Bio-accumulation of Trace Metals in Leafy Vegetables due to Effluent Water Irrigation in Periurban Area of Western Rajasthan

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ABSTRACT

The aim of this study is to access trace metal contamination of leafy vegetables (cauliflower, onion leaves, spinach and coriander) grown under effluent water and to establish correlation between bio-accumulation of these metals through soil pollution in peri-urban area of Jodhpur city situated in Western Rajasthan. Samples of fresh vegetables were collected randomly from different fields irrigated with untreated effluent water in vicinity of waste water drains. Both sample and blank solutions were analyzed by AAS to determine concentrations of Copper, Lead, Zinc, Cadmium, Iron and Nickel. Soil and water samples from each study site were also collected and analysed. Vegetables were severly contaminated with Lead and Cadmium. Concentration of lead and cadmium was in order: Cauliflower < Spinach < Onion < Coriander and Coriander> Onion Leaves > Cauliflower > Spinach respectively. Uptake of Iron was maximum. Levels of nickel and zinc were also higher than Indian safe limits in all vegetables. Correlation among different metals was also studied.

Keywords: Vegetables, trace metals, effluent water, contamination, AAS.

1. INTRODUCTION

The consumption of vegetables and fruits offer rapid and least means of providing adequate vitamin supplies, minerals and fibers. Environmental pollution has caused the contamination of soil; on the other hand waste water irrigation resulted in the significant mixing of the heavy metal content of the agricultural land. The chief cause is the waterways through which heavy metals are leached out of the soil and are taken by the vegetation. If plants decay, these toxic metals are redistributed and as a consequence their enrichment in the agricultural soil occurs. Heavy metals are not easily biodegradable which leads to their accumulation in human vital organs causing varying degree of illness on acute and chronic exposure [1]. Accumulation of toxic heavy metals in vegetables irrigated with waste water was studied, compared [2] and it was found that metal concentration was many fold higher than vegetables grown in controlled area. Present study of raw sewage irrigated crops (Cauliflower, Onion leaves, Coriander and Spinach) revealed that presence

of toxic metals like lead, chromium, cadmium, nickel, iron, zinc, copper etc. reduces soil fertility and agricultural out puts.

2. MATERIAL AND METHODS

Collection of samples and pretreatment. Samples of fresh vegetables were collected randomly from different fields irrigated with untreated effluent water during Nov-2009 to Feb-2010. Twelve samples (six from Vinayakiya and six from Tanawada) of each vegetable were collected, immediately put into well labeled polyethylene bags and transferred to laboratory for analysis. Soil and water samples from each study site were also collected. Vegetable samples were washed, cut into pieces of uniform size, air dried and then placed in dehydrator for 2-3 days, oven dried at 100°C and ground into fine powder using blender. Finally they were sieved and stored in polyethylene bags until for acid digestion.

Preparation of sample solutions. 20% sulphuric acid was added to 25 g of well homogenized sample into a clean silica dish and Content of the dish was dried in an oven at 110°C. Then it was heated over a soft flame until all volatile matter was removed. Now it was transferred to furnace set at 250°C and temperature was raised slowly to 500°C for about 6 to 8 hours. If the ash was not carbon free, 25 mL of nitric acid was added and dish was returned to the furnace at 500°C and ashing was done for about 30 minutes. The process was triplicated. Now 1 mL of nitric acid and 10 mL of water was added to the clean ash and the mixture was heated till the ash was dissolved. The content was qualitatively transferred to a 50 mL volumetric flask. Dish was heated with 10 mL of hydrochloric acid (1+1) and solution was transferred again to the same volumetric flask to volume with water. Sample and blank solutions were prepared using the same procedure for soil and water samples also and were analyzed on AAS (Modal no. nov AA400 analytik jena)[3].

3. RESULT AND DISCUSSION

Table 1. Mean heavy metal content (mg/kg) of water and soil samples of affected area

.SNo	Metal	Water	Soil
1	Cu	58.45	26.73
2	Pb	21.72	12.33
3	Zn	125.19	92.33
4	Cd	34.68	16.17
5	Fe	1273	816.82
6	Ni	63.94	39.78

Table 1. Mean heavy metal content (mg/kg) of water and soil samples of affected area

S. No.	Cu	Pb	Zn	Cd	Fe	Ni
1	12.93	3.73	71.08	6.44	643.25	16.54
2	14.09	2.38	62.12	8.23	612.32	18.95
3	15.12	2.95	61.71	5.96	687.15	17.96
4	14.28	3.54	63.25	6.14	667.11	18.46
5	24.85	5.99	62.45	7.15	701.23	18.75
6	15.74	2.56	82.85	6.85	687.54	20.23
7	12.98	3.84	63.23	4.55	615.24	18.36
8	16.32	6.65	78.42	6.12	635.23	19.14
9	15.56	2.74	62.47	6.08	559.84	18.57
10	14.74	3.12	64.21	8.34	674.58	17.85
11	20.52	2.84	73.17	6.75	664.23	19.02
12	15.75	4.88	61.55	6.89	667.24	18.49
Mean±SD	16.07±3.39	3.76±1.38	67.20±7.35	6.62±1.02	651.24±40.24	18.52±0.88

