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Environmental Assessment for Soils and Plants Irrigated from El-Mohett Drain

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ABSTRACT

The objective of this study was to evaluate the environmental risks of water, soils, and plans from the El-Mariouteya Canal and El-Rahawi drain at two seasons (summer and winter). To achieve this aim, were investigate the pH and electrical conductivity (EC) in water and soils, as well as sodium adsorption ratio (SAR) in water; some micro elements and heavy metals were estimated in both water; soils and plants. In addition to calculate of contamination factor (CF), degree of contamination (Cd), modified degree of contamination (mCd); pollution load index (PLI) and bio-accumulation factor of elements in plant.

The obtained results indicated that the values of pH and (SAR) in the water were different from season to another season. The (EC) values were very high and unsuitable for irrigation in the summer season; while they were suitable to medium suitable for irrigation of winter season according to FAO (1985).

Soil pH ranged from moderate to moderate alkaline and (EC) ranged from non-saline to highly saline soils. However, boron, cadmium, cobalt, chromium, nickel and lead were within the safe limits. The total content of cadmium exceeded the safe limits in both seasons, but other elements were within the safe limits.

The lowest concentration of iron, boron, cobalt and chromium were found in the Wheat plant. Manganese and nickel were found in the fruits of Eggplant, zinc and copper found in Cabbage. While the highest concentrations of iron, manganese, copper, cobalt, nickel and lead were found in Okra fruits. Also zinc, boron and chromium were found in Arugula plant. BCF indicates that most plants have more than 1 and indicate to high concentrations of heavy metals except Cd, Ni and Pb were not hyper-accumulator with all plants under studied at two seasons.

The values of (CF) were low for both zinc, boron and lead and medium for copper and cobalt at all sites and low to medium with both iron, manganese, chromium and nickel indicating that this contamination is related to human activities. Modified contamination degree (mCd) is moderate to high in some sites. The (PLI) is generally high (> 1) in all sites; exception one site. The (PLI) was low (<1) in some sites in winter.

Keywords: water, soil, plant, pollution, bioaccumulation risk assessment.

Introduction

Mohamed (2014) reported that El-Moheet drain receives all waste water *e.g.* agricultural, domestic and sewage from lateral minor drains. The maximum industrial units in the selected areas also discharge their effluents directly into El Moheet drain and the seepage taking from the effluents as well as other anthropogenic activities impair the quality of surface and ground water and making them unfit for irrigation purposes. Gaber *et al.* (2013) indicated that the values of the detected heavy metals in El-Rahawy drain are appreciably higher than those in the River Nile water. The mean values of the elements at different sites showed Fe to be the most abundant element in water whereas Cd was the least concentration.

Balkhair and Ashraf (2016) noticed that, the application of wastewater increased the soil salinity, available micro-elements and decreased the soil pH. Rusan *et al.* (2007) reported that the accumulation of micronutrients and heavy metals from wastewater application could be caused directly by the wastewater composition or indirectly through increasing solubility of the indigenous insoluble soil heavy metals as a result of the chelation or acidification action of the applied

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wastewater. Ene *et al*. (2009) found that the heavy metals may adversely affect soil ecology, agricultural production or product quality and ground water quality, and will ultimately harm to health of living organism by food chain. Singh *et al*. (2010) stated that elevated levels of heavy metals in irrigation water led to significantly higher concentrations in the soil at wastewater irrigated site compared to those obtained from clean water irrigated site.

Fytianos *et al*. (2001) stated that plant species have a variety of capacities to remove and accumulate heavy metals. The certain species may accumulate specific heavy metals, causing a serious risk to human health when plant – based foodstuffs are consumed. Kiziloglu *et al.* (2007) indicated that the application of wastewater to soil increased the yield and the N, P, K, Fe, Mn, Zn, Cu, B and Mo contents of Cabbage plants without causing undesirable side effects to the plants heavy metal contents.

Kapourchal *et al.* (2009) reported that the leafy vegetables, such as Cauliflower, Cabbage and Spinach, grow quite well in the presence of sewage water, whereas other vegetables, such as Radish, are sensitive to sewage water. Khan *et al.* (2012) found that the bioaccumulation of Pb and Cr in vegetables was above the critical concentrations of plant growth, while Pb and Cd were above the prescribed limit for animal diets. Mustapha and Adeboye (2014) showed that the concentrations of heavy metals in edible part of Spinach vary from metal to another. The trend of accumulation in the Spinach showed an order of decreasing magnitude from Fe to Cd (Fe > Cu > Mn > Pb > Cd). Iron had the highest content in Spinach sample and cadmium being the lowest of all the metals analyzed.

