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ASSESSMENT OF LEVELS OF LEAD, CADMIUM, COPPER AND ZINC CONTAMINATION IN SELECTED EDIBLE VEGETABLES

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ABSTRACT: The aim of this study was to measure the level of heavy metals in edible vegetables (tomato, onion and green pepper) collected from Bahir Dar market, garden of Bahir Dar town and Adet Agricultural Research center (near Reb River). Levels of Pb, Cd, Cu and Zn were determined using flame atomic absorption spectrometry after dry ashing process. The average concentrations of Pb, Cd, Cu and Zn were in the range of; 0.244 - 0.987, 0.115 - 0.536, 0.962 -3.430 and 2.344 - 4.136 mg/kg in tomato, 0.241- 0.43, 0.12- 0.441, 0.879-3.428 and 2.197- 3.259 mg/kg in onion and 0.28- 0.392, 0.128- 0.573, 1.229-2.991 and 3.081-4.242 mg/kg in green pepper respectively. The levels of those metals in all vegetables collected from the market site was higher than Adet Agricultural Research center but lower than garden in Bahir Dar town. The highest concentration of Zn in all vegetables of the analyzed metals was probably because it is considered as essential micronutrients for plants growth and can easily be taken up by plants or may be obtained from the water. The concentration of zinc and copper were within WHO guideline in all analyzed samples, while samples collected from the market and gardens of Bahir Dar town showed high increment in concentration of lead and cadmium from the permissible level set by FAO/WHO for consumption.

KEYWORDS: FAAS; heavy metals; vegetable; contamination; FAO/WHO.

1 INTRODUCTION

The increasing demand for food safety stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals and/or toxins. Food safety issues and potential health risks make as one of the most serious environmental concerns. Heavy metal accumulation in plants depends upon plant species, and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil-to plant transfer factors of the metals. Dietary exposure to heavy metals, namely cadmium (Cd), lead (Pb), zinc (Zn), copper (Cu) and other has been identified as a risk to human health through the consumption of vegetable crops. Heavy metals are given special attention throughout the globe due to their toxic and mutagenic effects even at very low concentration [1, 2].

Heavy metals are among the major contaminants of food supply and may be considered the major problem to our environment. Such problem is getting more serious all over the world especially in developing countries such as North and South Africa, Turkey, Yemen, Zimbabwe, Nigeria, Tanzania and Egypt. Contamination of vegetables with heavy metals may be due to irrigation with contaminated water, the addition of fertilizers and metal-based pesticides, industrial emissions, transportation, the harvesting process, storage and/or at the point of sale (market). Human beings are encouraged to consume more vegetables and fruits, which are beneficial for health. Heavy metals may enter the human body through inhalation of dust, consumption of contaminated drinking water and consumption of food plants grown in metal-contaminated soil [3, 4].

Lead and cadmium are among the most abundant heavy metals and are particularly toxic. The excessive content of these metals in food is associated with etiology of a number of diseases, especially with cardiovascular, kidney, nervous as well as bone diseases. In addition, they are also implicated in causing carcinogenesis, mutagenesis and teratogenesis. Copper and zinc are essential for important biochemical and physiological functions and necessary for maintaining health throughout life, but if theses metals have excessive concentration above the WHO value they may cause diseases [5].

The health effect of lead and cadmium is less studied even though peoples are consuming vegetable day to day in its raw and sauce form that may result the accumulation of trace metals in human body. However, to the extent of assessment done, there is no literature report on the determination of the levels of heavy metals in Ethiopian vegetables (tomato, onion and green pepper) around Bahir Dar town. Hence, this research is intended to determine the concentration of trace metals (cadmium, copper, zinc and lead) in edible vegetables from Bahir Dar town market and gardens of Bahir Dar around Lake Tanaand Adet Agricultural Research center (near Reb River).

2 MATERIALS AND METHODS

2.1 DESCRIPTION OF STUDY AREA

A study was conducted in Bahir Dar town and Adet Agriculture Research center from February to April 2011 to determine level of heavy metals in vegetables. Bahir Dar town is the capital city of the Amhara National Regional State in Ethiopia. It is located at 11^{0}38'N, 37^{0} 10'E on the Southern side of Lake Tana (where Blue Nile River starts). The altitude of the town is about 1800 m above sea level and average annual rainfall and temperature of 1455.5 mm and 18.8^{o}c respectively. Adet Agriculture Research center have three irrigation branches. The one which was considering in this study is found in Woreta around Reb River. It is found in Fogera woreda which is one of the 106 districts in the Amhara Regional State and found in south Gondor zone. It is situated at 37^{o} 29' to 37^{o} 59' E longitude and 12^{o} 41' to 12^{o} 02'N latitude. Samples were collected from two purposely selected areas in Bahir Dar (market and gardens around shore of Lake Tana near the St. George church) and Adet Agricultural Research center (near Reb River).

