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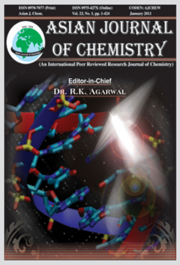

Chromium Contamination in Vegetable's Samples Irrigated Through Different Water Sources

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This work evaluates the effects of water of irrigation in comparison with the source of water with special reference to chromium contamination in vegetables grown in various areas of Pakistan. Twenty samples of each vegetable, *i.e.*, spinach (*Spinacia oleracea*), lettuce (*Lactuca sativa*), carrot (*Daucus cariota*), capsicum (*Capsicum fistulosus*), sweet pea (*Lathyrus odoratus*), potato (*Solanum tuberosum*) and cabbage (*Brassica oleracea*), were collected during the year 2006 and replicated in 2007 and 2008. The range of concentration of chromium in vegetables irrigated with tube well water, canal water and municipal sewage water was in between 0.3-5.3, 1.01-13.09 and 1.11-29.89 ppm, respectively. Statistical analysis shows that the vegetables grown by tube well water and canal irrigation are quite safe and show less than 1 % samples of vegetables showing chromium concentration more than that of permissible ambient levels. In case of vegetables irrigated by municipal sewage water more than 50 % samples contained Cr more than that of permissible ambient levels. The results reflect that the uptake of chromium in vegetables is facilitated under the condition where the source of irrigation is sewage water.

Key Words: Water of irrigation, Chromium, Toxicity, Vegetables, Permissible ambient levels.

INTRODUCTION

Chromium and its compounds have multifarious industrial uses. They are extensively employed in leather processing and finishing, in the production of refractory steel, drilling muds, electroplating cleaning agents, catalytic manufacture and in the production of chromic acid and some special chemicals. Hexavalent chromium compounds are used in industry for metal plating, cooling tower water treatment, hide tanning and, until recently, wood preservation[1]. Chromium is considered as an essential trace element for human metabolism. The amount of chromium in the diet is of great importance as Cr is involved in insulin function and lipid metabolism[2,3].

The determination of Cr levels in water, food and environment is of great importance because chromium toxicity is well known[4,5]. Several studies have assessed the chromium content in water, foods and environment with variable results. Several authors determined and reported the concentration of chromium in fresh vegetables, frozen vegetables and canned vegetables using different analytical techniques[6-12].

Environmental pollution is acting multidimensional in effecting the mankind living on this planet. It is directly affecting the health of people, trees and plants, the drinking water, the crops, the animals used as food of human beings and it is indirectly affecting our economy and social behaviours. Environmental protection and food safety is a burning issue of the present era all over the world. At international level a lot of research work is being carried out under different headings like heavy metal contamination, uptake of heavy metal in food items, basket survey, heavy metal contamination- a threat to life *etc*. In Pakistan it is yet to be investigated that what is the extent of heavy metal pollution in food items in different areas of the country. We have a little information about this issue and this part of our research work is supposed to be very useful to act as base-line information to identify the pattern of food problems in Pakistan.

EXPERIMENTAL

Twenty Samples of each vegetable, *i.e.*, spinach (*Spinacia oleracea*), lettuce (*Lactuca sativa*), carrot (*Daucus cariota*), capsicum (*Capsicum fistulosus*), sweet pea (*Lathyrus odoratus*), potato (*Solanum tuberosum*) and cabbage (*Brassica oleracea*), were collected keeping in view the source of irrigation *i.e.*, tube well water, canal water and municipal sewage water.

All samples of each vegetable were washed three times with de-ionized water and 0.05M HCl and then with de-ionized water to ensure dislodging and removal of dust particles. Samples were then dried in a fan-forced oven at 60 ± 5 ºC for

48 h, grounded using a stainless steel grinder, sifted through a 0.2-mm sieve and stored in plastic vials for further analysis of chromium[12].

Sulphuric acid, nitric acid, 4-methylpentan-2-one, sodium sulfite solution 6 % m/V, pentane-2, 4-dione (acetyl acetone) were procured from Merck/BDH. All glassware was cleaned with a sodium dichromate cleaning solution followed by detergent, deionized water, 1 M nitric acid and finally with doubly deionized water. The glassware was retained for chromium analysis and kept in 1M nitric acid when not in use.

Digestion method: Suitable food sample masses were placed in micro-Kjeldahl flasks and were then digested with a mixture of nitric (10 mL) and sulphuric acid (5 mL) by reported method[13,14]. The digest was diluted to 100 mL to give a colourless solution free from suspended solids. Two reagent blank solutions were prepared in a similar fashion simultaneously with each set of samples.

