TRACE AND HEAVY METALS COMPOSITION IN CROPS GROWN IN SEWAGE IRRIGATED *PERI* URBAN AREA OF VADODARA, INDIA

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SUMMARY

In a survey, plant samples of crops grown under sewage irrigated fields of *peri* urban area nearby Vadodara city were collected to know the composition of trace elements and also for assessment of the contamination of heavy metals in relation to tube well water irrigated fields of adjoining areas. The analytical results revealed that the total contents of trace elements (Fe, Mn, Zn, Cu) in leafy vegetables were higher than creeper and fruit vegetables in sewage irrigated soils. Among different crops, marigold showed higher accumulation of heavy metals (Pb, Ni and Co) followed by tobacco, drumstick, vegetables, weeds, pulse, cereals and fodder crops plants in sewage irrigated soil. The Pb was more accumulated in spinach and lucerne in sewage and tube well irrigated soils, respectively. The leafy vegetables grown on sewage irrigated soils also contained more Pb amongst different vegetables. The findings of the results emphasize the contamination of plant system in sewage irrigated *peri* urban areas, especially with heavy metals *viz.*, Pb, Ni and Co.

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In different parts of the country, the menace of a rapidly increasing population, the wanton growths of industries and increasing urbanization have created major problems with the disposal of sewage and industrial effluents. The disposal of wastes is a matter of serious concern because along with some essential plant nutrients, wastes also contain potentially toxic heavy metals such as Pb, Ni, Cd and Cr (Kausal *et al.*, 1993). A limiting factor in the long term application of sewage effluent to agricultural land is the accumulation heavy metals in the soil which may lead to increased in uptake of heavy metals by crops resulting into their entry in food chain (Anderson and Nilssion, 1972; Tadesse *et al.*, 1991). Therefore, the survey work carried out to assess the trace element content and contamination of heavy metals in crops grown in sewage irrigated Peri urban area of Vadodara city of middle Gujarat.

MATERIALS AND METHODS

In investigation, plant samples of edible and shoot part of crops were collected from sewage water (SW) irrigated fields, which received treated and untreated sewage since last three decades. At the same time, plant samples from tube well water (TW) irrigated fields of nearby area were also collected. The average trace and heavy metals content in SW soils were Fe- 11.3, Mn- 8.5, Zn- 3.7, Cu- 2.0, Cd- 0.033, Co- 0.323, Cr- 0.032, Ni- 0.537 and Pb- 0.978 mg kg^{-1} soil, while Fe- 6.10, Mn- 7.1, Zn- 1.4, Cu- 1.5, Cd - 0.029, Co- 0.193, Cr- 0.032, Ni- 0.276 and Pb- 0.695 mg kg^{-1} soil in case of TW soils. Altogether, 122 plant samples of which thirty eight (38) samples of edible part of vegetables and eighty four (84) samples of above ground part (leaf stem) of different groups of crops were collected from both the fields. The samples were washed with single and double distilled water in a sequence and air-dried and then oven dried at 70^0C temperature in a hot air oven and preserved for further analysis. Dried samples were ground in a stainless steel blade wiley mill and digested in diacid mixture (HNO_3: $HClO_4$ – 2:1). The acid extract was used for analysis of total trace and heavy metals using Atomic Absorption Spectrophotometer (PE 3110).

RESULTS AND DISCUSSION

The plant samples of the standing crops from sewage and tube well water irrigated fields were collected to know the effect of sewage irrigation practices on trace and heavy metal contents of different plants. The data on trace and heavy metal content of different plants are presented in Tables 1 to 4:

Trace elements :

The analytical results of plant samples were categorized under different groups of crop *viz.*, cereals, oilseeds, vegetables, fodder and others to know the accumulation of trace metals by crops. The data presented in Table 1 indicated that the total content of trace elements in edible part of different vegetables were higher in leafy vegetables than creeper and fruit vegetables. Among the leafy vegetables, the mean content of Fe, Mn, Zn and Cu in spinach leaf was 595.0, 9.8, 7.8 and 2.9 μg g^{-1} in the case of SW soil, while in case of TW soil, the content was 300, 5.5, 3.1 and 1.0 μg g^{-1}, respectively (Table 1). Among the different groups of

