TROPICAL AGRICULTURIST, VOL.166 (3), 2018

TOXIC TRACE ELEMENTS IN SOILS AND EDIBLE PARTS OF ROOT AND TUBER CROPS IN UP COUNTRY WET AND INTERMEDIATE ZONES OF SRI LANKA

N. R. N. SILVA, P. WEERASINGHE, K. M. S. KODIKARA and P. WAKWELLA

Horticultural Crops Research and Development Institute, Gannoruwa, Peradeniya.

ABSTRACT

Contamination of vegetables by toxic trace elements is a great concern because of the potential risk to human health. In this study toxic trace elements of As, Cd, Cu , Cr, Pb and Zn contents were determined in vegetable samples of beet (*Beta vulgaris*), carrot (*Daucus carota*) potato (*Solanum tuberosum*), and corresponding soil samples collected from the same field from up country wet zone and intermediate zones. Trace metal contents in vegetables were expressed in fresh weight basis. Bioaccumulation factors of toxic trace metals were also investigated. Mean values of the toxic trace element contents of all beet samples were 8.8 ± 0.4 mg/kg for Cu, 10.5 ± 1.7 mg/kg for Zn, 0.25 ± 0.066 mg/kg for Pb, 0.056 ± 0.01 mg/kg for Cd , 1.1 ± 0.22 mg/kg for Cr and 0.012 ± 0.002 mg/kg for As. Mean toxic trace element contents in potato samples were 2.0 ± 0.2 mg/kg for Cu, 7.8 ± 0.72 mg/kg for Zn, 0.24 ± 0.02 mg/kg for Pb, 0.07 ± 0.009 mg/kg for Cd , 1.6 ± 0.25 mg/kg for Cr and 0.015 ± 0.004 mg/kg for As. Mean toxic mean trace metal contents of Cu, Zn, Pb, Cd, Cr and As in carrot were 10.9 ± 1.9 mg/kg, 12.3 ± 2.3 mg/kg 0.33 ± 0.07 mg/kg 0.07 ± 0.011 mg/kg 1.35 ± 0.16 mg/kg 0.025 ± 0.009 mg/kg respectively. Highest Zn, Pb, As and Cd contents in carrot, Cu in beet and Cr content in potato were observed. The overall mean contents of toxic trace elements observed in tested vegetables were below the maximum permissible limit. Estimated dietary intakes of the toxic trace elements in all vegetables tested were within the tolerable dietary intakes established by WHO/FAO. Bioaccumulation factors of all toxic trace metals in all tested vegetables were also lower than one showing carrots, beets and potato are not accumulators of toxic trace metals.

Keywords: Bioaccumulation, Health risk, Maximum permissible limit

INTRODUCTION

The accumulation of toxic trace elements in agricultural soils is of major concern because of their toxicity, non-biodegradability and bioaccumulation nature (Khan *et al*., 2008). Main pathway of toxic trace elements migration into the food chain is from soil to crops affecting food quality (Jan *et al*., 2010). Although, some trace elements such as iron, copper, manganese and zinc are essential for plants and animals including humans, they may become toxic with the exposure to biota in excessive contents (Wickramarathna *et al*., 2016). Trace elements like cadmium, arsenic and lead are not essential for either plant or human/animal growth however could become risky when entered into food chain. Hence, bioavailability of toxic trace elements present in soils is a major determinant of agricultural product quality owing to their influence on crop growth, food quality and human health.

Agricultural practices often result in some toxic trace elements deposition in soils attributable to heavy use of inputs (Singh, 2005). Chemical fertilizers, pesticides, agricultural amendments such as organic manure, lime etc., may contain toxic trace elements as impurities leading to contaminate soils and subsequently transferring them to the humans through food chain (Premarathna *et al*., 2011). Upcountry region has been known as intensive and highly commercialized vegetable growing region of the country where heavy use of inputs is a common feature. Since vegetable farmers in these areas grow 2-3 crops per year in the same land and apply high amount of fertilizers, manures and other agrochemicals (Wijewardena and Yapa, 1999) contamination of soils with toxic trace elements is a possibility. Under such circumstance, edible parts grown at the proximity of ground level or below ground level, such as in root vegetables (carrot, beet, potato etc.) are at higher risk of contamination with toxic trace elements than the edible parts grown on the upper portion of the plants. Since this is the main vegetable producing area in Sri Lanka, it is important to study the status of toxic trace metals in soil- plant system with special reference to root and tuber vegetable crops.

Therefore, this study was carried out with the objectives of assessing the contents of toxic trace element contents in soils, in root and tuber vegetable crops and in estimating their bioaccumulation factors and dietary intakes.

MATERIALS AND METHODS

Collection of Samples

Soil and vegetable samples were collected from intensive vegetable growing areas in Kandapola (Up Country Wet Zone), Haputhale and Bogahakumbura (Up Country Intermediate Zone). Representative soil and vegetable samples were also collected from randomly selected farmer fields at the depth of 0-20cm from the surface. Beet (*Beta vulgaris*), carrot (*Daucus carota*) and potato (*Solanum tuberosum*) samples were collected along with the soils samples from the same field. Accordingly a total of 42 samples were collected from the three vegetables from the three locations (Table 1).

Table 1. Number of Soil and vegetable samples collected from each location

Location	Crop	No of samples
Kandapola	Carrot	06
	Beet	04
	Potato	04
Haputhale	Carrot	04
	Beet	04
	Potato	05
Bogahakumbura	Carrot	08
	Beet	04
	Potato	03

Preparation of soil and vegetable samples

Soil samples were air dried at room temperature and crushed to pass through a 2-mm sieve.