Likuku *et al.* (2013) stated that the overall contamination of soils based on the CF values indicate that soils were considerably contaminated with Fe, Mn, Pb, and Zn , but showed signs of low contamination with Co in the case of degree of contamination, the windward soils fall under considerable contamination. The modified degree of contamination suggest that the studied area is moderately contaminated (mCd=2.3). Omotoso and Ojo (2015) stated that the soil samples were moderately contaminated with Mn, Cu and Ni while Cr, Pb and Zn showed low contamination factor. 70% of the samples showed low degree of contamination while 30% indicated moderate degree of contamination. Ali *et al.* (2016). the calculated (PLI) values of metals were ranged from 1.36 to 2.07 during summer and 1.83 to 2.91 during winter confirming the studied location was contaminated (PLI > 1). Tang *et al.,* (2013) showed that, the EF values of Cd were highest reaching 7.92 on average, indicating a high degree of anthropogenic contamination by this metal mainly from industrial activities. The mean values of Zn, Pb, Cu, Cr and Ni were 2.25, 2.06, 2.04, 2.02 and 1.95, respectively, indicating that they also originated from anthropogenic sources in most samples. Ekengele *et al.* (2017) revealed that Co and Pb varied from no enrichment to minor enrichment; Ni and Zn displayed no enrichment to moderate; no enrichment to moderately severe was shown by Cr and Cu, while Cd displayed EF of moderate to moderately severe and minor to severe, respectively.

Therefore, the present study aims to identifying the sources of water pollution of El-Mariouteya canal (El-Mohett drain) and El-Rahawy drain, environmental risk assessment for soil, cultivated plants through using mathematical equations at two seasons.

Materials and Methods

The study area:

El- Mariouteya canal (El-Mohett and El-Rahawy drains) in El-Giza Governorate is considered one of the most polluted main drains, coming second to Bahr El-Baqar drain in the Eastern Delta Fig. (1). It extended from the south Giza to North El-Riah El-Naseri. It passes through several villages on both sides, and receives sewage, household wastes, industrial wastewater activities and agricultural drainage water from the area.

Water, soils and plants sampling:

Samples of water, Soils (surface and sub-surface soils) and plants are collected. Seventeen surface water samples, seven surface and sub-surface soil and twelve different plants. The samples were collected twice during summer and winter seasons, respectively. Some sites along (El-Mohett and El-Rahawy drains) were selected.

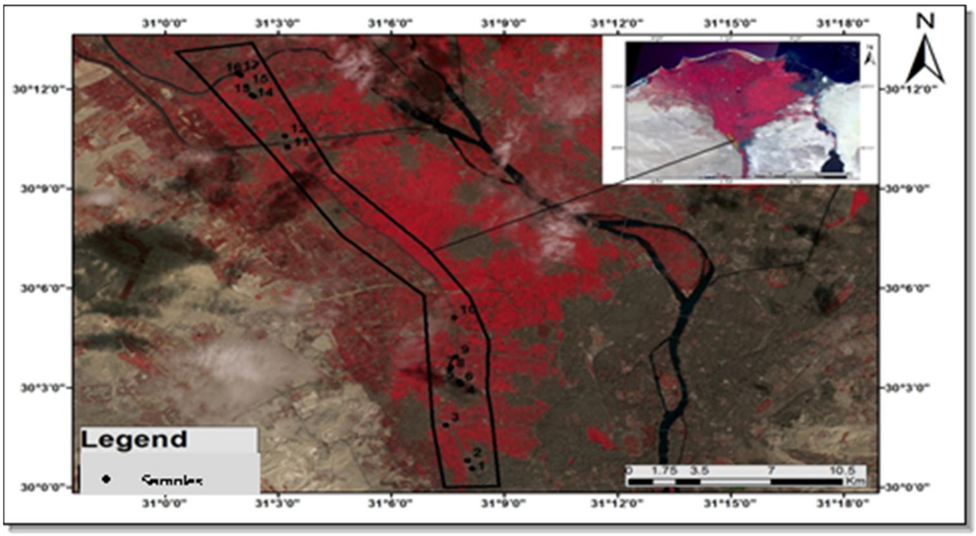

Fig. 1: Map of the study area and sampling sites.

Surface water samples were collected from different sites according to Environment Protection Authority Guidelines (EPA, 2007) and Rocky Mountain Research Station (RMRS, 2012). Samples were brought to the lab in ice tank and stored at 4°C until analysis. Soil samples from agricultural areas are collected using an auger. Soil samples were dried in air and crushed then sieved through a <0.2 mm sieve and stored in the labeled polythene sampling bags Lei *et al.* (2008) and Adepetu *et al.* (1996). A diversity of cereal crops and vegetables grown in the study area; Arugula (*Eruca sativa*), Okra fruits (*Abelmoschus esculentus* L. *Moenth*), Elephant grass (*Pennisetum purpureum*), Eggplant fruits (*Solanum Melongena),* Maize (*Zea mays,* L), Molokhia (Corchorus olitorius) were taken in summer. As well as Cabbage (*Brassica oleracea* var. capitata), Parsley (*Petroselinum crispum*), Wheat (*Triticum aestivum*), Mallow (*Malva parviflora*), Onion (*Allium cepa*), and Spinach (*Spinacia oleracea*) were taken in winter season. Different plants are collected from different sites of the sampling zone in 3–5 replicates and stored in labeled polythene sampling bags and brought to the lab, washed with tap water to remove any kind of contamination like soil particles finally washed by using distilled water then placed in drying oven for 72 hours at 70 °C after the dryness of the sample, it was completely grinded by using the stainless mill and digestion according to Adepetu *et al.* (1996).

