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RESEARCH ARTICLE

ANALYSIS OF SOME SELECTED HEAVY METALS AND SOME PHYSICO-CHEMICAL PARAMETERS IN ONIONS AND IRRIGATION WATER IN SELECTED WOREDAS OF GURAGE ZONE, ETHIOPIA

***Ashenafi Emiru Teka, Eyasu Gebrie Ajebe and Teshale Assefa Biru**

Department of Chemistry, Natural and Computational Sciences, Wolkite University, Wolkite, Ethiopia

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ABSTRACT

Accumulation of heavy metals and their uptake by different plant parts depend on the concentrations available heavy metals in the soil and form of metals. In the present study the levels of some selected heavy metals (Mn, Zn, Cr, Ni, Cu, Cd and Pb) in onion and irrigation water sampled from selected Woredas of Gurage Zone (i.e.Meskan, Mareko, Sodo, Muhir Aklil and Cheha Woredas), Southern Region, Ethiopia were analyzed. The onion samples were weighed to determine the fresh weight and dried in an oven at 80 oC for 72 hours to determine their dry weight. The dry samples were then grounded in a mortar and the resulting powder digested by weighing 0.5g of oven-dried ground and sieved (<1mm) into an acid-washed porcelain crucible and then incinerated at 500 oC in a muffle furnance. The crucibles were removed from the furnance and cooled. The ashes were then solubilised in concentrated HCl for analysis. The contents of the minerals in the digests were analyzed using flame atomic absorption spectrometer (FAAS). The following concentration ranges (mg/kg) were found in onion: Zn (11.55 - 24.91), Cu (ND – 6.63), Mn(12.23 - 49.22), Cr (ND-54.57), Ni (0.87 - 8.45), Pb and Cd were ND(i.e. Below method detection) in all woreda samples. In this study, all heavy metals were not found (below method detection limit) in water samples. However, levels of heavy metals in onion samples were found in appreciable amount. The level of heavy metals in onions samples determined in this study could be put in the following order Mn > Zn > Cr > Ni > Cu. However, Cd and Pb were not detected in onion samples. The concentrations of heavy metals in onions were found below the permissible limit prescribed by different standards. However, the amount of Cr determined in onion was found above allowable limit recommended by WHO.

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INTRODUCTION

Background of the study

Accumulation of heavy metals and their uptake by different plant parts depend on the concentrations available heavy metals in the soil and form of metals. Positive metal ions are attracted to negative charges like hydroxyl groups and electron pairs of oxygen in the structure of clay minerals and to the carboxyl and phenolic groups of organic substances (Mengel and Kirkby, 1982), whereas negative metal ions are attracted to positively charge hydrous oxides of Fe and Al. The rate of solublization of metals and differences in plant species also affect the availability of metals due to differences in their genotype and transport properties (Phalsson, 1989). Accumulation of heavy metals in soil has the potential to alter the physico chemical properties of the soil, cause toxicity to the plants and contaminate the food chain (Singah and Agrawal, 2007). In general, plant uptake is dependent on (1) movement of elements from the soil to the plant root, (2) elements crossing the membrane of epidermal cells of the root, (3) transport of elements from the epidermal cells to the xylem, in which a solution of elements is transported from roots to shoots, and (4) possible mobilization, from leaves to storage tissues used as food (seeds, tubers, and fruit), in the phloem transport system. After plant uptake, metals are available to herbivores and humans both directly and through the food chain. The limiting step for elemental entry to the food chain is usually from the soil to the root. Plant species and relative abundance and availability of necessary elements also control metal uptake rates. Abundant bioavailable amounts of essential nutrients, including phosphorous and calcium, can decrease plant uptake of non-essential but chemically similar elements, including arsenic and cadmium, respectively. Bioavailability may also be related to the availability of other elements. For example, copper toxicity is related to low abundances of zinc, iron,

Corresponding author:* **Ashenafi Emiru Teka,
Department of Chemistry, Natural and Computational Sciences, Wolkite University, Wolkite, Ethiopia.

molybdenum and (or) sulfate (Chaney, 1989). The bioavailability of elements to plants is also controlled by many factors associated with soil and climatic conditions, plant genotype and agronomic management, including: total concentration and speciation (physical-chemical forms) of metals, mineralogy, pH, redox potential, temperature, total organic content, and suspended particulate content, the type of plant root system and the response of plants to elements in relation to seasonal cycles (Kabata-Pendias and Pendias, 1984).

