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# Determination of heavy metal contents in vegetables from market basket survey at Rajshahi City, Bangladesh

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**Abstract**

The present study was conducted to determine the heavy metals *viz*. lead (Pb), nickel (Ni), cromium (Cr) and cadmium (Cd) accumulation in some popular vegetables from local markets at Rajshahi City, Bangladesh. The mean concentration of heavy metal was calculated for each sample collected from three local markets and compared the value with the permissible levels set by the FAO and WHO. The results showed that the levels of Pb, Cd, Ni and Cr in studied vegetables ranged from 0.017 mg/kg to 0.158 mg/kg; 0.015 to 0.019 mg/kg; 0.255 to 0.297 mg/kg; 0.185 to 0.324 mg/kg respectively. The values obtained from the results were within the permissible limits as recommended by *WHO/FAO. The mean performances of heavy metals accumulation between leafy and fruit-based vegetables were also compared and found that the subjected metals were mostly in similar level in both the vegetables except the Cr value. Comparing among the four metals high accumulation was observed for Ni and Cr than Pb and Cd in both the cases.

**Keywords:** Market vegetables, heavy metals, atomic absorption spectrometry.

## INTRODUCTION

Vegetables are the major part of daily food intake by human population all over the world which plays an important role in their daily diet. The nutritional status of Bangladesh is quite alarming with a great number of populations suffering from malnutrition. The household consumption survey showed that the average per capita consumption of vegetable in Bangladesh is about 166 g (BBS, 2010). About 60% of the total populations suffer from various micronutrient deficiencies, resulting the cause of serious health problems. Green leafy vegetables are an excellent sources of micronutrients, so the consumption of these food stuffs may contribute to meet the nutritional requirement as well as to overcome the micronutrient deficiency at minimum cost (Saikia, 2013; Ebert, 2014), However, these vegetables contain both essential and toxic metals over a wide range of concentration and have several toxicological effects on the human body (Orisakwe *et al*., 2012).

Heavy metal such as lead, cadmium, cromium contamination of food items is one of the most important considerations in food quality assurance (Marshall, 2004; Wang *et al*., 2005). Heavy metal contamination in vegetables cannot be underestimated since these food items are largely consumed in daily human diet. International and national regulations on food quality have declared the maximum permissible limits of toxic metals in food items since, these metals can pose serious food contamination directly or even in food chain (Wang *et al*., 2005). Sometimes, the heavy metals are become very toxic to humans even at a very low level. Excessive content of lead and cadmium metals in food is associated with a number of diseases especially with cardiovascular, kidney, nervous as well as bone diseases (WHO, 1992, 1995; Steenland and Boffetta, 2000; Jarup, 2003). It has also been implicated in causing carcinogenesis, mutagenesis and teratogenesis (IARC, 1993; Pitot and

Dragan, 1996). High level of Nickel may also result in zinc or iron deficiency as well as enzymic malfunctioning (Jarup, 2003). Excess of cadmium has been reported to cause renal tubular dysfunction accompanied by osteomalacia (bone softening) and other complications, which can lead to death (Itanna, 2002).

Vegetables take up heavy metals by absorbing them from contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Sobukola *et al.,* 2010). Generally, people do not have adequate knowledge or information on whether which vegetables are beneficial or not and have any toxic effect or not. When consumers buying vegetables they consider undamaged, fresh looking, dark green and big leaves as characteristics of good quality vegetables. But the external appearance of vegetables cannot assure safety from internal contamination or of any innate toxicity. Considering circumstances at the present day scenario, food safety is now a major public concern especially in Bangladesh perspective. With a view to address the potential toxicity of heavy metals with frequent consumption of vegetables by the people, safety aspect of foods and the awareness of the people, much research work is still needed to highlight this important issue.