Methods of analysis:

Electrical conductivity (EC) in water and soil samples were determined by Electrical conductivity meter model *WTW Series Cond 720*; pH values in water, and soil suspensions (1:2.5) are determined by using pH meter model *WTW Series pH 720*; as well as cations and anions in water and soil are determined according to ICARDA (2013). Available Fe, Mn, Zn, Cu, B Cd, Cr, Co, Ni and Pb of soil were extracted according to AB-DTPA (Soltanpour and Schwab, 1991). As well as total elements were digested by aqua regia according to Cottenie *et al*. (1982) and ICARDA (2013). Different micro and heavy metals in water, soils and plants are determined according to Environmental Protection Agency (EPA, 1991) using Inductively Coupled Plasma (ICP) Spectrometry (*Ultima 2 JY Plasma*).

Environmental assessment factors:

Contamination Factors (CF):

The contamination factor (CF) is used to determine contamination status in the studied surface soil samples (Liu *et al*., 2005) and calculated according to the following equation No. (1).

CF=Measured con. / Background con. Equation No. (1)

The background concentrations of different elements under study in mg kg^{-1} in the Earth's crust were 37, 001.0 for Fe; 646 for Mn; 149 for Zn; 28.7 for Cu; 18.98 for B; 14.9 for Co; 0.36 for Cd; 122 for Cr; 57 for Ni and 32.9 for Pb $mgkg^{-1}$ according to Turekian and Wedepohl (1961) and Bradford *et* *al.* (1996). The significance of contamination factor and the level of contamination values are described according to Hakanson (1980).

Contamination Degree (Cd):

The Cd is the sum of the contamination factors of all the elements examined according to Hakanson (1980) and calculated according to equation No. (2).

$$\mathrm{Cd} = \sum_{I=1}^{i=n} CF \qquad Equation\ No. (2).$$

Modified degree of contamination (mCd):

$$\mathrm{mCd} = \sum_{i=1}^{i=n} CF/n \qquad Equation\ No. (3)$$

The (mCd) was defined as the sum of all contamination factors Abrahim (2005) and calculated as equation No. (3).

Where: (n) = number of analyzed elements; (i=1) = the elements and (CF) = contamination factor. The classification and description of the modified degree of contamination (mCd) in soil show the following gradations are proposed by Abrahim and Parker (2008) as shown in Table (1). The CF and (Cd) were defined according to four categories as follows:-

Table 1: Contamination factor, degree of contamination level and modified degree of contamination.

CF classes	Cd classes	mCd classes	Categories
—	—	mCd < 1.5	Nil to very low contamination
CF < 1	Cd < 9	1.5 ≤ mCd < 2	Low contamination
1≤ CF < 3	9 ≤ Cd < 18	2 ≤ mCd < 4	Moderate contamination
3 ≤ CF < 6	18 ≤ Cd < 36	4 ≤ mCd < 8	High contamination or Considerable.
CF > 6	Cd ≥ 36	8 ≤ mCd < 16	Very high contamination
—	—	16 ≤ mCd < 32	Extremely high contamination
—	—	mCd ≥ 32	Ultra-high contamination

The pollution load index (PLI):

The PLI proposed by Tomlinson *et al.* (1980) is calculated using the following equation No.(4). and level index Tabulated in Table (2).

$$\mathrm{PLI} = (\mathrm{CF1} \times \mathrm{CF2} \times \mathrm{CF3} \times \ldots . . \times \mathrm{CFn})^{1/n} \qquad Equation\ No. (4)$$

Table 2: Pollution level index.

PLI classes	Degree of pollution level
PLI < 1	Perfection
PLI = 1	Base line Pollution level of pollution level index
PLI > 1	Deterioration of site quality

Bio concentration factor (BCF):

The BCF is calculated according to **Liu *et al.* (2006)** using the following equation No. (5).

$$\mathbf{BCF = C_{plant} / C_{soil}} \qquad \textit{Equation No. (5)}$$

where: - C_{plant} is the concentration of elements in the plant and C soil is the concentration of the same elements in the soil on dry weight basis BCF > 1 then the plants can be accumulators; BCF = 1 is no influences and BCF < 1 then the plant can be an excluder.