Table 1 : Trace and heavy metals content in edible part of vegetables grown on SW and TW soils

Crop/s	Soils	Content (μg g^{-1}) Fe	Mn	Zn	Cu	Cd	Co	Cr	Ni	Pb
Leafy vegetables										
Cabbage (2)*	SW	6.7-10.6 (8.7)**	1.7-1.9 (1.8)	1.7-3.0 (2.4)	0.25-0.25 (0.25)	0.05-0.05 (0.05)	0.30-0.42 (0.36)	0.35-0.51 (0.43)	0.80-0.93 (0.87)	1.26-1.76 (1.51)
	TW	3.7-4.5 (4.1)	1.9-2.2 (2.1)	1.6-1.9 (1.8)	0.26-0.30 (0.28)	0.05-0.06 (0.06)	0.15-0.17 (0.16)	0.19-0.22 (0.21)	0.34-0.45 (0.40)	0.26-0.32 (0.29)
Spinach (2)	SW	578.5-611.5 (595.0)	9.2-10.3 (9.8)	7.6-8.1 (7.8)	2.55-3.15 (2.85)	0.22-0.24 (0.23)	1.9-2.7 (2.3)	0.96-1.0 (0.98)	3.0-4.1 (3.5)	3.3-5.9 (4.6)
	TW	280.0-320.0 (300.0)	4.8-6.2 (5.5)	2.9-3.2 (3.1)	0.90-1.10 (1.00)	0.10-0.50 (0.28)	1.9-2.5 (2.2)	0.9-1.1 (1.0)	0.89-1.2 (1.1)	1.9-2.4 (2.1)
Cauli-Flower (2)	SW	9.1-10.0 (9.5)	2.1-2.5 (2.3)	4.1-6.6 (5.3)	0.53-0.70 (0.62)	0.06-0.07 (0.06)	0.39-0.69 (0.44)	0.22-0.48 (0.35)	0.35-0.42 (0.38)	1.25-1.29 (1.27)
	TW	10.5-16.2 (13.3)	2.0-2.2 (2.1)	1.5-1.7 (1.6)	0.35-0.50 (0.43)	0.07-0.09 (0.08)	0.37-0.50 (0.44)	0.09-0.11 (0.10)	0.10-0.12 (0.11)	0.81-0.90 (0.86)
Overall (6)	SW	4.6-611.5 (203.1)	2.1-10.3 (4.8)	1.6-8.1 (5.0)	0.22-3.15 (1.24)	0.05-0.24 (0.11)**	0.30-2.70 (1.03)	0.22-1.02 (0.59)	0.35-4.10 (1.59)	1.25-5.90 (2.45)
	TW	3.7-320.0 (105.8)	1.9-6.2 (3.2)	1.5-3.2 (2.1)	0.26-1.10 (0.57)	0.05-0.50 (0.14)	0.15-2.50 (0.93)	0.09-1.10 (0.44)	0.10-1.20 (0.52)	0.26-2.35 (1.08)
Fruit Vegetables										
Okra (2)	SW	14.3-16.8 (15.5)	5.7-8.0 (6.8)	3.8-4.2 (4.0)	1.99-2.08 (2.04)	0.19-0.20 (0.20)	0.38-0.45 (0.42)	0.15-0.21 (0.18)	0.49-0.55 (0.52)	1.05-1.55 (1.30)
	TW	10.2-13.6 (11.9)	4.3-5.1 (4.7)	2.6-3.7 (3.1)	1.56-1.94 (1.75)	0.16-0.20 (0.18)	0.25-0.28 (0.27)	0.20-0.30 (0.25)	0.29-0.31 (0.30)	0.70-0.95 (0.83)
Brinjal (2)	SW	19.6-32.5 (26.0)	1.9-2.1 (2.0)	2.1-3.3 (2.7)	1.10-1.20 (1.15)	0.05-0.06 (0.06)	0.34-0.43 (0.39)	0.19-0.21 (0.20)	0.25-0.30 (0.28)	1.15-1.23 (1.19)
	TW	29.0-45.2 (37.1)	2.4-3.1 (2.8)	2.6-3.2 (2.9)	1.50-2.10 (1.80)	0.03-0.06 (0.04)	0.24-0.38 (0.31)	0.09-0.10 (0.10)	0.07-0.09 (0.08)	0.52-0.68 (0.60)
