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OCCURRENCE, DISTRIBUTION AND HEALTH EFFECTS OF HEAVY METALS IN COMMERCIALLY AVAILABLE VEGETABLES IN KARACHI

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ABSTRACT

Human exposure to heavy metals is one of the leading public health concerns these days. The entrance of heavy metals in agricultural products through untreated wastewater is a major source that causes food chain contamination and affects humans and the environment. On the outskirts of Karachi, vegetables are cultivated on a large scale using untreated wastewater of Lyari and Malir Rivers. The present study conducted to assess levels of five heavy metals i.e. Arsenic (As), Chromium (Cr), Copper (Cu), Nickel (Ni) and Lead (Pb) in commercially available vegetables in Karachi, Pakistan. The selected vegetables found contaminated with heavy metals but in different orders i.e. in spinach, the contamination of heavy metals was in order of (Pb > Cu > As >Cr > Ni), lettuce (Ni > Pb > Cr > Cu > As), cabbage (Pb > Cu > As > Ni > Cr), spring onion (Pb > Cu > As > Cr > Ni), gourd (Pb > Cu > Ni > As > Cr), okra (Ni > Pb > Cr > Cu > As) and eggplant (Pb > Ni > Cr > Cu > As). The chronic exposure to these toxic metals via food may cause various clinical manifestations, damage vital organs and produce cancers. Moreover, the authors recommend banning the use of untreated wastewater for agricultural practices in Karachi.

Key-words: Heavy metals, Health, Vegetables, Karachi, Wastewater, Toxicity.

INTRODUCTION

Heavy metals are persistent, highly toxic to human health and have the ability of bioaccumulation (Ali *et al.*, 2019). The intoxication of heavy metals poses serious health risks to humans (Rai *et al.*, 2019). The health risks associated with heavy metals toxicity have been widely reported worldwide (Hembrom *et al.*, 2020; Jia *et al*., 2018; Rehman *et al.*, 2018; Balkhair and Ashraf, 2016; Sawut *et al*., 2018). Bioaccumulation of heavy metals by plants and subsequent accumulation in the good chain is an important aspect of describing the fate of heavy metals in the natural environment (Taghipour *et al.*, 2013; Singh *et al*., 2011).

Vegetables are essential source of nutrition and are required for a healthy immune system. Adequate intake of vegetables serves the purpose of a balanced diet and will help reduce risks of morbidity. However, since many of the vegetables are consumed raw, therefore the public health quality of vegetables should not be compromised (Naser *et al.*, 2018; Mayacela *et al.*, 2017; Ghosh *et al., 2012*). Vegetables, while contaminated with heavy metals, are likely to cause several clinical manifestations (Genthe *et al.*, 2018; Bempah and Ewusi, 2016; Wang *et al.*, 2009). A number of vegetables such as green and leafy vegetables including green onion, cabbage and spinach are considered to be good absorber of heavy metals (Singla *et al.*, 2017; Dziubanek *et al.*, 2015; Sipter *et al.*, 2008). Recently, various studies have been conducted in South Asia to assess the levels of heavy metals in soil and vegetables to estimate the health risks to the human population (Sharma and Nagpal, 2019; Khan *et al.*,2019; Liu *et al.*,2019; Mehmood *et al.*,2019).

In the suburbs of Karachi, vegetables are cultivated on a large scale using untreated wastewater of Lyari and Malir Rivers. These vegetables are being sold in the markets of Karachi without seeking any national or International Public health standards. The farmers are indiscriminately using untreated wastewater of both domestic and industrial origin without considering its potential health hazards. Illiteracy, unavailability of information and lack of enforcement of laws concerning public health are likely to possess serious health concerns among the population of Karachi and subsequently the bioaccumulation of heavy metals in different parts of the vegetables. The bioaccumulation of heavy metals particularly in the leafy parts of the vegetables provides an easy excess to the human food chain that consequently affects human health. In Karachi, the commonly grown vegetables are Chilies, Brinjal, Okra, Cauliflower, Gourd, Spinach, Radish, Carrots and Tomatoes that can concentrate heavy metals.

