Ethiopian Journal of Environmental Studies & Management 14(6): 694 – 704, 2021.
ISSN:1998-0507 doi: https://ejesm.org/doi/v14i6.2
Submitted: May 7, 2021 Accepted: September 29, 2021

HEAVY METALS IN CUCUMBER (*Cucumis sativus* L.) AS INFLUENCED BY ORGANIC AND INORGANIC FERTILISERS

FADINA, O.O., *NWANGUMA, C.S., FAYINMINNU, O.O. AND DAODU, B.J.
Department of Crop protection and Environmental Biology, University of Ibadan, Nigeria
*Corresponding author: nwangumachima@gmail.com

Abstract
Heavy metals are significant environmental contaminants found on the surface and in the tissue of fresh vegetables through the use of phosphate and animal manure fertilisers applied to soil during production. A field study was carried out at the experimental site of National Horticultural Research Institute, Idi-ishin, Ibadan, to assess the heavy metal concentration in cucumber planted under different levels of phosphate (synthetic) and animal manure (organic) fertilisers. There were five treatments: Poultry manure, Composted cow dung, Liquid Organic fertiliser, NPK (15:15:15) and the control which were laid out in a randomised complete block design replicated three times. Data were collected on growth and yield parameters; plant height (PH), stem girth (SG), leaf area (LA), number of fruits (NOF) and fruit weight (FW) of cucumber. Heavy metal analysis was carried on all the fertilisers before use, on the soil and fruits after harvesting using standard procedures. Risk Assessment to human exposure was also determined. Data were analysed using ANOVA at $p<0.05$.Results were compared with the WHO and EU standards. The findings were used to determine the Daily Intake of Metals (DIM), the Health Risk Index (HRI) and the Target Hazard Quotient (THQ). The HRI and THQ for Lead were highest in compost (0.45) and (0.88) respectively although it is still below the tolerable limit (1). If used over time or eaten more often could lead to bio-accumulation and eventually respiratory and other carcinogenic diseases in humans.

Key Words: *Health risk, Heavy metals, Soil, Cucumber*

Introduction

Cumunis sativus L. (Cucumber) of the Cucurbitaceae family is thought to be one of the oldest vegetables cultivated by man with historical records dating back to 5,000 years (Wehner and Guner, 2004). Cucumber is one of the main fruits that is eaten raw, cooked or in salad. The presence of terpenoid, a main phytochemical constituent in cucumber possesses medicinal properties against malaria, viral, bacterial and fungal agents (Egwaikhide, 2010) as obtained from its extract (Ankita *et al*., 2012). The soils where cucumber is cultivated require moderate to high nutrient levels so as to achieve high yields. Poor soils result in bitter and deformed fruits which are often rejected or abandoned by consumers hereby reducing farmer's income (Eifeyidi, 2010). These soils are enhanced by applying fertilizers that supply additional plant nutrients and also boost the plant growth.

Inorganic fertilisers are chemical compounds made in factory or obtained from mining, while organic fertilisers are composed mostly from waste, plant and animal residue. Application of inorganic and organic fertilisers to the soil has shown influence on human food chain toxicity because it contains not only major elements necessary for plant nutrient but also variable qualities of heavy metals (Curtis and Smith, 2002; Eifediyi and Remison, 2009). Heavy metals are metallic elements exceeding a density of 5 gm^3 (Ali *et al*., 2013). These include Cu, Fe Mn and Zn which are essential for biochemical and physiological activities in plants at low concentrations, while Pb, Cd, As, Hg, Ni are toxic to the environment even at their low concentrations with no established role in plants (Benavides *et al*., 2005).

As above, a feature that heavy metals have in common is that they become toxic when ingested; and are not metabolized by the body thereby accumulate in the tissues (Godfrey *et al*., 2003). Those who cannot excrete heavy metal efficiently appear to be genetically predisposed to this condition. Soil-to-plant transfer is one of the key components of human exposure to metals through the food chain (Opaluwa *et al*., 2012). The concentration of heavy metals increases up the food chain.

