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Short communication

A market survey of vegetables in Bangalore for heavy metal contamination in relation to human health

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ABSTRACT

Vegetable samples from one of the main whole sale markets of Bangalore city were collected over two years and analysed for heavy metals such as Cd, Pb, Cr and Ni. Heavy metal content of vegetables ranged from 0.24 to 2.54 mg Cd kg^{-1}, 2.16 to 10.40 mg Pb kg^{-1} , 3.08 to 16.2 mg Cr $kg^{-1}$and 1.66 to 11.52 mg Ni kg^{-1}. Leafy vegetables accumulated higher concentration of heavy metals followed by root vegetables. Fruit vegetables accumulated the lowest content of heavy metals. But the heavy metal content of all the vegetables crossed the safe limits permitted for human consumption to a far greater extent except that Cd content of root and fruit vegetables were within the safe levels. Among leafy vegetables, amaranthus and palak accumulated the highest content of all the four heavy metals studied.

Key words: Heavy metals, contamination, market samples and vegetables

Food chain contamination by heavy metals (Cd, Pb, As, Hg, Cr, Ni, CO etc.) is a major cause for concern in recent years from human health point of view since heavy metals as such are stable elements, cannot be metabolized by the body and are bio-accumulative. Industrialization, urbanization, improper use of city waste waters and industrial effluents for crop growth, application of sludge and other solid municipal wastes in agricultural lands, indiscriminate application of agro chemicals and pesticides are common in periurban cultivation. The growth rate of Bangalore city in the past two decades increased geometrically and industrialization was very rapid. This led to generation of both industrial effluents and domestic sewage containing several heavy metals and other pollutants. These effluents and pollutants are being led to streams, which carried these wastes out of city limits where these are being continuously used mostly for cultivating vegetables and fodders. Because of proximity to the city and great demand for fresh vegetables, the produce is sold in the city. The present study was conducted to identify the type and content of heavy metals (Cd, Pb, Cr and Ni) in vegetables produced from a Bangalore market to determine their levels with reference to human health.

To assess the quality of vegetables consumed by public, regularly sold vegetables from Krishna Rajendra Market (K. R. Market), one of the main wholesale markets of Bangalore city, have been collected. The following vegetables were collected: stem amaranth (*Amaranthus tricolor*), palak (*Beta vulgaris var bengalensis*), fenugreek (*Trigonella foenumgraecum*), coriander (*Coriander sativum*), dill (*Anethum graveolens*), mint (*Mentha piperita*), chakota (*Atriflex hotensis*), brinjal (*Solanum melangina*), tomato (*Lycopersicum esculentum*), french beans (*Phaseolus vulgaris*), cluster beans (*Cyamopsis tetragonaloba*) bhendi (*Abelmoschus esculentus*), cucumber (*Cucumis sativus*), capsicum (*Capsicum longifolia*), ridge gourd (*Luffa acutangula*), coccinia (*Momardica charantia*), carrot (*Daucus carota*), radish (*Raphanus sativus*), beetroot (*Beta vulgaris*), knolkhol (*Brassica gongylodes*),cabbage (*Brassica capitata*) , cauliflower (*Brassica botrytis*) and potato (*Solanum tuberosum*).

Three sets of each vegetable sample were collected at random at the arrival point of the K. R. Market in Bangalore city over two years (2005 and 2006). From the information given by vendors it was understood that vegetables were produced mainly from nearby towns, villages and peri urban areas of the city and are being regularly sold in the market.

The collected vegetable samples were washed thoroughly with mild detergent water, 0.1% HCl, distilled water and double distilled water. They were then cut into small pieces, dried at room temperatures for 2 days and later at 65 ±1 °C in an hot air oven. The dried samples were ground in warm condition, 2.5 g of this powdered sample was taken in to a 100 ml conical flask and predigested by adding 10 ml of conc. nitric acid at room temperature, later on digested in a hot plate by adding 10 ml of diacid mixture until the contents of the flask was colourless. After digestion the contents in the flask were made up to 100 ml using double distilled water and filtered with whatman no. 1 filter paper.