Heavy metals in water

The contamination of fresh waters with a wide range of pollutants has become a matter of great concern over the last few decades (Al-Weher, 2008). The aquatic systems receive a large amount of heavy metals from natural occurring deposits and natural processes and anthropogenic activities (Wogu and Okaka, 2011). Anthropogenic sources arising from human activities such as industrial, municipal effluents, as well as non-point source run off are the main sources of metals in rivers (Pint, 1976). Discharge of heavy metals into rivers or any other aquatic environment can change both aquatic species diversity and ecosystems due to their toxicity and accumulative behaviour (Al-Weher, 2008). Heavy metals dissolved in water also endanger the lives of the public who use it for drinking and also irrigation. When used for irrigation heavy metals have the danger of being incorporated in food chain and therefore ingested by the public (Wogu and Okaka, 2011). Heavy metals accumulate in the soils at toxic levels as a result of long term application of untreated waste water and therefore soils irrigated by wastewater accumulate heavy metals in their soil surface. When the capacity of the soil to retain heavy metals is reduced due to repeated application of waste water, the metals leach into ground water or soil solution available for uptake (Sonayei *et al*., 2009).

Sources of heavy metals in vegetables

Heavy metal contamination of an ecosystem is one of the major and most widely discussed ecotoxicological problems. Some heavy metals (Cu, Fe, Zn, Mn, etc) are essential for the growth and development of plants when present in trace amounts, but at excessive concentrations these become toxic. Both natural and anthropogenic sources are responsible for increasing the levels of heavy metals in the environment. Natural sources include parent geologic rock material, volcanic outcropping, forest fires, whereas anthropogenic sources include sewage sludge, pesticides, organic matter, composts, fertilizer supplements (Singah and Agrawal, 2007), industrial waste, mining, smelting and metallurgical industries (Singah, 2001) and use of treated or untreated industrial and municipal effluents for irrigation purposes (Berman *et al*., 2000). Agricultural practices like the use of pesticides, fungicides, organic and inorganic fertilizers have increased the concentrations of heavy metals in the top layer of the soil and consequently in crops in their uptake (McBride, 2003). Aerosols also cause heavy metal contamination of Cd, Pb, Zn, Cr and Ni through atmospheric deposition which are consequently absorbed and accumulated by plants or get absorbed on the aerial surfaces of the plants (Timmerman and Hoeng, 2004).

Atomic spectroscopy

This technique is applicable to most gas phase elements over a wide range of concentrations and involves detecting, measuring and analyzing radiation that is either absorbed or emitted from the atoms or ions of the element of interest. It involves three techniques: absorption, emission and fluorescence. In all the above, the sample is decomposed by intense heat into hot gases consisting of free atoms and ions of the element of interest (McMahon, 2007).

Objectives

General Objective

To investigate the level of heavy metals in irrigation water and onion irrigated in selected woreda's of Gurage Zone, Ethiopia

Specific Objectives

- To analysis physico-chemical parameters of water
- To determine heavy metals concentrations from onion which grown by irrigation
- To determine the levels of heavy metals in irrigation water
- To compare the obtained results with other accepted values

MATERIALS AND METHODS

Description of the study area

This study was conducted in selected woredas of Gurage Zone in the Southern region of Ethiopia which largely produce vegetables by irrigation. Geographically, the study area (Gurage Zone) is located between 7.8^0 - 8.5^0 North latitude and 37.5^0C - 38.7^0 East longitude of the equator. Wolkite, the capital of the zone, is 155 km away from Addis Ababa to southwest direction. Gurage zone has a total area of 5932 km^2. It has 13 Woredas with a total population estimated about 1,343,246 according to the survey conducted. The zone comprises altitudes ranging from 1,001 to 3,500 meters above sea level (m.a.s.l). The mean annual temperature of the zone ranges between 13-30 ^{0}C and the mean annual rainfall ranges 600-1600 mm. Woredas in which the study conducted were Meskan, Sodo, Mareko, Cheha and Muhir Aklil. The choices of the study sites (woredas) were on the basis of availability of vegetables in the regions.

