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Screening of Tomatoes and Onions for Trace Metals from Irrigated Farmlands on the Bank of River Challawa, Nigeria

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Abstract: The objective of this research investigation was to determine the concentrations of trace metals (Cd, Cr and Pb) in tomatoes and onions irrigated with tannery polluted water of river Challawa, Northern Nigeria using atomic absorption spectrometry. 32 samples of tomatoes and 16 samples of onion bulbs each were taken for analysis. In the study area, metal concentrations in tomatoes were found to be in the range 0.58-1.00 for Cd; 10.83-14.20 for Cr, 9.75-15.67 for Pb $mgkg^{-1}$ dry weight. Similarly, the mean concentrations of the same trace metals were also found to range from 0.82-0.98 for Cd; 5.20-8.54 for Cr and 8.50-11.67 for Pb, $mgkg^{-1}$ dry weight, for exposed onion bulbs. Also 0.58 - 0.70$mgkg^{-1}$ Cd; 0.45-0.84$mgkg^{-1}$ Cr; and 3.83-7.33$mgkg^{-1}$ Pb in respect of onions samples control. The findings of the investigation indicate the relative abundance of the trace metals in both the tomatoes and onions samples (exposed and control) analysed followed the sequence Pb>Cr>Cd. The trace metals values in both the exposed and controlled samples are higher than the WHO/EU and FAO/WHO acceptable limits for trace metals in food crops. However, the values for Pb and Cd are below the ICRCL (1987) values of Pb (1-50$mgkg^{-1}$) and Cd (0-1 $mgkg^{-1}$). This could put consumers of tomatoes and onions from River Challawa irrigated farmlands at risk of ingestion of toxic metals at an unacceptable concentrations.

Key words: Tomatoes, onions, trace metals, irrigated farmlands, River Challawa

Introduction

Food and vegetable crops production and its attended security is an important aspect of a nation's economic stability. It requires access to fertile land, water and in some cases fertilizers, pesticides and herbicides, particularly in poor and developing countries of the world and because of its importance as a measure of any growing economy, it requires all the inputs it deserve. However, in Nigeria, Government has in recent years built additional dams, canals for dry season farming and have increased the provision of fertilizers, herbicides, pesticides and modern farm equipments to boost both dry and rainy seasons farming of food and vegetable crops production done to increased population and rural-urban migration.

While efforts are being consolidated by the government towards improving and increasing food and vegetable crops production, the problem of industrial effluents is undermining these efforts especially, in Kano where tannery effluents are discharged into the Challawa River which is used for the irrigation of vegetable crops during the dry season farming.

Kano is a city in northern Nigeria (N 1159° 981', E 008° 31.491') is home to 70% of Nigerian's tanneries. Most of the tannery industries in Kano are in Challawa Industrial Estate. The effluents generated by the tanneries are channeled into drains and subsequently into the Challawa River. Consequently, the amount of pollutants and wastes generated by the tanning industries pose significant stress on the vegetable crops grown on the Challawa River bank. Since the polluted River water is used for irrigation to water the vegetable crops along the River bank, trace metals may enter the food chain through irrigated tomatoes and onions thereby exposing consumers of these vegetable crops to bioaccumulation of trace metals with time.

Research studies on Challawa industrial effluent indicate trace metals like As, Cr, Cu, Fe, Pb and Zn as components in tannery effluents (Lawal and Singh, 1981; Lawal, 1986; Yisa *et al.*, 2004). Similarly, Gbem *et al.* (2000) and Nasir (2002) have also reported trace metals accumulation in fishes within the Challawa River. Audu and Lawal (2005) have also reported Cr, Co, Fe, Cu, Mn, Ni, Pb and Zn in tomatoes, onions and pepper from Jakara irrigation gardens in Kano metropolis. However, there are no reports on the levels of trace metals in vegetable crops grown along the Challawa River bank. Mineral elements are known to be essential in our diet and may enter the food crops or vegetables from soil through mineralization by crops, food processing or environmental contamination (Onianwa *et al.*, 2001; Miller, 1996).

Thus, there is the need to carry out extensive screening on the vegetables grown in the vicinity of the Challawa River, in order to have a comprehensive report on the impact of tannery operations on vegetable crops grown on the bank of the river. It was in this regard, that tomatoes and onions which are some of the vegetable crops grown for both domestic and commercial purposes are screened in order to assess the level of trace metals accumulation as a result of the indiscriminate discharges of the untreated tannery effluents into the Challawa River which are used for irrigation.