This study was therefore conducted to assess the heavy metals concentration in cucumber, the varied health risk of the heavy metals and the transfer factor from the soil to the plant

Methodology

Experimental Site Description

The experiment was carried out at the National Horticultural Research Institute (NIHORT) Jericho, Ibadan, Oyo State. The area lies between Latitude 7°54′N, Longitude 3°54′E and 213m above sea level in the Greenwich meridian, its average rainfall is about 1250mm, while average mean temperature is 26°C. The average relative humidity is 74.53%

Treatments and Experimental Design

The seeds of cucumber (NAGANO F1), liquid organic fertiliser and NPK (15:15:15) were purchased from Agrotropics Seed Company Bodija, Ibadan. The cured poultry manure was collected from NIHORT poultry farm, the organic compost was bought from Aleshinloye Fertiliser Company. The treatments were: Liquid organic manure at a rate of 500ml/ha, compost organic manure at a rate of 20 tons/ha, inorganic manure at a rate of 65kg/ha, cured poultry manure at a rate of 20tons/ha recommended by Adeniyi (2014) and the control. The experiment was laid out in a Randomised Complete Block Design (RCBD) with each of the five treatments replicated three times.

Data Collection

Data were collected on the following:

1. Freshly harvested *Cumunis sativus* were taken to the laboratory and analyzed for the presence of heavy metals. Three replicates will be collected in the farm.
2. Heavy metals constituent in the soil were determined by analysing the soil sample using Atomic Absorption Spectrometry (AAS).

Soil Sampling and Heavy Metals Determination

A known weight of 0.5g of finely ground soil collected randomly with a hand trowel from a depth range of 0-15cm (top soil) was determined. The soil sample was properly placed in an aluminium foil and transported to the laboratory to air dry at room temperature for 24 hours for heavy metals analysis. The samples were digested at the Toxicology Research laboratory of the Department of Crop Protection and Environmental Biology, University of Ibadan following the procedures of (A.O.A.C, 2005). The absorbance of heavy metals contents of all samples was read for Cu, Zn, Pb, Cd, Cr and Ni on Atomic Absorption Spectrophotometer (AAS) at the FATLAB Nigeria Company, Ibadan, Nigeria.

Heavy Metal Determination in Cucumber

The Cucumber fruits were digested by the conventional method and heavy metal estimation was done using the modified protocol of Roychowdhury and Tah (2011). Ten grams of plant material (fruit weight) was weighted and crushed in the mortar and pestle. The crust material was taken in a 100ml beaker; 2ml of concentrated sulfuric acid (H_2SO_4) and 8ml of nitric acid (HNO_3) were added to it thereafter heated gently. Further nitric acid was added till the solution become colourless and transparent. Then these two acids were evaporated out and 0.25ml of perchloric acid was added and heated to dissolve the residue. Then again the acid was evaporated out and to the dry residue small amount of distilled water was added; the residue was dissolved, a small amount of $HN0_3$ was added thereafter. After that, the solution was transferred to a 25ml volumetric flask and the volume was made up to 25ml. The heavy metals (Fe, Cu and Zn) present in the sample were determined by atomic absorbance spectrophotometer (ASS, Varisan - 55B) against the calibration graph of the corresponding element.

Data Analysis

Data were analysed using analysis of variance and means were separated at a probability of five percent (5%) level of significance using the Duncan Multiple Range Test (DMRT).

Results

Analysis of the soil properties before planting of cucumber showed that the soil has a pH of 7.30, organic carbon of 29.2mg/kg, nitrogen 3.9mg/kg, phosphorus of 18.5mg/kg, potassium of 2.81 mg/kg and it is loamy sand as shown in Table 1. The soil is very ideal for cucumber production.

Comparison of Some Heavy Metals Concentration in the Soil Sample

Six heavy metals were determined, namely; copper, cadmium, chromium, zinc, lead and nickel. After harvesting, the highest value 50.4mg/kg was obtained from Zn, followed by 12.9 and 12.8mg/kg for Pb and Cr, respectively, however, Cu had the lowest value of 1.08mg/kg. The results were compared with the WHO standard and EU standard, (2006). The result for Zinc (Zn) is above the permissible limit for both the EU standard and WHO standard which are 50.00 and 0.3mg/kg respectively. While that which was detected for Zn was 50.4mg/kg. The result for lead (Pb) was detected to be below the permissible limit according to the EU standard and above the WHO standard which are 300mg/kg and 0.1mg/kg respectively. While that which was detected for Pb was 12.9mg/kg. The result for Copper (Cu) was detected to be below the permissible limit according to the EU standard and above the WHO standard which are 80mg/kg and 0.1mg/kg respectively. While that which was detected for Cu was 1.08mg/kg. The result for cadmium (Cd) was detected to be the same with the EU standard with was 3.0mg/kg. Therefore, it was within the permissible limit. Chromium (Cr) was detected to be 12.80mg/kg although according to the EU standard, Cr is not supposed to be present in agricultural soils. This suggests that it is above the permissible limit for the soil. Nickel (Ni) was detected to be 10.75mg/kg which was below the permissible limit according to EU standard of 50mg/kg. The results depicted that Zinc constituents had the highest concentration in the soil sample.