Bean (*Papadi*) (2)	SW	26.3-33.0 (29.7)	6.8-7.1 (7.0)	8.0-9.7 (8.8)	1.89-2.40 (2.15)	0.05-0.07 (0.06)	0.36-0.60 (0.48)	0.25-0.32 (0.29)	1.1-1.4 (1.2)	1.4-1.9 (1.6)
	TW	19.4-21.5 (20.5)	5.6-7.4 (6.5)	6.9-8.6 (7.8)	1.85-2.05 (1.95)	0.10-1.16 (0.13)	0.65-0.87 (0.76)	0.12-0.22 (0.17)	0.79-1.0 (0.90)	0.16-0.34 (0.25)
Pigeon Pea (2)	SW	35.7-42.3 (39.0)	5.1-7.2 (6.2)	8.9-10.3 (9.6)	1.56-2.85 (2.21)	0.04-0.07 (0.06)	0.60-0.72 (0.66)	0.16-0.20 (0.18)	0.89-1.15 (1.02)	0.76-1.21 (0.98)
	TW	24.2-30.1 (27.2)	3.0-4.2 (3.6)	7.6-9.5 (8.6)	2.00-2.10 (2.05)	0.03-0.06 (0.05)	0.50-0.62 (0.56)	0.15-0.19 (0.17)	0.72-0.90 (0.81)	0.43-0.55 (0.49)
Drumstick (2)	SW	27.5-36.1 (31.8)	3.3-5.1 (4.2)	3.9-5.0 (4.4)	1.55-2.10 (1.83)	0.03-0.04 (0.04)	0.46-0.57 (0.49)	0.51-0.68 (0.59)	0.53-0.86 (0.70)	1.6-1.9 (1.7)
	TW	16.4-27.9 (22.2)	3.8-4.1 (3.9)	3.8-4.6 (4.2)	0.90-1.02 (0.96)	0.06-0.08 (0.07)	0.32-0.45 (0.39)	0.22-0.29 (0.26)	0.34-0.42 (0.40)	0.9-1.2 (1.1)
Overall (10)	SW	14.3-42.3 (28.4)	1.9-8.0 (5.2)	2.1-10.3 (5.9)	1.10-2.85 (1.87)	0.03-0.20 (0.08)	0.34-0.72 (0.48)	0.15-0.68 (0.29)	0.25-1.35 (0.75)	0.76-1.92 (1.37)
	TW	10.2-45.2 (23.7)	2.4-7.4 (4.3)	2.6-9.5 (5.3)	0.90-2.10 (1.70)	0.03-0.20 (0.09)	0.24-0.87 (0.46)	0.09-0.30 (0.19)	0.07-1.00 (0.50)	0.16-1.20 (0.65)
Creeper vegetables										
Bottle gourd (2)	SW	8.8-10.2 (9.5)	1.4-2.9 (2.1)	2.1-3.3 (2.7)	0.78-1.01 (0.90)	0.05-0.06 (0.06)	0.36-0.51 (0.44)	0.21-0.26 (0.24)	0.43-0.61 (0.52)	0.83-0.91 (0.87)
	TW	6.9-7.5 (7.2)	1.2-2.1 (1.7)	1.5-2.5 (2.0)	0.65-0.80 (0.73)	0.03-0.05 (0.04)	0.20-0.30 (0.25)	0.10-0.19 (0.15)	0.25-0.36 (0.31)	0.35-0.41 (0.38)
Bitter Gourd (1)	SW	9.6	2.0	4.4	1.15	0.05	0.43	0.18	0.58	1.57
	TW	8.5	2.1	3.1	1.05	0.03	0.24	0.11	0.32	0.72
Overall (3)	SW	8.8-10.2 (9.5)	1.4-2.9 (2.1)	2.1-4.4 (3.3)	0.78-1.15 (0.98)	0.05-0.06 (0.05)	0.36-0.51 (0.43)	0.18-0.26 (0.22)	0.43-0.61 (0.54)	0.83-1.57 (1.10)
	TW	6.9-8.5 (7.6)	1.2-2.1 (1.8)	1.5-3.1 (2.3)	0.65-1.05 (0.83)	0.03-0.05 (0.04)	0.20-0.30 (0.25)	0.10-0.19 (0.13)	0.25-0.36 (0.31)	0.35-0.72 (0.49)