Method for the preparation of chromium chelate: To the aqueous phase retained, 1 mL of sodium sulfite solution was added followed by 3 ± 0.1 mL of pentane-2,4-dione. It was immersed in a boiling water bath for 0.5 h which was then removed and cooled at room temperature. It was transferred back into the 100 mL separating funnel used for the first extraction with the minimum rinsing. 10 ± 0.1 mL of 4-methylpentan-2-one was added with a dispenser. It was kept standing for 3 min and then shook for 30 s. Then again it was kept standing for 6 min, the aqueous layer was drained to waste and solvent was filtered through a silicon-treated filter-paper into a clean dry receiver as done by previous workers[15,16].

Chromium concentrations were determined in sample digestions by Zeeman background correction graphite furnace atomic absorption spectrometry (ZGF-AAS; Perkin-Elmer Analyst 800). A single-element hollow cathode lamp (Perkin-Elmer) was operated at 25 mA. Samples and standards were atomized and all data were recorded at 357.9 nm with a slit width of 0.7 nm. Argon of 99.99 % purity at 250 mL/min flow was used as internal gas. Readings on the spectrometer were taken using peak area mode. Injections (10 μL sample and 10 μL matrix modifier) were made in triplicate. Measurements were accomplished by direct calibration using aqueous standards (0-10 μg/L) made up each day by dilution from stock standard solution with enough sub-boiling nitric acid to a final acid concentration similar to digested samples.

RESULTS AND DISCUSSION

Range of concentration of chromium in vegetables (irrigated with tube well water) in five districts of Punjab, Pakistan: Table-1 shows the range of concentration of chromium in seven vegetables, *i.e*., spinach (*Spinacia oleracea*), lettuce (*Lactuca sativa*), carrot (*Daucus cariota*), capsicum (*Capsicum fistulosus*), sweet pea (*Lathyrus odoratus*), potato (*Solanum tuberosum*) and cabbage (*Brassica oleracea*), irrigated with tube well water in the five districts of Punjab, during the year 2006-2008. Range of concentration of chromium was found to be in spinach (0.6-3.5 ppm), lettuce (0.7-4.4 ppm), carrot (0.4-3.0 ppm), capsicum (0.5-3.1 ppm), sweet pea (0.3-2.5 ppm), potato (0.6-4.0 ppm), cabbage (0.7-5.3 ppm), in all the five districts of Punjab. The results are in agreement with previous workers[15,17] who reported chromium levels ranging from 0.01-0.13 μg/g with a mean of 0.030 μg/g, while[17,18] detected chromium levels ranging from 0.04-0.27 μg/g with a mean of 0.14 μg/g. Furthermore, it has been well reported that chromium levels in fresh vegetables range from 0.01-0.83 μg/g, average 0.15 μg/g[19].

Range of concentration of chromium in vegetables (irrigated with canal water) in five districts of Punjab, Pakistan: Table-2 shows the range of concentration of chromium in experimental vegetables, irrigated with canal water in the five districts of Punjab, during the year 2006-2008. Range of concentration of chromium in various vegetables was found to be 1.83-9.02 ppm for spinach and 2.48-13.09, 1.19-6.64, 1.59-6.91, 1.01-6.01, 1.83-9.32 and 2.43-13.06 ppm for lettuce, carrot, capsicum, sweet pea, potato and cabbage, respectively among all the five districts of Punjab.

Range of concentration of chromium in vegetables (irrigated with sewage water) in five districts of Punjab, Pakistan:: Table-3 shows the range of concentration of chromium in seven vegetables, irrigated with sewage water in the five districts of Punjab, during the year 2006-2008. Range of concentration of chromium in spinach is 4.26-29.86 ppm in all the five districts, in lettuce it is 3.18-22.8 ppm, in carrot it is 2.53-17.63 ppm, in capsicum it is 1.97-13.63 ppm, in sweet

TABLE-1
RANGE OF CONCENTRATION OF CHROMIUM (ppm) IN VEGETABLES IRRIGATED WITH TUBE WELL WATER IN FIVE DISTRICTS OF PUNJAB, PAKISTAN-2006-2008

