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UPTAKE OF HEAVY METALS BY *BRASSICA COMPESTRIS*, IRRIGATED BY HUDIARA DRAIN IN LAHORE, PAKISTAN

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ABSTRACT

The aim of this study was to investigate the uptake of heavy metals in a cash crop and vegetable, *Brassica compestris* irrigated by Hudiara drain. A survey was conducted along the whole length (55km) of Hudiara drain from Lallo village to Khurdpur village. Twenty nine samples of freshly plucked leaves of *B. compestris* were collected at three sites, Lallo village (Site 1), Mohlanwall (Site II) and Khurdpur village (Site III). Heavy metals like Na, Mg, Al, K, Ca, Mn, Fe and Zn were detected by PIXE technique from tender parts of *B. compestris* leaves of all samples. The mean concentrations of heavy metals in *B. compestris* leaves samples from Sites I, II and III were; Na (3053, 16941, 25025ppm), Mg (2668, 10826, 16158ppm), Al (1152, 4740, 27201ppm), K (35214, 104643, 112038ppm), Ca (13827, 49586, 110263ppm), Mn (0, 168, 244ppm), Fe 9277, 470,1615ppm) and Zn (223, 169, 179ppm). The heavy metals concentration in *B. compestris* increased from site I to site III gradually. The concentrations of heavy metals were significantly high in all samples, when compared to permissible International standards set by FAO/WHO, SEPA, and India. It is concluded that Hudiara drain is highly polluted due to the addition of untreated industrial effluents and city sewage both in India and Pakistan. The use of *B. compestris* grown on water from Hudiara Drain can have a very serious impact on human health and other organisms of the area.

Keywords: Hudiara drain, heavy metals, *Brassica compestris*.

INTRODUCTION

There are social and legal issues for the use of polluted water for agriculture purpose causing threats to plants. In this way elevated transfer of heavy metals to food chain cause threat to human health (Wang *et al*., 2003; Singh and Agrawal, 2010). However, long term irrigation of land with polluted water can cause their accumulation in the soil (Dai *et al*., 2006). Many food plants take these heavy metals from this soil and start to accumulate in various tissues (Khan *et al*., 2010). Some plants have adapted various strategies to deal with harmful effect of bioaccumulation of heavy metals on their bodies. Different plants have different ability to absorb, accumulate and to tolerate heavy metals (Bhogal *et al*., 2003; Singh and Agrawal, 2008, 2010; Hernandez *et al*., 2010). In spite of all this, heavy metals have adverse effects on plant health like oxidative stress, effects on photosynthesis, chlorophyllfluorescence, stomatal resistance and stunted growth (Monni *et al*., 2001; Fayiga *et al*., 2004). Metals tend to accumulate at both high and low concentration in the upper parts of plants as compared to soil (McGrath *et al*., 2001). This accumulation might be suggested as a self-defense strategy of plants against herbivores and pathogens (Poschenrieder *et al.*, 2006). When such contaminated plants are consumed by humans, heavy metals start to accumulate in human body through food chain. The main route of heavy metals to accumulate in human body is through dietry intake (Sharma *et al*., 2008). The ingestion of heavy metals (Na, Mg, Al, K, Ca, Mn, Fe, Zn and etc.) can cause serious diseases in human beings, such as; decrease in immunological defenses, Psychosocial dysfunctions, intrauterine growth retardation (caused by Al, Mn and Pb), and serious carcinogenic effects on various body parts (Lyengar and Nazir, 2000; Turkdogan *et al.*, 2003; Khan *et al.*, 2010; Singh and Agrawal, 2010; Khillare *et al.*, 2012). Excess of Na in human body causes cirrhosis, heart failure and high blood pressure (Lichtenstein *et al.*, 2006). Aluminium is familiar environmental neurotoxin. Excess of Al causes several neurodegenerative diseases such as Alzheimer's disease and amyotrophic Lateral Sclerosis/ Parkinsonism-dementia of Guam (Oyanagi, 2005; Miu and Benga, 2006; Savory *et al*., 2006). High level of Potassium in blood may lead to Hyperkalemia (USDHHS, 2010). Too much Calcium in the body causes Milk-Alkali Syndrome with symptoms ranging from hypercalcemia to potentially renal failure (Beall *et al.*, 2006). High level of oral exposure of Mn causes "Manganese-Induced Parkinsonism. Excess of Fe has been related to most common hereditary disease known as hemochromatosis.

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Increased oral intake of Fe causes many neurological disorders, cancer, fancoui anemia, stroke and aging. Higher uptake of Zn causes lethargy, focal neuronal deficit, respiratory disorders, epigastric pain, nausea/ vomiting, metal fume fever and increase prostate cancer risk (Plum *et al.*, 2010). The aim of this study was to determine heavy metals concentration in edible parts, the leaves of *B. compestris* irrigated with Hudiaradain. The whole plant of *B. compestris* is used as fodder, its leaves are used as vegetable in Pakistan and seeds are used for the extraction of mustard oil. Hence, it is very important cash crop.

