Assessment of Heavy Metals Pollution and Estimation of DImetal Values in Vegetables Impacted by Translocation and Geological Location

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Summary: Heavy metals contamination in food consumables especially in vegetables is primarily due to multiple environmental factors and a matter of serious public health concern. The presented study scrutinized the heavy metals level and estimation of daily dietary intake of six main root vegetables; potato, yam, radish, turnip, beet and carrot, which are widely consumed on regular basis by community. Data was collected from three major cities of Pakistan: Karachi, Rawalpindi and Peshawar. Average heavy metals concentration in vegetables were found in order of Fe>Cu>Pb>Cd (93.62, 32.16, 11.74, 0.94) $mg.kg^{-1}$ and the daily intake metals (DI metal) of root vegetables were estimated 0.0527 $mg\ d^{-1}$, 0.018 $mg\ d^{-1}$, 0.503 $\mu g\ d^{-1}$, 6.580 $\mu g\ d^{-1}$ for Fe, Cu, Cd and Pb respectively. This study highlights two main possible sources of heavy metals contamination in vegetables namely the urban area cultivation and vegetables obtained by long distance sources. The values of these metals ingestion were below the recommended maximum tolerable level that presently enforced in world anticipated by the joint FAO/WHO expert committee on food additives (1999), hence are safe to eat yet the risk of excessive ingestion of heavy metals from root vegetables cannot be ignored. In view of this, there is need to develop legislations against malpractices and to design new regulations for translocation of vegetables and training of agribusiness personals.

Key Words: Vegetables; Heavy metals; Daily intake of metals; Translocation

Introduction

Vegetables are widely consumed due to countless health benefits. Therefore, monitoring of heavy metals contamination in foodstuff is prerequisite for better health safety of humans from different health problems. The health benefits associated with vegetables are dependent on several agricultural practices and conditions including soil types, irrigation sources, translocations, atmospheric and anthropogenic events. These practices can either contribute towards the bad quality veggies by amplification of heavy metal concentration or to promote healthy veggies by the balanced concentrations of necessary metals, antioxidants and vitamins.

Urbanization, industrial activities, wastewater irrigation, atmospheric deposition and contaminated soil are the dominant causes of heavy metals excessive uptake by vegetables; these situations are more obvious in developing countries [1-7]. Excessive heavy metal ingestion poses severe risk for both human and animals because they have higher aqueous solubility, elongated biological half-lives and easily absorbed in body, in urban vicinities heavy metals exist mostly due to intense industrial activities and rapid civil progress, these can posed deleterious effects on health even at low concentration due to their limited elimination pathways [8]. Cadmium and lead are known as most toxic carcinogens, higher cadmium concentration can leads to the cell damage/cancer and urological interruptions while higher lead concentration leads to the death even at low concentration. Pb becomes more threatening to human health when it enters the human body through uptake of food (65%), water (20%) and air (15%), lead has destructive effects on reproductive functions, a rise in blood pressure, disruption of nervous system and biosynthesis of hemoglobin. Cu enters into the environment by both natural sources and human activities. High intakes of copper may cause renal disease, liver and brain damage. Iron is necessary for biological activities but excess iron displaces zinc, copper and manganese from tissues and causes neuromuscular disease called Parkinson's disease. Iron destroys vitamin C which results in scurvy [9-13].

A number of research reports have already highlighted that elevation in heavy metals concentration in vegetables is due to multi environmental factors. Toxic metals are non-biodegradable, emitted from industries and vehicles which may deposited on the surface and then absorbed into the tissues of vegetables. Perveen et al.

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(2011) reported high concentrations of Fe, Ni, Cr and Cd in vegetables grown in Peshawar city irrigated by using sewage water. Because of shortage of fresh water, farmers use polluted water in the big cities for growing of vegetables. Ahmed et al. (2010) was carried analysis on soil samples of Motorway M-2 (Islamabad-Rawalpindi to Lahore); the rout use for transportation have reported Pb, Zn, Ni, Cd, Cr 0.5, 81.40, 14.19, 0.46 and 14.61 µg g-1 respectively, all these metals were found high in concentration. Research conducted by Ahmed et al. (2012) observed that vegetables collected from local market in Rawalpindi have Cd, Cu, Fe, Pb and Zn content above than Maximum Residue Limits (MRLs) set by WHO. Transportation of vegetables from one city to other has great impact on contamination of vegetables with toxic metals [1-2, 7, 14-20]. Moreover consumption of contaminated food for long time period can diminishes essential nutrients in body that leads to weak immunological defenses, growth retardation, impaired psycho-social behavior, disabilities due to malnutrition and high prevalence of upper gastrointestinal cancer, instance cardiovascular, urological, hypertension, psychological abnormalities and number of diseases are associated with lead and cadmium uptake, these have ability to reduce the average life expectancy by 9-10 years [8, 21-22].