Apparatuses and instrument

Polyethylene bags, crucibles, stainless steel knife, muffle furnace, a drying oven, and electronic blending device in addition to this mortar and pestle were used for grinding soil sample. Stainless steel soil sampling auger was used to collect soil samples. Soil samples were ground using ceramic mortar and pestle. An electric motor grinder was also being used to ground vegetables. A digital analytical balance with +0.0001 g precision was used to weigh vegetable and soil samples. Volumetric flasks (25, 50 and 100 mL) were used during dilution of samples and preparation of heavy metal standard solutions. A water deionizer was used to produce demineralized water. Measuring cylinders, pipettes, micropipettes were used during measuring different volumes of sample solutions, acid reagents and metal standard solutions. Flame atomic absorption spectrophotometer was used to analyze the concentrations of Cu, Mn, Zn, Cr, Cd, Pb and Ni in samples.

Visible spectrophotometer was also used in the determination of available phosphorous in soil samples. The pH meter was used to determine the pH of soil and water samples after stirring by a magnetic stirrer. A conductometer was also used to measure the conductivity of water and soil samples.

Reagents and chemicals

All the chemical and reagents used were analytical grade. An acid mixture of conc. HCl (36 - 38%) and conc. HNO_3 (70%) were used for the digestion of the soil samples. Concentrated HNO_3 (70%) was also used in the soliblization of vegetable ashes and in preparation of stock standard solutions. $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$ and $K_2Cr_2O_7$, conc. orthophosphoric acid and 1, 10-phenanthroline ferrous sulfate solutions were used to determine soil organic matter. Standard stock solutions Zn, Cd and Cr were prepared from metal powders of each element after dissolving in a minimum volume of concentrated HCl (1:1 HCl: H_2O) and diluted to100 ml with 1% (v/v) HCl. Standard stock solution of Mn was prepared from metal powder of the element after dissolving in a minimum volume of concentrated HNO_3 (1:1 HNO_3:H_2O) and diluted to 100 ml with 1% (v/v) HCl and with deionized water respectively. Standard stock solutions of Cu and Pb were prepared from Cu metal powder and lead nitrate, $Pb(NO_3)_2$, respectively, after dissolving in a minimum volume of (1:1) concentrated HNO_3 (1:1 HNO_3:H_2O) and diluted to 100 ml with 1% (v/v) HNO_3. Standard working solutions were prepared freshly from the standard stock solutions (1000 mg/L) of each of the metals by appropriate dilution of the intermediate standard solution (100 mg/L).

Sampling of onion

Onion samples were collected from three agricultural sites of each woreda located within Gurage Zone. The selected sites are a commercial vegetable farms and they are considered one of the most important site to supply onions in nearby towns and cities. Samples obtained from these sites were representative of each woreda. Ground water samples were also collected from different water sources which were used for irrigation. Sampling procedure involves water samples from the surface and different depths to obtain representative samples. Onions from the agricultural sites were freshly harvested from farms and packaged into labeled polyethene bags, and transported to the laboratory awaiting analysis. Generally, a total of fifteen samples of onions and fifteen samples of water were collected from each site and homogenized to five representative samples of each woreda between December(2016)-March(2017). It is notice that the sampling points were statistically distributed all over the study area to ensure appropriate spatial coverage of the woreda. The considered sites were of commercial vegetable farms.

Sample preparation

Water sample preparation

In this step of the research, water samples (five separate samples from the three points of sites) were carefully taken and filtered through Whatman number 42 μm filter paper. Filtered water samples were mixed and stored at less than 4°C until analysis.