Vegetable samples were brought to the laboratory and thoroughly rinsed with tap water followed by distilled water. Root crops (beet, carrot, potato) were washed with tap water using a brush to remove attached soil particles and were peeled off after washing using a stainless steel knife. Peeled samples were again washed with tap water followed by distilled water. Washed samples were left in an open area free from dust for a few hours until the excess water on surface of the samples were dried. Then the fresh weight of whole sample was recorded after removing any remaining moisture left on the surface using a soft tissue. All samples were cut into small pieces using a stainless steel knife and the cut pieces were oven dried at 60 ^{0}C until a constant weight was reached. Moisture contents of the samples were determined gravimetrically and the oven dried whole sample was ground using a stainless steel grinder and passed through a 0.5 mm sieve.

Analysis of soil samples for basic soil properties

Soil pH, electrical conductivity, available P, exchangeable K and organic matter content were determined. pH was determined by 1:1 soil to water extraction and measured by the Calomel glass electrode. (Mc Lean, 1982). Soil available P was extracted by Olsen method and determined by spectrophotometer after developing colour with ammonium molybdate and ascorbic acid method. Exchangeable K was extracted by ammonium acetate extraction method and K concentration was determined by Flame Photometer (Jenway PFP 7). Soil organic matter was determined by dichromate oxidation method (Nelson and Sommers, 1982).

Analysis of soil samples for toxic trace elements

Soil samples (0.5g) were digested in a microwave digester (Model No. MARS 6) power at 1400 W with mixture of 8.0 ml of Conc. HNO_3 (69 %, AR) and 2.0 ml of 30%. H_2O_2. Digester took 20 minutes to reach 180 ^{0}C and this temperature was maintained for another 15 minutes until the digestion completes (USEPA 3051, 1994). Digested samples were filtered through Whatman No. 42 filter paper into 50 ml volumetric flask and made up to volume with distilled water. All the chemicals and solvents used were of analytical grade. Cu and Zn contents were determined by Flame Atomic Absorption Spectrometer (AAS) (Model Varian AA140/240/280) while Pb, Cr, Cd and As were determined by AAS (Model Varian AA140/240/280) assemblage of the Graphite furnace.

Analysis of plant samples

Vegetable samples were dried at 60 ^{0}C and dry weight was recorded. About 0.5g of finely ground sample was digested in a microwave digester (Model No. MARS 6) power at 1400 W with a mixture of 8.0ml of Conc. HNO_3 (69 %, AR) and 2.0 ml of 30% H_2O_2. Digester took 20 minutes to reach 180 ^{0}C and this temperature was maintained for another 15 minutes until the digestion completes (AOAC, 2015). A blank digestion was also performed using the digestion mixture without a sample. Digested samples were filtered through Whatman No. 42 filter paper into 50 ml volumetric flask and made up to volume with distilled water. All the chemicals and solvents used were of analytical grade. The contents of Cu and Zn were determined by AAS (Model Varian AA140/240/280) while Pb, Cr, Cd and As were determined by AAS (Model Varian AA140/240/280) with graphite furnace assemble. Trace element concentration in plant samples were expressed in fresh weight basis.

Certified Reference samples of Montana soil 2710 a and Tomato leaves 1573a, issued by National Institute of Standards and Technology, USA were analyzed as reference material for soil and plant respectively to calculate the recovery rate and to validate the results.

Bioaccumulation Factor

The Bioaccumulation Factor (BAF) was calculated as BAF = the metal concentration in the edible part of the vegetable/Metal concentration in the soil sample (Ma *et al*., 2001; Cluis, 2004).

RESULTS AND DISCUSSION

Validation results of Analytical Procedure

Table 2. Analyzed and certified values of the soil reference material of 2710a (mg/kg)

Element	Estimated value mg/kg	Certified value mg/kg	Percentage of Recovery
Zn	4393	4180	105
Cu	3319	3420	97
Pb	6193	5520	112
Cd	*	*	*
Cr	17.6	23	76
As	1618.5	1540	105

Correlation coefficient of estimated and certified values (r^2) = 0.993

**No certified values for Cd*

Table 3. Analyzed and certified values of the plant reference material of1573a (mg/kg)

Element	Estimated value	Certified value	Percentage of Recovery
Zn	32.8	30.9	106
Cu	4.6	4.7	98
Pb	5.4	6.3	86
Cd	1.29	1.52	85
Cr	1.73	1.99	86
As	0.116	0.11	103

There was a significant correlation between the certified and measured values for standard reference materials for both soil (r^2 = 0.993) and plant (r^2 = 0.998). Recoveries of all metals in soil were greater than 95 % except for Cr. Percent recoveries of the Cr was only 76 %. For soil reference sample Montana soil 2710a, errors of the estimation was less than 10 % of the certified values for Zn, Cu, and As. It was 12 % for Pb and 24 % for Cr (Table 2). For the plant reference sample tomato leaves 1573a, errors of the estimation was less than 15 % of the certified values for all tested elements (Table 3).

Moisture contents of vegetable samples

Moisture contents in vegetables used in the experiment contained more than 85 % moisture on fresh weight basis (Table 4).

Table 4. Mean moisture content of vegetable samples collected.