At present the sources and pathways studies of metal contamination in food chain and human ingestion is very important. Since, food is consumed on habitual basis and therefore, it is main source of metal intake. This study was conducted to evaluate the health risks due to excessive ingestion of essential (Fe and Cu) and toxic (Cd and Pb) metals from utilization of common root vegetables, these were locally cultivated in three diverse geological vicinities of Pakistan. The risks of excessive metals ingestion were also studied. Daily intake of heavy metals were calculated for adults and children based on average daily consumption of vegetables in order to study their potential detrimental effects and compared with permissible tolerable daily intake of metals (8–18 mg d-1 for iron, 3 mg d-1 for copper, 60 µg d-1 for cadmium and 214 µg d-1 for lead) [10] and reference daily intake of metals that were 8-18 mg d-1 for iron, 0.900 mg d-1 for copper, 0.00 mg d-1 for cadmium and 0.00 mg d-1 for lead as excessive ingestion from these values, toxic and harmful effects were observed [9, 19].

Experimental

Study Area and Sampling

Vegetable samples were purchased directly from markets, these were locally cultivated in three diverse geological vicinities of Pakistan i.e. [Karachi–Urban (24°51’36”N, 67°00’36”E, at an altitude of 26ft above sea level, Climate: Sub tropical and temperate)], [Rawalpindi–Semi Urban (36o36’0”N, 73o02’0”E, at an altitude of 1633ft above sea level, Climate: humid sub-tropical)], [Peshawar–Urban (34°0'29"N, 71°34'22"E, 1138ft above sea level, Climate: semi-arid)]. Immediately after purchasing these were packed in wooden crates and then transported for analysis to laboratory located at Karachi (Pakistan).

Sample Preparation

The vegetables were washed under running tap water, rinsed thrice with deionized water, dried in open air, detached leaves then cut into small homogenized pieces with help of sharp and clean stainless steel kitchen knife. The intention of washing treatment was to eliminate any dirt, pesticides or chemicals on the surface of vegetables. Individual and referenced fresh samples were weighed using an electronic balance having accuracy of 0.001 g (A×200 Shimadzu, Tokyo, Japan) for immediate moisture analysis whilst the remaining part was dried at 65±5°C for 26±2 hours in air circulated oven (Ecocell Einrichtungen-222, Medcentre), dried samples were further blended using National NG-786 (2004TG blender), dried and blended samples were further powdered by crushing with pestle and mortar, then passed through sieve and kept in a well-labeled airtight polythene bags for consequent chemical analysis.

Digestion of Samples

Three well mixed vegetables samples of each vegetable sample were precisely weighed and placed in 150ml beakers. Samples were prepared accordingly as suggested by Allen [31] with little substantiation in minutiae 0.5±0.01 g powdered sample was taken in 15ml of tri-acid mixture HNO3:HClO4:H2SO4 (5:1:1) and reflux overnight, refluxed samples were digested on hot stirrer plate at 80oC until honey white yellow clear solution obtained then 1-2ml of HClO4 added in solution and digest again until homogeneous and clear solution obtained, the resulting solution filtered through Whatman filter paper No.42 and further diluted to 50ml using deionized water, the resulting solution were used for detection of Fe, Cu, Cd and Pb by using an Atomic Absorption Spectrometer (Perkin-Elmer, Model: AAnalyst-700). Aforetime to run sample solutions a series of standard solutions having different concentrations for calibration and to check sensitivity of instrument were frequently run, the

calibration was repetitively done after each 6 samples to obtain maximum precision. The measurements were made using a hollow cathode lamp of Fe, Cu, Cd and Pb at wavelengths (nm) of 248.3, 324.8, 228.8 and 283.3 respectively, the slit width was adjusted for all the heavy metals at 0.7nm and for Fe this slit width was 0.2nm; percent recovery for all metals were in range of 96±2%.

Daily Intake of Metal Estimation

The daily intake of metal were estimated by using formula [MC x FC x DIAverage] / [WAverage] Where, [MC] is metal concentration present in vegetable (dry weight basis mg kg-1), FC is a conversion factor used to convert fresh weight to dry weight; FC value is 0.085 as described in literature by Rattan [32]. [DIAverage] is a daily intake of fresh vegetables for adults and children that were taken as 0.345 and 0.232 kg person-1 day-1 respectively, while [WAverage] is average body weight of adult and child that were 55.9 and 32.7 kg respectively as described and applied in previously reported literatures [8, 33].