METHODOLOGY

Sample collection

Karachi city is located at the southern region of Pakistan with a population of around 15 million. The samples of vegetables commonly consumed were collected from five different locations in Karachi. These areas were Federal B

Area, Shah Faisal Colony, Liaquat market, Sadder and Clifton. The vegetables samples were collected randomly from the street vended shops. The samples analyzed for heavy metals were Spinach (*Spinacia oleracea*), Lettuce (*Lactuca sativa*), Cabbage (*Brassica oleracea var. capitata*), Spring Onion (*Scallion*), Gourd (*Lagenaria siceraria*), Okra (*Abelmoschus esculentus*) and Eggplant (*Solanum melongena*). From each location, ten samples of each vegetable were collected in a clean plastic bag and transported to the labs of the Institute of Environmental Studies, University of Karachi.

Sample digestion and analysis of heavy metal

The vegetables samples were washed first with the running tap water followed by washing with distilled water. Approximately 25.0 grams of vegetable sample was chopped and grounded and placed in a China dish and dried in an oven at 60-70^{O}C. The dried sample was placed on hot plate and 25 ml of concentrated nitric acid was added in a way to avoid boiling during the process of digestion. The digestion process was continued till the sample of vegetable become colour less or pale yellow. Additional amount of nitric acid was added if necessary. When the sample became completely digested an additional 2.0 ml of nitric acid was added. The digested sample was passed through Whatman filter No. 42 and the filtrate was collected in a 25.0 mL volumetric flask. The volume was made up to 25 mL by using deionized water. Each digested sample was carefully labeled prior to the analysis. The heavy metals were analyzed using Merck Nova 60 by using appropriate kits of heavy metals. The vegetable samples were analyzed for As, Cr, Cu, Ni and Pb having three replicates for each sample.

RESULTS AND DISCUSSION

Spinach

Around 27.9 million tons of Spinach is produced worldwide in 2017 of which China contribution alone was 92 % (FAO, 2018). The edible portion of Spinach is in the form of leaves that are eaten fresh mostly. In Pakistan Spinach is available throughout the year and its healthy plant is about 30 cm tall. Spinach consists of 3% proteins, 4 % carbohydrates and around 91 % water. It is potentially rich source of Vitamin A, C and K. It also contains an appreciable amount of Fe. Cultivation of spinach requires well drainage soil with a proficient irrigation and fertilizer management (Shah *et al.*, 2015).

The results of heavy metals analysis of spinach (*Spinacia oleracea*) samples collected from street vended shop at Karachi are given in Table 1. The mean concentration of heavy metals in spinach samples was in the order of Pb > Cu > As > Cr > Ni. The average concentration of Pb was 1.1298mg/kg (i.e. in a range of 1.062-1.241mg/kg). Similar findings can be observed from Bangladesh where highest Pb conc. from vegetables was found to be 3.699 mg/kg only due to irrigation from polluted water (Ratul *et al.*, 2018). The mean lowest concentration of all the heavy metals was of Ni (0.0808mg/kg). The highest concentration of As was found in the samples collected from Clifton area while minimum concentration was observed in the samples collected from Federal B Area. The mean concentration of Cr and Cu were 0.1154 mg/kg and 1.1087mg/kg, respectively.

Lettuce

Lactuca sativa commonly known as lettuce is a leafy vegetable and considered as an annual plant. Generally, it is important constituent of meals and used in salads, soups and some ready to eat food such as sandwiches and wraps. The leaves of the lettuce have very little calories (100 grams of fresh leaves contains only 15 calories), however it is a rich source of other valuable vitamins such as Vitamin A, Vitamin K, Vitamin C and folates. The annual production of lettuce in 2017 was 27 million tones out of which China alone produced 15.2 million tons (FAOSTAT, 2018).

The results of heavy metal analysis in lettuce samples are shown in Table 2. The mean concentration of heavy metals in lettuce samples was in the order of Ni > Pb > Cr > Cu > As. Of all the heavy metals the mean concentration of Ni was highest in all the samples (1.349mg/kg). The minimum concentration of Ni (1.219mg/Kg) was found in the sample collected from Federal B area whereas the maximum concentration (1.453mg/kg) was noted in the samples collected from Clifton area. The average Pb concentration was 1.182 mg/kg whereas Cr was also present in notable amount. The minimum and maximum concentration of Cu was found in the samples of Federal B Area and Clifton. The average concentration of Arsenic was lowest in all the samples as compared to other heavy metals. In contrast to our findings, Arsenics concentration was found in a range of 21 to 108 mg/kg in Lettuce in Central Portugal (Avila *et al.*, 2017). Achakzai *et al.*, (2011) studied the heavy metal concentration in lettuce accumulated due to the irrigation with wastewater. Khan *et al.*, (2008) studies the heavy metal accumulation in lettuce (*Lactuca sativa* L.) and argued that the plants shoots contain high concentration of Cd , Cr, Ni and Pb that are higher than the limits set by State Environmental Protection Administration (SEPA), China and the World

Health Organization (WHO). This is in accordance with the present study where in Karachi the vegetables are mostly cultivated through untreated wastewater.