The heavy metal contamination in local areas depends on the different sources of pollution. Some researchers suggested that plants growing in polluted environment can be accumulated by the high concentration of toxic metals (Alloway 1990; Voutsa *et al.* 1996). It is rationale that if we know the level of heavy metals in various types of vegetables cultivated in the certain area, it can be predicted the toxicity level of the respective crop lands. The present study was investigated to determine the levels of accumulation of heavy metals (Pb, Cd, Ni and Cr), in some popular vegetables (lalshak, puishak, kochushak, kolmishak, tomato, bean and brinjal) collected from local market at Rajshahi city, Bangladesh in respect to meet the agreed international permissible limit.

Therefore, this study is expected to provide information of heavy metals accumulation status of studied vegetables in the local market places.

## .MATERIALS AND METHODS

### Collection of vegetables

The vegetables used for this study were collected from local markets at Rajshahi city, Bangladesh. The inedible portions of the vegetables were removed prior to study and a composite sample was prepared. The samples were collected during the period of January–March 2016. In each market, three vendors were selected randomly. The details of the vegetable materials used for present study are shown in Table 1:

**Table 1**. Vegetables used in the study.

| Vegetables | English name | Botanical name | Sampling sites (Rajshahi City) |
|---|---|---|---|
| Leafy Vegetables | | | |
| 1. Lalshak | Red amaranth | *Amaranthus gangeticus* L. | |
| 2. Puishak, | Indian green spinach | *Spinacia oleracea* L. | 1. Binodpur Bazar |
| 3. Kolmishak | Water spinach | *Ipomoea aquatica* L. | |
| 4. Kochushak | Leaf Green arum leaves | *Colocasia esculenta* L. | 2. Kazla Bazar |
| Fruit-based vegetables | | | |
| 1. Bean | Kidney bean | *Phaseolus vulgaris* L. | 3. Master Para Sobzi Bazar (adjacent to collegiate school, Rajshahi) |
| 2. Brinjal | Egg plant | *Solanum melongena* L. | |
| 3. Tomato | Tomato | *Lycopersicon esculentum L.* | |

### Sample preparation

The freshly collected vegetables (Table 1) were brought to the laboratory and washed up with tap water thoroughly to remove the surface dust particles, soil, and diseased or rotten parts. Then these were washed with distilled water and finally with deionized water. The washed vegetables were dried with blotting paper followed by filter paper at room temperature to remove surface water. The vegetables were immediately kept in desiccators to avoid further evaporation of moisture from the materials. The dried vegetables were chopped into small pieces followed by oven dried at 70 °C for 72 h. Chopped samples were grinded into a fine powder using a porcelain mortar and pestle. The resulting powder was kept in air tight polythene packet at room temperature until for acid digestion.

### Acid digestion

About 0.5 g of the dried samples were weighed and digested in a mixture of 1 ml of concentrated hydrochloric acid (HCl) and 3 ml of concentrated nitric acid( $HNO_3$ ) in a conical flask inside a fume hood. The content was mixed and heated gently at 180–220 °C for about 30 min on a hot plate. The content was continuously heated until dense white fumes appear. It was then finally heated strongly for about 30 min and then allowed to cool. After completion of digestion, the resulting pale yellow solution was transferred to 100 ml volumetric flask and made up to 50ml with de-ionized water and stored. The composite of the samples were made for each market. After cooling and the digested solution was filtered (Whatman No. 1) and transferred to the 15 ml tube. Each tube contained 10 ml of digested solution. All reagents used were of analytical grade.

**Heavy Metals Analysis**

The digested solution was analyzed using a flame atomic absorption spectrophotometer (AAS) at Central Science Lab, University of Rajshahi. A certified standard reference material was used to ensure accuracy and the analytical values were within the range of certified value. Blank and standards were run after five determinations to calibrate the instrument.

**Statistical analysis**

The data were statistically analyzed by MSTAT software. Mean separation was applied by DMRT for evaluating the difference of heavy metal concentrations among the studied vegetables.

## RESULTS AND DISCUSSION

The heavy metals concentrations of Pb, Cr, Cd and Ni obtained from the studied vegetables are shown in Figure 1 & 2. The values are given as mean ± SE and the results are the means of three replicates.

