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Effect of Sewage Water Irrigation on Micronutrient and Toxic Metal Contents in Plants

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ABSTRACT

A survey was conducted in Kaithal, Kurukshetra, Karnal, panipat and Faridabad cities of South-Eastern State, from where plant samples of different vegetables, forage and field crops collected from sewer water irrigated field and analyzed for micronutrient and toxic metal contents in plants at Department of Soil Science, CCS Haryana Agricultural University, Hisar. It was observed from the data that the copper concentration in different plant samples varied from 7.0—70.3 mg kg^{-1} and 7.5-63.5 mg kg^{-1} whereas iron content ranged from 90.0-1049.0 mg kg^{-1} and 464.0-1287.0 mg kg^{-1} in shoots and roots, respectively. Zinc concentration ranged from 6.0–140.3 mg kg^{-1} and 32.5-199.9 mg kg^{-1} whereas manganese content ranged from 0.4-3.9 mg kg^{-1} and 0.5-10.4 mg kg^{-1} in shoots and roots, respectively. It was also observed that the concentration of heavy metals except cd and Pb in sewage water irrigated plant samples were lower than maximum phytotoxicity limit in plants (20-100, 150-200,>500,>500, >0.8, >20, >50 and >10 mg kg^{-1} for Cu, Zn, Fe, Mn, Cd, Pb, Ni and Cr, respectively). The concentration of the micronutrients except Cu and all the toxic metals were found to be more in roots than in shoots.

Keywords Vegetables, Forage, Field crops, Micronutrient, Toxic metal.

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INTRODUCTION

Agricultural lands particularly near urban areas are irrigated with industrial, city or municipal waste water due to low availability of fresh water, Undemanding accessibility and discarding problems of waste water. In general, this resource contains substantial amounts of beneficial nutrients and toxic pollutants, which are creating opportunities and problems for agricultural production, respectively (Alghobar and suresha 2017). Heavy metals are injurious to humans and animals due to their solubility inwater, non-biodegradable nature and their potential to build up in various body parts. These are even toxic and detrimental to humans at very low concentrations as there is no proper route for their removal from the body. Waste water contains large quantity of metals such as lead (Pb), nickel (Ni), iron (Fe) copper (Cu), cadmium (Cd), chromium (Cr) (Zn) (Nazir et al.

2015). On the other hand, soils irrigated with waste water beneficial for farmers as these have enhanced organic matter content and essential plant nutrients as compared to fresh water irrigated soils and impart to lessen the expenditures of fertilizers (Rai et al.2011) mainly in soils situated near industries and peri-urban areas. This issue needs special attentin, When agricultural lands are continuously irrigated with untreated sewage water for longer times to cultivate crops/ vegetables. Heavy metal bioaccumulation in the food chain can be highly dangerous to human health (Dadar 2016). Under wheat crop, sewage irrigation for four decades resulted into a significant building of zinc (1241%), copper (2195), irron (514%) nickel (75.0%), and lead (28.1%) in sewage-irrigated soils adjacent tube water-irrigated ones (Meena et al. 20160. Concentration of heavy metals in sugar beet plant grown on industrial effluent was higher as compared to their tolerance level indicating their accumulation in plants (Rajput et al. 2017). Thus, the survey was conducted tostudy the effect of sewage water irrigation on micronutrient and toxic metal contents in plants primarily to quantify the concentration of metals in irrigation waste water crops/vegetables cultivated in Kaithal, Kurukshetra, Karnal, Panipat and Faridabad cities of South-Eastern Haryana State.

MATERIALS AND METHODS

Plant samples of different vegetables, forage and field crops were collected from sewer water irrigated field of Kaithal, Kurukshetra, Karnal, Panipat and Faridabad cities of Haryana State. The plant samples collected were first washed with tap water to remove the adhering soil particles, followed by acidifiedde-ionized water and then with double distilled water. The excess water was removed by gentle shaking and pressing against the filter paper. The washed plant samples were first air dried and then put in the paper bags and placed it in an air draft oven at 65 ±2^{o}C to a constant weight. Thereafter, the shoots and roots were separated and ground in a stainless steel grinder and stored in small paper bags for laboratory analysis. In order to determine themicronutrients and heavy metals viz. Cu, Zn, Fe, Mn, Cd, Pb, Ni and Cr in plant parts parts (shoot and root), 0.5 g of ground and well mixed material was digsted in a diacid mixture of nitric acid and perchloric acid (4 : 1). After digestion the volume was made to 50 ml with distilled water, filtered and stored in well washed plastic bottles. The Cu, Zn, Fe, Mn, Cd, Pb, Ni and Cr were estimated from the aliquot by using the Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Micronutrient concentration