Comparison of Some Heavy Metals Concentration in the Fertilisers

Results from Table 4 revealed heavy metals in different fertilisers used in this study. In compost, Cr had the highest value (310.00mg/kg) which was also the highest value in all the fertlisers` used. It also had highest value (349.18mg/kg) in Liquid fertiliser. The lowest value (3.00mg/kg) in compost was recorded from Cd. Zinc with 106.00 and 62.00mg/kg, respectively recorded the highest levels in poultry and NPK, while Ni had the lowest values of 5.00, 15.63 and 4.00mg/kg, respectively in poultry, Liquid and NPK fertilisers. However, Cd and Pb were not detected in poultry, Liquid and NPK fertilisers, while Cr was not detectable in NPK. These values were within the permissible levels of the WHO standard and EPA standard (Yari *et al*., 2016).

Comparison of Heavy Metals Concentration and Accumulation in Cucumber

Four heavy metals: Zinc (Zn), Lead (Pb), Cadmium (Cd) and Chromium (Cr) determined in comparison with its intake by the different fertilisers used. It is shown as presented in Table 5that Cr had the highest concentration in cucumber from all the fertilisers used in the experiment. The highest Cr value (110.27 mg/kg) was obtained from compost, followed by higher values of 109.85, 106.90 and 103.52mg/kg, respectively from poultry, NPK and Liquid fertilisers. The control treatment also recorded the highest value 92.86 of Cr over other heavy metals. Cadmium and Pb had the same lowest concentration of 0.08mg/kg from NPK and poultry fertilisers, heavy metals concentration in cucumber were within the tolerance level in vegetables according to EU, NAFDAC, FAO/WHO (2016) with the exception of Cr having higher levels and Pb in compost fertiliser only. The control treatment however, had higher concentration of Cr (92.86mg/kg) and Cd (0.47mg/kg) in cucumber fruit which were higher than the permissible level in vegetables.

Heavy Metals Transfer Factor (TF) from Soil to Crop

Results on Transfer Factor (TF) as presented in Table 6 shows that TF of Cr heavy metal revealed the highest values (ranged from 8.09-8.61) in Liquid, NPK, poultry and compost fertilisers which were greater than ≥ 0.5. Also the control treated plot recorded higher TF value (7.26). However, the TF values of all other metals from Zn, Pb and Cd in compost, NPK, poultry and Liquid fertilisers were lower than ≥ 0.5.

Potential Health Risk Through Ingestion of Cucumis sativus Fruit and Farm Soil

The Daily Intake of Metals (DIM), Health Risk Index (HRI) and Target Hazard Quotient (THQ) results of cucumber ingestion in this study is presented in Table 7. Significant differences ($p<0.05$) were observed amongst the treatments. The highest Zn value (0.0062) in DIM was obtained from poultry fertiliser, while the lowest (0.0024) was from compost. The HRI ingestion for cucumber showed the highest level of Zn (0.020) from the poultry fertiliser, while the lowest value (0.0082) was recorded from compost fertiliser. Zinc heavy metal had the maximum level of 0.029 from the control treated plot in THQ, while the minimum value of 0.014 was from poultry fertiliser. However, all the values obtained for Zn in this study were drastically low when compared to the acceptable values of DIM, HRI and THQ for fruit vegetables.