The heavy metal concentration in this extract was analysed with the help of Perkin Elmer (model AA analyst 200) Atomic Absorption Spectrophotometer. Three Replicates of each sample were used for confirmation of quantitative estimation of the metals. The average values for all the heavy metal contents were taken. Standard deviation values were calculated for all the results.

The heavy metal content of different vegetables is given in Tables 1 to 3. The safe limits of heavy metals for human consumption recommended by PFA (1954) are 1.5ppm for Cd, 2.5 ppm for Pb, 0.1 ppm for Cr and 1.5 ppm for Ni.

Cadmium

The content of Cd in the collected vegetables ranged from 0.24 mg kg^{-1} in cluster beans to 2.54 mg kg^{-1} in stem amaranth. Among different kinds of vegetables, leafy vegetables accumulated very high concentrations of Cd followed by root, fruit and other vegetables. Among leafy vegetables (Table 1) stem amaranth, palak and fenugreek recorded very high Cd concentrations and were crossing safe limits recommended for human consumption. Mint recorded the lowest content of Cd (0.88 mg kg^{-1}). None of the root, fruit and other vegetables crossed the safe level of Cd recommended for human consumption (Table 2). Among root vegetables, carrot contained maxiumum Cd concentration (1.40mg kg^{-1}). Among the fruit vegetables (Table 3) cluster bean contained lowest Cd content (0.24 mg kg^{-1}), whereas tomato and beans recorded the highest content. Cauliflower, cabbage and potato recorded 0.64, 0.48 and 0.52 mg kg^{-1}, respectively. Cadmium contamination of vegetables occurs in different ways. Cadmium is used in nickel-cadmium batteries, PVC plastics, and paint pigments. Indiscriminate disposal of these plastics and batteries by public and use of insecticides, fungicides, sludge, and commercial fertilizers containing cadmium particularly continuous use of single super phosphate containing high levels of Cd cause soil contamination, which in turn lead to absorption of Cd by plants grown on such soils and ultimately lead to food chain contamination (ATSDR, 1999a,). Low level chronic exposure to Cd can cause adverse health effects including gastro-intestinal, hematological, musculoskeletal, renal, neurological and reproductive effects. The main target organ for Cd following chronic oral exposure is the kidney (Jarup *et al*, 1998).

Table 1. Heavy metals content of leaf vegetables from Bangalore market

Leaf vegetables	**Heavy metal content (mg kg^{-1})			
	Cd	Pb	Cr	Ni
Stem Amaranth	2.54 (±0.38)	10.48 (±0.78)	13.44 (±1.14)	9.40 (±1.09)
Palak	1.76 (±0.57)	6.08 (±0.97)	16.20 (±1.18)	11.52 (±0.80)
Fenugreek	1.44 (±0.34)	4.80 (±0.43)	9.40 (±0.90)	6.46 (±1.02)
Coriander	1.12 (±0.23)	6.08 (±0.95)	9.88 (±0.58)	5.40 (±0.95)
Dill	1.16 (±0.29)	6.00 (±1.05)	9.48 (±1.00)	6.52 (±0.75)
Mint	0.88 (±0.15)	7.12 (±0.97)	8.60 (±1.32)	6.36 (±0.89)
Atriflex Sps	1.08 (±0.25)	9.20 (±0.91)	15.40 (±0.80)	10.32 (±1.06)

Values in parentheses are standard deviations.

**Mean of two years

Table 2. Heavy metals content of Root vegetables from Bangalore market

Root vegetables	**Heavy metal content (mg kg^{-1})			
	Cd	Pb	Cr	Ni
Carrot	1.40 (±0.42)	5.46 (±0.51)	9.58 (±1.47)	4.50 (±0.65)
Radish	1.00 (±0.20)	6.80 (±0.74)	10.02 (±0.97)	9.92 (±1.22)
Beetroot	0.88 (±0.18)	5.64 (±0.49)	14.32 (±1.31)	9.34 (±1.39)
Knolkhol	0.72 (±0.19)	5.08 (±0.24)	12.72 (±0.82)	8.12 (±0.22)

