



## Heavy Metals in Soils of Aligarh District: Depth wise Distribution and Accumulation of Cd, Cr, Ni and Pb in Vegetable Crops.

### KEYWORDS

Cadmium, nickel, chromium, lead, organic carbon, soils, sewage effluent, crops, DTPA-extractable.

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**ABSTRACT** In India, there is a gradual decline in availability of fresh water for irrigation. The sewage and other industrial effluents are being used to irrigate of agricultural fields. This study was undertaken to investigate the effect of continuous application of sewage-effluent irrigation on the DTPA-extractable Cd, Ni, Cr and Pb in soils and crops. For this purpose, periurban agricultural lands irrigated by different sewage effluent, from a point of entering the effluents to a distance of nearly 1.5 km and one irrigated by ground water from different parts of Aligarh district were selected where vegetable crops have successfully been grown. The data indicated that the concentration of these metals in sewage effluent irrigated soils became four to six folds in comparison to ground water irrigated soil. The data also denote that with increasing soil depth and distance from sewage entry point the concentration of these metals decreased indicating a low mobility of these metals in soils. Soil properties viz organic carbon, pH, EC and CEC exhibited positive relationship with DTPA-extractable metal content, while clay content showed a negative relationship. The concentrations of Cd, Ni, Cr and Pb in different vegetable crops grown on sewage effluent irrigated soils were higher (beyond permissible limit) as compared to those grown on ground water irrigated soils. The maximum accumulation of these metals were in potato followed by maize except for Pb. Based on these results, it can be concluded that proper management of water irrigation and periodic monitoring of soil and plant quality parameters are required to ensure successful, safe and long term sewage effluent irrigation.

### Introduction

Maintenance of good soil quality is of prime importance for sustainable agriculture. Heavy metals constantly interplay with human life environmentally, industrially and biologically<sup>1</sup>. Accumulation of toxic metals in human beings as a result of excessive exposure of heavy metals causes toxic effects like inhibition of haemoglobin formation, sterility, hypertension, kidney damage and mental retardation<sup>2</sup>. In India, there is a gradual decline in freshwater availability for agricultural fields so sewage and other industrial effluents are being used for irrigation of agricultural fields particularly in periurban areas. The indiscriminate disposal of industrial and sewage effluents on agricultural land is becoming a major source of heavy metal contamination in irrigated soils and ground water<sup>3,4</sup>. The uptake of heavy metals from contaminated soils by plants comprises a major path for such elements to enter the human and animal food chain<sup>5</sup>. Plant uptake of metals from sewage treated soils is related to the soil exchange capacity, pH of soil as well as the sewage contamination<sup>6</sup>.

The objectives of this study was to know the depth wise distribution of Cd, Cr, Ni and Pb in sewage irrigated soils and their uptake by vegetable crops grown therein.

### Materials and Methods

Ten agricultural fields ( $S_1$ - $S_{10}$ ) receiving sewage effluents for more than thirty years from different parts of Aligarh district, located in the sewage water disposal area starting from a point of entering the effluents to a distance of nearly 1.5 km were selected for this study. Soil samples at the depths 0-15, 15-30, 30-45 and 45-60 cm were collected bimonthly for two years (March 2009- Feb.2011) from these sites. The details of the selected sites are given in Table 1. The soil samples were air dried, crushed and grounded to pass through <70 mesh sieve before use. The physio-chemical properties were determined by usual laboratory methodology. The values are given in Table 2. The soil samples collected from different sites and depths were analyzed for pH, EC, organic carbon, DTPA-TEA-CaCl<sub>2</sub> extractable Cd, Ni, Cr and Pb. From these fields during the study five plant species including the root with 4 replications namely cauliflower, radish, egg plant, potato and maize, common at all the selected sites were sampled. Crop

samples were thoroughly washed successively with tap water, distilled water and 0.01 N HCl solutions for removing the impurities. The samples were dried with air circulation at 65°C and pulverized in a warming blender to make them homogeneous to be used for chemical analysis. The samples were digested in diacid mixture containing HNO<sub>3</sub>: HClO<sub>4</sub> (3:1). The digested mixture was heated over a hot plate till brown fumes ceased. It was then dissolved in 5 mL of 2M HCl and the supernatant was analysed for Cd, Ni, Cr and Pb by atomic absorption spectrophotometer (Model Varian AA 975).

