Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 3, No. 1, p. 16-22, 2013
http://www.innspub.net

INNSPUB

RESEARCH PAPER

OPEN ACCESS

Some heavy metals content of seeds of beans intercropped with yams cultivated under usage of agrochemicals

J. Abah[1*], F. I. Abdulrahaman[2], N. P. Ndahi[2], V. O. Ogugbuaja[2]

[1]*Department of Chemistry, Benue State University, P.M.B. 102119, Makurdi, Benue State Nigeria*

[2]*Department of Chemistry, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria*

Article published on January 21, 2013

Key words: Beans, agrochemicals, heavy metals, Benue State.

Abstract

The increasing usage of agrochemicals in crop cultivations has resulted in the accumulation of excess nutrient elements in the rooting and deeper soil zones. This study employed standard laboratory procedures to determine the levels of some heavy metals in seeds of beans (*Phaseous vulgaris*) intercropped with yams (*Dioscorea rotundata*) cultivated under uncontrolled applications of chemical fertilizers, herbicides and pesticides in Otukpo, Ohimini and Katsina-Ala Local Government Areas of Benue State, Nigeria. The study was carried out between August and December, 2009. Levels of the heavy metals were determined using SP Pye Unicam (1900) Atomic Absorption Spectrophotometer equipped with air-acetylene burner. Results of the heavy metals concentrations of the beans seeds obtained from farmers' fields varied between 0.023±0.001µg/g Co to 1.230±0.160µg/g Fe while records of 0.012±0.002µg/g Co to 0.788±0.230µg/g Fe were obtained in the seeds obtained from control farms. Soil samples from the farmers' fields recorded heavy metals contents of 0.052±0.005µg/g Ni to 3.820±0.220µg/g Pb and 0.068±0.004µg/g Co to 4.310±0.120µg/g Pb within 0-20cm and 20-40cm soil depth respectively. Analyses of the variations of the levels of the heavy metals differed significantly ($P < 0.05$) between sample farms and locations. The mean transfer factors of the heavy metals showed high absorption of zinc, nickel, chromium and cadmium. However, the beans contents of the metals were below the dietary toxicity limits recommended by WHO. The elevated levels of the heavy metals in beans and soil samples obtained from the farmers' fields may be due to anthropogenically induced source. Therefore, there is the need for increasing farmers awareness and training aimed at sustainable agriculture and proper agrochemical usage.

***Corresponding Author:** J. Abah ✉ abahjim@yahoo.com

Introduction

Poor soil fertility as drawback to production has been reported in areas with intensive agriculture whereby farmers are necessitated to use organic and inorganic fertilizers (Mati, 2005; Salami *et al.*, 2010). The increasing usage of agrochemicals in crop cultivations has contributed to high productivity of crops in Nigeria but this has however, resulted in the accumulation of excess nutrients in the rooting and deeper soil zones (Abah *et al.*, 2009). Reports have shown that heavy applications of chemical fertilizers, pesticides and herbicides in crop cultivations can lead to the buildup of residual chemicals in soils, plants and crops (Radojevic and Bashkin, 1999), and the effects of these practices may extend beyond agricultural system. Nonga *et al.* (2011), reported that easy access to agrochemicals in the local markets and retail outlets, limited knowledge of their effects on environmental health and limited extension services are among the major factors responsible for indiscriminate uses of agrochemicals. Of particular concern, the use of commercial fertilizer is done without proper advice from agricultural officers (Isham, 2002; Mati, 2005) and misuse including over- and under-dosage as well as mixing of different fertilizers may have unintended impacts on the crop production and environment (Nonga *et al.*, 2011).

One of the most important environmental challenges facing the developing world is how to meet current food needs without undermining the ability of future generations to meet theirs (Abah *et al.*, 2010). Thus, agricultural production must be efficiently carried out to feed us now and in the future. Risks due to chemical contaminants in the terrestrial environment are often assessed by comparing current concentrations against reference concentrations above which adverse effects are considered likely to occur. It was also reported that risk assessments cannot be extrapolated from one location to another (Balk and Koeman, 1984). Thus, it becomes pertinent for localised risk assessment with a view to determining and documenting the impact of anthropogenic activities on the environment.

