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HEAVY METALS IN GREEN LEAFY VEGETABLES FROM MARKET

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ABSTRACT

Due to water scarcity and cost, urban farmers generally use wastewater as irrigation source, since has high fertilizing capacity due to higher levels of major plant nutrients. Due to injudicious urban agricultural practices, high concentrations of heavy metals are reported in leafy vegetables, since they tend to absorb heavy metals. Hence the present investigation was carried out to ascertain heavy metals in the green leafy vegetables sold in the market. The heavy metals like Chromium, Nickel, Copper, Zinc and Lead in fifteen types of green varieties sold in Koyambedu market were analysed using Atomic Absorption Spectrometer (Perkin Elmer). The greens selected for the study are *Amaranthus blintum, Spleen amaranth, Amaranthus tricolor, Indian spincah, Portualco quadriflora, Alternamithara sessilis, Sesbania grandiflora, Hibiscus cannabanis, Solanum trilobatum, Cardiospermum halicacabum, Murraya koenigii, Mentha arvensis* and *Coriander sativum.* The results showed higher level of Pb and zinc. Pb was in the range of 3-35 mg/kg. Though Cu showed a variation of 0.52 to 36mg/kg, it was within the safe limits of FAO standard. The Zinc content of the samples varied from 0.9 to 2.7mg/kg and chromium content varied from 0.4 to 2.5, mg/kg, Ni was in the range of 0.5-2.3 mg/kg. It was found that Pb and Zn exceeded the permissible limits set by the FAO/WHO for human consumption. Present study provides data on heavy metal pollution of greens purchased from Koyambedu market. Besides the positive effects on human health, greens have shown the highest potential for heavy metal contamination.

KEY WORDS: Vegetable Market- Green leafy vegetables- Heavy metals.

INTRODUCTION

Rapid unorganized urban and industrial developments have contributed to the elevated levels of heavy metals in the urban environment of developing countries such as China and India. Due to increasing population as well as rapid development of transport, infrastructure and industry, heavy metals such as Cu, Zn, Pb, Cd, Cr, As, and Hg are emitted into the environment in large quantities through atmospheric deposition, solid waste emission and waste water irrigation. Some heavy metals such as Cr, Mn, Ni, Zn, and Cu are considered to essential components for the biological activities in the body. Prolonged consumption of unsafe concentrations of heavy metals through food stuffs may lead to chronic accumulation of heavy metals in the kidney, liver causing disruption of numerous biochemical processes leading to various cardiovascular , nervous, kidney and bone diseases. Green leafy vegetables are the cheapest of all the vegetables within the reach of poor man, being richest in their nutritional value. The lack of knowledge especially on the nutritive value of these green leafy vegetables among the public in general is the main drawback in their lower consumption. The World Health Organization (WHO) recommends a daily intake of more than 400g of vegetables per person. Aruna *et al.* (2017) opines that green leafy vegetables found in South India, used as a source of food have many health benefits like protection from eye problems, iron deficiency and oxidative damage. The rapid urbanization and industrialization have caused elevation of heavy metals content in urban environments in different developing countries (Radwan and Salama 2006). Thus, several studies have been carried out in order to assess the quality of vegetables purchased from green markets, as well as to evaluate potential health risk to local population (Milačić and Kralj 2003; Kiende *et al*., 2012) Hence, green leafy vegetables form a part of everybody's diet specially the vulnerable group which includes children, adolescents, pregnant, nursing and aged people where in their requirements for vitamins and minerals are higher. Vegetable farming includes application of pesticides and insecticides which are reported to be a source of metals in food. Most of the vegetable farms are situated either along the bank of polluted rivers, roadsides or highways which receive deposits of metals from vehicle emissions. Hence the present investigation was carried out to ascertain and find out the presence of heavy metals in the green varieties sold in the Koyambedu market.

MATERIALS & METHODS

The place chosen for sample collection was Koyambedu market in Chennai. A total of 45 samples over a period of three months July- September were collected and washed thoroughly to remove soil, dirt, and other airborne pollutants. Test portion were dried in an oven at 105^0C (Aruna *et al.,* 2017). To determine the heavy metals concentration a wet digestion method of the dried samples were used. The sample were analysed by Atomic Absorption Spectrophotometer (Perkin Elmer AAnalyst 400 AA Spectrometer). With true double-beam Echelle optical system with electrode less discharge lamps with air acetylene flame using the following appropriate instrumental parameters as given in Table 1.

