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EXTENT OF HEAVY METAL CONTAMINATION IN LEAFY VEGETABLES, SOIL AND WATER FROM SURROUNDING OF MUSI RIVER, HYDERABAD, INDIA

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ABSTRACT

Present research is aimed towards detection of heavy metals in leafy vegetables from surroundings of Musi River which is polluted with sewage, domestic effluents and industrial wastes flows through the city of Hyderabad, Andhra Pradesh, India. The leaf samples were analyzed for the heavy metals namely Cu, Zn, Pb, Fe, Cd and Mn using Atomic Absorption Spectrophotometer (AAS). The extent of heavy metal contaminations were investigated in three leafy vegetables viz., Palak (*Beta vulgaris*), Thotakura (*Amaranthus*) and Chukkakura (*Rumex* sp.), soil and water of Musi River. Results showed that, leafy vegetable Chukkakura had the highest metal load (801.78 mg kg^{-1}) followed by Palak (550.97 mg kg^{-1}) and Thotakura (493.34 mg kg^{-1}).

INTRODUCTION

Green leafy vegetables are predominantly known for their high nutritional content and are mostly consumed for health and nutritional benefits. Generally an industrial, mining and agricultural waste contains heavy metals and metalloids, viz. Cu, Zn, Pb, Fe, Cd and Mn (Devkota *et al*., 2000; Sharma *et al*., 2006). When the heavy metal polluted water from industries are uses as the source of irrigation for vegetable crops then it is absorb by crops through root transportation system. These absorbed heavy metals have a tendency to accumulate along the food chains, and cause health and toxicity problems not only for the environment, but also for human beings.

Hyderabad is a metropolitan city and there is no sufficient field for cultivation of agriculture due to insufficient land and water resources. Most of the farmers groves vegetable crops at surrounding of Musi River which is polluted with sewage and untreated

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industrial effluents. Rivers are being polluted with heavy metals coming from untreated or partially treated industrial effluents and by indiscriminate disposal of untreated domestic wastes and sewage directed to these rivers (Paulsson, 1990). Besides heavy metals, other harmful toxics such as pharmaceuticals, detergents, various salts, pesticides, toxic organics and flame retardants are also present in the sewage sludge (Reed *et al*., 2002; Togay *et al*., 2008).

Heavy metals are non-biodegradable and thermo stable and thus readily accumulate to toxic levels (Singh *et al*., 2006, 2010). Toxicological significance of heavy metals has been recognized several decades ago in developed countries (Tsuda *et al*., 1995). Untreated sewage water irrigation plays a pivotal role in significantly increasing heavy metals in soil and crops (Mapanda *et al*., 2005) and increases individual metal in soil by 2% to 80% and in crops by 14% to 90% (Ahluwalia and Goyal, 2007).

Vegetables constitute an important part of the human diet since they contain proteins, vitamins, as well as carbohydrates, minerals, and trace elements. Green leafy vegetables are predominantly known for their high nutritional content and are mostly consumed for health and nutritional benefits. It is known that serious systemic health problems can develop as a result of excessive accumulation of dietary heavy metals such as Cd, Cr, and Pb in the human body. Consumption of heavy metals-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho-social behavior, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et al*., 2008). This has given an impetus for the cultivation of leafy vegetables in soils and water without heavy metals to reduce the level of toxicants in leafy vegetables and vegetable crops.

MATERIAL AND METHODS

To study the level of trace heavy metal contaminants in leafy vegetables viz., Palak (*Beta vulgaris*), Thotakura (*Amaranthus*) and Chukkakura (*Rumex* sp.), soil, and water were collected from three different vegetable farms of Hyderabad (Nagole, Uppal and Edulabad). Leafy vegetables were collected randomly and washed thoroughly under tap water followed by distilled water to remove adsorbed elements. Samples were cut into small pieces; air dried for 2 days and kept in hot air oven at 100°C±1°C for 4 hrs. Dried samples were grounded to powder and then pass through a 1mm sift. 0.5g of samples was taken in reference vessels; added 4mL of HNO_3 and 0.2mL of H_2O_2 and carousel was positioned into microwave. The system was preprogrammed for 1 min. of microwave digestion at 250W power and another 5 min. at 500W power and left to automatic ventilation for 10min. Digested solution was cooled, filtered using Whatman filter paper No. 40 and made up to 100 mL with distilled water and stored in plastic bottles for analysis. Control leafy vegetables were obtained from areas where normal irrigation practices were followed with treated water. Random soil sample of about ½ kg were collected at a depth of 0 - 25 cm from 4 different places and stored in polythene covers. Samples were air dried at room temperature, ground to a fine powder using mortar and pestle and packed in1mm nylon mesh. 0.25g of soil samples were poured into reference vessels. Then 2.5 ml concentrated HNO_3 and 2.5 mL of HF (Hydrofluoric acid) acid was added and inserted into a carousel into microwave unit for digestion. System was preprogrammed for 6 min. of microwave digestion at 300W powers and another 5 min. at 500 W power and automatic ventilation for 10 min. Further solution was cooled, filtered using Whatman filter paper 40 and made up to 100 mL with distilled water then it was stored in pre-cleaned plastic bottles and used for analysis. Control samples were obtained from station where normal practices were followed.

