Wastewater Irrigation and Soil Contamination Effect on Some Leafy Vegetables Grown in Syrian Aleppo City

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The accumulation effect of contaminated soil and wastewater irrigation on the concentration of the following elements: As, Pb, Cd, Cr, Ni, Cu, Zn and Mn on some leafy vegetables grown in Syrian Aleppo City by atomic absorption spectrometry have been carried out. The following leafy vegetables: mint, parsley, mallow, spinach, endive and cress were investigated. Four different models (I-IV) of leafy vegetables were applied as follows: both contaminated soil and irrigation water, uncontaminated soil and irrigation by contaminated water, contaminated soil and irrigation by uncontaminated water and finally both uncontaminated soil and irrigation water. As the result of first important model based on both contaminated soil and wastewater irrigation, the measured concentration range of the investigating elements was as follows: As: 7.82 to 1.31; Pb: 8.73 to 2.12; Cd: 1.81 to 0.83; Cr: 2.40 to 1.16; Ni: 3.53 to 2.11; Cu: 10.80 to 6.02; Zn: 22.3 to 9.81 and Mn: 32.5 to 15.5 ppm which is the highest concentrations among the other 3 models. According to the data of daily intake of metals, DIM the toxic level values of Cd, As and Pb elements in mint, mallow and parsley were more than the recommended maximum tolerable levels proposed by the FAO/WHO which is a serious indication to a health hazard for human consumption.

Key Words: Vegetables, Wastewater irrigation, Soil, Elements.

INTRODUCTION

Due to the easy availability of wastewater, much of its consumption is mostly used for the irrigation of crops, trees and vegetables for disposal problems and scarcity of fresh water. Irrigation with wastewater is known to contribute significantly to surrounding and nearby soil contaminations with heavy metals.

The heavy metals accumulation in vegetables irrigated with wastewater from different sources in Rajasthan, India was determined to assess the levels of different heavy metals contamination like Fe, Mn, Cu and Zn[1]. Their results indicated a substantial build-up of heavy metals in vegetables irrigated with wastewater. The metals concentration range of wastewater-irrigated plants was 116-378, 12-69, 5.2-16.8 and 22-46 mg/kg for Fe, Mn, Cu and Zn respectively. The highest mean levels of Fe and Mn were detected in mint and spinach, whereas the levels of Cu and Zn were the highest in carrot.

Many planting contamination effects with toxic metals caused by the irrigation with both contaminated wastewater and soil in Dar es Salam, Tanzania[2] and in Kampala, Uganda[3] were studied. These studies recommended the need to adjust a regular monitoring level of toxic metals prior to any vegetable wastewaters irrigation in order to prevent the excessive accumulation of toxic metals in the irrigated vegetables.

In Bangladesh, different leafy vegetables irrigated with wastewater were sampled and the concentrations of As, Cd, Pb, Cu and Zn were determined using inductively coupled plasma emission spectroscopy (ICP-AES) and inductively coupled plasma mass spectroscopy (ICP-MS)[4]. It was found that the arsenic concentration was the highest which become a serious threat to the health of many Bangladeshi citizens.

The concentrations of 5 trace elements (Fe, Cu, Mn, Zn and Cr) in the common of 18 locally available vegetables for consumers in the markets of Karachi city using atomic absorption spectrometry were determined[5]. The maximum concentrations of Fe, Zn, Mn, Cu and Cr were found at 32.3, 8.6, 5.6, 3.3 and 1.2 (μg/g) in spinach, ladyfinger, mint, mustard and coriander, respectively. The overall content of trace metals appeared to be within the limit laid down for safe human consumption.