Quality Assurance Integrity

Convenient quality assurance measures were applied to make sure the results originality and integrity. Analytical grade reagents were used throughout the research work, all the reagents were purchased from Merck (Darmstadt Germany), distillation and make-up were carried out with deionized water. Samples were handled with maximum care to avoid any contamination and intrusion of any interfering specie. Glass wares were properly cleaned, washed thrice before use. All measurements were carried out at ambient environment (25±2 oC and 90% RH).

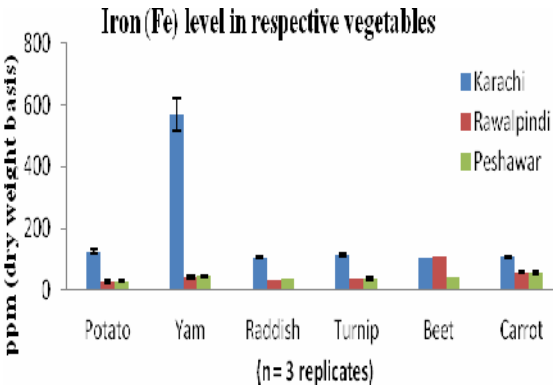
Statistical Analysis

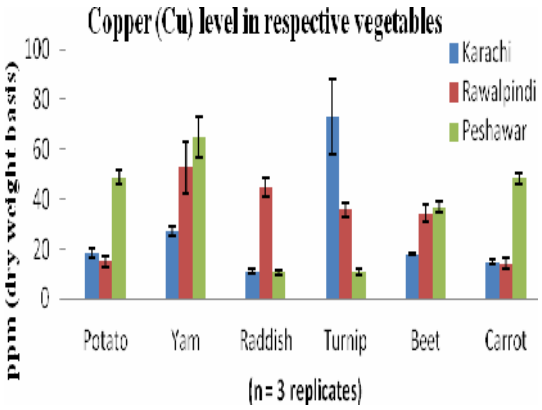
Data obtained were subjected to three statistical terms and in the form of Mean ± S.D and range of triplicates samples, by using Microsoft Excel programme 2007. One way analysis of variance is applied at 95% confidence level to find out the significance difference between the samples of each locality, Tukey's HSD tests were applied at 5% family error rate to classified the significance difference among samples, for ANNOVA and Tukey's HSD statistical programme MINITAB version 16.1 were used.

Results and Discussion

Heavy Metal Accumulation in Vegetables

All the heavy metal content were found to be several folds higher in vegetables cultivated in urban environment of Karachi in comparison with other vicinities i.e. Rawalpindi and Peshawar, Table-1 and Fig. 1 show the significant differences in heavy metal concentration ($P \leq 0.05$). Maximum metal concentration were found in order Fe>Cu>Pb>Cd except for yam, radish and potato of Rawalpindi whilst yam of Peshawar; for these vegetables the trend was Cu>Fe>Pb>Cd, beet from both Rawalpindi and Karachi area showed dissimilar trend from all others, the observed trend was Fe>Pb>Cu>Cd. Except in the case of copper all metals accumulation followed similar trend, maximum accumulation was found in urban area Karachi while minimum accumulation was observed in Rawalpindi and Peshawar areas cultivated vegetables.





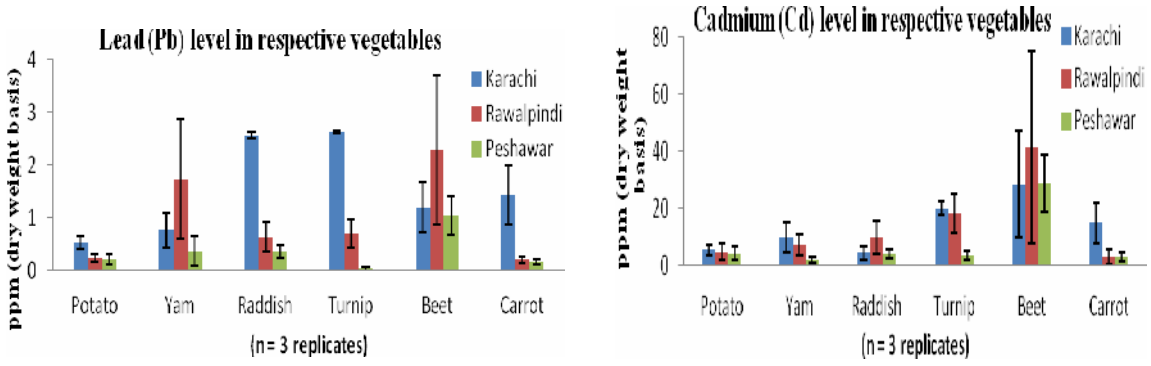


Fig. 1: Iron (Fe), Copper (Cu), Lead (Pb) and Cadmium (Cd) level (from top to bottom respectively) in root vegetables.

