Health risk assessment due to uptake of heavy metal

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ABSTRACT: *The objective of this study was to evaluate the heavy metal content in 13 different seasonal vegetables of six heavy metals in Delhi NCR region during the year 2010-2012 . The study also reveals the potential threat to the population (human health risk) while consuming these heavy metals. The hazard quotient (health risk index) of the population was also computed..The mean daily intake was found to be higher in spinach for Fe 0.567 mg/day/person whereas the minimum intake of heavy metal in 0.004 mg/day/person of Ni in cucumber. The health risk index of all the heavy metal was found to be less than 1.*

Key Words: *Heavy Metal, Vegetables, Human Health Risk, Health Risk Index*

5.1 Introduction

Food safety is a major public concern worldwide. The increasing demands for food and food security have drawn the attention of researchers to the risks asscociated with the consumption of contaminated foodstuffs i.e pesticides, heavy metal and or toxins in vegetables (D Mello2003, Hosseini et al 2009). Heavy metal contamination is a major problem of our environment and they are also one of the major contaminating agents of our food study(Arsar et al 2005; Khair et al 2009).This problem is receiving more and more attention all over the world, in general and in developing countries in particular. The biological half- lives of these heavy metalsare long and have potential to accumulate in different body organs and thus produces unwanted side effect (Jarup et al 2003 Agarwal et al 2004 Moore et al 2009).Excessive accumulation of these heavy metals in human bodies creates the problems like cardiovascular, kidney, nervous and bone diseases (Steeland 2000)It s known that serious systemic problems can develop as a result of increased accumulation of dietary heavy metals such as Cadmium and lead in human body (Oliver et al 1997). Heavy metal is extremely persistent in the environment, they are non biodegradable and non- thermo degradable and thus their accumulation readily to toxic levels (Bohn et al 1985). Heavy metals can impair important biochemical systems, constituting an important threat of plants and animals. The adverse health effects of several chemical elements have been documented throughout history. Currently, the advances of toxicology has improved our knowledge about human exposure to toxic elements and their health effects such as developmental retardation ,several type of cancer, kidney damage, endocrine disruption, immunological disorders and even death.Significant contamination of seeds, plants and plant products with toxic products with toxic chemical elements due to contaminated soil and water has been observed as result of release of these toxicants into the sea, rivers, and lakes and even into irrigation channels. Afterwards, the consumption of contaminated vegetables constitutes an important route of animal and human exposure.The tradition of growing vegetables within and at the edges of cities is very old (Smith 1996). These cultivated lands area contaminated with heavy metal contributed mainly through vehicular emissions, pesticides and fertilizers, industrial effluents and other anthropogenic activities. These contaminated soils have resulted in the of contaminated vegetables (Datta et al 2005; Ismail et al 2009). Heavy metal in soils reduce the yield of vegetables because of disturbing the metabolic processes of plants(Al Quraíny et al 2009).Singh and Kumar in 2006 concluded that soil, irrigation water and some vegetables from peri-urban sites are significantly contaminated by the heavy metals i.e Cu, Cd, Pb and Zn .It was concluded that Cd and Pb were of more concern than Cu and Zn.

The heavy metals not only affect the nutritive values of vegetables of vegetables but also affect the health of human beings and therefore the safe limits of these heavy metals are lowered regularly in these vegetables. This regulation is responsibility of National and International regulatory authority.(Mohammad et al 2006).Mostly, the concentration of heavy metals is higher in soils than vegetables grown on the same soils. This indicates that only a small proportion of heavy metals is transferred to the vegetables and the root acts as a barrier to the translocation of heavy metals within the plant (white et al 1981). The results of heavy metals contamination differed from area to area as the application of fertilizer and other human activity differ at each site. It is studied that phosphate fertilizers are the main source of soil heavy metal pollution. This pollution is because of the presence of Cd as an impurity in phosphate rocks. Because of the massive application of these fertilizers, the contamination of heavy metal in soil is resulted. Zhou et al (1994).

Material and methods

Study area

In order to quantify health risk assessment in vegetables, samples were taken from different market sources. Samples were collected on seasonal basis i.e sampling were done in the month of winter and summer. Vegetables collected for analysis includes Leafy Vegetables (spinach, Amaranthus), Root vegetables (potatoes, Onion) Fruit vegetables include (Bhindi, Brinjal, Chili, Cucurbits, beans etc). Heavy metals analyzed are the Fe, Mn , Zn , Cd, Cu, Pb, Ni. Each sample was collected by random sampling methods. Three replicates of the samples were collected.

Sample preparation and analysis

All the collected samples of various vegetables were washed with double distilled water to remove airborne pollutants. The edible parts of the vegetable samples were weighed and air-dried for a day, to reduce water content. All the samples were then oven-dried in a hot air oven at 70–80 oC for 24 h, to remove all moisture. Dried samples were powdered using a pestle and mortar and sieved through muslin cloth. For each vegetable, three powdered samples from each source of irrigation (0.5 g each) were accurately weighed and placed in crucibles, three replicates for each sample. The ash was digested with perchloric acid and nitric acid (1:4) solution. The samples were left to cool and contents were filtered through Whatman filter paper No. 42. Each sample solution was made up to a final volume of 50 ml with distilled water and analyzed by atomic absorption spectrophotometer (932AA, GBC Scientific Equipment, Dandenong, Australia).Standard solutions of heavy metals (1000 mg/l), namely copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe), Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni) were procured from Merck. Standard solution of 0.5 ppm, 1.0ppm, 2.5 ppm, 5.0 ppm was made from this stock solution.