Daily Intake of Toxic Metal (DIM)

Results shown in Table 8 revealed significant differences ($p<0.05$) amongst the treatments. Chromium had the highest value (0.0539) of DIM from compost fertiliser, while the lowest value (0.0450) was from the control treatment. Highest Cr value (0.0359) was obtained from compost fertiliser for the HRI. The THQ for Cr was highest (0.700) in both compost and poultry fertilisers and lowest (0.059) from the control treatment. All the values recorded for Cr in DIM, HRI and THQ from all the fertilisers were very low when compared to the permissible levels of fruit vegetables. However, the daily intake of metals (DIM) for Chromium in *C. sativus* was below the tolerable limit according to USEPA, 2013 (45). This is the same result for all other toxic metals detected in the fruit. These results were compared with some North Africa countries and FAO/WHO standard (FAO/WHO, 2001).

Health Risk Index

Significant differences ($p<0.05$) were observed in the treatments as shown in Table 9. The highest DIM value (0.0018) of Pb obtained in this study was from compost, while the lowest values (0.00) were from both poultry fertiliser and the control treated plot. The Pb had the highest value (0.4467) of HRI from compost, while the lowest value (0.000) was also from the control treatment. The THQ had its highest value (0.8760) for Pb from compost fertiliser, while the lowest (0.000) was recorded from the control treated plot. All values obtained for Pb were very low when compared with the upper tolerance limits of DIM, HRI and THQ for fruit vegetables. However, the health risk index for all the metals (HRI) in *C. sativus* was below the tolerable limit according to USEPA, 2013 (>1).

Target Hazard Quotient

Results presented on Table 10 showed significant differences ($p<0.05$) among the treatments. The control treatment recorded the highest value (0.002) of Cd for DIM, while the lowest value (0.000) was from NPK fertiliser. The highest value (0.2300) of HRI from Cd was from the control treated plot, while the lowest value (0.0400) was from NPK fertiliser. The THQ had its highest value (0.4510) of Cd from the control treatment, while the lowest value (0.0788) was from the NPK fertiliser. However, all the values of Cd recorded were very low when compared to the upper tolerable limits of DIM, HRI and THQ in fruit vegetables. However, the target hazard quotient for all the metals (THQ) in *C. sativus* was below the tolerable limit according to USEPA, 2013 (>1).

Discussion

Heavy metals concentration in soil is associated with biological and geochemical cycles and they are influenced by anthropogenic activities (Fayinminnu and Adekunle-Jimoh, 2015; Fadina *et al*., 2017). All toxic metals in this study were lower than the guidelines for soil (Ewers, 1991).Only Cd and Cr exceeded the tolerable levels in the soil, while Zn, Ni and Pb were less than the tolerable levels as determined by (Chary *et* *al*., 2008), this could be as a result of the high presence of chromium and cadmium in the soil with respect to the standard expected to be present in the soil.

The high transfer values for Cr from soil to fruit indicates a strong accumulation of the receptive metals in the region as reported by Fayinminnu and Adekunle-Jimoh (2015). An important aspect of assessing risk to human health from potentially toxic metals is the knowledge of the dietary intake of the metals (DIM), which must remain within the established safety margin as in the Provisional Tolerable Daily Intake (PTDI) by FAO/WHO, (2001), the Global Estimated Daily Intake (GEDI) and the Recommended Dietary Allowances (RDA) by the Food and Nutrition Board, (2004) (Cherfi *et al*., 2014; Chery *et al*., 2008).The dietary intake of Zn, Cd, Pb and Cr in fruit was found to be lower than the PTDI values; they were also lower than RDA values; and Ni, Pb and Cr lower than those reported in Libya (Elbagermi *et al*., 2012). Health quotient has been a useful parameter for evaluation of risk associated with consumption of metal contaminated food crops (Chary *et al*., 2008 and Zhuang *et al*., 2009). The existential potential for chromium and lead contamination and toxicity raises the issue of future monitoring (Udousoro and Essien, 2015). Also instances where cucumber is planted for the influx harvesting of fruits at a short period of time, the use of inorganic fertilisers when used at a reasonable rate of 65kg/ha is best suitable for a unique significant difference in output at both the sixth and seventh week after planting. This also ensures a tolerable rate of the various heavy metals detected in the cucumber fruit.

Conclusion

Cucumis sativus fruit may contribute to bio-concentration and magnification of nickel and chromium in humans. Although the human health risks associated with cucumber fruit consumption were negligible (health quotient<1), it was observed that lead in the fruit presented the highest values for the target hazard quotient in the study area. The results of this study may inform policy on prevention of food contamination by toxic metals.

