Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 4 (2): 132-135, 2005
ISSN 1682-3974

Toxicity of Trace Elements in Different Vegetables Grown on Potentially Contaminated Sites of the Korangi Industrial Area, Karachi Pakistan

[1]Midrar-ul-Haq, [2]Riaz A. Khattak, [1]Haji Khan Puno,
[1]M. Saleem Saif, [1]Kazi Suleman Memon and [1]Nabi Bux Sial
[1]Department of Soil Science, Sindh Agriculture University, TandoJam, Pakistan
[2]Department of Soil and Environmental Sciences, NWFP Agricultural University, Peshawar, Pakistan

Abstract: This study presents toxicity of trace elements (Zn, Cu, Fe, Mn, Cd, Cr, Ni, Pb) in different vegetables grown on potentially contaminated sites of the Korangi Industrial Area, Karachi (Sindh) Pakistan. A total of 40 effluent irrigated and 4 tubewell irrigated considered as background samples were collected and analyzed for trace elements concentration. The maximum concentrations of trace elements absorbed by different vegetables grown on effluent irrigated soils were 78.8, 103.25, 638.8, 973.3, 7.4, 22.5, 88.0 and 64.0 mg kg^{-1} for Zn, Cu, Fe, Mn, Cd, Cr, Ni and Pb, respectively. However, the background plant samples showed the maximum concentrations of 32.4, 19.5, 172.5, 111.8, 1.8, 4.2, 14.8 and 12.4 mg kg^{-1} for the above respective elements. The values observed in this study were also compared with the toxic and excessive levels. The comparison showed that 100, 13, 18, 50, 93 and 50% of samples contained toxic or excessive levels of Cu, Mn, Cd, Cr, Ni and Pb, respectively. The concentration of trace elements in effluents irrigated plants were higher than those in tubewell irrigated plants and also higher than those generally reported in the literature.

Key words: Industrial pollution, trace elements toxicity, heavy metals contamination

INTRODUCTION

Trace elements are absorbed by plants from soils as well as partly from waters and air. Some of these elements are essential for their normal growth while others are toxic and hence have ill effects on their growth and quality. Zn, Cu, Fe and Mn are essential for plant growth[1] while it has recently been established that Ni is essential to higher plants[2,3] Cd, Cr and Pb are non-essential and become toxic in elevated concentrations[4]. The higher or excessive levels of trace elements can contaminate our food chain by the process of bioaccumulation and biomagnification. So, their proper concentration in soil is much important for the plant growth.

The ability of plants to accumulate trace elements in their edible parts varies between plant species and among genotypes within species[5,6]. Thus, there are genetic controls over the trace elements concentrations found in edible portions of higher plants. These genetic differences can affect the nutritional status of animals and the geographic distribution of trace elements problem areas[7].

This study presents the bioaccumulation of trace elements (Zn, Cu, Fe, Mn, Cd, Cr, Ni, Pb) in different vegetables grown on potentially contaminated soils of the Korangi Industrial Area, Karachi, Sindh, Pakistan.

MATERIALS AND METHODS

The plant samples including bitter gourd (*Momordica carnantia*), bottle gourd (*Cucurbita maxima*), brinjal (*Solanum melongena*), coriander (*Corriandrum sativum*), hot pepper (*Capsium frutescens*), radish (*Raphanus sativus*), spinach (*Spinacia oleracea*) and sponge gourd (*Luffa acutaugula*) were collected from 11 different sites in which 10 sites, irrigated with effluents and possibly contaminated by the industrial effluents were selected from Korangi Industrial Area, Karachi, while the 11th site irrigated with tubewell water in Memon Goth was considered as background sample. The samples were collected both in summer and winter seasons of the years 2000 and 2001. A total of 40 effluents irrigated and 4 tubewell irrigated plant samples were collected and then washed with distil water, oven dried at 70°C and crushed by Willy Mill. The well ground samples were digested by using wet digestion method and analyzed for the concentration of trace elements (Zn, Cu, Fe, Mn, Cd, Cr, Ni and Pb) by atomic absorption spectrophotometer[8].