2.2 CHEMICALS AND APPARATUS

Concentrated nitric acid 69% from LOBA CHEMIE PVT.Ltd., India was used as dry ashing aid. Lead nitrate cadmium nitrate tetrahydrate, zinc nitrate hexahydrate, copper nitrate tetrahydrate all from BLULUX Laboratories PVT. Ltd., India was all used for standard solution preparation. Distilled water ,Refrigerator, Polyethylene bags, ceramic pestle and mortar, Digital analytical balance (Mettler Toledo, Model AT250, Switzerland), oven (J. P. Select, Spain), Muffle furnaces (Philips Harris Ltd, England) Finally, atomic absorption spectroscopy (novAA 300) equipped with deuterium ark background correctors was used for analysis of the trace metals (Cu, Zn, Cd, and Pb).

2.3 CLEANING OF GLASS WARES AND APPARATUS

All glassware and plastic containers used were washed with liquid soap, rinsed with water, soaked in 10 % nitric acid for 24 hrs, cleaned thoroughly with distilled water and dried in such a manner to ensure that any contamination does not occur. All pipette rinsed immediately prior to use, three times with distilled water and once with sample solution to be dispensed [5].

2.4 SAMPLE COLLECTION, PRESERVATION AND HANDLING

Samples were collected from Adet Agricultural Research center (near Reb River) irrigation, St. George church garden and market in Bahir Dar town in April 2011 and transported with polyethylene bags to the laboratory immediately. Nine composite samples of vegetables (three each of onion (*Allium cepa*), tomato (*Lycopersicum esculantum*) and green pepper (*capsicum annuum*)) were collected (4 kg for each commodity) from the three sites randomly. Each vegetable type was sampled twelve times from three sites. All vegetables were collected and stored in polyethylene bags according to their type and were brought to the laboratory for preparation and treatment. Samples were kept in a refrigerator, until the samples were homogenized and then prepared. The collected samples were washed with tap water and rinsed three times with distilled water to make them free of extraneous substances, including soil and dust particles that may influence analytical results. For the analysis, only the edible portions were included, whereas bruised or rotten parts were removed. All the vegetables were chopped into slices with plastic knife and the chopped vegetables were composited and homogenized [1, 5, 7].

2.5 SAMPLE PREPARATION AND TREATMENT

Sub-samples (1kg, for each commodity from each source) were taken at random from the composite sample and were processed for analysis by the dry-ashing method. The samples were first oven dried at 105 ^{o}C for 24 h. The dried samples were powdered with porcelain mortar taking care not to overheat the sample. The ground solid samples (5 g, each) for each food item were accurately weighed and placed in crucibles and 5 drops of concentrated nitric acid was added to the solid as an ashing aid. Dry-ashing process was carried out in a muffle furnace by stepwise increase of the temperature up to 550 ^{o}C and then left to ash at this temperature for 4 h. The ash was left to cool; the ash was kept in desiccators and then rinsed with 1M nitric acid. The ash suspension was filtered into a 25 ml volumetric flask using Whatman filter paper No. 41, and the solutions were completed to the mark with nitric acid (1 M). The blank solutions also were prepared by the mixture of reagents following the same as dry-ashing procedure and diluted to 25 mL with nitric acid (1M). Finally, the digested samples were kept in the refrigerator, until the level of all the metals in the sample solutions were determined using AAS [2, 3].

2.6 ANALYTICAL PROCEDURE FOR HEAVY METAL ANALYSIS BY FAAS

Vegetable samples were analyzed for heavy metals using flam atomic absorption spectroscopy (FAAS). The heavy metals analysis adjustment of the operating condition was very essential target. Wavelength, slit width, limit of detection was adjusted for the analysis of Pb, Cd, Zn and Cu. Standard solutions of heavy metals, namely lead (Pb), cadmium (Cd), copper (Cu) and zinc (Zn) were prepared for calibration curve. The standards were prepared from the standard salt of each metal in 1000 ml volumetric flask then 1000 mg/l standards in 10 ml HNO_3. From this stock solution 100 mg/l of each metal were freshly prepared by diluting the stock solution in 100 ml volumetric flask with distillated water then the working solution 10 ml of each metal was prepared in 100 ml volumetric flask. For the determination of these metals, three solutions were prepared for each sample from each source and four standard solutions were made for Pb, Cd, Zn and Cu. A rinse blank (distilled water) was used to flush the uptake system to reduce memory interferences [3, 8].

