village of Bade local Gov't area of Yobe State

Table 2, Fig. 2 show the concentration of arsenic in soil samples collected from Jawa village. The concentration of arsenic in the soil samples ranged from (22.34-1748.66) mg/kg which was higher than the permissible value 4.5mg/L laid by [25]. [23,32,33], reported that arsenic exceeded the threshold value to a larger extent (up to 125 times), value of Cd, Cu, And Zn were only around ten, eight, and two times higher respectively. [34] reported that soil from the forest shows relatively high levels of Arsenic and Nickel. [35,36], reported that the presence of arsenic strongly suppressed the uptake of arsenate by rice plants growing on a polluted soil.

Tables 3, 4, 5, and Figs. 3, 4, and 5 shows the arsenic concentration in tomato, lettuce, and spinach respectively which are regarded as vegetables. The arsenic concentration ranged from (903.27-965.07) mg/kg in tomato, (973.09-1416.36) mg/kg in spinach, and (770.94-790.65) mg/kg in lettuce respectively. All these values were higher than the permissible value (0.4 mg/kg) stipulated by [25] for the vegetable. The arsenic concentration in grain of Boro rice first increased with exposure but then decreased. [37,38], Reported that range of arsenic concentrations in water used for irrigation was high. The observed toxic effect of As accumulated in grains was far less compared to range in soil concentration [13]. [39], analysed numerous rice, and seafood samples, the percentage of inorganic arsenic was at least 50 percent with maximum values of more than 90 percent. [13,40], cited that high arsenic concentration causes weakness of the body, poor appetite, vomiting, headache, damage to the nervous system and cancer.

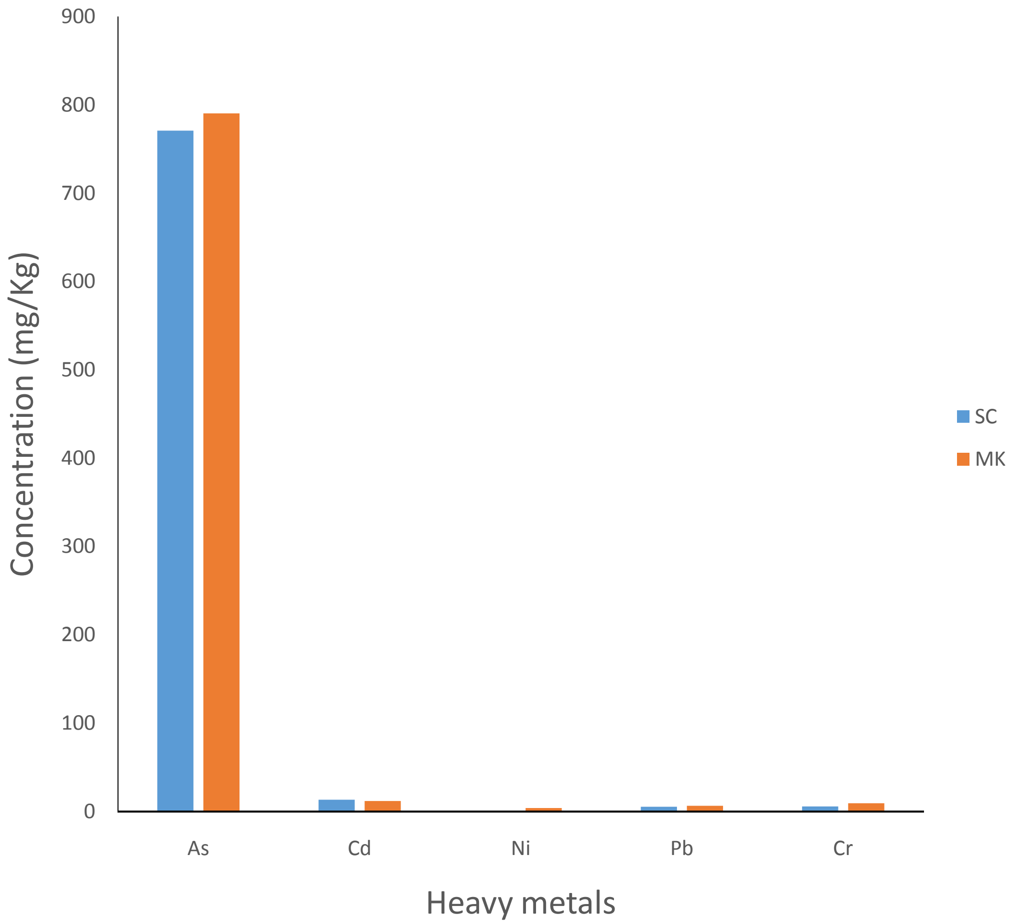

Fig. 5. Heavy metals concentrations in lettuce harvested from various farms in Jawa village of Bade local Gov't area of Yobe State