Water samples were collected separately from different locations of Musi River in pre-cleaned 100 mL polythene bottles and 2 mL of $HNO_3$was added as preservative. It was kept in insulated field kit containing ice 10 mL of water sample and 1 mL concentrated HNO_3 was taken in Teflon tubes. Vessel was closed with valve and tightened then it was inserted into a single safety shield carousel into microwave chamber. System was pre-programmed using Ethos D control terminal (equipped with software) for 5 min. of digestion at 250 W power and automatic ventilation for 2min. Digested solution cooled and made up to 100 mL with distilled water. Samples stored in precleaned plastic bottles were used for analysis with Atomic Absorption Spectrophotometer (AAS, GBC 902 Australia with 26 Hallow Cathode Lamps). Control samples were collected from station where normal water was used for irrigation.

RESULTS AND DISCUSSION

Present investigation showed that highest level (mg/

kg) of Zn (59.76) was observed in *Amaranthus* and lowest in Chukkakura. Further highest level of Cu (58.36), Fe (597.86), Cr (53.11) and Pb (34.56) was reported in Chukkakura, while it was lowest in *Amaranthus*. Likewise highest level of Mn (11.47) and Cd (2.97) was reported in Palak, while it was lowest in *Amaranthus* and Chukkakura (Table 1). The results indicated that high level of Zn and Pb found in soils ranged 0.890-17.46 and 1.12-37.32 mg.kg^{-1}, while the level of Zn and Pb in sewage sludge was 0.01-7.026 and 0.03-0.80 mg.kg-1respectively (Table 2 & 3). However, the Cd concentrations in all soil samples were within the normal range (0.0147-2.13 mg.kg^{-1} the levels of Cd in sewage sludge were 0.002-0.054 mg.kg^{-1}. The mean concentrations of Cu were found 16.53 and 0.016 mg.kg^{-1} dry for agricultural soil and sewage sludge respectively. The level of Fe in sewage sludge was obtained 86 mg. kg^{-1}, while in soil it was 71.32mg.kg^{-1}.

In accordance with the standard guideline of FAO/ WHO, it was found that concentrations of Ni, Cr and Pb in samples of soil and water samples collected from Nagole, Uppal and Edulabad farms exceeded the recommended levels. The amount of Pb in Chukka, Palak, and Amaranthus was significantly higher in samples collected from Nagole farms than those of, Uppal and Edulabad farms Also, the amount of Cr in the Palak, Amaranthus, Chukka was significantly higher in samples collected from Uppal farms than those of Nagole and Edulabad farms (Fig. 1). However, the amount of Pb in the Palak, Amaranthus, Chukka was significantly higher in samples collected from farms Nagole than those of Uppal, and Edulabad farms (Fig. 2). In the present investigation concentrations (mg/ kg) of the heavy metals in different locations were ranged from 15.82 (Uppal) to 97.5 (Nagole) for Zn, 5.38 (Edulabad) to 24.52 (Nagole) for Cu , 31.00

Table 1. Details of heavy metals (mg kg^{-1}) recorded in the selected leafy vegetables

Eleents in leafs	Palak	*Amaranthus*	Chukka	Mean
Zn	56.47	59.76	44.59	53.606667
Cu	42.06	37.41	58.36	45.943333
Fe	379	338	597.86	438.28667
Mn	11.47	7.96	11.36	10.263333
Cd	2.97	2	1.94	2.3033333
Cr	32.65	24.95	53.11	36.903333
Pb	26.35	23.26	34.56	28.056667
Total	550.97	493.34	801.78	615.36333

Table 2. Details of heavy metals (mg kg_{-1}) recorded in soil sample

Element	Range	Mean	Permissible
Zn	0.890-17.46	10.02	__
Fe	10.10-124.48	71.32	__
Mn	8.5-19.35	12.04	__
Cd	0.0147-2.13	0.27	0.5
Cr	0.160-2.10	1.29	2
Pb	1.12-37.32	13.12	5
Cu	1.22-41.60	16.53	__

Table 3. Details of heavy metals (mg kg^{-1}) recorded in water sample

Element	Range	Mean	Permissible
Zn	0.01-7.026	0.012	5
Fe	13-150	86	0.3
Mn	4.2-14.7	10.3	0.1
Cd	0.002-0.054	0.025	0.005
Cr	0.012-0.011	0.085	0.05
Pb	0.03-0.80	0.21	0.05
Cu	0.011-0.20	0.016	1

Table 4. Details of heavy metals (mg kg^{-1}) recorded in the leafy vegetables collected from different locations