Onion sample preparation

The onion samples were weighed to determine the fresh weight and dried in an oven at 80 ^oC for 72 hours to determine their dry weight. The dry samples were then grounded in a mortar and the resulting powder digested by weighing 0.5g of oven-dried ground and sieved (<1mm) into an acid-washed porcelain crucible and then incinerated at 500 ^oC in a muffle furnance. The crucibles were removed from the furnance and cooled. The ashes were then solubilised in concentrated HCl for analysis (Pint, 1976).

Instrument operating conditions and calibration

Stock standard solutions were used for preparing intermediate standards and working standards by using deionized water. Working standards of metals solutions were prepared by diluting the intermediate standards solutions of the metal with deionized water. Five points of calibration curve were established by running the prepared working standard solutions in Flame Atomic Absorption Spectrometer. Immediately after calibration, the sample solutions were aspirated into the FAAS instrument and direct readings of the metal concentrations were recorded. Triplicate samples measurement was carried out on each sample. The same analytical procedure was employed in the determination of elements in each four digested blank. The operating conditions of FAAS employed for each analyte are given in table 2.1.

Method Validation

To check accuracy of the extraction of tomato samples and efficiency of the FAAS various methods like certified standard reference material analyzing, spiking sample and comparing the values conducting in a different method, laboratory or analyst may be used. In this work, spiked samples were prepared by adding a small known quantity of standard solutions to subsamples of certain samples; applying similar extraction procedure analyzing for the metals and calculating the recovery percent.

Analysis of physico-chemical parameters

Water samples obtained from different sampling areas were subjected for the analysis of their physical and chemical properties. The reason in determination of physico-chemical parameters is due the quality of water depends on their physical properties such as conductivity, acidity, colour and different chemical properties. The physical properties and chemical properties largely determine the suitability of a soil and water for their planned use and the management requirements to keep them most productive in agricultural purposes largely. For water samples, different physicochemical parameters were also determined. pH and conductivity of water samples were determined using pH meter and conductometer respectively.

Also total solid, total suspended solid and total dissolved solids were determined in water samples as follows

Total suspended solid

Whatman filter paper rinsed in distilled water was dried in an oven at 105˚C for one hour and cooled in a desiccator. Its weight (W_1) was determined using a weighing digital balance. 100 ml of water sample was filtered through the paper and dried at 105˚C for one hour. The weight (W_2) of filter paper containing the residue was recorded and the total suspended solids were calculated.

Total dissolved solid: Amount of dissolved solids of the water sample was determined by subtracting the values of the suspended solids from the corresponding total solids of the samples.

Total hardness

The water sample was thoroughly shaken and 25 ml was taken and diluted to 50 ml with distilled water. 2 ml of phosphate buffer solution was added to bring the pH of the water sample to 10. Three drops of eriochrome black indicator was also added. This was titrated with 0.01 mol/L EDTA to a blue color end point.

Heavy metals analysis

After samples were digested; transparent solutions of water and cabbage samples were then filtered through Whatman number 42 µm filter paper and diluted to 100 mL with distilled water. The clear filtrate was then subjected for determination of heavy metals levels using flame atomic absorption spectrophotometer.

Data analysis: The data derived from various determinations was subjected to statistical analysis including mean and ANOVA. The means for the levels in samples were determined. Using one way ANOVA, the means were compared to determine whether they were significantly different.

RESULTS AND DISUSSION

Instrument calibration

The instrument was calibrated using five series of working standards. The working standard solutions of each heavy metal were prepared fresh by diluting the intermediate standard solutions. The concentrations of working standard solutions and the correlation coefficient obtained for each heavy metal is given in Table 3.1.

Physico-chemical parameters of water samples

Physicochemical properties of water samples were studied. The results obtained in the analysis of water samples are summarized in table 4.3.

