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Heavy metal contamination in vegetables by flash torch & battery manufacturing industry

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Abstract

Pollution of the biosphere with heavy metal has accelerated dramatically during the last century. Unlike organic pollutants heavy metal are persistent environmental contaminant, which can not be chemically or biologically destroyed. In low concentration, several heavy metals such as Fe, Mn , Zn, Cu,Ni and Mo are essential micronutrients for plants. Elevated concentration of heavy metals in the soil surface cause a variety of environmental problems, including toxicity to plants, animal and humans. The objective of this study was to evaluate the level of heavy metal contamination in a field irrigated with flash torch & battery manufacturing industry effluent and accumulation, distribution of heavy metals in vegetables grown in contaminated fields .An attempt has also been made to evaluate the exposure risk of heavy metals to human beings. Cabbage were found to have translocation index more than 100 i.e 103.06 for Fe, While Cauliflower has translocation index 110.77 for Cu. These plant species can be suggested, as hyper accumulator species for Fe and Cu, but these plant species are edible plant hence can not be suggested to grow on metal contaminated site. The exposure risk levels of the exposed population groups to heavy metals, it is quite clear from the results that except Cu (1.08) none of the metal were found to exceed the RQ value more than 1.0.While in case of Fe the RQ value were found 0.935 which is nearer to 1.0.

Keywords: *Heavy metals, Vegetables, Risk Quotient, Translocation index*

Introduction

The problem of environmental pollution on account of essential industrial growth is in practical terms, the problem of disposal of industrial waste, whether solid or gaseous. All three forms of pollution have the potentiality for taking ultimately the form of water pollution, soluble gases and solids adding to the pollution caused by liquid industrial effluents, directly affects not only soil in exclusively industrial areas but also agricultural fields as well as the beds of rivers, channels and barrage reservoirs, creating secondary sources of chronic pollution. Industrial effluents from paper factories, the automobiles industry, textile factories, and the food industry have adverse effects on soil properties, seed germination, and seedling growth (Somashekar *et al.,* 1984). The effluents from all these factories were alkaline and contaminated with variable amounts of plant nutrients such as Ca, Mg, B, Fe, and Cu, other toxic metals and minerals such as Na, K and nitrate were also present in varying concentrations. The raw effluent altered the physico-chemical properties of the treated soil and were responsible for a reduction in the rate of seed germination. Diluted effluents, however, showed favorable effects on seedling growth.

Pollution of the biosphere with heavy metal has accelerated dramatically during the last century. Unlike organic pollutants heavy metal are persistent environmental contaminant, which can not be chemically or biologically destroyed (Wade *et al.* 1993).

In low concentration, several heavy metals such as Fe, Mn , Zn, Cu,Ni and Mo are essential micronutrients for plants (Taiz and Zeiger 1988) .Elevated concentration of heavy metals in the soil surface cause a variety of environmental problems, including toxicity to plants, animal and humans.

The objective of this study was to evaluate the level of heavy metal contamination in a field irrigated with flash torch and battery manufacturing industry effluent and accumulation, distribution of heavy metals in vegetables grown in contaminated fields .An attempt has also been made to evaluate the exposure risk of heavy metals to human beings.

Material and Methods

A flash torch and battery manufacturing industry located in out skirt of Lucknow, Uttar Pradesh, India.Manufacturing process in this industry is based on electroplating. Effluent of this industry passes long distance through open channel and ultimately falls in to the nearest river Gomti. Local people also uses this effluent for cultivation of crop and vegetables as irrigation water as per requirements.

Soil and Vegetable samples were collected from a field irrigated with this effluent, the name of vegetables are given in table 1. For each plant sample 10 to 15 plants of the same species were collected randomly from each of the locations in the area from where soil samples were drawn. It was ensured that the different samples of each plant species had the same physiological age and identical appearance. The plant samples were washed first with running tap water to remove extraneous matter and then with distilled water. After washing, the plant material was blotted dry, finely chopped and oven dried at 65 °C. The dry plant material was pulverised and stored in kraft paper bags till needed for analysis, prior to analysis.