Table 1: Physicochemical properties of the soil before planting

Parameter	Values
pH	7.3
Organic Carbon (g/kg)	29.2
Nitrogen (g/kg)	3.9
Available Phosphorus	13.72
Exch. Acidity	0.42
Calcium (cmol/kg)	0.21
Magnesium (cmol/kg)	0.34
Sodium (cmol/kg)	10
Potassium (cmol/kg)	2.81
% clay	16.4
% slit	1.2
% sand	82.4
Textural Class	Loamy sand

Table 2: Guidelines of toxic metals in soil food and vegetable

Zn (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Standards
				Soil		
1-100		0.02-5.20	5.0 – 15.0	-	0.03-14.0	Normal ranges
300		60	100	-	-	Tolerable levels
71.0	20.0	20.0	20.0	0.098	35.0	Background value
300		50	100	3	100	Guidelines for the soil
			Food and Vegetables (mg/kg)			
9.4		66.9	0.3	-	2.3	Recommended maximum levels for vegetables FAO/WHO codex 20012001 (USEPA, 2011, FAO, 2001)
50		-	2	-	-	NAFDAC
50		-	0.43	0.2	1	EU, 2006

Table 3: Some heavy metals concentration in the soil sample before fertiliser application

No	mg/kg Cu	mg/kg Cr	mg/kg Zn	mg/kg Cd	mg/kg Pb	mg/kg Ni
WHOSOIL	1.08	12.80	5.856	3.0	12.9	10.75
WHO	0.1	-	0.3	-	0.1	-
EU (2001)	80	-	-	3.0	300	50

Table 4: Comparison of some heavy metals concentration in the Fertilisers Used

FERTILISER	mg/kg Cu	mg/kg Zn	mg/kg Cr	mg/kg Cd	mg/kg Pb	mg/kg Ni
COMPOST	23.00	145.00	310	3.00000	80.0000	11.0000
POULTRY	15.00	106.00	16	ND	ND	5.0000
LIQUID	216.025	60.625	349.175	ND	ND	15.625
NPK	22.000	62.000	ND	ND	ND	4.0000
WHO	90.260	800-1200	--	15-40	200-400	--
EPA	1500	--	1200	--	300	--

Table 5: Some heavy metals concentration in the Cucumber

Fertiliser	Zn	Cr	Pb	Cd
Compost	5.006	110.267	3.656	0.298
Inorganic	5.76	106.896	0.90223	0.0822
Poultry	4.3933	109.849	0.083	0.3063
Liquid	5.345	103.52	1.1175	0.1499
Control	9.165	92.861	0	0.47075
EU	50	1	0.43	0.2
NAFDAC	50	-	2	-
FAO/WHO, 2016	9.4	2.3	0.1	-

Table 6: Comparison of Heavy metals transfer factor (on dry weight basis) of soil to crop

TREATMENT	Zn	Cr	Pb	Cd
Compost	0.0993	8.6146	0.2800	0.0990
Inorganic	0.1140	8.3513	0.0699	0.0274
Poultry	0.0870	8.5819	0.0064	0.1021
Liquid	0.1061	8.0870	0.0866	0.0500
Control	0.1818	7.2550	0.0000	0.1569

Footnote: T F ≥0.5 indicates high rate of transfer of metals from soil to vegetable (fruit) (Khan *et al*., 2009)

Table 7: Potential Health Risk Assessment of Zinc in the treatments used through ingestion of *Cucumis sativus* fruit

TREATMENT	Zinc		
	DIM	HRI	THQ
COMPOST	0.0024	0.0082	0.0160
INORGANIC	0.0028	0.0094	0.0184
POULTRY	0.0062	0.0200	0.0140
LIQUID	0.0026	0.0087	0.0170
CONTROL	0.0045	0.0149	0.0293
Upper tolerable limits	45	>1	>1

Footnote: DIM = Daily Intake of Metals, HRI = Health Risk Index and THQ = Target Hazard Quotient

Table 8: Potential Health Risk Assessment of Chromium in the treatments used through ingestion of *Cucumis sativus* fruit