Figure in bracket indicate * number of samples and ** mean value

Table 2 : Trace and heavy metals content in shoot of crops grown on SW and TW soils

Crop/s	Soils	Content (µg g^{-1}) Fe	Mn	Zn	Cu	Cd	Co	Cr	Ni	Pb
Cereals										
Wheat (11)*	SW	174 – 665 (299)**	72 – 220 (145)	23.3 – 64.5 (39.7)	6.3 – 13.5 (8.7)	0.1-1.5 (0.7)	4.0-9.5 (5.5)	0.12-0.51 (0.33)	1.1-2.8 (1.9)	0.9-5.9 (2.1)
Wheat (4)	TW	154 – 371 (227)	75 – 125 (103)	9.3 – 22.3 (17.4)	3.5 – 8.9 (6.5)	0.7-1.1 (0.9)	5.0-10.5 (7.5)	0.10-0.30 (0.22)	1.3-2.0 (1.6)	1.1-1.8 (1.5)
Pulse										
Pigeon Pea (5)	SW	164 – 433 (280)	58 – 267 (176)	16.8 – 63.0 (32.3)	7.8 – 23.0 (14.3)	0.1-1.6 (0.9)	4.0-18.5 (8.0)	0.13-0.60 (0.32)	0.9-2.3 (1.8)	1.2-4.1 (2.5)
Pigeon Pea (1)	TW	621	415	29.5	18.0	1.9	11.0	0.52	5.6	1.0
Oilseeds										
Castor (3)	SW	188 – 884 (463)	136 – 267 (210)	50.8 – 72.0 (64.1)	7.3 – 11.0 (8.9)	0.5-4.0 (2.2)	5.0-16.5 (10.5)	0.18-0.73 (0.40)	1.1-4.6 (2.6)	1.2-2.5 (1.9)
Castor (1)	TW	197	78	15.5	14.8	2.2	4.0	0.48	2.2	2.4
Cotton (4)	SW	150 – 593 (296)	88 – 329 (170)	20.3 – 84.3 (50.2)	3.3 – 6.8 (5.3)	1.2-2.6 (1.7)	5.0-12.0 (7.8)	0.10-0.16 (0.12)	1.1-1.8 (1.5)	1.7-3.4 (2.2)
Cotton (2)	TW	134 – 207 (171)	106 – 120 (113)	21.8 – 38.3 (30.0)	6.0 – 7.5 (6.8)	1.5-1.9 (1.7)	2.5-3.5 (3.0)	0.10-0.20 (0.15)	0.9-1.4 (1.1)	1.0-1.2 (1.1)
Overall (7)	SW	150 – 884 (368)	88 – 329 (187)	20.3 – 84.3 (50.2)	3.3 – 11.0 (6.9)	0.5-4.0 (1.9)	5.0-16.5 (8.9)	0.10-0.73 (0.24)	1.1-4.6 (2.0)	1.2-3.4 (2.1)
Overall (3)	TW	134 – 207 (179)	78 – 120 (101)	15.5 – 38.3 (25.2)	6.0 – 14.8 (9.4)	1.5-2.2 (1.8)	2.5-4.0 (3.3)	0.10-0.48 (0.26)	0.9-2.2 (1.5)	1.0-2.4 (1.5)
Vegetables										
Cabbage (2)	SW	272 – 737 (505)	71 – 206 (138)	23.3 – 31.8 (27.5)	6.0 – 12.0 (9.0)	0.1-0.8 (0.4)	2.5-16.0 (9.3)	0.13-0.75 (0.44)	1.1-3.3 (2.2)	2.0-7.1 (4.5)
Spinach (1)	TW	862	269	32.8	13.8	1.8	8.0	0.41	2.3	1.6