Table 1. Mean heavy metal concentration (mg/kg) in spinach (*Spinacia oleracea*) samples collected from the street-vended shop at Karachi.

Locations	Heavy metals (mg/kg)				
	As	Cr	Cu	Ni	Pb
Federal B Area N = 5	0.245	0.117	1.067	0.078	1.062
Shah Faisal colony N =3	0.282	0.112	1. 163	0.080	1.113
Liaquat market N =5	0.283	0.103	1.117	0.084	1.141
Sadder N =4	0.286	0.118	1.112	0.071	1.092
Clifton N =3	0.287	0.127	1.139	0.091	1.241
Average (N = 20)	0.2766	0.1154	1.10875	0.0808	1.1298
Min. – Max.	0.245-0.287	0.103-0.127	1.067-1.139	0.071-0.091	1.062-1.241
Std. dev	0.018	0.009	0.036	0.007	0.069
Max. permissible Limit	0.7	2.3	20	66	0.3

Table 2. Mean heavy metal concentration (mg/kg) in lettuce (*Lactuca sativa*) samples collected from street vended shop at Karachi.

Locations	Heavy metals (mg/kg)				
	As	Cr	Cu	Ni	Pb
Federal B Area N = 6	0.069	0.976	0.145	1.219	0.897
Shah Faisal colony N =4	0.042	0.874	0.171	1.324	1.129
Liaquat market N = 5	0.036	0.921	0.352	1.365	1.326
Sadder N = 5	0.054	0.873	0.678	1.384	1.412
Clifton N = 6	0.073	0.923	0.823	1.453	1.146
Average (N = 26)	0.0548	0.9134	0.4338	1.349	1.182
Min.-Max.	0.036-0.073	0.873-0.976	0.145-0.823	1.219-1.453	0.897-1.412
Std. dev	0.0162	0.0426	0.3042	0.0863	0.1994
Max. permissible Limit	0.7	2.3	20	66	0.3

Cabbage

The results of heavy metal analysis of cabbage (*Brassica oleracea var. capitata*) are shown in Table 3. The plant grows normally as a large bud where it head consists of overlapped leaves surrounded by a rosette. It is a rich source of nutrients containing Vitamin A, B-6, C E. K and D. It also contains appreciable concentration of Ca, Fe, Mg and K. Its carbohydrate contents are 6% (Patel *et al.*, 2018). A number of studies confirm the correlation between the consumption of cabbage and fortification against several chronic diseases, including cancers (Byers and Perry 1992). Ashfaq *et al.*, (2018) prove that the red cabbage in Pakistan have better nutritional value as compared to green one. The mean concentration of heavy metals in cabbage samples was in the order of Pb > Cu > As > Ni > Cr. Pb was present in the highest concentration in all the samples. The mean concentration of Pb was 1.303mg/kg whereas minimum and maximum concentration ranged between 1.122 to 1.631 mg/kg found in the samples collected from Federal B area and Clifton. The lowest concentration of all the heavy metals in cabbage samples was of Cr. The minimum and maximum concentration ranged between 0.214 - 0.276 mg/kg found in the samples of Liaquat market and Shah Faisal colony respectively. Rehman *et al.*, (2018) reported higher levels of Cr, Ni and Cu from vegetables in KPK, Pakistan. Hara and Sonoda (1979) reported that Cr (VI), Cu, Cd, and Hg (II) are mainly toxic to the plant growth of cabbage by affecting the cabbage head formation. The edible portion of cabbage plant is mostly the head. If it remains premature and unable to gain its full size then it is not acceptable to the consumer. In our study area, the major source of the heavy metals found in the cabbage samples could be the untreated wastewater used for the cultivation of cabbage.

Table 3. Mean heavy metal concentration (mg/kg) in cabbage (*Brassica oleracea var. capitata*), samples collected from street vended shop at Karachi.