The data presented in Table 1 showed that the copper concentration in different plant samples collected from Kaithal, Kurukshetra, Karnal, Panipat and

Table 1. Effect of sewage water irrigation on micronutrients and toxic metals contents (mg kg^{-1}) in different field crops.

Crop		Kaithal							
	Parts	Cu	Zn	Fe	Mn	Cd	Pb	Ni	Cr
Okra	Shoot	46.3	106.5	830	44.6	7.0	19.8	3.2	1.9
(*Ablemoschus esculantus*)	Root	24.8	106.8	565	92.7	5.5	26.0	3.6	3.8
Bitter gourd	Shoot	34.8	45.5	571	19.9	4.0	17.1	3.6	ND
(*Momordica charantia*)	Root	10.3	129.9	542	73.1	8.5	22.1	6.4	1.6
Mint	Shoot	69.3	53.5	850	70.4	4.0	14.5	5.5	3.7
(*Montha arvensis*)	Root	39.8	150.0	1191	110.8	5.0	20.3	8.3	6.6
Chilli	Shoot	17.3	116.5	745	53.3	5.0	12.6	3.7	0.5
(*Capsium annum*)	Root	54.3	121.9	1189	100.6	8.0	25.2	10.5	8.7
Spinach	Shoot	35.8	63.0	970	54.9	6.0	16.9	5.8	3.2
(*Beta vulgaris*)	Root	34.3	58.0	970	96.6	6.5	18.9	7.0	1.9
Jowar	Shoot	23.3	140.3	644	51.0	5.0	22.2	4.7	0.9
(*Sorghum bicolo*r)	Root	39.8	128.9	1252	120.8	5.0	26.1	10.8	3.8
Coriander	Shoot	35.8	66.0	552	18.7	3.5	17.3	3.7	0.4
(*Coriandrum sativum* L.)	Root	12.8	85.5	967	66.3	5.0	22.4	6.5	3.0

Table 1. Continuted.