Table 2.1. Instrumental operating conditions for the determination of heavy metals in different samples using FAAS

		Parameters			
No	Element	Wavelength (nm)	Bandwidth (nm)	Lamp current (mA)	Instrumental Detection limit (mg/L)
1	Zn	285.2?	0.4	5.0	0.0018
2	Cu	324.7	0.4	3.0	0.0042
3	Mn	279.5	0.2	2.0	0.005
4	Cr	357.9	0.4	4.0	0.002
5	Cd	228.8	0.4	2.0	0.0046
6	Pb	283.3	0.4	2.0	0.01
7	Ni	232.0	0.2	4.0	0.008

Table 3.1. Working standard solutions and correlation coefficients for heavy metals

No	Element	Standard Concentration (ppm)	Correlation Coefficient
1	Zn	0.250, 0.500, 1.000, 1.500, 2.000	0.9975
2	Cu	0.500, 1.000, 2.000, 3.000, 4.000	0.9994
3	Mn	0.250, 0.500, 1.000, 1.500, 2.000	0.9997
4	Cr	0.250, 0.500, 1.000, 1.500, 2.000	0.9989
5	Cd	0.250, 0.500, 1.000, 1.500, 2.000	0.9965
6	Pb	0.250, 0.500, 1.000, 1.500, 2.000	0.9998
7	Ni	0.250, 0.500, 1.000, 2.000, 3.000	0.9997

Table 3.2. Some physicochemical parameters of water samples from different woredas of Gurage zone

		Woredas				
No	parameters	Meskan	Mareko	Sodo	Muhir Aklil	Cheha
1	pH	7.8	8.5	8.1	7.2	7.7
2	Conductivity	0.64	0.76	0.71	0.41	0.63
3	Total suspended solid (mg/L)	350	353	362	280	313
4	Total dissolved solid (mg/L)	210	215	230	130	165
5	Total hardness (mg/L)	150	152.5	166	88	122.5

Table 3.3. Concentration (mean ± SD, n = 3, mg/kg dry weight basis) of heavy metals in Onion samples

		Woredas				
No	Parameter	Meskan	Mareko	Sodo	Muhir Aklil	Cheha
1	Zn	18.61±0.66	16.99±0.46	19.47±1.00	11.55±0.64	24.91±1.42
2	Cu	6.63±0.32	0.4±0.035	2.47±0.23	ND	3.48±0.25
3	Mn	16.83±0.49	31.13±1.23	16.3±0.61	12.23±0.45	49.22±2.17
4	Cr	54.57±2.07	47±1.39	ND	5.47±0.25	2.1±0.44
5	Cd	ND	ND	ND	ND	ND
6	Pb	ND	ND	ND	ND	ND
7	Ni	0.93±0.21	2.57±0.32	2.17±0.35	0.87±0.090	8.45±0.83

Table 3.4. Concentration (mean ± SD, n = 3, mg/kg) of heavy metals in water samples

		Woredas				
No	Parameters	Meskan	Mareko	Sodo	Muhir	Cheha
1	Zn	ND	ND	ND	ND	ND
2	Cu	ND	ND	ND	ND	ND
3	Mn	ND	ND	ND	ND	ND
4	Cr	ND	ND	ND	ND	ND
5	Cd	ND	ND	ND	ND	ND
6	Pb	ND	ND	ND	ND	ND
7	Ni	ND	ND	ND	ND	ND

Table 3.5: Recommended maximum limit of concentration of heavy metals in vegetables and irrigation water [WHO, 2007].

	Vegetables	Water(mg/l)	
Parameter	WHO standard	FAO Standard	National Environment
	(mg/kg, on dry wt.)		Quality Standard
Zinc	50	2	5
Copper	10	0.2	1
Manganese	500	0.2	1.5
Chromium	1.3	0.1	1
Cadmium	0.02	0.01	0.1
Lead	0.5 - 1.0*	0.065[a]	-
Nickel	10	0.2	1

In analyzed water samples, the pH values were ranged from 7.4 to 8.5 (table 3.2). Maximum pH value was obtained at Mareko and minimum was recorded at Muhir Aklil woreda. The pH above 7.5 exhibits a basic nature. Therefore, the water samples analyzed in the current study were basic in nature exceptional to Muhir Aklil. According to the Pakistan environmental quality standard and Food and agriculture organization (FAO), the permissible pH values for irrigation water for growing vegetables are 6 - 10 and 6.5 – 8.4 respectively.