RESULTS AND DISCUSSION

Zinc: The values of Zn varied between 32.5-78.80 mg kg^{-1} with the mean value of 42.64±7.10 (Table 1). The maximum

Corresponding Author: Dr. Midrar-ul-Haq, House # 2/12-A Survey # 88, Golden Town, Karachi # 43, Karachi, Pakistan

and minimum values were observed in samples of spinach and sponge gourd, respectively. The spinach, which was collected from background soil, showed the maximum value of 32.4 mg kg^{-1}.

The t-test comparison showed that concentrations of Zn in effluent irrigated plants were significantly higher than those in tube well irrigated plants (Table 2). The variations can be associated to the industrial as well as domestic wastewater used for irrigation purposes.

Katyal and Randhawa[9] reported that normal range of Zn in healthy vegetables is 20-100 mg kg^{-1} while Kabata-Pendias and Pendias[4] reported that toxic or excessive levels of Zn in plants is 100-400 mg kg^{-1}. Comparing with normal and toxic range, all the plant samples were found within sufficiency range rather than toxic one.

Copper: The maximum and minimum values of Cu were 103.25 and 21.8 mg kg^{-1} in samples of bottle ground and coriander, respectively (Table 1). The background plant sample (spinach) contained the maximum value of 19.5 mg kg^{-1}.

The t-test comparison showed that the Cu concentrations in effluent and tubewell irrigated plants differed non-significantly (Table 2).

Berman and Lal[10] reported Cu concentration which ranged from 9 to 93 with an average value of 58.2 mg kg^{-1} in different vegetables and weeds grown in industrially polluted fields, while Wazir[11] observed Cu concentration in the range of 12.13-32.8 mg kg^{-1} in plant samples collected from possible contaminated sites within the proximity of Peshawar. So, the reported values in this study are similar to those observed for contaminated sites.

Iron: The Fe concentration ranged from 98.0-638.8 mg kg^{-1} with the average value of 261.37±85.22 (Table 1). The maximum and minimum values were observed in samples of spinach and brinjal, respectively, while the background plant sample (spinach) showed the highest value of 172.5 mg kg^{-1}.

The t-test comparison showed that the concentration of Fe in effluent irrigated plants remained significantly higher than those in tubewell irrigated plants (Table 2). The possible reason can be industrial effluents used for irrigation and soil organic matter content.

Katyal and Randhawa[9] reported that Fe concentration less than 50 mg kg^{-1} are generally considered as deficient while Jones *et al.*[12] reported sufficiency level of Fe content in leaf which ranged from 50-75 mg kg^{-1}. However, Kabata-Pendias and Pendias[4] observed Fe content in edible parts of vegetables ranging from 29-130 mg kg^{-1}. So, it is obvious from the results that 78% of samples containing Fe content greater than 130 mg kg^{-1} while, the rest are within the range reported by Kabata-Pendias and Pendias[4] for the edible parts of vegetables.

Manganese: The values of Mn varied between 52.8-973.3 mg kg^{-1} with the highest value in sample of radish and lowest in bitter gourd (Table 1). The spinach collected from background soil showed the maximum value of 111.8 mg kg^{-1}.

According to t-test comparison, the concentration of Mn in effluent and tubewell irrigated plants varied non-significantly (Table 2).

Kabata-Pendias and Pendias[4] reported Mn content ranging from 20-30 mg kg^{-1} as sufficient and toxic or excessive when ranged from 300-500 mg kg^{-1} in mature leaf tissue. Keeping in view these limits Mn concentration in plant samples were found within sufficiency range. However, 13% of samples contained toxic level of Mn content (Table 3).