### Results and Discussion

#### Soil pH, EC and organic matter

The average values of soil pH, EC and organic carbon at various depths are given in Table 3. The data of Table 3 denoted that pH decreases with increasing depth which may be due to downward movement of organic acid, humic and fulvic acid (present in sewage effluent). Electrical conductivity (EC) of soils increased with sewage effluent irrigation, while EC decreased with depth suggesting a slow downward movement of ions. An examination of Table 3 also denote that soils treated with sewage effluent have a higher concentration of organic carbon as compared to ground water irrigated soils and the organic carbon content in soils varied significantly from one site to the other depending on the distance from the point of discharge of effluent. The organic carbon content at all the sites decreased with increasing depth. The higher concentration of organic carbon content in sewage effluent irrigated soils may be due to accumulation of sewage effluent organic carbon in the soils. Our preliminary studies have also shown that accumulation of organic carbon occurs mainly in top (0-15 cm) layer. Similar results are also reported by Malla and Totawat<sup>7</sup> and Kumar et al.<sup>8</sup>.

#### DTPA-extractable Cd, Ni, Cr and Pb

The concentration of DTPA- extractable Cd, Ni, Cr and Pb in sewage effluent treated soils at various depths are given in Table 4. The examination of Table 4denote that the concentrations of DTPA- extractable Cd, Ni, Cr and Pb in sewage effluent treated soils build up continuously as compared to ground water treated soils. The concentration of DTPA-

extractable metals in sewage effluent irrigated soils was approximately four times for Cd; 3.5 times for Ni; six times for Cr and 5.5 times for Pb than ground water treated soils. The higher concentration of DTPA-extractable metals sewage effluent irrigated soils may be due to accumulation of heavy metals present in sewage effluent in the soils. The concentration of metals decreased with depth and with increasing distance from effluent discharge point (the concentration of DTPA-extractable Cd, Ni, Cr and Pb throughout the period of study and at different depth in ground water irrigated soil ( $S_{10}$ ) was almost same). The concentration of DTPA-extractable metals at various depths ranged from; Cd from 0.442 to 0.106; Ni from 9.64-2.22; Cr from 25.4-3.1 and Pb from 18.2-2.4.

The DTPA-extractable Cd, Ni, Cr and Pb in surface soil exhibited a significant correlation (Table 5) with soil pH ( $r = 0.865-0.939$ ), soil EC ( $r = 0.894-0.977$ ), organic carbon ( $r = 0.883-0.910$ ), CEC ( $r = 0.894-0.927$ ) and clay content ( $r = -0.820- -0.918$ ), indicating that pH, EC, organic carbon, CEC and clay content significantly influence the availability of Cd, Ni, Cr and Pb in soil.

The higher concentration of Ni, Cr and Pb in soils 1, 2, 3 and 4 may be due to addition of Ni, Cr and Pb in the form of gasoline, personal care products and aerosol by urban population as these sites are close to urban residential area.

The concentration of DTPA-extractable metals declined with depth which may be due to lower permeability and vertical movement of the metals. The results also indicate that organic carbon plays a major role in mobility and transport of Cd, Ni, Cr and Pb in the sewage effluent treated soils. The immobilization of metals might have been due to adsorption and occlusion on the surface by hydroxides and oxides in soils and tend to remain in the zone of incorporation<sup>9</sup>.