The inorganic pollutants of lettuce and radish grown in contaminated horticultural soils in the city of New Zealand by arsenic, cadmium, copper and lead were determined using atomic absorption spectroscopy[6]. The occurrence of cadmium in soils samples and in some vegetables (onion, lettuce, cabbage, carrot, spinach, gherkin and leek) produced in the area near the lead and zinc smelting plant in Veles city, Macedonia has been presented[7]. The determination of cadmium was performed by atomic absorption spectrometry[7]. It was found that the concentration of cadmium in the soil samples which are near to the Pb-Zn smelter is higher than in the samples which are far-away from the smelter. It was found that the content of cadmium in some leafy vegetables is higher than in the others and evident differences in the cadmium concentrationsin washed and unwashed vegetable samples. In most of the investigation vegetables the content of cadmium is higher than those permitted by Macedonian government regulations (maximum 0.05 mg/kg). Cambra *et al.*[8] were also studied a risk analysis of a farm area near a lead and cadmium contaminated industrial site.

The arsenic concentrations in many vegetables and fruits grown in contaminated soil and irrigated by wastewater in Aleppo city, Syria have been determined[9]. It was found that, these vegetables and fruits contain high concentration of arsenic exceeding the permissible limits set by Syrian Government regulations. Other toxic elements (As, Pb, Cd, Ni, Mn and Fe) were also present in wastewater used for irrigation of different vegetable, trees and cereal crops in Aleppo were determined[10]. The effect of long time interval irrigation using wastewater on heavy metal accumulation in soils and the grown vegetables in Zimbabwe[11], China[12] and Uganda[13] were estimated.

The presence of some trace metals (Cu, Pb, Cd, Ni and Zn) in some cereal crops (yellow corn, barley and lentil) which were irrigated by wastewater in Aleppo was reported[14]. The results showed that the contamination level in the order of yellow corn >> barley > lentil. Khan *et al.*[15] reported that there is a substantial buildup of heavy metals in wastewater-irrigated soils, collected from Beijing, China. Furthermore, this study highlights that both adults and children consuming food crops grown in wastewater-irrigated soils ingest significant amount of the metals studied. Results indicate that the concentrations of heavy metals were exceeded the permissible limits set by the World Health Organization (WHO).

The seasonal variations of lead levels in roadside soils, vegetables and plants of Damascus, Syria were measured[16]. The lead concentrations in soil samples varied from 78.4 to 832 ppm, while the concentration of lead in plants ranged from 2.6 to 19.3 ppm. The highest levels were found to be in grass (44 ppm).

The present paper reports the accumulation effect of contaminated soil and wastewater irrigation on the concentration of the following elements: As, Pb, Cd, Cr, Ni, Cu, Zn and Mn on leafy vegetables: mint, parsley, mallow, spinach, endive and cress grown locally in Aleppo, Syria using atomic absorption spectroscopy.

EXPERIMENTAL

Six leafy vegetables were selected for this study *i.e.*, used in present studies are mint, parsley, mallow, spinach, endive and cress. Four different contaminations of leafy vegetables models were applied. The 4 models were: contaminated soil and wastewater irrigation (model I), uncontaminated soil and irrigation by contaminated wastewater (model II), contaminated soil and irrigation by uncontaminated water (model III) and finally both uncontaminated soil and irrigation by drinking water used as reference for comparison (model IV). In each sampling model, 5 of replicate samples (vegetables, wastewater and soil, soil was at 0-20 cm in depth) was random collected.

Atomic absorption spectrometer used for analysis was manufactured by Shimadzu type AA-6601 equipped with lamps type HCL particular of analysis studied elements and corrected for background reference BGC-D2K with flame (Air-C_2H_2). The analytical used lines Cd, Pb, Cu, Cr, Zn, Mn, Ni and As were at 228.8, 217.0, 324.7, 358.0, 213.9, 279.5, 232.0 and 193.7 nm, respectively. For samples aching, the oven (1200 ± 5 ºC) from Nabetherm was used, while another furnace (300 ± 1 ºC) from Ecocell was used for drying samples.

Samples preparation: Five samples of each leafy vegetable (mint, parsley, mallow, spinach, endive and cress) were studied. 250 g of each sample at regular season were taken. The samples were washed well with distilled water and then dried at 105 ºC, followed by crushing in a porcelain mortar, then sieved using 1 mm mesh and finally dried again, mixes once again and kept in polyethylene packages for next procedures.

