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Heavy Metal Accumulation in Vegetables and Assessment of their Potential Health Risk

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Abstract

Vegetables constitute essential diet components by contributing carbohydrates, proteins, vitamins, iron, calcium and other nutrients that are in short supply. The present study was conducted to evaluate vegetables such as leafy (spinach), melon (gourd, long gourd and pumpkin) and solonaceous (brinjal) for their potential to accumulate different heavy metals like Cadmium (Cd), Manganese (Mn), Chromium (Cr), Copper (Cu), Iron (Fe), Nickel (Ni), Lead (Pb) and Zinc (Zn). The content of these metals was measured by using Atomic Absorption Spectrophotometer. Mean values were recorded against each vegetable for accumulating heavy metals. It was observed that maximum concentration of Mn (137.3 mg/kg), Cr (6.62 mg/kg) and Fe (968.25 mg/kg) was found in spinach, exceeding the allowed threshold 2.2 mg/kg, 2.3 mg/kg and 425 mg/kg respectively, as set by WHO/FAO. While melon showed great potential to absorb Ni (5.05 mg/kg) which elevated safe limit 0.1 mg/kg and Cu (65 mg/kg) was within the safe range. Brinjal displayed maximum absorption of Zn (41 mg/kg), which did not cross the WHO reference limit 73 mg/kg. In case of Cd both gourd and brinjal showed equal concentration of 0.39 mg/kg but was not at the safe limit 0.241 mg/kg. However levels of Pb were below the FAO/WHO recommended limits in all the vegetables. Low concentrations of Pb indicate that these plants contribute less toxic effects of metals. Overall this order of absorption was recorded as leafy>melon>solonaceous. Human DIM has also been computed and was observed below recommended values by the FAO/WHO. However, to prevent any chronic health risk and extent of heavy metal contamination, steps must be taken to reduce human activities at the sites. Regular monitoring of heavy metals in the vegetables grown in wastewater irrigated areas is also necessary.

Keywords: Heavy metals; Sewage water; Health risk; WHO/FAO limits; Daily intake

Abbreviations:

AAS: Atomic Absorption Spectrophotometer; DIM: Daily Intake of Metals; PDTI: Provisional Tolerable Daily Intake; HRI: Health Risk Index.

Introduction

Vegetables are basic eating routine taken by populations all through the world, being wellsprings of fundamental supplements, antioxidants agents and metabolites. They likewise go about as buffering specialists for acid substance obtained during the digestion process. However, both essential and toxic components are available in vegetables over an extensive variety of concentrations as they are said to be great absorber of metals from the soil [1]. The metals pollute the soil and mix with soil solution and enter into the plant body and hence can be accumulated at high levels in the edible parts of vegetables, even low levels in soil [2]. Different plants accumulate its different concentration. Some accumulate more than others. Vegetables being carrier of metals, when taken up by human beings, get ingested into human body. Heavy metals can be exceptionally unsafe to the human body even in low concentrations as there is no powerful excretion mechanism [3]. These metals are deadly dangerous for human health and cause cancer, liver, heart and many other problems. Some general dangerous impacts of overwhelming metals are hepatic damaging, renal system damaging, mental retardation, CNS breakdown, looseness of the bowels, hookworm disease and degeneration of basal ganglia of brain and liver [4]. Unnecessary take-up of dietary overwhelming metals may bring about various genuine medical issues in people. In addition, the utilization of sustenance polluted with metals can truly drain some basic nutrients in the body which causes a depletion of immunological resistances, intrauterine development hindrance, incapacities related with ailing health and a high commonness of upper gastrointestinal cancer [5]. Metals can pose as a significant health risk to humans, particularly in elevated concentrations above the very low body requirements. Heavy metals can be very harmful to the human body

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even in low concentrations as there is no effective excretion mechanism [3].