**Heavy metals accumulation in leafy vegetables**

The accumulation of heavy metals in leafy vegetables varied depended on the types of vegetables. The accumulation of Pb obtained in leafy vegetables ranged from 0.017 to 0.158 mg/kg as shown in Figure 1. Significant differences were found among the leafy vegetables in Pb accumulation. The highest value of Pb accumulation was obtained in Lalshak (0.158 mg/kg) followed by Kolmishak (0.77 mg/kg) and the lowest value was in Kochushak (0.017 mg/kg). It was reported that contamination of Pb in plants might be derived from fertilizers application during agricultural practices (Alloway 1990). Other researchers studied that the use of excessive pesticides increased the Pb content in agricultural soils between 0.59 and 0.86 mg/kg which ultimately absorbed by the plants (Ogunlade and Agbeniyi 2011). In case of Cd accumulation, no significant differences were noticed among the leafy vegetables while Ni accumulated in leafy vegetables were found significantly different. The highest value for Ni was noted in Kochushak (0.297 mg/kg) and the lowest was for Puishak (0.259mg/kg). The accumulation of Cr in all types of leafy vegetables was found significantly different (Figure 1). In this study, Kochushak resulted highest level of Cr (0.288 mg/kg) and Lalshak accumulated the lowest value of Cr (0.185 mg/kg). Among the studied metals, high accumulation was observed for both Ni and Cr compare to that of Pb and Cd. In all cases the values of Pb, Cr, Cd and Ni obtained from the studied leafy vegetables were below the permissible limit as recommended by WHO/FAO (Codex 2001). So, the levels of heavy metals accumulated by the subjected vegetables were not threat for the consumers.

**Heavy metals accumulation in fruit-based vegetables**

In case of fruit based vegetables significant differences were observed only for Pb accumulation but not for other metals (Figure 2). The highest value of Pb (0.109 mg/kg) and Cr (0.324 mg/kg) accumulation was obtained in tomato while the lowest value of Pb (0.021 mg/kg) and Cr (0.313 mg/kg) was noted in bean. On the other hand bean accumulated the highest value of Cd (0.019 mg/kg) and Ni (0.287 mg/kg). The heavy metals accumulated in each fruit-based vegetables was also found lower than the maximum permissible value regulated by WHO/FAO (Codex 2001).

The different levels of accumulation in different vegetables might be due to their accumulation ability and levels of contaminated soil. Different plant types and parts of plants have different ability in accumulating heavy metals (Remon *et al.*, 2005). It was reported that heavy metals concentrations in roots and leaves were not significantly different since the metals were in equilibrium between roots and leaves (Remon *et al.*, 2005). Generally leafy type vegetables accumulated higher level of metals compared to fruit types. But our study noticed that both types of vegetables (leafy and fruit-based) accumulated in heavy metals were mostly comparable except the value of Cr (Figure 3).

It was reported that lead being a serious toxic enters into the body system through air, water and food and cannot be removed by washing fruits and vegetables (Divrikli *et al*., 2003). The level of Pb reported in this study was less than the permissible limit by WHO/FAO (Codex 2001). Cadmium is a non-essential element in foods and natural waters and it accumulates principally in the kidneys and liver (Divrikli *et al*., 2006). Various values of Cd have been previously reported for leafy vegetables which include 0.090 mg/kg for fluted pumpkin by Sobukola *et al* (2010), 0.049 mg/kg for lettuce (Muhammed and Umer, 2008). The study is in agreement with our findings. Nickel also plays some role in body functions including enzyme functions. It occurs naturally more in plants than in animal flesh. It activates some enzyme systems in trace amount but its toxicity at higher levels is more prominent (Divrikli *et al.*, 2006). The Cr content in the subjected vegetables were within the permissible value. It can be suggested that the Cr contained in the vegetables was derived from polluted soils or probably from extensive use of inorganic fertilizers and synthetic pesticides. A study reported by Osma *et al*. (2012) that the higher Cr concentrations were found in vegetables grown in the vicinity of the road side.

The values of heavy metals obtained from both of the studied vegetables were followed by WHO/FAO permissible limit since its concern with the people's health.