Values in parentheses are standard deviations

**Mean of two years

Table 3. Heavy metal content of Fruit and other vegetables from Bangalore market

Fruit and other vegetables	**Heavy metal content (mg kg^{-1})			
	Cd	Pb	Cr	Ni
Tomato	0.60 (±0.17)	3.64 (±1.32)	9.90 (±1.35)	5.63 (±0.26)
Brinjal	0.44 (±0.17)	4.56 (±0.80)	10.30 (±1.16)	3.42 (±0.20)
Okra	0.48 (±0.10)	5.00 (±1.18)	7.40 (±1.11)	3.51 (±0.12)
French Beans	0.60 (±0.11)	4.00 (±1.12)	7.76 (±1.20)	8.02 (±0.14)
Cluster Beans	0.24 (±0.08)	2.32 (±1.01)	6.00 (±1.09)	3.91 (±0.21)
Cucumber	0.56 (±0.16)	3.36 (±0.99)	6.32 (±0.92)	3.45 (±0.23)
Capsicum	0.48 (±0.12)	2.16 (±0.93)	5.20 (±0.98)	8.63 (±0.34)
Ridge Gourd	0.56 (±0.13)	3.48 (±1.26)	6.04 (±1.36)	5.62 (±0.37)
Coccinia	0.53 (±0.12)	2.24 (±0.70)	3.08 (±0.66)	2.88 (±0.26)
Cabbage	0.48 (±0.14)	3.65 (±1.73)	5.64 (±1.58)	1.66 (±0.10)
Cauliflower	0.64 (±0.10)	6.13 (±1.23)	4.76 (±0.57)	8.21 (±0.54)
Potato	0.52 (±0.06)	3.19 (±0.51)	3.32 (±0.71)	6.32 (±0.27)

Values in parentheses are standard deviations

**Mean of two years

Lead

Except for coccenia, capsicum and cluster bean, all the vegetables crossed PFA safe limit of 2.5 mg kg^{-1} for Pb content to a far greater extent. All the leafy vegetables accumulated very high concentration of Pb, 3-4 folds higher than the safe limits recommended for human consumption. (Table1). Among root vegetables, radish, beetroot and carrot showed considerable amounts (Table 2). Among fruit vegetables okra contained highest Pb content (5.00 mg kg^{1}) and capsicum contained lowest Pb content (2.16 mg kg^{-1}) (Table 3). The high concentration of lead in all the vegetables especially leafy and root vegetables are a great cause for concern with regard to human health. Naturally the soils contain Pb in very low concentrations in the range of 2-200 mg kg^{-1} (Kabata and Pendias, 1984). But some soils get contaminated due to addition of lead from industries such as paints, pollution by automobile emissions due to use of leaded fuel etc. Similarly the soils near highways and busy road sides contain higher amounts of lead than the soils away from the main roads. The vegetables grown in these contaminated soils accumulate heavy metals to a considerable extent. It is alarming that the Pb content in all the vegetables of present study crossed safe levels and it will have adverse effects on health especially of children and pregnant women (ATSDR, 1999b). Lead gets deposited in the soft tissues of the body and can cause musculoskeletal, renal occular, immunological, neurological, reproductive and developmental effects. (Todd *et al*, 1996). The symptoms like poor memory, irritability, distractibility, lethargy, stomach aches, diarrhoea etc. usually go unnoticed.

Chromium

All the vegetables accumulated Cr to a greater extent compared to other heavy metals and Cr contents were above safe levels recommended for human consumption. Cr accumulation in different vegetables was in the range from 3.08 to 16.2 mg kg$^{-1.}$ The highest concentration of 16.2 mg kg^{-1} Cr was recorded in palak. (Table1). Mint showed 8.60 mg kg^{-1} of Cr, the lowest among all the leafy vegetables. Root vegetables (Table 2) such as beetroot, radish and carrot also recorded considerable amounts. Among fruit vegetables brinjal (10.3 mg kg^{-1}) and tomato (9.9 mg kg^{-1}) recorded higher concentrations compared to other fruit vegetables (Table 3). Cr contamination comes from the industries of chrome plating, leather tanning, wood preserving, etc. Chromium compounds are known carcinogens. Long term exposure to high or moderate levels of Cr cause damage to the nose and lungs and may cause lung cancer. Skin contact with Cr may cause skin ulcers. Over exposure may also damage liver and kidneys (Dayan and Paine, 2001). City sewage waters also contain Cr to a considerable extent (Sorme and Lagerkvist, 2002).