Finally, the data was analyzed by Origin, Excel and One way ANOVA and its significance was determined at $P < 0.05$ level.

3 RESULT AND DISCUSSION

3.1 CONCENTRATION OF PB, CD, CU AND ZN USING FAAS IN VEGETABLES

The concentration of each metal in samples of the three sites was calculated from their corresponding absorbance value using the calibration curve. Table 3.1 shows mean concentrations of these metals investigated in the edible vegetable commonly consumed in Bahir Dar, Ethiopia. The heavy metal levels determined were based on plants dry weight. The values are given as mean ± SD and the results are means of three replicates.

Table 3.1. Mean (±SD) values of heavy metals concentration in vegetable for different area of study.*

Area of the study	Vegetable type	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
Adet Agricultural Research center (near Reb River)	Tomato	0.244 ± 0.010	0.115 ± 0.028	0.962 ± 0.038	3.902 ± 0.012
	Onion	0.241 ± 0.018	0.120 ± 0.011	0.879 ± 0.011	2.197 ± 0.258
	Green pepper	0.280 ± 0.005	0.128 ± 0.029	1.229 ± 0.346	3.081 ± 0.116
Gardens of Bahir Dar town around Lake Tana	Tomato	0.987 ± 0.017	0.536 ± 0.010	3.430 ± 0.013	4.136 ± 0.055
	Onion	0.441 ± 0.019	0.430 ± 0.001	3.259 ± 0.011	3.428 ± 0.368
	Green pepper	0.342 ± 0.033	0.573 ± 0.041	2.991 ± 0.003	4.242 ± 0.006
Bahir Dar market	Tomato	0.371 ± 0.002	0.291 ± 0.003	2.344 ± 0.003	2.494 ± 0.234
	Onion	0.358 ± 0.005	0.254 ± 0.002	3.237 ± 0.010	3.332 ± 0.204
	Green pepper	0.392 ± 0.001	0.331 ± 0.019	2.289 ± 0.334	3.181 ± 0.011

* Values are mean of the three determinations at 95 % confidence level

This means: $$\mu = \bar{X} \pm \frac{ts}{\sqrt{n}} \qquad (1)$$

Where: μ - the expected value of the determination $\bar{X}$ - mean of the replication

t- Statistical factor whose value is determined by number of samples and the desired confidence level

s- The standard deviation of the measured value

n- The number of replicate measurement

3.2 COMPARISON OF THE AVERAGE HEAVY METALS CONCENTRATIONS AMONG THE THREE SITES

All vegetable (tomato, onion and green pepper) samples collected from the study areas showed the presences of Pb, Cd, Cu and Zn and all were found to be above their detection limits within nine (three each of tomato, onion and green pepper) samples. Comparison of the level of metal in tomato, onion and green pepper among the three sites are given in Figure 3.1, 3.2 and 3.3 respectively.

Tomato samples: in all the analyzed metals zinc content was high as compared to other metals (Figure 3.1). Its concentration ranges from 2.494 to 4.136 mg/kg. Garden provided maximum of 4.136 mg/kg while its concentration was found minimum in market (2.494 mg/kg) and the order of its concentration is garden > Adet > market. The second most accumulated trace metal next to zinc found in tomato was copper. Its mean concentration was found between 0.962 to 3.430 mg/kg (Figure 3.1). The maximum amount was found in tomato from garden (3.430 mg/kg) while minimum amount was found in Adet (0.962 mg/kg). The total accumulation of copper was in the order of garden > market > Adet.