Soil collection has been made at depth ranging from 0 to ~30 cm during Dec. 2000 to Nov. 2001. The samples were freed from extraneous matter (stones, pebbles etc) and air-dried. After air-drying, the samples were ground and sieved through 2 mm sieve to ensure uniform particle size. The potentially toxic elements- Fe, Cu, Pb, Cr and of Cd were analysed in soil and plant samples by atomic absorption spectrophotometer (Perkin Elmer 5000) Digestion of plant and soil sample were carried out according to the method of Piper (1942). All determinations were carried out in triplicate and the data were analyzed statistically for standard deviation of each value (Panse, 1954).

Results and Discussion

The concentration of Fe was found higher in cabbage (88.17 µg/g) while lower in Capsicum (30.45 µg/g). In case of Cu it was higher in Cabbage (80.32 µg/g) and lower in cauliflower (24.77 µg/g). The concentration of Cr was higher in Cabbage (137.96 µg/g) and lower in Cauliflower (5.37 µg/g). In case of Pb & Cd it was higher in Cabbage i.e 7.65 ìg/g & 1.60 ìg/g respectively while lower in Capsicum i.e 0.88 µg/g & 0.93 µg/g respectively.

The heavy metal concentration in soil were higher than the plant species in most of the cases, it means the presence of heavy metal in growing media i.e. soil or water is not an important factor for metal uptake by plant from their respective soil, similar results were shown by Kisku *et al.,* in 2000.

The different heavy metal levels in plants grown on un polluted soil are Fe=140, Cu=4-15, Zn=8, Ni=1, Cr=0.2-10, Pb=0.1-10, Cd=0.2-0.8 µg/g dry weight as suggested by Allaway (1968).

Except Fe & Pb all metals exceed the normal limits suggested by Allaway (1968).

The concentration of heavy metals in different plant parts is presented in Table 2.The concentration of metals in edible parts of different vegetables especially Cr, Pb and Cd are much higher in Cabbage & Cauliflower (table 2) and may exceed the average normal concentration reported by others and are beyond human consumption level. This may create health problems in the long run. The average normal concentration of Cd is 0.05 μg/g (Elinder 1988), Pb is 0.01 to 1.0 μg/g (Warren and Delavault, 1962), Cr is 60 μg/day (WHO, 1994).

Accumulation of metals in root from soil and subsequent translocation to other parts of plant like stem, leaves and fruits is important for the selection of plant specially crops & vegetables. Plant accumulating least quantity of metals in the edible parts with the concentration within the permissible limit then the variety or species can be selected for the cultivation on field having high level of metal concentration (Barman *et.al* 2000).

Translocation index of different heavy metals in different plants were computed using the Eq. (1)

$$\text{Translocation index (T.I)} = \frac{\text{Average heavy metal in soil samples}}{\text{Average heavy metal in plant samples}} \times 100 \qquad (1)$$

Translocation index may be an important parameter for selection of plant species that can grow on a contaminated site of heavy metals. The plants that has translocation index more than 100 can be suggested as hyper accumulator plant species for particular metal.

Cabbage were found to have translocation index more than 100 i.e 103.06 for Fe, While Cauliflower has translocation index 110.77 for Cu (table3). These plant species can be suggested as hyper accumulator species for Fe and Cu, but these plant species are edible plant hence can not be suggested to grow on metal contaminated site.

The environmental exposure risk to the populations from these elevated levels of metals in vegetables in area receiving wastewater has been evaluated by first computing the mean estimated total daily intake (TDI) of each of these metals using Eq. (2)

$$\text{TDI (mg/day)} = \text{S C.D} \qquad (2)$$

Where C is the mean concentration of individual metal in the vegetables and D is the mean daily intake of the same media by a person. The major intake routes considered are drinking water (2.5 l/d), food grains (600 g/d), vegetables (300 g/d) and milk (200 g/d). The computed TDI (mg/d) values for each metal are then compared with their respective acceptable daily intake (ADI) values (mg/d). Worked out from their individual ADIs (mg/d) as available in literature for a person of 60 kg body weight.

The risk quotient (RQ) for each metal was computed using Eq. (3)

$$\text{RQ} = \text{TDI} / \text{ADI} \qquad (3)$$

The computed results for the metals only for which ADI values are available are presented in table (4).

As a general principle, the population exposed to toxic metals will be at risk with respect to metals, if the value of the respective risk quotient (RQ) is above 1.0. (Singh *et al.* 2004). However if we compare the two population groups for their relative risk with respect to some common heavy metals to which these are exposed, their respective RQs may give an assessment of their relative risk level for that particular metal.