### Vegetables

Table 6 which denote the Cd, Ni, Cr and Pb concentration in crops grown on sewage irrigated soils showed that concentration of metals in vegetables grown on sewage effluent irrigated soils ranged : Cd from 0.52-5.46; Ni from 4.76-26.56; Cr from 6.98 – 20.12 and Pb from 13.34-28.44 mg kg<sup>-1</sup> while in ground water irrigated soil it ranged from 0.24- 0.90; 1.66-6.66; 1.88-4.22; 2.66-4.44 mg kg<sup>-1</sup> for Cd, Ni, Cr and Pb respectively. The maximum accumulation of these metals was in potato followed by maize except for Pb. Similar results are also reported by Brar et al<sup>10</sup>. The metal concentrations in vegetables were significantly positively correlated with soil DTPA-extractable metal concentration. A linear relationship between Cd, Ni, Cr and Pb concentration in plant species and DTPA-extractable Cd, Ni, Cr and Pb were noted. The relationship for Cd is as below:

Cauliflower-Cd = 3.55 DTPA-Cd -0.336 ( $r = 0.94$ ); Radish-Cd = 3.42 DTPA-Cd -0.064; ( $r = 0.85$ )

Eggplant-Cd = 7.56 DTPA-Cd -1.04; ( $r = 0.79$ ); Potato-Cd = 13.37 DTPA-Cd -1.32; ( $r = 0.83$ )

Maize-Cd = 9.37 DTPA-Cd -0.76; ( $r = 0.86$ );

### The relationship for Ni is as follows:

Cauliflower-Ni = 1.31DTPA-Ni -2.08; ( $r = 0.96$ ); Radish-Ni = 1.33DTPA-Ni -2.26; ( $r = 0.91$ )

Eggplant-Ni = 1.59DTPA-Ni -1.66; ( $r = 0.85$ ); Potato-Ni

=2.51DTPA-Ni -2.02; ( $r = 0.89$ )

Maize-Ni = 1.91DTPA-Ni-1.42; ( $r = 0.90$ )

### For Cr the linear relationship is as:

Cauliflower-Cr = 0.51DTPA-Cr +1.11; ( $r = 0.94$ ); Radish-Cr = 0.43DTPA-Cr +1.51; ( $r = 0.92$ )

Eggplant-Cr = 0.43DTPA-Cr +0.27; ( $r = 0.93$ ); Potato-Cr = 0.72 56DTPA-Cr +1.35; ( $r = 0.88$ )

Maize-Cr = 0.54DTPA-Cr+2.64; ( $r = 0.77$ )

### The concentration of Pb in crops and soil can be related as:

Cauliflower-Pb= 1.35DTPA-Pb-0.48; ( $r = 0.82$ ); Radish-Pb = 1.28DTPA-Pb -0.62; ( $r = 0.89$ )

Eggplant-Pb = 1.13DTPA-Pb +0.51; ( $r = 0.90$ ); Potato-Pb = 1.58DTPA-Pb+0.81; ( $r = 0.86$ )

Maize-Pb = 0.77DTPA-Pb+0.012 ( $r = 0.78$ )

Thus the metal concentration in various vegetable crops may be predicted by estimation of DTPA-extractable metals in soils.

These results suggest that sewage effluent disposal on agricultural land enhanced the Cd, Ni, Cr and Pb concentration in soils and in crops as compared to ground water irrigated soils. Uptake of heavy metals by crops were positively correlated with soil organic matter, suggesting that there is a formation of metal- humic acid complex in soil by application of sewage effluent for longer period and these forms of metal get transferred into the plants grown on these soils<sup>5</sup>.

### Conclusions

From this study it is evident that continuous use of sewage effluent for irrigation on agricultural land is increasing the concentration of DTPA- extractable Cd, Ni, Cr and Pb in soils and crops grown on such soils beyond their toxic limit. The study also revealed that maximum accumulation of heavy metals is in potato a most commonly used vegetable in India. These results also denote that potato and maize is good accumulator of metals hence growing of potato and maize on such soils should be avoided. Higher concentration of heavy metals Cd, Ni, Cr and Pb due to more accumulation probably may cause phytotoxicity which result in decrease of crop yield. If the non-judicious use of sewage effluent is not stopped it will not only harm the consumer of the crops but also retard the soil fertility and crop yield.