Of the toxic metals, in all tomato samples the concentration of cadmium was relatively least amount than any other trace metal analyzed but its concentration is above WHO/FAO in all areas of study except in Adet. The concentration of Cd varies within the tomato sample analyzed. The cadmium content in this study was in the range of 0.115 to 0.536 mg/kg (Figure 3.1). The highest and the least concentration were absorbed 0.536 mg/kg and 0.115 mg/kg in garden and Adet respectively. The concentration pattern of cadmium follows in order of garden > market > Adet. The other toxic metal accumulated in tomato sample was lead. Its concentration in samples was 0.244 mg/kg, 0.987 mg/kg and 0.371 mg/kg in Adet, garden and market respectively. Moreover, the lowest level of lead was accumulated in Adet tomato and the highest was in garden.

As can be seen from Figure 3.1, the order of all metals concentration in tomato samples in Adet, garden and market is in the same order of Zn > Cu > Pb > Cd. This trend suggests that zinc found in the highest concentration and cadmium is the least. The concentration of Pb and Cd are beyond the WHO guideline value in garden and market.

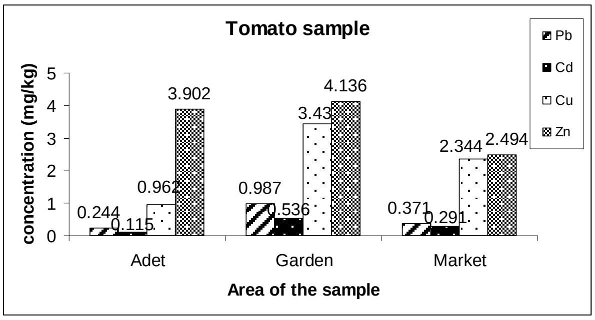

Fig.3.1. Mean concentration of Pb, Cd, Cu and Zn in tomato from different area of study.

Onion sample: Figure 3.2, shows the level of Pb, Cd, Cu and Zn of their average concentration among the study areas. The concentrations of the elements in the analyzed samples were quite varied. In the onion sample the same to that of tomato, Zn was observed at higher concentration than other metals with concentration range from 2.179 mg/kg in Adet to 3.428 mg/kg in garden followed by Cu with mean concentration range 0.879 mg/kg to 3.259 mg/kg. The concentration pattern of zinc and copper follows in order of garden > market > Adet.

Among the toxic metals lead and cadmium, Pb was found at higher concentration than Cd in all the three sample sites and its concentration ranging from 0.241 mg/kg in Adet to 0.441 mg/kg in garden. The lowest observed concentration for all the three sites was that of Cd and the maximum concentration was in garden (0.430 mg/kg) while its minimum concentration was in Adet (0.120 mg/kg). The total accumulation of lead and cadmium was in the order of garden > market >Adet. The trend occurrence with the selected vegetable (onion) of metal concentration of Adet, garden and market was in the order of Zn > Cu > Pb > Cd.

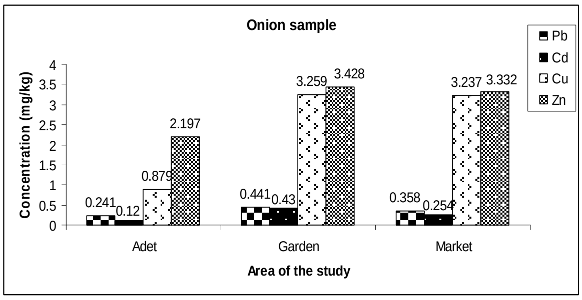

Fig.3.2. Mean concentration of Pb, Cd, Cu and Zn in onion from different area of study.

Green pepper sample: Figure 3.3, shows the metals average concentration in the three green pepper samples. For most of metals, garden has relatively more metals concentration followed by market, while Adet contains the least metal concentration. The concentration of zinc is higher in all the three samples followed by copper. The order of zinc and copper have the same trend that is garden > Market > Adet. For all the three green pepper samples Cd have least average concentration like that in tomato and onion samples and the order of its concentration is the same as that of Zn and Cu.

Concerning to lead in the study, the concentration with the analyzed green pepper samples was found to be 0.280 mg/kg, 0.342 mg/kg and 0.392 mg/kg in Adet, garden and market respectively. The increasing order of metals concentration in green pepper in Adet and market were in the order of Zn > Cu > Pb > Cd. However, the trend occurrence of metals concentration in garden were in the order of; Zn > Cu > Cd > Pb.