Vegetables	Lahore			Kasur			Multan			Bahawalpur			R.Y. Khan		
	06	07	08	06	07	08	06	07	08	06	07	08	06	07	08
Spinach (*Spinacia oleracea*)	0.9-1.9	0.6-2.1	0.6-1.9	0.8-2.4	0.9-3	1.2-3.5	0.7-1.8	0.7-1.9	0.8-1.8	0.8-1.9	0.7-1.9	0.6-1.7	0.8-2	0.9-2.1	0.6-1.9
Lettuce (*Lactuca sativa*)	1.0-2.1	0.9-1.9	0.9-2.1	1.2-2.8	1.1-3.8	1.6-4.4	0.7-2.1	0.7-1.9	0.7-1.9	1.1-2.1	1.0-2.1	0.9-2.1	1.1-2.2	1.2-2.3	0.8-2.2
Carrot (*Daucus cariota*)	0.7-1.3	0.5-1.4	0.5-1.3	0.9-2	0.7-2.3	1.1-3	0.6-1.1	0.5-1.2	0.5-1.2	0.7-1.3	0.6-1.2	0.4-1.1	0.6-1.3	0.6-1.4	0.5-1.4
Capsicum (*Capsicum fistulosus*)	0.8-1.4	0.6-1.5	0.6-1.4	0.9-2.1	0.8-2.4	1.1-3.1	0.7-1.2	0.6-1.2	0.6-1.3	0.8-1.3	0.6-1.2	0.5-1.2	0.6-1.3	0.6-1.4	0.5-1.3
Sweet pea (*Lathyrus odoratus*)	0.5-0.9	0.4-1.0	0.3-1.0	0.6-1.6	0.5-1.9	0.8-2.5	0.5-1.0	0.3-0.9	0.3-1.0	0.4-1.0	0.3-0.9	0.5-1.1	0.4-1.1	0.4-1.2	0.3-1.0
Potato (*Solanum tuberosum*)	0.9-1.6	0.6-1.8	0.6-1.8	1.1-2.6	0.9-3	1.2-4	0.8-1.5	0.6-1.4	0.6-1.7	0.9-1.8	0.7-1.7	0.6-1.6	0.8-1.8	0.7-1.7	0.6-1.9
Cabbage (*Brassica oleracea*)	1.3-2.3	0.9-2.5	0.7-2.1	1.5-3.7	1.3-4	1.9-5.3	1.0-2.1	0.8-2.1	0.9-2.1	1.2-2.4	1-2.1	0.9-2.1	1.1-2.2	1-2.2	0.8-2.2

TABLE-2
RANGE OF CONCENTRATION OF CHROMIUM (ppm) IN VEGETABLES IRRIGATED WITH CANAL WATER IN FIVE DISTRICTS OF PUNJAB, PAKISTAN-2006-2008

Vegetable	Lahore			Kasur			Multan			Bahawalpur			R.Y. Khan		
	06	07	08	06	07	08	06	07	08	06	07	08	06	07	08
Spinach (*Spinacia oleracea*)	3.01-6.11	3.08-8.11	4.51-8.51	5.81-7.24	5.71-9.02	4.6-9.15	2.81-5.61	2.78-6.19	3.36-7.83	2.73-4.84	1.83-6.01	3.1-7.60	3.11-5.88	3.91-7.76	4.26-7.83
Lettuce (*Lactuca sativa*)	4.04-9.06	4.01-10.9	6.02-10.95	7.86-9.99	7.63-12.14	6.02-13.09	3.86-7.66	3.78-8.62	4.19-10.01	3.79-6.74	2.48-8.13	4.13-10.12	4.19-7.86	5.22-10.64	5.38-11.01
Carrot (*Daucus cariota*)	2.15-4.92	2.24-5.61	3.11-5.39	4.01-5.11	3.96-6.59	3.11-6.64	2.09-3.98	2.23-4.43	2.50-4.61	2.01-3.53	1.19-4.0	2.12-5.19	2.2-3.99	2.76-5.44	2.98-5.71
Capsicum (*Capsicum fistulosus*)	2.61-4.93	2.44-5.71	3.32-5.89	4.42-5.56	4.12-6.88	3.42-6.91	2.36-4.51	3.28-4.99	2.78-5.94	2.22-3.96	1.59-4.6	2.42-5.58	2.46-4.39	3.02-5.81	3.11-5.98
Sweet pea (*Lathyrus odoratus*)	1.98-4.16	1.91-5.01	2.93-5.03	3.44-4.6	3.5-6.01	2.8-6.01	1.72-3.6	1.80-4.13	2.19-5.19	1.57-3.09	1.01-3.86	1.98-4.96	2.0-3.76	2.41-5.01	2.59-5.18
Potato (*Solanum tuberosum*)	3.02-6.11	3.19-7.82	4.61-7.56	6.01-7.44	6.02-8.98	4.6-9.32	2.87-5.62	2.78-6.49	2.63-7.92	2.77-4.94	1.83-6.33	3.11-7.61	3.13-4.69	3.92-7.82	4.16-8.01
Cabbage (*Brassica oleracea*)	4.02-9.16	4.23-10.61	6.02-11.31	7.88-9.99	7.63-12.51	6.01-13.06	3.91-7.82	3.78-8.72	4.61-10.58	3.82-6.84	2.43-8.11	4.26-10.1	4.31-7.92	5.11-10.78	5.73-11.01

TABLE-3
RANGE OF CONCENTRATION OF CHROMIUM (ppm) IN VEGETABLES IRRIGATED WITH MUNICIPAL SEWAGE IN FIVE DISTRICTS OF PUNJAB, PAKISTAN-2006-2008

