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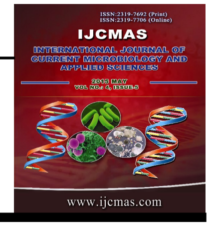

Original Research Article

Heavy Metals in Soils and Vegetables Irrigated with Urban Sewage water - A Case Study of Grater Hyderabad

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A B S T R A C T

There is currently an increased consumption of vegetables within the local urban community. However, contamination of these vegetables with heavy metals poses a potential health hazard. Consequently, the potential contamination problem due to the effect of levels of some heavy metals like Copper (Cu), cadmium (Cd), chromium (Cr) nickel (Ni), lead (Pb), Iron (Fe), Manganese (Mn) and zinc (Zn) contents of various vegetables Spinach (*Spinacia oleracea*), Ladyfinger (*Abelmoschus esulentus*), pepper mint (*Menthe pipereta*), coriander (*Coriandrum sativum*), Tomato (*Lycopersicon esculentum*), produced Musi river adjacent area, Hyderabad, Telangana, India was determined using Atomic absorption spectrophotometer (AAS). These plants are the basis of human nutrition in the study area. All vegetables grown at sewage water by farmers showed the highest contamination of heavy metals, followed by Progressive farmers. The concentration ranges in mg/kg were (1.45 -2.55) for Cd, (3.10 to 4.92) Cr, (12.15-20.50) Cu, (25.00-51.00) for Fe, (7.80 to 15.60) for Mn, (10.16 to 15.42) for Ni, (2.12 to 5.41) Pb and (16.58 to 24.08) for zinc. The contamination was above the Maximum Residue Limits (MRLs), set out by WHO. Irregular trends in concentration were also observed in vegetables obtained from progressive farmers.

Keywords

Heavy metals,
Contamination,
Vegetables,
Concentrations

Introduction

Food safety is a major public concern throughout the world. Consumption of nutritious and wholesome food has increased the demand of safe food. During the last few decades there is increase in research and efforts regarding the risk and health hazards associated with foodstuffs contaminated with heavy metals and pesticides, J.P.F. D'Mello*et al*., (2003).

Heavy metals in general are non-biodegradable, long biological half-lives and have high potential to accumulate in various body parts. Being water soluble they are highly toxic and have adverse effects on life even at low concentrations. Higher amounts of toxic heavy metals are found in waste water. Because of their excessive use in industrial applications, they are found every where,K.P. Singh *et al* .,(2004);Y. Chen *et al*., (2005).

There are many factors which contribute to heavy metal contamination such as contaminated irrigation water, fertilizers and pesticides applications, emissions of different waste materials from industries, lack of good transportation facilities, harvesting process and storage. The main sources of heavy metals are natural inputs like parent material weathering and anthropogenic inputs like metalliferous industries, mining, vehicle exhaust and agronomic practices, C. Zhang *et al*., (2006). An alarming situation is that human input has greatly exceeded the natural input of these metals due to pedogenic processes in soils, A.E. Facchinelli *et al*., (2001).The heavy metals availability to plants is regulated by many characteristics of soil like pH, cation exchange capacity, organic matter content, redox conditions and chloride content. In soil, increasing salinities has been reported to accelerate heavymetals mobilization and promote the metals uptake by plants, W.A. Norvell *et al*., (2000); K. Weggler, *et al*., (2004);A.R.A. Usman *et al*., (2005). Plants absorbs these heavy metals from contaminated soils. Plants accumulation with heavy metal relies on plant speciesand the metal absorbing efficiency of different plants,R. K. Rattan*et al*., (2005).

Vegetables are contaminated with heavy metal because of untreated city effluent and usage of sewage water especially in big cities, M. Qadir, *et al*., (1998). Vegetables are the most important components of human diet, N. Zheng *et al*., (2007) and are rich in vitamins, minerals and fibers. But these vegetables are contaminated with heavy metal and intake of these contaminated vegetables has shown risk to the human health Toxic heavy metals are associated with cardiovascular, kidney, nervous and bone diseases, WHO. Cadmium.*et al*., (1992);WHO. Lead. *et al*., (1995);. K. Steenl and *et al*., (2000);. L. Jarup.*et al*., (2003). Vomiting, diarrhea, stomach irritation, decreases in reaction time, kidney problems, anemia and blood disorders in humans are some of the diseases associated with heavy metals, ATSDR *et al*.,(1993). They may also cause respiratory tract cancer and muco dermal ulceration,. S. K. Agrawal. (2002). Current scenario demands to assess heavy metal contamination in soil, their bioaccumulation in vegetables and finally entering into the food chain that affects human health. Therefore a research work was planned to quantify the heavy metal accumulation in different vegetables.

Materials and Methods:

Apparatus

Heavy metals analyses were carried out using Unicam 929 Atomic Absorption Spectrophotometer.