Table 2: Heavy Metal Concentration (mg/kg) in Samples of Cauliflower

S. No.	Cu	Pb	Zn	Cd	Fe	Ni
1	18.59	10.69	51.95	8.43	283.6	12.13
2	17.54	10.73	52.11	8.67	320.5	15.65
3	18.24	10.63	53.28	7.43	285.1	13.88
4	17.54	12.81	73.88	7.6	322.7	12.24
5	18.24	11.76	54.12	9.42	292.2	12.37
6	19.24	10.19	53.52	8.65	392.6	14.89
7	19.31	12.2	62.05	8.43	382.1	16.46
8	18.95	11.88	53.18	8.69	385	14.91
9	16.89	12.41	53.65	9.62	423.1	14.25
10	19.13	11.91	62.52	9.59	389.6	12.14
11	23.95	9.9	53.56	6.66	421.9	15.52
12	19.69	7.23	74.31	9.61	286.1	13.03
Mean±SD	18.94±1.78	11.02±1.51	58.17±8.23	8.56±0.94	348.70±55.42	13.95±1.54

Table 3: Heavy Metal Concentration (mg/kg) in Onion Leaves

S. No.	Cu	Pb	Zn	Cd	Fe	Ni
1	22.05	9.89	71.12	6.48	215.12	22.31
2	23.12	10.15	62.01	5.55	267.41	18.52
3	23.53	10.39	63.25	5.63	312.23	17.78
4	22.65	10.82	52.52	6.61	207.56	21.59
5	23.89	11.05	62.12	5.69	356.78	16.66
6	21.98	9.95	71.51	6.61	225.49	16.95
7	22.77	9.56	61.35	7.58	237.68	21.06
8	23.91	10.62	62.89	5.57	301.94	18.88
9	23.42	10.32	59.01	6.63	251.07	21.13
10	24.03	10.43	62.84	6.61	317.83	19.24
11	21.05	11.12	71.98	5.61	242.15	23.01
12	21.31	10.36	61.95	6.49	189.26	22.93
Mean±SD	22.80±1.022	10.38±0.46	63.54±5.61	6.25±0.63	260.37±51.44	20.00±2.28

Table 4: Heavy Metal Concentration (mg/kg) in Spinach

S. No.	Cu	Pb	Zn	Cd	Fe	Ni
1	12.15	10.51	71.02	9.96	388.11	8.13
2	12.25	11.12	62.81	9.95	412.48	15.35
3	10.06	6.89	63.51	9.83	310.67	9.28
4	13.01	11.58	81.89	10.99	289.89	12.46
5	13.85	13.11	62.25	10.88	354.51	10.14
6	12.08	12.52	80.67	10.01	332.22	10.27
7	11.98	12.08	72.21	10.12	405.74	7.59
8	15.58	10.87	61.45	10.97	399.12	7.82
9	12.78	7.68	61.98	10.86	348.14	11.02
10	9.88	11.21	76.38	9.019	363.33	8.93
11	13.54	13.02	63.62	9.05	389.95	6.76
12	13.68	14.75	78.53	10.98	315.06	9.61
Mean±S.D	12.57±1.58	11.27±2.21	69.69±8.0	10.21±0.72	359.10±40.87	9.78±2.37

Table 5: Heavy Metal Concentration (mg/kg) in Coriander Leaves

SNo	Vegetable	Cu	Pb	Zn	Cd	Fe	Ni
1	Cauliflower	16.07	3.768	67.2	6.62	651.24	18.52
2	Onion	18.94	11.02	58.17	8.56	348.7	13.95
3	Spinach	22.8	10.38	63.54	6.25	260.37	20.66
4	Coriander	12.57	11.27	69.69	10.21	359.1	9.78
5	FAO/WHO (1984)	40.00	5	0.60	0.3	-	-
6	FAO (1985)	0.20	5	2.0	0.01	5.0	0.2
7	Indian Standards	30.00	2.00	50.00	1.50	-	4.00

Table 6. Comparision between safe limits and mean concentration of different metals in six vegetables (mg/kg)

Almost all the metals were found in greater amounts than the maximum safe limits given by FAO/WHO [4] and FAO [5]. The major source of these toxic metals is the waste disposal by local industries. Concentrations of metals in vegetable samples have been give in table 2,3,4 and 5. Mean heavy metal concentration and permitted safe limits have been given in table 6. A comparision has been shown in figure 1.

By comparision it has been seen that concentration of copper well below the limits of FAO/WHO but above the safe level of 0.20 mg/kg given by FAO.

