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To Detect Heavy Metals Accumulation in Sewage Water Irrigated Green Leafy Vegetables

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ABSTRACT

Disposal of sewage water and industrial wastes is a great problem. Often, it is drained to the agricultural lands where it is used for growing crops including vegetables. Though, these sewage effluents are considered a rich source of organic matter and other nutrients but they also elevate the level of heavy metals like Iron, Manganese, Copper, Zinc, Lead, Chromium, Nickel, Cadmium, and Cobalt in receiving soils. As a result, it leads to contamination of the food chain, because vegetables (especially green leafy vegetables) absorb heavy metals from the soil polluted by air and water. In the present research work the concentration of four heavy metals viz. cadmium, lead, zinc and copper was analyzed in ten types of vegetables whereby the soil was irrigated by sewage contaminated water in the areas of village Banur, tehsil Rajpura, district Patiala, Punjab, India. It was found that concentrations of cadmium, lead, zinc and copper was highest in mustard, fenugreek, mint and tomato respectively with values of 37.60, 37.45, 202.40 and 39.99 mg/kg which was beyond the safe limits and lowest respectively in case of tomato, radish, cauliflower and again cauliflower with values of 0.01, 0.75, 0.564 and 0.221 mg/kg.

The metal content in vegetables from agricultural areas indicates high levels of soil contamination and there is a potential danger of heavy metal accumulation particularly cadmium and lead in vegetables grown in vicinity of Village Banur. The results indicate that the consumers are purchasing vegetables with high level of heavy metals.

Keywords: sewage effluent, agricultural land, heavy metals, concentration, soil pollution.

I. INTRODUCTION

Vegetables form an important part of the human diet because they are a source of balanced diet. Green leafy vegetables are the example of minimally processed foods, which are often consumed raw or with minimal processing. In recent year's consumption of vegetables as food has increased gradually, particularly among the urban community. This is due to increased awareness on the food value of vegetables, as a result of exposure to other cultures and acquiring proper education. In many parts of world, wastewater used for irrigation is either contaminated with sewage water or completely of sewage origin. Little information is available on the quality of agricultural produce from wastewater-irrigated fields and /or its quality at local markets, although it is evident that the use of wastewater in agriculture is common in many parts of India. This water is used without any treatment as the building of treatment plants is expensive, and the farmers are also willing to use the untreated wastewater. Though, farmers know that yields would increase by using this water, however, they are not aware of increased health risks and environmental concerns of using this untreated wastewater. Different substances occur naturally in our environment as a consequence of natural events. Chemical contamination from sources such as industries, vehicles and pesticides can affect the safety and quality of food.

Heavy metals are one of the important contaminants found on this surface and in the tissue of fresh vegetables. Heavy metals are mobile and easily taken up by the plants in the environment and accumulation of metals in vegetables may pose a direct threat to human health (Mohajer *et al*., 2012). Prolonged human consumption of unsafe concentrations of heavy metals in foodstuffs may lead to the disruption of numerous biological and biochemical processes in the human body. Heavy metal accumulation gives rise to toxic concentrations in the body, while some elements (e.g. arsenic, cadmium, chromium) act as carcinogens and others (e.g. mercury and lead) are associated with developmental abnormalities in children. Heavy metals are given significant interest throughout the globe due to their toxic, mutagenic and teratogenic effects even at very low concentrations (Oluwole *et al*., 2013). The major sources of metals are wastewater untreated or partially treated industrial effluents, municipal wastes and vehicles (Mahmood and Malik, 2014; Rasheed *et al.*, 2014).

The health risks are when these metals are present above the safe or permissible limits (Balkhair *et al.*, 2015). The same depends on the chemical composition of the waste material, its physical characteristics, the vegetables cultivated and the exposure to heavy metals (continuous and ever increasing). The present study is therefore proposed with the objective of detection of accumulation of the concentrations of various heavy metals in the sewage water irrigated green leafy vegetables so as to access the potential risk of exposure to human populations if these metals are consumed along with the vegetables on regular basis.

II. MATERIAL AND METHODS

2.1 Study Site And Sampling

Sample of ten types of vegetables (Spinach, Coriander, Cabbage, Mint, Cauliflower, Onion, Mustard, Radish, Tomato, Fenugreek) were collected from wastewater irrigated fields of village Banur, tehsil Rajpura, district Patiala, Punjab, India (photoplate-1). 6 specimens of each vegetable were collected randomly at a time in sterilized plastic bags for detection of heavy metals. All the specimen samples were collected carefully by placing the sterilized plastic bag over the plant. The plastic bags were then sealed and immediately transferred to laboratory for processing.