Incineration of samples: The incineration process of the 5 samples was as follows: taking appropriate quantity of powder sample and placed in the dish of platinum and added 5 mL of H_2O_2 and 0.5 mL of sulfuric acid as drops. The samples were heated on an electric heater with caution until the end of the drought and then transferred to the incineration furnace. The samples were placed in the furnace for 6 h at 600 ºC and cooled under room temperature conditions and the obtained ash was dissolved with 0.25 mL of HNO_3 (1:1), then transferred into volumetric flask volume of 10 mL and the final volume was completed to 10 mL using distilled water[14].

Reference solution preparation: 25 mL of H_2O_2 and 2.5 ml of sulfuric acid were taken and placed in dish of platinum and heated on an electric heater with caution until the end of the drought. Then 1.25 mL of HNO_3 solution (1:1) was added and then transferred into volumetric flask volume of 50 mL and the final volume was completed to 50 mL using distilled water.

Standard solutions preparation: Standard solutions of the follows elements: As, Pb, Cd, Cr, Ni, Cu, Zn and Mn (1000 mg/L) were purchased from Merck. Solutions of different elements concentrations were prepared by diluting with the previous standard solutions.

RESULTS AND DISCUSSION

Analysis of wastewater and soil: Twenty samples of contaminated irrigation wastewater and also 20 samples of soil (soil was cored at 0-20 cm in depth) were randomly collected. In the field, samples were placed in polyethylene bags and then transferred to the laboratory within 4 h. Metal concentrations were determined and the obtained results are summarized in Table-1. The element concentrations in wastewater were higher than the allowance levels in irrigation water, according to Syrian Standard No2752/2003(SASMO)[17] (Table-1).

TABLE-1
IDENTIFICATION OF ELEMENTS (As, Pb, Cd, Cr, Ni, Cu, Zn AND Mn) IN IRRIGATION WASTEWATER AND IN CONTAMINATED SOIL USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Measured value*			
	In irrigation wastewater (mg/L)		In soil (ppm)	
	Samples	Maximum according (SAMSO) [Ref. 17]	Solute elements	Total elements
Cd	0.28	0.01	0.54	0.62
Cr	1.60	0.1	0.21	0.87
As	2.81	0.1	3.20	9.10
Ni	3.42	0.2	1.90	2.30
Pb	2.70	0.5	1.80	7.40
Cu	12.4	0.2	7.52	8.90
Zn	14.9	2.0	8.91	10.30
Mn	15.8	0.2	10.90	11.80

*Average of 5 determinations.

The concentrations of soluble and total elements (As, Pb, Cd, Cr, Ni, Cu, Zn and Mn) in contaminated soil were: 3.20 and 9.10; 1.80 and 7.40; 0.54 and 0.62; 0.21 and 0.87; 1.90 and 2.30; 7.52 and 8.90; 8.91 and 10.30; 10.90 and 11.80 ppm, (Table-1).

Metal accumulation in leafy vegetables models I, II, III and IV: Mean contents of elements (As, Pb, Cd, Cr, Ni, Cu, Zn and Mn) in samples of leafy vegetables *i.e.*, mint, parsley, mallow, spinach, endive and cress of models I, II, III and IV were identified. In general, all elements in model I were accumulated in leafy vegetables and were much higher than the concentrations in the cereal crops[14] and more than the allowance levels proposed by the [Joint FAO/WHO Expert Committee on Food Additives, 1999], (Table-2). These results show that the concentrations of considered elements, $C_{elm.}$ for various leafy vegetables varied greatly between vegetable species. The mean, C_{elm} of vegetables (mint, parsley, mallow and spinach) for these elements are in the following order: Mn > Zn > Cu > Pb > As > Ni > Cr > Cd, while in endive and cress are in the order of: Mn > Zn > Cu > Pb > Ni > As > Cr > Cd.