TABLE 1. Instrumental Parameters during Elemental Quantification in AAS

S. No	Conditions	Pb	Cr	Cd	Ni
1.	Lamp current (mA)	5	4	5	4
2.	Fuel	Acetylene	Acetylene	Acetylene	Acetylene
3.	Fuel support	Air	Air	Air	Air
4.	Flame stoichiometry	Oxidizing	Oxidizing	Oxidizing	Oxidizing
5.	Optimum working range (µg/mL)	0.1 - 30	0.1 - 30	0.1 - 30	0.1 - 30
6.	Wavelength (nm)	217.0	357.6	228.8	232.0
7.	Slit width (nm)	1.0	0.2	1.0	0.2
8.	Flame support	Nitrous oxide	Nitrous oxide	Nitrous oxide	Nitrous oxide

RESULTS AND DISCUSSION

The greens collected from the market was analysed for heavy metals and the results indicated the presence of metals like Cr, Ni, Pb and Zn (tables 2-4).

Heavy metal in the greens collected in the month of July

Chromium content varied between 0.48 to 2.56 mg/kg falls well below the standard level in all the greens. The Nickel content (0.34 to 1.67 mg/kg) in all the analysed samples showed the presence of Nickel but within the safe level as per FAO standard. The copper content of the samples showed wide variations among the samples. It varied from 0.52 to 34.3 mg/kg. The sample *Solanum trilobatum* showed the lowest level at 0.52 mg/kg and maximum was observed in *Hibiscus Cannabanis*. Out of 15 samples 5 samples showed below 10ppm copper. Even though large variations were observed all the samples had copper content well below the FAO standard. Lead content was also analysed in all the 15 types of greens, it varied from 3.01 mg/kg to 35.32 mg/kg. The greens *Allium fistolusum* recorded the lowest content of lead (3.01mg/kg) and *Alternamithara sessilis* recorded the highest lead content (35.32mg/kg). Unfortunately all the greens had higher concentration of lead than the FAO standards. Among the 15 samples only 4 samples showed less than 10ppm (table 2). The zinc content of the greens varied from 0.64mg/kg to 3.65 mg/kg. The lowest zinc content was recorded in *Mentha arvensis* (0.64 mg/kg) and highest was recorded in *Hibiscus cannabanis* (3.65 mg/kg).

TABLE 2: Heavy metal levels of greens collected in the month of July

S.No	Botanical name	Chromium mg/ kgMAC 2.3 *	Nickel mg/ kg MAC 4*	Copper mg/ kg MAC 40*	Lead mg/kg MAC0.3*	Zinc mg/kg MAC 2.0*
1.	*Amaranthus blintum*	1.18	0.56	26.80	32.01	1.89
2.	*Spleen amaranth*	0.48	0.87	16.30	09.89	2.49
3.	*Amaranthus tricolor*	2.07	0.44	16.31	03.32	2.98
4.	*Allium fistolusum*	1.09	0.34	05.83	03.01	1.65
5.	*Indian spinach*	2.56	0.49	11.52	24.09	1.45
6.	*Portualco quadriflora*	1.60	1.13	15.12	31.60	1.43
7	*Alternamithara sessilis*	0.72	0.52	16.23	35.32	1.84
8.	*Sesbania grandiflora*	1.10	0.52	02.46	15.22	0.96
9.	*Hibiscus cannabanis*	2.03	0.56	34.3	10.92	3.65
10.	*Centella asiatica*	0.76	1.12	03.43	08.98	1.32
11	*Solanum trilobatum*	0.65	0.89	00.52	14.65	2.65
12.	*Cardiospermum halicacabum*	1.21	1.04	06.56	11.21	2.05
13.	*Coraindrum sativum*	1.23	0.45	21.89	15.51	2.51
14.	*Murraya koenigii*	ND	0.72	22.43	16.54	2.55
15.	*Mentha arvensis*	1.23	1.67	02.65	15.23	0.64