Locations	Heavy metals (mg/kg)				
	As	Cr	Cu	Ni	Pb
Federal B Area N = 4	0.257	0.231	0.852	0.078	1.122
Shah Faisal colony N = 5	0.352	0.276	0.796	0.172	1.154
Liaquat market N = 5	0.286	0.214	0.584	0.231	1.263
Sadder N = 7	0.254	0.242	0.861	0.432	1.345
Clifton N = 8	0.279	0.238	0.794	0.369	1.631
Average	0.2856	0.2402	0.7774	0.2564	1.303
Min.-Max	0.254-0.352	0.214-0.276	0.584-0.861	0.078-0.432	1.122-1.631
Std. dev	0.040	0.023	0.112	0.144	0.204
Max. permissible Limit	0.7	2.3	20	66	0.3

Table 4. Mean heavy metal concentration (mg/kg) in spring onion (*Scallion*), samples collected from street vended shop at Karachi.

Locations	Heavy metals (mg/kg)				
	As	Cr	Cu	Ni	Pb
Federal B Area N = 4	0.254	0.112	0.608	0.174	1.026
Shah Faisal colony N = 5	0.241	0.127	0.567	0.129	1.320
Liaquat market N = 5	0.327	0.134	0.476	0.098	1.291
Sadder N = 7	0.278	0.142	0.571	0.106	1.362
Clifton N = 8	0.256	0.152	0.623	0.117	1.394
Average (N =29)	0.2712	0.1334	0.569	0.1248	1.2786
Min.-Max.	0.241-0.327	0.112-0.152	0.476-0.623	0.098-0.174	1.026-1.394
Std. dev	0.034	0.015	0.057	0.030	0.147
Max. permissible Limit	0.7	2.3	20	66	0.3

Spring onion

Spring onions or Scallions can be eaten raw and sometime cooked and generally used in salads and salsas. In Pakistan it is eaten in both the forms. The nutritional value of 100 gm of spring onion consists of 6.5 g carbohydrates, 0.4 g fats and 1.9 g of proteins. It also contains appreciable amount of Vitamin B, C, E and K. It is rich source of sulphur that is beneficial for human health and its compounds like allyl sulphide and flavonoids prevent against cancer. Owing to high sulphur content it helps to prevent diabetes. It also has both antiviral and antibacterial properties. China is among the top producing country of spring onion followed by India (Hanci, 2018).

The results of heavy metals concentration in spring onion are shown in Table 7.4. The heavy metal concentration in spring onion samples was in the order of Pb > Cu > As > Cr > Ni. The average concentration of Pb was highest (1.2786 mg/kg) in all the spring onion samples with minimum and maximum range between 1.026-.394mg/Kg found in the samples collected from Federal B area and Clifton respectively. The mean concentration of Cu was 0.569mg/kg. Minimum and maximum concentration of Arsenic was recorded in the samples of Shah Faisal colony and Liaquat market. The mean concentration of Ni and Cr were 0.152 and 0.174mg/kg respectively. These findings are comparable with a recent study conducted in North West Nigeria where heavy metals concentration in Onion bulbs were found in an order of Pb > Cr > Ni (Yaradua *et al.,* 2020). However, the other study show entirely different order i.e. the uptake of metals by onion was Zn > Cu > Cr > Pb >As as observed by Weber *et al*., (2019).

Table 5. Mean heavy metal concentration (mg/kg) in gourd (*Lagenaria siceraria*), samples collected from street vended shop at Karachi.

Locations	Heavy metals (mg/kg)				
	As	Cr	Cu	Ni	Pb
Federal B Area N = 4	0.036	0.024	0.078	0.049	0.284
Shah Faisal colony N = 4	0.042	0.036	0.086	0.052	0.324
Liaquat market N = 5	0.059	0.042	0.069	0.056	0.426
Sadder N = 6	0.046	0.038	0.058	0.066	0.368
Clifton N = 5	0.048	0.032	0.086	0.076	0.426
Average (N =24)	0.0462	0.0344	0.0754	0.0598	0.3656
Min.-Max	0.036-0.059	0.024-0.042	0.058-0.086	0.049-0.076	0.284-0.426
Std. dev	0.008	0.007	0.012	0.011	0.063
Max. permissible Limit	0.7	2.3	20	66	0.3

Table 6. Mean heavy metal concentration (mg/kg) in Okra (*Abelmoschus esculentus*) samples collected from street vended shop at Karachi.