Vegetable	Moisture content %	*Reported Moisture contents %
Beet	85.9(±0.6)	92
Carrot	88.4(±0.2)	88
Potato	93.2(±0.6)	79

*Values within parenthesis are the standard errors of the estimates. * Albert (2011)*

Properties and toxic trace metal contents soils

Table 5. Selected physic o-chemical properties of the soil

No of samples		pH	Electrical Conductivity (dS/m)	Available P (mg/kg)	Exch. K (mg/kg)	Organic matter %
	Mean	4.8	0.357	61.2	381.3	3.2
30	Range	4.2 -5.7	0.198 – 0.756	27 - 85	249 - 528	2.2 – 4.0
	SD*	0.47	0.176	16.7	85.9	0.52

The pH of the studied fields was acidic and ranged from 4.2 to 5.7 (Table 5). Electrical conductivity of the studied soils was ranged 0.198 dS/m to 0.756 dS/m and was comparatively high in the most of the fields. The observed organic matter contents were ranged from 2.2% to 4.0%. Available phosphorus and exchangeable potassium were found in the range of 27 mg/kg to 85 mg/kg and 249 mg/kg to 528 mg/kg respectively. Organic matter and available P and K contents were in high in soils collected from the most of the fields. Farmers in those area use high quantities of poultry manure together with high rates of chemical fertilizers (Wijewardena and Yapa, 1999). Therefore, the observed values for P, K and organic matter showed high contents in the studied area.

Table 6. Total trace metal contents in soils (mg/kg)

Location		Cu	Zn	Pb	Cd	Cr	As
Kandapola(n=10)	Mean	52.8	180.4	37.2	0.35	66.5	18.23
	Range	30.8-88.6	108.1-353.7	18.7 - 51.2	0.14 - 0.66	36.9-95.5	4.9 - 46.8
	SE	5.2	15.8	2.4	0.04	4.0	3.9
Haputale (n = 9)	Mean	51.1	124.4	26.6	0.276	65.0	29.3
	Range	27.3-83.5	48.2-209.4	18.2-44.8	0.120-0.658	29.5-95.0	2.9-55.1
	SE	5.5	15.1	2.6	0.048	6.3	5.9
Bogahakumbura (n= 11)	Mean	51.1	108.3	53.6	0.413	98.9	18.8
	Range	14.5-121.9	53.8-198.9	18.7-139.1	0.145-0.92	45.4-181.8	3.5-61.7
	SE	6.0	10.7	6.5	0.057	9.9	4.2
EU		50-140	150-300	50-300	1-3	*300	-

*EU: European Union set standards for sewage sludge amended soils (McGrath and McCormack, 1999), *USEPA (McGrath et al., 1999)*

TOXIC TRACE ELEMENTS IN SOILS AND EDIBLE PARTS

Toxic trace metal contents in soils samples analyzed were quite variable and ranged from 14.5 – 121.9 mg/kg for Cu, 48.2 – 353.7 mg/kg for Zn, 18.2 – 139.1 for Pb, 0.12 – 0.92 kg/mg for Cd, 29.5 – 181.8 mg/kg for Cr and 2.9 – 61.7 mg/kg.

Among the toxic trace metal contents in tested soils samples, Zn recorded the highest concentration (353.7 mg/kg) while cadmium had the lowest value at all three locations (Table 6). Data in table 6 show that higher toxic trace metal contents of Cu, Pb, Cd, Cr and As were observed in soils collected from Bogahakumbura and the highest Zn content was observed in Kandapola area. Toxic trace metal contents observed in most of the tested soils were lower than those of the upper limit of European Community set standards for Cu, Pb, Cd and USEPA standards for Cr. However, the highest Zn content (353.7 mg/kg) in soils collected from Kandapola area exceeded the upper limit of European Community set standards for Zn. Further, results obtained from this study were lower than those obtained by Premarathna *et al*., (2011). Premarathna *et al*., (2011) further reported that Cd and Pb contents in several soil samples from up country area have exceeded the maximum allowable limit set by the European Community.

The European Community set standard values for Pb is 50–300 mg kg^{-1} (McGrath and McCormack, 1999). The highest concentration of Pb (139.1 mg/kg) in soil was found in Bogahakumbura which had exceeded the lower limit of the EU set standard of 50 mg kg^{-1}. Pb contents in all other fields were below the lower limit of the European Community set standards except highest Pb content (51.2 mg/kg) in Kandapola area. Similarly, Cu contents in several soil samples in all three locations were exceeded the lower limit of EU set standards and below the upper limit of European Union.

Toxic trace metal contents in vegetables

The highest mean content of toxic trace element found in all vegetables collected from different locations was Zn followed by Cu (Table 7). Nonetheless, mean toxic trace metal contents in all vegetables collected were lower than the maximum permissible limit stipulated by WHO/FAO (2001) joint Codex. However, Cu content in several beet samples have exceeded the maximum permissible limit of 40 mg/kg. Comparison of the average toxic trace metal content in all tested vegetables were in the order of Zn>Cu>Cr>Pb>Cd>As. Similar trend has been reported by Iran (Afshin *et al*., 2008), Nigeria (Amin *et al*., 2013) and Turkey (Saglam, 2013).

Table7. Total toxic trace metal contents in vegetables in fresh weight basis (mg/kg)

Vegetables		Cu	Zn	Pb	Cd	Cr	As
Beet	Mean	8.8±0.4	10.5±1.7	0.25±0.066	0.056±0.01	1.1±0.22	0.012 ± 0.002
	Range	0.98 - 50.8	2.9 – 21.9	0.044-0.72	0.004-0.194	0.21-3.1	0.001-0.02
Carrot	Mean	10.9±1.9	12.3±2.3	0.33±0.07	0.07±0.011	1.35±0.16	0.025 ±0.009
	Range	1.1-31.8	3.6-46.6	0.014-1.16	0.024-0.205	0.311-2.84	0.001-0.137
Potato	Mean	2.0±0.2	7.8±0.72	0.24±0.02	0.07±0.009	1.6±0.25	0.015 ± 0.004
	Range	0.84-3.6	4.1-11.8	0.12-0.42	0.011-0.105	0.55-3.4	0.008-0.026
*MPL		*40	**60	0.3	0.2	2.3	0.43

*MPL - Maximum Permissible level WHO/FAO (2001). * WHO/FAO (1985) Codex general standard for contamination and toxin foods cited by Duresa and Leta (2015). **WHO/FAO (1991) Joint Codex Alimentarius commission; ± - standard errors of the estimates as cited by Duresa and Leta (2015)*

Data in Table 7 shows that Pb content in tested beet, carrot and potato samples were ranged from 0.044-0.72 mg/kg, 0.024-0.205 and 0.12 - 0.42 respectively. It was observed that Pb content in several beet, carrot and potato samples was higher than the maximum permissible level of 0.3 mg/kg for Pb stipulated by WHO/FAO Joint Codex Alimentarius (2001). High Pb content in potato samples collected from market in Kandy district was reported by Silva *et al*., (2016).