Pakistan is blessed with one of the largest canal system in the world. It is an agricultural country having the world's largest canal irrigation system. Indus basin that covers 70% of irrigated area for crop production is the major source of water in the country. The distribution of water is based on Wara Bandi. Such system has its own merit and demerits but the most critical aspect is that such system limits timely availability of required water for irrigation purpose. Like most of the cities in Pakistan, Dera Ghazi Khan is also facing the scarcity of water. The farmers are not able to get their turn at right time, forcing them to apply sewage water as a source of irrigation. Municipal sewage water comes from different sources like domestic liquids, industrial effluents and market [6]. This sewage water enters into a canal which is locally named as Manka Canal. Sewage water contains many substances like discharged effluents from factories, dissolved nutrients and various metals discharged. Sewage water gives basic smaller scale supplements to plants including Fe, Mn, B, Zn, Cu, Mo, Cl, and Ni, and insignificant As, Cd, Hg, and Pb. Though the sewage water has harmful elements in it, still the farmers use it for irrigation purpose because it is nutrient rich and nothing has to be spent on it. It nourishes the soil and enhances the nutrients in the soil. The use of sewage effluent works as a source of nutrients, organic matter. Effluent users are mainly interested in it and consider it as an effective way of effluent disposal [6].

The present study was conducted with an aim to determine the heavy metals (Cadmium, Manganese, Chromium, Copper, Iron, Nickel, Lead and Zinc) accumulation potential of some of the commonly grown vegetables like melon (gourd, long gourd, pumpkin), solonaceous (brinjal) and leafy (spinach), as use of waste water for irrigation purposes is a very common practice in this particular area. The effect of irrigation with wastewater is studied in these vegetables to observe the concentration of accumulated metals to which human beings are exposed. The bio-concentration of metals and dietary daily intake of metals through vegetables for adults has also been taken into account.

Material and Methods

Description of study area

Dera Ghazi Khan District is situated between river Indus and Suleiman range and lies between 20.40 North and 70.75 East (Figure 1). The aggregate land region of the region is 4.07 million hectares out of which 2.36 million hectare region is under cultivation while 68.03 hectare under forest and the rest are either not accessible for cultivation or social waste. Out of the developed region of 7,15,846 hectares are canal flooded and rest is barren. The atmosphere of locale is dry with almost no rain fall. The winter is frosty and summer is extremely hot. The yearly precipitation in the locale is insufficient.

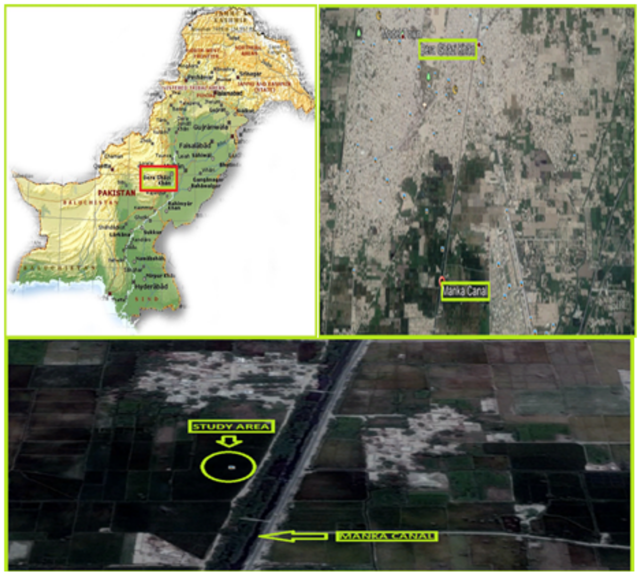

Figure 1: Study area showing sampling done for heavy metals determination.

Sampling of vegetables and preparation of samples

Soil and vegetable samples were taken from a site irrigated with Manka canal sewage water and analysis was done at Soil and Water Testing Laboratory for Research Dera Ghazi Khan, Pakistan. Soil samples were taken at the depth of 0-15 cm and were mixed thoroughly to make a composite sample and twenty vegetable samples were collected at harvesting stage for heavy metal investigation study: gourd, brinjal, long gourd, spinach and pumpkin as given in Table 1. The edible parts of vegetables were collected (about 500 g), thoroughly washed with fresh water in order to remove the adhering dirt and finally with deionized water. Then approximately 10 g of each sample were taken to a mortar for grinding to obtain a homogenous mass. Finally the samples were taken to the small airtight polythene bags and then kept to the refrigerator for further analysis. The current study will enable us to study the absorption of the heavy metals and deadly heavy metals effect on it.