Cadmium: The highest and lowest concentrations of Cd were 7.4 and 0.85 mg kg^{-1} in samples of spinach and bitter gourd, respectively (Table 1) while the spinach sample collected from background soil contained the maximum value of 1.8 mg kg^{-1}.

The t-test comparison showed that Cd concentrations in effluent irrigated plants were

Table 1: Range and mean±SD (mg kg^{-1}) of trace elements in effluent and tubewell irrigated (background) plant samples collected from various sites of Karachi, Sindh Province

Trace elements	Effluent irrigated plant values (n=40)		Tubewell irrigated plant maximum (n=4)	
	Range	Mean±SD	Range	Mean±SD
Zn	32.50-78.8	42.64±7.10	22.60-32.4	28.75±4.26
Cu	21.80-103.25	49.80±21.25	18.40-19.50	18.92±0.46
Fe	98.00-638.8	261.37±85.22	108.00-172.50	133.70±27.4
Mn	52.80-973.3	140.29±45.23	57.80-111.8	73.40±25.70
Cd	0.85-7.4	2.62±1.08	0.40-1.8	0.95±0.62
Cr	1.50-22.5	5.78±2.08	2.00-4.2	2.98±0.98
Ni	26.95-88.0	34.71±10.39	8.60-14.8	12.40±2.74
Pb	0.50-64.0	29.25±8.56	5.60-12.4	10.20±3.13

SD: Standard Deviation.

Table 2: Statistical difference among trace elements in effluent vs tubewell irrigated plant samples collected from various sites of Karachi, Sindh Province

Trace elements	t-value
Zn	5.18*
Cu	2.86
Fe	3.28*
Mn	2.92
Cd	6.72**
Cr	4.43*
Ni	4.91*
Pb	3.90*

*, **, Significant at p<0.05 and 0.01, respectively

significantly higher than those in tubewell irrigated plants (Table 2). This suggests that the effluents from different industries contributed Cd to the plants in irrigation waters and enhanced its accumulation to undesirable level.

The results of this study can be compared with those reported by Faber and Niezgoda[13], Berman and Lal[10]. According to Faber and Niezgoda[13] the concentration of Cd ranged from 1.7-3.7 mg kg^{-1} in carrot roots collected from industrially contaminated sites of Poland while Berman and Lal[10] reported Cd concentration which ranged from 1-8 mg kg^{-1} with an average value of 3.2 mg kg^{-1} in plant samples (vegetables and weeds) grown in industrially polluted fields. Kabata-Pendias and Pendias[4] reported that leafy vegetables such as spinach and root vegetables such as turnip, should be considered to be the main routes of Cd supply to man.

Chromium: The Cr concentration ranged from 1.5-22.5 mg kg^{-1} with the mean value of 5.78±2.08 (Table 1). The maximum and minimum values were reported in samples of spinach and spong gourd, respectively. The background plant sample (spinach) showed the highest value of 4.2 mg kg^{-1}.

According to t-test comparison the concentrations of Cr in effluent irrigated plants were significantly higher than those in tubewell irrigated (background) plants (Table 2).

Bown[14] observed Cr content in the range of 0.02-14.0 mg kg^{-1} (DW) in the edible parts of vegetables. However, according to Qadir[15] the concentration of Cr ranged from 2.47-6.83 mg kg^{-1} in edible portions of some vegetables grown with industrial and city effluent irrigation. The results observed in this study are in agreement with those reported for vegetables by the aforementioned investigators. Moreover, Kabata-Pendias and Pendias[4] reported that normal or sufficient level of Cr concentration in mature leaf is 0.1-0.5 mg kg^{-1} while excessive or toxic level is 5-30 mg kg^{-1}. Comparing plant samples with the above mentioned limits, it was found that 50% of samples have toxic level of Cr (Table 3), while the rest of the samples also contained Cr concentration above normal level which could reach to toxic level, if the water of the same quality is used for a longer period.

Nickel: The values of Ni varied between 26.95-88.0 mg kg^{-1} with the highest value in sample of spinach and lowest in bitter gourd (Table 1). The spinach collected from background soil showed the maximum value of 14.8 mg kg^{-1}.