Table-1: Heavy metals content mg kg^{-1} (dry weight basis) in vegetables[X].

Vegetable	Values[Y]	Fe	Cu	Cd	Pb
Potato[K]	Range	118.52-137.35	14.84-21.31	0.29-0.69	3.18-8.76
	Mean±SE	125.63^{b}±5.90	18.52^{de}±1.92	0.53^{a}±0.11	5.31^{a}±1.74
Yamv	Range	506.27-672.51	25.00-30.67	0.29-1.39	2.09-19.82
	Mean±SE	569.99^{a}±51.76	27.12^{cde}±1.78	0.76^{a}±0.32	9.76^{a}±5.25
Radish	Range	101.59-108.36	9.56-11.75	2.49-2.68	0.69-8.26
	Mean±SE	105.64^{bcdef}±2.05	11.02^{e}±0.73	2.55^{a}±0.06	4.25^{a}±2.19
Turnip	Range	108.06-120.51	43.73-92.92	2.58-2.68	17.23-24.70
	Mean±SE	113.77^{bc}±3.63	73.17^{a}±15.00	2.62^{a}±0.03	19.92^{a}±2.39
Beet	Range	105.27-107.27	17.43-18.32	0.29-1.89	6.07-65.73
	Mean+SE	106.27^{bcdef}±0.57	17.89^{de}±0.25	1.19^{a}±0.47	28.42^{a}±18.77
Carrot	Range	104.68-112.55	13.84-16.33	0.29-1.99	4.78-28.88
	Mean±SE	107.80^{bcde}±2.42	14.77^{e}±0.78	1.42^{a}±0.56	14.77^{a}±7.25
Potato[R]	Range	24.50-38.24	10.65-17.62	0.09-0.29	0.69-10.05
	Mean±SE	29.32^{g}±4.47	15.00^{e}±2.18	0.23^{a}±0.06	4.68^{a}±2.79
Yam	Range	35.45-48.70	39.04-73.10	0.59-3.98	2.39-14.44
	Mean±SE	41.37^{fg}±3.89	52.72^{abc}±10.38	1.72^{a}±1.12	7.10^{a}±3.71
Radish	Range	31.27-33.86	39.04-51.89	0.29-1.19	2.88-21.01
	Mean±SE	32.63^{g}±0.75	44.82^{bcd}±3.76	0.63^{a}±0.28	9.72^{a}±5.68
Turnip	Range	35.35-40.83	30.47-40.23	0.29-1.19	10.05-31.67
	Mean±SE	37.64^{g}±1.64	35.69^{cde}±2.83	0.69^{a}±0.26	18.16^{a}±6.80
Beet	Range	106.07-110.75	30.27-40.93	0.19-4.98	2.59-108.86
	Mean±SE	109.19^{bcd}±1.56	34.13^{cde}±3.41	2.29^{a}±1.41	41.37^{a}±33.87
Carrot	Range	56.17-60.55	9.66-17.23	0.09-0.29	0.29-8.46
	Mean±SE	57.80^{cdefg}±1.38	14.21^{e}±2.31	0.19^{a}±0.05	3.02^{a}±2.72
Potato[P]	Range	28.78-32.27	45.61-54.68	0.09-0.39	0.09-8.96
	Mean±SE	30.15^{g}±1.07	48.70^{abc}±2.98	0.19^{a}±0.09	4.18^{a}±2.58
Yam	Range	37.94-50.19	50.09-78.48	ND-0.89	0.19-3.38
	Mean±SE	45.15^{defg}±3.69	64.61^{ab}±8.20	0.36^{a}±0.27	1.72^{a}±0.92
Radish	Range	35.45-37.05	9.26-12.15	0.19-0.59	1.19-6.67
	Mean±SE	36.05^{g}±0.50	10.69^{e}±0.83	0.36^{a}±0.11	3.75^{a}±1.59
Turnip	Range	30.07-43.72	9.66-12.84	ND-0.09	0.89-5.97
	Mean±SE	37.05^{g}±3.94	10.76^{e}±1.04	0.03^{a}±0.03	3.51^{a}±1.46
Beet	Range	40.53-43.82	32.17-38.44	0.29-1.39	15.03-48.40
	Mean±SE	42.46^{efg}±0.98	36.85^{cde}±2.38	1.02^{a}±0.36	28.72^{a}±10.08
Carrot	Range	52.39-65.13	43.92-50.99	0.09-0.26	0.77-5.67
	Mean±SE	57.37^{cdefg}±3.93	48.37^{abc}±2.23	0.15^{a}±0.05	2.98^{a}±1.43
Overall	Values	Fe	Cu	Cd	Pb
Minimum	X_1	29.32	10.69	0.03	1.72
Maximum	X_2	569.99	73.17	2.62	41.37
Average[Z]	X_n	93.62^{a}	32.16^{b}	0.94^{b}	11.74^{b}