While increased agriculture and agrochemical uses are generally considered as panacea for farmers to increase production; the farming practices and uses of agrochemicals including possible environmental pollution from agriculture in many parts of Benue State (The Food Basket of the Nation) have not been investigated. The current study was conducted to investigate the effects of chemical fertilizers (phosphate fertilizers), pesticides (mostly diazinon, endrin and endosufan) and herbicides (round up) on the levels of some heavy metals in soils and seeds of beans intercropped with yams in Otukpo, Ohimini and Kastina-Ala Local Government Areas of Benue State, Nigeria and the outcome recommended to Government Agricultural and Rural Development Authority for education to rural farmers. It is envisaged that the baseline information presented in this study will contribute to the understanding of agricultural situation in developing countries and the possible types of agrochemical pollutions. This may be useful for sustainable agriculture, identify training need for appropriate and healthy crop production and limit consumers' exposure to dietary chemical contaminants.

Materials and method

Study area

This study was carried out in Otukpo (latitude 6049' N and longitude 8040' E), Ohimini (latitude 6025' N and longitude 7047' E) and Kastina-Ala (latitude 9020' N and longitude 7011' E). In these Local Government Areas of Benue State, beans cultivation constituted a major source of food and income for majority of the farmers and is assuming an interesting position on large scale production. The systems of beans cultivations observed in these areas involved an intercrop with yam (Dioscorea rotundata) and cassava (Manihot esculenta) for early cultivation and mono-crop for late cultivations respectively. Recently, yam and cassava cultivations in these parts of Benue State involved high usage of chemical fertilizers, herbicides and pesticides to improve soil fertility, control weeds and pests respectively. Thus, beans intercropped with yam or cassava under this practice have high potential to absorb chemical residues from soil solutions and bio-accumulate into tissues. Under excessive absorption of chemical residues, contamination of bean produce is very likely.

Table 1. Concentrations (µg/g) of Some Heavy Metals in the Beans Grain Grown in Selected L.G.As of Benue State, Nigeria (August to December, 2009).

Heavy Metals	Otukpo	Ohimini	Katsina-Ala
Cr (A)	$0.030^{a*}\pm0.001$	$0.033^{b*}\pm0.008$	$0.031^{c*}\pm0.003$
(B)	$0.022^{a+}\pm0.003$	$0.020^{b+}\pm0.006$	$0.025^{c+}\pm0.002$
Pb (A)	$0.605^{a*}\pm0.110$	$0.621^{b*}\pm0.230$	$0.632^{c*}\pm0.190$
(B)	$0.361^{a+}\pm0.210$	$0.330^{b+}\pm0.140$	$0.383^{c+}\pm0.120$
Co (A)	$0.025^{a*}\pm0.004$	$0.023^{b*}\pm0.001$	$0.026^{c*}\pm0.005$
(B)	$0.014^{a+}\pm0.005$	$0.012^{b+}\pm0.002$	$0.020^{c+}\pm0.005$
Ni (A)	$0.030^{a*}\pm0.002$	$0.038^{b*}\pm0.003$	$0.042^{c*}\pm0.003$
(B)	$0.021^{a+}\pm0.003$	$0.025^{b+}\pm0.001$	$0.027^{c+}\pm0.006$
Cu (A)	$0.064^{a*}\pm0.013$	$0.062^{b*}\pm0.015$	$0.067^{c*}\pm0.020$
(B)	$0.020^{a+}\pm0.012$	$0.023^{b+}\pm0.016$	$0.028^{c+}\pm0.017$
Cd (A)	$0.430^{a*}\pm0.019$	$0.524^{b*}\pm0.024$	$0.550^{c*}\pm0.036$
(B)	$0.320^{a+}\pm0.021$	$0.384^{b+}\pm0.025$	$0.353^{c+}\pm0.019$
Fe (A)	$1.183^{a*}\pm0.170$	$1.038^{b*}\pm0.230$	$1.230^{c*}\pm0.160$
(B)	$0.788^{a+}\pm0.230$	$0.760^{b+}\pm0.160$	$0.783^{c+}\pm0.110$
Zn (A)	$0.630^{a*}\pm0.160$	$0.658^{b*}\pm0.200$	$0.673^{c*}\pm0.180$
(B)	$0.543^{a+}\pm0.130$	$0.522^{b+}\pm0.220$	$0.512^{c+}\pm0.200$

Data presented are means ± SD of 8 replicate analyses. Within rows, ANOVA of paired means with different alphabets are statistically significant ($p < 0.05$). Within columns, t-test of paired means with asterisks (*) and plus (+) are statistically significant ($p < 0.05$). A = Farmer's Field, B = Control Farm.

