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ASSESSMENT OF HEAVY METAL CONTENTS OF *LYCOPERSICUM ESCULENTUM* MILL. (TOMATO) AND *CAPSICUM CHINENSE* L. (PEPPER) IRRIGATED WITH TREATED AND UNTREATED DETERGENT AND SOAP WASTEWATERS.

FATOBA, P. O.,[1] OGUNKUNLE, C. O.,[1] *OYEDEJI, A. A.[2], and OLADIMEJIO. O.[1]

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Abstract

Tomato and pepper are staple and common vegetables consumed by all classes of Nigerian populace. Due to high consumption rate of these vegetables, they are cultivated all year round in many localities including the peri-urban cities. The problem of freshwater scarcity in peri-urban cities and the northern part of Nigeria has made peasant farmers in these areas to resolve to the use of wastewaters for irrigation with no knowledge of their status and safety. Therefore, the level of heavy metal contents in Lycopersicum esculentum and Capsicum chinense grown in the Screen House of the University of Ilorin, North-central Nigeria were studied using treated and untreated detergent and soap wastewaters. Fallowed soils collected from the University Botanical Garden, homogenized and packed into planting bags were used for the experiment. Viable seeds of Lycopersicum esculentum and Capsicum chinense were sown in 10 planting bags for each crop and irrigated with 0%, 5%, 10%, 20% and 40% Treated and Untreated wastewaters. After 12WAP, leaf samples of Lycopersicum esculentum and Capsicum chinense were collected, air-dried, digested and the digests were analyzed for Manganese (Mn), Copper (Cu), Chromium (Cr), Lead (Pb) and Cadmium (Cd) by Atomic Absorption Spectrophotometry. It was evident that there was prevalence of heavy metals in the wastewaters particularly the untreated wastewater and the content of the heavy metals were concentration-dependent in the leaves of the test crops. It is therefore imperative to inform and enlighten the local farmers and the consumers on the danger of using such water for irrigation of agricultural crops in order to ensure safety.

Key words: *Capsicum chinense, cultivation, heavy metals, irrigation, Lycopersicum esculentum, wastewater.*

Introduction

Industrial and municipal wastewater is mostly used for irrigation of crops, mainly in peri-urban environments due to scarcity of freshwater and problem of wastewater disposal (Arora *et al.*, 2008; Scott *et al.*, 2000). Scott *et al.* (2000) reported that some farmers often prefer wastewater because its high nutrient contents reduce or even eliminate the need for chemicals, fertilizers that are often expensive (Faith *et al.*, 2007). The use of wastewater for irrigation is considered a technical solution to reducing soil degradation and restoring nutrient contents of soils (Fatoba *et al.*, 2011). In many areas of developing nations like Nigeria, untreated and treated wastewater are diverted by peasant farmers to be used in the irrigation of vegetable farms and this, Dreschsel *et al.* (2002) complimented by reporting that a rough estimate of at least 20million hectares of land are irrigated with raw or partially treated water in developing nations.

However, there are risks associated with wastewater use and these include; contamination by pathogenic organisms and diseases vectors which are attracted by farming activities (Lock *et al.*, 2003). Mead and Griffin (1998) reported that consumption of such vegetables irrigated with wastewater and sewages have resulted in outbreak of diseases. Wastewater also enriches agricultural soils with loads of toxic heavy metals which result not only in soil contamination but also affect food quality and safety (Mojiri and Aziiz, 2011). In an investigation into the effects of untreated and treated wastewater irrigation on cauliflower and red cabbage

[1]*Department of Plant Biology, University of Ilorin, Ilorin, Nigeria.*
[2]*Department of Biological Sciences, Niger Delta University, Wilberforce Island, Nigeria.*
**Corresponding author:* ayodele.oyedeji@yahoo.com

grown on calcareous soil in Turkey by Kiziloglu *et al*. (2008); the results showed that the application of wastewater increased the Cu, Pb, Ni, Zn, Mn and Cd contents of cauliflower and red cabbage. Karami *et al*. (2008) also reported their investigation into the effects of municipal sewage sludge on the Pb and Cd contents of soil and yields of wheat. The results of their research showed an increase in concentrations of Cd and Pb in roots and shoots of wheat.

Tomato and pepper are staple and common vegetables consumed by all classes of Nigerian citizens. Due to the pressure on these vegetables as reported by Fatoba *et al*. (2011); they are locally produced throughout the year with assistance from the World Bank Fadama III project. The problem of freshwater scarcity in peri-urban cities and the northern part of Nigeria has made peasant farmers in these areas to resort to the use of wastewater for irrigation with no knowledge of the status and the safety of such water. It is therefore imperative to assess the elemental contents and concentrations of these vegetables irrigated with treated and untreated wastewater from detergent and soap industry for food security.

