Determination of Heavy Metals Concentration in Vegetables Irrigated with Water from Industrial Streams in Kano State.

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Abstract

Consumption of vegetables is on the increase world-wide as a result of its health benefits. Consequently, the demand for vegetables keeps increasing while the easiest means of vegetable cultivation especially in urban centers is by irrigation. Proliferation of vegetable gardens along industrial streams in Kano metropolis prompted this study aimed at determining the concentration of heavy metals in vegetables grown with such water body and ascertains their suitability for human consumption. Against this background objective, concentrations of (Fe, Cr, Ni, Cu and Zn) were determined in onions, tomato and carrot grown in these areas. Samples were collected for eight months; Atomic absorption spectrometry was used to determine the concentrations and t-test to analyze the metals in the vegetables. The mean and standard deviation concentration for each heavy metal in the samples was determined. Findings indicated the value (mg/kg) for onions 507.87 ± 12.80, Fe; 4.97± 0.00, Cr; 3.28 ± 1.08, Ni; 8.73 ± 0.81, Cu and 336.50 ± 242.83, Zn. Carrot had 402.93 ± 40.93, Fe; 5.95 ± 0.01, Cr; 6.65 ± 0.98, Ni; 22.50 ± 3.17, Cu and 220.00 ± 67.33, Zn .The values for tomato were; 431.80 ± 111.80, Fe; 5.72 ± 0.38, Cr; 2.73 ± 0.13, Ni; 15.40 ± 0.80, Cu and 72.83 ± 24.50 mg/kg, Zn. With the exception of Ni and Cu and for Fe in Carrot and Zn in tomato other values were higher than the permissible levels set by the Food and Agriculture Organization (FAO) and World Health Organization (WHO). Invariably, it is obvious that vegetables grown in this region may pose health hazard if consumed. The Ministries of Health and Environment should wade in, provide possible treatment for effluents or discourage vegetable farming along these streams or provide alternative locations for them.

Keywords: Concentration, Effluent, Heavy metals, Industrial stream, Vegetables.

INTRODUCTION

Vegetables absorb heavy metals from contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Sobukola et al., 2010). Soils are the major sink for heavy metals released into the environment by anthropogenic activities. Unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action, most metals do not undergo microbial or chemical degradation (Kirpichtchikova, 2006), and their total concentration in soils persists for a long time after their introduction (Adriano, 2003). Effluents discharged from Industrial areas contain a higher amount of metals especially chromium, copper and cadmium. These effluents released on the land as well as dumped into the surface water leaches to ground water, lead to contamination due to accumulation of toxic metallic components which had resulted in a series of well documented problems in living beings because they cannot be completely degraded (Malarkodi et. al. 2007).

A number of studies have shown heavy metals as important contaminants of the vegetables. For instance, anthropogenic sources reveals that heavy metals in the soil tend to be more mobile, hence, bioavailable than pedogenic, or lithogenic ones (Kaasalainen and M. Yli-Halla, 2003). Heavy metal contamination of soil may pose risks and hazards to humans and the ecosystem through: direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated ground water, reduction in food quality (safety and marketability) via phytotoxicity, reduction in land usability for agricultural production causing food insecurity, and land tenure problems (McLaughlin, et. al, 2000).

The high level of heavy metals in the soil could indicate similar concentration in plant by accumulation at concentration causing serious risk to human health when consumed (Singh et al., 2010). The aim of this study was to determine the concentrations of heavy metals in vegetables cultivated using effluents from industrial areas of Kano State and ascertain their suitability for human consumption.