Collection of samples

The fresh samples of five vegetables; Spinach (Panacea oleracea), Ladyfinger (Abelmoschus esulentus), pepper mint (Menthe pipereta), coriander (*Coriandrum sativum*), and Tomato (Lycopersicon esculentum), were collected from four different localities at Musi adjacent farms who grow vegetables on fresh water. After collection of vegetable samples they were transported to laboratory and stored at low temperature (4-8ºC) until use.

Vegetables preparation for analysis

Vegetable samples were digested foranalysis of heavy metals according to the method reported by L. A. Richard. *et al*.,(1996). The fresh samples of vegetables collected were washed with deionized water to eliminate air-borne contaminants. Afterwashing uneatable portions of the vegetable were removed and eatable portions were chopped intosmall pieces. The test portion was then dried in an oven at 100 °C to remove moisture. 0.5g of the test portion were taken in 100 ml conical flask with the addition of 10 ml HNO3 at 60-70 °C for 20 minutes and then the samples were digested with 5 ml HClO4at 60-70 °C for 20 minutes. Finally the temperature was raised to 195 °C till the samples were transparent and reduced to 1-2 ml. The digested samples were diluted in a volumetric flask with deionized water.

Statistical analysis

The data obtained from each parameter was analyzed statistically to assess the changes in various parameters of the study as described by R. G. D. Steel, et al., (1997). Completely Randomized Design was applied on the data to assess the significance of different sources of variation and the differences among the means were compared with Duncan's Multiple Range test(DMR) using Statistical Package (MSTAT C Software).

Results and Discussion

The statistical results indicated that the cadmium, chromium, copper, iron, manganese, nickel, lead and zinc were affected significantly ($P<0.05$) due to differences in sources. Similarly, differences in vegetables regarding heavy metals content were found to be significant. The interaction between sources and vegetables were also found to be significant.

Cadmium

The mean values for cadmium have been presented in Table-1. The results showed significantly the highest content of cadmium in sewage water used vegetable (1.930 mg kg-1) followed by the fresh water used vegetables (0.016 mg kg^{-1}). The results further substantiated that cadmium content was found to be significantly highest in Spinach (0.912 mg kg^{-1}) and significantly lowest in Tomato(0.466 mg kg-1), however, variation in vegetables for cadmium in Spinach and Tomato was non-significant.

Chromium

The mean values for chromium have been presented in Table-1. The results showed significantly ($P<0.05$) highest content of chromium in sewage water used vegetables (3.810 mg kg^{-1}) followed by the samples collected from fresh water used vegetables (0.134 mg kg^{-1}). The results further demonstrated that chromium content was found to be significantly higher in Spinach (1.725 mg kg^{-1}) and significantly lower in coriander (0.937 mg kg^{-1}) However, variation in vegetables for chromium in Spinach and Ladyfinger was non-significant.

Copper

The mean values for copper have been presented in Table-2. The results showed significantly highest content of copper in sewage water used vegetables (15.840 mg kg^{-1}) followed by the samples collected from fresh water used vegetables (0.112 mg kg^{-1}).

The results further substantiated that variation in vegetables for copper in Spinach and pepper mint was non-significant, however copper content was found to be significantly higher in pepper mint(8.625 mg kg^{-1}) and significantly lower in coriander (5.465 mgkg^{-1}).

Iron

The mean values for iron have been presented in Table-2. The results showed significantly highest content of iron in sewage water used vegetables(36.600 mg kg^{-1}) followed by the samples collected from fresh water used vegetables (0.839 mg kg^{-1}). The results further substantiated that iron content was found to be higher in Spinach (19.742 mg kg^{-1}) and lower in Ladyfinger (9.150 mg kg^{-1}) However, variation in vegetables for iron content was found to be significant in all vegetables.

Manganese

The mean values for manganese have been presented in Table-3. The results showed Significantly highest content of manganese in sewage water used vegetables (11.170 mg kg^{-1}) followed by the samples collected from fresh water used vegetables (0.063 mg kg^{-1}).The results further substantiated that manganese content was found to be higher in Spinach (6.104 mg kg-1) and lower in Ladyfinger (3.037mg kg-1).However, variation in vegetables form anganese in Ladyfinger, coriander and Tomato was non-significant.

Nickel

The mean values for nickel have beenpresented in Table-3. The results showed significantly highest content of nickel in sewage water used vegetables(12.060 mg kg^{-1}) followed by the samples collected from fresh water used vegetables (0.056 mg kg^{-1}). The results further substantiated that nickel content was found to be higher in Tomato (5.275 mg kg^{-1}) and lower in Spinach (2.909 mg kg^{-1}); however, variation in vegetables for nickel was significant in all vegetables.

Lead

The mean values for lead have been presented in Table-4. The results showed significantly highest content of lead in sewage water used vegetables (3.838 mg kg^{-1}) followed by the samples collected from fresh water vegetables (0.099 mg kg^{-1}). The results further substantiated that lead content was found to be higher in Spinach (2.025 mg kg-1) and lower in coriander (0.837 mg kg^{-1});however, variation in vegetables for lead in all vegetables was significant.