2.2 Determination Of Heavy Metals In Plant Samples:

Samples weighing about 5g were washed in running tap water followed with distilled water and dried in oven at 70°C for 24 hour. From these, 1g samples were grounded using mortar and pestle followed by wet digestion with HNO_3 and $HClO_4$ in the ratio of 3:1 (Tappi, 1989). The samples were digested on a hot plate at 100°C for 3-4 hours (photo plate-2). Heating was done in such a way that it did not boil the samples and dried up completely to a whitish dry mass. After cooling to room temperature, the residues were extracted in acid water mixture (HCl and distilled water in the ratio of 1:1) and filtered through whatman filter paper No 42. The volume was made up to 50 ml. The filtrate was analyzed for metal content using Atomic Absorption Spectrophotometer.

III. RESULTS AND DISCUSSION

3.1 Sample:

Six specimen of each vegetable sample that is (10 in number) were collected from wastewater irrigated fields of village Banur, tehsil Rajpura, district Patiala, Punjab, India and numbered properly to analyzed and record for the presence of four heavy metals cadmium, lead, zinc and copper and the results obtained are given below (Table 1).

3.2 Heavy Metals Concentration In Vegetable Samples:

All the collected vegetable samples observed had cadmium value within the permissible limits except for mustard (*Brassica Juncea*) which had very high concentration of cadmium with value of 37.6 mg/kg and onion (*Allium cepa*) having cadmium concentration of 5.7 mg/kg. In case of lead, maximum vegetables had lead content above permissible limits with exception to radish, tomato and cauliflower. Maximum lead content of 37.45 mg/kg was observed in samples of fenugreek. In case of zinc the following vegetables fenugreek, cabbage, mustard, tomato and cauliflower had metal concentration below the safe limits whereas the other vegetable samples had metal concentration above safe limits and among them mint had the highest concentration of 202.40 mg/kg. In case of copper all the vegetables samples had heavy metal content below the safe limits except tomato which had the metal concentration of 39.99 mg/kg. Thus, most of vegetables according to our observation had more contamination of lead as compared to other metals cadmium, zinc and copper and the order was Pb>Zn>Cd>Cu. The results were compared according to the safe limits of metals in edible parts of vegetable according to the Indian Standards (Awasthi, 2000).

Table-1: Heavy metal concentration in random samples of vegetables (mg/kg)

Vegetable	Scientific Name	Cadmium	Lead	Zinc	Copper
Spinach	*Spinacea oleracea*	1.00	27.75	94.5	11.65
Coriander	*Coriandrum sativum*	0.95	5.75	70.25	5.13
Fenugreek	*Trigonella foenum-graecum*	0.80	37.45	31.30	5.20
Cabbage	*Brassica oleracea var. capitata*	0.55	29.95	28.75	9.70
Mustard	*Brassica Juncea*	37.6	17.5	26.0	3.25
Radish	*Raphanus sativus*	0.59	0.75	63.15	12.52
Tomato	*Lycopersicon esculentum var. esculentum*	0.01	1.94	46.20	39.99
Mint	*Mentha requienii*	0.09	3.07	202.40	24.43
Cauliflower	*Brassica oleracea var. botrytis*	0.11	1.22	0.564	0.221

Onion	*Allium cepa*	5.7	22.8	110	16.30
Indian Standards of Safe Limit of Heavy Metals in Edible Parts (Awasthi, 2000)		**1.5**	**2.5**	**50**	**30**

Several studies have shown that vegetables, particularly leafy crops, grown in heavy metal contaminated soils have higher concentrations of heavy metals than those grown in uncontaminated soil (Guttormsen *et al.*, 1995; Dowdy and Larson, 1995).

Singh *et al*. (2010) reported very high concentrations of Pb and Cd for vegetables collected around the Dinapur sewage treatment plant in Varanasi, India and these were very high than the safe limits. Ramesh and Murthy (2012) analyzed waste water, soil and green leafy vegetable samples from five stations of Bangalore urban district for the heavy metals namely Cu, Zn, Pb, Cr, Cd and Mn. Of the two leafy vegetables palak (Beta vulgaris) and coriander (Coriandrum sativum), palak leaves contained Cu, Zn, Pb, Cr and Mn in all the sampling points. Cr at S1, S2 and S5 stations crossed safe value limit recommended by FAO/WHO. In coriander leaves Cu, Zn and Mn was found in all stations. Pb concentration was exceedingly high in palak (28.43ppm to 149.50ppm) and coriander (54.69ppm to 75.50ppm) in all sampling stations. Cd was detected only at two stations in S2 (0.81ppm) and S4 (1.50ppm). Cr was detected at S1, S2 and S3 stations and at S2 station, Cr content in palak (70.79ppm) and coriander (127.27ppm) was alarmingly exceeding the allowable limit.