Cd contents in beet, carrot and potato samples analyzed ranged from 0.004 mg/kg to 0.194 mg/kg, 0.07 to 0.205 mg/kg and 0.011 to 0.115 mg/kg respectively. It was noted that maximum value of Cd in carrot has marginally exceeded the maximum permissible limit of 0.2 mg/kg. Premarathna *et al.,* (2011) also reported that Cd contents in carrot samples collected from the up country area have exceeded the maximum permissible limit. Further, Cr contents in several potato samples analyzed were also higher than the maximum permissible limit of 0.3 mg/kg. However, Zn and As in all vegetable samples were lower than the Maximum permissible limit imposed by WHO/FAO Joint Codex Alimentarius (2001 and 1991). The variation of toxic trace element contents in vegetables was due to variation in their absorption and accumulation tendency.

Zurera *et al*., (1989) stated that vegetables take up trace elements by absorbing them from contaminated soil as well as from the deposits on the parts of vegetables exposed to air in polluted environments. Absorption and accumulation of trace elements in plant tissues depend not only on total trace metal concentration in soil but also on various other factors, which include temperature, moisture, soil pH, organic matter, Cation Exchange Capacity of soil, Electrical conductivity of soil, nutrient availability in soil (Muller, 1969). The accumulation of toxic trace metals also depends on plant factors such as plant age, plant part and plant species (Aktaruzzaman *et. al*., 2013)

Toxic trace element contents in vegetables and soils

There was no significant relationship between As (Figure 1) and Cd (Figure 2) contents in all three vegetable crops and their total concentration in soils. Cr contents in carrot were slightly increased with soil contaminant level (Figure 3). However, there was no significant increase of Cr content in edible part of the potato (Figure 9) and beet (Figure 15) with increasing soil Cr even at the highest soil Cr content. Similarly there was no trend of increasing Pb in the edible part of all three vegetable crops tested with increasing soil Pb. There was small tendency for transfer of soil Cu and Zn in to the edible part of the potato. On the other hand there were no any relationship between Zn and Cu contents in carrot and beet and those elements in respective soils.