[X] indicates n=3 replicates. [Y(a–g)] values with different subscripts within a same column are significantly different [Tukey's HSD test (5%), $P \leq 0.05$]. [K] indicates samples were of Karachi origin, [R] indicates samples were of Rawalpindi origin, [P] indicates samples were of Peshawar origin, [Z (a–b)]values with different subscripts within a same row are significantly different [Tukey's HSD test (5%), $P \leq 0.05$].

As shown in Table-1 (Fig. 1) Fe is the main element found in each vegetable, except in yam of both Rawalpindi and Peshawar and radish of Rawalpindi in which copper found to be pervasive element. The concentrations of iron were found in the range of 101.59–672.51, 24.50–110.75 and 28.78–65.13 mg kg-1 in vegetables from Karachi, Rawalpindi and Peshawar respectively. The highest content of iron was found in Yam of Karachi in the range of 506.27–672.51 mg kg-1 and then followed by potato 118.52–137.35 mg kg-1 and turnip 108.06–120.5 mg kg-1.

The highest concentration of Cu was detected in turnip of Karachi (43.73–92.92 mg kg-1) and then highest concentrations were found in vegetables of Rawalpindi and Peshawar i.e. yam of Peshawar (50.09–78.48 mg kg-1), yam of Rawalpindi (39.04–73.10 mg kg-1), potato and carrot of Peshawar (45.61–54.68 and 43.92–50.99 mg kg-1) respectively. On overall the ranges for copper concentration found to be in range of 9.56–92.92 mg kg-1, 9.66–73.10 mg kg-1 and 9.26–78.48 mg kg-1 for Karachi, Rawalpindi and Peshawar respectively. Significant differences in copper concentration among localities are presented in Table-1 and Fig. 1.

Cd content in an evocative range was present in vegetables from urban locality, predominantly in turnip (2.58–2.68 mg kg-1) and radish (2.49–2.68 mg kg-1). Cadmium was not found in yam and turnip cultivated in Peshawar area. The highest cadmium values were found in beet (4.98 mg kg-1) followed by yam (3.98 mg kg-1) of semi urban Rawalpindi area. In all vegetable samples cadmium was found 0.29–2.68, 0.09–4.98 and BDL–1.39 mg kg-1 for Karachi, Rawalpindi and Peshawar respectively.

Pb were detected in all localities samples, similar pattern like cadmium is observed (Table-1 and Fig. 1). Lead in vegetables from Karachi urban area (0.69–65.73 mg kg-1) found to be much higher in comparisons with semi urban Rawalpindi (0.29–108.86 mg kg-1) and Peshawar area (0.09–48.40 mg kg-1). There is no significant difference noted among samples results for lead ($P \leq 0.05$).

Heavy metal concentration differences among vegetables from diverse vicinities were observed that might be due to the dissimilar absorption capacities of vegetables linked with multifold environmental factors such as airborne deposition, surface area type, marketing, transportation and urbanization. As previously reported that multiple environment factors can contribute in heavy metal uptake by vegetables [1-3, 6-8, 11, 18, 19].

Significant differences ($P \leq 0.05$) have been observed in these urban and semi urban localities. Karachi vegetables have significantly higher levels of iron in comparison to other areas vegetables that might be due to irrigation resources of Karachi that is waste water. It was previously reported that urban environment and waste water irrigation in Karachi leads to the excess accumulation of iron in plants [6, 8, 19, 23].

The highest concentration of Cu was observed in turnip from Karachi which might be due to the waste water irrigation that contaminated with metal plating industrial waste and leads to excessive uptake of copper [8]. In Karachi several metal plating and metal production industries are operational which effluents are used for cultivation process. Copper concentration in vegetables of Peshawar and Rawalpindi were found higher than the all Karachi area vegetables except turnip of Karachi, it might be due to application of copper-containing pesticides, use of chicken manure or cow dung as natural fertilizer, as these are common practices of respective areas, besides this copper is also used as additive for improvement in food quality, which results in excessive uptake of copper by humans [24]. High copper concentrations were also reported by the Tam & Tiquia [25] in natural organic waste. The repetitive application of organic wastes which contains substantial amounts of copper, leads to copper concentration increment in the soil and then uptake by plant [26]. Copper leaching process is slow due to higher absorption by clay particles and organic matter [27].