*Maximum allowable concentration in mg/kg as per FAO/ WHO, 1999

Heavy metal in the greens collected in the month of August

The greens analysed for Chromium content varied between 0.53 to 2.75mg/kg. It is slightly above the standard prescribed by FAO for *Amaranthus tricolor* which showed a value of 2.72mg/kg and Indian spinach which showed a value of 2.75mg/kg. All the other 13 varieties chromium was within the safe limit. Nickel content varied from 0.56 to 2.6mg/kg which was also within the safe limit as per FAO standard. The copper content of the samples showed wide variations among the samples. It varied from 0.95 to 36.25mg/kg. The sample *Solanum trilobatum* showed the lowest and *Hibiscus cannabanis* showed the highest as in the month of July. Out of the 15 samples analysed only 6 samples were below the level of 10ppm for copper. Though there was wide variations, all the samples had copper content well below the FAO standard. Lead content varied from 3.03 to 32.85mg/kg *Portualco quadriflora* showed a high of 32.85 and *Amaranthus tricolor* showed a low of 3.03mg/kg. Among the samples analysed all the fifteen samples showed an increase in the value of Lead which is well above the FAO standards. Among the fifteen varieties only 6 showed a value of less than 10ppm. Zinc content of the greens varied from 1.65 to 3.5mg/kg. The lowest zinc content was in *Allium fistolusum* and high of 3.5 for *Coriandrum sativum*. Eight varieties showed an increase above the FAO standard, whereas the other samples were below the FAO standard (table 3).

TABLE 3: Heavy metal levels of greens collected in the month of August

S.No	Botanical Name	Chromium mg/ kg MAC 2.3 *	Nickel mg/ kg MAC 4*	Copper mg/ kg MAC 40*	Lead mg/ kg MAC0.3*	Zinc mg/kg MAC 2.0*
1.	*Amaranthus blintum*	1.08	0.43	25.9	31.021	2.76
2.	*Spleen amaranth*	0.53	1.73	18.12	8.81	3.32
3.	*Amaranthus tricolor*	2.72	0.56	17.42	3.03	2.87
4.	*Allium fistolusum*	1.11	1.38	06.74	3.12	1.65
5.	*Indian spinach*	2.75	0.95	11.59	22.01	1.85
6.	*Portualco quadriflora*	2.15	1.95	17.12	32.85	1.80
7	*Alternamithara sessilis*	0.85	0.89	18.35	6.2	1.75
8.	*Sesbania grandiflora*	2.35	1.12	03.35	15.25	2.30
9.	*Hibiscus cannabanis*	2.03	1.38	36.25	5.12	12.35
10.	*Centella asiatica*	1.25	2.32	03.54	9.1	2.19
11	*Solanum trilobatum*	1.25	1.8	00.95	15.35	2.15
12.	*Cardiospermum halicacabum*	1.12	1.05	07.43	12.5	2.31
13.	*Coraindrum sativum*	1.56	0.76	25.46	17.85	3.50
14.	*Murraya koenigii*	ND	0.89	22.73	16.54	3.10
15.	*Mentha arvensis*	2.30	2.60	03.50	16.35	0.96

*Maximum allowable concentration in mg/kg as per FAO/ WHO, 1999

TABLE 4: Heavy metal levels of greens collected in the month of September

S.No	Botanical Name	Chromium mg/ kg MAC 2.3 *	Nickel mg/ kg MAC 4*	Copper mg/ kg MAC 40*	Lead mg/ kg MAC0.3*	Zinc mg/kg MAC 2.0*
1.	*Amaranthus blintum*	2.15	0.45	24.32	31.00	2.53
2.	*Spleen amaranth*	0.46	0.78	16.30	08.98	2.49
3.	*Amaranthus tricolor*	2.80	0.85	15.70	03.65	2.98
4.	*Allium fistolusum*	1.20	1.38	06.74	03.12	1.65
5.	*Indian spinach*	2.75	0.47	05.30	03.05	1.65
6.	*Portualco quadriflora*	1.80	1.13	15.31	31.40	1.80
7	*Alternamithara sessilis*	0.85	0.89	18.35	6.20	1.75
8.	*Sesbania grandiflora*	1.10	0.54	02.43	15.22	0.96
9.	*Hibiscus cannabanis*	2.35	0.56	33.4	11.31	2.85
10.	*Centella asiatica*	0.56	1.18	02.85	08.95	1,31
11	*Solanum trilobatum*	0.66	0.75	00.52	14.35	2.56
12.	*Cardiospermum halicacabum*	1.21	1.04	06.85	10.56	2.24
13.	*Coraindrum sativum*	1.12	0.44	20.75	14.50	2.51
14.	*Murraya koenigii*	ND	0.56	21.43	15.64	2.35
15.	*Mentha arvensis*	1.20	1.45	02.45	14.75	0.56