Vegetables	Lahore			Kasur			Multan			Bahawalpur			R.Y. Khan		
	06	07	08	06	07	08	06	07	08	06	07	08	06	07	08
Spinach (*Spinacia oleracea*)	4.26-14.43	4.29-14.53	9.86-29.63	9.83-18.96	8.25-10.56	14.03-29.86	4.53-14.8	5.89-17.12	9.85-27.36	5.69-14.52	6.32-16.4	9.86-29.43	5.52-15.36	4.83-14.46	7.99-27.01
Lettuce (*Lactuca sativa*)	3.18-10.02	3.92-10.69	7.13-20.16	7.45-13.59	6.0-15.41	10.3-22.8	3.32-10.86	4.45-12.32	7.16-20.0	4.23-11.92	4.65-12.34	7.1-21.19	4.02-10.69	4.11-14.56	5.89-18.83
Carrot (*Daucus cariota*)	2.53-8.51	2.67-8.39	5.92-17.63	5.63-10.98	4.95-12.83	8.11-16.46	2.7-8.98	3.34-9.61	5.34-15.98	3.42-8.16	3.72-9.6	5.46-16.96	3.12-8.91	2.53-8.34	4.5-15.8
Capsicum (*Capsicum fistulosus*)	1.97-6.92	4.73-13.63	4.2-8.98	3.93-9.22	6.19-12.02	2.01-6.83	2.51-7.82	4.15-11.12	2.16-7.19	2.92-7.14	3.16-9.19	4.82-12.0	2.41-6.72	2.11-6.89	3.14-11.98
Sweet pea (*Lathyrus odoratus*)	1.28-3.56	1.19-3.52	2.51-7.82	2.53-4.62	2.15-5.19	3.48-7.56	1.19-3.65	1.42-4.23	2.81-6.73	1.42-3.96	1.56-4.18	2.43-7.51	1.36-3.56	1.11-3.54	2.09-6.36
Potato (*Solanum tuberosum*)	2.28-7.36	2.29-7.61	4.86-14.03	4.74-9.41	3.92-10.1	6.66-13.89	2.2-7.14	2.99-8.41	4.96-12.83	2.67-7.79	3.23-8.16	4.86-13.84	2.55-6.89	2.2-7.15	4.0-12.89
Cabbage (*Brassica oleracea*)	4.26-15.11	4.29-14.43	9.86-29.41	9.63-19.02	8.92-20.36	13.98-29.89	4.53-15.02	5.86-16.23	9.84-27.23	5.78-15.81	6.23-16.0	9.89-29.36	5.46-14.83	4.49-14.51	7.9-27.33

pea it is 1.11-7.82 ppm, in potato it is 2.2-14.03 ppm, in cabbage it is in between 4.26-29.89 ppm, in all the five districts of Punjab.

Statistical evaluation of chromium concentration in spinach with respect to water of irrigation: Table-4 shows the mean ± SE of chromium in spinach with respect to Tube well water, canal water and sewage water, *i.e*., 1.213 ± 0.029, 5.321 ± 0.091 and 13.871 ± 0.380, respectively. The highest concentration level of chromium in spinach was observed with respect to sewage water *i.e*., 29.86 ppm. The total number of samples above the permissible ambient levels, *i.e*., 3-12 mg/day for a body weighing 60 Kg (50-200 ppb/day recommended by NRC in 1989 were 163 (0 from Tube Well, 0 from Canal water and 163 from Sewage Water). Similarly the highest concentration level of chromium in lettuce (22.8 ppm) was seen with respect to Sewage water (Table-4). The total number of samples above the permissible ambient levels, *i.e*., 3-12 mg/day for a body weighing 60 Kg (50-200 ppb/day recommended by NRC in 1989) were 109 (0 from Tube Well, 3 from canal water and 106 from sewage water). The average concentration level of chromium in Spinach was statistically significant with respect to all irrigation systems (p-value = 0.000).

Table-5 shows the mean ± SE of chromium in carrot with respect to tube well water, canal water and sewage water, *i.e.*, 1.041 ± 0.024, 3.673 ± 0.057 and 8.695 ± 0.2301, respectively. The highest concentration level of chromium in carrot *i.e.*, 17.63 ppm was observed where carrots were irrigated by Sewage water. The total number of samples above the permissible ambient levels were 64 (0 from tube well, 0 from canal water and 64 from Sewage water). Table-5 further indicates the highest concentration level of chromium in potato *i.e.*, 14.03 ppm is also due to sewage water.

Table-6 also shows the highest concentration level of chromium in capsicum and sweet pea (*i.e.*, 13.63 and 7.82 ppm) when these were irrigated by sewage water. The mean ± SE of chromium in cabbage was found to be 1.791 ± 0.039, 7.040 ± 0.107 and 14.480 ± 0.372 for tube well water, canal water and sewage water. The highest concentration level of chromium in cabbage was seen with respect to sewage water *i.e.*, 29.89 ppm (Table-7). The total number of samples above the permissible ambient levels, *i.e.*, 3-12 mg/day for a body weighing 60 kg (50-200 ppb/day recommended by NRC in 1989) were 189 (0 from tube well, 3 from canal water and 186 from sewage water).