The t-test comparison showed that the concentrations of Ni in effluent irrigated plants were significantly higher than those in tubewell irrigated plants (Table 2). The possible reason can be industrial effluents in irrigation water.

Beavington[16] and Kronemann *et al.*[17] observed the average Ni values of 2.7 mg kg^{-1} and 11 mg kg^{-1} (DW) in leaves of lettuce grown in contaminated sites of Australia and East Germany, respectively. According to Ikramullah[19] the concentration of Ni ranged from 7.8-29.3 mg kg^{-1} in vegetables grown with industrial and city effluent irrigation. Kabata-Pendias and Pendias[4] reported Ni content ranging from 0.1-5 mg kg^{-1} as sufficient and toxic or excessive when ranged from 10-100 mg kg^{-1} in mature leaf tissue. Keeping in view these limits, 93% of samples were found at the toxic range (Table 3), while the remaining samples contained Ni content above normal level. The results of this study are quite high when compared with the values reported by the above investigators.

Lead: The maximum and minimum values of Pb were 64.0 and 0.5 mg kg^{-1} in samples of radish and spong gourd, respectively (Table 1). The spinach sample collected from background soil contained the maximum value of 12.4 mg kg^{-1}.

According to t-test comparison, the Pb concentrations in effluent irrigated plants were significantly higher than those observed in tubewell irrigated plants (Table 2). Such a high concentration can be related to the industrial wastewater used for irrigation and atmospheric fallout from industrial and automobile emissions.

Page *et al.*[19] reported Pb concentration which ranged from 16-24 mg kg^{-1} in leaves of corn grown in contaminated sites of United States while Faber and Niezgoda[13] observed Pb concentration ranging from 27-57 mg kg^{-1} in the roots of carrot grown in industrially contaminated sites of Poland.

Kabata-Pendias and Pendias[4] reported that normal level of Pb concentration in mature leaf is 5-10 mg kg^{-1} while excessive or toxic level is 30 to 300 mg kg^{-1}. Comparing plant samples with the above-mentioned limits, we can conclude that 50% of samples are at the toxic range (Table 3) while other samples except one contained Pb concentration above normal level.

By comparing the observed values with those reported by Kabata-Pendias and Pendias[4], most of the samples were found at the levels, which could be potentially toxic while only few samples contained these trace elements at the sufficiency or normal levels. The toxic effects on the plants i.e. appearance of dark green leaves, wilting of older leaves, brown margin of leaves, blackish brown spots on leaves were also noted in the field by visual observations. The contamination of plants

Table 3: Classification of plant samples on the basis of trace elements toxicity

Trace elements	¥Toxic or excessive levels (mg kg^{-1} DW)	Sindh (n= 40) No. of samples	% of samples
Zn	100-400	-	-
Cu	20-100	40	100
Fe	--	--	--
Mn	300-500	5	13
Cd	5-30	7	18
Cr	5-30	20	50
Ni	10-100	37	93
Pb	30-300	20	50

¥source: Kabata-Pendias and Pendias[4]

can be associated with the use of irrigation water contaminated by the industrial effluents and domestic sewage, atmospheric fallout, contaminated soils and the use of various fertilizers, insecticides and pesticides. The various plant samples also showed different concentrations of trace elements which can be ascribed to the variations in trace elements concentrations in soils, soil properties, plant species and types which have different affinity for the soil elements.

Comparing the results with those reported for tubewell irrigated plant samples, trace elements in most of the samples were higher, which can mainly be ascribed to the industrial waste water used for irrigation. However, some of the trace elements in tubewell irrigated plant samples were observed at high level which may be due to atmospheric fallout and the use of chemical fertilizers, animal and poultry manure, various agro chemicals, herbicides, pesticides and insecticides. As a matter of fact, it is not easy to find a site, which can be called a background level. Therefore, these so-called sites are merely providing comparison between effluent vs tubewell irrigated plant samples.