Element	Uppal		Nagole		Edulabad	
	Range	Mean	Range	Mean	Range	Mean
Zn	15.82-96.10	55.01	21.78-97.56	61.08	18.62-9.65	52.035
Cu	5.92-21.62	13.47	6.03-24.52	14.85	5.38-22.43	12.92
Fe	61-1205	603.5	31-1319	626	65-897	505
Mn	4.9-81.1	42.15	7.1-82.5	39.75	5.91-81.45	42.675
Cd	1.21-9.32	5.005	0.67-7.94	6.73	1.2-10.25	4.035
Cr	22.03-64.29	41.43	18.76-54.10	34.64	16.27-52.13	33.065
Pb	1.53-70.42	39.465	6.11-87.87	43.205	4.96-77.55	41.465
Total heavy metal load		800.03		826.255		691.195

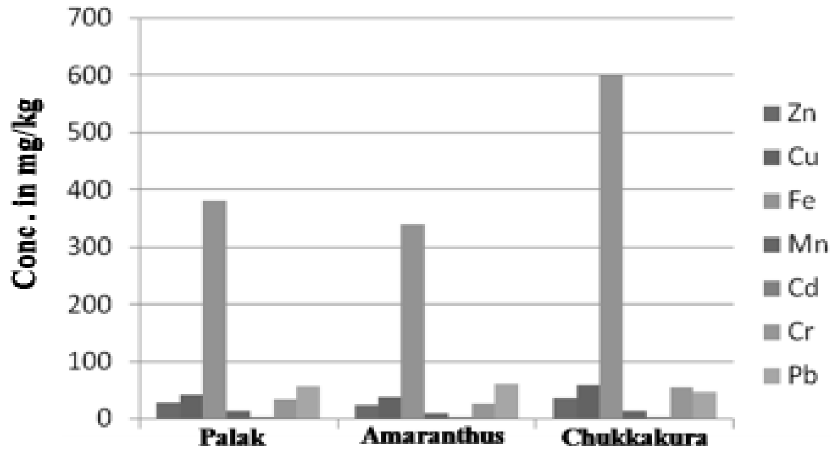

Fig. 1 Concentration of heavy metals in mg/kg in different leafy vegetables

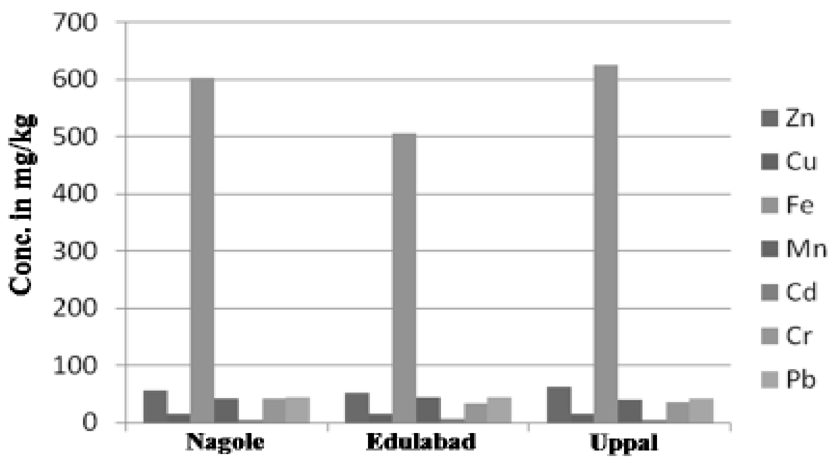

Fig. 2 Concentration of heavy metals in mg/kg in different locations

(Nagole) to 1319 (Nagole) for Fe, 4.9 (Uppal) to 82.5 (Nagole) for Mn, 0.67 (Nagole) to 9.32 (Uppal) for Cd,16.27 (Uppal) to 64.29 (Uppal) for Cr ,1.53 (Uppal) to 87.55 (Nagole) for Pb (Table 4). Our findings showed that the highly concentrated heavy metal was Pd in case of Chukkakura (Table 4)

Urbanization and industrialization in many parts of the world have increased the presence of metals into the terrestrial environment which have potential health impacts of consuming contaminated products such as vegetables. In this study, samples and coworkers showed that the daily intake of Cd, Cr and Pb in Iranian women was about 0.027, 0.05 and 0.091 mg, respectively and in Iranian men it was about 0.046, 0.050 and 0.109 mg, respectively (Gharib *et al*., 2003). WHO/FAO recommended a minimum of 400g of fruit and vegetables per day (excluding potatoes and other starchy tubers) for the prevention of chronic diseases such as heart disease, cancer, diabetes, and obesity (http://www.who.int/dietphysicalactivity/fruit/en/).Therefore, vegetables contamination with heavy metal could be an important concern in Iranian suggesting periodical monitoring of them in the human food chain. Different studies have shown that there were significant differences between vegetables of various cities and villages (Demirezen *et al*., 2006). It can be concluded, from the findings of this study, that the amounts of Cd, Cr, and Pb were higher than the acceptable levels recommended by WHO/FAO. Also, higher amount of Cd and Cr in some samples collected from the amount of total heavy metal load was higher in Nagole (826.255) than those of Uppal (800.03) and Edulabad (691.195 mg kg^{-1}) farms. In three green vegetables Chukka (801.75) was reported highest heavy metal load than Palak (550.97) and *Amaranthus* (493.34). Due to the importance of this issue and changes in the sources of contamination, it is recommended to conduct studies with this nature periodically.

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