Materials and Methods

The experiment was carried out at the Screen House in Biological Garden of the University of Ilorin, North-central Nigeria under controlled environmental conditions. Treated and untreated wastewaters were collected from Global Soap and Detergent Industry, Ilorin while seeds of *Lycopersicum esculentum* and *Capsicum chinense* were obtained from the Ministry of Agriculture, Ilorin. Garden soils were collected from the Biological Garden. The soils were completely homogenized using hand trowel and packed into planting bags. The treated and untreated wastewaters were serially diluted with borehole water into acid-washed plastic containers to give 5%, 10%, 20%, 40% wastewater respectively. Floatation method, according to Anoliefo and Vwioko (1995), was used to determine the viability of the seeds of *L. esculentum* and *C. chinense* and viable seeds of *Lycopersicum esculentum* and *Capsicum chinense* were sown separately into 10 pots, 2 pots per treatment per plant while 2 pots per plant served as Control. The various dilution ratios of untreated wastewater were applied according to the method of Fatoba *et al*. (2011). The same procedure was carried out for the treated wastewater applications. Twelve weeks after planting (12WAP), leaf samples of *Lycopersicum esculentum* and *Capsicum chinense* were collected, air-dried and subjected to wet digestion according to Allen *et al.* (1974) as adopted by Okunola *et al*. (2007). The digested plant samples and the blanks were analyzed for manganese (Mn), copper (Cu), chromium (Cr), lead (Pb) and cadmium (Cd) by Atomic Absorption Spectrophotometry. The treated and untreated waters were analyzed for heavy metals according to the method of Ibeh and Omoruyi (2011) while the pH was determined according to Shukla *et al*. (2007).

Results

The pH and background heavy metals contents of the treated and untreated wastewater are shown in Table 1. The two types of wastewaters were alkaline. It is evident that heavy metals were abundant in the wastewaters except chromium and there is no doubt that the treatment given to the treated wastewater before its release reduced the heavy metals burden compared to the untreated one (Table 1).

Tables 2 and 3 show heavy metal contents of the leaves of *Lycopersicum esculentum* and *Capsicum chinense* irrigated with treated wastewater respectively. The Controls had the least accumulations of heavy metals and a positive correlation was observed between the heavy metals accumulation in the leaves and the concentrations of the treated wastewater; the higher the concentrations of the wastewater, the higher the accumulations of these heavy metals in the leaves. Chromium concentrations in the Controls, 5% and 10% treatments of Tables 1 and 2 are not significantly differently ($p \leq 0.05$). Bioaccumulation of Cd and Cu at 40% by *C. chinense* from the treated wastewater was high (2.322mg/l and 1.305mg/l respectively) (Table 3). From the accumulation of heavy metals shown in Tables 1 and 2, it is clear that *L. esculentum* and *C. chinense* have great bioaccumulation potential for chromium, concentrations of Cr were increased 400 folds in the two vegetable.

Tables 4 and 5 show the elemental concentrations in the leaves of *Lycopersicum esculentum* and *Capsicum chinense* irrigated with untreated wastewater. Chromium concentrations in Control, 5% and 10% treatments were also the same statistically ($p \leq 0.05$) but not numerically as in Tables 2 and 3. The elemental concentration of Chromium in the vegetables was small and the reduced Cr bioaccumulation rate could probably be due to high concentrations of other heavy metals in the untreated wastewater. Bioaccumulation of all the heavy metals followed the same trend in Tables 2 and 3; the higher the concentration of irrigant, the more heavy metal is bioaccumulated. The exception to this trend was the concentrations of Cr in 20% and 40% treatments. This trend seems to depict that more heavy metals are available, the more it is being bio-accumulated by these vegetables.

Discussion

The different concentrations of heavy metals absorbed by vegetables planted may be due to the contents of heavy metals present in the soil, fertilizer and or environmental pollution (Oyedele, 1998). The presence of these heavy metals could also be from release of a number of heavy metals from wastewater disposed, either treated or untreated. The use of wastewater to irrigate crops such as vegetables has further increased the quantity of heavy metals in agricultural soils (Salem *et al.*, 2000).