Cauliflower (2)	SW	707 – 927 (817)	206 – 307 (256)	44.5 – 52.3 (48.4)	14.3 – 18.8 (16.5)	0.6-1.1 (0.8)	8.0-14.0 (11.0)	0.50-0.70 (0.60)	4.0-4.1 (4.1)	5.6-6.2 (5.9)
Cauliflower (1)	TW	154	95	9.3	3.5	0.7	10.5	0.21	2.0	1.8
Bottle guard (3)	SW	251 – 752 (506)	68 – 203 (154)	42.8 – 62.0 (53.8)	7.3 – 19.8 (14.8)	0.5-2.2 (1.5)	3.5-13.5 (9.0)	0.12-0.78 (0.37)	1.7-3.6 (2.6)	3.0-4.3 (3.5)
	TW	--	--	--	--	--	--	--	--	--
Brinjal (2)	SW	520 – 530 (525)	93 – 135 (114)	48.8 – 53.3 (51.0)	12.0 – 22.0 (17.0)	1.1-1.9 (1.5)	7.5-10.0 (8.8)	0.25-0.31 (0.28)	2.0-2.3 (2.2)	3.1-5.3 (4.2)
	TW	202 – 862 (516)	103 – 269 (219)	26.5 – 38.0 (32.6)	12.8 – 19.5 (15.7)	1.8-2.3 (2.0)	3.5-16.5 (9.0)	0.12-0.47 (0.29)	1.4-3.4 (2.2)	1.6-3.1 (2.4)
Bean (*Papdi*) (2)	SW	242 – 304 (273)	110 – 160 (135)	34.3 – 58.0 (46.1)	6.5 – 25.8 (16.1)	0.5-1.3 (0.9)	6.0-6.0 (6.0)	0.19-0.65 (0.42)	1.9-3.4 (2.6)	3.4-6.0 (4.7)
(1)	TW	202	254	33.0	12.8	2.3	3.5	0.18	1.6	2.5
Drum stick	SW	385	206	45.0	18.0	1.5	10.0	0.34	1.7	3.0
(1)	TW	862	269	32.8	13.8	1.8	8.0	0.41	2.3	1.6
Overall (12)	SW	242 – 927 (512)	68 – 307 (163)	23.3 –62.0 (46.0)	6.0 – 25.8 (15.0)	0.1-2.2 (1.1)	2.5-16.0 (8.9)	0.12-0.78 (0.41)	1.1-4.1 (2.6)	2.0-7.1 (4.3)
Overall (06)	TW	154 – 862 (513)	95 – 269 (206)	9.3 – 38.0 (28.7)	3.5 – 19.5 (13.3)	0.7-2.3 (1.7)	3.5-16.5 (9.1)	0.12-0.47 (0.30)	1.4-3.4 (2.2)	1.6-3.1 (2.1)
Bottle guard (3)	SW	251 – 752 (506)	68 – 203 (154)	42.8 – 62.0 (53.8)	7.3 – 19.8 (14.8)	0.5-2.2 (1.5)	3.5-13.5 (9.0)	0.12-0.78 (0.37)	1.7-3.6 (2.6)	3.0-4.3 (3.5)
	TW	--	--	--	--	--	--	--	--	--
Brinjal (2)	SW	520 – 530 (525)	93 – 135 (114)	48.8 – 53.3 (51.0)	12.0 – 22.0 (17.0)	1.1-1.9 (1.5)	7.5-10.0 (8.8)	0.25-0.31 (0.28)	2.0-2.3 (2.2)	3.1-5.3 (4.2)
	TW	202 – 862 (516)	103 – 269 (219)	26.5 – 38.0 (32.6)	12.8 – 19.5 (15.7)	1.8-2.3 (2.0)	3.5-16.5 (9.0)	0.12-0.47 (0.29)	1.4-3.4 (2.2)	1.6-3.1 (2.4)