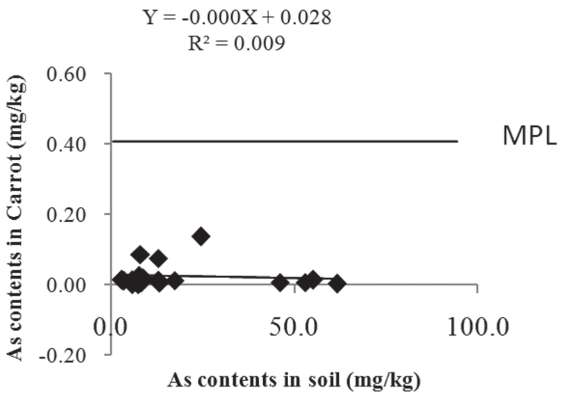


Figure 1. Relationship between As content in carrot and soil

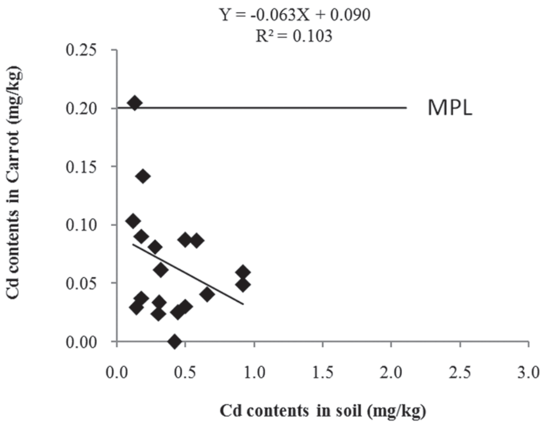


Figure 2. Relationship between Cd content in carrot and soil

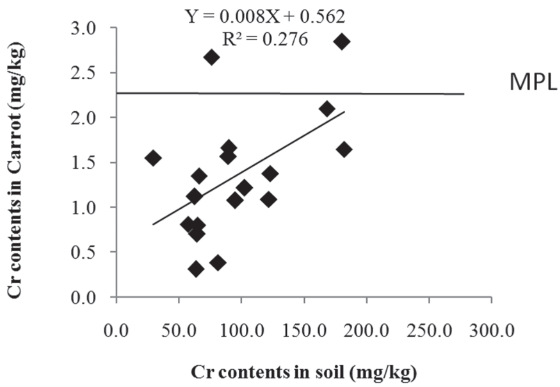


Figure 3. Relationship between Cr content in carrot and soil

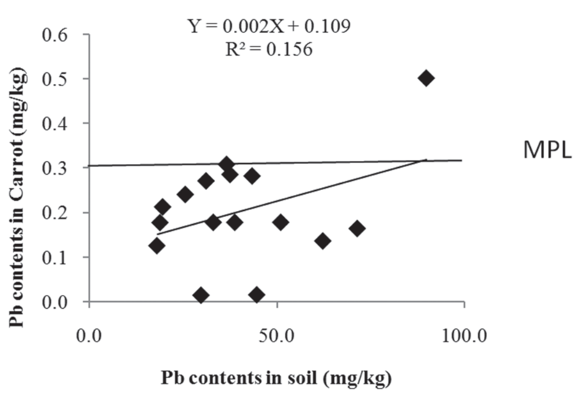


Figure 4. Relationship between Pb content in carrot and soil

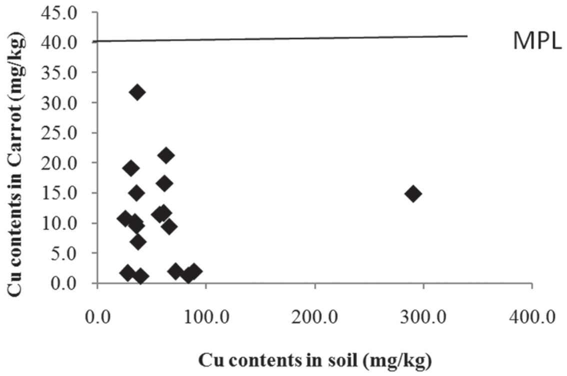


Figure 5. Relationship between Cu content in carrot and soil

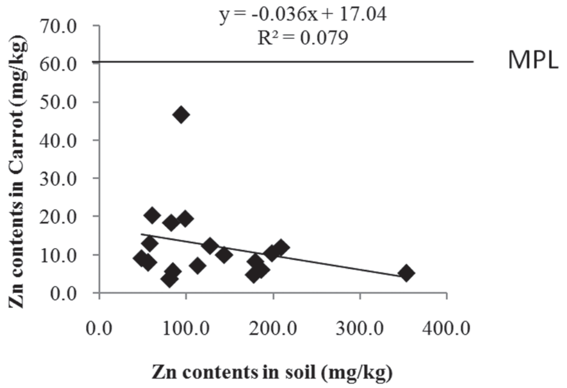


Figure 6. Relationship between Zn content in carrot and soil

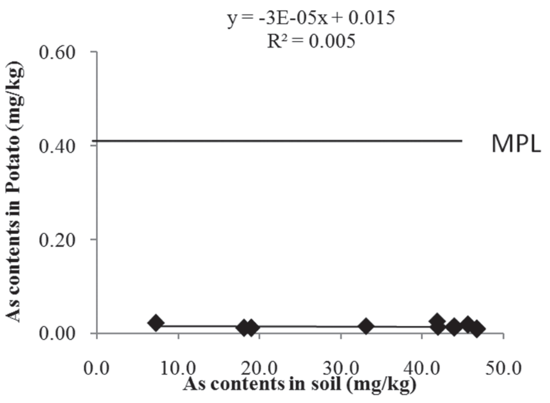


Figure 7. Relationship between As content in potato and soil

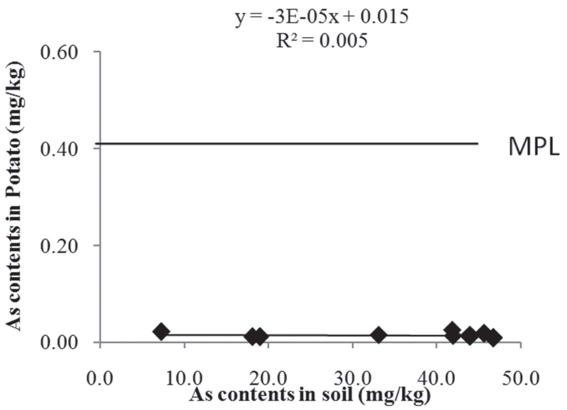


Figure 8. Relationship between Cd content in potato and soil

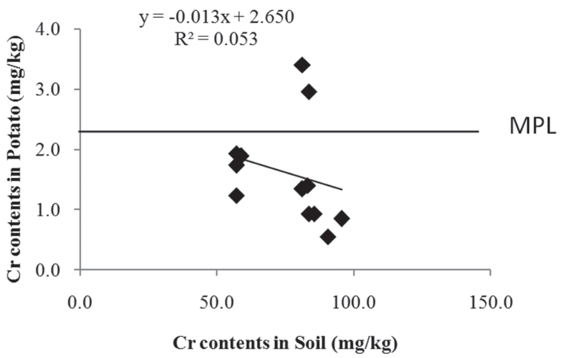


Figure 9. Relationship between Cr content in potato and soil

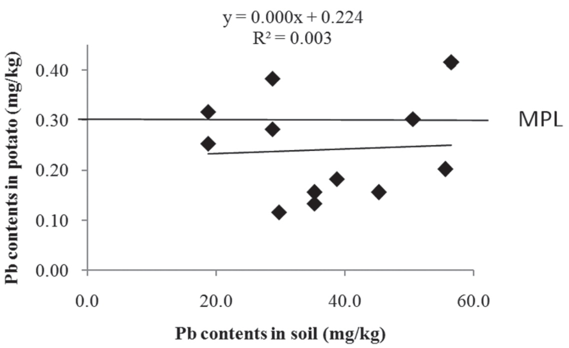