Calculation of health risk assessment index

Hazard Quotient (Health risk index)

Risk of intake of metal-contaminated vegetables to human health was characterized by Hazard Quotient (HQ). This is a ratio of determined dose to the reference dose (RfD). The population will pose no risk if the ratio is less than 1 and if the ratio is equal or greater than 1 then population will experience health risk. The following equation was used

$$HQ = [W_{plant}] \times [M_{plant}] / RfD \times B$$

Where
[Wplant] is the dry weight of contaminated plant material consumed (mg/day),
M plant is the plant concentration of metal in vegetables (mg/kg),
RfD is the reference dose (safe limit)
B is the body mass (kg)

Average adult weight -55.9 kg, Average child weight- 32.7 Kg, Average daily intake of vegetable by adult- 0.345 kg and Average daily intake of vegetable by child- 0.232 kg were taken in account.

Daily Dietary Index (Daily intake of heavy metal

As food crops are contaminated by heavy metals so their daily intake needs to be evaluated for comparison as given by US-EPA. Daily dietary index is determined by the following formula:

$$DDI = X \times Y \times Z / B$$

Where
X = metal in vegetable, Y = dry wt. of the vegetable, Z = approximate daily intake, B = average body mass of the consumers

Result and discussion

Theheavy metal uptake by human being depends on the consumption, the characteristic of vegetables and intensity of the metal content. Result showed the heavy metal value less than 1 mg/day/person. in order of for copper consumption of Coriander>Tomatos >Okra> Onion> Brinjal >Shimla Mirch

Heavy metal content in different vegetables

Vegetables	Ni	Zn	Fe	Cu	Pb	Cd	Cr
Radish	17.78	26.40	323.78	13.73	0.71	1.03	17.30
Potato	13.25	14.17	352.32	12.27	1.23	3.28	15.24

Brinjal	10.85	28.50	116.53	22.70	0.91	0.75	14.70
Tomatos	18.68	32.82	335.48	26.05	1.56	0.22	26.49
Chilli	16.85	15.65	216.93	14.99	0.42	1.85	15.72
Shimla mirch	15.68	36.28	280.30	23.72	0.74	0.73	17.27
Onion	21.39	41.63	273.30	19.60	1.39	1.80	22.97
Coriander	20.65	33.87	1227.48	28.93	1.48	1.22	13.23
Spinach	13.38	31.74	1077.13	20.78	1.87	2.51	33.33

Mean daily intake of heavy metal of adult

Vegetable	Cu	Mn	Zn	Ni	Cr	Fe
Potato	0.006	0.021	0.007	0.006	0.007	0.182
Onion	0.011	0.025	0.015	0.010	0.011	0.127
Brinjal	0.010	0.005	0.013	0.003	-	0.059
Radish	0.006	0.018	0.011	0.009	0.008	0.159
Chilli	0.007	0.017	0.008	0.009	0.007	0.118
Shimla Mirch	0.009	0.013	0.019	0.008	0.008	0.133
Coriander	0.012	0.048	0.015	0.009	0.006	0.482
Spinach	0.009	0.083	0.014	0.006	0.035	0.567

The health risk index (HRI) showed similar trend (Table 5.2). The maximum value for Ni consumption was found to be in order to Onion> Radish >Chilli>Coriander>Shimla Mirch (Table5.1). HRI value also showed similar trend. The value for Mn found to be maximum in Spinach> Coriander> Onion> Potato> Radish. The HRI value showed similar trend for Mn concentration. The value for the consumption of Zinc and HRI was found >1 also in order to Okra> Cucumber> Shimla Mirch > Tomato>Onion. The similar trend was also seen in HRI factor. The result for mean daily value for Chromium was found to less than 1 mg/day/person in order of Coriander >Tomatos >Okra> Onion> Brinjal >Shimla Mirch (Table 5.2). While the value for Chromium was observed to be more than 1 in all vegetables crops. This is little higher than the safer value (IRIS).

It was observed that the maximum intake for Cu and Ni was found to be less than 1 (mg/day/person) in leafy vegetable (Coriander, Spinach) >fruit vegetable>tuber crops. This may be because of higher translocation of the metals in leafy crops. The similar trend reported was also reported by Singh et al(2012).According to the IRIS., (2003), if the value of HRI is less than 1 then the exposed population is said to be safe. Thevalues for HRI observed in the study indicate that the metal uptake was within the permissible limit and there is no threat to human population in NCR Delhi.

Health risk index of different heavy metals

Vegetables	Cu	Ni	Mn	Cr	Zn
Potato	0.012	0.30	0.168	2.33	0.021
Onion	0.022	0.50	0.197	3.66	0.045
Brinjal	0.020	0.15	0.039	-	0.039
Radish	0.012	0.45	0.144	2.66	0.033
Chilli	0.014	0.45	0.134	2.33	0.024

Shimla Mirch	0.018	0.40	0.101	2.66	0.057
Coriander	0.024	0.45	0.375	2.00	0.045
Spinach	0.018	0.30	0.411	11.6	0.042

Conclusion

Heavy metal contamination of the food items is one of the most important aspects of food quality assurance. Rapid and unorganized urban and industrial developments havecontributed to the elevated levels of heavy metals in the urbanenvironment Delhi. In the present investigation six heavy metals, namely Cu, Zn, Fe, Mn, Ni, and Cr in thirteen edible vegetables were collected from four different market sources. The samples of all vegetables wereanalyzedfor heavy metals by Atomic Adsorption Spectroscopy.The result for mean daily intake for Cu, Zn, Fe, Mn, Ni, and Cr metals content of most crop were below 1 (mg/day/person) and the HRI<1, the population is under the safe limit.

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