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Bean (*Papdi*) (2)	SW	242 – 304	110 – 160	34.3 – 58.0	6.5 – 25.8	0.5-1.3	6.0-6.0	0.19-0.65	1.9-3.4	3.4-6.0
		(273)	(135)	(46.1)	(16.1)	(0.9)	(6.0)	(0.42)	(2.6)	(4.7)
(1)	TW	202	254	33.0	12.8	2.3	3.5	0.18	1.6	2.5
Drum stick (1)	SW	385	206	45.0	18.0	1.5	10.0	0.34	1.7	3.0
	TW	862	269	32.8	13.8	1.8	8.0	0.41	2.3	1.6
Overall (12)	SW	242 – 927	68 – 307	23.3 –62.0	6.0 – 25.8	0.1-2.2	2.5-16.0	0.12-0.78	1.1-4.1	2.0-7.1
		(512)	(163)	(46.0)	(15.0)	(1.1)	(8.9)	(0.41)	(2.6)	(4.3)
Overall (06)	TW	154 – 862	95 – 269	9.3 – 38.0	3.5 – 19.5	0.7-2.3	3.5-16.5	0.12-0.47	1.4-3.4	1.6-3.1
		(513)	(206)	(28.7)	(13.3)	(1.7)	(9.1)	(0.30)	(2.2)	(2.1)
Fodder crops										
Maize(F) (6)	SW	136 – 825	90 – 136	25.5 – 68.0	4.5 – 9.3	0.1-2.2	2.5-9.0	0.13-0.73	1.0-3.2	1.0-2.7
		(365)	(116)	(47.2)	(6.9)	(0.9)**	(5.3)	(0.42)	(2.0)	(1.8)
(4)	TW	189 – 706	99 – 238	25.8 – 39.3	7.8 – 21.0	1.4-2.2	4.0-12.0	0.19-1.29	1.0-3.0	1.2-3.1
		(362)	(176)	(31.0)	(11.7)	(1.9)	(7.0)	(0.65)	(1.7)	(1.8)
S. Jowar (2)	SW	206 – 317	103 – 111	30.3 – 46.5	6.5 – 7.0	0.2-0.4	3.0-4.0	0.27-0.28	1.4-1.6	0.8-0.8
		(262)	(107)	(38.4)	(6.8)	(0.3)	(3.5)	(0.28)	(1.5)	(0.8)
(1)	TW	169	169	37.3	7.5	1.5	4.5	0.23	1.4	0.8
Gajraj grass(1)	SW	280	123	42.0	30.8	0.6	5.0	0.17	1.1	1.9
Lucerne(1)	TW	420	147	38.8	13.0	1.9	8.0	0.45	3.0	3.4
Overall (9)	SW	136 – 825	90- 136	25.5 – 68.0	4.5 – 30.8	0.1-2.2	2.5-9.0	0.13-0.73	1.0-3.2	0.8-2.7
		(333)	(115)	(44.6)	(9.5)	(0.7)	(4.9)	(0.36)	(1.8)	(1.6)
Overall (6)	TW	169 – 706	99 – 238	25.8 – 39.3	7.5 – 21.0	1.4-2.2	4.0-12.0	0.19-1.29	1.0-3.0	1.2-3.4
		(340)	(170)	(33.3)	(11.2)	(1.8)	(6.8)	(0.55)	(1.9)	(1.9)
Weeds										
Dharo weed (1)	SW	181	196	87.8	14.3	1.4	9.5	0.63	3.3	3.9
(2)	TW	497-625	148-160	15.3-41.8	7.8-17.0	1.6-1.7	6.0-9.0	0.06-0.90	2.3-3.6	1.4-1.4
		(561)	(154)	(12.4)	(12.4)	(1.6)	(7.5)	(0.48)	(2.9)	(1.4)
Chill weed (1)	SW	593	341	72.8	30.5	1.6	15.0	0.73	3.4	3.6
(2)	TW	105-136	86-116	24.8-29.3	6.0-12.3	1.5-1.8	4.0-5.5	0.29-0.29	1.1-1.5	0.6-1.1
		(121)	(101)	(27.0)	(9.1)	(1.6)	(4.8)	(0.29)	(1.3)	(0.8)
*Bavch*i weed	SW	391	126	79.3	15.0	2.1	9.5	0.27	2.2	3.2
	TW	651	247	63.3	17.3	1.3	14.0	0.33	2.7	2.6
Overall (3)	SW	181 –651	126 – 341	63.3 – 87.8	14.3 – 30.5	1.3-2.1	9.5-15.0	0.27-0.73	2.2-3.4	2.6-3.9
		(454)	(227)	(75.8)	(19.3)	(1.6)	(12.0)	(0.49)	(2.9)	(3.3)
(5)	TW	105 –625	86 – 160	15.3 – 41.8	6.0 – 17.0	1.5-1.8	4.0-9.0	0.06-0.90	1.1-3.6	0.6-1.4
		(341)	(127)	(27.8)	(10.8)	(1.6)	(6.1)	(0.38)	(2.1)	(1.1)
Other crops										
Tobacco	SW	702	230	66.5	20.3	1.7	17.5	0.49	3.5	3.7
Marigold	SW	811	244	29.3	17.0	1.5	8.0	0.52	2.4	9.5

