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CONCENTRATION OF HEAVY METALS IN VEGETABLES CULTIVATED AROUND A POLLUTED RUNNEL, LUDHIANA, PUNJAB

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ABSTRACT -*The concentration of some heavy metals; Chromium(Cr), Zinc(Zn) , Copper(Cu), Cadmium(Cd), Nickel(Ni), and Lead(Pb) and in vegetables; Cauliflower, Spinach, and Tomato, cultivated in Ludhiana, Punjab, was examined. Vegetables and Soil samples were collected from farms, around the Buddha Nala as 'Site A' and 'Site B' and other samples from an area which is not near to Buddha Nala, which served as 'control'. The level of heavy metals in soils and vegetables from both sites were determined using digestion and Atomic Absorption Spectrophotometer methods (AAS). The values of all the metals analyzed for samples from 'Site A' and Site B' were higher than those from the 'control site suggesting possible mobility of metals from polluted runnel to farm lands through leaching and runoffs and was above the values recommended by the World Health Organization (WHO). The concentration of Cr, Cd, Zn and Pb in the vegetable samples was very high compared to the FAO/WHO maximum permissive limits. Study suggested that there is need for further monitoring since the inhabitants depend on these areas for farming.*

Key words*: Heavy Metals, Vegetables, Buddha Nala, Control, AAS, WHO, Transfer factor*

1. INTRODUCTION

Vegetables are sources of mineral, vitamin, carbohydrate,

Protein and fibers; therefore they are important for human diet. Although the vegetables are very useful for human body,they often act as media carrying poison, such as pesticide residues and heavy metals derived from lands where the vegetables are grown. Thecontamination can be resulted from the excessive use of inorganic fertilizers and pesticides, emission gas from motor vehicles, contaminated irrigation water and from other sources. Heavy metals in environment are important hazard for human health due to their properties such as persistent, bio-accumulative, and toxic to plants, animals, and humans. Plants accumulating toxic metals at high concentration are serious risk to animals and human health when they are consumed. The excess of heavy metals in human bodies can cause anemia, kidney damage, lung disease, nervous system disorders, hyperactivity, hypertension, behavioral changes, infertility to male, cancers, and even cause death. Vegetable crops are often grown in polluted and degraded environmental conditions in the peri-urban zone and are subject to further pollution from vehicles and industries during marketing. Rapid and unorganized urban and industrial developments have contributed to the elevated levels of heavy metals in the urban environment of developing countries such as China (Wong et al., 2003) and India (Sharma et al., 2008). There is, therefore, significant cause for concern regarding contamination. The present study is aimed at assessing the pollution status of the farm lands around the Buddha Nala in Ludhiana, the extent to which the crop plants grown on these farmlands were exposed to heavy metals, and hence, the safety levels of the plant leaves and crops produced for human consumption. The heavy metals investigated were;Chromium(Cr), Zinc(Zn), Copper(Cu), Cadmium(Cd), Nickel(Ni), and Lead(Pb). The vegetables analyzed were Cauliflower, Spinach, and Tomato. The best method for the determination of concentration of Trace elements (accumulation either in vegetables or in water) applied is Atomic Absorption Spectrometer (AAS).

METHODOLOGY

1.1Description of Study Area

The sampling sites are two main sites, one located along side of Buddha Nala on Clock Tower Road 'site A' and second location was also near the site A named as 'site B' and control samples were taken from few kilometers from site A and site B, Ludhiana, where the Buddha Nallah was at far distance or where there was not any form of human activities that could generate wastes. Sampling was done for three months of winters from November 2015 to January 2016.

2.2 Collection of samples

Five sampling spots at a distance of 30 m from each other were mapped out for soil samples collection within the sampling sites, using clean stainless steel shovel from 0-10 cm depth. A soil sample to serve as control was also collected. The collected dried soil samples were thoroughly mixed in clean plastic bucket to obtain a representative sample, crushed and sieved with 2 mm mesh before stored in labeled polythene bags prior to analysis. Three vegetable samples from both sites – Cauliflower, Spinach, and Tomato cultivated within the vicinity of the Buddha Nala were randomly collected in a pre-distilled water-washed polyethylene bags and then transported to the laboratory for preparation and treatment for the analysis. Sampling was done for three months period. Vegetable samples of the same species were also collected as control from farms around the control site for same time period.

1.1 Sample Pretreatment

Samples were washed with distilled water to eliminate the suspended particles and dried in hot air oven at a temperature of 80°C for 24 hours. Samples were then ground into powder state using a stainless steel blender and passed through a 2 mm sieve. The resulting fine powder was kept at room temperature in polythene bags for further analysis.

2.4 Sample Digestion

Samples of both soils and vegetables (1.00 ± 0.001 g each) were placed into 100 ml beakers separately and digested 60% $HClO_4$, concentrated HNO_3 and H_2SO_4 and placed on a hot plate for 3h. After cooling at room temperature, the digest was filtered using Whatman filter paper 42 into a 100 ml volumetric flask and made up to the mark with de-ionized water.