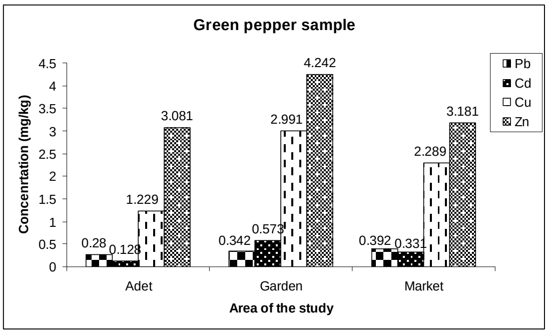

Fig.3.3. Mean concentration of Pb, Cd, Cu and Zn in green pepper from different area of study.

In general**,** as can be seen from Figures 3.1, 3.2, 3.3, the levels of all the heavy metals in all the vegetables collected from the market sites and garden of Bahir Dar town are higher than those of heavy metals in the respective vegetables collected from the production site of Adet Agricultural Research center. As Mr. Habtomu Tegegn (the horticulturalist of Adet Agricultural Research center) recommended, the institution use natural waters for irrigation from Reb River with the help of water pump, organic fertilizer like urea, which leads to less concentration of metals as compared to the other sites. However, small concentration was observed which may be from the soil and environmental pollution. The concentrations of all metals obtained from Adet in all vegetable samples are within permissible levels given by the FAO and WHO and are safe for human consumption.

The levels of Pb, Cd, Cu and Zn in all the vegetables collected from the market site are higher than Adet Agricultural Research center but lower than garden in Bahir Dar town. This might be due to heavy metal depositions on the vegetables during transport, marketing at the point of sale and most of Ethiopian farmers use fertilizer and pesticide in order to get good yield and protect from pests. The high contamination levels found in all vegetables in garden of Bahir Dar town may be related to pollutants in irrigation water, from soil and pollution from highway traffic, municipal wastewater, metal-based pesticides and inorganic fertilizer such as DAP (diammonium phosphate).

The high concentration of Zn is probably because it is considered as essential micronutrients for plants growth and can easily be taken up by plants. The higher concentration of Zn in the vegetable may also be ascribed to the use of Zn in fertilizers and metal-based pesticides around production site. The concentration of zinc and copper were within WHO guideline value in all analyzed samples. All analyzed samples that were collected from the market and gardens of Bahir Dar town showed slight increment in concentration of lead and cadmium are above the permissible level set by FAO/WHO for consumption. On whole, all vegetables (except Adet Agricultural Research center) that were studied in this study, are contaminated by lead and cadmium which were toxic to consumer.

Vegetables are important part of every human diet. Consumptions of toxic heavy metals in unsafe concentrations through vegetables may lead to accumulation of Pb and cadmium in kidney and liver [3] and could cause problem such as: **Lead** – brain damage, seizure, central nervous system disorders, kidney disease both acute and chronic, gastrointestinal disturbances, slight liver impairment and damage a child's central nervous system, kidneys, and reproductive system. **Cadmium -** accumulates in kidneys, where it damages filtering mechanisms. It also causes diarrhoea, stomach pains and severe vomiting, bone fracture, reproductive failure and possibly even infertility, damage to the central nervous system, damage to the immune system, psychological disorders and possibly DNA damage.

3.3 COMPARISON BETWEEN THE AVERAGE HEAVY METAL CONTENT OF VEGETABLES OF THIS STUDY WITH THAT OF LITERATURE AND WHO VALUES

There are some reports from different countries on the analysis of the metal contents of the tomato, onion and green pepper**.** It is important to compare the result obtained from the analysis of the three vegetables in this study with the values sited in other countries and WHO guideline values. The comparative study of metals of tomato, onion and green pepper determined in this study and the reported values of other researchers are presented in Table 3. 2. The concentration of copper in tomato, onion and green pepper is in the average range of (**0.962 - 3.430, 0.879 – 3.428, 1.229 – 2.991**) mg/kg respectively and for zinc (**2.344- 4.136, 2.197 - 3.259, 3.081- 4.242**) mg/kg in tomato, onion and green pepper respectively. Both copper and zinc are found within the WHO values. The average concentration range value of lead is (**0.244 - 0.987, 0.241 – 0.43, 0.28 – 0.392**) and cadmium (**0.115 - 0.536, 0.12 – 0.441, 0.128 – 0.573**) mg/kg in tomato, onion and green pepper respectively. Hence the lower value of all the analyzed samples of lead and cadmium accepted by WHO guideline value and the higher concentration values of the range exceeded the WHO value; therefore, there is need of remedial action.