MATERIALS AND METHODS

A study was conducted along the whole stretch of Hudiara drain in District Lahore Pakistan to assess the bioaccumulation of heavy metals in *B.compestris* irrigated by Hudiara drain. Three sampling sites were selected. The first sampling site S- I was Lallo village; which is located about 100 meters away from India boundary in Pakistan. The second site S-II was Mohlenwal village near Multan road. The water of Hudiara drain near this village receives polluted water of Sattukatla drain. This drain is also one of the major tributaries of Hudiara drain and receives waste water of Lahore Metropolitan and from some industries. The third sampling site was S-III at Khurdpur village located at a point where Hudiara drain joins the River Ravi. Fresh samples of *Brassica* leaves were collected from agricultural fields that are permanently irrigated by drain water. Samples were first washed with clean water and then with distilled water and kept in labeled polythene bags and transported to laboratory and stored in refrigerator at 0°C. Each sample was weighed and placed in oven at 65-75°C for 72 hours for drying. Each dried sample was grinded into fine powder by pestle and mortar. Five milligram powder of each sample was taken and placed in Aluminum foil to avoid any contamination especially the moisture. Five milligram of powder of each sample was fixed on the center of transparent triangular sheet with calculated volume of Yatrium salt ($YaNO_3$). Each triangular sample attached sheet was attached with the target holder rod. All triangular sheets each with a particular sample were attached with the sample holder, and were placed in PIXE (Proton Induced X-rays Emission) chamber for metals analysis.

Proton Induced X-rays Emission (PIXE)

The analysis by PIXE is more accurate and authentic as compared to other techniques. This is a non-destructive technique, and can analyze 72 different inorganic elements. It is a time saving process (Carmona *et al*., 2010).

RESULTS

Hudiara drain

Hudiara drain is an International drain that originates from Batala, District Gurdaspure India. After being joined by many tributaries and covering 40kms it enters into Pakistan near Lallo village, east of Lahore city. This drain was originally a storm water drain but now carries sewage water mixed with untreated industrial waste, and is turned into a perennial drain (Khan *et al.*, 2003). It passes by Lallo village, Hudiara and Bedian village and then travels east of Defence road, receiving effluents from SattuKatla drain about 1km south of Raiwind road, crosses Multan road, (about 23km from Lahore) and finally joins River Ravi (about 8km west of Multan road) at Khudpur village. In Pakistan, it flows for about 55km and then falls into Ravi River (Parwaz, 1996). On its way it receives sewage disposal and various untreated industrial effluents from both India as well as Pakistan. At the point of its entry into Pakistan, Hudiara drain is highly polluted (Dar *et al.*, 1999). In District Lahore different factories and industrial units (like sugar mills, paper mills and textile mills) discharge their untreated effluents into the drain. It also receives sewage disposal from Lahore cantonment, the Defense Housing Society and Package industry. So the water of Hudiara Drain is highly polluted, grayish in color with obnoxious smell (Ayub and Tabinda, 2000).

Heavy metals accumulation in *Brassica compestris*

Eight heavy metals (Na, Mg, Al, K, Ca, Mn, Fe and Zn) were detected in the *B. compestris*. The Lowest concentration of Na (2343ppm) was detected at S-I and highest concentration (28379ppm) was observed at S-III. Lowest concentration of Mg (2127ppm) was detected at S-I and highest concentration (18300ppm) was studied at S-III. Lowest concentration of Al (991ppm) was observed at S-I and highest concentration (67378ppm) was detected at S-III. Lowest concentration of K (33901ppm) was studied at S-I and highest concentration (123441ppm) was observed at S-III. Ca in least concentration (12273ppm) was studied at S-I and in highest concentration (114113ppm) was studied at S-III. Mn was not detected at S-I, at S-II and it was in lowest concentration (127ppm) and at S-III it was detected in highest concentration (289ppm). Lowest concentration of Fe (215ppm) was studied at S- I and highest concentration (1662ppm) was studied at S-III. Lowest and highest concentration of Zn (73-322ppm) was observed at S-II (Table 1).

The comparison between the concentrations of some heavy metals recorded during present study with FAO/WHO is given in table 2. No SEPA and Indian standards value are available except for Zn (100mg/kg), and 50mg/kg respectively. Nordic counsel standards has also given only one value i.e for Fe only (10-15mg/day) and FNB standards value for Ca is 1000-1300 mg/day.

Table 1. Heavy metals concentration (ppm) in *Brassica compestris* irrigated with Hudiara Drain water at three sampling sites.