Figure 10. Relationship between Pb content in Potato and soil

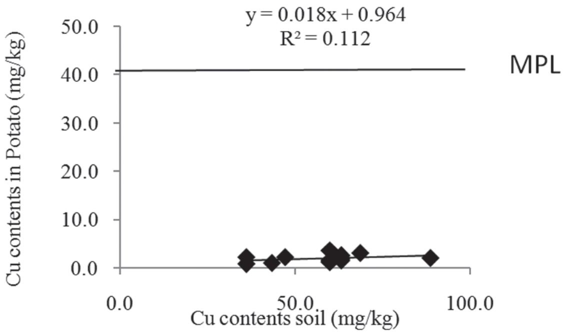


Figure 11. Relationship between Cu content in potato and soil

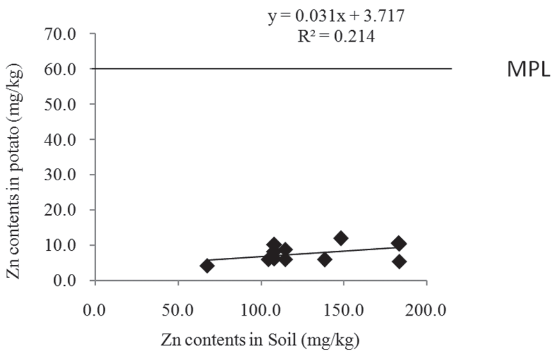


Figure 12. Relationship between Zn content in Potato and soil

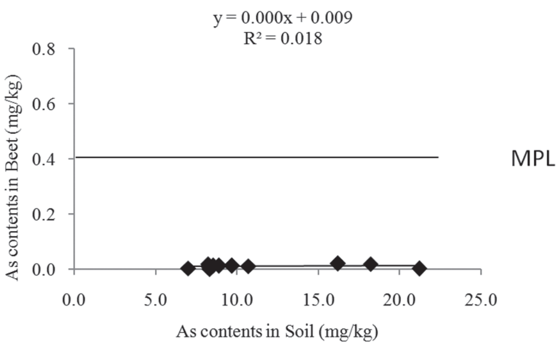


Figure13. Relationship between As content in Beet and soil

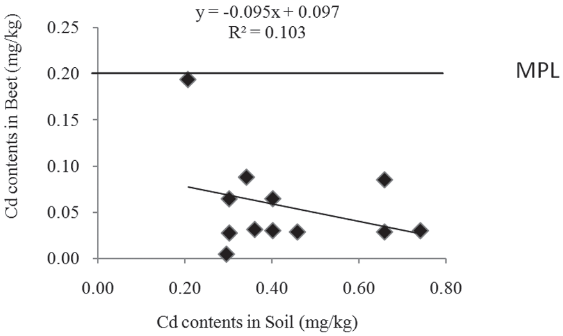


Figure 14. Relationship between Cd content in Beet and soil

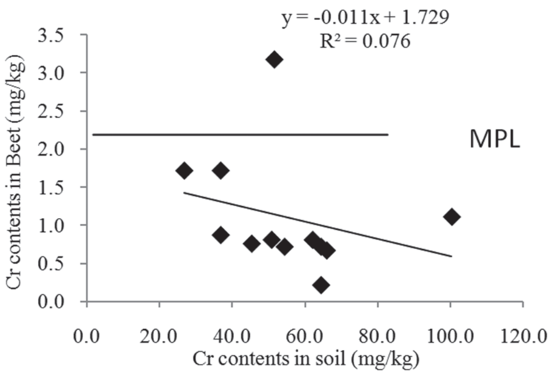


Figure15. Relationship between Cr content in Beet and soil

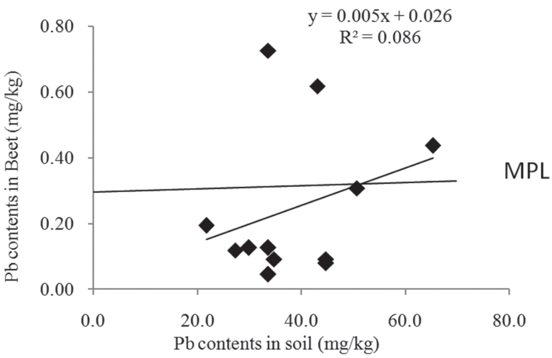


Figure 16. Relationship between Pb content in Beet and soil

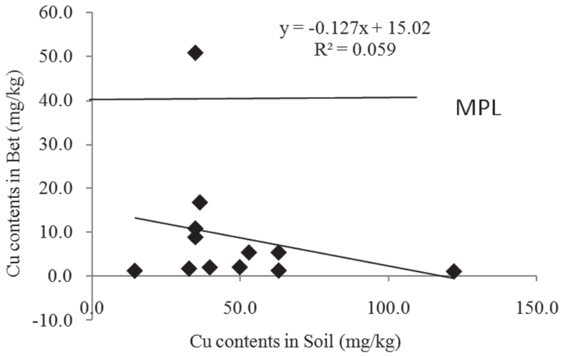
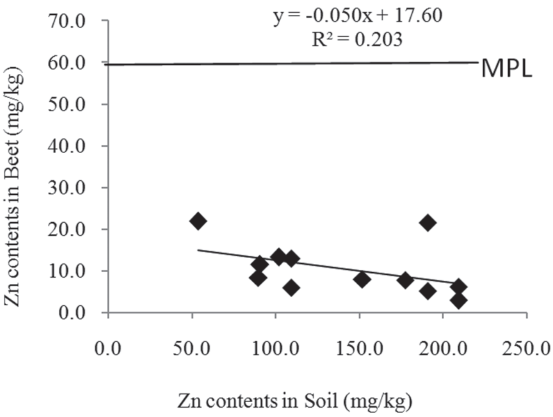


Figure 17. Relationship between Cu content in Beet and soil



Line parallel to X axis in all graphs denote the Maximum Permissible Limit imposed by the WHO/FAO Joint Codex Alimentarius (2001) for each element.