Zinc

The mean values for zinc have been presented in Table-4. The results showed significantly highest content of zinc in sewage water used vegetables(18.964 mg kg^{-1}) followed by the samples collected from fresh water used vegetables (0.247 mgkg-^{1}) The results further substantiated that zinc content was found to be higher in pepper mint (8.501mg kg-1) and lower in Ladyfinger (6.197 mg kg^{-1}),however, variation in vegetables for zinc in all vegetables was significant.

The results of analysis revealed that cadmium, chromium, copper, iron, manganese, Nickel, lead and zinc content in vegetables samples collected from sewage water were higher than the Maximum Residue Limits (MRLs) prescribed by WHO,. WHO. Guidelines., (1996). It has been observed that environmental contamination and naturally occurrence of cadmium in local soils is the cause of accumulation of cadmium in vegetables, J. O. Nriagu.,(1990);N. I. Ward.,(1995). Ward, F. E. Mapanda *et al*., (2005) also described the sewage and industrial effluents as the cause of metal enrichment in agricultural fields near urban areas. Long term use of wastewater for vegetable production has shown elevation of heavy metals in vegetables, S. Singh, *et al*.,(2005);R. K. Sharma, et al.,(2006);. R. K. Sharma(2007).

Table.1 Mean detection of cadmium & chromium (mg kg-1) in different vegetables collected from different sources

Vegetables	Cadmium		Chromium	
Spinach	2.100±0.100	0.041±0.002	4.140±0.100	0.235±0.004
Ladyfinger	1.450±0.250	0.009±0.001	4.920±0.010	0.137±0.008
pepper mint	2.550±0.200	0.004±0.001	3.390±0.070	0.077±0.007
coriander	1.800±0.050	0.015±0.003	3.100±0.010	0.113±0.001
Tomato	1.750±0.050	0.012±0.002	3.500±0.400	0.108±0.007

Table.2 Mean detection of copper & Iron (mg kg-1) in different vegetables collected from different sources

Vegetables	Copper		Iron	
Spinach	20.500±0.500	0.308±0.006	51.000±1.500	0.470±0.005
Ladyfinger	14.900±0.400	0.041±0.002	25.000±0.400	0.120±0.010
pepper mint	18.450±0.100	0.105±0.005	38.000±0.500	0.212±0.005
coriander	12.150±0.070	0.039±0.003	27.000±1.000	0.214±0.003
Tomato	13.200±0.400	0.065±0.002	42.000±1.100	3.181±0.006

Table.3 Mean detection of Manganese & Nickle (mg kg-1) in different vegetables collected from different sources

Vegetables	Manganese		Nickel	
Spinach	15.600±0.200	0.115±0.005	10.180±0.060	0.000±0.000
Ladyfinger	10.750±0.060	0.000±0.000	15.420±0.060	0.114±0.004
pepper mint	12.250±0.040	0.075±0.007	10.160±0.090	0.116±0.003
coriander	7.800±0.600	0.030±0.003	12.100±0.200	0.000±0.000
Tomato	9.450±0.070	0.096±0.004	12.440±0.090	0.052±0.002

Table.4 Mean detection of Lead & Zink (mg kg-1) in different vegetables collected from different sources

Vegetables	Lead		Zinc	
Spinach	5.410±0.040	0.165±0.004	19.560±0.030	0.301±0.003
Ladyfinger	4.820±0.070	0.059±0.005	16.580±0.080	0.067±0.006
pepper mint	3.310±0.020	0.157±0.003	24.080±0.070	0.243±0.003
coriander	2.120±0.010	0.067±0.006	16.860±0.120	0.240±0.040
Tomato	3.530±0.040	0.067±0.006	17.740±0.060	0.386±0.003

The heavy metal concentration in sewage water may not only cause soil contamination as well as their uptake by crops may deteriorate food quality and safety M. Muchuweti, *et al*., (2006). A number of different studies have indicated the presence of toxic metal in waste water and also in soil irrigated with waste water, K.P. Singh, *et al*.,(2004);F. E. Mapanda, *et al*., (2005);. Z. H. Cao *et al*., (2000);J. Nyamangara, *et al*.,(1999).

Vegetable samples collected from progressive farmers have chromium, copper, iron, manganese, nickel and zinc below the maximum permissible limit described by WHO, WHO.,(1996). Three samples of vegetables i.e. Spinach (0.04 ± 0.002),Tomato (0.01 ± 0.002) and coriander (0.02 ±0.003) have cadmium content above the critical limit, whereas the Ladyfinger and Tomato, coriander have cadmium content below the maximum permissible limit. Zinc content in progressive farmers vegetables i.e. Spinach (0.91 ± 0.001) and pepper mint(0.93 ±0.002) were found to be above the critical limit, whereas Tomato, Ladyfinger and coriander have zinc content below the critical limit.

The study concluded that there is significant buildup of heavy metals in vegetables irrigated with sewage water. So there is a need to create an awareness program for the farmers not to use wastewater for irrigating vegetables. Appropriate precautions should also be adopted during transportation, marketing and storage of local market vegetables.

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