The pH of the analyzed water were within NEQS limits and pH was also within the Food and Agriculture Organization (FAO) guidelines (Ayers and Westcot, 1985) for the quality of irrigation water. The electrical conductivity for water samples was also analyzed and values were ranged from 0.41 to 0.76 mhos (table 3.2) which are present in the normal range. The total hardness is the total soluble magnesium and calcium salts present in the water expressed as $CaCO_3$. In most natural water, the predominant ions are those of bicarbonates associated mainly with calcium to lesser degree with magnesium. Total hardness in determined water samples lie between 88 and 166 mg/l. It was below the permissible limit of 170 mg/l. Total dissolved solids (TDS) and total suspended solids (TSS) values were well within the permissible limits of NEQS (15) and FAO (Ayers and Westcot, 1985).

Distribution pattern of heavy metals in onion samples

Onions are used for common human nutrition. Some vegetables are consumed as leaf like kale, cabbage whereas other are used as fruit or root like onion and tomato. Even though consumption of these vegetables is good for our health but they may accumulate toxic heavy metal which cause adverse health effects. Metal uptake from the soil solution is done in three major ways root interception, mass flow and diffusion (Ronan, 2007). The availability of mineral in plant depend on soil pH, cation exchange capacity, organic matter content, types and varieties of plants, and nature of the plant (Jung, 2008). The uptake of heavy metal by vegetables is not only affected by plant species and physicochemical characteristics of soil but temperature and rain fall also exert substantial effect (Ajmal *et al*., 2013). The distribution pattern for heavy metals in tomato samples in different sampling areas is discussed below. The mean concentrations of heavy metals found in the analyzed onion samples are summarized in table 3.3. Zinc was present in all onion samples studied (table 3.3). It had a concentration ranging from 11.55 to 24.91 mg/kg with the lowest value of 11.55 mg/kg at Muhir Aklil woreda and the highest value of 24.91 mg/kg at Cheha woreda. Copper was detected in all sampling areas except at Muhir Aklil woreda. With the lowest value of 0.4 mg/kg at Mareko woreda and highest value of 6.63 mg/kg at however it was not detected at Muhir Aklil woreda. Manganese was recorded in all tomato samples ranging from 12.23 mg/kg to 49.22 mg/kg.

The highest value of Mn was detected in onion sample obtained from Cheha woreda while lowest value was present at Muhir Aklil. Chromium was present in all sampling areas except at Sodo woreda. With the highest value of 54.57 mg/kg was recorded at Meskan woreda and lowest value of 2.1 mg/kg was obtained from Mareko. However, Cr was not detected at Sodo woreda. The very toxic heavy metals such as cadmium and lead were not detected (below detection limit) in all onion samples obtained from five sampling areas. Nickel was detected in all onion samples ranging from 0.87 to 8.45 mg/kg. The minimum value of Ni was recorded at Muhir Aklil while the maximum concentration of Ni was present at Cheha. The concentrations of Zn, Cu, Mn, Cd, Pb and Ni present in all onion samples were below the recommended values as specified by different standards viz. WHO/EU (1983), FAO/WHO (2001), CMH (2005), WHO (2007), (FAO/WHO (2001), Joint Codex Alimentarius Commission). Therefore, the consumption of onion grown in this zone had no health hazard.

Distribution pattern of heavy metals in water samples

In all water samples, heavy metals were below method detection limit (ND).

Statistical analysis

It is also important to compare these toxic agents available in different samples statistically to know whether they differ significantly or not.