3.3 Cadmium

Table 1, Fig. 1 shows the concentration of cadmium in water samples in various farm sites in Jawa Village of Bade local government area of Yobe state. The concentration of Cadmium ranged from (0.15-0.69) mg/kg which was higher than the permissible value (0.005 mg/L) stipulated by [25]. [41], reported that high level of Cadmium in water from Kirisia division compared to Lorroki results from sewage sludge was due to human activities such as; excretion, domestic produce and storm water containing particles of rubber. Table 2, Fig. 2 shows the concentration of Cadmium in soil samples in Jawa village. The concentration of cadmium in the soil samples ranged from (0.97-1748.66) mg/kg which was higher than the permissible value (0.15 mg/kg) stipulated by [25]. In contrast [42], reported a lower level of Cadmium (3.4mg/kg) in the wastewater irrigated soil in Zimbabwe. [43], Reported high values of Cadmium located principally in Monterrey shale area of California, known to be a geological source of cadmium. Tables 3, 4, 5 and Figs. 3, 4 and 5 shows the concentration of Cadmium in tomato, lettuce and spinach respectively. The cadmium concentration ranges from (10.12-15.40) mg/kg in tomato, (17.43-19.11) mg/kg in spinach and (12.08-12.98) mg/kg in lettuce respectively. All these values were higher than the permissible value (0.02 mg/kg) laid down by [25] for vegetable. High concentration of cadmium in leafy vegetables increased in the soil as was reported by [44]. The concentration of Cadmium inedible portion of palak plants grown at 20% and 40% sewage sludge-amended soil were above the permissible limits of Indian standards [45].

High concentration of cadmium causes kidney failure and liver damage [46].

3.4 Nickel

Table 1; Fig. 1 shows the concentration of Nickel in water samples of various farm site in Jawa village. The concentration of Nickel ranged from (0.01-0.08) mg/kg which was higher than the permissible value (0.01 mg/L) stipulated by [25]. [47], Reported increased nickel concentration in groundwater and municipal tap water (100-2500 ug/L) in the polluted area, in which natural nickel was mobilized. Water left standing overnight in plumbing fittings plated with chromium on a base of nickel, contained nickel concentration of 490 ug/L [31]. Certain stainless steel materials were identified as the sources of increased nickel concentrations in groundwater at Arizona, USA as reported by [48]. [49], Reported nickel concentration in drinking water in European countries ranged from 2-13 ug/L. Table 2, Fig. 2 shows the concentration of Nickel in soil sample in Jawa village, the concentration ranged from (1.75-20.45) mg/kg which was higher than the permissible value (2.6 mg/kg) stipulated by (WHO. 2001). Researchers, reported that agricultural soil contain nickel at level of 3-1000 mg/kg; in 78 forest floor samples from north-eastern part of Europe. United State of America nickel concentration was observed to be 8.5-15 mg/kg as reported by environmental Monitoring Assess [50]. Tables 3, 4, 5, and Figs. 3, 4, and 5 shows the concentration of Nickel respectively. The nickel concentration ranges from (0.92-9.37) mg/kg in tomato, (2.21-4.59) mg/kg in spinach and (0.14-3.82) mg/kg in lettuce respectively. All these values were above the permissible value (0.8 mg/kg) stipulated by [25]. In most food products, nickel content is less than 0.5mg/kg, as reported by [51]. High concentration of nickel is considered to cause cancer and loss of hair on the body [9,52].