It is quite obvious that the urban area cultivated vegetables have high Cd concentration that might be due to atmospheric deposition during translocation, excess application of phosphate fertilizers in these areas, locality environment, metal plating industrial waste water, lubricating oil contamination and numerous human activities [23, 28- 29], moreover it has been reported that urbanization growth and development is allied with enhancement of cadmium concentration [29- 30].

The highest Pb concentration found in Karachi area samples is might be due to unplanned civil progress, urbanization and heavily traffic load in Karachi as urban locality and airborne pollutants related to traffic load are responsible to increase the lead concentration in environment [23]. Lead concentration was found higher in Rawalpindi samples in contrast with Peshawar samples this may be due to the distance differences between sampling region and translocation distance covered by samples to reach at laboratory which is 1107km and 1134km by road from Rawalpindi and Peshawar to Karachi respectively. We conclude that the market location, traffic load and mileage can affect on lead content and can leads to excessive uptake of lead. There are varieties of factors reported which contributing towards the contamination of lead such as dust, atmospheric lead, lead containing pesticides, sewage slush, mud, pH, vehicle exhaust, automobile

emission, urbanization, transportation, lead containing fuel and duration of exposure [8, 17].

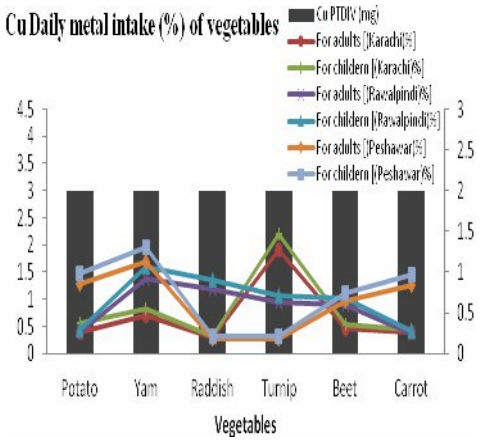
Daily Intake of Metals (DImetal)

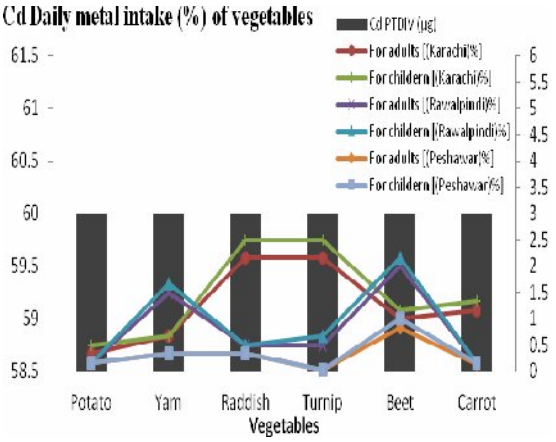
As estimated in Table-2 (Fig, 2), the daily intake metals (DImetal) from root vegetables for community on average basis estimated to be Fe 0.0527 mg d-1, Cu 0.018 mg d-1, Cd 0.503 µg d-1 and Pb 6.580 µg d-1. The highest values of Fe and Cd ingestion for adults and children were estimated from the consumption of urban area cultivated vegetables especially from potato, yam, turnip and beet. On consumption of vegetables obtained from long distance i.e. Peshawar and Rawalpindi, have higher probability of Pb exposure especially from beet of both Rawalpindi and Peshawar.

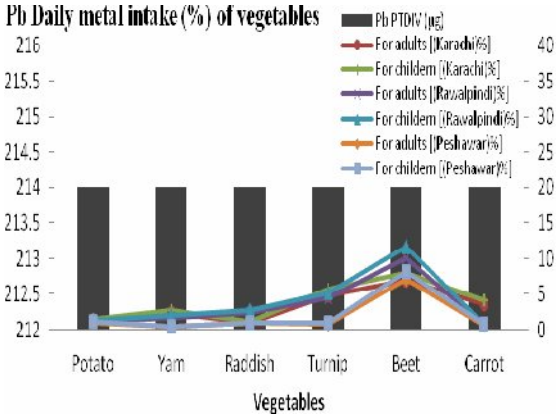
Table-2: Daily intake of metals through utilization of vegetables.