*Maximum allowable concentration in mg/kg as per FAO/ WHO, 1999

Heavy metal in the greens collected in the month of September

The greens analysed for heavy metal showed the presence of metals like Cr, Ni, Pb, Zn and Cu. Chromium content varied between 0.46 tof 2.8mg/kg. Except for two varieties Indian spinach and *Amaranthus tricolor* all the other varieties chromium was well below the FAO standard. Indian spinach showed a high of 2.75mg/kg and *Amaranthus tricolor* showed a value of 2.8mg/kg. The other varities the value of Chromium was well below the standard. Nickel content varied from 0.45 to 1.45mg/kg. The nickel content was within the safe limit for all the varieties as per the FAO standard. The Copper content of the samples showed wide variations among the samples it varied between 0.52 to 24.32mg/kg. The sample *Amaranthus blintum* showed a value of 24,32 and *Solanum trilobatum* showed a value of 0.52. Lead showed a variation of 3.05 to 31mg/kg for the samples. For all the samples lead level was above the standard of FAO. *Amaranthus blintum* showed a high of 31mg/kg. Indian spinach showed a low of 3.05mg/kg. Unfortunately all the samples had an increased lead content. Zinc varied between 0.56 to 2.9mg/kg. Lowest was recorded in *Mentha arvensis* and highest was in *Amaranthus tricolor*. More than fifty percent of the samples zinc was within the standard prescribed by FAO. The remaining samples showed a slight increase (table 4).

Leafy vegetables were found with very high levels of heavy metal contamination including Cd, Zn, Cu, Mn and Pb. Previous studies in India such as done by Singh and Kumar 2006 reported total heavy metal concentration; whereas Sharma *et al*. 2008a focused on metal pollution index. Many research studies have been conducted with reference to total heavy metal in green leafy vegetables. Al-Jassir *et al*. 2005; Arora *et al*., 2008; Sharma *et al*. 2008; Pan *et al*., 2016 also reported increased level of heavy metal contamination in vegetables sold in the markets. Elevated concentration of toxic elements are result of different anthropogenic activities, environmental pollution from industrial emission, utilization of waste water for irrigation, certain agricultural practices, application of nitrogen and phosphorous fertilizers, atmospheric depositions during transportation and marketing, etc. (Sharma et al., 2006; Nikolić et al., 2014). The heavy metal accumulation in sewage was studied by several scientists. Studies at TNAU have shown that the

sewage water contains heavy metals at an alarming concentration and disposal of these sewage severely affected the sewage water irrigated sites.
The present study revealed that Cr and Ni was within the safe limits in all samples. **Cr** in our present study was in the range of 0.5 to 2.13mg/kg in all the green varieties. It was well below the range of 2.3 mg/kg of the FAO. The study conducted by Kananke *et al*., 2014 reported Cr in the range of 0.18 to 5.05mg/kg in green leafy vegetables, which was bit higher than our present study. As far as Nickel is concerned, in our present study it ranged between 0.5 to 2.32 mg/kg. It is lesser than the recommended level of FAO which is 4mg/kg. Copper content varied between 0.52 to 36.25mg/kg in the greens collected from the market site for all the 3 months. Similar results were reported by Kananke et al., 2014 (7.05-18.44mg/kg) and Sharma et al 2008a (35.27-20.27 mg/kg). The levels of Zn varied from 0.56-3.65mg/kg in all the fifteen green varieties collected during the three months. In a similar study conducted by Sharma et al 2006, in the market sites of varnasi in lady's finger, palak and cauliflower (29.6 to 39.2, 30.1 to 45.5 and 38.6 to 63.3 respectively) reported higher levels of Zn when compared to the present study. The increase in the levels of zinc can be ascribed to the use of Zn in fertilizers and metal -based pesticides apart from ash from brick kilns. Singh and Kumar(2006) have reported 3-15 fold higher concentration of Cu, Zn, Cd and Pb in waste water irrigated areas of Kanpur and Varnasi as compared to those reported in the present study. Pb varied in the range of 3.01 to 35.32mg/kg in all the varieties for the three months. The study conducted by Sharma *et al*., 2007 in the market sites of Varanasi India showed an increase in Pb (1.03 to 1.59 mg/kg) , which can be ascribed to the fact that leaves can absorb vast quantities of Pb from the atmosphere. Lead has been reported as a severe cumulative body toxin which enters the body through food, air, and water and cannot be eliminated by washing of vegetables. The elevated levels of Pb in leafy vegetables may also occur due to contaminants in irrigation water, soil, or industrial and vehicular emission as lead occurs in the fuel as anti-knocking agents. With the rapid industrialization and urbanization in the areas the increment of traffic activities may contribute to the accumulations of heavy metals in the roadside environment.
Uptake of the heavy metals is often affected upon the plant species, growth phase, type of soil and metal species, soil condition, weather and environment. Moreover, the atmospheric depositions and marketing systems of vegetables play a significant role in elevating the levels of heavy metals in Green leafy vegetables. Even though Cu, Ni and Cr are considered as essential elements for various biological activities within the human body, elevated levels of these metals can affect negatively on consumer health. The variations in the concentrations of the heavy metals in vegetables observed during the present study may be ascribed to the physical and chemical nature of the soil of the production sites. It also depends on anthropogenic activities such as brick kiln activities, addition of phosphate fertilizers or use of metal-based pesticides around production sites and urban industrial activities in the market sites. The market sites are located close to the national highways. Irrigation water was mostly bore water which is already contaminated. It also depends on the absorption capacities of heavy metals by vegetable. Atmospheric deposition of heavy metals which may be influenced by innumerable environmental factors such as temperature, moisture and wind velocity and the nature of the vegetables I.e. leafy root fruit, exposed surface are am hairy or smoothness of the exposed parts . A monitoring plan and a health risk assessment are necessary to evaluate the levels of metal concentration in vegetables in order to develop the proper measures for reducing excessive build-up of these metals in the food chain..