3.5 Lead

Table 1 and Fig. 1, shows the concentration of Lead in water samples in various farm sites in Jawa village. The frequency of Lead ranged from (0.10-3.58) mg/kg which exceeded the permissible value by [25]. Table 2 and Fig. 2 shows the concentration of Lead in soil samples in various farm sites in Jawa village. Tables 3, 4, 5 and Figs. 3, 4, and 5, shows the concentration of Lead in vegetable samples which ranged from (7.75-14.36) mg/kg in spinach, (12.17-24.63) mg/kg in tomato and (4.89-6.52) mg/kg in lettuce respectively were higher than the permissible value 0.3 mg/kg laid by WHO [25]. The concentration of lead content in the vegetable seems to be alarming in cases of excessive consumption. [53] In confirmation reported high level of lead in amaranths analyzed ranging from (0.4-45.0) mg/kg. The Lead concentration in this study was compared to the values reported by [54] in samples from farms which were located along the high ways in Dar es Salaam. Studies in Tinga reported Lead concentration ranged from below detection limits to 0.188 mg/kg according to [29]. [50] Evaluated the Lead levels in consumed vegetables in the Niger Delta Oil area of Nigeria, which were slightly higher than the limits of heavy metal in the United Kingdom and resulted in a health risk to people who were dependent on these contaminated vegetables for their daily meal. Lead is a very toxic heavy metal because of its global distribution, accumulation tendency in the body and toxicity even at shallow concentration. High concentration of Lead causes convulsions, coma, renal failure and even death when the metabolic function of the body is disturbed [51].

3.6 Chromium

Table 1, Fig. 1 shows the concentration of Chromium determined in water samples ranged from (0.04-0.07) mg/kg obtained from Jawa village, was slightly higher than the permissible limit 0.05 mg/L according to WHO [25]. Table 2, Fig. 2 shows the concentration of Chromium determined in soil samples ranged from (9.89-17.59) mg/kg obtained from Jawa village which was higher than the permissible limit 0.12 mg/kg stipulated by WHO [53]. Tables 3, 4, 5, and Figs. 3, 4, and 5 shows the concentration of heavy metals determined from vegetable samples obtained from Jawa village of Bade local government of Yobe state. The concentration of Chromium from vegetable samples ranged from (0.69-3.97) mg/kg in spinach, (0.91-5.05) mg/kg in tomato and (5.44-9.28) mg/kg in lettuce respectively. In line with these results, [28], reported that lettuce generally had the highest concentrations of Chromium at peacock Vegetable farm.

4. CONCLUSION

The study revealed the presence of heavy metal (As, Cd, Ni, Pb, and Cr) in the water, soil, and vegetable samples grown in various farm sites in Jawa village in Bade local government area of Yobe state. The level of arsenic in the ground was (22.34-1748.66) mg/kg higher than the concentration in the vegetables and water. The different frequency in the samples from different sample site. Comparable results were found with some of the values reported in the literature, and for most of the metals, the concentration exceeded the permissible limit which could be attributed to the agricultural practices employed such as the use of fertiliser, pesticides and herbicides. In general, the consumption of vegetables by humans in Jawa village, Bade local government area and Yobe state at large in their daily food, poses a significant public health risk. Since there is a growing interest in the use of vegetables throughout the world, particular attention should be given to continuous monitoring of the levels of heavy metals as their accumulation with time causes severe health impact.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Webster (2010). New World College Dictionary. Wiley Publishing Incorporated, Cleveland, Ohio. 1-2011.
2. Hamaidi-Chergui H, Errahmani MB, Benouakhil F, Hamaidi MS. preminary study of physicochemical parameters and phytoplankton of chiffa river (Blida, Ageria) Journal of Ecosystem. 2013;2015:1-9.
3. Alloway JB. Trace metal in soils irrigated with waste in a periurban area Downstream Hanoi city, Vietnam, Seminar paper, Institution for markvelenskap, Sverigeslantbruk Universities (SLU), Uppsala, Sweden; 2007.
4. Qishlaqi A, Moore F, Forghani G. Impact of untreated wastewater irrigation on soil and crops in Shiraz Sub Urban Area, SW Iran. Environmental Monitoring and Assessment. 2008;141:257-273.
5. Raju KV, Somashekar R, Prakash K. Heavy metals status of sediment in River Cawvery, Karnataka. Environmental Monitoring and Assessment. 2013;148(1): 361-373.
6. Saeed MD, Mahmoud AM. Determination of some physicochemical parameters and some heavy metals in boreholes from Fagge local government area of Kano metropolis Nigeria. World Lournal of Analytical Chemistry. 2014;2(2):42-46.
7. Onianwa PC, Lawal JA, Ogunkeye AA, Orejimi BM. Cadmium and Nickel composition of some Nigeria foods. J. Food Analysis. 2000;13:961-969.
8. Khairiah T, Zalifah MK, Yin YH, Aminath A. The uptake of heavy metals by fruit type vegetables, grown in selected agricultural areas. Pak. J. Biol. Sci. 2004;7(2):1438-1442.
9. Ambrose AM, Larson DS, Borzelleca JR, Hennigar GR Jr. Long-term toxicologic assessment of nickel in rat and dogs. J. Food Sci. Technol. 1976;13:181-187.
10. Eriyamremu GE, Asagba SO, Akpoborie A, Ojeaburu SI. Evaluation of lead and cadmium levels in some commonly consumed vegetables in the Niger Delta Oil Area of Nigeria. Bulletin of Environmental Contamination and Toxicology. 2005;75:278-283.
11. Audu AA, Lawal AO. Variation in metal contents of plants in vegetable garden sites in Kano metropolis J. Appl. Sci. Environ. Manage. 2005;10(2):105-109.
12. Ogwuegbu MOC, Muhanga W. Investigation of lead concentration in the blood of people in the copper belt province of Zambia, Journal of Environment. 2005;1: 66-75.
13. Mohammed Jahuruddin. Arsenic, cadmium, lead and chromium concentrations in irrigated and rain fed rice and their dietary intake implications. Australian Journal of Crop Science. 2017;11(7):806-812.
14. Cobb GP, Sands K, Water M, Wixson BG, Dorward-King E. Accumulation of heavy metal by vegetables grown in mine waste. Environ. Toxicol. Chem. 2000;19(3):600-607.
15. Divrikli U, Hozum N, Soylak M, Elci L. Trace heavy metal contents of some spices and herbal plants from western Anatolla, Turkey. Int. J. Food Sci. Technology. 2006;41:712-716.
16. Fisseha I. Metal concentrations of some vegetables irrigated with industrial liquid waste at Akaki, Ethiopa. Ethiop. J. Sci. 1998;21(1):133-144.
17. Okoronkwo NE, Igwe JC, ONwuchekwa EC. Rick and health implications of pollution in cocoa soils of Cross-River State, Nigeria. African Journal of Agricultural Reseach. 2005;6(16):3725-3728.
18. Asamoah-Boateny EK. Master’s Thesis. Kwama Nkrumah University of Science and Technology (KNUST) Kumasi