Table 3.6. One way-ANOVA for comparison of heavy metals in onion at 95% CL

	Mean (SD)					F-test		Remark
Heavy etals	Meskan	Mareko	Sodo	Muhir	Cheha	F-calculated	F-critical	
Zn	29.38(0.14)	17.23(0.2)7	11.9(0.85)	18.5(1.30)	6.5(0.56)	387.5	3.478	Significant difference
Cu	7.02(0.40)	ND	ND	ND	3.3(0.36)	-	-	-
Mn	30.7(0.57)	16.23(0.15)	17.53(0.47)	14.83(0.45)	46.77(1.35)	1063.9	3.478	Significant difference
Cr	3.5(0.26)	8.93(0.42)	16.33(0.72)	14.4(0.76)	ND	298.1	4.066	Significant difference
Cd	ND	ND	ND	ND	ND	-	-	-
Pb	ND	ND	ND	ND	ND	-	-	-
Ni	3.05(0.40)	1.43(0.15)	1.8(0.26)	ND	6.43(0.35)	259.2	4.066	Significant difference

Table 3.7: Comparison of mean concentration of determined heavy metals concentration (mg/kg, DW) in some selected vegetables with literature values

Vegetable	Parameter	Current value (mg/kg)	Reported value (mg/kg)	Country	Ref.
Onion	Cu	ND - 6.63±0.32	7.19	Tanzania	[20]
			2.2 - 7.8	India	[21]
	Mn	12.23±0.45 - 49.22±2.17	1.68±2.72	Nigeria	[22]
	Cr	ND - 54.57±2.07	20.4	Tanzania	[20]
			1.31 ± 0.89	Ethiopia	[23]
			1.51±0.9	Nigeria	[22]
	Cd	ND	0.09	Tanzania	[20]
			1.0 - 3.3	India	[21]
			1.38 ± 1.07	Ethiopia	[23]
	Pb	ND	1.6 - 2.4	India	[21]
			0.37 ± 0.14	Ethiopia	[23]
			1.11±0.8	Nigeria	[22]
	Ni	0.87±0.090 - 8.45±0.83	3.28±1.76	Nigeria	[22]

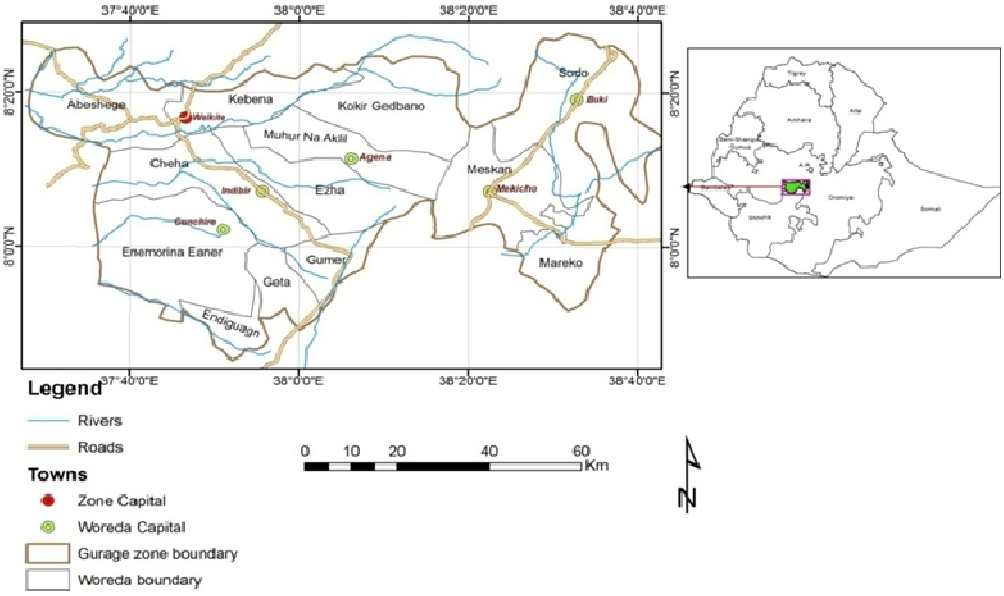

Figure 2.1. Map of the study areas (adapted from Abate, *et al.*, 2011)

