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EVALUATION OF HEAVY METAL CONCENTRATION IN BARI TOMATO-5 AND ALSO IN ASSOCIATED WITH IRRIGATION WATER AND SOIL OF SHARIAKANDI UPAZILLA IN BOGRA DISTRICT, BANGLADESH

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ABSTRACT

In this study, soil, water and different plant parts and fruits of tomato (Lycopersicon esculentum Miller) were collected from three different places of Shariakandi Upazilla in Bogra district. The samples water and soil were used to analyze p^H, Electric Conductivity (EC) and Total Dissolved Solid (TDS)/ Organic Matter (OM) and also following heavy metals as like cadmium; chromium, copper, iron, nickel, lead and zinc concentrations by using atomic absorption spectrophotometer (AAS) (Varian Spectra AA55B, Australia). But in case of tomato plant parts and fruits were analyzed to identify the amounts of above described heavy metals. In accordance with the results, the lowest and highest heavy metal accumulations measured in fruits were as follows; cadmium (0.03-0.07 mg kg^{-1}), chromium (0.21-1.35 mg kg^{-1}), copper (13.34-13.35 mg kg^{-1}), iron (61.12-65.10 mg kg^{-1}), nickel (0.68-2.79 mg kg^{-1}), lead (0.16-0.28 mg kg^{-1}) and zinc (11.86-24.16 mg kg^{-1}). As a result, the relative abundance of heavy metals in ripen tomato samples were observed as iron>zinc>copper>chromium >nickel >lead>cadmium. This study, it can be said that ripen tomato fruits reflect heavy metal amounts well in polluted areas such as excess use of several agro chemicals, uses, urban and industrial area when compared to unpolluted (control) areas.

Keywords: *Toxic Metals, Electrical Conductivity, Total Dissolved Solid, Metal Pollution Index, Health Risk Index.*

INTRODUCTION

Tomato belongs to solanaceae family is one of the world's most cultivated vegetables with a worldwide production of 129.65 million tons.

In the mid-1500s, Spanish conquistadors carried tomato seeds to Europe and it was later introduced from Europe to southern and eastern Asia, Africa and the Middle East (Bassey *et al*., 2014)

Tomato fruits are usually eaten whole in salads, cooked in sauces, soup and meat, fish dishes or consumed as paste and catsup (Manohara *et al.,* 2014) (Naser *et al.,* 2009). It contains many nutrients, anti-oxidants and secondary metabolites such as vitamins C and E, b-carotene, lycopene, flavonoids, organic acids, phenolics and chlorophyll, which are important for human health (Naser *et al.,* 2009; Siddiqui, 2010).

Nevertheless, metals most often found as contaminants in vegetables include As, Cd and Pb. These metals can pose as a significant health risk to humans, when they reach high concentrations in the body (Othman, 2001), (Kilimia, 2001). This can be expressed in the inhibition or activation of certain enzyme processes affecting their productivity from both qualitative and quantitative aspects (Mwijage, 2002). Contamination of the soil by heavy metals is often a direct or indirect consequence of anthropogenic activities (Chove, *et al.,* 2006). Sources of anthropogenic metal contamination in soils include - urban and industrial wastes; mining and smelting of non-ferrous metals and metallurgical industries (Kilimia *et al.,* 2001; Kibassa *et al.,* 2013). Additionally, one of the main sources of air pollution in urban areas is traffic, industry and fossil fuel burning for heating purposes (Akinola *et al.,* 2008). Food and vegetable crops production requires assess to fertile land, water and in some cases fertilizers, particularly in poor and developing countries of the world. Thus, it requires all the necessary inputs it deserves to realize this goal (Kothari *et al.,* 2004).

In this study, tomato fruits (Lycopersicon esculentum Miller) were collected from three different station of Shariakandi Upazilla in Bogra district. Samples were used to analyze cadmium, chromium, copper, iron, nickel, lead and zinc concentrations by using atomic absorption spectrophotometer (AAS) (Varian Spectra AA55B, Australia) to determine heavy metal levels in different station of selected area.

METHOD AND MATERIALS

Determination of physical and chemical properties in irrigation water

The pH value of water samples was calculated by taking 90 ml of water in 100 mL beaker and immersing the electrode of pH meter (Model-WTW pH 522) into samples as revealed by Singh *et al.* (1999).

To calculate electrical conductivity of water, 90 mL of the accumulated samples was taken in a beaker. EC of the samples was calculated with the help of EC meter (Model-D. 6072 Dreieich, West Germany) following the technique as drawn by Ghosh *et al*. (1983) and Singh *et al*. (1999).

