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Health Hazard from Dry River Bed Agriculture

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A field survey was conducted for heavy metal contamination in the vegetable and soil samples collected from dry river bed of the river Ganga flowing through the heart of Kanpur city located 12.6 m above the sea level at 88°22'E longitude and 26°26'N latitude. Kanpur is an industralized and densly populated city of northern India. River Ganga carries considerable amount of city sewere and industrial effluent from tanneries, textile mills, steel plants, chemical plants and thermal power plants situated on the bank of the river. When the water level in river retrieves in summer months, farmers use the dry land for cultivation of summer vegetable and fruits. No base line data are available so far on the level of heavy metal pollution in the soil and fruits/vegetable grown alongside dry river bed. In the present study, we describe the results of the analysis of heavy metal accumulation on a variety of fruit and vegetable samples grown on the dry river bed.

MATERIALS AND METHODS

Samples of soil and vegetable cultivated in the fields of dry river bed were collected during the summer months from the entry point **(A),** middle point **(B)** and the exit point **(C)** of the river in the city of Kanpur. The entry point was Bethore which is a historical and pilgrimage place located at about 50 Km from the city. The middle point was Ganga Ganj, an area in the middle of the city. Jajmau was the exit point located immediately after an Industrial area. Plant samples were collected from different species of vegetables and fruit crop available in the fields of dry river bed. Samples were air dried, grounded and seived before analysis. Most of the vegetables/fruit crops selected for the study have widespread distribution in the country and are popular summer delicacies (Table-1). Soil samples were collected from the same site chosen for vegetable sampling. The samples were collected from the subsurface horizon (2-15 cm) at three different positions and were mixed thoroughly. The composed samples (1000 gm) were brought to the laboratory in polythene bags, air dried and seived before analysis (Scott et al. 1971). Soil of dry bed of river Ganga was sandy in nature. For metal analysis, 1 gm dried plant material was digested with a mixture of nitric acid and perchloric acid (2:5, v/v) until a clear solution was obtained. The resulting mixture was filtered, reconstituted to the desired volume and analyzed on a Atomic Absorption Spectrophotometer (Perkin

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Table 1. List of vegetable/fruit crops with their botanical, common and local names (in paranthesis) and number of samples collected from different sites

Vegetable	Uses as vegetable	Number of samples collected			
		A	B	C	Total
Lagenaria siceraria (Bottle Gourd, Louki)	Fruits	6	6	12	24
Momordica charantia (Bitter Gourd, Karela)	Fruits	3	3	11	17
Randia sativus (Radish, Muli)	Roots and leaves	5	2	8	15
Luffa cylindrica (Sponge GourdTori)	Fruits	5	7	8	20
Citrullus varifistulosus (Tinda Punjab, Tinda)	Fruits	6	NA	10	16
Spinacia Oleracea (Garden Spinach, Palak)	Leaves	NA	5	9	14
Cucumus melo (Snake Cucumber, Kakri)	Fruits	5	NA	5	10
Soil	-	7	6	7	20

NA = not available

Elmer model 5000). The metal content of soil samples was determined by following similar procedure as was used for plant material (Anonymous, 1976). Standard solutions were diluted to same acid matrix as for extraction. Efficiency of the analytical procedure ranged between 92±4% in recovery experiments. Soil organic matter was estimated by heating the samples at 450°C (8 hr) in a muffle furnace. The reduction in soil weight was taken as soil organic matter. The pH of soil was measured in the supernatent of dry soil (10 gm) shaken with deionised water (100 ml, 30 min). The leachable metal content of the soil was measured by extraction with HCI (.01 N) followed by filtration and analysis on an Atomic Absorption Spectrophotometer (Scott et al., 1971). The data of city site **"B"** and industrial site **"C"** were compared with the data of village site **"A"** which was used as a control. All the numerical data collected were analyzed statistically. Average values, standard deviation and significance were determined by Student "t" test (Baily, 1959).

RESULTS AND DISCUSSION

In Table-2 we show the concentration of total as well as leachable level of heavy metals (in mean ± SD range), leachable metal as percent of total

Table 2. Total and leachable metal content (mg/kg) organic matter and pH of the soil samples at various sites