Results and Discussion

I. Some characteristics of irrigation water for EL-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites during summer and winter seasons:

Values of pH; electrical conductivity (EC dSm^{-1}); sodium absorption ratio (SAR) and residual sodium carbonate (RSC) along El-Mariouteya canal (El-Mohett and El-Rahawy drains) are illustrated in Table (3). Data revealed that the average of pH values ranged from 6.10 to 8.49 in summer season and 7.71 to 8.86 in winter season, respectively. EC values for irrigation water in summer season varied from 0.49 to 9.24 dS m^{-1} and in winter season were 0.37 to 3.80 dSm^{-1}. SAR values ranged from (1.02 to 7.57) and (0.42 to 4.49) in summer and winter seasons, respectively.

Table 3: Some chemical analysis of irrigation water for El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites.

Sites No.	pH	EC (dS m^{-1})	SAR	pH	EC (dS m^{-1})	SAR
	Summer season			Winter season		
1	6.10	6.51	6.91	8.77	2.51	3.07
2	8.46	7.95	7.57	8.00	3.80	4.49
3	8.49	7.70	7.52	8.60	2.73	3.40
4	8.28	7.80	7.53	8.86	2.23	3.07
5	8.06	2.04	3.88	8.67	2.01	1.75
6	7.95	8.66	6.61	8.80	2.22	3.18
7	7.76	8.81	3.68	8.64	1.20	1.19
8	7.71	9.24	5.96	8.69	1.46	2.02
9	8.15	6.07	6.67	8.35	1.48	2.02
10	8.30	5.91	6.81	8.71	1.39	1.63
11	7.79	1.99	3.76	8.36	0.99	1.20
12	7.60	2.01	3.67	8.28	1.00	1.10
13	7.57	2.13	3.23	8.51	0.81	0.42
14	7.57	1.98	3.61	8.53	0.98	0.72
15	7.39	1.85	3.35	8.34	0.95	0.87
16	7.23	1.97	2.89	8.37	1.10	1.14
17	7.48	0.49	1.02	7.71	0.37	0.64
Minimum	6.10	0.49	1.02	7.71	0.37	0.42
Maximum	8.49	9.24	7.57	8.86	3.80	4.49

- RSC was zero in summer and winter seasons.

Samples were free from RSC in two seasons. Balkhair and Ashraf (2016) reported that the pH of irrigation water is not an acceptable criterion of water quality because it tends to be buffered by the soil and most crops can tolerate a wide pH range. It is clear from these results that the values of EC in summer exceeded the degree of restriction on use (severe restriction). El Tohamy *et al.* (2015) reported that EC in El-Mariouteya Canal ranged between (0.53 to 5.26 dS m^{-1}) and (1.26 to 6.72 dS m^{-1}) in winter and summer seasons respectively. On the other hand, EC indicating a slight to moderate degree of restriction on the use of this water for irrigation in winter season according to the standards of the Food and Agriculture Organization (FAO) of the United Nations (Ayers and Westcot, 1985). Therefore, it is necessary to control the salinity when using wastewater for irrigation.

II. Micro-nutrients and heavy metals concentration in irrigation water used from (El-Mohett and El-Rahawy drains).

The results of Tables (4 and 5) revealed that the concentration (mg l^{-1}) of micro-nutrients and heavy metals in El-Mariouteya canal water during summer and winter seasons. The results indicated that the mean concentrations (mg l^{-1}) of elements in water were highest, relatively for the Fe followed by Zn, Mn, B, Pb, Cu, Cr, Ni, Co and Cd.

Data also showed, that the heavy metal concentrations displayed as the following decreasing order: Zn > Mn > Fe > B > Pb > Ni > Co ≈ Cr. Regarding the concentration of Cd, Co, Cr, Ni and Pb were very low compared with standard limits for irrigation water according to FAO (1992) and FAO (1985). As data showed in Tables (4 and 5), the average values of micro-nutrients and heavy metal concentrations in summer season was higher than that in winter season. However, the heavy metals not exceeded than the recommended maximum concentrations of trace elements and heavy metals in irrigated water according to Ayers and Westcot (1985); Row and Abdel-Majid (1995) and FAO (1992).

Table 4: Micro-nutrients content in irrigation water for El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites.