To calculate total dissolved solids of water, 90 ml of the accumulated samples was taken in a beaker. TDS of the samples was calculated with the help of TDS meter (Model-HACH sens IONTM + EC5, USA).

Determination of heavy metals in irrigation water

Determination of several heavy metals in water samples was done by using an atomic absorption spectrophotometer (AAS) (Varian Spectra AA55B, Australia). Mono component hollow cathode lamp was employed for the determination of each heavy metal of interest. At first, the AAS was calibrated following the manufacturer's commendation. The filtered water sample was run openly for the determination of heavy metal in water samples. A standard curve was ready by plotting the absorbance reading on Y-axis versus the concentration of each standard solution of metal on X-axis. Then, the concentration of metal in the water samples of interest was calculated by plotting the AAS reading on the standard line.

Determination of physical and chemical properties in soil

Soil pH was determined by glass electrode pH meter (WTW pH 522; Germany) as explained by Jackson (1962). Twenty (20) grams of air dried soil from each sampling site was taken in 200 mL beakers separately and 100 mL of distilled water was added to each beaker. The suspension was stirred well for 30 minutes and allowed to stand for about 30 minutes. Then each sample was stirred for 2 minutes before reading. The position of the electrode was adjusted in the clamp of the electrode holder. Then the electrode was immersed into the partly settled soil suspension and pH was measured. The result was reported as soil pH measured in water (soil: water ratio being 1:2.5).

The electrical Conductivity was measured by conductivity meter (Model D.6072 Dreieich, West Germany) as explained by Anderson and Ingram (1996) in 1:5 of soil water suspension.

Determination of Organic Matter

The amount of organic matter in soil samples was calculated by multiplying the content of organic carbon by Van Bemmelen factor, 1.73 (Piper, 1950).

% Organic matter = % OC x 1.73

Determination of heavy metals in soil

The concentrations of heavy metals in soil samples were determined at the soil science laboratory of the Bangladesh Agricultural Research Institute (BARI), Joydebpur. For the determination of total metal concentration, exactly 1.00 g of powdered soil sample was digested with aquaregia (HNO_3: HCl = 1:3). Then the content was evaporated to dryness and again 5 ml aquaregia was added. This process was repeated 2-3 times for efficient extraction of metals. Then the digest was filtered through a filter paper (Whatman no. 42) and the filtrate volume was made to 25 mL with HNO_3. The determination of different heavy metals in soil samples was done by using an atomic absorption spectrophotometer (AAS) (Varian Spectra AA55B, Australia). Mono element hollow cathode lamp was employed for the determination of each heavy metal of interest. At first the AAS was calibrated followed by the manufacturer's recommendation. Then the soil extract was diluted (if required) and/or run directly in AAS for the determination of heavy metal in the sample. A standard curve was prepared by plotting the absorbance reading on Y-axis versus the concentration of each standard solution of metal on X-axis. Then, the concentration of metal was calculated in the soil samples of interest by plotting the AAS reading on the standard curve.

Analysis of plant parts and fruits (BARI tomato-3) samples

The plant parts and fruits of BARI tomato-3 samples were collected from Shariakandi Upazilla in Bogra district. Samples were collected at the stage of harvest by farmers. The growth stage for tomato sample was more or less same. The samples of different plant parts and fruits (green, ripen) were put into the individual polythene bag with definite marking and tagging and brought to the central laboratory of BARI. In the laboratory, the collected samples were cut into small pieces and air-dried. The dried samples were then oven dried at 65 °C for 48 hour. The samples were then ground using grinder machine and stored in plastic containers in the desiccators.

Determination of heavy metals in tomato plants and fruits

For the determination of total metal concentration, exactly 1.00 g of powdered sample was digested with aquaregia (HNO_3: HCl = 1:3). Then the content was evaporated to dryness and again 5 mL aquaregia was added. This process was repeated 2-3 times for efficient extraction of metals. Then the digest was filtered through a filter paper (Whatman no. 42) and the filtrate volume was made to 25 mL with HNO_3. The determination of different heavy metals in prepared sub samples was done by using an atomic absorption spectrophotometer (AAS) (Varian Spectra AA55B, Australia). Mono element hollow cathode lamp was employed for the determination of each heavy metal of interest. At first the AAS was calibrated followed by the manufacturer's recommendation. Then the soil extract was diluted (if required) and/or run directly in AAS for the determination of heavy metal in the sample. A standard curve was prepared by plotting the absorbance reading on Y-axis versus the concentration of each standard solution of metal on X-axis. Then, the concentration of metal was calculated in the soil samples of interest by plotting the AAS reading on the standard curve.