In comparing the result of this study with cited in literature, the concentrations of Cu in tomato, onion and green pepper samples found in this study was more or less agrees with the results of Mohamed *et al.* (4.47, 2.81, 4.49 mg/kg) [6], Onianwa *et al.* (1.41, 1.057, 1.279 mg/kg) [10], Radwan *et al.* (1.83, 1.49, 4.53 mg/kg) [3] from Saudi Arabia, Nigeria and Egypt respectively. However, it is lower than with the values reported by Dilek *et al.* (32.6, 53.83, 37.06 mg/kg) [9] from Turkey.

When the level of Zn in tomato, onion and green pepper obtained in this study is compared with literature values, it is higher than the result reported by Onianwa *et al.* (0.559, 1.276, 1.359 mg/kg) of Nigeria [10], while it is much lower than with the values reported by Mohamed *et al.* (14.4, 17.4, 8.51mg/kg)[6], Dilek *et al.* (3.56, 21.34, 10.47 mg/kg)[9], Radwan *et al.* (7.69, 11.4, 12.5 mg/kg) [3] from Saudi Arabia, Turkey and Egypt respectively except concentration of zinc in tomato from Turkey which is the same with this study.

Regarding the toxic metal, the level of lead in the analyzed samples (tomato, onion and green pepper) from this study is higher than those recorded by Onianwa *et al.* (0.03, 0.057, 0.63 mg/kg) in Nigeria [10]. But it is comparable with the values of Radwan *et al.* (0.26, 0.14, 0.47 mg/kg) [3] obtained from Egypt. However, higher concentrations of lead were recorded by Mohamed *et al.* (2.59, 10.29, 1.9 mg/kg)[6] and Dilek *et al.* (9.7, 8.7, 5.3 mg/kg)[9] from Saudi Arabia and Turkey respectively.

As shown in Table 5.6, concentration of cadmium in tomato, onion and green pepper obtained in this study and the result from Dilek *et al*. (0.41, 0.97, 0.62 mg/kg)[9] and Mohamed *et al*. (0.77, 0.76, 0.8 mg/kg) [6] from Turkey and Saudi Arabia are comparable. But, cadmium concentration found in this study is higher than data cited by Onianwa *et al*. (0.004, 0.005, 0.006 mg/kg) [10] and Radwan *et al*. (0.01, 0.02, 0.05 mg/kg) [3] from Nigeria and Egypt.

As described above, the results obtained in this study are comparable favorably with the finding of other researchers from other parts of the world. However, results with those given by Dilek *et al*. are observed to be that there are greet difference about the content of Pb, Cu and Zn in all samples. This difference in the concentration of heavy metals may be ascribed to variation due to application of fertilizer, metal-based pesticide, at time transportation and marketing, emission of vehicles, atmospheric deposition, soil composition, irrigation of wastewater industries and municipal wastewater.

Table 3.2 Comparison of average concentrations of metals in this study with literature and WHO values.

Method	Types of vegetables	Heavy metals concentration in (mg/kg)				Country
		Pb	Cd	Cu	Zn	
AAS	Tomato	9.7	0.41	32.6	3.56	Turkey
	Onion	8.7	0.97	53.83	21.34	
	Green pepper	5.3	0.62	37.06	10.47	
GFAAS	Tomato	2.59	0.77	4.47	14.4	Saudi Arabia
	Onion	10.29	0.76	2.81	17.4	
	Green pepper	1.9	0.8	4.49	8.51	
FAAS	Tomato	0.03	0.004	1.41	0.559	Nigeria
	Onion	0.057	0.005	1.057	1.276	
	Sweet pepper	0.063	0.006	1.279	1.359	
FAAS	Tomato	0.26	0.01	1.83	7.69	Egypt
	Onion	0.14	0.02	1.49	11.4	
	Green pepper	0.47	0.05	4.53	12.5	
FAAS	Tomato	0.244 - 0.987	0.115 - 0.536	0.962 - 3.430	2.344- 4.136	This study
	Onion	0.241 – 0.43	0.12 – 0.441	0.879 – 3.428	2.197 - 3.259	
	Green pepper	0.28 – 0.392	0.128 – 0.573	1.229 – 2.991	3.081- 4.242	
FAAS	vegetables	0.3	0.2	40	60	(WHO) Permissible level