Nickel

Nickel (Ni) was the second heavy metal that was present in higher concentrations in vegetables after Chromium. The concentration ranged from 1.66 mg kg^{-1} to 11.52 mg kg^{-1} in different vegetables. Palak contained higher concentration of Ni followed by Atriflex sps and stem amaranth among leafy vegetables (Table 1). In root vegetables, radish and beetroot accumulated higher Ni content. Among root vegetables (Table 2) carrot contained lowest Ni content. In fruit vegetables (Table 3) coccinia recorded lowest Ni content and capsicum recorded highest Ni content. Nickel is found in all soils. Auto exhausts, fertilizers especially super phosphate, industrial waste, etc. cause nickel contamination of soils. Domestic and industrial sewage waters also contain Ni, which when applied to agricultural soils, enter food chain. The most common adverse health effect of nickel in humans is an allergic reaction. It also affects the activity of alpha –tocopherol, the common antioxidant of the body (Chen *et al*, 2002).

The results of the study showed that vegetables supplied to Bangalore market are contaminated with heavy metals such as Cd, Pb, Cr and Ni. Rahul Chakraborthy *et al* (2004) reported contamination of Pb and Ni in market samples of Shillong city. Accumulation pattern of heavy metals were different for leafy, root and fruit vegetables. Irrespective of the heavy metal, leafy vegetables accumulated greater amounts of heavy metals than root and fruit vegetables above recommended levels for human consumption. Therefore, the farmers should avoid use of road - side fields and reduce the use of city - generated composts for vegetable cultivation. Further, when farmers do not have fresh water sources for cultivating vegetables and if they were to use sewage waters for irrigation, they better grow non-edible crops like flower crops and mulberry.

REFERENCES

ATSDR. 1999a. Toxocological profile for Cadmium. United States Department of Health and Human Services. Public Health service. 205-93-0606.

ATSDR. 1999b. Toxocological profile for lead. United States Department of Health and Human Services. Public Health service, 205-93-0606.

Chen, C. Y., Su, Y. J., Wu, O. F. and Shyn, M. M. 2002. Nickel induced Plasma lipid Peroxidation and effect of anti-oxidants in human blood: Involvement of Hydroxyl Radical Formation and Depletion of tocopherol. *J. Toxicol. Environ. Health.*, **28**:843-852

Dayan, A. D. and Paine, A. J. 2001. Mechanisms of Chromium toxicity, carcinogenicity and allergenicity: review of the literature from 1985 to 2000. *Hum. Exp. Toxicol.*, **42**:35-36.

Jarup, L. Berglund, M., Elinder, C. G., Nordberg, G. and Vahter, M. 1998. Health effects of cadmium exposure- a review of the literature and a risk estimate. *Scandinavian J. Work. Environ. Health* , **24**:1-51.

Kabata-pendias, A and Pendias, H. 1984. Trace elements in soils and plants. 2nd edition, Boca Raton, Florida, p.365.

PFA, 1954. Prevention of Food Adulteration Act, 1954 with prevention of food adulteration rules, 1955. International Law Book Company, Delhi, 2003, pp.168-174.

Rahul Chakraborthy, Sudip Dey, Dkhar Paul, S., Clarice Thabah, R., Myrboh, B., Ghosh, D. and Sharma, D. K. 2004. Determination of few heavy metals in some vegetables from North Eastern Region of India in relation to human health. *Poll Res.*, **23**:537-542.

Sorme, L. and Lagervist, R. 2002. Sources of heavy metals in urban waste in stockholm. *Sci. Total Environ.*, **298**:131-145.

Todd A. C., Wetmur J. G., Moline J. M., Godbold, J. H., Levin, S. M. and Landrigan, P. J, 1996. Unravelling the chronic toxicity of lead; an essential priority for environmental health. *Environ. Health Perspect.*, **104 :**141-146.

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