Sites No.	Concentration (mg l^{-1})									
	Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
	Summer season					Winter season				
1	0.416	0.155	0.863	0.080	0.130	0.080	0.092	0.025	0.066	0.060
2	0.523	0.067	0.654	0.050	0.150	0.160	0.125	0.030	0.046	0.135
3	0.602	0.082	0.160	0.073	0.146	0.080	0.501	0.095	0.050	0.140
4	0.600	0.126	0.765	0.060	0.180	0.110	0.057	0.440	0.054	0.149
5	0.314	0.048	0.418	0.053	0.115	0.140	0.071	0.420	0.030	0.095
6	1.017	0.677	0.183	0.050	0.084	0.380	0.554	0.362	0.038	0.086
7	0.506	0.201	0.898	0.088	0.111	0.130	0.160	0.250	0.040	0.040
8	0.794	0.136	0.147	0.091	0.128	0.090	0.246	0.360	0.030	0.060
9	0.810	0.177	0.468	0.086	0.457	0.090	0.082	0.480	0.040	0.070
10	2.465	0.122	0.480	0.030	0.320	0.150	0.060	0.250	0.027	0.102
11	0.286	0.316	0.483	0.050	0.249	0.150	0.065	0.315	0.031	0.110
12	1.925	0.179	1.320	0.040	0.206	0.130	0.120	0.286	0.023	0.113
13	0.645	0.203	0.253	0.055	0.322	0.130	0.105	0.300	0.040	0.123
14	1.811	0.130	0.178	0.138	0.122	0.110	0.074	0.170	0.030	0.072
15	0.325	0.185	0.145	0.040	0.128	0.100	0.069	0.110	0.030	0.120
16	0.263	0.193	0.111	0.030	0.126	0.140	0.052	0.090	0.024	0.118
17	0.105	0.035	0.088	0.004	0.032	0.050	0.016	0.030	0.003	0.002
Minimum	0.105	0.035	0.088	0.004	0.032	0.050	0.016	0.025	0.003	0.002
Maximum	2.465	0.677	4.830	0.138	0.457	0.380	0.554	0.480	0.066	0.149
Average	0.789	0.178	0.704	0.060	0.177	0.131	0.144	0.236	0.035	0.094
*	5.00	0.20	2.00	0.020	0.70	5.00	0.20	2.00	0.020	0.70

*Permissible limit according to (Ayers and Westcot, 1985).

Table 5: Heavy metals content in irrigation water for El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites.

Sites No.	Concentration (mg l^{-1})									
	Cd	Co	Cr	Ni	Pb	Cd	Co	Cr	Ni	Pb
	Summer season					Winter season				
1	0.000	0.001	0.003	0.003	0.006	0.000	0.000	0.002	0.001	0.002
2	0.000	0.001	0.003	0.003	0.006	0.000	0.000	0.002	0.001	0.002
3	0.000	0.001	0.002	0.003	0. 012	0.000	0.000	0.001	0.001	0.010
4	0.000	0.001	0.001	0.002	0.012	0.000	0.000	0.000	0.000	0.009
5	0.003	0.002	0.002	0.003	0.010	0.001	0.001	0.001	0.001	0.005
6	0.000	0.003	0.002	0.003	0.018	0.000	0.002	0.001	0.002	0.012
7	0.002	0.003	0.002	0.003	0.110	0.001	0.002	0.001	0.001	0.007
8	0.002	0.002	0.002	0.005	0.034	0.001	0.001	0.000	0.001	0.014
9	0.005	0.002	0.004	0.009	0.006	0.002	0.002	0.002	0.004	0.006
10	0.002	0.002	0.026	0.004	0.103	0.001	0.000	0.001	0.003	0.014
11	0.000	0.002	0.004	0.003	0.009	0.000	0.000	0.003	0.005	0.002
12	0.000	0.003	0.003	0.006	0.016	0.000	0.002	0.002	0.002	0.012
13	0.004	0.001	0.023	0.006	0.029	0.001	0.002	0.002	0.001	0.012
14	0.002	0.003	0.010	0.009	0.019	0.001	0.000	0.003	0.002	0.006
15	0.000	0.002	0.011	0.002	0.018	0.000	0.000	0.001	0.002	0.010
16	0.000	0.000	0.002	0.003	0.010	0.000	0.000	0.001	0.001	0.002
17	0.000	0.000	0.000	0.001	0.007	0.000	0.000	0.000	0.000	0.000
Minimum	0.000	0.000	0.000	0.001	0.006	0.000	0.000	0.000	0.000	0.000
Maximum	0.005	0.003	0.026	0.009	0.110	0.002	0.002	0.003	0.005	0.014
Average	0.001	0.002	0.006	0.004	0.025	0.000	0.001	0.001	0.002	0.007
*	0.01	--	0.10	0.20	5.00	0.01	--	0.10	0.20	5.00

*Permissible limit according to Ayers and Westcot, (1985).

This may be due to the adsorption of the micro elements and heavy metals on the dissolved colloids in water of the stream which precipitate at the bottom. These results are in agreement with El-Kholy *et al.* (2015) and Sherif *et al.* (2015) who reported that, the values of heavy elements are considerably below the permissible limits.

III. Soils pH and salinity irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) in different sites during summer and winter seasons.

Soil pH values in different sites are illastrated in Table (6). The soil pH values for all sites was ranged from normal and slightly alkaline. The results showed that the soil pH and EC values ranged from (7.18 to 7.98 and 7.56 to 7.93) and (2.04 to 17.50 and 1.36 to 7.70 dS m^{-1}) in summer and winter seasons, respectively. Fatih *et al.* (2007) found that soil pH values increased with soil depth, while soil irrigated with wastewater were lower compared to soil irrigated with non-wastewater; this was probably ascribed to high load of organic matter in wastewater.

Table 6: Some chemical analysis of surface and sub-surface soil irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites during summer and winter seasons.