Improper treatment of wastewater by industries before disposal is a major way by which agricultural soils are contaminated. The limit of heavy metals (Pb, Cu, Cd, Cr and Mn) in waste water from all industries in Nigeria has been directed to be less than 1mg/l except Mn (200mg/l) by FEPA (1991). But from the analysis of the treated wastewater used in the study, it is clear that the treatment was inadequate which is obvious and has resulted in the high elemental content. Long term use of this type of wastewater can increase accumulation level of heavy metals to phytoxic state and result in reduced plant growth (Fatoba *et al.*, 2011) and consequently transfer up to the food chain. Bowen (1979) reported the normal natural concentration ranges for land plants as Cd: 0.2-2.4µg/g, Pb: 1-13 µg/g, Mn: 20-700 µg/g and Fe: 70-700 µg/g. Comparison of the results from the study showed that the amounts of heavy metals are far higher. Also according to Alloway (1995), Cd concentration in plants grown on uncontaminated or unmineralized soils generally does not exceed 1.0 µg/g but over 1.0 µg/g has been found in plant leaves grown with wastewaters.

Conclusion

It has been observed that bioaccumulation of heavy metals prevails in crops irrigated with untreated wastewater; the use of such water for irrigation of agricultural crops should be discouraged for the health safety of the consumers.

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Table1 The pH and heavy metal concentrations in the treated and untreated Wastewaters

Sample	pH	Heavy metal concentrations (mg/l)				
		Cr	Cd	Pb	Mn	Cu
Untreated wastewater	10.98	0.48	10.13	9.25	15.90	10.76
Treated wastewater	10.05	0.18	6.07	4.17	3.61	6.17

Table 2: Concentrations of heavy metals in the leaves of *Lycopersicum esculentum* irrigated with treated wastewater.

Wastewater	Heavy Metal Concentrations (mg/l)				
Treatments	Cr	Cd	Pb	Mn	Cu
Control	0.010^{c}	0.120^{e}	0.115^{e}	0.010^{e}	0.141^{d}
5%	0.006^{c}	0.210^{d}	0.164^{d}	0.196^{d}	0.250^{d}
10%	0.008^{c}	0.310^{c}	0.307^{c}	0.394^{c}	0.501^{c}
20%	0.180^{b}	0.927^{b}	0.581^{b}	0.643^{b}	0.999^{b}
40%	0.530^{a}	0.115^{a}	0.868^{a}	0.991^{a}	1.422^{a}

Note. Values with the same superscript in the same column are not significantly different at $p \leq 0.05$.

Table 3 Concentrations of heavy metals in the leaves of *Capsicum chinense* irrigated with treated wastewater.

Wastewater Treatments	Heavy Metal Concentrations (mg/l) Cr	Cd	Pb	Mn	Cu
Control	0.006^{c}	0.012^{e}	0.012^{e}	0.007^{e}	0.065^{e}
5%	0.010^{c}	0.212^{d}	0.170^{d}	0.164^{d}	0.217^{d}
10%	0.012^{c}	0.294^{c}	0.315^{c}	0.382^{c}	0.394^{c}
20%	0.185^{b}	0.897^{b}	0.596^{b}	0.525^{b}	0.909^{a}
40%	0.585^{a}	2.322^{a}	0.905^{a}	0.892^{a}	1.305^{a}

Note. Values with the same superscript in the same column are not significantly different at $p \leq 0.05$.

Table 4 Concentrations of heavy metals in the leaves of *Lycopersicum esculentum* irrigated with untreated wastewater.

Wastewater Treatments	Heavy Metal Concentrations (mg/l) Cr	Cd	Pb	Mn	Cu
Control	0.010^{d}	0.120^{e}	0.115^{e}	0.010^{e}	0.452^{d}
5%	0.019^{c}	0.384^{d}	0.319^{d}	0.586^{d}	0.452^{d}
10%	0.023^{c}	0.534^{c}	0.646^{c}	1.457^{c}	1.017^{c}
20%	0.455^{b}	1.158^{b}	0.859^{b}	3.056^{b}	2.082^{b}
40%	0.080^{a}	3.050^{a}	1.833^{a}	5.694^{a}	4.005^{a}

Note. Values with the same superscript in the same column are not significantly different at $p \leq 0.05$.

Table 5 Concentrations of heavy metals in the leaves of *Capsicum chinense* irrigated with untreated wastewater.

Wastewater Treatments	Heavy Metal Concentrations (mg/l) *Cr*	*Cd*	*Pb*	*Mn*	*Cu*
Control	0.012^{b}	0.120^{e}	0.012^{e}	0.007^{e}	0.065^{d}
5%	0.024^{b}	0.411^{d}	0.319^{d}	0.490^{d}	0.308^{d}
10%	0.047^{b}	0.708^{c}	0.834^{c}	0.793^{c}	0.607^{c}
20%	0.089^{a}	2.025^{b}	1.085^{b}	1.493^{b}	1.030^{b}
40%	0.139^{a}	4.077^{a}	2.738^{a}	3.000^{a}	2.260^{a}

Note. Values with the same superscript in the same column are not significantly different at $p \leq 0.05$.