**Table 1. Location of soil samples used for studies**

S.N.	Site No.	Location of sites
1.	S <sub>1</sub>	Near the discharge point, Mathura Road
2.	S <sub>2</sub>	Half km west-south of discharge nala of Mathura road
3.	S <sub>3</sub>	Near the discharge point, surendranagar
4.	S <sub>4</sub>	One km south of discharge nala of Surendra nagar
5.	S <sub>5</sub>	Near the discharge point, Killa Road
6.	S <sub>6</sub>	Half km east of discharge nala of Killa road
7.	S <sub>7</sub>	Near the discharge point, Quarsi
8.	S <sub>8</sub>	3/4 km west of discharge nala of Quarsi
9.	S <sub>9</sub>	One and half km east of discharge nala of Quarsi
10.	S <sub>10</sub>	Ground water irrigated near Quarsi

## 2: Physico-chemical properties of soils

Properties	Soils									
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>
pH	8.42	8.38	8.35	8.40	8.30	8.32	8.25	8.24	8.10	8.06
EC (dS m <sup>-1</sup> )	1.36	1.24	1.20	1.18	1.16	1.14	1.10	1.02	1.06	0.64
Org. C (g kg <sup>-1</sup> )	22.4	20.8	15.1	13.2	14.8	12.6	11.5	10.7	10.5	5.8

CEC [cmol(p+) kg <sup>-1</sup> ]	30.6	27.4	24.8	20.6	21.0	18.0	17.0	15.0	13.4	12.2
Clay (%)	16.5	12.4	18.7	17.2	20.1	21.6	22.4	20.5	23.7	27.5
Silt (%)	33.3	41.5	47.5	40.3	35.5	50.5	38.4	44.5	52.2	47.5
Sand (%)	50.2	46.1	33.5	42.5	44.4	27.9	39.2	35.0	24.1	25.0
DTPA- Extractable (mg kg <sup>-1</sup> )										
Cd	0.442	0.406	0.388	0.362	0.394	0.350	0.302	0.264	0.244	0.122
Ni	9.64	9.06	8.72	8.34	7.08	6.22	6.54	5.92	5.22	2.64
Cr	25.4	21.4	22.1	20.2	14.6	12.8	15.8	13.4	10.2	4.4
Pb	18.2	15.5	16.6	13.7	14.2	12.2	12.8	10.8	11.0	3.4

**Table 3: Variation in pH, electrical conductivity (dS m<sup>-1</sup>) and organic carbon (g kg<sup>-1</sup>) in the sewage irrigated soils**

Depth (cm)	Soils										
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	Mean
0-15	8.42	8.38	8.35	8.40	8.30	8.32	8.25	8.24	8.10	8.06	8.28
15-30	8.00	8.02	8.05	7.92	7.96	7.82	7.80	7.92	7.64	7.60	7.87
30-45	7.72	7.64	7.70	7.64	7.72	7.58	7.60	7.72	7.42	7.38	7.61
45-60	7.42	7.36	7.40	7.32	7.46	7.42	7.36	7.60	7.28	7.26	7.38
Mean	7.89	7.85	7.88	7.82	7.86	7.78	7.75	7.87	7.61	7.57	----
CD (5%)	Soil = 0.036; Depth= 0.020										

**Electrical conductivity (dS m<sup>-1</sup>)**

Depth (cm)	Soils										
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	Mean
0-15	1.36	1.24	1.20	1.18	1.16	1.14	1.10	1.02	1.06	0.64	1.11
15-30	1.06	1.02	0.98	0.94	0.92	0.96	0.90	0.86	0.92	0.54	0.85
30-45	0.98	0.88	0.86	0.80	0.84	0.82	0.78	0.76	0.80	0.48	0.75
45-60	0.90	0.80	0.78	0.72	0.78	0.74	0.70	0.68	0.76	0.44	0.66
Mean	1.10	0.99	0.95	0.91	0.92	0.91	0.87	0.83	0.88	0.53	----
CD (5%)	Soil = 0.012; Depth= 0.008										