Sites No.	Soil depth in cm	pH	EC (dS m^{-1})	pH	EC (dS m^{-1})
		Summer season		Winter season	
1	0-20	7.30	11.62	7.80	7.70
	20-40	7.84	4.19	7.90	4.77
2	0-20	7.40	13.18	7.80	3.55
	20-40	7.60	4.12	7.93	3.43
3	0-20	7.18	4.95	7.90	4.15
	20-40	7.98	3.26	7.90	3.09
8	0-20	7.70	17.50	7.66	6.84
	20-40	7.70	10.80	7.66	2.09
10	0-20	7.70	15.25	7.72	5.75
	20-40	7.60	6.85	7.72	2.49
11	0-20	7.55	17.40	7.56	4.89
	20-40	7.90	2.97	7.80	2.90
15	0-20	7.60	5.99	7.75	3.55
	20-40	7.90	2.04	7.69	1.36
Minimum		7.18	2.04	7.56	1.36
Maximum		7.98	17.50	7.93	7.70
Average		7.64	8.58	7.77	4.04

The increased in soil salinity may be due to the high salinity of the agricultural drainage water used in irrigation as well as the untreated domestic wastewater and human activities which discharged along El-Mohett and El-Rahawy drains as well as reused in irrigation. High temperature in summer season, leading to the high evaporation from water and soils surface. Use this type of water which of highly salts beside evaporation from soils surface leading to the drying; then rise of salts by the poetic property to surface soil, leading to the increase of content of salts in the soil as a result of the infiltration water from soil and drought.

IV. Available micro-nutrient and heavy metal contents in soils.

Available content of micro-nutrient and heavy metals in surface and sub-surface soils irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites during summer and winter seasons are presented in Tables (7 and 8). Data explained that available Fe, Mn, Zn and Cu in summer and winter seasons were very high content and more highly limits allowed according to Soltanpour and Schwab (1991), but B, Cd, Co, Cr, Ni and Pb are within the safe limits allowed according to Soltanpour and Schwab (1991); Elrashidi *et al.* (2003) and Michael *et al.* (2007). The average values of available micro-nutrients and heavy metals content of soils in summer and winter seasons were (23.335, 7.743, 4.319, 6.576, 0.084, 0.017, 0.050, 0.018, 0.375 and 1.129 mg kg^{-1}) and (17.512, 6.230, 3.282, 5.508, 0.068, 0.01, 0.035, 0.013, 0.307 and 0.830 mg kg^{-1}) for Fe, Mn, Zn, Cu, B, Cd, Co, Cr, Ni and Pb, respectively.

Table 7: Available micro nutrients in surface and sub-surface soil irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites and seasons.

Sites No.	Soil depth (cm)	Soil micro-nutrient content (mg kg^{-1})									
		Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
		Summer season					Winter season				
1	0-20	24.268	7.652	3.758	6.636	0.100	17.454	6.214	3.362	6.144	0.090
	20-40	21.220	5.586	3.052	5.868	0.044	15.076	5.966	3.220	5.348	0.038
2	0-20	12.814	12.454	3.704	4.784	0.180	9.620	8.866	3.316	4.784	0.128
	20-40	12.078	8.130	2.092	4.600	0.052	8.468	5.806	1.824	4.378	0.058
3	0-20	18.520	7.054	3.524	6.192	0.220	16.078	8.106	2.876	4.726	0.204
	20-40	14.384	2.760	2.800	6.012	0.082	11.170	4.520	2.094	4.418	0.062
8	0-20	24.598	10.630	4.984	5.858	0.080	9.968	10.190	3.862	5.324	0.082
	20-40	19.116	8.144	2.692	5.646	0.040	4.510	4.424	1.872	5.324	0.034
10	0-20	52.910	8.516	9.502	12.382	0.116	47.366	8.128	8.463	9.712	0.056
	20-40	42.408	7.596	7.428	9.398	0.040	39.190	5.718	7.486	8.064	0.038
11	0-20	31.614	11.076	8.172	7.472	0.110	20.170	7.756	3.214	6.614	0.084
	20-40	21.218	5.322	4.908	7.344	0.044	15.570	4.128	1.662	5.380	0.036
15	0-20	16.724	7.648	2.350	5.032	0.044	15.910	4.066	1.854	3.448	0.028
	20-40	14.814	5.828	1.506	4.838	0.024	14.622	3.332	0.848	3.442	0.020
Minimum		12.078	2.760	1.506	4.600	0.024	4.510	3.332	0.848	3.442	0.020
Maximum		52.910	12.454	9.502	12.382	0.220	47.366	10.190	8.463	9.712	0.204
Average		23.335	7.743	4.319	6.576	0.084	17.512	6.230	3.282	5.508	0.068
Critical limit		> 5.0[a]	> 1.0[a]	> 1.5[a]	> 0.5[a]	0.80[b]	> 5.0[a]	> 1.0[a]	> 1.5[a]	> 0.5[a]	0.80[b]

a- Soltanpour and Schwab (1991), b-Michael *et al.* (2007).