TABLE-4
STATISTICAL EVALUATION OF CHROMIUM CONCENTRATION IN SPINACH AND LETTUCE WITH RESPECT TO WATER OF IRRIGATION

	Spinach				Lettuce			
Source	TW*	CW**	SW***	Total	TW	CW	SW	Total
Mean	1.213	5.320	13.871	6.793	1.634	6.858	10.903	6.465
Std. Dev	± 0.513	± 1.571	± 6.578	± 6.563	± 0.659	± 1.962	± 4.632	± 4.793
Std. Error	± 0.029	± 0.091	± 0.380	± 0.219	± 0.038	± 0.113	± 0.267	± 0.159
>PAL[1]	0	0	163	163	0	3	106	109
N[2]	300	300	300	900	300	300	300	900
F = 815.536, *p*-value = 0.000					F = 755.017, *p*-value = 0.000			
Multiple comparison test					Multiple comparison test			
Source				*p*-Value	Source		*p*-Value	
TW		CW		0.000	TW	CW	0.000	
SW		CW		0.000	SW	CW	0.000	
TW		SW		0.000	TW	SW	0.000	

*TW = Tube well water, **CW = Canal water, ***SW = Sewage water. 1" > PAL. Greater then permissible Ambient Level. 2. N. Total no of samples.

TABLE-5
STATISTICAL EVALUATION OF CHROMIUM CONCENTRATION IN CARROT AND POTATO WITH RESPECT TO WATER OF IRRIGATION

	Carrot				Potato			
Source	TW*	CW**	SW***	Total	TW	CW	SW	Total
Mean	1.041	3.673	8.695	4.469	1.288	5.286	7.037	4.537
Std. Dev	± 0.414	± 0.987	± 3.986	± 3.969	± 0.497	± 1.522	± 3.063	± 3.125
Std. Error	± 0.024	± 0.057	± 0.230	± 0.132	± 0.029	± 0.088	± 0.177	± 0.104
>PAL[1]	0	0	64	64	0	0	30	30
N[2]	300	300	300	900	300	300	300	900
F = 799.221, *p*-value = 0.000					F = 654.426, *p*-value = 0.000			
Multiple comparison test					Multiple comparison test			
Source				*p*-Value	Source		*p*-Value	
TW		CW		0.000	TW	CW	0.000	
SW		CW		0.000	SW	CW	0.000	
TW		SW		0.000	TW	SW	0.000	

*TW = Tube well water, **CW = Canal water, ***SW = Sewage water. 1" > PAL. Greater then permissible Ambient Level. 2. N. Total no of samples.

TABLE-6
STATISTICAL EVALUATION OF CHROMIUM CONCENTRATION IN CAPSICUM AND SWEET PEA WITH RESPECT TO WATER OF IRRIGATION

	Capsicum				Sweet pea			
Mean	1.095	3.962	6.834	3.964	0.779	3.462	3.572	2.604
Std. Dev	± 0.353	± 0.972	± 2.881	± 2.935	± 0.312	± 2.332	± 1.653	± 2.102
Std. Error	± 0.020	± 0.056	± 0.166	± 0.098	± 0.018	± 0.135	± 0.095	± 0.070
>PAL[1]	0	0	12	12	0	0	0	0
N[2]	300	300	300	900	300	300	300	900
F = 791.139, *p*-value = 0.000					F = 272.489, *p*-value = 0.000			
Multiple comparison test					Multiple comparison test			
Source				*p*-Value	Source		*p*-Value	
TW		CW		0.000	TW	CW	0.000	
SW		CW		0.000	SW	CW	0.000	
TW		SW		0.000	TW	SW	0.000	

*TW = Tube well water, **CW = Canal water, ***SW = Sewage water. 1" > PAL. Greater then permissible Ambient Level. 2. N. Total no of samples.

The average concentration level of chromium in all the vegetables was statistically significant with respect to all irrigation systems (*p*-value = 0.000).

Environmental pollution is acting multi-dimensional in effecting the mankind living on this planet. It is directly affecting the health of people, vegetable world, the drinking water, the crops, the animals used as food of human beings and it is indirectly affecting our economy and social behaviours. Among all of these effects the health issues due to contaminated food is the problem discussed in present research work. Our food contains meat, milk, fish, vegetables, cereals and staple food which in most of the cases directly or indirectly effected by the quality of water used for the purpose of irrigation for vegetables, forage and other crops as it exists in Pakistan country, there are three types of water used for irrigation, namely tubewell, canal and waste water/sewage water/grey water. Among