Figure 18. Relationship between Zn content in Beet and soil

Bio Accumulation Factors (BAF) of toxic trace metals in vegetables

BAF of toxic trace elements calculated as BAF= Metal concentration in the edible part of the vegetable/metal concentration in the soil. If the ratios >1, plants have accumulated elements, the ratios around 1 indicate that the plants are not influenced by the elements and ratios < 1 show that plants exclude the elements from the uptake (Ma *et al*., 2001; Cluis, 2004, Duressa and Leta 2015, Radulescu *et al*., 2013).

Table 8. Bioaccumulation factors of edible vegetables

Vegetable	Cu	Zn	Pb	Cd	Cr	As
Beet	0.269	0.098	0.008	0.142	0.022	0.001
Carrot	0.150	0.133	0.013	0.263	0.100	0.003
Potato	0.027	0.053	0.008	0.295	0.025	0.0007

In all tested vegetable samples, BAF values for Cu (0.027-0.26), Zn (0.053-0.133), Pb (0.008-0.013), Cd (0.142-0.295), Cr (0.022-0.100) and As (0.0007-0.003) were less than one showing that plants only absorbed toxic trace metals but did not accumulate them. The BAF calculated for these vegetables were in the order of Cu> Cd> Zn> Cr>Pb> As for beet, Cd >Cu>>Zn >Cr>Pb> As for carrot, Cd>Zn >Cu >Cr >Pb>As for potato (Table 9).

Similarly the highest BAF value of Cu was observed in beet (0.269) followed by carrot (0.150). The highest BAF of Zn was obtained in carrot (0.133) where as the highest BAF value of Cd was observed in potato and followed by carrot. On the other hand, Cd showed that high tendency of accumulation in the edible parts of the root and tuber crops. The values of BAF for As were the lowest for all edible parts of the vegetables followed by Pb. It has been observed that plant species differed greatly in their tolerance and ability to take up and transport metals within the plant. Further, this variation has been due to absorption of toxic trace metals by plants depends on many plant, soil and environmental factors. According to the chemical properties of the soil (Table 5) this variation could have occurred due to high organic matter content in soil as they reduce the accumulation of trace metals in vegetables. Several scientists reported that the mobility and availability of many toxic trace elements in soil is generally low when the soil is high in pH, clay and organic matter (Jung and Thornton 1996, Roselli *et al*., 2003).

In the present study concentrations of Cd, Cr and Pb are higher in several samples of beet, carrot and potato. Raphael *et al*., (2010) stated that the bioaccumulation factor indicates most of the trace metals concentrate more in the roots of the food crops than in the stems and leaves.

Dietary exposure of toxic trace elements via vegetables

There are several possible pathways of exposure of toxic trace metals to humans but among them the food chain is the main pathway. Exposure of contaminants is usually expressed as provisional tolerable daily intake, a reference value based on body weight for an average adult (60 kg body weight) established by FAO/WHO (1999). The daily intake of toxic trace elements via vegetables were estimated assuming that each person is consuming 250 g of each vegetable as no sufficient data available on the dietary consumption of each vegetable. (Table7).

Despite excessive intake of toxic trace elements can have deleterious effect on human health, the estimated dietary intakes of toxic trace elements studied did not exceed the Tolerable Daily Intake (TDI) levels stipulated by FAO/WHO (1999) (Table 9).

Results of this study showed the toxic trace element contents in most of the vegetable crops were far below the maximum permissible limit imposed by FAO/ WHO (2001) and the estimated dietary intakes of toxic trace elements did not exceed the Tolerable Daily Intake (TDI) levels stipulated by FAO/WHO (1999). Further bioaccumulation factor of all these root and tuber vegetables was less than one. Therefore, at present toxic trace metal contents in soils and vegetables do not pose a serious threat to environment and human health. However, continuous exposure to them could cause detrimental impacts. Therefore, regular monitoring of the level of toxic trace elements in soils and crops is essential to prevent the contaminations of toxic trace elements in human food chain. In addition, it is necessary to prevent the pollution of agriculture environment owing to the unnecessary application of many inputs with strict quality monitoring of the inputs and their use.

Table 9. Daily dietary intake of toxic trace elements from vegetables (mg/day/person) (Calculated based on assuming that a person consumes 250 g of each of the vegetable per day)

Vegetable	Cu	Zn	Pb	Cd	Cr	As
Beet	0.60	2.2	0.07	0.014	0.30	0.002
Carrot	3.0	2.4	0.04	0.013	0.25	0.006
Potato	0.39	1.7	0.065	0.017	0.50	0.004
TDI (FAO/WHO,1999)	3.0	15	0.214	0.06	NA	NA

NA-Not Available

CONCLUSIONS

Toxic trace metal contents of Cd, Pb and Cr in soil samples tested in this study were below the maximum permissible limit of those elements stipulated by European Union set standards for Cd and Pb and USEPA standards for Cr. However, Cu and Zn contents of several soil samples exceeded the European Community set standards for soil. Results of this study revealed that the mean contents of the toxic trace element contents of Zn, Cu, Cd and As in all tested root and tuber crops were lower than Maximum Permissible Limit imposed by FAO/WHO (2001, 1985) except for lead and chromium content of several samples. Although, lead and chromium content of several samples of root crops exceeded Maximum Permissible Limit, daily dietary intakes of Pb in those vegetables were lower than TDI values of FAO/WHO (1999). Bioaccumulation factors of all vegetables were also lower than one, indicating of greater retention of toxic trace metals in soil or not accumulated in the edible parts of the root and tuber vegetables.

REFERENCES

Afshin, M. and M. A. Zarasvand. 2008. Heavy metals in selected vegetables and estimation of their daily intake. Sanandaj, Iran.SouthEast Asian Journal of Tropical Medicine and Public Health. 39 (2).