MATERIALS AND METHODS

Description of the Study Area

Kano state with a population of well over 9.0million people lies between latitude 12°00’ and 09.4°N and longitude 08°31’ and 07°29’E in Northern Nigeria. Majority of the industries in the city are tanneries, textiles, and allied chemicals. Effluent from most of the industries are discharged into the Challawa River located within latitude $11^0$55'N and longitude $8^0$22'E. It is ranked as second largest river in Kano after Kano River which serves as source of water for agricultural, industrial and domestic purposes in Kano metropolis. Being historically a commercial and agricultural State, Kano is one of the most irrigated States in the country with more than 3 million hectares of cultivable land which ensure all year round farming. (Dan’azumi and Bichi (2010).
Challawa and Sharada Industrial Estates in Kano State were selected (due to clusters of vegetable gardens within the Estates) to determine the heavy metal content in vegetables cultivated using effluents from the surrounding.

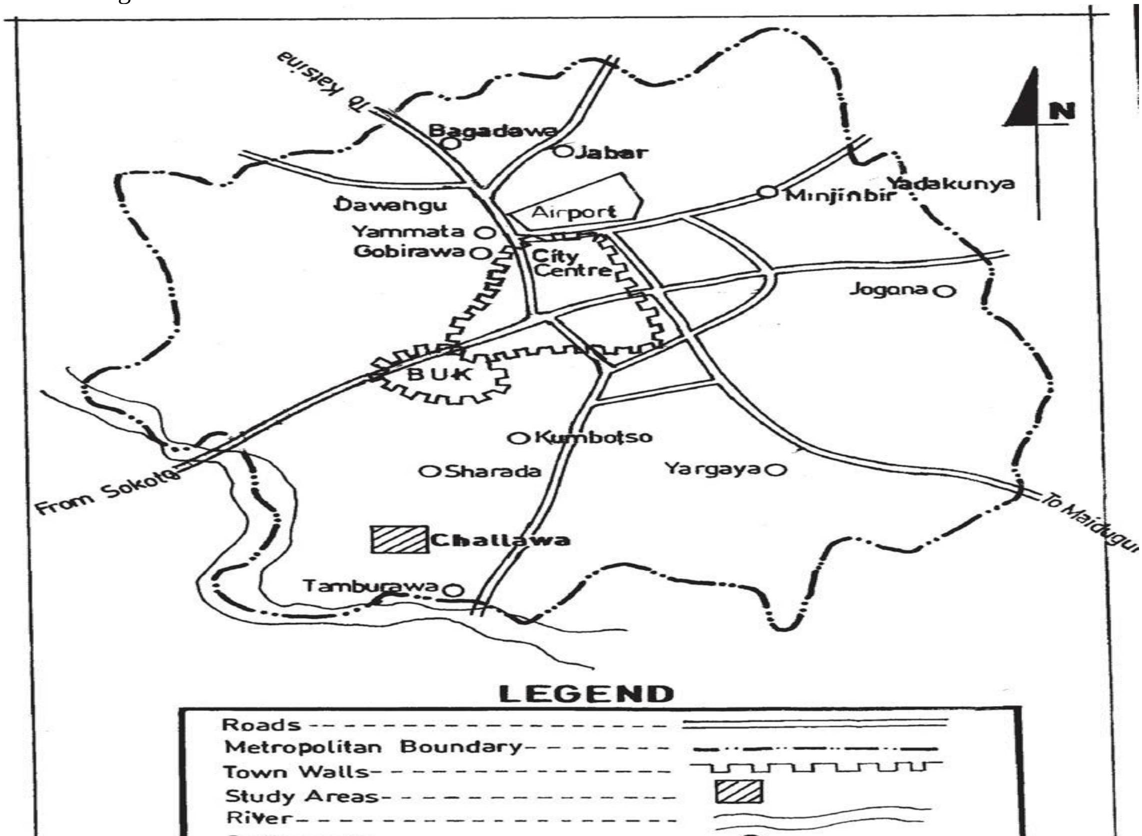

Figure 1: Kano Metropolis showing the study areas. Source: Muazu et al. (2010)