Figure in bracket indicate * number of samples and ** mean value, F = Fodd

crops, shoot of vegetables accumulated maximum Fe, while Mn, Zn and Cu concentrations were found higher in weeds in SW and TW soils. The marigold flower plant also extracted higher trace elements from SW soil (Table 2 and 4).

The vegetables are known for their capacity to have higher uptake of the nutrients including associated elements like heavy metals. The production of higher biomass results in to higher uptake of the nutrients as well as heavy metals, which might be due to the genetic make up of different crops. Saraswat *et al.* (2005) also observed that treated sewage irrigated vegetables contained relatively higher amount of the micronutrients than the tube well water irrigated vegetables. Among different crops the edible parts of okra, cauliflower, radish and broad bean had higher amount of Zn, Fe, Cu and Mn than non-edible ones. Similar observation was also recorded by Paul *et al.* (2006).

Heavy metals :

The data on heavy metals *viz.*, Cd, Co, Cr, Ni, Pb contents in plant samples revealed that in SW soil, the Ni content in leafy, fruit and creeper vegetables ranged from 0.35 to 4.10, 0.25 to 1.35 and 0.43 to 0.61 with a mean of 1.59, 0.75 and 0.54 $\mu g\ g^{-1}$, respectively. Among the different vegetables, the highest Ni content was observed in spinach leaf in SW (3.5 μg Ni g^{-1}) and TW (1.1 μg Ni g^{-1}) soils, respectively (Table 1 and 3). In most of the cases, Cd, Co and Cr contents were lower in vegetables grown on TW soils than SW soils. The results are in conformity with the results of Mitra and Gupta (1999) and Som *et al*. (1994).

Table 3: Trace elements contents in edible parts of vegetables grown on SW and TW soils

Crop Group	Soil	Content (μg g^{-1})			
		Fe	Mn	Zn	Cu
Leafy vegetables (6)*	SW	4.6-611.5 (203.1)**	2.1-10.3 (4.8)	1.6-8.1 (5.0)	0.22-3.15 (1.24)
	TW	3.7-320.0 (105.8)	1.9-6.2 (3.2)	1.5-3.2 (2.1)	0.26-1.10 (0.57)
Fruit vegetables (10)	SW	14.3-42.3 (28.4)	1.9-8.0 (5.2)	2.1-10.3 (5.9)	1.10-2.85 (1.87)
	TW	10.2-45.2 (23.7)	2.4-7.4 (4.3)	2.6-9.5 (5.3)	0.90-2.10 (1.70)
Creeper vegetables (3)	SW	8.8-10.2 (9.5)	1.4-2.9 (2.1)	2.1-4.4 (3.3)	0.78-1.15 (0.98)
	TW	6.9-8.5 (7.6)	1.2-2.1 (1.8)	1.5-3.1 (2.3)	0.65-1.05 (0.83)