Albert, S. 2011.Watering and water contents of vegetables. Gardening Tips www.harvest totable. com/2011/07/watering and water conten t of vegetables. (Accessed on 21.09.2017)

Aktaruzzaman M, A. N. M. Fakhruddin, M. A. Z. Chowdhury, Z. Fardous and M. K. Alam 2013. Accumulation of Heavy metals in soil and their Leafy vegetables in the region of Dhaka Aricha Highway, Savar, Bangaladesh, Pakistan Journal of Biological Sciences 16(7): 332-338.

Amin O. I., H. A. Chibugo and A. N. Charles. 2013. A Survey of Heavy Metal (Lead, Cadmium and Copper) contents of Selected Fruit and Vegetable crops from Borno State of Nigeria. International Journal of Engineering and Science 2 (1).

AOAC Official method of 2015.01, Heavy metals in food

Cluis C. 2004. Junk –Greedy Greens: Phyto remediation as a new option for Soil decontamination. Biotechnology Journal 2:60-70.

Duresa, T. F. and Leta, S. 2015. Determination of levels of As, Cd, Cr, Hg and Pb in soils and some vegetables taken from river mojowater irrigated farmland of Koka village OramaState East Ethiopia. International Journal of Science: Basic and Applied Research. 21(2) : 352 -372.

FAO/WHO, 2001. Food additives and contaminants. Joint Codex Alimentarius Commission, FAO/WHO Food Standards programme. ALINORM 01/12A.

FAO/WHO. 1999. Expert Committee on Food additives. Summary and Conclusion, 53rd meeting Rome: Joint FAO/WHO, 1-10.

Jan, F. A., M. Ishaq, S. Khan, I. Ihsanullah, I. Ahmad and M. Shakirullah. 2010. A comparative study of human health risks via consumption of food crops grown on waste water irrigated soil and relatively clean water irrigated soil. Journal of Hazardous Materials. 179: 612-621.

Jung, M. C. and I. Thornton. 1996. Heavy metal contamination of soils and plants in the vicinity a lead –zinc mine Korea. Applied Geochemistry 11:53-59.

Khan, S., Q. Cao, Y.M. Zheng, Y. Z. Huang and Y. G. Zhu. 2008. Health risks of heavy metals in contaminated soils and food crops irrigated with waste water in Beijing, China. Environmental Pollution. 152: 686-692.

Ma, L. Q., K. M. Komar, C. Tu, W. Zhang, Y. Cai and E. D. Kenelly. 2001. A fern that hyper accumulates arsenic. Nature 409: 579 - 582.

McGrath, D. and R. J. McCormack. 1999. The significance of heavy metal and organic micro pollutants in soils. Rural Environment. Ser. 23. Johnstown Castle Research Centre, Wexford, Ireland. p278.

Mc Lean, E. O. 1982. Methods of Soil Analysis Part 2. Chemicals and Microbiological Properties. Second Edition. Soil Science Society of America Inc. Madison, Wisconsin USA.

Muller, G. 1969. Index of Geo accumulation in Sediments in Rhine River. Geological Journal 2(109).

Silva, N. R. N., P. Weerasinghe and H. D. K. Rathnapriya. 2016. Toxic Trace Elements in Vegetables collected from Markets in Kandy District. Annals of the Sri Lanka Department of Agriculture 18: p19.

Nelson, D. W. and L. E. Sommers. 1982. Methods of Soil Analysis. Chemical and Microbiological Properties (Second Edition). Soil Science Society of America, Madison, Wisconsin.

Premarathna, H. M. P. L., G. M. Hettiarachchi and S. P. Indrarathne. 2011. Accumulation of Cadmium in intensive vegetable growing soils in the up country. Tropical Agricultural Research 17: 93-103.

Radulescu, C., Sfihi, C. I. V. Popescu, I. D. Dulama, E. D. Chelarescu and A. Chilian. 2013. Heavy metal accumulation and Translocation in different parts of Brassica oleracia L. Romanian Journal of Physics 58 (9 -10): 1337-1354.

Raphael O, S. Kolawole and Adebayo. 2010. Assessment of trace heavy metal contaminations of some selected vegetables irrigated with water from River Benue within Makurdi Metropolis, Benue State Nigeria. Advances in Applied Science Research 2(5): 590-601.

Roselli W., C. Keller and K. Bosch. 2003. Phytoextraction capacity of trees growing on metal contaminated soil. Plant and Soil 256:265-262.

Saglam, C. 2013. Heavy Metal Accumulation in the Edible Parts of Some Cultivated Plants and Media Samples from a Volcanic Region in Southern Turkey Journal of Ecology 22 (86): 1-8.

Singh K, D. Mohan, V. Singh and A. Malik. 2005. Studies on distribution and fractionation of heavy metals in Gomti river sediments – a tributary of the Ganges, Indian Journal of Hydrology 312:14-27.

Wickramarathna, N., T. M. Maduranga and L. L. S. Chamara. 2016. Contamination of Heavy Metals in Aquatic Vegetables Collected from cultivation sites in Sri Lanka. IOSR –JESTFT 10: 76-82.

Wijewardena, J.D.H. and U. W. S. P. Yapa. 1999.Effect of the combine use of animal manure and chemical fertilizer on potato and vegetable cultivation in the up country of Sri Lanka. Sri Lankan Journal Agricultre Science 36: 70-82.

USEPA METHOD 3051. Revision September 1994. pp1-14.

Zurera, G., R. Moreno, J. Salmeron and R. Pozo. 1989. Heavy metal uptake from greenhouse border soils for edible vegetables. Journal of Science and Food agriculture 49 (3):307-314.