TABLE-2
IDENTIFICATION OF ELEMENTS (As, Pb, Cd, Cr, Ni, Cu, Zn AND Mn) IN THE LEAFY VEGETABLES FOR MODEL (I) USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Measured value (ppm)*					
	Mint	Parsley	Mallow	Spinach	Endive	Cress
Cd	1.81±0.019	1.56±0.017	1.75±0.020	1.10±0.013	1.04±0.012	0.83±0.010
Cr	2.40±0.071	2.18±0.070	2.43±0.070	1.83±0.054	1.43±0.050	1.16±0.040
As	7.82±0.410	6.54±0.340	6.96±0.370	5.21±0.280	1.54±0.087	1.31±0.077
Ni	3.53±0.095	3.21±0.092	3.30±0.094	2.44±0.072	2.05±0.066	2.11±0.068
Pb	8.73±0.380	7.10±32.00	8.84±0.390	7.44±0.340	2.44±0.120	2.12±0.100
Cu	10.80± 0.19	10.52±0.180	10.61±0.180	9.41±0.180	8.34±0.170	6.02±0.120
Zn	22.3±0.300	21.0±0.290	20.1±0.280	24.2±0.330	16.5±0.240	9.81±0.200
Mn	32.5±0.400	29.5±0.340	32.7±0.360	34.8±0.430	19.1±0.430	15.5±0.290

*Average of 5 determinations at 95 % level of confidence: mean ± $t_{0.05}\frac{SD}{\sqrt{n}}$

The percentage quantities of elements (As, Pb, Cd, Cr, Ni, Cu, Zn and Mn) in the examined leafy vegetables (model II) were generally decreased between 23-40 % in comparison with model I for all leafy vegetable. But the decreasing of Pb in cress and endive was in the range of 10-15 %, (Table-3). These results clearly emphasized the impact of irrigation by contaminated water which leads to the increase concentration of toxic elements in vegetable. The mean, of vegetables for these elements are in the order similar to model I.

The decreasing concentration quantities of elements (As, Pb, Cd, Cr, Ni, Cu, Zn and Mn) in the leafy vegetables model III were between 48-68 % in comparison with model I for all leafy vegetable. But the decreasing of Pb in cress and endive is in the range of 20-22 %, (Table-4). These results show that, the impact of contaminated wastewater is higher than the impact of contaminated soil (180 %). Mean $C_{elm.}$ of all vegetable species for these elements are in the order of: Mn > Zn > Cu > Pb > As > Ni > Cr > Cd.

TABLE-3
IDENTIFICATION OF ELEMENTS (As, Pb, Cd, Cr, Ni, Cu, Zn AND Mn) IN THE LEAFY VEGETABLES FOR MODEL (II) USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Measured value (ppm)*					
	Mint	Parsley	Mallow	Spinach	Endive	Cress
Cd	1.26±0.014	0.93±0.011	1.03±0.012	0.76±0.009	0.68±0.008	0.50±0.006
Cr	1.56±0.054	1.50±0.052	1.68±0.058	1.55±0.054	1.02±0.037	0.88±0.032
As	5.71±0.310	4.93±0.280	5.32±0.290	4.30±0.240	1.20±0.070	0.95±0.055
Ni	2.30±0.071	2.01±0.0650	2.04±0.066	1.79±0.060	1.34±0.048	1.62±0.060
Pb	6.42±0.290	4.92±0.230	6.38±0.290	5.82±0.270	2.08±0.100	1.91±0.095
Cu	8.71±0.170	6.35±0.130	6.81±0.140	5.63±0.120	6.10±0.140	4.80±0.110
Zn	15.6±0.250	13.6±0.240	13.7±0.240	18.6±0.280	12.3±0.260	6.80±0.160
Mn	22.9±0.310	14.7±0.270	20.1±0.300	27.9±0.350	13.4±0.320	9.52±0.190