Table 2. Some physicochemical properties of the soils in the sample locations.

Location	Soil Depth (cm)	pH (1:2.5 H_2O)	EC (mmho/cm)	CEC ($cmolKg^{-1}$)	Organic Matter (%)	Particle Size (%) Sand	Silt	Clay	Textural Class
Otukpo (A)	0-20	6.20±1.50	0.27±0.04	8.62±1.31	2.30±0.60	36.50±1.20	51.00±2.10	12.50±1.21	Clay-loam
	20-40	6.10±1.10	0.16±0.03	5.60±1.25	1.60±0.41	30.25±2.13	53.40±0.25	16.35±0.82	
(B)	0-20	5.92±1.20	0.22±0.05	8.26±2.20	2.82±0.33	37.60±3.10	50.13±3.22	12.27±1.16	
	20-40	5.90±0.55	0.14±0.01	5.40±1.32	2.00±0.42	31.30±0.88	55.28±1.30	13.42±1.80	
Ohimini (A)	0-20	6.40±1.30	0.24±0.02	8.85±1.54	2.65±0.40	33.40±2.30	47.10±2.20	19.50±0.62	Clay-loam
	20-40	6.15±0.11	0.18±0.03	6.11±1.37	1.45±0.32	31.15±1.10	48.45±2.41	20.40±1.20	
(B)	0-20	6.00±0.72	0.20±0.07	8.20±1.21	2.88±0.52	35.93±1.27	50.00±5.10	14.07±1.35	
	20-40	5.85±1.40	0.16±0.02	5.72±1.15	2.10±0.30	32.24±2.13	49.38±2.70	18.38±3.11	
K-Ala (A)	0-20	6.25±1.23	0.28±0.03	8.47±1.22	3.22±0.20	38.00±4.10	45.30±1.80	16.70±2.21	Clay-loam
	20-40	6.12±0.18	0.17±0.02	5.22±1.13	1.80±0.13	34.45±1.80	43.65±2.55	21.90±0.85	
(B)	0-20	6.30±1.16	0.24±0.05	7.70±1.16	2.90±0.50	35.31±2.80	52.10±1.20	12.59±0.47	
	20-40	6.15±1.02	0.13±0.02	5.30±1.25	1.76±0.11	32.00±2.20	50.46±3.30	17.54±1.11	

Data presented are means ± SD of 8 replications. A = Farmers' Fields, B = Control Farms, K-Ala = Kastina-Ala

Sample collection

Samples of beans (Phaseous vulgaris) and soils were randomly collected using standard procedures described by Radojevic and Bashkin (1999). The beans were intercropped with yams in the farmers' fields where chemical fertilizers (urea and single superphosphate) pesticides (carbofuran and diazinon) and herbicides (diuron and paraquat) were applied to enhance soil fertility, control pests and weeds respectively. Bulk soil samples were collected at depths of 0-20cm and 20-40cm using soil auger. Samples were also collected from control farms cultivated without the application of the agrochemicals in each of the sample locations. The beans were harvested four months after planting (4MAP) (August to December, 2009) from eight farms each in Otukpo, Ohimini and Kastina-Ala Local Government Areas of Benue State.

Determination of heavy metals

Sample preparations

Bean seeds: The beans seeds were air-dried, ground with porcelain mortar and pestle and then sieved (<1mm). 2.0g each of the powder were weighed into labelled acid-washed porcelain crucibles and placed in muffle furnace and the temperature was raised slowly over 2hrs to reach 500oC. The samples were ashed at this temperature for 4hrs after which they were removed and cooled in desiccators at room temperature. Then, 10.0cm3 of 6M HCl was added to each sample, covered and heated on a steam bath for 15mins followed by the addition of 1.0cm3 of concentrated HNO3 and evaporated to dryness. The heating was continued further for 1hr to dehydrate silica (Radojevic and Bashkin, 1999, AOAC, 1984). Another 1.0cm3 of 6M HCl was added and swirled to mix followed by the addition of 10.0cm3 distilled water. Again, it was heated on a steam bath to complete dissolution, cooled and filtered through Whatman No. 541 filter paper into separate 50cm3 volumetric flasks and the volume made up to the mark with water.