Metal	Total Metal			Leachable Metal		
	A	B	C	A	B	C
Cd	0.41	0.46	0.50	0.04	0.04	0.057
	±0.11	±0.09	±0.13a	±0.01	±0.00	±0.03d
		(12.2)	(22)		(0.0)	(42.5)
				9.75+	8.7+	11.4+
Co	5.46	6.16	6.68	1.88	2.00	2.09
	±1.23	±1.81	±1.08b	±0.46	±0.16	±0.71
		(12.8)	(22.3)		(6.4)	(11.2)
				34.43	32.46	31.28
Cr	3.83	3.87	5.13	0.58	0.71	0.80
	±0.62	±0.77	±0.92c	±0.07	±0.1c	±0.17d
		(1.04)	(33.6)		(22.4)	(37.9)
				15.14	18.39	15.59
Cu	2.29	2.46	3.75	0.75	0.95	1.14
	±0.51	±0.46	±1.29c	±0.1	±.13c	±0.48b
		(7.4)	(65)		(26.6)	(52)
				32.75	38.67	30.40
Mn	87.85	107.7	95.7	41.2	63.20	38.44
	±10.35	±11d	±19.2	±0.84	±3.7d	±8.5
		(22.7)	(8.9)		(58.4)	(6.7)
				46.89	58.64	40.17
Ni	6.95	7.5	7.6	1.16	1.41	1.12
	±0.63	±0.7a	±1.58	±0.11	±.28b	±0.60
		(7.9)	(9.3)		(21.5)	(3.4)
				16.69	18.80	14.73
Pb	2.25	3.25	6.96	2.15	2.10	2.50
	±0.75	±1.64	±4.56b	±0.20	±0.28	±0.91
		(44)	(209)		(-2.3)	(16.3)
				95.55	64.61	35.91
Zn	5.33	6.5	9.4	2.55	3.11	3.13
	±1.79	±0.86b	±2.72d	±0.21	±0.3d	±0.99a
		(14.9)	(76.4)		(22)	(22.7)
				47.84	47.84	33.29
Total organic content (g/kg)	6.76±3.37	6.80±0.62 (0.6)	8.11±2.14 (20)			
pH	6.95±0.92	8.46±0.51	8.36±0.54			

The values are the mean ± SD with the percent increase over entry point **A** in paranthesis
Significance: a = p<0.1, b= p<0.05, c = p-<0.01, d = p<0.001

metal content and the percent increase over reference point A. The table also provides data on the total organic content and pH of the soil at reference points **A, B** and **C** of the dry river bed. The concentration of total trace metal and leachable metal content in soil was found to be higher at the exit point **(C)** than **A** and **B.** Significant increase were found in the content of Pb (209%) followed by Zn (76%), Cu (65%), Cr (34%), Co (22%), Cd (22%) and marginal increase in Mn (9%) at **C** in comparison to **A.** At the reference point **B,** the increase in the concentration of Pb was maximum (44%) followed by Mn (23%), Zn (15%), Co (13%), Cd (12%) and Ni (8%). The concentration of leachable elements was higher at **B** than at **A** except for Pb. Maximum increase was found in Mn (58%) followed by Cu (27%), Cr (22%), Zn (22%), Ni (22%) and Co (6%). The concentration of leachable metals further increased at C except for Mn and Ni. At site **C,** significant increase was found in the content of Cu (52%) followed by Cd (42.5%), Cr (38%), Zn (23%) and also an insignificant increase was observed in Pb (16%) and Co (11%) content. The leachable metal content (as percent of total metal content) was minimum with Cd and only about 10% was found in the soluble form whereas rest was bound to the soil matrics. The leachable content of Cr & Ni was in the range of 15-19%, Co & Cu 30-38% and Mn & Zn were in the 33-58% range. Pb was the only metal present largely in soluble form (95.5%) at **A.** At the reference point **B** and **C,** however, comparatively lower quantities of Pb were found in soluble form (65% and 36%, respectively). The soil organic content at **A** and **B** was more or less the same but at **C** the level were found to have insignificantly increased (20%). The pH of soil at **A** was near neutral (6.95±.9) while it was alkaline both at **B** (8.46±.5) and **C** (8.36±.5) reference points.

The metal content of vegetable/fruit crop samples are reported in Table 3. In general, the concentration of metal was higher at **B** in comparison to **A** with the following exception: Co and Cr in bitter gourd, Cr in snake cucumber, Cu in radish, Mn in bottle gourd, Ni in bitter gourd and Zn in radish. The concentration of metal at **C** was much higher then at **A.** The Cd content in vegetable was in the range of 1-14 mg/kg. The percent increase in Cd content at C was highest in spinach (316%) followed by tinda punjab (75%) bottle gourd (38%) and radish (25%). The Co content of vegetable was in the range of 1.5-42 mg/ kg with highest content in bottle gourd (15-42 mg/kg). Significant increase in Co content were found at **C** in all vegetable except tinda punjab. The Cr content in vegetable ranged between 0.5-51 mg/kg. Bitter gourd and spinach had more Cr accumulation than other vegetable at the reference point **A.** Significant increase in the level of Cr were found in sponge guard (112%) at **B.** At the reference point **C,** highly significant increase in Cr content was found in every vegetable except snake cucumber. The increase in Cr content was found in every vegetable except snake cucumber. The increase in Cr content at **C** over **A** was of the following order: Sponge gourd> radish> bottle gourd>tinda punjab>bitter gourd. The Cu content was found to increase significantly at **B** and at **C** in all the vegetable samples except bottle gourd. Maximum accumulation of Cu was found in radish (962%) followed by spinach (610%), snake cucumber (342%), bitter gourd (237%), tinda punjab (188%) and sponge gourd (102%). The Mn content of vegetable at various sites ranged between 8-167 mg/kg. At **A,** Mn content of garden spinich, bottle gourd and bitter gourd were much higher than other vegetable. At **B,** significant increase in Mn content was found in radish (49%) followed by bitter gourd (39%) and sponge gourd (13%). At **C,** Mn content increased significantly in all the vegetable except bottle gourd and garden spinach. The Ni content in vegetable were in the range