Local name	English name	Scientific name	Vegetable type	Growing season
Tori	Gourd – Ridged	Luffa	Melon	Spring and summer
Baingan	Brinjal	Solanum melongena	Solanaceous	Spring and summer
Lambi Tori	Ridge Gourd	Luffa	Melon	Spring and summer
Palak	Spinach	Spinacia oleracea	Leafy	Autumn and winter

Kaddu	Pumpkin	Cucurbita maxima	Melon	Spring and summer

Table 1: Vegetable species used in the experiments.

Digestion of vegetable and soil samples

To decide the convergence of overwhelming metals in vegetable examples, aliquot (around 0.3 g) measure of the ground dried examples were taken in a vessel (Model no XP-1500) of the microwave broiler where 4 ml of concentrated HNO_3 was poured. The warming system utilized was the one proposed in the client's manual. The three stage temperature programs were connected-180°C with an inclining time of 10 min; holding time 15 min and cooling time 10 min. After completion of digestion, it is important to chill off rotor at a temperature of 60°C and afterward in the wake of cooling, loosen the upper screw of the vessel deliberately with a torque to discharge weight under fume hood. The samples therefore acquired were separated and leveled up to the stamp with deionized water in a 10 ml volumetric cup. At long last the samples were examined with AAS for heavy metals estimation.

Soil samples were processed by following the technique for Kumar [7]. 1 g soil was put to a 250 cm^3 digestion tube containing 10 cm^3 concentrated HNO_3. The tubes were then boiled for 30 to 45 min. After oxidation, the samples were subjected to cool, 5 cm^3 of 70% $HClO_4$ was then included and the substance was boiled again till the presence of white fumes. The tubes were permitted to cool for quite a while and 20 cm^3 of distilled water was put and boiled again till the vapor vanished totally. The solution was then permitted to cool, separated through Whatman filter paper No. 42. The filtrate was transferred to 25 cm^3 volumetric jar. The last volume was marked with deionized water. A blank was likewise arranged after the correct procedure without including soil sample. Water samples were set up by taking 50 cm^3 in a beaker and treated it with 10 cm^3 concentrated HNO_3. The solution in container was warmed until 40 cm^3 volume remained. The solution was gone again through Whatman filter paper No. 42 and diluted to 50 cm^3 by including deionized water. A blank solution was made in the comparable path without including water sample.

Experimental procedure for metals determination

A serial dilution method was utilized to arrange the working standards and the concentration of the metals in every sample. The concentration was measured by utilizing AAS (Buck Model 210 VGP) outfitted with a computerized readout framework.

Daily intake of heavy metals from vegetables

Bio-concentration Factor (BCF): BCF is the ratio of the elemental concentration in plant tissue such as, leaves, stem, root etc. and the "exchangeable" or potentially available portions of metals in rhizospheric soils. The BCF for edible part of vegetable was calculated with the following formula:

$$BCF=Cp/Cs$$

Where, Cp=concentration of metal in edible part of vegetable (mg/kg), Cs=metal content in soil (mg/kg).

Daily intake estimates:

$$DIM=M \times K \times I/W$$

Where, DIM=Daily intake of metals, M=concentration of heavy metals in plants (mg/kg), K=conversion factor, I=daily intake of vegetables, W=average body weight.

Fresh weight of vegetables was converted to dry weight by using the conversion factor 0.085, as described previously. The average adult and child body weights were considered to be 59.9 and 32.7 kg, respectively, while average daily vegetable intakes for adults and children were considered to be 0.345 and 0.232 kg/person/day, respectively.