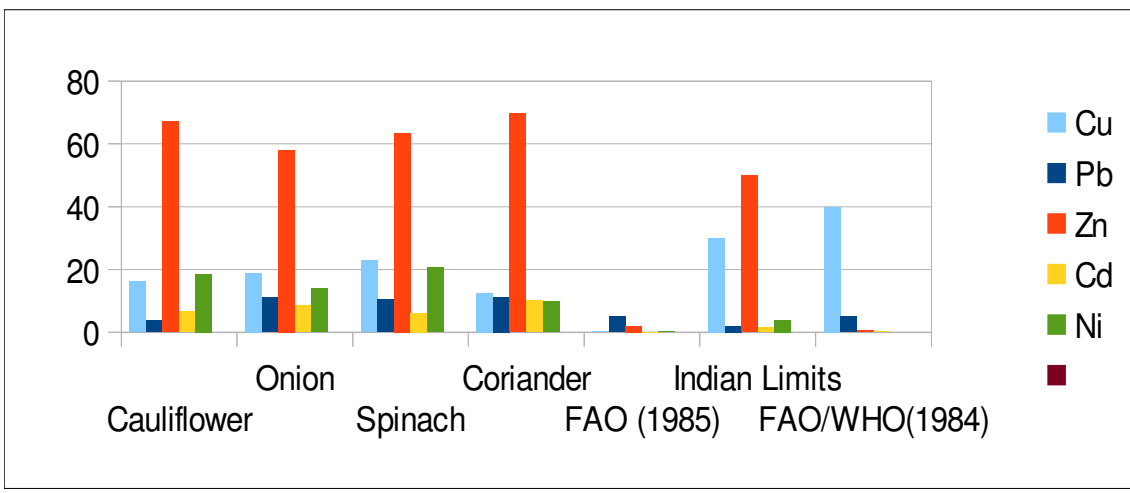

Figure 1. Comparision of metal content with standard limits

Table 7. Correlation cofficient of metals

	Cu	Pb	Zn	Cd	Fe	Ni
Cu	1	**0.14**	-0.67	-0.73	-0.44	**0.78**
Pb	**0.14**	1	-0.3	**0.56**	-0.93	-0.48
Zn	-0.67	-0.3	1	**0.22**	**0.36**	-0.23
Cd	-0.73	**0.56**	**0.22**	1	-0.23	-0.99
Fe	-0.44	-0.93	**0.36**	-0.23	1	**0.14**
Ni	**0.78**	-0.48	-0.23	-0.99	**0.14**	1

Copper toxicity was also studied by Yang [6]and was found that root and shoots both showed increased levels of copper. Mean lead concentration in vegetables is found to be in the range of 2.38-14.75 mg/kg and its accumulation was severe when compared to the permissible limits of China [7]. Thus there is a need to develop awareness in the local livelihood to not consume such contaminated vegetables. Lead contamination in onion, spinach and coriander was severe and many folds higher than safe limits. Order of Pb contamination in studied vegetables was: Chandaliya < Cauliflower < Radish < Spinach < Onion < Coriander. The Zinc accumulation exceeded the safe limits of both FAO/WHO and FAO. The level was comparable with Indian standards. Maximum level of zinc tolerance for human health is 20mg/kg according to CDPM [8]. Concentration of zinc was found as: Radish > Coriander > Cauliflower > Chandaliya > Spinach > Onion. The acute exposure of zinc can cause tachycardia, vascular shock, dyspeptic nausea, vomiting, pancreatic disorder, diarrhea and damage of hepatic parenchyma [9]. Uptake of Iron was maximum and exceeded the safe levels of FAO/WHO & FAO. The order of content of Fe: Spinach < Onion < Coriander < Cauliflower. Thus cauliflower and coriander were severely contaminated with Fe toxicity. Again levels of nickel in all vegetables were above FAO and Indian standards. Ni in spinach and radish was 5 & 7 times higher than Indian safe limits. Nickel is toxic thus vegetables are hazardous on consumption and can cause acute or chronic sickness. The order of nickel accumulation was: Radish > Spinach > Cauliflower > Chandaliya > Onion > Coriander.

All vegetables were severely contaminated with cadmium toxicity as the level is far greater than the safe limits. The order of accumulation of Cadmium: Chandaliya > Coriander > Radish > Onion Leaves > Cauliflower > Spinach. It has been reported that cadmium is highly mobile metal and can be easily absorbed by the plants areal parts. Correlation coefficients between mean concentrations of all metals in vegetables have been given in table 7. Strong linear correlation was found between

copper and nickel showing there assistance in vegetables. Similarily lead and cadmium are also positively correllated. Linear negative correlation was obtained between Cu-Zn, Cu-Cd, Pb-Fe and Cd-Ni. Zn-Pb and Cd-Fe were least correlated thus their accumulation may be because random sources.

4. CONCLUSION

The study reveals that untreated sewage water is the main cause of soil pollution that lead to increase in levels of toxic metals in the leafy vegetables. Level of metals in vegetables will provide a base for extensive sampling and quantification of data in future. As leaves are generally rich in heavy metal accumulation, it is recommended to not to grow such vegetables in farms and fields irrigated with sewage water or water contaminated by heavy metals.

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