It can be concluded from the above discussion that trace elements in the edible portions of the vegetables were found above the permissible levels for human consumption. By eating effluent irrigated vegetables, the metals may build up concentration with time to potentially toxic level for human body as envisaged by the concept of bioaccumulation and biomagnification.

REFERENCES

1. Underwood, E.J., 1977. Trace Elements in Human and Animal Nutrition. 4th Edn., Academic Press, New York.
2. Brown, P.H., R.M. Welch and E.E. Cary, 1987. Nickel: A micronutrients essential for higher plants. Plant Physiol., 85: 801-803.
3. Eskew, D.L., R.M. Welch and E.E. Cary, 1983. Nickel: An essential micronutrients for legumes and possibly all higher plants. Science, 222: 621-623.
4. Kabata-Pendias, A. and H. Pendias, 1984. Trace Elements in Soils and Plants. CRC Press, Inc., Florida, USA.
5. Peterson, P.J., 1972. Unusual accumulations of elements by plants and animals. Sci. Prog. (Oxford), 59: 505-526.
6. Welch, R.M., 1986. Effects of nutrient deficiencies on seed production and quality. Adv. Plant Nutr., 2: 205-247.
7. Allaway, W.H., 1986. Soil, Plant, Animal and Human Interrelationships in Trace Element Nutrition. In: Nmertz, W. (Ed.), Trace Elements in Human and Animal Nutrition. 5th Edn., Academic Press, New York, pp: 465-488.
8. Association of Official Analytical Chemists (AOAC), 1990. 15th Edn., Official methods of analysis. AOAC, Inc. Arlington, USA.
9. Katyal, J.C. and N.S. Randhawa, 1983. Micronutrients. FAO fertilizer and plant Nutrition Bulletin 7. Rome. Food and Agriculture Organization of the United Nations.
10. Berman, S.C. and M.M. Lal, 1994. Accumulation of heavy metals (Zn, Cu, Cd and Pb) in soil and cultivated vegetables and weeds grown in industrially polluted fields. J. Environ. Bio., 15: 107-115.
11. Wazir, K.K., 1994. Trace elements Cd, Cu, Zn, Fe and Pb and P pollution in crops grown in contaminated soils in the proximity of Peshawar city. M.Sc Thesis, NWFP Agric. Univ. Peshawar.
12. Jones, Jr., J. Beton, B. Wolf and H.A. Mills, 1991. Plant Analysis Hand Book. Micro-Macro publishing. Inc., Athens, Georgia (USA).
13. Faber, A. and J. Niezgoda, 1982. Contamination of soils and plants in a vicinity of the Zine and Lead smelter. Rocz. Glebozn., 33: 93.
14. Bowen, H.J.M., 1979. Environmental Chemistry of the Elements. Academic Press, New York, pp: 333.
15. Qadir, M., 1999. City people eating poisoned vegetables. The daily Dawn, Pak. Natl. Newspaper, December, 22.
16. Beavington, F., 1975. Heavy metal contamination of vegetables and soil in domestic gardens around a smelting complex. Environ. Pollut., 9: 211.
17. Kronemann, H., M. Anke, S. Thomes and E. Riedel, 1980. The Nickel Concentration of Different Food and Feed-stuffs from Areas with and with out Nickel Exposure, in Proc. Nickel Symp. Anke, M., H.J. Sneider and Chr. Bruckner, (Eds.), Friedrich-Schiller University, Jena, E. Germany, pp: 221.
18. Ikramullah, 2000. Investigation of trace elements in water, soil and vegetables of Mingora city area (Swat) M.Sc Thesis, NWFP Agric. Univ. Peshawar.
19. Page, A.L., T.S. Ganje and M.S. Joshi, 1971. Lead quantities in plants, soil and air near some major highways in Southern California, Hilgardia, 41: 1.