Locations	Heavy metals (mg/kg)				
	As	Cr	Cu	Ni	Pb
Federal B Area N = 5	0.003	0.012	0.026	0.154	0.011
Shah Faisal colony N = 4	0.002	0.004	0.028	0.164	0.023
Liaquat market N = 4	0.012	0.002	0.019	0.173	0.027
Sadder N = 5	0.003	0.032	0.031	0.178	0.063
Clifton N = 4	0.004	0.034	0.021	0.132	0.084
Average (N = 22)	0.0048	0.0168	0.025	0.1602	0.0416
Min.-Max	0.002-0.012	0.002-0.034	0.019-0.031	0.132-0.178	0.011-0.084
Std. dev	0.004	0.015	0.005	0.018	0.031
Max. permissible Limit	0.7	2.3	20	66	0.3

Table 7. Mean heavy metal concentration (mg/kg) in Eggplant (*Solanum melongena*). Samples collected from street vended shop at Karachi.

Locations	Heavy metals (mg/kg)				
	As	Cr	Cu	Ni	Pb
Federal B Area N = 5	0.0023	0.0054	0.0031	0.0072	0.017
Shah Faisal colony N = 4	0.0021	0.0058	0.0035	0.0068	0.018
Liaquat market N = 4	00.00	0.0062	0.0065	0.0126	0.018
Sadder N = 5	00.00	0.0071	0.0025	0.0087	0.021
Clifton N = 4	0.0014	0.0069	0.0028	0.0092	0.024
Average (N = 22)	0.00116	0.00628	0.00368	0.0089	0.0196
Min.-Max.	0-0.0023	0.0054-0.0071	0.0025-0.0065	0.0068-0.013	0.017-0.024
Std. dev	0.001	0.001	0.002	0.002	0.003
Max. permissible Limit	0.7	2.3	20	66	0.3

Gourd

Gourd (*Lagenaria siceraria*) also known as Calabash found in variety of shapes. Its protein and fats contents are 0.5 and 0.1% respectively while carbohydrates contents are 3.5 gm. It also contains an appreciable amount of Vitamin A, B and C. The energy value is about 63 kJ/100 g. The heavy metal concentration was in the order of Pb>Cu>Ni>As>Cr. Iqbal *et al*.,(2019) investigated a number of genotypes of bottle gourd for their fruit yield and quality traits and suggested that the genotype Anmol performed better than rest of the genotypes in Pakistan. The mean concentration of Pb was 0.426mg/kg that was the highest concentration of all the heavy metals. While minimum and maximum concentration of Pb 0.284- 0.426 mg/kg found in the samples of Federal B area and Liaquat market respectively. The heavy metal concentration of gourd samples are shown in Table 7.5. The mean concentration of Cu was 0.086 while that of As and Cr were 0.059 and 0.042mg/kg respectively. Hasan *et al*., (2020) and Proshad *et al*., (2019) also recorded heavy metals concentration in Gourd in Bangladesh. This shows the distribution of heavy metals across the countries due to industrial activities and unsafe agricultural practices.

Okra

Okra (*Abelmoschus esculentus* (L.) Moench) commonly known as lady's fingers is grown worldwide. In Pakistan it is commonly known as *bhindi* that is an important vegetable diet of Pakistani people. High yield of Okra is likely to be expected in well and nutrient rich soil. It has grown worldwide throughout the year in the tropical region (Akinyele and Temikotan, 2007). India is the largest producer that accounts for 67.1% of world production while Nigeria (15.4%) and Sudan (9.3 %) were second and third largest Okra producing countries (Varmudy, 2011). It is one of the most heat and drought tolerant vegetable species (Singh *et al.,* 2014). Okra is also reported in curing ulcers and relief from hemorrhoids (Adams, 1975). In Pakistan Okra cultivated in an of around 2.21×10^5 hectares with an annual production of about 2.86×10^6 tons of green pods (Hussain *et al.,* (2012).

The results of heavy metal analysis in Okra are presented in Table 7.6. The heavy metal concentration in the sample is in the order of Ni > Pb > Cr > Cu > As. In general the concentration of heavy metals is fairly low as compared to the other vegetable samples. The mean concentration of Cu and Cr were 0.031 and 0.034mg/kg respectively. The minimum and maximum concentration of As were 0.002-0.12mg/kg (Shah Faisal colony and Liquat market). In industrial areas, Okra and other edible crops are usually found contaminated with heavy metals in Bangladesh (Islam *et al*., 2020). Nawaz *et al*., (2020) also supported the aforesaid statement of industrial pollution in edible crops in Pakistan that should now be taken seriously to secure public health.