Vegetable	Fe (mg)		Cu (mg)		Cd (µg)		Pb (µg)	
	Adults	Children	Adults	Children	Adults	Children	Adults	Children
Potato^{K}	0.0659	0.0757	0.0079	0.0111	0.2	0.3	2.7	3.2
Yam	0.2990	0.3437	0.0142	0.0163	0.4	0.4	5.1	5.8
Radish	0.0554	0.0637	0.0057	0.0066	1.3	1.5	2.2	2.5
Turnip	0.0596	0.0686	0.0383	0.0441	1.3	1.5	10.4	12.0
Beet	0.0557	0.0640	0.0093	0.0107	0.6	0.7	14.9	17.1
Carrot	0.0565	0.0650	0.0077	0.0089	0.7	0.8	7.7	8.9
Potato^{R}	0.0153	0.0176	0.0078	0.0090	0.1	0.1	2.4	2.8
Yam	0.0217	0.0249	0.0276	0.0317	0.9	1.0	3.7	4.2
Radish	0.0171	0.0196	0.0235	0.0270	0.3	0.3	5.1	5.8
Turnip	0.0197	0.0227	0.0187	0.0215	0.3	0.4	9.5	10.9
Beet	0.0572	0.0658	0.0179	0.0205	1.2	1.3	21.7	24.9
Carrot	0.0303	0.0348	0.0074	0.0085	0.1	0.1	1.5	1.8
Potato^{P}	0.0158	0.0181	0.0255	0.0293	0.1	0.1	2.1	2.5
Yam	0.0236	0.0272	0.0338	0.0389	0.2	0.2	0.9	1.0
Radish	0.0189	0.0217	0.0056	0.0064	0.2	0.2	1.9	2.2
Turnip	0.0194	0.0223	0.0056	0.0064	0.017	0.02	1.8	2.1
Beet	0.0222	0.0256	0.0193	0.0222	0.5	0.6	15.0	17.3
Carrot	0.0300	0.0345	0.0253	0.0291	0.082	0.094	1.5	1.8
Overall	Fe (mg)		Cu (mg)		Cd (µg)		Pb (µg)	
Minimum	0.0153	0.0176	0.0056	0.0064	0.017	0.02	0.9	1
Maximum	0.299	0.3437	0.0383	0.0441	1.3	1.5	21.7	24.9
Average^{X}	0.0490	0.0564	0.0167	0.0193	0.4722	0.5341	6.1167	7.0444
% of PTDIV	NA	NA	0.515	0.596	0.739	0.836	2.691	3.099
% of RDIV	NA	NA	1.719	1.987	NA	NA	NA	NA
Values	Fe (mg)		Cu (mg)		Cd (µg)		Pb (µg)	
PTDIV^{Y}	DNA		3		60		214	
RDIV^{Z}	8(18)		0.900		0.000		0.000	

^{K} indicates samples were of Karachi origin, ^{R} indicates samples were of Rawalpindi origin, ^{P} indicates samples were of Peshawar origin. $^{X(a-b)}$values with different subscripts within a same row are significantly different [Tukey's HSD test (5%), $P \leq 0.05$], ^{Y} Joint FAO/WHO Expert Committee on Food Additives 1999. ^{Z}Food and Drug Administration.Dietarysupplements.Center for Food Safety and Applied Nutrition 2001. DNA (Data not available), NA (Not applicable)







Note: PTDIV and RDIV values for Iron (Fe) are not defined yet (2012).

Fig. 2: Copper (Cu), Cadmium (Cd) and Lead (Pb) Metal daily intake vs. Permissible tolerable daily intake values for adults and children (from top to bottom respectively).

Table-3: DImetal from vegetables for different countries around the world[X].