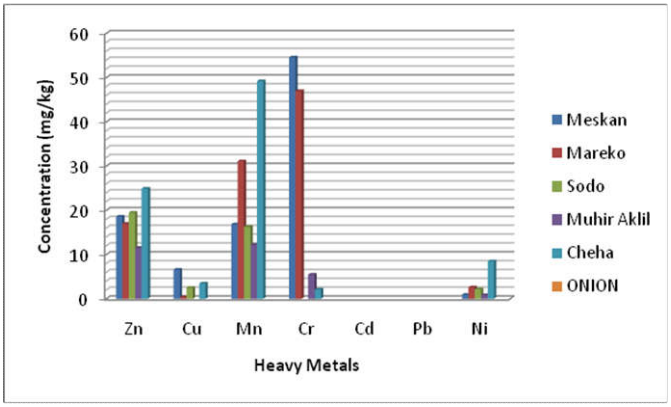

Figure 3.1: Concentration of heavy metals in onion samples from different Woredas

In this study, we had compared samples for their heavy metal levels obtained from different sampling areas and mean concentrations of heavy metals among vegetables were also compared. Statistical values for one way ANOVA analysis are listed from table 3.6. It was revealed from the one way ANOVA results as presented in table 3.6 that onion samples have heavy metal concentrations (except Cd and Pb) which showed a significant difference among the sampling areas.

Comparison of levels of heavy metals of this study with literature values

From the above table, which the concentrations of the heavy metals analyzed in this study, are, in most cases, there were difference in the range of the reported values, the difference in concentration of metals determined in the present study may be due to the nature of vegetables studied and differences in nature of soil or it may be due differences climatic condition and geography. The onion samples investigated for their heavy metal levels were compared with reported values. The levels of Cu determined in this study were comparable with the values reported in Tanzania (Lugwisha and Othman, 2016) and India (Kailas, 2013). However, the concentration of Manganese reported in the current finding is lower than the value reported in Nigeria (Udiba *et al*., 2015).

Conclusion and recommendations

Conclusion

The level of heavy metals in vegetables (onions) cultivated in some selected woredas of Gurage zone along with the water used for irrigation were determined by flame atomic absorption spectrometer. All samples were subjected to digestion with optimized procedures prior to their heavy metals determinations. Water samples were also investigated for their some physico-chemical properties. From the results of the analysis, the pH value for water samples lie in between 7.1 to 8.2 and conductivity varied from 0.41 – 0.76. Total suspended solid (mg/L), total dissolved solid (mg/L) and total hardness (mg/L) present in water samples were varied from 280 – 362, 165 – 230 and 88 – 166 respectively. From different standards, all soil and water physical and chemical parameters are within the normal range. Therefore, application of the ground water for agricultural purposes in these areas were found favourable.
In this study, all heavy metals were not found (below method detection limit) in water samples. However, levels of heavy metals in onion samples were found in appreciable amount. Concentrations of zinc (mg/kg) in onion was 11.55 – 24 mg/kg. While the concentration of manganese (mg/kg) in onion was 12.23 - 49.22 mg/kg. ND - 6.63 mg/kg of Cu was found in onion samples. Similarly the concentrations of Cr found in onion was ND – 54.57 mg/kg. 0.87 - 8.45 mg/kg of Ni was detected in onion samples. The level of heavy metals in onion samples determined in this study could be put in the following order Mn > Zn > Cr > Ni > Cu. However, Cd and Pb were not detected in onion samples. The concentrations of heavy metals in onions were found below the permissible limit prescribed by different standards. However, the amount of Cr determined in onion was found above allowable limit recommended by WHO.

Recommendations

Though the levels of heavy metals in vegetables lower than the accepted values in most international standards, high consumption of vegetables in the area results the following recommendations:

- Decision makers must formulate relevant agricultural policies encompassing education and training of farmers to make them understand the effects of these heavy metals on human health and the importance of nutrient management.
- Continuous monitoring of soil, plant and water quality together with prevention of metals entering vegetables is a prerequisite in order to prevent potential health hazards to human beings.

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