2.5 Instrumental analysis

The digested samples were analyzed for heavy metals (Cr, Zn, Cu, Cd, Ni and Pb) using Atomic Absorption Spectrophotometer (AAS). Setup of AAS fitted with a specific lamp of particular metal. Working standards were also prepared by diluting 1,000 ppm stock solution of each of the metals.

RESULTS AND DISCUSSION

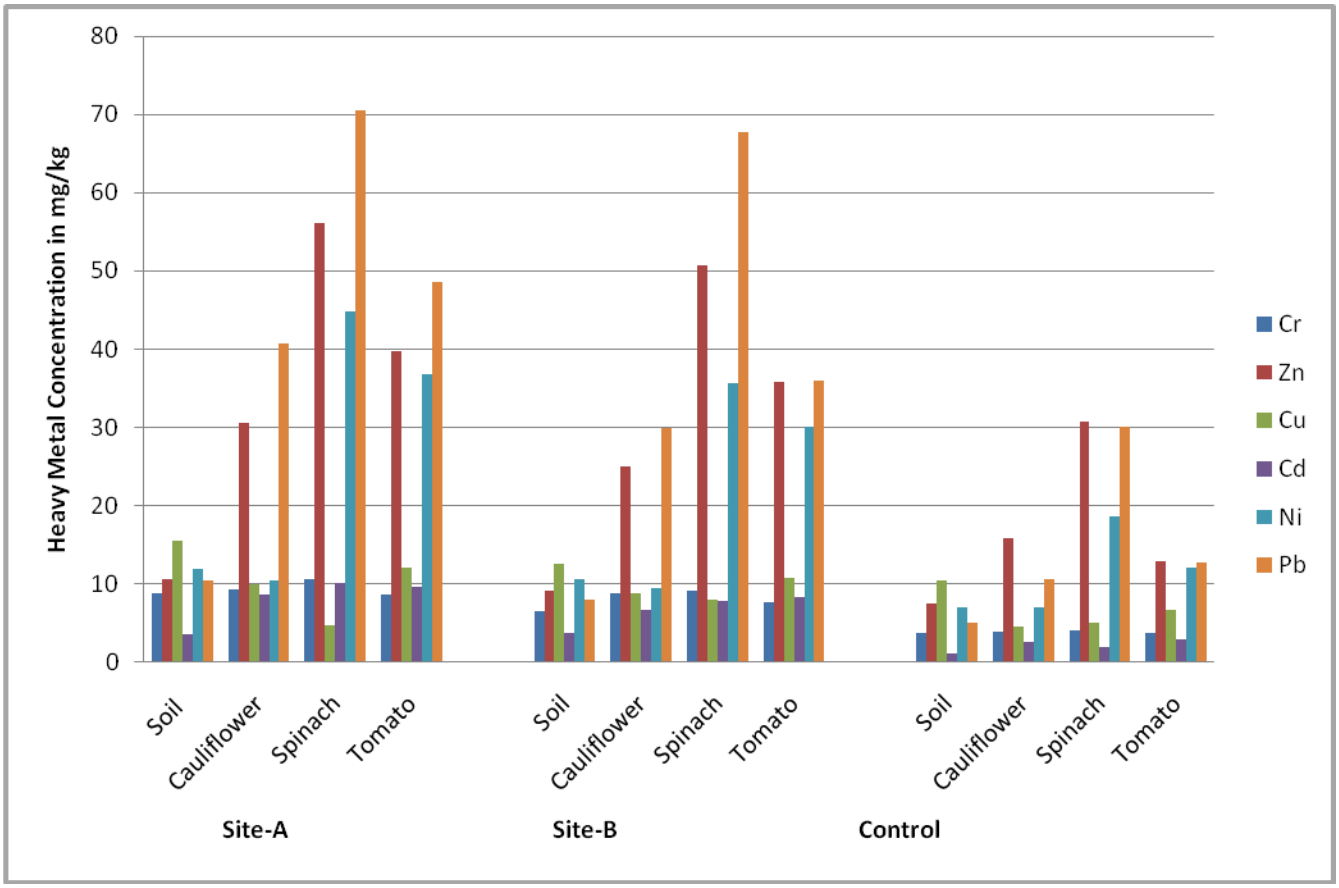
Table 1 shows the average concentration of heavy metals in soil and vegetables for Site-A and Site-B, around the Buddha Nala. The concentrations obtained for the metals are 8.85, 10.56, 15.60, 3.6, 11.9 and 10.50 mg/kg in soil sample from site A and 8.50, 8.11, 12.56, 3.75, 9.67 and 10.00 mg/kg in soil sample from site B, for Cr, Zn, Cu, Cd, Ni and Pb respectively . The concentration of all heavy metals in soil samples of site-A and site-B were within the limits recommended by World Health Organization (WHO) except Pb(10.5 & 8.00) and Cd(3.6 & 3.75) for both sites A and B.Lead is known for lead poisoning in humans as well as chronic neurological disorders especially in children. The sequence of occurrence is Cu > Ni > Zn > Pb > Cr >Cd in soil samples from site A and Cu >Pb > Ni > Cr > Zn > Cd in soil sample from site B of the selected area.