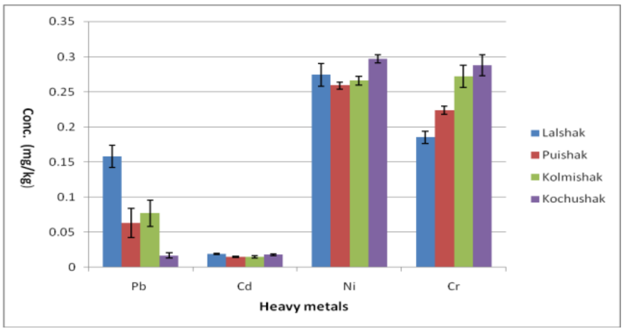


Figure 1. The accumulation of heavy metals in selected leafy vegetables.

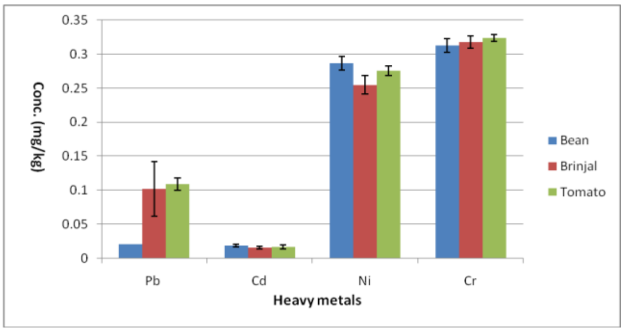


Figure 2. The accumulation of heavy metals in selected fruit-based vegetables.

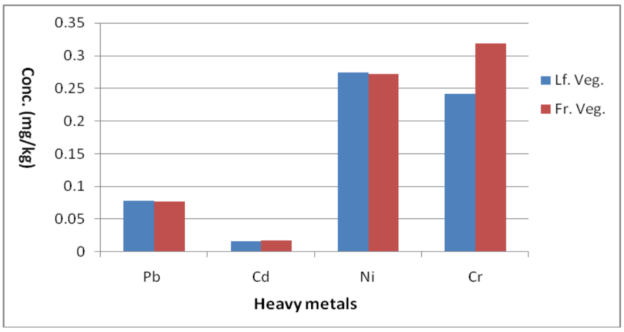


Figure 3. The comparative accumulation level of heavy metals between leafy vegetables and fruit-based vegetables.

* *WHO/FAO permissible limit for vegetables: Pb=0.3 (mg/kg); Cr=2.3(mg/kg ; Cd= 0.2(mg/kg) ; Ni= 1.0 (mg/kg);* (Codex 2001)

## CONCLUSION

The vegetables consumed in Bangladesh have the potential to provide essential nutrients needed to human diet for maintaining the normal body function. The results obtained from the investigation would provide some information for background levels of heavy metals contents in popularly consumed vegetables in the local markets of Rajshahi city. Heavy metals contained in different types of vegetables are varied depended upon the species of the vegetables. Different species have different ability to absorb the heavy metals since their amounts use for metabolic process in different plants are also vary. The studied vegetables containing heavy metals were within the permissible limit regulated by FAO/WHO.

The results of this study is suggesting that the accumulation of heavy metals in vegetables is reflected the status of agricultural soil as well. Thus, it can be predicted that the level of toxicity in local agricultural soils were might be of poorly contaminated. The present investigation can give illustrations for further study to find the status of heavy metals in local agricultural soil corresponding with their cultivating crops.

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## REFERENCES


Alloway, B.J. 1990. Heavy Metals in Soils. New York: John Wiley & Sons, Inc.

BBC. 2010. Bangladesh Bureau of Statistics. Dhaka. Statistical yearbook of Bangladesh. Chapter 13–Health, family planning and social statistics. [Online] Availablefrom:http://203.112.218.66/WebTestApplication/userfiles/Image/SY2010/Chapter-13.pdf [Accessed on 20th May, 2015]

Codex Alimentarius Commission (FAO/WHO) (2001). Food Additive and Contaminants. Joint FAO/WHO Food Standard Program, ALINORM 01/12A, 1-289.