Shariakandi Upazilla in Bogra district was selected for samples collection (irrigation water, soil and plant materials). Physical and chemical properties of irrigation water and soil were measured following the above mentioned procedures. Heavy metal concentration in different samples of irrigation water, soil and tomato (plant root, shoot, leaf, green tomato and ripen tomato) were measured by atomic absorption spectrophotometer (AAS) (Varian Spectra AA55B, Australia).

RESULT AND DISCUSSION

Common properties and heavy metal concentration in irrigation water and soil

The considered irrigation water samples were assembled from experimental area of Savar Upazilla sadar industrial area in Dhaka district (Table 1). The samples contained different levels of p^H value, EC (Electrical Conductivity) and TDS (Total Dissolved Solid) value. Result showing that the average value of pH, EC and TDS from three water samples were analyzed 7.09, 908 µ cm^{-1} and 582 mg L^{-1} respectively. And the average level (mg L^{-1}) of heavy metal (Cd, Cr, Cu, Fe, Ni, Pb and Zn) concentration in irrigation water were 0.00 mg L^{-1}, 0.08 mg L^{-1}, 0.53 mg L^{-1}, 4.86 mg L^{-1}, 0.01 mg L^{-1}, 0.22 mg L^{-1} and 0.30 mg L^{-1}. On the other hand, the studied soil samples of Shariakandi Upazilla in Bogra district were summarized in (Table 1.) and also revealed that the average value of p^H, EC and OM were 7.92, 487 µ cm^{-1} and 260 (mg kg^{-1}) respectively from three collected samples. Also, the heavy metal concentration of soil (mg kg^{-1}) of tomato growing field were analyzed regarding Cd, Cr, Cu, Fe, Ni, Pb and Zn (Table 1.). The average value of heavy metal in the order of Cd, Cr, Cu, Fe, Ni, Pb and Zn were 0.48 mg kg^{-1}, 2.41 mg kg^{-1}, 10.23 mg kg^{-1}, 44.25 mg kg^{-1}, 1.69 mg kg^{-1}, 5.23 mg $kg^{-1}$and 1.97 mg kg^{-1} respectively.

In the different experimental areas of Shariakandi Upazilla in Bogra district of Bangladesh, the heavy metals concentration of Cd, Cr, Cu, Fe, Ni, Pd and Zn was bellow than permissible level in maximum parameter. But in case of some parameter heavy metal status in rare high than standard level. Permissible limit of different heavy metals was determined by different scientists and organizations. So, all collected irrigation water samples and soil samples from selected areas of Bangladesh are not problematic for human health and environmental issues.

Heavy metal concentration

The collected samples of tomato fruits or plant parts from Shariakandi Upazilla in Bogra district contained different heavy metals at several concentration (Table 2). The average value of selected heavy metals *viz*. Cd, Cr, Cu, Fe, Ni, Pb and Zn were 0.07 mg kg^{-1}, 0.93 mg kg^{-1}, 13.45 mg kg^{-1}, 64.15 mg kg^{-1}, 0.68 mg kg^{-1}, 0.18 mg kg^{-1} and 22.98 mg kg^{-1}respectively which were ranged from 0.03-0.07 mg kg^{-1}, 0.21-1.35 mg kg^{-1}, 13.34-13.35 mg kg^{-1}, 61.12-65.10 mg kg^{-1}, 0.68-2.79 mg kg^{-1}, 0.16-0.28 mg kg^{-1} and 11.86-24.16 $mgkg^{-1}$ respectively. It was found that the highest value of Cr (1.35 $mgkg^{-1}$) and Ni (2.79 $mgkg^{-1}$) were found in Plant root but highest Cd (0.07 mg kg^{-1}) and Cu (13.35 mg kg^{-1}) were found in Ripen Tomato where highest Fe (65.10 mg kg^{-1}), Pb (0.28 mg kg^{-1}) and Zn (24.16 mg kg^{-1}) were found in Plant Shoot, Leaf and Green Tomato respectively. On the other hand, the lowest heavy metals status of Cd, Pb and Zn (0.03 mg kg^{-1}, 0.16 mg kg^{-1} and 11.86 mg kg^{-1} respectively) were found in Plant root but lowest Cu (13.34 mg kg^{-1}) and Fe (61.12 mg kg^{-1}) were found in Leaf. The lowest Cr (0.21 mg kg^{-1}) and Ni (0.68mg kg^{-1}) were found in Green Tomato and Ripen Tomato respectively.