Crop	Parts	Cu	Zn	Fe	Mn	Cd	Pb	Ni	Cr
Tomato	Shoot	30.3	39.5	749	30.9	4.0	21.3	5.5	ND
(*Lycopersicon esculantum*)	Root	28.3	44.5	895	74.8	6.0	22.8	5.7	1.9
Bottle gourd	Shoot	42.3	42.5	632	37.1	3.5	19.0	2.8	1.3
(*Lagenaria siceraria*)	Root	22.8	107.6	1136	112.3	6.0	25.8	8.2	4.4
Brinjal	Shoot	30.8	98.5	1049	76.0	5.5	68.9	7.2	3.9
(*Solanum melongena*)	Root	15.3	103.5	1103	115.9	7.0	26.3	6.6	2.7
Long melon	Shoot	24.8	50.0	668	40.3	5.0	15.2	5.1	0.7
(*Cucumis ujillimus*)	Root	21.8	50.5	901	80.3	5.0	15.9	5.5	4.8
			Kurukshetra						
Chilli	Shoot	22.7	76.0	389	57.7	5.5	21.6	5.5	ND
(*Capsium annum*)	Root	24.8	55.5	849	133.8	4.5	14.2	3.5	3.4
Kidney bean	Shoot	29.3	124.9	299	25.3	4.5	21.9	3.7	ND
(*Phaseolus vulgaris* L.)	Root	32.8	69.0	1037	31.6	5.0	12.0	3.4	1.3
Tomato	Shoot	70.3	38.0	831	29.2	6.5	16.4	5.4	2.6
(*Lycopersicon esculantu*m)	Root	29.3	199.9	1127	67.1	9.0	13.3	8.1	4.3
Onion	Shoot	15.3	137.5	879	52.3	4.5	19.9	4.9	ND
(*Allium cepa*)	Root	35.8	113.2	925	88.7	6.0	60.9	6.2	2.5
Barseem	Shoot	16.3	103.8	647	42.8	5.5	12.7	5.0	0.8
(*Alxandrum trifolium*)	Root	30.2	154.9	1284	288.7	7.0	39.1	12.9	10.4
Bitter gorud	Shoot	23.8	69.0	808	53.5	7.0	28.5	5.0	1.1
(*Momordica charantia*)	Root	11.3	1145	1094	169.6	18.0	32.3	7.8	4.0
			Karnal						
Chilli	Shoot	28.8	62.0	1027	83.6	6.5	27.4	6.2	3.9
(*Capsium annum*)	Root	26.3	103.5	1065	121.4	6.0	31.5	6.4	7.7
Barseen	Shoot	32.8	103.5	1040	89.9	6.0	21.6	8.1	2.2
(*Alexandrum trifolium*)	Root	30.3	149.3	1266	229.8	7.0	39.8	12.8	8.2
Jowar	Shoot	34.8	38.0	867	34.5	4.0	6.5	3.6	3.5
(*Sorghum bicolor*)	Root	14.3	73.5	1227	91.6	5.0	15.2	7.7	2.9
Bottle gourd	Shoot	9.3	46.5	1052	55.1	5.5	23.3	7.7	2.8
(*Lagenaria siceraria*)	Root	27.3	50.5	1093	110.5	4.5	15.1	6.8	6.2
Tomato	Shoot	28.3	42.0	857	54.2	6.0	18.8	6.9	3.8
(*Lycopersicon esculantum*)	Root	8.3	93.0	1055	69.4	6.0	26.6	6.7	4.1
Ridge gourd	Shoot	45.8	88.5	1078	96.6	6.0	19.0	8.8	2.8
(*Luffa acutangula*)	Root	37.8	136.2	1287	104.2	8.5	24.9	22.4	8.2
			Panipat						
Water Melon	Shoot	11.8	45.0	238	41.4	2.5	9.4	3.4	ND
Citrullus vulgaris	Root	25.8	64.5	1084	116.3	6.5	13.6	8.7	3.3
Ridge Gourd	Shoot	19.5	65.5	462	32.6	5.5	12.0	1.9	0.6
Luffa acutangula	Root	13.5	46.5	879	129.0	7.0	29.0	7.7	4.5
Onion	Shoot	12.0	24.0	457	36.0	5.5	14.4	6.9	ND
Allium cepa	Root	7.5	32.5	606	59.8	6.0	18.0	5.5	0.8
Round Melon	Shoot	17.0	56.5	638	38.9	7.5	24.7	8.3	0.4
(*Citrullus vulgaris* var. *Fistilosus)*	Root	18.5	96.5	640	87.5	5.5	17.0	6.3	0.9
Cauliflower	Shoot	7.0	49.0	306	43.6	6.0	16.3	4.7	ND
Brassica oleracea var. *botrysis*	Root	13.5	59.5	555	40.0	6.0	14.3	5.1	2.2
			Faridabad						
Okra	Shoot	1.2	6.0	90	24.8	3.0	4.9	1.8	ND
(*Ablemoschus esulantus*)	Root	14.0	37.0	464	73.1	6.5	16.2	7.6	0.5

Table 1. Continued.

Crop	Parts	Cu	Zn	Fe	Mn	Cd	Pb	Ni	Cr
Jowar	Shoot	14.0	39.5	427	76.0	6.0	19.6	5.7	ND
(*Sorghum bicol*or)	Root	17.5	99.0	1096	92.3	5.5	15.5	6.7	1.0
Brinjal	Shoot	25.0	53.0	719	49.6	6.5	17.4	5.6	0.5
(*Solanum melongena*)	Root	63.5	77.0	1039	79.8	6.5	22.6	9.7	2.8
Mint	Shoot	12.5	106.9	480	48.7	5.5	15.5	5.3	ND
(*Montha arvensis*)	Root	15.0	104.5	966	42.7	6.0	14.8	9.5	3.2
Spinach	Shoot	16.5	46.0	681	106.9	6.5	17.1	9.6	0.3
(*Beta vulgaris*)	Root	26.0	50.5	786	136.0	6.5	14.5	9.0	1.6