4 CONCLUSIONS AND RECOMMENDATION

Heavy metals are not only affecting the nutritive values of vegetables but also have deleterious effect on human beings using these food items. Determination of heavy metals concentration in vegetables and food products is important for health risk assessment during food consumption. The levels of heavy metals in studied vegetables, and the permissible levels required for safe food were compared. The toxic metals, lead and cadmium were found in the least concentrations compared to other metals analyzed. However, the levels of Pb and Cd exceeded the permissible

level set by FAO/WHO specifications in all vegetable samples collected from market and gardens in Bahir Dar town. Especially, the levels of metals analyzed for all vegetables from garden were found at higher concentration compared to market and Adet agricultural research center (near Reb River). The higher concentration of Pb and Cd above the permissible level in vegetables used for human food may pose health risk to consumer although the concentration of Cu and Zn were below the recommended levels.

Concentrations of metals between samples were also compared using one-way ANOVA. The results of ANOVA indicated that there were significant differences in the levels of most metals between the three samples each of tomato, onion and green pepper among the three sites.

Generally, the levels of metals in similar vegetable samples differed between the three sampling site, that may be due to variation in sources and processes of contaminations that could attribute to metals contamination to take place during pre-harvest and post-harvest process. Possible sources during pre-harvest include from soil type, fertilizers, pesticides, municipal wastewater and water used for irrigation, while post harvest sources may include contamination through air pollution and during transport to the market or at the point of sale.

Lastly the researcher recommends the following

- It is recommended that these types of vegetables should not be cultivated in farms and fields nearby urban areas which have heavy vehicle movements and irrigated with questionable water quality which could be sources of heavy metals contamination.
- This study further suggests that to reduce the health risk, vegetables should be washed properly before consumption as washing can remove a significant amount of aerial contamination from the vegetable surface.
- Markets establishments for vegetable sale should be away from motor vehicle parking and movement areas, as motor vehicle emissions can be a source of heavy metal contamination in vegetables at road side market.
- Use of good agricultural practices under supervision for proper fertilizer application.
- Further works should be carried out in the soil samples where the vegetables are grown, irrigation water and compost or fertilizers on the availability of metals to different vegetable, as it could be useful to take remedial measures by regulatory agencies of the town to abate the metal pollution and also restrict the cultivation of vegetables on contaminated soils.

REFERENCES

[1]. A. Maleki and M. A. Zarasvand, Heavy metals in selected edible vegetables and estimation of their daily intake in Sanandaj, Iran, *J. Med. Scie., Sanandaj, Iran*, vol. 39**,** no. 2, pp. 335- 337, 2008.

[2]. R. k. Sharma, M. Angrawal and F. M. Marshal, Heavy metal in vegetable collected from production and market sites of tropical urban area of India, *J. Food and Chem. Toxicol.,* vol.47, 583-591, 2009.

[3]. M. A. Radwan and A. K. Salama, Market basket survey for some heavy metals in Egyptian fruits and vegetables, *Food and Chem. Toxicol.*, vol. 44, 1273-1278, 2006.

[5]. S. R. Khan, Farooq, S. Shahbaz, M. A. Khan and M. Sadique, Health risk assessment of heavy metals for population via consumption of vegetables, *J. World App. Scie.,* vol. 6, no.1 1602-1606**,** 2009.

[6]. A. E. Mohamed, M. N. Rashed, and A. Mofty, Assessment of essential and toxic elements in some kinds of vegetables, *Ecotoxicol. and Environ. Safety*, vol. 55, 251–260,2003.

[7]. T. E. Bahemuka and E. B. Mubofu, Heavy metals in edible green vegetables grown along the sites of the Sinza and Msimbazi rivers in Dares Salaam, Tanzania, *J. Food Chem.*, vol. 66, 63-66,1999.

[8]. A. K. Salama and M. A. Radwan, Heavy metals (Cd, Pb) and trace elements (Cu, Zn) contents in some foodstuffs from the Egyptian market, *Emir. J. Agric. Scie. vol.* 17, no.1, 34-42,2005.

[9]. D. Demirezen and A. Aksoy, Heavy metal levels in vegetables in Turkey are within safe limits for Cu, Zn, Ni and exceeded for Cd and Pb, *J. of Food Quality*, **29** (2006) 252–265.

[10]. P. C. Onianwa , A. O. Adeyemo, O. E. Idowu, E. E. Ogabiela, Copper and zinc contents of Nigerian foods and estimates of the adult dietary intakes, *Food Chem.*, vol.72, 89-95, 2001.