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Heavy Metal Contents of Vegetables Irrigated by Sewage/Tubewell Water

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ABSTRACT

A field study was conducted to find the effect of sewage/tube well water irrigation on the accumulated concentration of heavy metal contents in okra fruit and spinach leaves. Three adjacent fields were selected for each crop and separately irrigated by sewage water, tube well water and mixture of sewage and tube well water. Okra (*Abelmoschus esculentus*) and spinach (*Spinacea oleracea*) were planted in spring and winter respectively. Both vegetables were given a basal dose of 100 and 50 kg ha^{-1} N and P respectively. The heavy metal and micronutrient contents in both vegetables were present in significantly higher amount in order of sewage>sewage and tube well water >tube well water except Cu and Fe which showed variation for both the crops. Spinach leaves showed higher accumulation of heavy metals and micronutrients as compared to okra fruit.

Key Words: Heavy metals; Vegetable; Sewage; Tubewell; Irrigation

INTRODUCTION

Environmental pollution is an undesirable change in atmosphere, hydrosphere and lithosphere. Advanced industrialization processes have provided comforts to human beings on one hand but it has also resulted in indiscriminate release of gasses and liquids, which pollute the environment of biological system. Now a days large amount of untreated sewage / industrial water is being discharged into surface bodies for disposal (Saleemi, 1993). As there is water shortage in the country therefore, farmers are using this waste water to irrigate their vegetable fields in city conurbations. Such irrigation practices give very good crop yields as it contains large amount of organic material and some inorganic elements essential for plant growth. But it also may contain non-essential heavy metals which when present in large amount could be transferred to animal and human beings through food chain (Ghafoor *et al.*, 1995; Nriagu, 1990). It has been indicated that long-term exposure of Cd in food and water leads to build up of Cd in kidneys causing kidney diseases (ATSDR, 1993). Nickel proves fatal if it exceeds the recommended concentration in food (Nriagu & Pacyna, 1988). Generally the growers are not aware of such consequences of high build up of heavy metals in food chain, hence they continue to grow vegetables on sewage and industrial effluents. Therefore a field study was conducted to see the effect of sewage / tubewell water on heavy metal content of Okra and spinach crops.

MATERIALS AND METHODS

Three adjacent fields were selected in Hassanabdal area district Attock, in such a way that each field was separately irrigated by sewage, mixture of sewage / tubewell water and tubewell water only. In these studies tubewell water was taken as control. The control field had silt loam texture with pH 7.1. It was non-saline and non-sodic with low organic matter content (0.48 %). During spring (March, 2000) okra (*Abelmoschus esculentus*) and during winter (October, 2000) spinach (*Spinacea oleracea*) were grown on each field. The fertilizers were applied in the form of Urea and DAP @ 100 and 50 kg/ha of N and P respectively to each field as per farmer's practice. The fields were irrigated 10 times during course of crop growth. The cultural practices adopted at experimental sites were same as those of local farmers at Hassanabdal area.

Table I. Analysis of waters used for irrigation

Parameter	Sewage Water	Tube Well Water
pH	7.6	7.8
ECe (dS m^{-1})	3.2	0.2
SAR	18.6	2.20
Soluble Cations (me L^{-1})		
Na	9.00	1.42
Ca + Mg	8.54	4.80
Soluble Anions (me L^{-1})		
HCO_3	12.10	2.6
CO_3	2.5	0.46
Cl	1.53	0.21
Micronutrients (mg L^{-1})		
Cu	0.70	0.02
Zn	0.42	0.009
Fe	2.67	0.07
Mn	0.53	0.02
Heavy Metals (mg L^{-1})		
Ni	2.23	0.03
Cd	0.031	0.001
Pb	0.42	0.03
Cr	0.71	0.04

At the end of experiments, okra fruits and spinach leaves were collected. Samples were washed with distilled, deionized water and oven dried at $65^{o}C$ till constant weight. The samples were ground with micro grinding mill and stored in clean and dried bags for chemical analysis. The water used for irrigation was also analyzed for pH, total soluble salts, micronutrients and heavy metal contents, which is given in Table I. The methods of soil analyses were those described by Page *et al.* (1982). Plant samples were digested in nitro-perchloric acid mixture and micronutrients and heavy metals were determined by atomic absorption spectrophotometer.

The data collected were subjected to statistical analysis using T test as given by Steel and Torrie (1980) and results were drawn accordingly.

RESULTS AND DISCUSSION

The effect of different quality waters on heavy metal and micronutrient contents of okra plant were significant except for Fe and Cu, which showed variation (Table II). The maximum values of heavy metal contents and micronutrients were recorded with sewage water followed by sewage and tube well water mixed and minimum in treatment tube well water only. The trend of accumulation of heavy metals and micronutrients in okra fruit was Ni>Pb>Cr>Cd and Fe>Mn>Cu>Zn respectively. Fe and Cu contents of okra fruit were found statistically significant over tube well water treatment but non significant as compared to sewage and tube well water mixed treatment.