Sample Collection and Analysis

Fifty four samples consisting eighteen each from three vegetables (Onions, Tomatoes, and Carrot) were collected between the months of March - October, 2013 from the vicinity of industrial estate (Challawa and Sharada) and analyzed using Atomic Absorption Spectrometry (AAS) (Buck Scientific210 Model) for iron, chromium, nickel, copper and Zinc. A thoroughly weighed sample appropriate for the expected metals concentration was transferred to a beaker covered with a ribbed watch glass to minimize contamination. In the hood, 15ml concentrated HNO_3 was added and slowly boiled to evaporate; conc. HNO_3 was added continuously until digestion was completed. The beaker walls and watch glass were washed down with metal-free water and filtered. Filtrate was transferred to a 100ml volumetric flask and was diluted to mark and thoroughly mixed. A portion was taken for the required metal determinations. Standard methods were used (APHA, 1998)

RESULT AND DISCUSSION

Table 1: Range, Mean (mg/kg) and Std Deviation Concentrations of Heavy Metals in Onions at Challawa.

Heavy Metals	Mean	Std. Deviation	Std Error Mean
Fe	520.67	85.24	49.21
Cr	4.97	0.59	0.34
Ni	2.20	0.20	0.12
Cu	7.92	1.32	0.76
Zn	93.67	7.77	4.49

Table 1 shows the result of the analysis of heavy metals in onions from Challawa industrial area, these means gave the concentrations parameters in the order of Fe > Zn > Cu > Cr > Ni. The concentrations of 520.67 for Fe and 4.97 for Cr were higher than WHO/FAO permissible limit while 2.20 for Ni, 7.92 Cu and 93.67 Zn were within limit.

Table 2: Range, Mean (mg/kg) and Std Deviation Concentrations of Heavy Metals in Onions at Sharada

Heavy Metals	Mean	Std. Deviation	Std Error Mean
Fe	495.07	336.90	194.51
Cr	4.97	0.15	0.09
Ni	4.367	0.21	0.12
Cu	9.53	2.50	1.44
Zn	579.33	53.15	30.60

Table 2 shows the concentration of heavy metals in onions from Sharada industrial area. 495.07 for Fe, 4.97 for Cr and 579.33 for Zn were values above the set limit, but 4.37 for Ni, and 9.53 for Cu were within acceptable limit. The concentrations of Ni, Cu and Zn were higher at Sharada area. The concentrations parameters were equally in the order of Fe > Zn > Cu > Cr > Ni.

Table 3: Range, Mean (mg/kg) and Std Deviation Concentrations of Heavy Metals in Tomato at Challawa.

Heavy Metals	Mean	Std. Deviation	Std Error Mean
Fe	320.00	75.35	43.50
Cr	5.33	0.35	0.20
Ni	2.60	0.17	0.10
Cu	14.60	3.14	1.81
Zn	48.33	3.51	2.03

Table 3 shows the result of the analysis of heavy metals in tomato from Challawa industrial area. Fe, 320.00, Ni, 2.60, Cu, 14.60 and Zn 48.33 with the exception of Cr, 5.33 were within recommended value.

Table 4: Range, Mean (mg/kg) and Std Deviation Concentrations of Heavy Metals in Tomato at Sharada.

Heavy Metals	Mean	Std. Deviation	Std Error Mean
Fe	543.60	255.12	147.29
Cr	6.10	0.854	0.49
Ni	2.87	0.25	0.15

Cu	16.20	4.70	2.72
Zn	97.33	26.63	15.38

Table 4 shows the result of the analysis of heavy metals in tomato from Sharada industrial area. With the exception of Fe, 543.60 and Cr, 6.10 all the other Ni, 2.87, Cu 16.20 and Zn 97.33 are within the permissible limit. The concentration of Cr, Ni, Cu and Zn were equally higher for tomato in Sharada area.

Table 5: Range, Mean (mg/kg) and Std Deviation Concentrations of Heavy Metals in Carrot at Challawa.