Eggplant

Solanum melongena commonly known as Eggplant or Brinjal belongs to family Solanaceae. Essential nutrients are present in low concentration except manganese that accounts for 11%. Egg plants also contain Vitamin B, C, E and K. The egg plant also contains Polyphenols that have anticancer properties while Anthocyanins and Chlorogenic acid present in eggplant have antioxidants and anti-inflammatory properties. Ashraf *et al* (2017) recommended the use of varieties Shamli and Egg plant deep black as recommended varieties that can produced maximum yield with minimum losses to the attack of insects and pests. The results of heavy metal analysis of *Solanum melongena* are presented in Table 7.7. The heavy metal concentration was in the order of Pb > Ni > Cr > Cu >As. The mean Pb concentration was 0.0196 mg/kg whereas the minimum and maximum concentration ranged between 0.017-0.024mg/kg found in the samples of Federal B area and Clifton. According to European Union (EU) standards for the maximum permissible limits of Cd and Cu are 0.2 mg/kg and 20 mg/kg, respectively. The maximum permissible limit of Pb, permissible is 0.3 mg/kg while for As and Ni the permissible limit are allowed are 0.7 and 50 mg/kg (WHO/FAO, 1995; Eslami *et al.* 2007; Skrbic *et al*., 2008). Soil contaminated with the heavy metals due to irrigation by untreated wastewater is posing serious threat due to the potential health risk involved.

Sharma *et al.* (2009) studied the heavy metal concentration in *Beta vulgaris* L., *Abelmoschus esculentus* L. and *Brassica oleracea* L. in India and described that the average concentration of heavy metals was higher as concerning the maximum permissible. These results are consistent with the findings of the present research. Hussain and Qureshi (2020) reported the lowest heavy metal contamination in eggplant irrigated from treated wastewater in the UAE. However, the present study also suggested the safe use of treated wastewater for agricultural purpose in water scarce urban areas.

Human health perspective of heavy metals polluted vegetable consumption

The route of entry of heavy metals in plants is from soil to the roots and travel in the food chain, ultimately affecting living organism through consumption of such plant products (Shahid *et al*., 2013). The non-biodegradable nature of heavy metals cause serious issues in human body as these metals have long half-life and greater ability to store in different body tissues and organs such as fatty tissues (Shahid *et al.,* 2015). It has been noted in literature that due to water solubility of heavy metals, they are highly toxic even in lowest concentrations having adverse impacts on human health (Uzu *et al.,* 2011). These toxic metals affect human organs causing various clinical manifestations including renal failure, mental illness, osteoporosis, cardiovascular disorders, lungs and liver impairments etc. (Yargholi *et al.*, 2008). Through chronic exposures to heavy metals via food, the mentioned organs get highly damaged and develop multiple disorders even cancers (Jarup, 2003). As is extremely toxic for humans producing dermal allergies, cardiovascular, respiratory, immunological and carcinogenic effects, renal and hepatic as well as developmental disorders (Lin *et al.,* 2013). Cr is carcinogenic and mutagenic causing tubular necrosis and renal failure (Rahman and Singh, 2019). Pb is toxic for its ability to accumulate in skeletal structures of human and animals (Musa *et al.,* 2013). Also, it causes developmental disorders; reduce brain functioning, mental retardation, kidney, liver and reproductive issues (Muhammad *et al*., 2014).

The heavy metals concentration in vegetables samples is also likely to be increased during transportation and marketing of vegetables that may pose serious threats to the consumer. Karachi is also an industrial city and as such no efficient mechanism exists to treat the heavy discharge of domestic and industrial wastewater. Moreover, the quality of air is also deplorable that could be an additional source of heavy metals in the vegetable samples either grown or sold in the markets of Karachi. Li *et al.,* (2015) studied the concentration of Cr, Ni, Cu, Pb and Cd in vegetables and suggested that the bioaccumulation of heavy metals in vegetables is mainly from the soil. The study concluded that foliar uptake could also be an important pathway of heavy metal accumulation in vegetables from the environment that corroborates the present findings. However, Moreno *et al.* (1997) were of the opinion that As, Ni and Cu usually form insoluble complexes with the organic matter of the sewage which are not readily absorbed by the plants whereas, Cd and Zn exhibit the highest bioavailability index.

From present study we can conclude and recommend that heavy metals consumed through vegetables is potential health risk for humans and increases in concentration due to the process of bioaccumulation and bio-magnification. Strict ban should be imposed on the use of un-treated wastewater for agricultural purposes in Karachi city to secure public health.

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