Table 8: Available heavy metals in surface and sub-surface soil irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites and seasons.

Sites No.	Soil depth (cm)	Soil heavy metal content (mg kg^{-1})									
		Cd	Co	Cr	Ni	Pb	Cd	Co	Cr	Ni	Pb
		Summer season					Winter season				
1	0-20	0.016	0.038	0.020	0.290	1.748	0.016	0.026	0.014	0.252	1.204
	20-40	0.012	0.022	0.012	0.276	1.660	0.012	0.012	0.012	0.194	0.832
2	0-20	0.028	0.114	0.018	0.546	1.642	0.010	0.086	0.010	0.342	1.414
	20-40	0.008	0.090	0.006	0.390	1.194	0.008	0.062	0.004	0.168	1.190
3	0-20	0.016	0.060	0.024	0.368	0.918	0.010	0.046	0.020	0.344	0.594
	20-40	0.012	0.012	0.010	0.332	0.624	0.006	0.004	0.004	0.284	0.242
8	0-20	0.024	0.064	0.048	0.426	1.476	0.008	0.038	0.036	0.396	0.724
	20-40	0.022	0.054	0.016	0.378	1.268	0.008	0.014	0.008	0.230	0.586
10	0-20	0.024	0.062	0.018	0.404	1.358	0.018	0.052	0.016	0.654	1.486
	20-40	0.018	0.054	0.016	0.378	1.176	0.012	0.052	0.012	0.442	1.110
11	0-20	0.020	0.070	0.026	0.764	1.258	0.012	0.044	0.020	0.354	0.974
	20-40	0.020	0.030	0.018	0.260	0.704	0.010	0.020	0.014	0.162	0.690
15	0-20	0.012	0.020	0.008	0.236	0.416	0.006	0.020	0.006	0.286	0.316
	20-40	0.012	0.016	0.006	0.196	0.358	0.006	0.014	0.006	0.190	0.264
Minimum		0.008	0.012	0.006	0.196	0.358	0.006	0.004	0.004	0.162	0.242
Maximum		0.028	0.114	0.048	0.764	1.748	0.018	0.086	0.036	0.654	1.486
Average		0.017	0.050	0.018	0.375	1.129	0.010	0.035	0.013	0.307	0.830
Critical limit		0.31[b]	-- [b]	8.0[b]	8.1[b]	13.0[b]	0.31[b]	-- [b]	8.0[b]	8.1[b]	13.0[b]

b- Michael *et al.,* (2007).

V. Total micro-nutrients and heavy metal contents in soils.

The values of micro-nutrient and heavy metal contents are presented in Tables (9 and 10). The sequence of elements according to their total content in surface and sub-surface soil during summer season was Fe > Mn > Cr > Zn > Cu > Ni > B > Co > Pb > Cd. The sequence of micro elements and heavy metals according to their total content in surface and subsurface soil during winter season was Fe > Mn > Cr > Zn > Cu > Ni > Co > Pb > Cd > B.

The studied elements are toxic with respect to the total concentration of cadmium only in all sites at two seasons; and total iron in sites No. 1 and 3 in summer season, but the other elements were non-toxic and within the safe limits allowed exception Cr and Ni in sites No.1 and 3 in summer and winter season; according to (EU, 2002). The averages of total elements of soils in summer and winter seasons were (37852, 744.6, 71.7, 54.3, 2.4, 8.9, 19.2, 94.7, 50.1 and 17.6 mg kg^{-1}) and (40040, 660.8, 61.8, 46.7, 2.2, 7.4, 18.4, 82.7, 50.0 and 16.6 mg kg^{-1}) for Fe, Mn, Zn, Cu, B, Cd, Co, Cr, Ni and Pb, respectively.

Table 9: Total micro-nutrients contents in surface and sub-surface soil irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites and seasons.

Sites No.	Soil depth (cm)	Soil micro-nutrient content (mg kg^{-1})									
		Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
		Summer season					Winter season				
1	0-20	73410	884.7	73.0	52.9	41	70470	705.2	67.3	51.7	39
	20-40	67920	642.0	66.6	50.8	35	65655	641.2	51.8	50.9	32
2	0-20	30899	643.5	67.5	48.2	26	27466	597.8	62.8	47.3	22
	20-40	27299	545.5	53.0	42.5	22	25023	590.1	52.5	41.9	21
3	0-20	58620	875.7	74.6	68.6	36	53591	734.0	61.2	52.0	29
	20-40	58410	832.2	72.8	53.3	36	52591	733.0	57.3	48.2	23
8	0-20	35775	773.5	69.5	55.0	26	34073	722.4	67.1	44.4	21
	20-40	32600	534.6	49.0	55.0	25	32382	699.1	48.8	43.6	20
10	0-20	38831	818.6	90.4	68.0	27	36855	816.5	87.8	50.2	22
	20-40	36475	674.0	81.2	54.7	22	33767	695.7	83.0	49.4	18
11	0-20	34812	802.8	89.2	64.2	125	33333	582.2	64.1	43.3	16
	20-40	32664	642.9	73.3	50.3	22	31452	547.5	51.8	43.4	15
15	0-20	35335	968.6	75.2	46.3	14	33668	634.0	56.6	43.6	13
	20-40	32507	823.3	65.0	45.0	12	30276	551.9	53.4	43.5	13
Minimum		27299	534.6	49.0	42.5	12	25023	547.5	48.8	41.9	13
Maximum		58620	968.6	90.4	68.6	41	70470	816.5	87.8	52.0	39
Average		37852	744.6	71.7	54.3	26	40043	660.8	61.8	46.7	22
Critical limit		200-50000[a]	20-10000[a]	300-600[b]	2-250[a]	--	200-50000[a]	20-10000[a]	300-600[b]	2-250[a]	---