Materials and Methods

Reagents and glass wares: Analytical reagent (AnalaR) grade chemicals and distilled water were used throughout the study. All glasswares and plastic containers used were washed with detergent solution followed by soaking in 10% (v/v) nitric acid and then rinsed with distilled water.

Sampling: The tomatoes and onions irrigated from the Challawa River bank were freshly harvested from three farms sites and packaged into labeled paper bags.The samples were immediately moved to the laboratory for first hand treatment with distilled water. Samples were collected from both the study and control sites, except for tomatoes which was not available at the control sites at the time of sampling.

Sampling preparation: The tomatoes and onions samples were cut into nearly uniform size. This was done to facilitate drying of the pieces at the same rate. The cut pieces were placed in clean acid-washed porcelain crucibles according to label and oven-dried at 105°C for 24 hours in Mommert oven (Schutzart DIN 400-50-IP20) until they were brittle and crisp. At this stage no micro-organisms can grow and care was taken to avoid any source of contamination. All crucibles were labeled according to sample numbers. The dried tomatoes and onion samples were pounded into fine particles using acid-washed mortar and pestle. The powdered samples were placed in labeled Petri dishes and dried to constant weight in desiccators with charged Silica gel until they were digested.

Recovery experiment: In order to ascertain the reliability of the method for the analysis of the samples for Cd, Cr and Pb, Certified Standard Reference Materials (CSRM) were not readily available for use, instead spiking method was adopted using digestion method.

Sample digestion: The procedure according to Awofolu (2005) was used for digestion of samples. 0.5g of sieved samples was then weighed into 100ml beaker. A mixture of about 5ml concentrated Trioxonitrate (IV) acid and 2ml Perchloric acid was added and this was digested on low heat using hot plate for 15 minutes at 70°C until a light coloured solution was obtained. The sample solution was not allowed to dry during digestion. The digest was allowed to cool, filtered into 50ml standard flask. The beaker was rinsed with small portions of distilled water and then filtered into the flask. Triplicate digestion of each sample was carried out together with blank digest without the sample. Then the quantitation of metallic content of digested samples was carried out with the flame atomic absorption spectrophotometry model AA 650.

Table 1: Percentage Recoveries of Spiked Tomatoes and Onions Samples

Trace metal	% Mean Recovery (Tomatoes)	% Mean Recovery (Onions)
Cd	91.70	96.60
Cr	87.50	95.80
Pb	96.60	93.00

Spiking experiment: Spiking experiment was conducted on onion and tomatoes samples in order to evaluate the experimental procedures and efficiency of atomic absorption spectrophotometer. This was done by spiking the pre-digested onion and tomatoes samples with multielement metal standard solution. The spiked samples were then digested as the sample procedure described above.

Analysis: Appropriate working standards were prepared for each of the metal solution by serial dilution of the stock solutions. Each of the sets of serial dilutions were then aspirated one after the other into the Atomic Absorption Spectrometry and their absorbance recorded. Calibration curves were plotted for each of the trace metals standard using absorbance against concentrations (ppm).

Results and Discussion

The results of recovery of tomatoes and onions samples are shown in Table 1 above. The mean percentage recoveries for the metals Cd, Cr and Pb are 91.7%, 87.5% and 96.6%, for tomatoes, 96.6%, 95.8% and 93.0% for onions respectively. These recoveries validate the experimental procedures adopted.

Results of tomatoes and onions samples showing the mean (±SD) and range are shown in Table 2.

However, the mean concentrations range of the trace metals Cd, Cr and Pb for the tomatoes samples (exposed) are Cd (0.58-1.00mgkg^{-1}), Cr (10.83-14.20mgkg^{-1})and Pb (9.75-15.67mgkg^{-1}), while the mean concentration range for the onion samples (exposed) are Cd (0.82-0.98mgkg^{-1}), Cr (5.20-8.54mgkg^{-1}) and Pb (8.50-11.67mgkg^{-1}). The onion samples (control) have Cd (0.58-0.70mgkg^{-1}), Cr (0.45-0.84mgkg^{-1}) and Pb (3.83-7.33mgkg^{-1}).