The exposure risk levels of the exposed population groups to heavy metals are given in table (4).It is quite clear from table (4) that except Cu(1.08) none of the metal were found to exceed the RQ value more than 1.0.While in case of Fe the RQ value were found 0.935 which is nearer to 1.0. Thus it can be concluded that these two metals were at higher exposure risk and will pose threat to human health in the exposed area receiving wastewater.

Table: 1 Average concentration of heavy metals in the different plant and soils collected from the field irrigated with the industrial effluent.

Name of the plant	Fe	Cu	Cr	Pb	Cd
Brinjal	42.40 ± 1.92	39.43 ±15.27	14.45 ±0.64	0.98 ±0.18	0.95 ±0.05
Soil	46.53 ±2.90	42.12 ±2.65	16.35 ±0.76	5.32 ±0.67	4.32 ±0.15
Capsicum	30.45 ±2.88	28.38 ±0.95	6.87 ±2.12	0.88 ±0.08	0.93 ±0.05
Soil	55.08 ±3.00	29.90 ±0.92	18.55 ±0.85	3.72 ±0.20	4.43 ±0.72
Cauliflower	53.08 ±1.61	24.77 ±0.72	5.37 ±0.17	2.27 ±0.21	1.05 ±0.20
Soil	84.50 ±0.50	22.36 ±0.46	12.73 ±0.54	3.03 ±0.15	4.30 ±0.26
Cabbage	88.17 ±1.46	69.26 ±19.16	137.96 ±39.64	7.65 ±1.17	1.60 ±0.13
Soil	85.55 ±2.00	80.32 ±0.85	207.68 ±2.07	10.89 ±0.33	4.58 ±0.41

± = Standard Deviation
All values are in µg/g

Table 2: Concentration of metals in different parts of plants.

Plants	Fe	Cu	Cr	Pb	Cd
Brinjal	L>S>R>E.P (46.25)(44.92)(34.25)(20.12)	L>S>R>E.P (41.3)(34.7)(28.35)(18.23)	L>S>R>E.P (15.65)(12.0)(11.45)(10.45)	R>L>S>E.P (1.2)(0.68))(0.54)(0.52)	R>L>S>E.P (1.0)(0.59)(0.54)(0.52)
Capsicum	L>S>R>E.P (35.45)(32.14)(29.32)(19.25)	L>S>R>E.P (28.25)(22.75)(18.25)(14.52)	S>R>L>E.P (16.25)(15.25)(12.12)(11.35)	L> <R>S>E.P (2.0)(2.0)(1.6)(0.68)	R>L>S>E.P (1.1)(0.88)(0.76)(0.62)
Cauliflower	L>R>S>E.P (66.5)(54.56)(45.75)(35.26)	L>R>S>E.P (55.6)(42.5)(30.4)(28.25)	R>S>L>E.P (18.25)(17.25)(15.6)(12.45)	R> <L> <S>E.P (2.5)()(2.5)(2.5)(2.1)	R>L>S>E.P (1.2)(1.0)(0.99)(0.95)
Cabbage	R>S>E.P (84.8)(52.8)(45.23)	R>S>E.P (82.3)(42.8)(41.25)	R>S>E.P (16.2)(15.26)(14.25)	R>S>E.P (3.0)(2.5)(2.1)	R>S>E.P (1.2)(0.96)(0.92)

L= Leaves, R = Root, S = Stem, E.P=Edible part

Table: 3 Translocation index of different heavy metals in different plant

Plants	Fe	Cu	Cr	Pb	Cd
Brinjal	91.12	93.61	88.37	18.42	21.99
Capsicum	55.28	94.91	37.03	23.65	20.99
Cauliflower	62.81	**110.77**	42.18	74.91	37.20
Cabbage	**103.06**	86.23	66.42	70.24	22.92

Table: 4 Exposure risk of metals in area contaminated with flash torch and battery manufacturing industry

Metal	Metal concentration Vegetable (Edible part) µg/g	Intake per day Vegetable µg/d (300g)	TDI mg/d	ADI mg/kg b.w	TDI mg/d b.w=60 k.g	Risk Quotient TDI/ ADI
Fe	29.96	8988	44.88	0.8	48	0.935
Cu	25.56	7668	32.66	0.5	30	1.08
Cr	12.13	3639	7.35	----	---	-----
Pb	1.35	405	0.091	0.05	3	.030
Cd	0.75	225	0.028	0.007	0.42	.066

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