Location	Sample	Heavy Metals (mg/kg)					
		Cr	Zn	Cu	Cd	Ni	Pb
Site A	Soil	8.85	10.56	15.60	3.6	11.9	10.5
	Cauliflower	9.35	30.55	9.98	8.65	10.5	40.69
	Spinach	10.59	56.06	4.81	10.15	44.90	70.56
	Tomato	8.59	39.72	12.08	9.69	36.80	48.56
Site B	Soil	8.50	8.11	12.56	3.75	9.67	10.00
	Cauliflower	8.76	25.00	8.79	6.76	9.53	30.00
	Spinach	9.09	50.67	8.09	7.78	35.60	67.77
	Tomato	7.73	35.90	10.76	8.39	30.09	36.07
Control	Soil	3.71	7.46	10.42	1.15	7.06	5.07
	Cauliflower	3.95	15.79	4.50	2.62	7.09	10.70
	Spinach	4.07	30.69	5.09	1.98	18.70	30.03
	Tomato	3.76	12.96	6.67	2.87	12.06	12.70

Table 1The Average Metal concentrations for three months in soils and Vegetable (mg/kg)

Heavy Metals (mg/kg) Cr	Zn	Cu	Cd	Ni	Pb
FAO/WHO limits for Soil	50	300	100	3	50	100
FAO/WHO limits for Vegetables	2.3	20	30	0.2	65	0.3

Table 2 Levels recommended by WHO/FAO for metals in vegetables and soil



Graph 1 showing the comparison between two sites; site A & site Band control

Table1 also shows the level of heavy metals (Cr, Zn, Cu, Cd, Ni and Pb) in Vegetables; Cauliflower, Spinach and Tomato. The concentrations of these metals in vegetables from sites A and B are all above those obtained for these vegetables from the control site. This is also evident in the case of the soil which could be attributed to the mobility of metals from Nala to farmlands through leaching and runoffs. Except Cu and Ni, concentration of all metals exceeded the levels recommended by WHO/FAO. The concentrations of all metals in these vegetables analyzed are all above those obtained for the control site. For soil samples at control site except Pb, all metal were below the levels recommended by WHO/FAO. Although, the level of Cr, Cd and Pb exceeded the levels recommended by WHO/FAO and Cu, Ni, and Zn were within the limit except Zn in Spinach. Table 2 shows the levels recommended by WHO/FAO for metals in vegetables and also for soil.

Table 3: Transfer Factor (TF) of heavy metals from soil to plants

Location	Sample	Heavy Metals					
		Cr	Zn	Cu	Cd	Ni	Pb
Site A	Cauliflower	1.06	2.89	0.64	2.40	0.88	3.88
	Spinach	1.19	5.30	0.30	2.82	3.77	6.72
	Tomato	0.97	3.76	0.77	2.69	3.09	4.62
Site B	Cauliflower	1.03	3.08	0.70	1.80	0.99	3.00
	Spinach	1.07	6.25	0.64	2.07	3.68	6.77
	Tomato	0.90	4.43	0.86	2.24	3.11	3.60
Control	Cauliflower	1.06	2.17	0.43	2.28	1.00	2.11
	Spinach	1.09	4.11	0.49	1.72	2.65	5.92
	Tomato	1.01	1.74	0.64	2.50	1.70	2.50

Table 3: shows the Transfer Factor (TF) of heavy metals from the soil to plants, which is the ratio of the concentration of metals in plants to the total concentration in the soil. The TF for the same metal in the farm lands were significantly different from those for control and according to the type of plants. Pb and Zn had high transfer factors which are 6.77 and 6.25 respectively. The highest TF value obtained for Cauliflower were; Pb(3.88) and Zn(3.08); Spinach Pb(6.77) and Zn(6.25); Tomato Cu(0.53) and Pd(0.43); and spinach Pb(4.62) and Zn(4.43). The TransferFactor of all elements were high range in plant.

CONCLUSION

The concentration of heavy metals determined were in sequence Cu > Ni > Zn > Pb > Cr >Cd in soil samples from site A and Cu >Pb > Ni > Cr > Zn > Cd in soil sample from site B and they are all found in vegetables grownaround the Buddha Nala studied with lead (Pb) having the highest concentration in the vegetable sample, while cadmium had lower concentration. Although these metals were found in soils and plant around the Buddha Nala, it is worthy ofnote that they were above WHO permissive levels. However some metal was found to be below the WHO standard. But in very high concentrations plants may pose danger to consumers of plants around these areas. The Transfer Factor of all elements werehigh range in plant. Therefore continuous usage of these farmlands for growing crops could lead to bioaccumulation of these metals and theireventual entry into the food chain with the associated health risks being manifested. As these vegetables are widely consumed by human, through these plants toxic elements can be transferred to human body creating disruption in various biological systems. Therefore, the residents of these areas are in high health risks of toxic metal exposure.It is therefore suggested that regularmonitoring of heavy metals in vegetables is essential inorder to prevent excessive build-up of these metals inthe human food chain.

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