Faridabad citries receiving sewage water irrigation varied 7.0-70.3 mg kg^{-1} and 7.5-63.5 mg kg^{-1} in shoots and roots respectively. The concentration of Cu in shoot samples was maximum (70.3 mg kg^{-1}) in tomato (*Lycopersicon esculantum*) and minimum (7.0 mg kg^{-1}) was found in cauliflower (*Brassica oleracea* var. *botrytis*) While, in case of root samples the Cu concentration was maximum (63.4 mg kg^{-1}) in brinjal (*Solamum melongena*) and minimum (7.5 mg kg^{-1}) in onion (*Allium cepa*). As per the maximum permissible limit of Cu 4.0 to 15.0 mg kg^{-1} for most plant species (Alloway 1968), all of the plant samles in the present study were found below the maximum phytotoxicity level of 20-100 mg kg^{-1} as mentioned by Mortvedi et al. (1991) and Tandon (1995). Anwar et al. (2016) reported that the maximum Cu concentrations were accumulated in mint roots as compared to coriander and fenugreek. The results are in confirmation with the findings of (Alwayet al. 2018 and Chaoua et al. 2019).

Zinc concentraion in plants ranged from 6.0-140.3 mg kg^{-1} and 32.5-199.9 mg kg^{-1} in shoot and root respectively (Table 1). In case of shoot samples the Zn concentration was maximum (140.3 mg kg^{-1}) in Jowar (*Sorghum bicolor*) and minimum (6.0 mg kg^{-1}) in Okra (*Ablemoschus esculantus*). Whereas, inroots samples it was noticed maximum (199.9 mg kg^{-1}) in tomato (*Lycopericon esculantum*) and minimum (32.5 mg kg^{-1}) in onion (*Allium cepa*). The content of Zn in all the plant samples was below the maximum phytotoxicity levels of 150–200 mg kg^{-1}. The biomass of all the vegetables were negatively affected when irrigated with sewage water. Zinc was accumulated in the sequence of leaves>roots>shoots under polluted water irrigation (Anwar et al. 2016). Results are consistent with the findings of (Alawsy et al. 2018 and Chaoua et al. 2019).

The iron content in shoots and roots of plant (Table 1). ranged from 90.0-1049.0 mg kg^{-1} and 464.0-1287.0 mg kg^{-1} respectively. In shoots, it was maxium (1049.0 mg kg^{-1}) in brinjal (*Solanum melongena*) and minimum (90.0 mg kg^{-1}) in okra (*Ablemoschusesculantus*). Likewise in roots, the concntration was maximum (1287.0 mg kg^{-1}) in ridge gourd (*Lijaria sinaria*) and minimum (464.0 mg kg^{-1}) in okra (*Ablemoschus esculntus*) plants. As the critical limit of phytotoxicity reported by Mortvedt et al. (1991) and Tandon (1995) for Fe is > 500 mg kg^{-1}, hence the level of Fe content in different plant of the study area was much above the critical levels. The results are in confirmation with the results of (Naz et al. 2018 and Alawsy etal. 2018).

The shoots and roots manganse content of different plants collected from the study area ranged from 18.7-106.9 mg kg^{-1} and 31.6-288.7 mg kg^{-1} respectively (Table 1). The concentration of Mn was maximum (106.9 mg kg^{-1}) in spinach (*Beta vulgaris*) leaf and minimum (18.7 mg kg^{-1}) in coriander (*Coriandrum sativum* L.) leaves. While in roots the concentration of Mn was highest (288.7 mg kg^{-1}) in barseen (*Alexandrum trifolium*) and lowest (31.6 mg kg^{-1}) in kindney bean (*Phyaseolus vulgaris* L.) The Mn content in different plant samples were much below the phytotoxicity level of >500 mg kg^{-1} as mentioned by Mortvedt et al. (1991) and Tandon (1995). The low contnt of Mn in plants can be attributed to the antagonistic effect of toxic metal present in the sewage (Knezek and Grenert 1971). Always et al. (2018) found that the absorbed Mn by the maize and barley crops is increased with increaing concentration of Mn in sewage water.