Ghana 2009. Physico-chemical and Microbiological Quality of surface waters within the Newmont Ghana Gold Mining Concession Areas. 50-52.
19. Fakayode SO, Olu-Owolabi BI. Heavy metal contamination of roadside topsoil in Oshogbo, Nigeria, its relationship to traffic density and proximity to high ways. Environmental Geology. 2003;44:150-157.
20. Mansour SA, Belal MH, Abou-Arab AAK, Gad MF. Monitoring of pesticides and heavy metals in cucumber fruit produced from different farming system. Chemosphere. 2009;75:601-609.
21. Akinola K, Njoku L, Ifitezue NV. Journal of Ecology and the Natural Environment. 2011;3(16):509-514.
22. Intawongse M, Dean J. Uptake of potentially toxic metals by vegetable plants grown on contaminated soil and their bioavailability in the human gastrointestinal track. Food Additive. Contam. 2006;23:36-48.
23. Mmolawa KB, Likuku AS, Gaboutloeloe GK. Assessment of heavy metal pollution in soil along major roadside area in Botswana. Africa Journal of Environmental Science and Technology. 2011;5(3):186-196.
24. Ang H, Lee K. Analysis mercury in Malaysian herbal preparation peer-review. Biomed Sci. 2005;4:31-36.
25. WHO. Arsenic and Arsenic compounds, Environmental Health Criteria, Geneve. 2001;224:33-39.
26. Musa H, Yakasai IA, Musa HH. Determination of lead concentration in well and bore hole water in Zaria, Nigeria. Chem Class Journal. 2004;1:14-18.
27. Sayadi MH, Razael MR. Impact of land use on the distribution of toxic metals in surface soils, Birjand city, Iran. International Academy of Ecology and Environmental Science. 2014;4(1):18-29.
28. Garba ZN, Gimba CE, Hamza SA, Galadima A. Titrimetric determination of arsenic in well water from Getso and Kutama, Gwarzo Local Government Area of Kano State, Nigeria. Chem Class Journal. 2008;5:78-80.
29. Cobbina SJ, Dagben JZ, Obiri S, Tom Dery D. Assessment of non-cancerous health risk from exposure to Hg. As and Cd by resident children and adults in Nangodi in the Upper East Region, Ghana water Qual Expo Health. 2012;10(3):225-232. DOI: 1007/s 12403-012-0059.
30. Radwan MA. Salama AK. Market basket survey for some heavy metals in Egyptian fruits and vegetables. Food Chem. Toxic 2006;44:1273-1278.
31. Andersen RA. Effect of chromium on the body composition and weight loss. Nutr Rev. 1998;56(9):266-270.
32. Mbong G, Jimenez-Espejo FJ, Garcia-Allix A, Martinez-Ruiz F, Mattielli N, Finlayson C, Ohkouchi N, Sanchez MC, Bermudez de Castro JM, Blasco R, Jordi R, Jose C, Rodriguez-Vidal J, Finlayson G; 2013.
33. Moreno-Jimenez E, Penalosa JM, Manzano R, Carpena Ruz RO, Gamarra R, Esteban E. Heavy metals distribution in soil surrounding an abandoned mine in NW Madrid (Spain) and their transference to wild flora. J Hazard Mat. 2009;162:854-859.
34. Yuanan Hu, Xueping Liu, Jinmei Bai, Kaimin Shih, Eddy Y, Zeng Hefa Cheng. State key laboratory of organic Geochemistry, Chinese Academy of Science. Guangzhou 510640, China.
35. Abedin MJ, Feldmann J, Mehang AA. Uptake kinetics of arsenic in rice plants. Physiol. 2002;128:1120-1128.
36. Sayyed and Sayadi. Variations in the heavy metal accumulation within the surface soils from chigar industrial area of Tehran. 2011;1(1):36-46.
37. Islam MS, Hoque MF. Concentration of heavy metals in vegetables around the industrial area of Dhaka city, Bangladesh and health risk assessment. International Food Research Journal. 2014;21(6):2121-2126.
38. Sridhar MKC, Olawuyi JF, Adogame, LA, Okekearu, Linda A. Lead in Nigeria environment: problem and prospects. 11th Annual international conference on heavy metals in the environment. University of Michigan, School of Public Health. 2000; 862.
39. Kohlmeier M. Heavy metals in vegetable and potential risk for human health. San Diego, CA, USA. 2003;54-60.
40. Smith CJ, Hopmans P, Cook FJ. Accumulation of Cr, Pb, Cu, Ni, Zn and Cd in soil following irrigation with untreated urban effluent in Australia. Environ. Pollution. 1996;94(3):317-323.
41. Selinus O, Alloway B, Centeno JA, Finkelman RB, Fuge R, Lindh U, Smedley P. Essentials of Medical Geology, Impact of natural environment on public health. 2005;144:890-891.