Health Risk Index (HRI): The HRI for Cr, Ni, Cu, Pb, Cd, Mn and Zn by consumption of contaminated vegetables was calculated by following equation:

HRI=DIM/Rfd [8]

Where, DIM=daily intake of metals, Rfd=reference oral dose.

Rfd value for Cr, Ni, Cu, Pb, Cd, Mn and Zn is 1.5, 0.02, 0.04, 0.004, 0.001, 0.033 and 0.30 (mg/kg bw/day) respectively (US-EPA IRIS).

Statistical analysis

Data obtained were analyzed using Microsoft Excel and results were expressed as mean ± standard deviation.

Results and Discussion

Heavy metals in soil

Like other under-developed nations, Pakistan likewise has poor environmental management. Sewage and industrial wastewater are regularly utilized as water system for the production of vegetables and different products especially in the rural regions. Metal contamination in wastewater irrigated soil was given in Table 2.

Sr No.	Metal	Conc. in soil (mg/kg)
1	Cd	0.05
2	Mn	2.96
3	Cr	0.35
4	Cu	1.5
5	Fe	3.45
6	Ni	0.23
7	Pb	0.05
8	Zn	3.1

Table 2: Heavy metals concentration in soil.

Metals accumulation in vegetables

Vegetables are an essential part of human diet and assume an essential part in the human nourishment since the start of human life.

However, as it may, the edible portion of vegetables shifts and relies on the convention and particular vegetables to be consumed, for example, leaves for spinach and root for radish and so on. The examined vegetables showed different concentration for every metal taken under study. Their concentrations most of the time crossed the safe limits as set by WHO/FAO, as given in Table 3. The studied heavy metals concentration in plants is as under.

Plant sample	Cd	Mn	Cr	Cu	Fe	Ni	Pb	Zn
Gourd	0.122 ± 0.026	18.675 ± 0.713	3 ± 0.816	22.75 ± 1.707	129 ± 2.160	3.85 ± 0.208	ND	26.75 ± 4.57
Brinjal	0.39 ± 0.026	23.15 ± 1.3	3 ± 0.816	32.25 ± 0.957	171.75 ± 3.304	1.8 ± 0.081	ND	41 ± 1.1547
Long gourd	0.39 ± 0.0374	23.927 ± 0.441	3.725 ± 0.170	32.25 ± 0.957	198.25 ± 3.774	2.8 ± 0.081	ND	32.5 ± 1.290
Spinach	0.35 ± 0.024	137.3 ± 1.039	6.625 ± 0.419	22.25 ± 0.957	968.25 ± 4.991	4.65 ± 0.129	ND	19.5 ± 1.290
Pumpkin	0.045 ± 0.020	33.75 ± 0.785	2.725 ± 0.287	65 ± 2.449	454.5 ± 5.507	5.05 ± 0.129	ND	25 ± 1.825
Range	0.045-0.390	18.675-137.3	2.72-6.62	22.25-65.24	129-968.25	1.8-5.05	ND	19.5-41
FAO/WHO [9]	0.2	0.2	2.3	73	425	0.1	0.3	99
ND=Not Detected, SD=Standard Deviation								

Table 3: Concentration (mg/kg) of heavy metals in vegetables (mean+standard deviation).

Cadmium (Cd): The element like Cd, is non-essential and has no advantageous part in plants, animals and people and has no nutritious capacity, as they are exceptionally toxic. Cd and micronutrients have solid cooperation in gastrointestinal assimilation. Fe and Zn are the most critical micronutrients associated with these interactions. This retention includes intestinal Fe transporters. Women and children have higher body Cd than men in light of the fact that their Fe necessities are more noteworthy than men. Therefore, satisfactory sustenance is imperative for youthful youngsters and pregnant ladies in the prior stages to have ideal improvement and growth. The level of Cd concentration ranged from 0.045 to 0.39 mg/kg. Concentration of Cd in five selected vegetables varied significantly. Its maximum concentration 0.39 mg/kg was observed in brinjal, followed by long gourd with the same concentration. This resulted concentration is higher than safe limit 0.2 mg/kg set by FAO/ WHO for vegetables (Table 3). In spinach the concentration of Cd (0.35 mg/kg) again crossed the safe limits hence proving to be dangerous for human being consumption. These results are in line with Rapheal [10] who documented 0.110 to 160 mg/kg Cr in spinach. However in pumpkin its concentration was recorded 0.045 mg/kg, which is safe enough to be used. Cd higher and lower concentration can be described as sequence brinjal (0.39)>long gourd (0.39)>spinach (0.35)>gourd>pumpkin (0.045) (Table 2).