Kumar *et al*. (2017) in their study observed high level of Pb in all vegetables grown at SWI zone. Among the edible parts, the maximum Pb concentration at SWI locations which exceeded the Indian safe limits was recorded in spinach (at Dalan east) followed by cabbage (at Sarinia east), cauliflower (at Deheria), coriander (at Dalan east), carrot and potato (at Deheria). The Pb content in vegetables grown at GWI zone was lower than EU standards (0.43 mg/kg) except cauliflower at Sarnia east and spinach at Deheria. The accumulation of Cu in the test vegetables grown at SWI zone was found to be in the range of 1.68-11.2 mg/kg which was 10 fold greater than vegetables collected from GWI zone (0.35-1.21 mg/kg). The concentration of Cu in vegetables at SWI zone was in the range of normal plant value (5-15 mg/kg) but below the critical plant value. Mean concentration of Cu was significantly high in non leafy vegetables such as potato (8.72 mg/kg) and carrot (8.45 mg/kg).

Yang *et al.,* (2002) reported that Cu levels in both root and shoot increased, but in root Cu concentration increased more sharply than shoot with increasing Cu levels in the growth media. Copper mainly accumulated in roots while certain fraction of absorbed Cu was transferred to shoot. Alam *et al.,* (2003) reported mean Cu accumulation in leafy and non leafy vegetables as 15.5 and 8.51 mg kg-1 respectively. The concentration of copper in the shoots was significantly influenced by Cu concentration in soil (Xiong and Wang, 2005). The accumulation of Cu (0.221-39.99 mg/kg) in our study was also lower than accumulation of Cu (22.19-76.50 mg/kg) in the leafy vegetables reported by Demirezen and Alsoy, 2006. The mean Cu concentration value was minimum (0.9 mg/kg) in rice (AS-1) and maximum (123.5 mg/kg) in amaranthus (AS-13) and except for rice, brinjal, and cauliflower, concentration of Cu exceeded the safe limits in all vegetables. Pb and Cd were found higher than the safe limits of both the elements in all the vegetables / cereals. Similarly, Zn and Ni concentrations were much above the permissible limits in all crops / vegetables except Zn in rice (Chabukdhara *et al*., 2016). The risk of human health by heavy metals through the intake of common vegetables i.e. *Solanum lycopersicum*, *Solanum melongena*, *Amaranthus tricolor* L., *Chenopodium album* L., *Spinacia oleracea* and *Coriandrum sativum* obtained from the largest coal burning basin, Korba, India was accessed. The vegetables were found to contain Fe, As, Cr, Mn, Cu, Zn, Cd, Pb and Hg (Ramteke *et al*., 2016).

The reason for this could be that the uptake of metals by plants depended on the availability of metals in the soil to the plants (Khairiah *et al.*, 2004). However, only soluble, exchangeable and chelated metal species in the soil are mobile and hence, more available forms for plants (Arambarri, 1999). Elevated levels of heavy metal in soils may lead to their uptake by plants, which depends not only on heavy metal content in soils but is also determined by soil pH, metal content in soil, organic matter and clay contents and fertilizers. These parameters cannot change the total amount of heavy metals but can significantly affect the bioavailable part.

Most of leafy (aerial) part of vegetable shows higher Cd accumulation compared to root (ground) part. It has been found that Cd is a highly mobile metal and can be easily absorbed by the plant through root surface and moves to wood tissue and transfers to upper parts of the plant. Therefore, there is direct relation between the levels of presence of Cd in the root zone and its absorption by plant (Rarnos *et al.*, 2002). One of the explanations for high level of Pb in sewage water and some locations of ground water irrigated vegetables could be the uptake of Pb promoted by soil pH and the levels of organic matter (Balkhair and Ashraf, 2015).

Within the same environment, different vegetables have different accumulation power to accumulate the heavy metals. The concentration of Ni, Cr, Cu, Cd, Pb and Mn was high in cauliflower which may be due to higher exposed area of inflorescence and has greater capacity to absorb heavy metals from atmosphere (Sharma *et al.*, 2009). The accumulation of heavy metals in coriander, cabbage spinach (leafy vegetables) was high and it may be due to the large surface area of their leaves, their high transpiration and faster growth rate, which enhances the metal translocation in leafy vegetables sensitizes them to be recipient of dust and rain water splashes (Luo *et al.*, 2011).

IV. CONCLUSION

The soil irrigated with sewage water in the studied area was extremely contaminated with heavy metals specially Pb, Zn, Cd and Cu. They were accumulated in the vegetables and their continuous consumption may disturb the biological and biochemical function in the human body. The heavy metals in the edible parts of vegetables indicate greater accumulation, which may be due to high biomass production. Therefore, continuous monitoring of the water quality, soil and plant of the study area and develop different strategies to prevent the entering of heavy metals in food chain may ultimately minimize the potential health hazards to human beings.

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Photo Plate 1 : Waste water irrigation at Banur Village