TABLE-7
STATISTICAL EVALUATION OF CHROMIUM CONCENTRATION IN CABBAGE WITH RESPECT TO WATER OF IRRIGATION

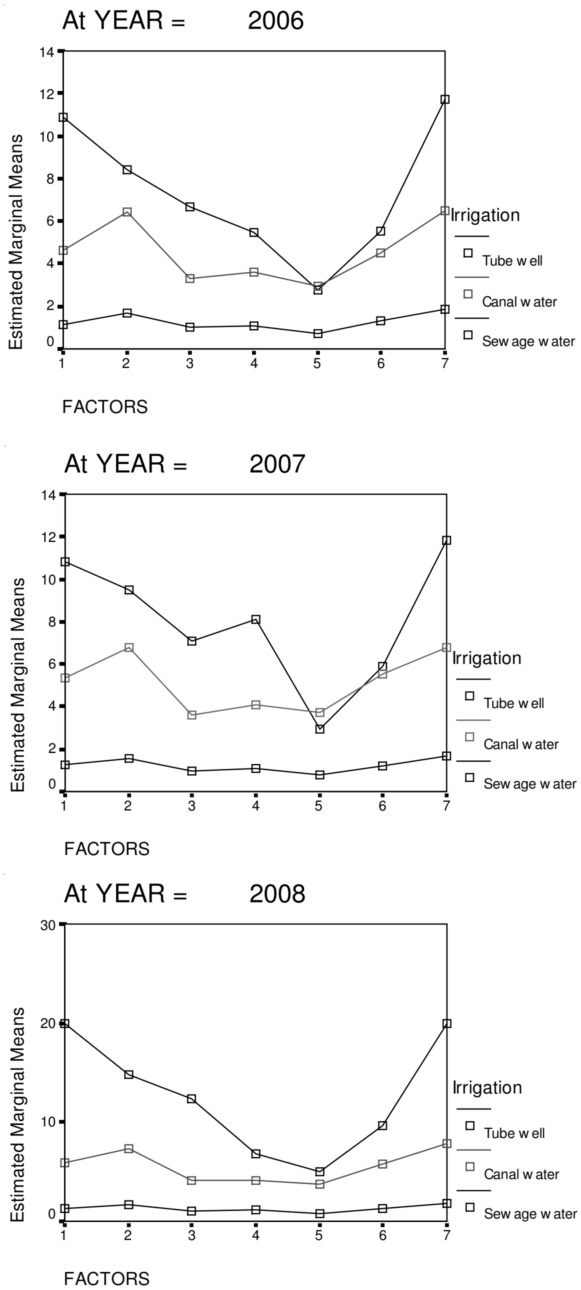
Cabbage				
Source	Tube well	Canal water	Sewage water	Total
Mean	1.791	7.040	14.480	7.771
Std. Dev	± 0.689	± 1.857	± 6.443	± 6.499
Std. Error	± 0.039	± 0.107	± 0.372	± 0.217
>PAL[1]	0	3	186	189
N[2]	300	300	300	900
F = 805.145, p-value = 0.000				
Multiple comparison test				
	Source	p-Value		
Tube well	Canal water	0.000		
Sewage water	Canal water	0.000		
Tube well	Sewage water	0.000		

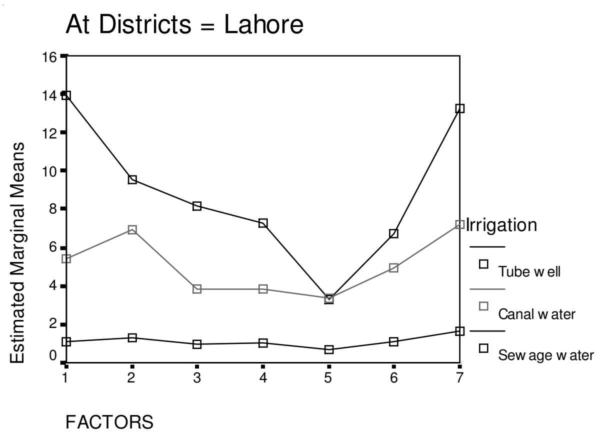
1: > PAL Greater than permissible ambient level. 2: N: Total no of samples.

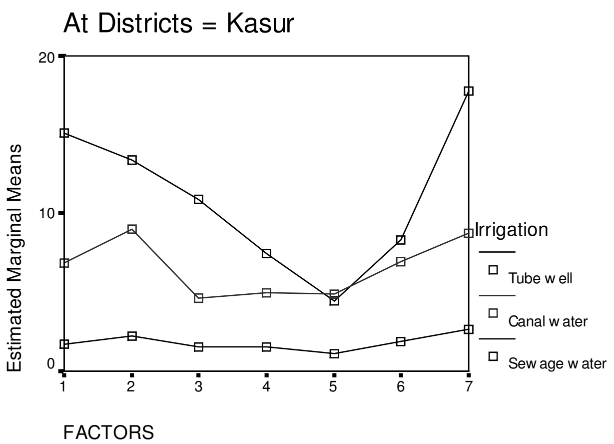
these types sewage water or waste water is considered fertilized water for the irrigation of the crops. In case, if the option is available sewage water is preferred even the farmer may pay more price for this water. The reason being that it contains nitrogenous material which is required by the plants and can substitute to a good extent, the use of fertilizers. In Lahore, Kasur and Multan most of the vegetable crops, if possible are irrigated by waste water or sewage water. In most of the cases it happens that the local administration, *i.e.*, tehsil municipal administration (TMA) collects the sewage water in a big dug plot of land and sells it to any contractor to generate the funds and the contractor sells it as a business to recover his amount paid to TMA. The water is never treated for any type of contamination but sieved for the removal of plastic bags and other floating materials by any means it is not a treatment according to the rules and does not change the harmful qualities of water.