Heavy Metals	Mean	Std. Deviation	Std Error Mean
Fe	443.87	181.01	104.51
Cr	5.90	0.458	0.265
Ni	7.63	0.59	0.34
Cu	25.67	17.21	9.94
Zn	287.33	42.44	24.51

Table 5 shows the result of the analysis of heavy metals in Carrot from Challawa industrial area. It was observed that Fe 443.87, Cr 5.90 and Zn 287.33 were higher than the permissible limit, while the other Ni 7.63 and Cu 25.67 were within recommended values.

Table 6: Range, Mean and Std Deviation Concentrations of Heavy Metals in Carrot at Sharada.

Heavy Metals	Mean	Std. Deviation	Std Error Mean
Fe	362.00	143.36	82.77
Cr	6.00	0.79	0.46
Ni	5.67	0.416	.24037
Cu	19.33	9.45	5.46
Zn	152.67	11.02	6.36

Table 6 shows the result of the analysis of heavy metals in Carrot from Sharada industrial area. Only Cr 6.00 and Zn 152.67 were above recommended limit, while Fe 362.00, Ni 5.67, and Cu 19.33 were within limit. The values of Fe, Ni, Cu and Zn were found higher at Challawa industrial area.

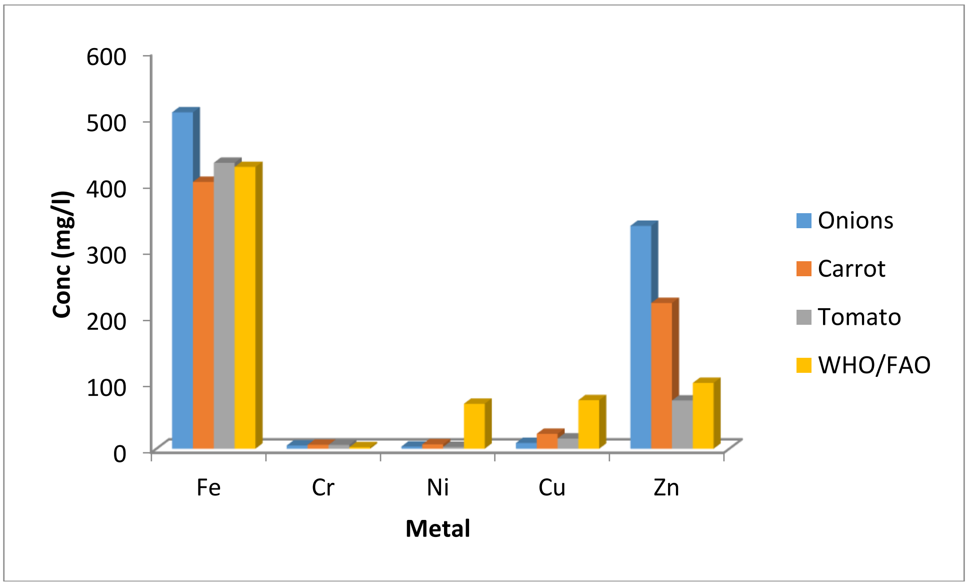

Figure 2a: Graph for Summary of Mean concentrations of heavy metals in Onions, Carrot, and Tomato Irrigated using Industrial effluent.