*Average of 5 determinations at 95 % level of confidence: mean ± $t_{0.05}\frac{SD}{\sqrt{n}}$

TABLE-4
IDENTIFICATION OF ELEMENTS (As, Pb, Cd, Cr, Ni, Cu, Zn and Mn) IN THE LEAFY VEGETABLES FOR MODEL (III) USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Measured value (ppm)*					
	Mint	Parsley	Mallow	Spinach	Endive	Cress
Cd	0.87±0.010	0.54±0.006	0.65±0.008	0.56±0.004	0.46±0.005	0.28±0.003
Cr	1.12±0.031	0.74±0.025	0.88±0.028	0.77±0.026	0.68±0.024	0.37±0.013
As	4.10±0.220	2.62±0.140	3.09±0.170	2.12±0.120	0.58±0.034	0.55±0.032
Ni	1.46±0.047	1.04±0.035	0.99±0.033	0.93±0.032	0.48±0.018	0.47±0.018
Pb	4.85±0.210	3.18±0.140	4.10±0.180	3.10±0.140	1.70±0.080	1.65±0.080
Cu	6.05±0.120	4.00±0.084	4.96±0.098	3.92±0.083	2.76±0.061	2.67±0.063
Zn	11.4±0.230	8.43±0.190	9.61±0.200	7.22±0.180	6.68±0.18	4.31±0.140
Mn	17.2±0.290	11.2±0.220	14.6±0.270	12.2±0.230	12.8±0.24	5.48±0.120

*Average of 5 determinations at 95 % level of confidence: mean ± $t_{0.05}\frac{SD}{\sqrt{n}}$

The average contents of the measured elements in samples of studied leafy vegetables for model IV were measured. In general, all leafy vegetables accumulated much lower amount for all studied elements (≤ 0.17 ppm; 22-222 times lower than model I) in comparison with all 3 previous models. However, the obtained values of these elements by this model were below the recommended maximum tolerable levels proposed by the [Joint FAO/WHO Expert Committee on Food Additives, 1999], (Table-5).

Bio-accumulate factor: The bio-accumulate factors (BAF) of elements (As, Pb, Cd, Cr, Ni, Cu, Zn and Mn) from soils to leafy vegetables were calculated as follows[18]:

$$BAF = E_v / E_c$$

where: E_v is the element content (dry weight basis) in leafy vegetable; E_c is the element content (dry weight basis) in corresponding soil. To appraise the bio-accumulate factors (BAF) effects of leafy vegetable that uptake pollutant elements from the

TABLE-5
IDENTIFICATION OF ELEMENTS (As, Pb, Cd, Cr, Ni, Cu, Zn AND Mn) IN THE LEAFY VEGETABLES FOR MODEL (IV) USING ATOMIC ABSORPTION SPECTROSCOPY

Element	Measured value (ppm)*					
	Mint	Parsley	Mallow	Spinach	Endive	Cress
Cd	0.019±0.0008	0.018±0.0008	0.020±0.0008	0.017±0.0007	0.012±0.0004	0.011±0.0005
Cr	0.021±0.0012	0.020±0.0011	0.021±0.0012	0.017±0.0010	0.013±0.0008	0.012±0.0008
As	0.130±0.0070	0.121±0.0070	0.141±0.0080	0.112±0.0070	0.063±0.0040	0.061±0.0070
Ni	0.046±0.0025	0.043±0.0024	0.048±0.0026	0.041±0.0023	0.031±0.0018	0.028±0.0016
Pb	0.023±0.0020	0.021±0.0020	0.022±0.0020	0.020±0.0020	0.015±0.0010	0.013±0.0010
Cu	0.170±0.0040	0.152±0.0037	0.161±0.0040	0.140±0.0037	0.086±0.0026	0.083±0.0033
Zn	0.191±0.0095	0.160±0.0083	0.182±0.0090	0.310±0.0110	0.283±0.0100	0.101±0.0056
Mn	0.36±0.0098	0.31±0.0085	0.34±0.0930	0.41±0.0110	0.39±0.0200	0.140±0.0520

