Assessing potential risk of heavy metal exposure in green leafy vegetables.
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Abstract
Green leafy vegetables such as Spinach (Beta vulgaris L), Brassica (Brassica campestris) and Cabbage (Brassica oleracea) randomly collected from market and from agricultural fields in and around Patiala city were analyzed for heavy metals Fe, Zn, Cd, Cr, Cu and Pb. Nearly 16 % samples of palak from market had high level of Cd than the permissible limits of 1.5mg/kg, 23% samples of brassica had high Pb and 26% samples of cabbage had high Zn than the permissible limit of 2.5mg/kg as per Indian Standard of Food Adulteration Act. Heavy metals in the randomly collected samples were in the order of Fe>Zn>Pb>Cu>Cd whereas in vegetables collected from agricultural fields around Patiala city were in the order of Zn>Pb>Cu>Fe>Cd. The metal content in vegetables from agricultural areas indicates high levels of soil contamination and accumulation of Pb and Cd in vegetables.

Keywords: heavy metals; palak; yellow sarson; cabbage

1. Introduction
Metal-contaminated soils are potentially harmful to plants, animal and humans. Toxic substances such as heavy metals have increased in natural waters and agricultural soils particularly in industrialized countries. Atmospheric deposition of heavy metals in soil and or in vegetables growing near industrial areas has been investigated [1] which indicate high concentrations of heavy metals in leafy vegetables. Majority of soil contamination is through atmospheric deposition of heavy metals from sources such as: metaliferous mining, smelting and industrial activities. The heavy metals being immobile get accumulated in the soil endangering crops and vegetables [2]. Potential risk to population subgroups living on and consuming vegetables grown on large urban sites were assessed and was considered that young children are highly exposed [3]. The potential cancer risk from Cd and Ni are addressed as a result of occupational inhalation exposure [4].

Heavy metals may enter the body through inhalation of dust, direct ingestion of soil and consumption of food plants grown in metal-contaminated soil [5, 6]. Potentially toxic metals are also present in commercially produced foodstuffs [7]. Exposure to potentially toxic metals from dust inhalation or soil ingestion is usually modeled simply as the concentration of a contaminant measured in the soil multiplied by the quantity of dust inhaled or soil digested [8]. Municipal sludge is a valuable organic manure and soil conditioner and has been used as a fertilizer over decades but at the same time sludge may contain heavy metals and organic pollutants, which are harmful to crops and microorganisms in soil. Therefore, in current investigation metal analysis was carried out in randomly collected fresh samples of green leafy vegetables such as spinach (Beta vulgaris L), brassica (Brassica Campestris) and cabbage (Brassica oleracea) from vendors and agricultural fields.

2. Materials and Method
2.1 Collection and preparation of leafy vegetable samples
A total of 45 vegetable samples were collected from places in and around Patiala district of Punjab (India) during the period from Feb to April 2006 to assess the heavy metal contamination. The samples procured from market and agricultural fields included Spinach (Beta vulgaris L), Brassica (Brassica. campestris) and Cabbage (Brassica. oleracea). Vegetables samples were collected and then washed with running tap water to remove soil and dirt,
Fig I: Heavy metals (mg/kg of dry weight) in random samples of green leafy vegetables.

Fig II: Heavy metals (mg/kg of dry wt) in random samples of green leafy vegetables Collected from villages around Patiala.
followed by distilled water. All samples were dried at 70°C for about 48-72 hours, then cooled to ambient temperature, crushed by means of a pestle and mortar and sieved. The sieved samples were stored in airtight sealed plastic bags until required for analysis.