Table 3. Metal content (mg/kg dry wt) in vegetables at different sites

Vegetables/Sites	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
Bottle Gourd								
A	6.8 ±1.9	21.8 ±6.7	1.8 ±0.8	35.2 ±4.2	57.8 ±19.1	2.8 ±1.1	90.0 ±44.0	10.7 ±2.1
B	8.5 ±2.7	25.7 ±3.6	2.0 ±1.2	47.8 ±4.5d	21.2 ±4.1d	12.7 ±3.9d	101.5 ±75.5	10.3 ±2.9
C	9.3 ±3.8b	36.1 ±5.5d	5.1 ±2.1d	41.8 ±21.3	18.0 ±3.2d	17.8 ±2.8d	131.8 ±26.7b	15.8 ±3.6d
Bitter Gourd								
A	5.6 ±0.5	5.7 ±1.3	6.3 ±0.6	10.0 ±1.6	29.7 ±2.9	14.0 ±3.6	7.5 ±2.1	7.3 ±1.2
B	5.7 ±0.5	3.7 ±2.1a	4.7 ±1.5	20.7 ±1.7d	41.3 ±5.2c	12.0 ±7.0	8.3 ±7.7	7.7 ±0.5
C	5.8 ±0.4	10.3 ±2.1d	9.8 ±2.1d	38.7 ±17.6d	48.0 ±16.7d	20.6 ±6.2d	12.5 ±3.3d	7.5 ±1.1
Garden Spinach								
B	2.0 ±0.0	9.2 ±5.4	6.0 ±2.5	34.2 ±8.7	50.0 ±17.3	6.0 ±1.7	16.3 ±17.1	3.4 ±1.6
C	8.3 ±5.0d	11.3 ±4.3	20.0 ±11.3d	208.7 ±95.6d	102.3 ±12.8d	20.4 ±8.1d	52.6 ±43.6b	4.4 ±2.4
Radish								
A	1.6 ±0.5	5.8 ±3.7	2.6 ±2.5	126.6 ±88.5	10.4 ±2.6	3.3 ±2.5	1.6 ±0.5	5.0 ±1.4
B	1.5 ±0.8	16.0 ±0.0d	2.5 ±0.7	66.5 ±0.5a	15.5 ±2.1b	3.5 ±2.1	1.5 ±2.1	4.5 ±0.5
C	2.0 ±0.0b	20.5 ±5.6d	30.1 ±21.3c	1344.5 ±429d	16.5 ±3.3d	23.5 ±14.4d	8.0 ±7.2d	11.0 ±4.2c
Snake Cucumber								
A	7.2 ±4.3	7.0 ±2.5	3.3 ±2.2	98.0 ±43.7	13.8 ±0.7	3.5 ±0.7	146.2 ±36.3	3.0 ±1.6
C	12.0 ±2.1b	19.4 ±2.1d	0.6 ±0.1b	483.2 ±265.6c	20.3 ±7.1b	4.8 ±3.8	183.5 ±33.5a	7.5 ±2.3d
Sponge Gourd								
A	2.2 ±1.0	6.4 ±5.7	0.4 ±0.9	21.6 ±7.8	14.2 ±1.2	6.0 ±2.8	5.5 ±5.6	5.3 ±0.4
B	2.9 ±1.8	13.9 ±4.2b	4.9 ±2.3d	29.4 ±3.7b	16.0 ±2.8a	8.0 ±2.6	12.7 ±10.3d	11.2 ±3.5d
C	2.5 ±1.6	16.9 ±7.6c	6.1 ±2.3d	43.7 ±20.0d	19.3 ±5.5b	8.4 ±5.0	14.2 ±13.0a	8.4 ±3.1d
Tinda Punjab								
A	2.0 ±0.8	12.0 ±3.0	4.4 ±2.1	64.0 ±17.9	13.8 ±5.3	5.0 ±4.1	12.5 ±7.6	2.5 ±0.5
C	3.5 ±0.9d	6.6 ±3.8c	11.1 ±3.4d	184.5 ±98.6d	27.2 ±4.4d	11.4 ±7.9b	23.6 ±19.7a	5.8 ±1.7d