CONCLUSION

From the present study it can be concluded that Cu, Zn, and Pb concentration in leafy vegetables procured from the markets were above the permissible limits set by FAO/WHO for human consumption. It is therefore suggested that regular monitoring of heavy metals in vegetables and other food items should be performed to prevent excessive build up of these heavy metals in the human food chain. Appropriate precautions should also be taken at the time of transportation and marketing of vegetables.

REFERENCES

Al-Jassir, M.S., Shaker, A., Khaliq, M.A. (2005) Deposition of heavy metals on green leafy vegetables sold on roadsides of Riyadh city, Saudi Arabia. Bull. Environ. Contam. Toxicol.75: 1020–1027.

Arora, M., Kiran, B., Rani, S., Rani, A., Kaur, B., Mittal, N. (2008) Heavy metal accumulation in vegetables in irrigated with water from different sources. Food chem. 811–815.

Aruna Narayanan, Keerthana, G. & Varsha Ravikumar (2017) Mineral and Anti-nutrient Content of Common and Uncommon Green Leafy Vegetables Before and After Drying, Elixir Food Science 108: 47403-47407.

FAO/ WHO (1999) Joint Expert Committee on Food Additives "Summary and Conclusion", in proceedings of the 53rd Meeting of Joint FAO/WHO Expert committee on Food Additives, Rome, Italy

Kananke, T., Wansapala, J., Anil Gunaratne (2014) *Heavy Metal Contamination in Green Leafy Vegetables Collected from Selected Market Sites of Piliyandala Area, Colombo District, Sri Lanka*. American Journal of Food Science and Technology, 2014, Vol. 2, No. 5, 139-144.

Kiende, J.I., Kawaka, F., Orinda, G., Okemo, P. (2012) Assessment of heavy metal concentrations in urban grown vegetables in Thika Town, Kenya. Afr. J. Food Sci. 6: 41–46.

Milačić, R., Kralj, B. (2003) Determination of Zn, Cu, Cd, Pb, Ni and Cr in some Slovenian foodstuffs, Eur. Food Res. Technol. 217: 211–214.

Nikolić, N., Borišev, M., Pajević, S., Arsenov, D., Župunski, M. (2014) Comparative assessment of mineral elements and heavy metals accumulation in vegetable species. Food and Feed Research. 41: 115–123.

Pan, X.D., Wu, P.G., Jiang, X.G. (2016) Levels and potential health risk of heavy metals in marketed vegetables in Zhejiang, China. Scientific Reports 6, Article number: 20317. doi: 10.1038/srep20317.

Radwan, M.A., Salama, A.K. (2006) Market based survey for some heavy metals in Egyptian fruits and vegetables. Food chem.Toxicol. 44, 1273-1278

Sharma, R.K., Agrawal, M., Marshall, F. (2006) Heavy metal contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. Bull. Environ. Contam. Toxicol. 77: 312–731.

Sharma, R.K., AgarwaL, M. and Marshall, F.M. (2007) Heavy metals contamination of soil and vegetables in suburban areas of Varnasi, India. Ecotoxicology and Environmental Safety 66, 258-266.

Sharma, R.K., Agrawal, M., Marshall, F.M. (2008) Heavy metal (Cu, Zn, Cd and Pb) contamination of vegetables in urban India: A case study in Varanasi. Environ. Pollut.154: 254–263.

Sharma, R.K., Agrawal, M., Marshall, F.M. (2008a) Atmospheric depositions of heavy metals (Cd, Pb, Zn, and Cu in Varnasi city. India. Environ. Monit. Assess. 142(1-3), 269-278.

Singh, S. Kumar, M. (2006) Heavy metal load of soil, water and vegetables in periurban Delhi. Environ. Monitor. Assess. 120, 71-79.