Ref #	Country	City	Year	Cause	Fe	Cu	Cd	Pb
This Study	Pakistan	Karachi, Rawalpindi, Peshawar	2012	General	0.053 mg d^{-1}	0.018 mg d^{-1}	0.503 µg d^{-1}	6.581 µg d^{-1}
34	Bangladesh	Overall	2012	General	..	..	12.03 µg d^{-1}	..
19	Romania	Banat County	2011	Mining area	9.829 mg d^{-1}	0.437 mg d^{-1}	0.015 mg d^{-1}	0.272 mg d^{-1}
35	China	Beijing	2011	Soil contamination	..	0.885 mg kg^{-1}	0.011 mg kg^{-1}	0.063 mg kg^{-1}
11	India	Varanasi	2010	Seasonal variation	..	0.130 mg d^{-1}	9.477 µg d^{-1}	6.057 µg d^{-1}
36	Tanzania	DarEs Salaam	2010	General	..	..	11.80 µg w^{-1}	264.6 µg w^{-1}
8	India	Rajhastan	2008	Different irrigation sources.	0.127 mg d^{-1}	0.006 mg d^{-1}	..	..
2	India	Varanasi	2008	Waste water	..	133.3 g d^{-1}	46.78 g d^{-1}	190.1 g d^{-1}
37	Iran	Sanandaj	2008	General	..	2.5 mg d^{-1}	0.07 mg d^{-1}	2.96 mg d^{-1}
38	China	Beijing	2008	Waste water	..	0.013 mg d^{-1}	0.197 mg d^{-1}	0.0353 mg d^{-1}
39	Zimbabwe	Harare	2007	Waste water	..	0.045 mg d^{-1}	0.03 mg d^{-1}	0.0675 mg d^{-1}
40	Pakistan	Karachi	2007	General	24.175 µg g^{-1}	2.500 µg g^{-1}	..	..
41	Pakistan	Karachi	2005	General	1320.5 mg g^{-1}	80.5 mg g^{-1}	..	..
30	Saudi Arabia	Riyadh	2005	Dust	..	0.22 mg d^{-1}	3.46 µg d^{-1}	1.23 µg d^{-1}
42	China	Nanning	2004	Soil contamination	11.28 mg d^{-1}	0.26 mg d^{-1}	0.12 mg d^{-1}	1.05 mg d^{-1}
43	Spain	Tarragona	2003	General	..	..	2.02 µg d^{-1}	14.6 µg d^{-1}

Many studies have been determined the daily metal intake values in vegetables from different localities around the world as well as local localities as shown in Table-3. In Bangladesh 12.03 µg d^{-1} of Cu was reported [34], Other countries reported data were: China (Soil contamination) Cu 0.885 mg kg^{-1}, Cd 0.011 mg kg^{-1} and Pb 0.063 mg kg^{-1}; Tanzania Cd 11.80 µg w^{-1} and Pb 264.6 µg w^{-1}; Iran Cu 2.5 mg d^{-1}, Cd 0.07 mg d^{-1} and Pb 2.96 mg d^{-1}; China (Waste water) Cu 0.013 mg d^{-1}, Cd 0.197 mg d^{-1} and Pb 0.0353 mg d^{-1} ; Zimbabwe waste water Cu 0.045 mg d^{-1}, Cd 0.03 mg d^{-1} and Pb 0.0675 mg d^{-1}; Pakistan (2007) Fe 24.175 µg g^{-1} and Cu 2.500 µg g^{-1}; Pakistan (2005) Fe 1320.5 mg g^{-1} and Cu 80.5 mg g^{-1}; China (Nanning) Fe 11.28 mg d^{-1}, Cu 0.26 mg d^{-1} ,Cd 0.12 mg d^{-1} and Pb 1.05 mg d^{-1} ; Spain Cd 2.02 µg d^{-1} and Pb 14.6 µg d^{-1} [34-43] but this study is more comprehensive due to cadmium daily ingestion estimation, as cadmium is most toxic element, Pakistani community can ingest significantly high value of Cd and Pb (0.5, 6.5) % in contrast with two main elements on percentage basis i.e. Fe and Cu (0.05, 0.01) % on comparison with PTDIV. This study highlighted the two main sources of heavy metal contamination in vegetables, namely the urban area cultivation and vegetables obtained by long distance translocation, which directly puts in result of excessive metal ingest by humans, and these findings are in line with previously reported literature. Consequently appropriate safety measures and standard monitoring is necessary for metal intake estimation [3, 8, 30].

Conclusion

This study highlights the two main sources of heavy metals contamination in vegetables; the urban area cultivation and vegetables obtained by long distance source, also for Pakistani community daily ingests estimation of metals through vegetable utilization is lower than other communities, the probability of facing deleterious health risk were higher for Pakistani community by excessive ingestion and long time exposure to cadmium and lead, furthermore the values of these metals ingestion

were below the recommended maximum tolerable level that presently enforced in world anticipated by the joint FAO/WHO expert committee on food additives (1999), hence are safe to eat but the risk of excessive ingestion of heavy metals cannot be ignored; therefore regular monitoring is requisite to minimize the health risks in upcoming future. Furthermore there is need to apply strict rules and legislations against malpractices, also there is a need of designing new regulations for the training of agribusiness personals and introduction of new emerging agricultural technologies in order to minimize health risk in upcoming future, as hazardous effects caused by metal exposure can observed after several years.

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