Values are expressed as mean ± SD; significance a = p<0.1, b = p<0.05, c = p<0.01, d = p<0.001

of 1-38 mg/kg with comparatively higher level in bitter gourd than other vegetable at **A.** At **B,** significant increase in Ni content was found in bottle gourd (347%) and sponge gourd (33%). At **C,** Ni level increased in all the vegetable e.g. radish (623%), bottle gourd (529%), garden spinach (240%), tinda punjab (129%), bitter gourd (46%), sponge gourd (40%) and snake cucumber (36%). The Pb content in vegetable ranged from 0-240 mg/kg with higher degree of accumulation at **B** in comparison to **A** in all the vegetable samples. Although, bottle gourd and snake cucumber were high accumulators of Pb, significant increase in its level at **B** was found only in sponge gourd (75.6%, $p<0.1$). At **C,** significant increase in Pb content were found in radish (394%) followed by garden spinach (224%), spongue gourd (157%), tinda punjab (89%), bitter gourd (67%) and bottle gourd (46%). Snake cucumber (which already contained high Pb level) accumulated only 25% more Pb at **C.** The Zn content in various vegetable ranged between 1-21 mg/kg. At **A,** bottle gourd and bitter gourd contained substantial amount of Zn (10.66±2.1 mg/kg and 7.33±1.2 mg/kg, respectively). At **B,** significant increase were observed in spongue gourd (113%). At **C,** significant increase in Zn content was observed in snake cucumber (150%), tinda punjab (132%), radish (120%), sponge gourd (59%), bottle gourd (48%), garden spinach (30%) and the level of bitter gourd remained more or less the same as were present at the reference point **A.**

Human activities have greatly increased the concentration of toxic substances in the aquatic environment (Culbard et al., 1988; Kabata & Pendia, 1992). The effluent of sugar, brewery, paper, textile and city sewer water are mainly organic pollutants which are oxidized in water utilizing dissolved oxygen. The effluent of electroplating, tanneries, chemicals, steel, chlor-alkali, thermal power stations and drainage of mine works cause largely metal pollution. Metal containing industrial effluent may accumulate in the sediments and contaminate the soil in adjoining low lying area where flooding occurs.

The soil chemical processes affecting the metal uptake by plants are important in consideration of the impact of soil contamination on human health due to the risk of increased dietary exposure to consumers. Food is the principle route by which general population can be exposed to toxic metals. Therefore, the information on bioavailability of metals which accumulate in food crops (and hence in human diet) is urgently needed. Plants take up metals from soil via roots corresponding to the nutrient uptake. The uptake depends upon individual soil and plant parameters such as concentration, specialties, solubility of the element, soil moisture content, pH, organic content, redox condition, sorptive capacity of soil, microbial activity, plant species and cultivar age and organ of the plant.

Metal levels in Indian leafy vegetables, roots and tubers grown in normal soil was reported by NIN (Amonymous, 1982). Metal content (··µg/g) in green leafy vegetables ranged from 16 to 95 for Zn, 8 to 96 for Mn, 1.9 to 18 for Cu and 0.52 to 4.37 for Cr. In case of other vegetables (bringals, cucumber, beans, pumpkin, bitter gourd) the values were Zn (5-46), Mn (5-29), Cu (0.87-11) and Cr (0.28-4.8). Metal content in roots and tubers (e.g. sweet potato, colocasia, radish) were Zn (15-58), Mn (7-14) Cu (0.8-9) and Cr (0.2-0.4).

A comparison of our data clearly shows that the minimum value is much higher in many cases. Extra ordinarily high values of Cu was found in radish (0.1%) and snake cucumber (0.05%). Crops grown in contaminated soil may accumulate excessive quantities of metal by complexing with intracellular phytochalatin or formation of metalothionins. A number of terrestarial plant accumulate large quantities of metals such as Zn, Mn Ni, Co and Cu. The largest group of these so called metal hyperaccumulator is found in genus alyssum in which nickle concentration can reach 3% of dry biomass. Free histidine was found as a metal chelator in plants that accumulate nickle (Kramer et al., 1996).

The soil of dry river bed in urban area of India has enormous agricultural significance as the vegetables grown in dry river bed make a finite contribution to domestic consumption. Some of the vegetable are eaten as cooked food (e.g. bottle gourd, spongue gourd, tinda punjab, spinach, radish and bitter gourd), some are used in salad (e.g. radish) and the rest (e.g. snake cucumber) are used as a thrust quencher during scorching heat of summer months in tropical countries. The results of present survey reveal the use of dry river bed for growing summer vegetable fruit crops by the farmers constitute a high risk area due to large quantity of metal accumulation specially near industrial areas. We recommend that vegetable grown in such areas should be under constant watch and be monitored periodically for toxic contamination.

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