42. Mapanda F, Mangwayana EN, Nymangara J, Giller KE. The effect of long-term iirigation using wastewater on heavy metal contents of ssoil under vegetables in Harare, Zimbabwe. Agricultural Ecosystem & Environment. 2005;107:151-165.
43. Lund LJ, Betty EE, Page AL, Elliot RA. Occurrence of high cadmium levels in soil and its accumulation by vegetation. J. Environ. Qual. 1981;10:551-556.
44. Smilde KW, van Luit B, van Drirl W. The extraction of soil and absorption by plants of applied Zinc and Cadmium. Plant and Soil. 1992;143:233-238.
45. Singh RP, Agrawal M. Effect of sewage sludge amendment on heavy metal accumulation and consequent respose of Beta vuigaris plant. Chemosphere. 2007; 67:2229-2240.
46. D'Mello JPF. Food safety: contamination and toxin CABI publishing, walling Ford. Oxon, UK, Cambridge, M.A. 2003;480.
47. McNeely MD, Nechay MW, Sunderman FW Jr. Measurement of nickel in serum and urine as indices of wnvironmental exposure to nickel. Clinical Chemistry. 1972;18:992-995.
48. McConnell JR, Edward R. Coal burning leave toxic heavy metal legacy in the arctic. PANS. 2008;105(34):2140-12144.
49. Amavis R, Hunter WJ, Smeets. Effect of heavy metal contamination on soil. J.G.P.M., Eds.; 1976.
50. EMA. Development of National Non-point Source (NPS). Pollution Management Programme for Environmental management authority. TT; 2014. Available:http://www.ema.co.tt/new/index.php/non-point-source-pollution-management-programme
(Accessed 4 January 2015)
51. ATSDR (Agency for Toxic substances and Diseases Registry). Toxicological profile for Arsenic. U. S. Department of Health and Human Services, Public Health Service, U.S.A; 2000.
52. Tchounwou PR, Yedjou CG, Patiolla AK, Sutton DS. Heavy metal toxicity and environment. 2012;101:133-164.
53. Najat K. Mohammed, Fatma O. Khamis. Assessment of heavy metal contamination in vegetables consumed in Zanzibars; 2012.
54. Othman OC. Heavy metals in green vegetables and soils from vegetable garden in Dar es Salaam, Tanzania. Tanzania Journal of Science. 2001;27: 37-48.

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