TREATMENT	Chromium		
	DIM	HRI	THQ
COMPOST	0.0539	0.0359	0.0700
INORGANIC	0.0522	0.0348	0.0680
POULTRY	0.0537	0.0358	0.0700
LIQUID	0.0506	0.0337	0.0660
CONTROL	0.0450	0.0300	0.0590
Upper tolerable limits	45	>1	>1

Footnote: DIM = Daily Intake of Metals, HRI = Health Risk Index and THQ = Target Hazard Quotient

Table 9: Potential Health Risk Assessment of Lead in the treatments used through ingestion of *Cucumis sativus* fruit

TREATMENT	Lead		
	DIM	HRI	THQ
COMPOST	0.0018	0.4467	0.8760
INORGANIC	0.0004	0.1100	0.2160
POULTRY	0.0000	0.0100	0.1990
LIQUID	0.0005	0.1365	0.2680
CONTROL	0.0000	0.0000	0.0000
Upper tolerable limits	45	>1	>1

Footnote: DIM = Daily Intake of Metals, HRI = Health Risk Index and THQ = Target Hazard Quotient

Table 10: Potential Health Risk Assessment of Cadmium in the treatments used through ingestion of *Cucumis sativus* fruit

TREATMENT	Cadmium		
	DIM	HRI	THQ
COMPOST	0.0001	0.1456	0.2860
INORGANIC	0.0000	0.0400	0.0788
POULTRY	0.0001	0.1497	0.2937
LIQUID	0.0001	0.0733	0.1437
CONTROL	0.0002	0.2300	0.4510
Upper tolerable limits	45	>1	>1

Footnote: DIM = Daily Intake of Metals, HRI = Health Risk Index and THQ = Target Hazard Quotient

Table 11: Dietary intake of toxic metals (mg/day) in *Cucumis sativus* fruit compared with others and standard

Source	Zn	Pb	Cd	Cr
COMPOST	0.0024	0.0018	0.0001	0.0539
INORGANIC	0.0028	0.0004	0	0.0522
POULTRY	0.0062	0	0.0001	0.0537
LIQUID	0.0026	0.0005	0.0001	0.0506
CONTROL	0.0045	0	0.0002	0.045
		Other Countries		
*India	1.3	25.1	4.33	-
*Algeria (Cherfi*et al.*, 2014)	0.2720	0.169	-	0.096
Libya, 2012 (Elbagermi*et al.*, 2012)	0.0082	0.024	0.0133	-
Provisional tolerable daily intake, PTDI (FAO/WHO,2001) (Cherfi*et al.*, 2014)	1	0.0036	-	1.5
Global estimated daily intake GEDI, (Cherfi*et al.*, 2014)	0.018	0.0157	-	7.547
Recommended Dietary Allowances (RDA) (Chary *et al.*, 2008) Male	11-Sep	*10-20	-	*25-30
RDA (Chary *et al.*, 2008) Female	8-Jun	*10-15	-	*15-20

bw = body weight * µg/kg bw/day

References

Adeniyi, H.A (2014). Effects of Soil Amendment on Productivity and Fruit Quality of Intercropped Tomato (*Lycopersicon lycopersicum* (L) H.Karst).Ph.D. Thesis of the Department Agronomy, Faulty of Agriculture, University of Ilorin.

AOAC. Official Methods of Analysis (2005). 18th ed. Association of Official Analytical Chemists, Washington DC, 2005.

Ankita, S., Kaur, P. and Gupta, R. (2012). Phytochemical screening and antimicrobial assay of various seeds extracts of Cucurbitaceae Family. *International Journal of Applied Biology and Pharmaceutical Technology*. 3(3): 401-409.

Chary, N.S., Kamala, C.T. and Raj, D.S.S. (2008). Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. *Ecotoxicol. Environ. Safety*, 69: 513-524.

Cherfi, A., Abdoun, S. and Gaci, Q. (2014). Food Survey: Levels and potential health risks of chromium, lead, zinc and copper content in fruits and vegetables consumed in Algeria. *Food and Chemical Toxicol*., 70: 48-53.

Curtis, L. R and Smith, B. W (2002). Heavy Metal in Fertilisers: Considerations for Setting Regulations in Oregon. Prepared for Oregon Department of Agriculture Salem, Oregon. Department of Environmental and Molecular Toxicology, Oregon State University, Corvallis, Oregon.