Manganese (Mn): Results show that Mn range was recorded between 18.67 mg/kg to 137.75 mg/kg. Mn maximum concentration 137.3 mg/kg was recorded in spinach and lowest 18.67 mg/kg was seen in gourd. Similar results were described by Rapheal [10] in their studies as 7.70 mg/kg in spinach. This concentration is much higher than safe limit 0.2 mg/kg [11] as proposed by FAO/ WHO. Amin [5] reported Mn concentration in the vegetables ranged between 1.90 to 128.70 mg/kg. In brinjal and long gourd not much difference was seen in case of Mn concentration, which were 23.92 mg/kg and 23.15 mg/kg respectively. The factors responsible for the high content of Mn in vegetables were proposed to be the soil type and the application of agricultural pesticides and fertilizer [12]. The sequence of metals absorbance mg/kg can be put in order: spinach (137.3)>pumpkin (33.75)>long gourd (23.92)>brinjal (23.15)>gourd (18.67) (Table 2).

Chromium (Cr): The level of Cr was in of range 2.72 mg/kg to 6.63 mg/kg. Cr maximum concentration 6.63 mg/kg was recorded in spinach and lowest 2.72 mg/kg was seen in pumpkin as shown in Table 1. Maximum value in current study in line with Salvatore [13], who reported 6.40 mg/kg Cr concentration in vegetables. Leafy vegetables in the present study showed the maximum level of heavy metals that might be linked with the high absorption rates of leafy vegetables having a large surface area. Concentration in spinach exceeds standard limit 2.3 mg/kg. Spinach is followed by long gourd with the concentration 3.72 mg/kg. Gourd and brinjal concentration recorded was same 3 mg/kg. However all the vegetables in terms of Cr concentration exceeds than the allowed limit 0.1 mg/kg by FAO/ WHO and 0.002 mg/kg [14]. Garbage utilization in the agricultural land can be the source of heavy metals pollution in soil of our study area. Their sequence was recorded: spinach (6.63)>long gourd (3.72)>gourd (3)>brinjal (3)>pumpkin (2.72) (Table 3).

Copper (Cu): Cu is an essential micronutrient which functions as a biocatalyst, required for body pigmentation. However, most plants contain the amount of Cu which is insufficient for ordinary development which is typically guaranteed through artificial or organic fertilizers. The level of Cu content was recorded in range between 22.72 mg/kg to 65 mg/kg. Cu maximum concentration 65 mg/kg was recorded in pumpkin and lowest 22.25 mg/kg was seen in spinach. This concentration did not exceed standard limit 73 mg/kg. Our findings are parallel with previous study conducted by Rapheal [10], who recorded Cu concentrations in vegetables ranged from 1.220 to 5.220 µg/g, pumpkin and spinach were found to contain highest concentration of 5.220 and 5.12 µg/g respectively. Brinjal and long gourd stand equal in Cu absorbance (32.25 mg/kg). However all the vegetables in terms of Cu concentration did not elevate the safe limit of FAO/WHO. Cu values (mg/kg) in the vegetables were in following sequence: pumpkin (65)>long gourd (32.25)>brinjal (32.25)>gourd (22.75)>spinach (22.25) (Table 3).