Table II. Effect of different quality waters on heavy metal and micronutrient contents of okra fruit (mg kg^{-1} DW)

Element	Sewage	Sewage + tube well water	Tube well water
Ni	20.80 a	6.03 b	0.11 c
Cd	2.60 a	0.36 b	0.003 c
Pb	9.35 a	2.13 b	0.18 c
Cr	3.09 a	1.77 b	0.004 c
Cu	22.91 a	20.45 a	6.32 b
Zn	20.05a	11.53 b	4.26 b
Fe	353.80 a	300.12 a	16.221 c
Mn	73.51 a	50.83 b	19.13 c

The means having different letters in each row are significantly different from each other at five percent level of probability, where as having same letter indicate non-significant differences

The effect of different quality waters on heavy metal and micronutrient contents of spinach leaves is given in Table III. All the results obtained for heavy metal and micronutrient contents were found significant except Cu and Fe in spinach leaves, which showed variation. Mean maximum values of heavy metal and micronutrients contents were recorded with sewage water and minimum values with tube well water for spinach leaves. The accumulation trend of heavy metals in spinach leaves was Ni>Pb>Cr>Cd. Mean maximum values of micronutrient contents of spinach leaves were recorded with sewage water treatment in order of Fe>Mn>Cu>Zn. The results for micronutrient contents of spinach leaves were found statistically significant for all treatments with exception of Cu and Fe. Cu and Fe contents of spinach leaves were statistically non significant in treatments sewage water and sewage/ tube well water mixed, whereas these contents were found statistically significant over tube well water.

Table III. Effect of different quality waters on heavy metal and micronutrient contents of spinach leaves (mg kg^{-1} DW).

Element	Sewage	Sewage + tube well water	Tube well water
Ni	28.00 a	7.10 b	0.13 c
Cd	3.20 a	0.35 b	0.005 c
Pb	10.43 a	4.10 b	0.16 c
Cr	3.93 a	2.14 b	0.004 c
Cu	28.56 a	26.66 a	8.30 b
Zn	26.169 a	16.38 b	7.71 c
Fe	500.00 a	430.00 a	24.57 b
Mn	104.10 a	73.26 b	15.30 c

The means having different letters in each row are significantly different from each other at five percent level of probability, where as having same letter indicate non-significant differences

The over all perusal of data regarding effect of different quality waters on heavy metal contents of spinach and okra plants revealed that the application of different water types greatly affected Ni, Cd, Cr and Pb contents in fruits. Sewage water application in general resulted higher and tube well irrigation in minimum accumulation of heavy metals in plant matter. Higher contents of heavy metals by sewage water may be attributed to fact that sewage water was composed of various types of domestic and industrial effluents, which contained a variety of chemical compounds having different metals. The chemical analysis of sewage water (Table I) confirms this fact. All micronutrient contents were found significantly higher in spinach and okra plants with application of sewage water. Similarly tube well water alone resulted in lowest micronutrient contents of spinach and okra plant. The higher micronutrient contents of spinach and okra plants may be ascribed to fact that sewage water was composed of mainly domestic waste with some industrial discharge. The waste had variety of compounds of various element including micronutrients under study. After application of sewage water to fields, these metal elements tended to accumulate in soil and thus their availability increased in soil solution and ultimately higher metal contents were recovered in spinach and okra plants. More Fe contents, compared to other micronutrients may be attributed to the fact that Fe accumulates more than any other metal ion in plants (Adhikari *et al.*, 1998). The above results obtained are in line with Kansal and Singh (1983) and Schirado *et al.* (1986) who studied the effect of waste water on maize, berseem, cauliflower and spineach. And found considerably higher concentration of Fe,Mn, Zn, Cu, Pb and Cd than those soils irrigated with tubewell water.

The accumulation concentration of Ni, Cd, Pb and Cr was much higher than the permissible level of these metal

Table IV. Critical level of different metal ions in edible portion of vegetables

Cu	Zn	Fe	Mn	Ni	Cd	Pb	Cr
10.00	5.00	150.00	6.61	10.00	0.02	2.00	1.30

WHO (1996); Asaolu (1995)

ions in edible portion of vegetables (Table IV) with sewage water and blend of sewage / tube well water. But the metal ions of vegetables grown with tube well water were below permissible limits and were safe for human consumption. Thus there is an urgent need to educate the formers and adopt new technologies for treating sewage / industrial effluents before their use for vegetables.

REFERENCES

Adhikari, S., A. Mitra, S.K. Gupta, and S.A. Banerji, 1998. Pollutant metal contents of vegetables irrigated with sewage water. *J. Indian Soil Sci.*, 46: 153–5

Asaolu, S.S., 1995. Lead content of vegetables and tomatoes at Erekesan market. *Pakistan J. Sci. Ind. Res.*, 38: 399–401

ATSDR (Agency for Toxic Substances and Disease Registry), 1993. *Toxicological Profile for Cadmium Atlanta.* US Dept. of Health and Human Services, Public Health Service.

Ghafoor, A., A. Rauf, M. Arif and W. Muzzafar, 1995. Chemical composition of effluent from different industries from Faisalabad city. *Pakistan J. Agric. Sci.,* 31: 37–69

Kansal, B.D. and J. Singh, 1983. Influence of municipal waste water and soil properties on accumulation of heavy metals in plants. *J. Environ. Pollut.*, 6: 13–6

Nriagu, J.O. and J.M. Pacyna, 1988. Quantitative assessment of worldwide contamination of air, water and soil by trace metals. *Nature,* 33: 134–9

Nriagu, M.B., 1990. Problems of using waste water on vegetable crops. *J. Hort. Sci.,* 21: 24–7

Page, A.L., R.H. Miller and D.R. Keeney, 1982. *Methods of Soil Analysis.* pp: 169–238. American Soc. Agron. Inc., Madison, USA.

Saleemi, M.A., 1993. Environmental assessment and management of irrigation and drainage scheme for sustainable agriculture growth. *Environ. Protection Agency Bull. (Lahore),*: 64

Schirado, T., I. Vergara, E.B. Schalscha and P.F. Pratt, 1986. Evidence of movement of heavy metals in soil irrigated with untreated waste waters. *J. Environ. Qual.*, 15: 9–12

Steel, R.G.D. and J.H. Torrie, 1980. *Principles and Procedure of Statistics. A Biometrical Approach.* p. 507. McGraw Hill Book Co., Inc. New York, USA.

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