2.2 Determination of heavy metals in leafy vegetables

1g oven dried sieved sample was digested by wet digestion method with concentrated HNO₃ (15 ml) and HClO₄ (5 ml) in the ratio 3:1 [9]. The samples were digested on a hot plate at a temperature corresponding to 100°C for 3-4 hrs. Heating was done till it dried up completely and whitish brown dry mass was obtained. It was then cooled and the precipitate/digest mixture was extracted in acid water mixture (concentrated HCl: distilled water in the ratio 1:1) and filtered through whatman filter paper No. 42. Volume was made up to 50 ml. The filtrate was analyzed for metal content using Atomic Absorption Spectrophotometer (GBC 932 AA). The instrument was calibrated using standard solutions of Cr, Fe, Ni, Pb, Zn and Cd. The various metals along with their sensitivity limits (μg ml⁻¹) are as follows: Cr: - 0.05, Fe: - 0.05, Ni: - 0.04, Pb: - 0.06, Zn:-0.008 and Cd: – 0.009.

3. RESULTS

3.1 Metals in random samples of green leafy vegetables

In randomly collected samples of palak (Beta vulgaris L), cabbage (Brassica oleracea) and yellow sarsoo (Brassica campestris) from 45 different vendors within the city of Rajpura and Patiala, heavy metals Fe, Zn, Pb, Cr and Cd analyzed showed great variation (Fig. I). In palak Zn varied from 24 to 69.55 mg/kg, Cd varied from 0.2 to 3.35 mg/kg, Fe varied from 5 to 12.5 mg/kg. Whereas Cr and Ni were below detection limit in all the vegetables. Analysis showed that the trend for the heavy metals in palak samples was in the order Fe>Zn>Pb>Cu>Cd. In cabbage Fe ranged from 0 to 3925 mg/kg, Zn varied from 2.2 to 59.6 mg/kg, Pb was from 0.04 to 5 mg/kg, Cd was from 1.05 to 6.95 mg/kg whereas Cr and Ni were below detection limit in all and the trend was Fe>Zn>Pb>Cu>Cd. In yellow sarsoo Cd ranged from 0.85 to 37.6 mg/kg, Zn from 26 to 69.8 mg/kg. Fe was from 1.06 to 44.8 mg/kg, Pb was from 9.1 to 50 mg/kg whereas Cr and Ni were again below detection limit in all the samples.

Amongst the various heavy metals analyzed for different green leafy vegetables a similar trend in metal content was observed i.e. Fe>Zn>Pb>Cu>Cd, however their values in all vegetables were different. Fe was found highest in palak with a mean of 24 ± 3.5 mg/kg followed by cabbage with a mean of 17.45 ± 3.3 mg/kg and yellow sarsoo as 17.35 ± 3.3 mg/kg. Zn was highest in yellow sarsoo with a mean of 35.6 ± 4.03 mg/kg followed by palak with a mean of 24 ± 5 mg/kg and cabbage having 16.3 ± 5.04 mg/kg. Cd was highest in cabbage with a mean of 23.5 ± 6.6 mg/kg followed by palak with a mean of 18.75 ± 5.3 mg/kg and minimum in brassica i.e. 17.35 ± 3.3 mg/kg. Cu was maximum in case of palak with a mean of 56.25 ± 5.5 mg/kg, followed by cabbage with a mean of 5.3 ± 0.52 mg/kg and 3.95 ± 0.37 mg/kg was for yellow sarsoo which was least.

3.2 Metals in random samples of green leafy vegetables collected from agricultural fields

Vegetables were collected from different agricultural fields around Patiala city to study the metal concentration in the fresh farm produce (Fig II). In yellow sarsoo maximum concentration of Fe was found in samples of villages Banur (44.45 mg/kg) whereas lowest concentration was reported in samples from village Bathonia (2.4 mg/kg). Cd concentration was highest in samples from village Kami-Kalan (37.6 mg/kg) followed by samples from village Banur (8.98 mg/kg) and village Bhadak (1.45 mg/kg). Whereas lowest concentration was reported in samples from Bathonia (1.1 mg/kg). Zn was maximum in samples from village Banur (421 mg/kg) followed by samples from Bathonia, Bhadak and Main village (44.9 mg/kg, 53.3 mg/kg and 41.8 mg/kg respectively). Cu was maximum in samples from village Banur (81.8 mg/kg) and minimum in samples from village Bathonia (2.4 mg/kg). Pb was maximum in samples from village Banur (170 mg/kg) whereas lowest was reported in samples from Kami-Kalan (3.25 mg/kg). Analysis trend showed that the order of metal content in brassica was Zn>Pb>Cu>Fep>Cd.