Iron (Fe): Fe is a fundamental component for every single living life form and is important for keeping up cell homeostasis. It is essential for the synthesis of chlorophyll and activates a number of respiratory enzymes in plants. The deficiency of Fe results in severe chlorosis of leaves in plants. High levels of exposure to Fe dust may cause respiratory diseases such as chronic bronchitis and ventilation difficulties. Deficiency of Fe in developing countries like Pakistan is reported by a number of studies [15,16]. Present study shows that level of Fe in vegetables was found in range of 129 mg/kg to 968.25 mg/kg. Fe maximum concentration 968 mg/kg was recorded in spinach and lowest 129 mg/kg was seen in gourd. The results obtained from the present study are in agreement with Ismail [17] who reported 4.76 to 202.66 mg/kg in the vegetables. In terms of Fe concentration, all other vegetables except spinach, did not exceed standard limit 425 mg/kg proposed by FAO/ WHO. Hence these vegetables could be a good supplement of Fe. Fe values (mg/kg) in the vegetables were in following sequence: spinach (968.25)>pumpkin (454.5)>long gourd (198)>brinjal (171.77)>gourd (129) (Table 3).

Nickle (Ni): Ni is a poisonous heavy metal. Its range was between 1.8 mg/kg to 5.05 mg/kg (Table 3). Ni maximum concentration 5.05 mg/kg was recorded in pumpkin and lowest 1.8 mg/kg was seen in brinjal. These concentrations exceed standard limit 0.1 mg/kg FAO/ WHO. These results are in close with Shirkhanloo [18], who reported 1.20 and 0.775 mg/kg of Ni concentration in vegetables respectively. Pumpkin followed by spinach with the concentration 4.65 mg/kg. Ni concentration in long gourd and gourd crossed the reference limit. Ni values (mg/kg) in the vegetables were in following sequence: pumpkin (5.05)>spinach (4.65)>gourd (3.85)>long gourd (2.8)>brinjal (1.8).

Lead (Pb): Pb is a dangerous component that can be unsafe to plants, despite the fact that plants more often than not indicate capacity to gather a lot of Pb without obvious changes in their appearance or yield. In numerous plants, Pb collection can surpass a few hundred times the edge of most extreme level reasonable for human utilization. This can be related that long term exposure to Pb may bring about debilitated central nervous system, delayed response times and decreased capacity of comprehension, while in kids the introduction to Pb may bring about behavioral disturbances and also learning and focus troubles. In present study no concentration was detected in all the samples, it might be associated because Dera Ghazi Khan is not an industrial city. According to Funtua [19], industries can be attributed to become a source of Pb. The standard limit set by FAO/ WHO is 0.3 mg/kg.

Zinc (Zn): Zn and Mn are additionally one of the micronutrients basic for normal plant development, however just a little amount of these components is required particularly Zn (25-150 µg/g). Zn is the slightest lethal and a basic component in human eating regimen as it is required to keep up the working of the immune defense. Zn lack in the eating routine might be exceedingly negative to human health than an excess of Zn in the eating diet. The Zn content was measured in range of 19.5 mg/kg to 41 mg/kg (Table 3). Zn maximum concentration 41 mg/kg was recorded in brinjal and lowest 19.5 mg/kg was seen in spinach. These concentrations did not exceed standard limit 99.4 mg/kg. However all the vegetables in terms of Zn concentration did not exceed the safe limit of FAO/ WHO. Regular consumption of these four vegetables may assist in preventing the adverse effect of Zn deficiency which results in retarded growth and delayed sexual maturation because of its role in nucleic acid metabolism and protein synthesis. Zn values (mg/kg) in the vegetables were in following sequence: brinjal (41)>long gourd (32.5)>gourd (26.75)>pumpkin (25)>spinach (19.5).

Bio-concentration Factor (BCF)

The results of this study show that BCF values differ significantly among different vegetables because, for a given metal, the transfer factor varies greatly with the plant species [20]. BCF values for under observation metals in various crops collected from the study area are shown in Figure 2.