**Organic carbon (g kg<sup>-1</sup>)**

Depth (cm)	Soils										
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	Mean
0-15	22.4	20.8	15.1	13.2	14.8	12.6	11.5	10.7	10.5	5.8	13.7
15-30	14.0	13.6	10.6	10.0	10.4	9.7	9.0	8.5	8.4	4.0	9.1
30-45	10.2	9.6	8.7	8.2	8.5	7.5	7.0	6.6	6.6	3.1	7.6
45-60	9.4	8.8	7.8	7.4	7.9	7.0	6.5	6.1	6.1	2.7	7.2
Mean	14.0	13.2	10.5	9.7	10.4	9.2	8.5	7.9	7.9	3.9*	----
CD (5%)	Soil = 0.042; Depth= 0.026										

**Table 4: Distribution of DTPA-extractable cadmium, nickel, chromium and lead (g kg<sup>-1</sup>) in the sewage irrigated soils**

Depth (cm)	Soils										
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	Mean
0-15	0.442	0.406	0.388	0.362	0.394	0.350	0.302	0.264	0.244	0.122	0.327
15-30	0.370	0.334	0.306	0.290	0.322	0.276	0.232	0.200	0.186	0.108	0.262
30-45	0.304	0.286	0.272	0.264	0.288	0.254	0.206	0.164	0.152	0.100	0.229
45-60	0.264	0.252	0.240	0.236	0.256	0.230	0.188	0.138	0.130	0.094	0.202
Mean	0.345	0.320	0.302	0.288	0.315	0.278	0.232	0.192	0.178	0.106	----
CD (5%)	Soil = 0.002; Depth= 0.001										

**DTPA-extractable nickel**

Depth (cm)	Soils										
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	Mean
0-15	9.64	9.06	8.72	8.34	7.08	6.22	6.54	5.92	5.22	2.64	6.94
15-30	6.88	6.34	6.16	5.86	4.42	3.76	4.02	3.56	3.16	2.28	4.65

30-45	4.12	3.74	3.60	3.40	2.82	2.28	2.60	2.20	2.00	2.06	2.84
45-60	2.64	2.22	2.14	2.00	2.26	1.84	2.10	1.90	1.74	1.92	2.08
Mean	5.82	5.34	5.16	4.90	4.15	3.53	3.82	3.40	3.03	2.22	----
CD (5%)	Soil = 0.364; Depth= 0.221										

**DTPA-extractable chromium**

Depth (cm)	Soils										Mean
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	
0-15	25.4	21.4	22.1	20.2	14.6	12.8	15.8	13.4	10.2	4.4	16.0
15-30	18.7	15.6	16.2	14.4	10.8	10.0	11.2	10.4	7.6	3.9	11.9
30-45	15.2	13.2	13.8	12.6	9.2	8.5	9.6	9.1	6.2	3.5	10.1
45-60	13.6	12.0	12.4	10.8	8.4	8.0	8.6	8.2	5.8	3.1	9.1
Mean	18.2	15.6	16.1	14.5	10.8	9.8	11.3	10.3	7.5	3.7	----
CD (5%)	Soil = 0.465; Depth= 0.312										

**DTPA-extractable lead**

Depth (cm)	Soils										Mean
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	
0-15	18.2	15.5	16.6	13.7	14.2	12.2	12.8	10.8	11.0	3.4	12.8
15-30	13.3	11.4	12.1	10.6	11.0	9.4	9.1	8.7	8.2	3.0	9.7
30-45	10.2	9.3	9.9	8.7	9.2	8.0	7.6	7.2	6.6	2.8	8.0
45-60	9.1	8.7	9.9	8.0	8.2	7.4	7.1	6.8	6.2	2.4	7.2
Mean	12.7	11.2	12.1	10.3	10.9	9.3	9.2	8.4	8.0	2.9	----
CD (5%)	Soil = 0.386; Depth= 0.275										