Palak had maximum Fe concentration in samples from Banur (23.35 mg/kg) followed by samples from village Bathonia, Bhadak and Main village (7.75 mg/kg, 7.75 mg/kg and 3.8 mg/kg respectively). Cd was maximum in samples from village Banur (6.45 mg/kg) followed by samples from village Main (0.6mg/kg) and Bhadak (0.55mg/kg). Zn was maximum in village Banur (246 mg/kg) followed by village Kami-Kalan (94.5 mg/kg) and Bhadak (47.75mg/kg). Pb was reported to be maximum in village Banur (81 mg/kg) followed by village Kami-Kalan, Main and Bathonia (27.75 mg/kg,17.65mg/kg and 10.15 mg/kg respectively). Cu was maximum in samples from village Banur (39.55mg/kg) followed by Kami-Kalan (16.85 mg/kg) and Main village (5.9 mg/kg). Trend in metal content was Zn>Pb>Cu>Fep>Cd.

Cabbage had showed maximum Fe concentration in samples from village Bathonia (7.45 mg/kg) followed by Banur (6.75mg/kg) and Bhadak (4.55mg/kg). Zn was maximum in samples from village Bathonia (47.35 mg/kg) followed by village Kami-Kalan (28.75 mg/kg) and village Badhak (27.15 mg/kg). Cd was highest in samples from village Kami-Kalan (0.55 mg/kg) followed by village Banur (0.3 mg/kg) whereas in other villages like Bathonia, Main and Bhadak it was below detection limit. Cu was maximum in samples from village Bathonia (16.3 mg/kg) and minimum in samples from Bhadak (8.2 mg/kg). Pb was reported to be maximum in village Bathonia (60.3 mg/kg) followed by samples from
village Banur (34.95 mg/kg) and village Main (29 mg/kg). Trend observed in the heavy metal content was Pb>Zn>Cu>Fe>Cd. The study showed that the concentration of metals in different samples from different villages were different, indicating varied metal uptake. In all vegetables from different places it was found that Banur had high concentration of Fe, Zn, Cu and Pb. Samples from Village Kami-Kalan had higher concentration of Cd whereas Cr and Ni were below detection limits.

4.0 Discussion

4.1 Heavy metal contamination in random and field samples

The results indicate that the metal content in the randomly collected samples of brassica, cabbage and spinach were in the order of Fe>Zn>Pb>Cu>Cd, whereas in vegetables collected from agricultural fields around Rajpura city the order of metal content in general was Zn>Pb>Cu>Fe>Cd. The metal content in all the vegetables was above as defined by nutritiondata.com and elook.org. Nearly 16 % samples of palak from market had high level of Cd than the permissible limits of 1.5mg/kg, 23% samples of brassica had high Pb and 26% samples of cabbage had high Zn than the permissible limit of 2.5mg/kg as per Indian Standard of Food Adulteration Act. The peak of the harvest was chosen keeping in consideration that the metal concentration in plants varies with their age and season. A major cause for the occurrence of high content of metals in leafy vegetables is due to the presence of high content of metals in the soil in which these vegetables are growing as these places were located near to industries and or high content is also due to irrigation by metal contaminated water released from the industries in the vicinity. A major pathway of soil contamination is through atmospheric deposition of heavy metals from point sources such as metalliferous mining, smelting and industrial activities. Other non point sources of contamination affecting predominately agricultural soils are due to various inputs such as fertilizers, pesticides, sewage sludge, organic manure and compost [10]. Additionally foliar uptake of atmospheric heavy metals from emission gas also been identified as an important pathway of heavy metal contamination in vegetable crops. Several studies have shown that vegetables, particularly leafy crops, grown in heavy metal contaminated soils have higher concentrations of heavy metals than those grown in uncontaminated soil [11, 12].

References


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