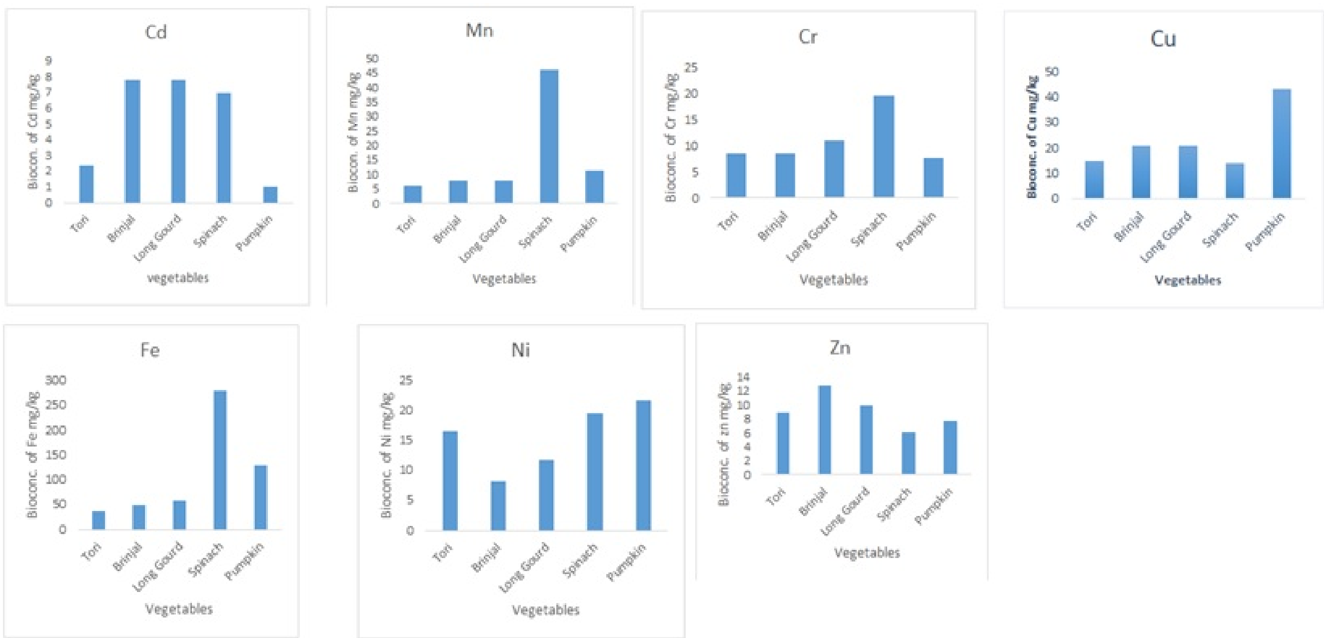

Figure 2: Bio-concentration factor, a ratio of concentration in edible parts of vegetables to that of the corresponding soil.

BCF in case of Cd is maximum in brinjal and long gourd (upto 7.8) while minimum in pumpkin (1). Bi [21] found 2.39 BCF in vegetables in their study. BCF of Mn was found greatest in spinach (upto 46.52) and minimum in gourd (6.38). The highest BCF value of Cr was noticed in spinach (19.71) and lowest in pumpkin (7.71). BCF value of Cu was observed maximum in pumpkin (43.33) and minimum in spinach (14). In case of Fe, highest BCF was recorded in spinach (279.13) and lowest in gourd (37.39). BCF value of Ni was greatest in pumpkin (21.73) and lowest in brinjal (8.26). Zn value for BCF was noticed maximum in brinjal (12.90) and minimum in spinach (6.12). Kabata-Pendias and Pendias described the BCF for metals such as Mn, Cu, Zn, Pb and Cd can vary from 300-500, 20-100, 100-400, 30-300, 5-30 mg/kg respectively. Overall a variation was found in vegetables in terms of BCF. The variations in transfer factor of metals in different vegetables are also related to each vegetable's absorption capability, soil nutrient management and soil properties [22]. Therefore, by choosing suitable crops, the risk of human exposure to metal contamination can be considerably reduced.