Egwaikhide, P.A., Bulus, T. and Emua, S.A. (2010). Antimicrobial activities and phytochemical screening of extracts of the fever tree, *Eucalyptus globulus*. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 9(5): 940-945.

Eifediyi, E.K. (2010). The effects of Inorganic Fertilisers on Yield of two varieties of Cucumber (*Cucumis sativus* L.) *Report and Opinion*, 2(11): 74-80.

Eifediyi, E.K. and Remison, S.U. (2010). Growth and yield of Cucumber (*Cucumis sativus)* as influenced by Farmyard manure and inorganic fertilisers. *Journal of Plant Breeding and Crop Science*, 2(7): 216-220. Available online http://www.academicjournals.org/jpbcsISSN 2006-9758 ©2010

Elbagermi, M.A., Edwards, H.G.M. and Alajtal, A.L. (2012). Monitoring of heavy metal content in fruits and vegetables collected from production and market sites in the Misurataarea of Libya. *Int. Scholarly Res Network (ISRN) Anal. Chem. 2012*: Article ID 827645, 5pp. DOI: 10.5402/2012/827645.

EU. European Union Commission Regulation (2006). (EC) No. 1881/2006 of 19 December 2006 Setting Maximum Levels for Certain Contaminants in Foodstuffs. *Off. J. Eur. Union L*. 364: 5-24.

Ewers, U. (1991). Standards, Guidelines and Legislative Regulations Concerning Metals and Their Compounds. In: E Merian (Ed). Metals and Their Compounds in the Environment: Occurrence, Analysis and Biological Relevance, Weinheim: VCH: 458-468.

Fadina, O.O., Ibrahim, M.A., Fayinminnu. O.O., Ibrahim, M., Bulama-Modu, M. and Gangpete, S.I. (2017). Health risk of heavy metals in *Celosia argentea* L. Grown on municipal waste soil in Ibadan, Nigeria. *Ethiopian Journal of Environmental Studies and Management* 10(6): 705-712. ISSN: 1998-0507

FAO/WHO-Codex (2001). Alimentarius Commission, Food additives and contaminants. Joint FAO/WHO Food Standards Programme, ALI-NORM 01/12A: 1-289.

Fayinminnu, O.O. and Adekunle-Jimoh, J.M. (2015). Evaluation of heavy metals and health risk index in *Amaranthus hybridus* L. vegetable grown in selected places in Ibadan Nigeria. *Nigeria Journal of Science,* 49: 11-21.

Godfrey, M., Wojuk, D.P., Krone, C.A. (2003). Apolipoprotein E.

Genotyping as a potential biomarker for mercury neurotoxicity. *J. Alzheimer Dis.,* 5(3): 189-195.

Roychowdhury, R. and Tah, J. (2011). Differential response by different parts of *Solanum melongena* L. for heavy metal accumulation. *Plant Sci. Feed*, 1(6): 80-83.

Udousoro, I.I. and Essien, M.E. (2015). Transfer of heavy metals from soil to *Cucumis sativus* Fruit and possible health risk assessment under actual field condition. *African Journal of Food, Agriculture Nutrition and Development*. 15(3): 10077-10098. ISSN 16845374

USEPA, (2013). Reference dose (RfD): Description and use in health risk assessments, Background Document 1A, Integrated risk information system (IRIS); United States Environmental Protection Agency: Washington, DC, 15 March 2013.

Wehner, T.C. and Guner, N. (2004). Growth stage, flowering pattern, yield and harvest date prediction of four types of cucumber tested at 10 planting dates. Proc. xxvi IHC. Advances in Vegetable Breeding (Eds) J.D McCreight and E. *J Ryder Acta. Hort*., 637, ISHS 2004.

Yari, M., Rahimi, G., Ebrahimi, E., Sadeghi, S., Fallah, M. and Ghesmatpoor, E. (2016). Effect of three types of organic fertilisers on the heavy metals transfer factor and maize biomass. Waste Biomass Valor. DOI 10.1007/S12649-016-9719-6

Zhuang, P., McBride, M.B., Xia, H., Li, N. and Li, Z. (2009). Health risk from heavy metals via consumption of food crops in the vicinity of Dabaashan mine, South China; *Sci. Total Environ*., 407: 1551-1561.