Table 1. Common (physical and chemical) properties and heavy metal concentration of irrigation water and soil samples collected from different locations of Shariakandi Upazilla in Bogra district

Sample's Value & Reference's Value		Common properties of irrigation water and soil samples			Heavy metal concentrations in irrigation water and soil samples (mg L^{-1}/ mg kg^{-1})						
		pH	**EC** (µ cm^{-1})	**TDS** (mg L^{-1})/OM ($mgkg^{-1}$)	**Cd**	**Cr**	**Cu**	**Fe**	**Ni**	**Pb**	**Zn**
Value of Water sample		**7.09**	**908**	**582**	**0.00**	**0.08**	**0.53**	**4.86**	**0.01**	**0.22**	**0.30**
Reference Value	Everett Wilson & Carl Solomon	0	0	0	0	0	1.0	0	0	0.1	0.5
	DoE (1997), Standard	6.5-8.5	350	1000	0.005	0.05	0	0.3-1.0	0.1	0.05	5.0
	WHO (1993), guideline	0	0	0	0.003	0.05	0	0	0.02	0.01	3.0
	USEPA (2008), guideline	0	0	0	0.005	0.1	0	0.3	0	0	5.0
Value of Soil sample		**7.92**	**487**	**260**	**0.48**	**2.41**	**10.23**	**44.25**	**1.69**	**5.23**	**1.97**
Reference Value	Kabata & Pendis (1992)	0	0	0	0	0	100.0	0	0	0	0
	WHO (2004), SQG	0	0	0	6.0	25.0	0	0	20.0	0	123.0
	USEPA (1999), SQG	0	0	0	0.6	25.0	0	30.0	16.0	30.0	110.0
	CCME (1999), SQG	0	0	0	0.06	37.0	0	0	0	0	123.0

Table 2. Concentration of heavy metal (mg kg^{-1}) in BARI tomato-5 at Shariakandi Upazilla in Bogra district

Sample of plant parts and fruit	**Concentration of heavy metal (mg kg^{-1}) in BARI tomato-5 at Shariakandi Upazilla in Bogra district.**						
	Cd	**Cr**	**Cu**	**Fe**	**Ni**	**Pb**	**Zn**
Plant root	0.03	1.35	12.23	64.22	2.79	0.16	11.86
Plant Shoot	0.04	0.66	11.56	65.10	1.48	0.26	21.76
Leaf	0.05	0.77	13.34	61.12	1.76	0.28	21.44
Green Tomato	0.06	0.21	12.45	64.45	2.22	0.17	24.16
Ripen Tomato	0.07	0.93	13.35	64.15	0.68	0.18	22.98
Range	**0.03-0.07**	**0.21-1.35**	**13.34-13.35**	**61.12-65.10**	**0.68-2.79**	**0.16-0.28**	**11.86-24.16**
Mean	0.07	0.93	13.45	64.15	0.68	0.18	22.98
Max.	0.07	1.35	13.35	65.10	2.79	0.28	24.16
Min.	0.04	0.22	13.34	61.12	0.68	0.16	11.86
WHO (1985), *	0.06	0	0.1	0	0	0.1	15.00
FAO (1985), **	0.01	0	0.20	5.00	0.20	5.00	2.00
J E P *** (2016-2017)	1.79	0.8	2.66	14.00	0	1.17	41.00

Considering the present status of selected heavy metals (Cd, Cr, Cu, Fe, Ni, Pd and Zn) in tomato fruits or plant parts collected from Shariakandi Upazilla in Bogra district of Bangladesh is not so much harmful to human body because of the heavy metals levels in plant parts & fruits were lower limit than toxicity level. Allowable limit of heavy metals in tomato were measured by WHO, FAO and/or Health risk index of metals referred by Journal of Environmental Protection. According to Health risk index (2016-2017), allowable limit of heavy metals in tomato regarding Cd, Cr, Cu, Fe, Pb and Zn are 0.1, 0.8, 26.6, 425, 0.2 and 100 mg kg^{-1} respectively. So it is definitely stated that the heavy metal limit of tomato fruits from selected areas of Bangladesh is not harmful for health.

CONCLUSION

Considering the analyzed experimental samples of irrigation water, soil and different parts of tomato plant and fruit it was observed that the heavy metal status is very high or equal with standard value of national or international scientist or organization. But in case of some irrigation and soil sample in some heavy metal was poor high but in tomato plant part and fruit contained lower status than standard level. To reduce the pollutant in fresh tomatoes there should be improvement in our cultivation practices, water and soil pollution in agricultural field and maintenances agro chemical uses.

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