Divrikli, U., N. Horzum, M. Soylak and L. Elci. 2006. Trace heavy metal contents of some spices and herbal plants from western Anatolia,Turkey. Int. J. Food Sci. Technol. 41**:** 712-716.

Divrikli, U., S. Saracoglu , M. Soylak and L. Elci. 2003. Determination of trace heavy metal contents of green vegetables samples from Kayseri- Turkey by flame atomic absorption spectrometry. Fresenius Environ. Bull. 12: 1123-1125.

Ebert, A. W. 2014. Potential of underutilized traditional vegetables and legume crops to contribute to food and nutritional security, income and more sustainable production systems. Sustainability. 6 (1). pp. 319–335.

IARC. 1993. Cadmium and cadmium compounds. In: Beryllium, Cadmium, Mercury and exposure in Glass manufacturing Industry. IARC Monographs on the evaluation of carcinogenic risks to humans, International Agency for Research on Cancer, Lyon. 58: 119-237.

Itanna, F. 2002. Metals in leafy vegetables grown in Addis Ababa and toxicology implications. Ethiopian Journal of Health Development. 16: 295-302.

Jarup, L. 2003. Hazards of heavy metals contamination. British Medical Bulletin 68: 167-182.Kahn, S., Cao, Q., Zheng, Y. M., Huang, Y. Z. and Zhu, Y. G. 2008. Health risk of Heavy metals in contaminated soils and Food crops irrigated with waste water in Beijing, China. Environmental Pollution Publication. 152: 686 – 692.

Marshall . 2004. Enhancing Food chain integrity: Quality assurance mechanism for air pollution impacts on fruits and vegetables systems Crop post Harvest program, Final Technical Report (R7530).

Muhammad, F., A. Farooq and R. Umer. 2008. Appraisal of heavy metal contents in different Vegetables grown in the vicinity of An industrial area. Pak. J. Bot. 40(5): 2099-2106.

Orisakwe O.E., N.J. Kanayochukwu, A.C. Nwadiuto, D.Daniel and O. Onyinyechi. 2012. Evaluation of potential dietary toxicity of heavy metals of vegetables. J Environ Anal Toxicol. 2 (3) p. 136

Osma, E., M. Serin, Z. Leblebici and A. Aksoy. 2012. Heavy metals accumulation in some vegetables and soils in Istanbul. *Ekoloji*, 21 (82): 1-8.

Pitot, C.H. and P.Y. Dragan. 1996. Chemical carcinogenesis, 5th edition: In: Casarett, D. (ed.), Toxicology Inter. Edi., McGraw Hill, New York, pp. 210-260.

Remon, E., J. L. Bouchardon , B. Cornier, B. Guy, J.C. Leclere and O. Faure. 2005. Soil Characteristics, Heavy Metal Availability and Vegetation Recovery at a Former Metallurgical Landfill: Implications in Risk Assessment and Site Restoration. Environmental Pollution, 137: 316-323.

Steenland, K. and P. Boffeta. 2000. Lead and cancer in humans: where are we now? American Journal of Industrial Medicine 38: 295-299.

Saikia, P. and D.C. Deka. 2013. Mineral content of some wild green leafy vegetables of North-East India J Chem Pharm Res. 5 (3): 117–121.

Sobukola, O. P., O.M. Adeniran, A.A. Odedairo and O.E. Kajihausa. 2010. Heavy metal levels of some fruits and leafy vegetables from selected markets in Lagos, Nigeria. African Journal of Food Science. 4(2): 389 – 393.

Voutsa, D., A. Grimanis and C. Samara. 1996. Trace Elements in Vegetables grown in an Industrial Area in Relation to Soil and Air Particulate Matter. Environmental Pollution, 94(3): 325-335.

Wang, X. T., B. Sato-Xing and S. Tao . 2005. Health risks of Heavy metals to the general public in Tiajin, China via consumption of vegetables and fish. Science of Total Environment Publication, 330: 28-37.

WHO. 1992. World health organization. Cadmium, Environmental Health Criteria, Geneva. Vol. 134.

WHO. 1995. World health organization. Lead. Environmental Health Criteria, Geneva, Vol. 165.