Daily intake of heavy metals through vegetables and health risk index

Estimation of the level of exposure and following the routes of contaminants to the target living beings are of extraordinary significance for watching the underlying health risks. An essential pathway of human presentation to substantial metals is natural food chain. In kids and in addition grown-ups, the DIM was computed from the normal measure of vegetables they devoured on every day basis. The DIM from different vegetables in adults and children is shown in Table 4. The DIM values for heavy metals is nearly free of risks, as the dietary intake Provisional Tolerable Daily Intakes (PTDIs) for Cu, Zn, Cd, Pb and Mn are 3 mg, 60 mg, 60 µg, 214 µg and 20 mg, respectively [23,24]. However, there are also some other sources of metal exposure, like dermal contact, dust inhalation, and ingestion of metal-contaminated soils, which have not been taken into account in the present study. It can therefore be concluded that our estimated DIM studied here are below those reported by the FAO/WHO, which had set a PTDI limit for heavy metal intake based on body weight for an average adult (60 kg) for Pb, Cd, Zn, and Cu as shown in Table 4.

Heavy metal	Mean conc. (mg/kg)	Daily intake adults (mg/day)	Daily intake children (mg/day)	FOA/WHO limits (mg/µg)[a]	HRI
Cd	0.26	0.00012	0.00015	60 µg	0.12
Mn	47.67	0.02323	0.02862	20 mg	0.7039
Cr	3.9	0.0019	0.002351	-	0.00126
Cu	3.4	0.00166	0.00205	3 mg	0.0414
Fe	381.4	0.18762	0.23	48 µg	-
Ni	3.58	0.00175	0.00125	-	0.875
Pb	-	-	-	214 µg	-
Zn	28.4	0.0139	0.01712	60 mg	0.46
Source: a=Join FAO/WHO Expert Committee on Food Additives, 1999. Conclusions. In: 53rd Meeting, Rome, June 1-10-1999.					

Table 4: Estimation of heavy metal intake through consumption of vegetables in Dera Ghazi Khan.

To evaluate the health risk related with these metals, the HRI were ascertained by partitioning every day intake of substantial metals by their reference dosages. HRI is ordinarily adopted to evaluate the health risk to peril materials in food. HRI<1 shows that the anticipated presentation is probably not going to posture potential health risk. Nonetheless, a risk file >1 does not really demonstrate that a potential adverse health impacts will come about, yet just shows a high likelihood of posturing heath risk.

Conclusion

Over all it can be concluded that selected vegetables (pumpkin, spinach, gourd, long gourd and brinjal) differ in their potential to accumulate heavy metals (Cd, Mn, Cr, Cu, Fe, Ni, Pb and Zn). Leafy vegetables like spinach have great tendency to accumulate higher concentration of Mn, Cr and Fe. This higher absorption of the said heavy metal might be linked with the high absorption rates of leafy vegetables bearing a large surface area [12]. In line with our study Singh also suggested that spinach should not be grown on heavy metal-contaminated soils due to its higher absorption potential. Food plants especially green leafy vegetables are the major dietary source being consumed all over the world. They play a significant part in nutritious commitment to the customers. Non-leafy vegetables are likewise a decent source of dietary components and are a critical piece of balance diet. But it may, on introduction to natural contaminants they collect substantial metals in their eatable parts. Melon (pumpkin, gourd, long gourd) showed great tendency to absorb heavy metals like Ni and Cu while solonaceous (brinjal), followed by leafy and melon vegetables, showed the maximum absorption potential of Zn. The outcomes detailed here affirm that the vegetables acquired from the Manka Canal site contained considerable measures of the metals with special case of Pb which recorded zero concentration or Pb concentration were observed to be underneath the identification furthest reaches of the machine. Levels of the metals are found to be different in different vegetables, as some found within the safe limits prescribed by the FAO/WHO and some crossed the safe limits. This is an important result as human health is directly affected by consumption of vegetables. Thus, estimated DIM by the selected vegetables was found below the limits. Hence, it is imperative to treat sewage water and industrial effluents before their discharge into water bodies. Awareness should be given to the formers of the area regarding the serious consequences of using contaminated wastewater for irrigation purpose. Analysis of waste water was not considered in this particular study.

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