Soil: Bulk soil sample from each location was air-dried, ground and sieved (< 2mm) and 1.0g each was weighed into 100cm3 tall beaker followed by the addition of 30.0cm3 of 1:1 HNO3. This was boiled gently on a hotplate until the volume reduced to about 5cm3 with stirring on a magnetic stirrer (AOAC, 1984; USEPA, 1996; Radojevic and Bashkin, 1999). Then, another 10.0cm3 of 1:1 HNO3 was added and the heating was similarly repeated after which the extract was cooled to room temperature and filtered through Whatman No. 541 filter paper. The beaker was washed with successive small portions of 0.25M HNO3 and filtered. Thereafter, the filtrate was transferred into 50cm3 volumetric flask and diluted to the mark with water.

Five serial calibration standards were prepared for all the metals by diluting aliquots of the working metal solutions with 0.25M HNO3 and the calibration standards were made to cover the optimum absorbance range of 0.2-10mg/L for the standard calibration curves.

Analyses of the samples extracts

Both the beans seeds and soil extracts were analyzed for their levels of chromium (Cr), lead (Pb), cobalt (Co), nickel (Ni), copper (Cu), cadmium (Cd), iron (Fe) and zinc (Zn) using an SP Pye (1900) Unicam Atomic Absorption Spectrophotometer equipped with air – acetylene burner.

Determination of some physicochemical properties of the farms soils

Sample preparation and analysis

Bulk soil samples from the depth of 0-20cm and 20-40cm respectively were homogenized and sieved (< 2.00mm) and laboratory analyses of the soil properties were carried out on the < 2.00mm particles using standard procedures. Particle size was determined using the hydrometer method (Gee and Bauder, 1986), pH was measured in 1:2.5 suspension in water and organic matter was determined by dichromate oxidation method (Nelson and Sommers, 1982). Effective Cation Exchange Capacity (CEC) was determined by summation method following the determination of exchangeable cations (USDA, 2004) and the extraction of exchangeable acidity in

1N KCl (IITA, 1979). The soil electrical conductivity was determined by the modified method of Radojevic and Bashkin (1999) and Rayment and Higginson (1992).

Results and discussion

Table I presents the concentrations (µg/g) of some heavy metals in beans seeds grown in Otukpo, Ohimini and Katsina-Ala Local Government Areas (L.G.A) of Benue State, Nigeria between August and December, 2009. In the farmers' fields, the beans were sown on pre-treated soils (2-3 months) where chemical fertilizers, herbicides and pesticides were applied to yam to enhance soil fertility, control weeds and pests respectively. The beans were also sprayed with pesticides (endosulfan) at the flowering stage to prevent them from insects attack. The concentrations of the heavy metals recorded in the beans seeds varied between 0.023±0.001µg/g Co to 1.230±0.160µg/g Fe. Lower concentrations of 0.012±0.002µg/g Co to 0.788±0.230µg/g Pb were obtained in the beans seeds grown in control farms cultivated across the sample locations. Analyses of the variations of the levels of the heavy metals in the beans seeds were statistically significant ($p < 0.05$) between sample farms and locations.

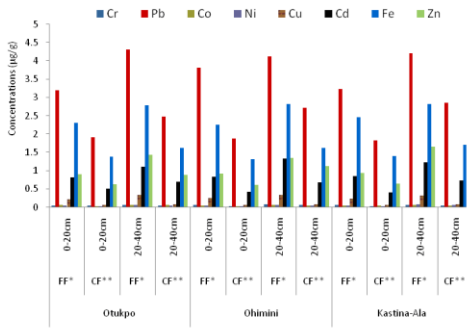

Figure 1. Concentrations (µg/g) of the Heavy Metals in the Farm Soils

Fig. 1. FF = Farmer's Field, CF = Control Farm. Different asterisk (*) on the Farmer's Field and Control Farm indicated that the heavy metals' concentrations are statistically significant ($P < 0.05$)

The higher levels of the heavy metals recorded in beans obtained from the farmers' fields may be due to anthropogenically induced source. It was observed in the study area that agrochemicals were randomly applied to yams without regard to the local environmental conditions. These have significant effects on the accumulation of agrochemical metabolites in soils and absorption by crops grown on such soil. It has been reported that anthropogenic activities aimed at enhancing food production could facilitate the accumulation of undesirable substances in plants and affect the qualities of both soil and water resources adversely (Uwah *et al.*, 2007; NAAS, 2005). The rampant uncontrolled agriculture in most parts of developing countries was attributed to poverty, poor policy governing agriculture and land use as well as the low level of awareness on sustainable land use, agriculture and environmental management (Nonga *et al.*, 2011). It was also reported that the increased use of pesticides; apart from increasing crop production, have long term negative effects on fauna and flora, changes to soil characteristics and reduced production (Pimentel and Greiner, 1997; Edmeades, 2003).