Figure in bracket indicates * number of samples and ** mean value

Among the different heavy metals *viz.* Cd, Co, Cr, Ni, Pb, the concentration of Pb in edible part of leafy vegetables was higher as compared to other vegetables grown in SW soil (Table 1 and 3). The concentration of Pb in cabbage, spinach and cauliflower grown in SW soil was 1.51, 4.6 and 1.27 μg g^{-1}, respectively while in case of TW soil, the corresponding values were 0.29, 2.1 and 0.86 μg g^{-1} (Table 1). The content of Pb in leaf of spinach was above the safe limit (2.0 μg g^{-1}) as suggested by WHO (1996). Further, Pb content of leafy vegetables and marigold flower plant grown under sewage irrigated soil had crossed the permissible level of Pb (5 mg kg^{-1}) as prescribed by Chapman (1975) and none of the samples fall under the toxicity category of Pb as suggested by Roviro (1996). However, the contents of trace elements and other heavy metals were below the tolerance limits prescribed above by Kabata and Pendis (1992).

Table 4 : Heavy metals contents in edible parts of vegetables grown on SW and TW soils

Crop Group	Soil	Content (μg g^{-1})				
		Cd	Co	Cr	Ni	Pb
Leafy vegetables (6)*	SW	0.05-0.24 (0.11)**	0.30-2.70 (1.03)	0.22-1.02 (0.59)	0.35-4.10 (1.59)	1.25-5.90 (2.45)
	TW	0.05-0.50 (0.14)	0.15-2.50 (0.93)	0.09-1.10 (0.44)	0.10-1.20 (0.52)	0.26-2.35 (1.08)
Fruit vegetables (10)	SW	0.03-0.20 (0.08)	0.34-0.72 (0.48)	0.15-0.68 (0.29)	0.25-1.35 (0.75)	0.76-1.92 (1.37)
	TW	0.03-0.20 (0.09)	0.24-0.87 (0.46)	0.09-0.30 (0.19)	0.07-1.00 (0.50)	0.16-1.20 (0.65)
Creeper vegetables (3)	SW	0.05-0.06 (0.05)	0.36-0.51 (0.43)	0.18-0.26 (0.22)	0.43-0.61 (0.54)	0.83-1.57 (1.10)
	TW	0.03-0.05 (0.04)	0.20-0.30 (0.25)	0.10-0.19 (0.13)	0.25-0.36 (0.31)	0.35-0.72 (0.49)

Figure in bracket indicates * number of samples and ** mean value

In general, the total content of trace and pollutant elements were higher in crops grown on SW than TW soils. The researchers revealed that accumulation of metals in leaves and tubers of potato grown on sewage-irrigated soils was higher than ground water-irrigated soils (Brar *et al*., 2000). Brar and Arora (1997) reported that Ni and Pb were accumulated in the soils irrigated with sewage effluent, but plants did not absorb these elements in proportion to their concentrations in the soils. Thus, plants themselves act as filters to check the translocation of heavy metals from soils to the edible plant parts *i.e.* seeds/ fruits. This is especially true for Ni, Cu and Pb (Sidle *et al*., 1976). Datta *et al*. (2000) reported that by and large, the concentrations of metals in different species grown on sewage-irrigated soils were generally below the accepted critical levels of phytotoxicity.

Thus, the overall results indicated that the use of sewage water in agriculture over the years recycle the nutrients and thereby nourished the crops, but the health risks associated through heavy metals contamination may restrict their reuse, requiring management aspects for decontamination of heavy metals in soils.

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