Toxic metal concentration

The cadium content in shoots and roots of sewage water irrigated plants from 2.5-18.0 mg kg^{-1} and 4.5-9.0 mg kg respectively (Table 1). The content in shoot samples was maximum (18.0 mg kg^{-1}) in bitter gourd (*Momordica charantia*) and minimum (2.5 mg kg^{-1}) in water melon (*Citrullus vulgaris*). In root samples the Cd content was maximum (9.0 mg kg) in tomato (*Lycopersicon esculantum*) and minimum (4.5 mg kg^{-1}) in chilli (*Capsium annum*). The Cd content in all of the plant samples was above the toxicity threshold limit of 0.8 mg kg^{-1} as metioned by Alloway (1968). He reported that mean concentrations of Cadmium (Cd) in plantsamples of Palak. Amaranthus, Spinach, Coriander, Green chillies and Faragrass under sewage irrigated condition were higher as compared to ground water irrigation and the corresponding values were relatively lower under no irrigation (control). Naz et al. (2018) also found that the vegetables irrigated with sewage water had greater concentrations of Cd which was higher than the safe limits recommended by WHO (1996). The results are in confirmation with the results of (Khaled et al. 2016 and Chaoua et al. 2019).

The lead content in different plant samples was found to from 4.9-68.9 mg kg^{1} in shoots and 12.0-60.9 mg kg in roots (Table 1). It was maximum in shoot (68.9 mg kg^{-1}) in brinjal (*Solanum melongena*) and roots (60.9 mg kg^{-1}) in onion (*Allium cepa*). Whereas it's minimum concentration was found in shoots (4.9 mg kg^{-1}) of okra (*Ablemoschus esculanttus*), and roots (12.0 mg kg^{-1}) of kindey bean (*Phasolus vulgaris* L.) The Pb content in most of the plants under study was above the critical limit of phytotoxicity of >20 mg kg^{-1} as mentioned by Mortvedt et al. (1991) and Tandon (1995) and hence proper monitoring of sewage water is essential before its use for irrigation in the present study area. Anwar et al. (2016) reported that the maximum Pb concentrations were accumulated in mitrootsas compared to coriander and fenugreek. The vegetables irrigated with sewage water had greater concentrations of Pb which was higher than the safe limit (Naz et al.2018). The results are in consistent with the findings of Always et al. 2018 and Chaoua et al. 2019).

The nickel content in various sewage water irrigated plants ranged from 1.8-9.6 and 3.4-22.4 mg kg^{-1} in shoots and roots respectively (Table 1). The concentration was maximum (9.6 mg kg^{-1}) in shoots ofspinach (*Beta vulgaris*) and minimum (1.8 mg kg^{-1}) in okra (*Ablemoschus esculantus*). In roots samples, maximum Ni concentration (22.0 mg kg^{-1}) was noticed in ridge gourd (*Lijaria sinaria*) and minimum (3.4 mg kg^{-1}) in kindly bean (*Physeolus vulgaris* L.). As the critical limit of Niphytotoxicity for plant tissue is >50 mg kg^{-1} as mentioned by Mortvedt et al. (1991) and Tandon (1995), so all the plants are safe for consumption in the study area as far as Ni content is concerned. Wheat roots accumulated significantly higher amount of Ni in sewage-rrigated land compared to bore well-irrigated land. The same trend was noticed in stem. In general concentration of Ni was higher in root followd by stem and lower in grain (Salakinkop and Hunshal 2014). The results are in confirmation with the results of (Salakinkop and Hunshal 2014 and Naz et al. 2018).

The chromium content in shoots and roots of different plants (Table 1) was found to range from 0.4-3.9 mg kg^{-1} and 0.5-10.4 mg kg^{-1} respectively. Maximum Cr content (3.9 mg kg^{-1}) was fiund in brinjal shoot (*Solanum melongena*) and minimum (0.4 mg kg^{-1}) in coriander (*Coriandrum sativum* L.) and round melon (*Citrullus vulgaris* var *Fistilosus*). Similarly in roots also the concentration was more (10.4 mg kg^{-1}) in barseem (*Alexandrum trifollum*) and less (0.5 mg kg^{-1}) in okra (*Ablemoschus esculantus*). The Cr content in all the above ground plant parts in the study area was below permissible level of 10 mg kg^{-1} (alloway 1968) in all the crop except barseem (*Alexandrum trifolium*) and hence at present there is no toxicity of Cr in crop grown of sewage water irrigated area in different districts of Haryana under study. The results of the present investigation are in line with the finding of (Salakinkop and Hunshal 2014 and Naz et al. 2018).

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