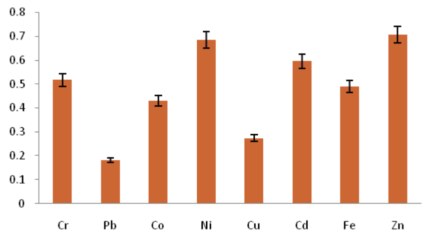

Figure 2. Soil Mean Transfer Factors of the Heavy Metals to the Beans

Fig. 2. Transfer factors = beans heavy metal concentration/soil heavy metal concentration.

Figure 1 presents the concentrations (µg/g) of the heavy metals in the farms soils. The results showed similar trend of elevated levels of the metallic elements in the farmers' fields where chemical fertilizers, herbicides and pesticides were variously used to enhance crop productivity. The results varied between 0.052±0.005µg/g Ni to 3.820±0.220µg/g Pb and 0.068±0.004µg/g Co to 4.310±0.120µg/g Pb within 0-20cm and 20-40cm soil depth respectively. The heavy metals concentrations recorded in the soils of the control farms were significantly ($p < 0.05$) lower. The results varied between

0.039±0.002µg/g Co to 1.92±0.024µg/g Pb within 0-20cm soil depth and 0.051±0.003µg/g Co to 2.86±0.014µg/g Pb within 20-40cm soil depth.

The soil mean transfer factors of the heavy metals (Figure 2) revealed that beans seeds have higher potential to absorb and bio-accumulate zinc, nickel, cadmium and chromium. This therefore, present great concern to beans growers in the studied areas because of the human health effects resulting from ingesting excess dietary content of these toxic heavy metals. Generally, the present levels of the heavy metals were below the established critical limits of 10-20.00mg/kg Fe, 0.5-10.00mg/kg Cr, 3-20.00mg/kg Pb, and 60-400.00mg/kg Zn causing phytotoxicity in plants and 200.00mg/day Fe, 200.00mg/day Cr, 1.00mg/day Pb and 150-600.00mg/day Zn causing toxicity in humans (WHO/FAO, 1985). However, prolonged exposure of consumers to excess dietary toxic metallic elements present adverse health effects. The effects of exposure even at a short duration may be delayed but there is possibility of cumulative effects (Gupta, 1994).

The results of some physicochemical properties of the farms soils (Table 2) showed that both the farmers' fields and control farms are slightly acidic with pH of 6.20-6.40 and 5.90-6.30 within 0-20cm soil depth respectively. Hoskin (1997), reported that soil pH of 6.10-7.30 were very good for normal crops response. The soil particle size distributions revealed clay-loam textural class across the sample locations. Both the electrical conductivities and cation exchange capacities of the soils are moderate but the organic matter content was high. These properties showed that the soils have good potential for retaining nutrients elements and trace metals within the top soil layer. The implication of these properties is that when the soil becomes contaminated with residual chemicals, crops grown on it may absorb and bio-accumulate high amount of heavy metals which are transferred into the human food chain.

Conclusion

The results of this study revealed that beans intercropped with yams where chemical fertilizers and herbicides were heavily applied may lead to anthropogenic build up of heavy metals in soils and beans seeds. Notwithstanding this situation, there were no plans for intervention measures by the responsible authority in the study area, probably because of limited information on the problem. Exposures of consumers to excess dietary contents of heavy metals present adverse health effects. Therefore, farmers should be trained to adopt proper agronomic practices and limit human exposure to dietary chemical contaminants.

Acknowledgements

The authors greatly acknowledged the effort of the staff of the National Agency for Food and Drug Administration and Control (NAFDAC) regional laboratory, Maiduguri and that of the Soil Science Department, University of Maiduguri for providing conducive analytical environment for the success of this work. God bless you all.