The trend of occurrence of the metal concentrations in the tomatoes samples (exposed) is in the order of Pb>Cr>Cd. This trend suggests that tomatoes (exposed) have higher concentrations of Pb and Cr than Cd. This observation is similar to those reported by Beavington (1975), Davis and White (1981) and, Audu

Table 2: Mean (± SD) and Concentration Range for Trace Metals in tomatoes and onions samples

Site	Tomatoes			Onions		
Study Area	Cd	Cr	Pb	Cd	Cr	Pb
Mean (± SD)	0.89±0.862	12.87±0.805	12.58±1.640	0.90±0.54	7.06±0.869	9.82±1.002
Range	0.58 -1.00	10.83 - 14.20	9.75 - 5.67	0.82 - 0.98	5.20 - 8.54	8.50 -11.67
Control Area	Cd	Cr	Pb	Cd	Cr	Pb
Mean (± SD)				0.64±0.04	0.60±0.12	4.76±1.68
Range				0.58 - 0.70	0.45 - 0.84	3.83 - 7.33
FAO/WHO	0.02-0.2	-	0.5-1.0	0.02-0.2	-	1-50
ICRCL Limit	0-1	-	1-50	0-1	-	1-50
WHO/EU Limit	0.01	0.1	5.0	0.01	0.1	5.0

Table 3: Trace Metal Ranges in Tomatoes and Onions Samples from Challawa River bank and Published Ranges in Tomatoes and Onions in Some Countries

Trace Metal	This Study Conc. Range		Conc. range Levels in Similar Studies elsewhere	
	Tomatoes	Onions	Tomatoes	Onions
Cd	0.43-1.05	0.80-1.00	1.34-14.5[b]	0.05-43[d]
Cr	10.08-14.89	3.87-8.87	0.34-0.58[a]	0.43-0.64[a]
Pb	3.92-19.42	6.00-13.00	0.48-1.56[a], 0.02-6.13[b]	0.53-0.95, 1.04[c]

Key: a = Audu and Lawal (2005). b = Anthony and Balwant (2004). c = Erwin and Ivon (1992). d = Davis and White (1981).

Table 4: Normal and Phytotoxic Level (mg kg-1) of Trace Metals found in Plant Leaves

Trace Metal	Normal Range	Toxicity Range	Toxic Doses to Plants (mg kg^{-1})	Toxic Doses for Man (mg kg^{-1})
Cd	0.1-2.4	1-30	-	-
Pb	5-10	30-300	3-20	1
Cr	-	-	0.5-10	200

Source : Awofolu *et al*, (2005) anf Francis (2005).

and Lawal (2005) in which tomatoes recorded the highest concentration for Pb. Similarly, the trend of occurrence of the trace metals concentration in the onion samples (exposed and control) are in the same order: Pb>Cr>Cd. Thus, the trend also suggest Pb and Cr to record higher levels than Cd in both samples. This observation was also noted by Audu and Lawal (2005) where Pb concentration was higher than that of Cr and Pushpanjahli and Santosh (1993) where onions recorded the highest concentration among the various vegetables analyzed. Table 3 below shows the comparison of trace metals levels (mg kg^{-1}) in tomatoes and onions in this study and similar studies elsewhere.The results shows that concentration levels of the trace metals (Pb>Cr>Cd) in tomatoes and onions (exposed) are in the same order as reported by Pennington *et al.* (1995), Audu and Lawal (2005) and Onianwa (2001).

The high concentrations of the metals could be attributed to the untreated tannery effluents, run-off of fertilizers from the farmlands, wastes dumped into the River, their availability in the earth crust, etc as noted by Audu and Lawal (2005), Brown (1982), Onianwa and Egunyomi (1983) and Gbem (2000). Also as reported by Awofolu (2005), Francis (2005) Pesticides and herbicides are some of the contributing factors of the high concentration of these metals in the tomatoes and onions.

However, tannery effluents discharged into the Challawa River and its use for the irrigation of the tomatoes and onions might be a core factor responsible for the high level of the trace metals in these vegetable crops in addition to the by-product of phosphate fertilizer application into the Challawa River which in turn are taken up by the irrigated tomatoes and onions by mineralization by crops. However, the levels of the trace metals obtained in this study fall within the range reported in literature (Table 3).

Conclusion: The results indicate that both tomatoes and onions (exposed) have relatively high levels of the trace metals than control values in onions. Though, the trace metal levels were higher than the Food and Agricultural Organization (FAO/WHO, 1993) and the WHO/EU (1983) joint limits but have not reached the toxicity level of Cd (5-30 mg kg^{-1}), Pb (30-300 mg kg^{-1}) with the exception of Cr which was not provided (Awofolu, 2005) as shown in Table 4 above. The high levels of these trace metals in tomatoes and onions put the consumers of these and other vegetable crops grown within the Challawa River bank at health risk with time except an urgent step is taken by the government to address this issue.

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