*Average of 5 determinations at 95 % level of confidence: mean ± $t_{0.05} \frac{SD}{\sqrt{n}}$

contaminated soils. BAF is calculated for each leafy vegetable at each site separately. The results show that BAF values of considered elements for various leafy vegetables varied greatly between vegetable species and studied models (soil and wastewater) (Table-6). The average BAF of 6 vegetables for these considered elements are in

TABLE-6
BIO-ACCUMULATE FACTOR (BAF) OF ELEMENTS (As, Pb, Cd, Cr, Ni, Cu, Zn AND Mn) CONTENT (DRY WEIGHT BASIS) IN LEAFY VEGETABLES (MINT, PARSLEY, MALLOW, SPINACH, ENDIVE AND CRESS) GROWN IN CONTAMINATED SOIL AND IRRIGATION BY CONTAMINATED WASTEWATER MODEL I AND IN CONTAMINATED SOIL AND IRRIGATION BY UNCONTAMINATED WATER MODEL III

Element	Model	Measured value (ppm)					
		Mint	Parsley	Mallow	Spinach	Endive	Cress
Cd	I	2.92	2.52	2.82	1.77	1.68	1.34
	III	1.40	0.87	1.04	0.90	0.74	0.45
Cr	I	2.76	2.51	2.79	2.10	1.64	1.33
	III	1.28	0.85	1.01	0.88	0.66	0.42
As	I	0.85	0.71	0.75	0.56	0.16	0.14
	III	0.45	0.28	0.33	0.22	0.074	0.06
Ni	I	1.53	1.39	1.43	1.06	0.89	0.91
	III	0.63	0.41	0.46	0.40	0.21	0.21
Pb	I	1.18	0.96	1.19	1.00	0.33	0.29
	III	0.66	0.43	0.55	0.42	0.23	0.22
Cu	I	1.21	1.18	1.19	1.18	0.92	0.68
	III	0.68	0.45	0.56	0.44	0.31	0.30
Zn	I	2.17	2.04	1.95	2.35	1.60	0.95
	III	1.11	0.82	0.93	0.82	0.65	0.42
Mn	I	2.75	2.50	2.77	2.95	1.62	1.31
	III	1.46	0.93	1.23	1.03	1.08	0.46

*Average of 5 determinations.

the order of: Mn > Cd > Cr > Zn > Cu > Pb > Ni > As for samples in the model III (soil is contaminated only) and Cd > Cr > Mn > Zn > Ni > Cu > Pb > As for all vegetables except spinach samples in model I (soil and wastewater are contaminated). Moreover, the BAF values for elements As, Pb, Cd, Cr, Ni, Cu, Zn and Mn for various vegetables varied greatly between vegetable species and source of irrigation water and soil.

Daily intake estimate of metals (DIM) through food: The daily intake of elements (As, Pb, Cd, Cr, Ni, Cu, Zn and Mn) as mg/person/day was calculated by the following equation[18]:

$$DIM = M. K. I$$

where M represents the element content (dry weight basis) in leafy vegetables (mg/kg), K represents conversion factor used to convert fresh green leafy vegetables weight to dry weight was 0.22, 0.19, 0.24, 0.090, 0.092 and 0.17 for mint, parsley, mallow, spinach, endive and cress, respectively, where is 0.085 according to Arora *et al.*[1], I: represent average daily vegetable intake by an adult was considered to be 0.345 kg/person/day[1]. The results are presented in Table-7.