Metals	SITE 1			SITE 2			SITE 3		
	Range	Mean	S.D	Range	Mean	S.D	Range	Mean	S.D
Na	2343-3965	3053	±829.5	10282-25173	16941	±7569	22798-28379	25025	±2956
Mg	2127-3283	2668	±581	8575-15108	10826	±3710	14783-18300	16158	±1879
Al	991-1287	1152	±150	0-8229	4740	±4255	7047-67378	27201	±34794
K	33901-36301	35214	±216	97842-116803	104643	±10555	99882-123441	112038	±11796
Ca	12273-15885	13827	±1858	40291-56372	49586	±8329	104382-114113	110263	±5439
Mn	0	0	0	127-195	168	±36	205-289	244	±42
Fe	215-316	277	±55	442-495	470	±27	1587-1662	1615	±41
Zn	210-241	223	±16	73-322	169	±134	107-218	179	±63

Table 2. Comparison between the concentrations of heavy metals (ppm) in the study area and International Permissible Standards

Metals	Na	Mg	Al	K	Ca	Mn	Fe	Zn
Present study	2342-28379	2127-18300	991-67378	33901-123441	12273-110263	0-289	215-1662	73-322
FAO/WHO standards	-------	-------	1.0mg/ Kg/day	---------	------	2.0-5.0mg/day	0.8mg/kg	9.4mg/kg

DISCUSSION

Eight heavy metals Sodium (Na), Magnesium (Mg), Aluminum (Al), Potassium (K), Calcium (Ca), Manganese (Mn), Iron (Fe) and Zinc (Zn)] were detected in the *B. compestris* leaves during this study. It was observed that the concentration of all metals increased from S-I through S-II to S-III. This increase in the concentration of metals in *B. compestris* is due to excessive discharge of industrial effluents along drain stretch, as it flows toward its confluence point with River Ravi. Khan (2003) also associated high concentration of metals in Hudiara Drain with increase in Number of industrial units along the both sides of drain downstream. Concentration of heavy metals in the leaves of *B. compestris* showed a trend of highest concentration of K (33901-123441ppm) followed by Ca (12273-114113ppm), Al (991-67378ppm), Na (2343-28379ppm), Mg (2127-18300ppm), Fe (215-1662ppm), Zn (73-322ppm) and then Mn (127-289ppm).

High concentration of heavy metals in leaves reduce the rate of photosynthesis per unit area (Vassilev *et al*., 2002). When metals contaminated water is used for irrigation purpose, these metals start to accumulate in the soil and then taken up by the plants and start to store in edible parts of plants like roots, stems, shoots and fruits. These heavy metals can cause adverse effects on plants health and ultimately reach to the human body directly or indirectly through food chain and causes serious diseases. The green leafy vegetables start to accumulate high concentration of heavy metals in their different body parts; compared to soil that has low concentration of the metals (Khan *et al.,* 2010). Chary *et al*. (2008) also reported the highest enrichment factor for the leafy vegetables. Some workers argue that high concentration of heavy metals in leafy parts of vegetables is due to high rate of transpiration, to retain the moisture content and growth of these plants (Tani and Barrington, 2005). The concentration of all heavy metals especially Al, Fe, Zn and Mn exceeded the permissible international standards set by SEPA (2005), and FAO/WHO (1976, 2001, 2011).

Mean concentration of Aluminium at three sampling site is significantly higher than the permissible standards set by FAO/WHO (2011). Daily dietary aluminum intakes suggested range from 2 to 6 mg/day for children and 6-14mg/day for teenagers and adults. (Sorenson *et al*., 1974; Havas and Jaworski, 1986) Tolerable Upper Intake Levels (ULs) for Calcium set by FNB (2010), for the children is 2500-3000mg/day, for young adults is 2,500mg/day and for old is 2000mg/day. Hence, the concentration of Calcium greatly exceeds the permissible standards set by the FNB at all three sampling sites in present study. Excess of Ca causes serious health hazards like kidney stone, constipation, vascular and soft tissue calcification

(FNB, 2010). At site S-I Mn was not detected but at S-II and S-III its mean concentration was considerably higher than the permissible standards set by FAO/WHO (1976), Ahmad *et al*. (2012) and Nawajei *et al*. (2012). Iron shows significant differences between S-I – S-III and S-II – S-III were but no significant difference were studied between S-I and S-II sites. The recommended daily intake of Fe as 10-15mg/day and the toxic dose of Iron in vegetables ranged from 10-200mg/kg dry and for the man 200mg/day (FAO/WHO, 1976). The concentrations of Fe were higher in the study area at all sites as compared to all International standards for Iron, and are reported by Ayub and Tabinda (2000), Khan (2003), Ahmad *et al.* (2012) and Nwajei *et al*. (2012). The concentrations of Fe in the study area were similar to the results of Yamin and Ahmad (2007). Fe concentrations were lower in the study area as compared to findings of Hernandez *et al*. (2010).

The mean concentration of Zn in leaves of *B. compestris* samples at all sampling sites exceeded the permissible limits set by SEPA (2005), Indian standards (Awashti, 2000), FAO/WHO (2001), Khan (2003), Naqvi (2006), Yamin and Ahmad (2007) and Ahmad *et al.* (2012). The concentration of Zn in the study area is lower than the results of Khan *et al.* (2010) and Hernandez *et al*. (2010).

CONCLUSION

It is concluded that Hudiara drain is highly polluted due to the addition of untreated industrial effluents from India, Pakistan and Lahore city sewage. These results derive our attention to the threat to the entire ecosystem including human population which receives these pollutants directly or indirectly through food chain. The consequences may be even worse as the Hudiara drain flows into River Ravi that irrigates millions of acres of land in the province of Punjab.

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