References

Abah J, Ishaq MN, Wada AC. 2010. The Role of Biotechnology in Ensuring Food Security and Sustainable Agriculture. Afr. J. Biotechnol **9(52),** 8896-8900.

Abah J, Ogugbuaja VO, Geidam MA. 2009. Effect of chemical fertilizers on the levels of some Anions in some cereals grown in Benue State, Nigeria. Proceedings of the 43rd Annual conference of the agricultural society of Nigeria, Abuja 2009. 879-883.

AOAC. 1984. Official Methods of Analysis of the Association of Analytical Chemist. 14th Ed. *AOAC. Inc.* Arlington, Virginia, USA. p 53-55.

Balk F, Koeman JH. 1984. Future Hazards from Pesticides Use. The Environmentalist 4, *IUCN Commission on Ecology Paper* 6.

Edmeades DC. 2003. The long-term effects of manures and fertilizers on soil productivity and quality: a review. Nutr. Cycl. Agroecosyst**(66),** 165-180.

Gupta RCJ. 1994. Carbofuran toxicity. Toxicol. Environ. Health **(43),** 383-418.

Gee GW, Bauder JW. 1986. Particle size analysis. In: Klute, A (Ed). Methodsof soil analysis "Tropical and mineralogical methods. Agronomy. *Am. Soc. of Agron.*, Madison, Part 1.Wisconsin. p. 383-411.

Hoskin BR. 1997. Soil Testing Handbook for Professionals in Agriculture, Horticulture, Nutrient and Residuals Management, 3rd Ed, Maine Forestry & Agricultural Experiment Station University of Maine. p 14-15.

IITA. 1979. Selected Methods for Soil and Plant Analysis of the International Institute for Tropical Agriculture. *IITA, Ibadan.*

Isham J. 2002. The Effect of Social Capital on Fertilizer Adoption: Evidence from Rural Tanzania" J. Afr. Econ**(11),** 39-60.

Mati BM. 2005. Overview of Water and Soil Nutrient Management Under Smallholder Rainfed Agriculture in East Africa. Working Paper 105. Colombo, Sri Lanka: International Water Management Institute (IWMI)

NAAS. 2005. Policy Options for Efficient Nitrogen Use. Policy Paper No. 33. *National Academy of Agricultural Science,* New Delhi. p 1-4.

Nelson DW, Sommers LS. 1982. Total Carbon, Organic Carbon, and Organic Matter. In: Page A. L. *et al* (eds). Methods of Soil Analysis. Part 2 *Agron. Monogr*. 9 (2nd edition) p. 539-579.

Nonga HE, Mdegela RH, Lie E, Sandvik M, Skaare JU. 2011. Assessment of Farming Practices and Uses of Agrochemicals in Lake Manyara basin, Tanzania. *Afr. J. Agric. Res.* **6(10),** p. 2216-2230.

Pimentel D, Greiner A. 1997. Environmental and socioeconomic costs of pesticide use. In: Pimentel, D. (Ed.), Techniques for Reducing Pesticide Use: Economic and Environmental Benefits. John Wiley and Sons, Chichester, p. 51-78.

Radojevic M, Bashkin NV. 1999. Practical Environmental Analysis. *Royal Society of Chemistry and Thoma Graham House,* Cambridge, U.K. pp 356-377, 400-408.

Rayment GE, Higginson FR. 1992. Australian Laboratory Handbook of Soil and Water Chemical Methods. *Inkarta Press*. Melbourne. p 25-30.

Salami A, Kamara AB, Brixiova Z. 2010. Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities, Working Papers Series No 105, African Development Bank, Tunis, Tunisia.

USDA. 2004. Natural Resources Conservation Service: Soil Survey Laboratory Methods manual. *Soil Survey Investigation Report No. 42 version 4.0.* Natural Resources Conservation Service. p 700.

USEPA. 1996. Acid Digestion of Sediment, Sludge and Soils. Method 305B. *USEPA*, Washington. p 5-15.

Uwah EI, Akan JC, Moses EA, Abah J, Ogugbuaja VO. 2007. Some Anions Levels in Fresh Vegetables in Maiduguri, Borno State, Nigeria. Medwell online Agric. J. **2(3),** 392-396.

WHO/FAO. 1985. WHO/FAO Food Additives Data Systems. Evaluation by the Joint committee on Food Additives, 1956-1984. *FAO Food and Nutrition Paper* 30/Rev. Rome.