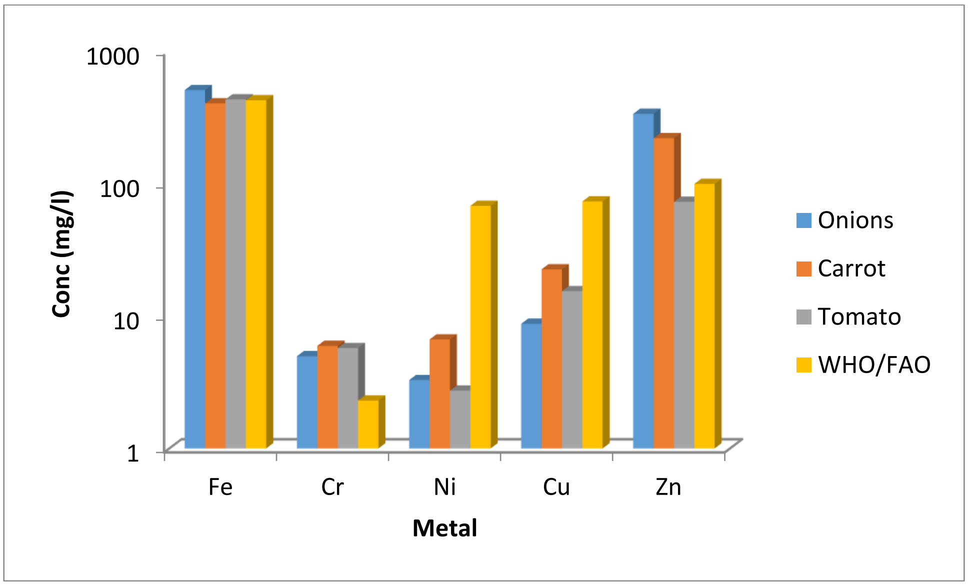

Figure 2b: Axis with Log Scale

In summary, from figures 2a and 2b the mean concentrations for heavy metal parameters in both Challawa and Sharada industrial areas are in the order of Fe > Zn > Cu > Cr > Ni for onions, tomato and carrot but Challawa had Fe > Zn > Cu > Ni> Cr for carrot. Given that WHO/FAO Guideline (mg/kg) for vegetables as 425.5 for Fe, 2.3 for Cr and 67.90 for Ni and others are 73.30 for Cu and 99.40 for Zn. The value for Cr in all the samples was over 100% higher than WHO/FAO permissible limits. These results were similar to the earlier ones obtained by Audu et al (2002) and Muazu et al. (2010) who recorded value as high as 13.594 in the same area of Kano state. Akan, et.al (2013) in Borno, and Nazemi, (2012) in Iran were also in agreement. This can be credited to the use of high quantity of Cr mostly from tannery and other related industries. Ni and Cu in all the samples were within WHO/FAO acceptable limit, corroborating the reports by Mohsen and Mohsen (2008) from Iran, Odoh and Kolawole (2011) Benue state. Adu, et. al (2012) and Muhammad, et al, (2008). The concentration of Fe in Carrot and Zn in Tomato were also within WHO/FAO acceptable limit. Muazu et al. (2010) reported lower values from the same study area, these differences may be attributed to the fact that, heavy metal concentrations in harvested vegetables often show large variations from year to year even at the same location in the field due to variations in the emission rates, atmospheric transport, deposition processes and plant up take. (Iyaka, 2007)

Dan'azumi and Bichi (2010) in the analysis of industrial pollution and heavy metals profile of Challawa River in Kano, which is a major industrial area where irrigation is prominent found that the mean concentrations of heavy metals discharged into the river for both wet and dry season exceed the maximum permissible limit and Bernard, and Ogunleye (2015) reported same except for Fe which was below the set limits from the same area.

CONCLUSION

Results obtained in this study show the high level of contamination of vegetables irrigated with industrial streams in Kano State, Nigeria. The use of contaminated water in irrigating the vegetables in these areas has given rise to the presence of heavy metals to a concentration that is detrimental to the ecosystem and these metals in the vegetables analyzed place the consumers of these vegetables at health risk with time unless an urgent step is taken by relevant agencies to address the issue. The Ministries of Health and Environment should wade in, discourage vegetable farming along these streams and provide alternative locations for them or provide effluent treatment facilities to check the introduction pollutants into the water bodies.

Acknowledgement. We acknowledge the sponsorship of this research by the Tertiary Education Trust Fund (TETFUND) via its research grant intervention to the Federal College of Education (Technical) Bichi.

REFERENCES

Adriano, D. C. (2003) Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability and Risks of Metals, Springer, New York, NY, USA, 2nd edition.

Akan, J. C, Kolo, B.G, Yikala, B. S, Ogugbuaja, V. O,(2013) Determination of Some Heavy Metals in Vegetable Samples from Biu Local Government Area, Borno State, North Eastern Nigeria, International Journal of Environmental Monitoring and Analysis; 1(2): 40-46.