TABLE-7
DAILY INTAKE OF METALS (DIM, mg/person/day) FOR INDIVIDUAL ELEMENTS (As, Pb, Cd, Cr, Ni, Cu, Zn AND Mn) CONTENT IN LEAFY VEGETABLES FOR MODELS (I, II, III AND IV)

Element	Model	Measured value (ppm)*					
		Mint	Parsley	Mallow	Spinach	Endive	Cress
Cd	I	0.1370	0.1020	0.1450	0.03400	0.03300	0.047
	II	0.0960	0.0610	0.0850	0.02400	0.02200	0.029
	III	0.0760	0.0350	0.0540	0.01700	0.01500	0.016
	IV	0.0014	0.0012	0.0017	0.00530	0.00038	0.00065
Cr	I	0.1800	0.1430	0.2000	0.05700	0.04500	0.06800
	II	0.1200	0.0980	0.1390	0.04800	0.03200	0.05200
	III	0.0850	0.0490	0.0730	0.03400	0.02200	0.02200
	IV	0.0016	0.0012	0.0017	0.05300	0.00041	0.00059
As	I	0.5900	0.4300	0.5800	0.16200	0.04900	0.07700
	II	0.4300	0.3200	0.4400	0.13400	0.03800	0.05600
	III	0.3100	0.1700	0.2600	0.06600	0.01800	0.32000
	IV	0.0099	0.0079	0.0120	0.00350	0.00200	0.00360
Ni	I	0.2700	0.2100	0.2700	0.09100	0.06500	0.12400
	II	0.1700	0.1300	0.1700	0.05600	0.04300	0.09500
	III	0.1100	0.0680	0.0820	0.02900	0.01500	0.02800
	IV	0.0035	0.0028	0.0040	0.00130	0.00098	0.00160
Pb	I	0.6600	0.4700	0.7300	0.23000	0.07700	0.12400
	II	0.4900	0.3200	0.5300	0.18000	0.06600	0.11200
	III	0.3500	0.2100	0.3400	0.09600	0.05400	0.09700
	IV	0.0017	0.0014	0.0018	0.00062	0.00050	0.00076

Element	Model	Measured value (ppm)*					
		Mint	Parsley	Mallow	Spinach	Endive	Cress
Cu	I	0.8200	0.6900	0.8800	0.29000	0.26000	0.35000
	II	0.6600	0.4200	0.5600	0.17500	0.19000	0.28000
	III	0.4600	0.2600	0.4100	0.08500	0.08800	0.16000
	IV	0.0130	0.0100	0.0130	0.00430	0.00270	0.00490
Zn	I	1.6900	1.3800	1.6600	0.75000	0.52000	0.58000
	II	1.1800	0.8900	1.1300	0.58000	0.39000	0.40000
	III	0.8700	0.5500	0.8000	0.02200	0.21000	0.25000
	IV	0.0140	0.0100	0.0150	0.00960	0.00900	0.00590
Mn	I	2.4700	1.9300	2.7100	1.08000	0.61000	0.91000
	II	1.7400	0.9600	1.6600	0.87000	0.43000	0.56000
	III	1.3100	0.7200	1.2100	0.38000	0.41000	0.32000
	IV	0.0270	0.0200	0.0280	0.01300	0.01200	0.00820

*Average of 5 determinations.

Human exposure to metal contamination: Table-7 shows that, the values of toxic elements level as Cd, As and Pb in some studied leafy vegetables (mint, mallow and parsley) were more than the recommended maximum tolerable levels proposed by the [Joint FAO/WHO Expert Committee on Food Additives 1999] for both model I and II and even in model III for mint only. These data clearly show that the presence of toxic elements in some local Syrian leafy vegetables using both contaminated soil and wastewater for irrigation will increase the concentration of these toxic elements. Therefore, an essential remodel of the wastewater is required in order to reduce toxic elements concentration before any irrigation of vegetables, trees and cereal crops with wastewater.

Conclusion

The values of toxic elements as Cd, As and Pb in some studied leafy vegetables (mint, mallow and parsley) were more than the recommended maximum tolerable levels proposed by the [Joint FAO/WHO Expert Committee on Food Additives 1999]. Present data clearly show that the presence of toxic elements in some leafy vegetables is possible and very important precaution measures should be considered when the wastewater is used for the irrigation of leafy vegetables without any premodel.

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