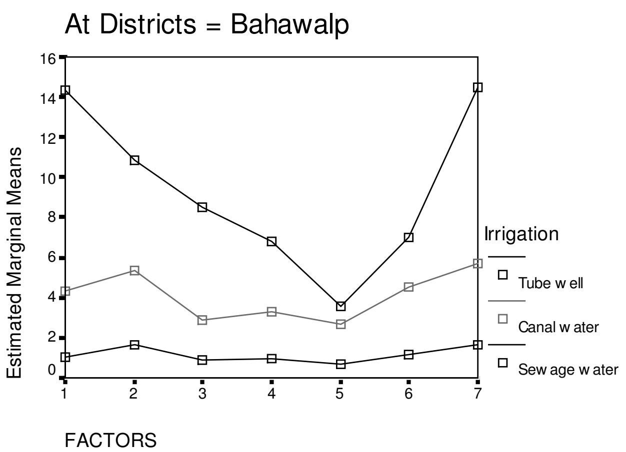
This research work evaluates the effects of water of irrigation in comparison with the source of water, *i.e.*, tube well, canal and municipal sewage water, with the special reference of chromium contents exhibited by the different vegetables grown in different areas, where single type of water is used for irrigation purposes. It is worth mentioning here that chromium is one of those elements, which are essentially required by our body or in other words it is categorized as indispensable elements for life. This requirement of chromium within our body gives a considerable arrear to chromium for its toxic effects or there is a considerable tolerance available in the human body regarding chromium contents in the food. This is the reason that the maximum permissible limit of chromium is comparatively high as compared to other elements in the environment. Chromium as well as other metals are easily absorbed by roots and leaves of plants and then transported via the vascular system. The high levels of chromium found in water and sediment samples are worrying because this metal is known to be toxic[20,21].

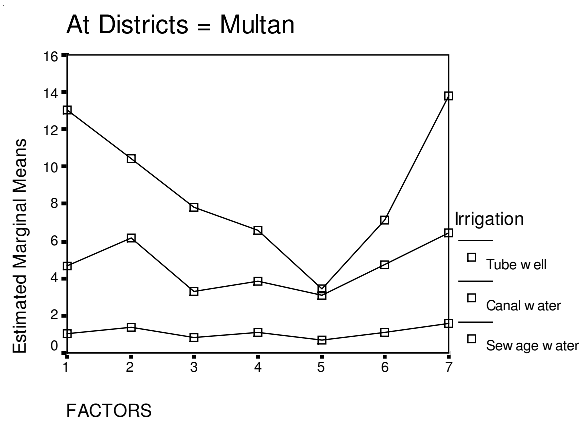
The results show that the chromium contents in the vegetables irrigated by tube well water is from 0.6-5.3 mg/Kg in different vegetables grown in five districts of Punjab, in vegetables irrigated by the canal water the chromium content ranges from 1.01-13.6 mg/Kg and in case of sewage water it ranges in between 1.11-29.86 mg/Kg of vegetables. The statistical evaluation of chromium concentration in vegetables infers that it is maximum in the leafy vegetables like spinach, lettuce and cabbage and minimum in case of seedy vegetables such as capsicum and sweet pea (Figs. 1 and 2). The root vegetables show a medium trend. In case of tube well water the chromium contents of all of the vegetables was within the permissible ambient levels and in case of canal water irrigated vegetables less than 1 % samples contained chromium more than that of permissible ambient levels, but in case of sewage water irrigated vegetables the leafy vegetables showed that in more than 50 % of the samples the chromium concentration is more than that of permissible ambient levels and in case of seedy vegetables nearly 4 % of the samples contained chromium more than that of permissible ambient levels. It reflects that the uptake of chromium in vegetables is facilitated under the conditions where the water of irrigation is sewage water.