APHA, (1992) Standard methods for the examination of water and wastewater 16th edition, American public health association. New York.

Audu, A. A. and Lawal, A. O., (2002) Variation in metal contents of plants in Vegetable Garden sites in Kano metropolis. J. applies science. Environmental management, 10(2) 105-109

Bernard, E and Ogunleye A, (2015) Evaluation of tannery effluent content in Kano metropolis, Kano State Nigeria. Int. J. Phys Sci. 10(9), 306-310.

Coimbatore district in Tamil Nadu. Journal of Agronomy; 6(1): 147-51

Dan'azumi, S. and Bichi, M. H., (2010) Industrial pollution and heavy metals profile of challawa River in Kano, Nigeria. Journal of applied science in environmental sanitation. 5(1): 23- 29.

FAO/WHO, (2001). Food Additives and contaminations. Joints FAO/WHO food standard programme 2001 ALINORM 01/12A 1-289.

Iyaka, Y. A., (2007). Concentration of Cu and Zn in some fruit and vegetables Commonly available in North- Central zone of Nigeria. EJEAF chem, 6(6): 2150-2154

Kaasalainen, M and Yli-Halla, (2003). "Use of sequential extraction to assess metal partitioning in soils," EnvironmentalPollution, 126(2), 225–233,

Kirpichtchikova, T. A., Manceau, T. A., Spadini, A., Panfili, L., Marcus, F and Jacquet, T, (2006) "Speciation and solubility of heavy Metals in contaminated soil using X-ray microfluorescence, EXAFS spectroscopy, chemical extraction, and thermodynamic modeling," Geochimica et Cosmochimica Acta, 70(9), 2163–2190.

Malarkodi, M., Krishnasamy, R., Kumaraperumal, R. and Chitdeshwari, T. (2007) Characterization of heavy metal contaminated soils of

McLaughlin, M. J., Hamon, R. E., McLaren, R. G., Speir T. W. and Rogers, S. L. (2000) "Review: a bioavailability-based rationale for controlling metal and metalloid contamination of agricultural land in Australia and New Zealand," Australian Journal of Soil Research, 38(6), 1037–1086.

Mohsen 1 B and Mohsen S, (2008) Investigation of Metals Accumulation in Some Vegetables Irrigated with Waste Water in Shahre Rey-Iran and Toxicological Implications American-Eurasian J. Agric. & Environ. Sci., 4 (1): 86-92.

Muazu, I., Uzairu, A., Kabgu, J.A,. Issa, B.R. and Ndamitso, M.M. (2010), Assessment of some heavy metals in lettuce, Sesame and Okra irrigated from the bank of Challawa River Kano, Nigeria. Orient. J. Chem., 26(4), 1299-1308.

Muhammad F, Farooq A and Umer R (2008) Appraisal of heavy Metal Contents in Different Vegetables Grown in the Vicinity of an Industrial Area. Pak. J. Bot., 40(5): 2099-2106.

Nazemi, S. (2012), Concentration of Heavy Metal in Edible Vegetables Widely Consumed in Shahroud, the North East of Iran. J. Appl. Environ. Biol. Sci., 2(8)386-391.

Odoh R and Kolawole S A (2011), Assessment of trace heavy metal contaminations of some selected vegetables irrigated with water from River Benue within Makurdi Metropolis, Benue State Nigeria. Advances in Applied Science Research, 2 (5):590-601.

Singh, A., Sharma, R.K., Agrawal, M. and Mashall, F.M. (2010). Health risk assessment of heavy metals via dietary intake of foodstuffs from the wastewater irrigated site of a dry tropical area of India. Food and ChemicalToxicology, 48: 611-619.

Sobukola, O.P., Adeniran, O.M., Odedairo, A.A., and Kajihausa, O.E. (2010): Heavy metal levels of some fruits and leafy from selected markets in Lagos, Nigeria vegetables, Afr. J. Food Sci. 4 (2), 389-393