**Table 5 Correlation coefficients of cadmium, nickel, chromium and lead with soil Properties**

Parameters	DTPA-Cd	DTPA-Ni	DTPA-Cr	DTPA-Pb
pH	0.939	0.934	0.935	0.865
EC	0.967	0.938	0.894	0.977
Org. C	0.908	0.910	0.883	0.885
CEC	0.927	0.947	0.949	0.894
Clay content	-0.857	-0.918	-0.874	-0.820

**Table 6: Distribution of DTPA-extractable cadmium, nickel, chromium and lead (g kg<sup>-1</sup>) in different crops grown in the sewage effluent irrigated soils**

**DTPA-extractable cadmium**

Vegetable crop	Soils										Mean
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	
Cauliflower	1.46	1.24	1.10	0.98	0.80	0.70	0.66	0.60	0.52	0.24	0.83
Radish	1.84	1.62	1.34	1.18	1.00	0.90	0.84	0.76	0.66	0.42	1.05
Egg Plant	2.14	2.00	1.82	1.66	1.52	1.40	1.16	1.06	1.00	0.54	1.43
Potato	5.46	4.86	3.94	3.24	3.02	2.74	2.36	2.10	1.96	0.90	3.06
Maize	3.46	3.12	3.00	2.72	2.42	2.16	1.94	1.80	1.70	0.76	2.30
Mean	2.87	2.59	2.24	1.96	1.75	1.58	1.39	1.26	1.17	0.50	-----
CD (5%)	Soil = 0.19; Crops= 0.11										

**DTPA-extractable nickel**

Vegetable crop	Soils										Mean
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	
Cauliflower	12.44	10.12	9.32	8.14	7.26	6.64	6.02	5.22	4.84	2.24	7.24
Radish	11.66	9.84	9.02	8.16	6.66	6.04	5.84	5.32	4.76	1.66	6.89
Egg Plant	14.64	12.22	12.00	11.14	9.46	8.88	8.14	7.76	7.48	2.20	9.39
Potato	26.56	21.24	18.45	16.24	15.14	14.06	12.84	12.12	10.42	6.66	15.37
Maize	16.66	15.88	15.12	15.06	12.14	11.32	10.88	10.10	9.48	2.66	11.83
Mean	16.39	13.86	12.78	11.55	10.13	9.39	8.74	8.10	7.40	3.08	-----
CD (5%)	Soil = 0.86; Crops= 0.62										

## DTPA-extractable chromium

Vegetable crop	Soils										
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	Mean
Cauliflower	14.58	13.12	11.46	10.12	9.34	8.82	8.06	7.72	7.30	2.46	9.30
Radish	13.12	11.42	10.24	9.14	8.62	8.10	7.62	7.22	6.98	2.08	8.45
Egg Plant	11.12	10.22	9.46	8.88	7.24	6.66	6.02	5.45	4.95	1.88	7.09
Potato	20.12	18.24	16.36	15.12	13.24	12.16	11.08	9.76	9.14	4.22	12.94
Maize	16.22	14.44	13.66	13.12	11.68	11.12	10.64	10.12	9.68	2.88	11.36
Mean	15.03	13.49	12.23	11.28	10.02	9.37	8.68	8.05	7.61	2.70	----
CD (5%)	Soil = 0.94; Crops= 0.68										

## DTPA-extractable lead

Vegetable crop	Soils										
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>	Mean
Cauliflower	23.64	21.88	20.16	19.32	18.12	16.76	16.12	15.32	14.14	3.36	16.87
Radish	21.44	20.36	19.22	18.42	17.22	16.14	15.24	14.06	13.34	2.86	15.83
Egg Plant	19.44	18.88	18.02	17.42	16.12	15.52	15.00	14.14	13.66	2.66	15.09
Potato	28.44	26.32	25.10	24.02	22.12	21.22	20.44	20.00	18.66	4.44	21.08
Maize	13.64	12.88	12.12	11.36	10.66	10.00	9.24	8.88	8.22	2.32	9.93
Mean	21.32	20.06	18.92	18.11	16.85	15.93	15.21	14.48	13.60	3.13	-----
CD (5%)	Soil = 1.08; Crops= 0.74										

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