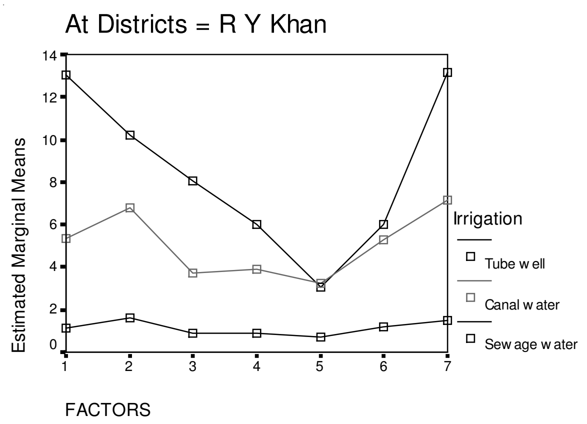
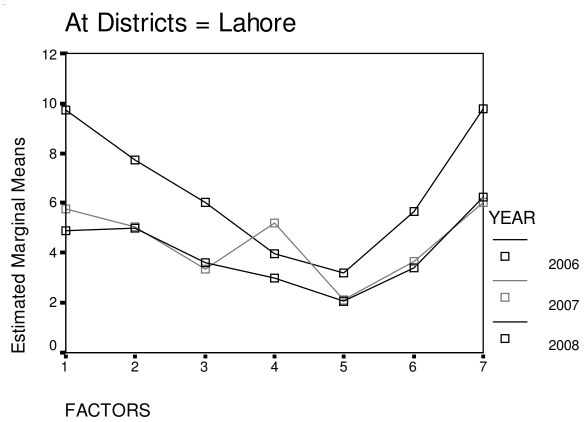
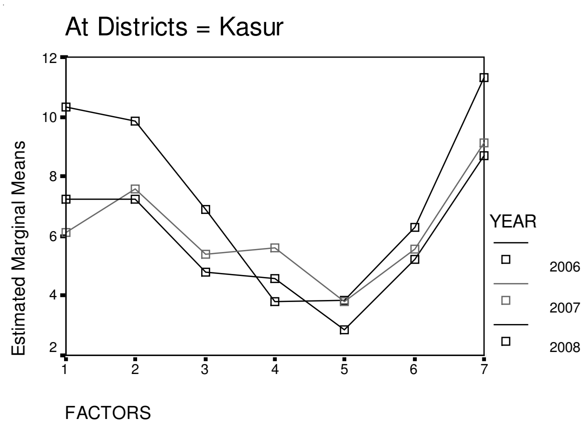
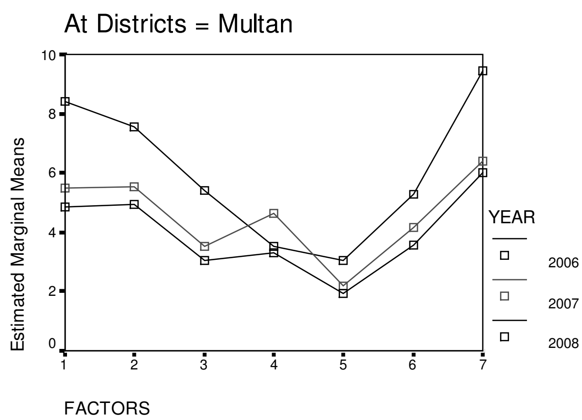


Fig. 1. Profile plots of chromium in vegetables with respect to source with years and districts. Factor 1-7 are cabbage, spinach, lettuce, carrot, capsicum, sweet pea and potato, respectively







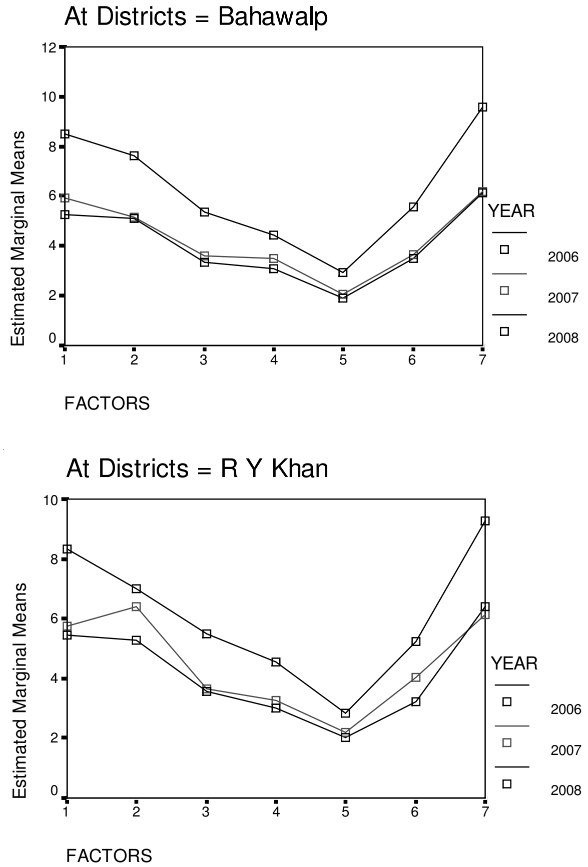


Fig. 2. Profile plots of chromium in vegetables with respect to district and years. Factor 1-7 are cabbage, spinach, lettuce, carrot, capsicum, sweet pea and potato, respectively

Conclusion

This work suggests that the effects of chromium contents in vegetables irrigated by sewage water may also be studied through biological tests of their users. A research should be conducted in this regard and a combined inference thus evolved should be used as evidence while making the policies for food safety. A regulation is required including such affairs for implementation and the sphere of food safety may also be enhanced to such natural food items for the contents of heavy metals in it.

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