a Kabata-Pendias and Pendies (1992). b-ISI. (1983).

Table 10: Total heavy metals in surface and sub-surface soils irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites and seasons.

Sites No.	Soil depth (cm)	Soil heavy metals content (mg kg^{-1})									
		Cd	Co	Cr	Ni	Pb	Cd	Co	Cr	Ni	Pb
		Summer season					Winter season				
1	0-20	10.1	21.8	147.6	107.2	22.1	9.5	21.9	143.4	160.5	19.6
	20-40	6.5	21.6	67.4	57.0	21.1	5.8	21.0	41.2	41.1	18.4
2	0-20	6.5	17.6	121.1	59.7	20.9	6.3	17.0	117.2	53.0	20.1
	20-40	6.2	16.0	62.3	49.2	19.5	5.7	15.5	45.5	43.3	18.3
3	0-20	17.5	25.3	157.8	77.4	19.2	14.2	22.7	152.3	48.7	18.4
	20-40	15.2	20.9	122.3	52.1	16.1	13.5	19.6	114.9	38.4	14.4
8	0-20	12.2	19.9	96.1	42.8	16.4	8.4	18.0	62.0	35.0	15.3
	20-40	9.5	19.6	50.1	40.6	14.4	7.9	14.3	49.4	30.3	13.9
10	0-20	7.6	20.8	108.8	51.8	18.4	6.3	19.6	76.4	48.0	18.2
	20-40	7.4	18.1	64.8	42.6	16.0	5.5	17.2	62.8	45.4	15.6
11	0-20	6.6	19.3	130.4	45.9	18.7	5.9	18.3	92.4	33.7	16.7
	20-40	5.8	19.3	105.2	44.9	17.0	4.7	17.7	90.2	32.7	15.1
15	0-20	6.3	17.8	60.2	49.4	18.3	5.3	17.8	57.1	46.9	14.2
	20-40	6.4	16.1	57.2	44.4	15.9	4.5	16.6	53.2	42.3	14.2
Minimum		5.8	16.0	50.1	40.6	14.4	4.5	14.3	41.2	30.3	13.9
Maximum		17.5	25.3	157.8	77.4	20.9	14.2	22.7	152.3	160.5	20.1
Average		8.9	19.2	94.7	50.1	17.6	7.4	18.4	82.7	50.0	16.6
Critical limit		3[a]	--	150[a]	75[a]	300[a]	3[a]	--	150[a]	75[a]	300[a]

a-European union standards (EU, 2002).

VI. Micro-nutrient and heavy metal contents in different plants irrigated for El-Mariouteya canal (El-Mohett and El-Rahawy drains) in different sites during summer and winter seasons.

Data showed in Table 11. the irrigation with low quality water generally leads to change in chemical properties of soil and consequently micro-nutrient and heavy metal contents in growing plants at sites under study. The different values of Fe, Mn, Zn, Cu, B, Cd, Co, Cr, Ni and Pb in plants grown in soils irrigated from (El-Mohett and El-Rahawy drains) at different sites during summer and winter seasons was obtained. The lowest content values in summer for Fe, Zn, Cu, B and Cr respectively, found in Maize plant; for Mn and Ni found in Eggplant fruits. While the highest content values for Fe, Mn, Co, Ni and Pb were found in Okra fruits, as well as Zn, B and Cr found in Arugula. In winter season, the lowest content values found in Wheat plant at site 3 the content values were (99.0; 1.9, 0.20, 0.04 and 0.02 mg kg^{-1}) for Fe, B, Co, Cr and Ni respectively; Also found in Cabbage plant at site 15 the content values were 26.60 mg kg^{-1} for Mn; 12.9 mg kg^{-1} for Zn and 3.7 mg kg^{-1} for Cu. While, the highest content values were (866.0 and 0.35 mg kg^{-1}) for Fe and Cr respectively, in Onion plant; (71.6; 54.4 and 15.4 mg kg^{-1}) for Mn, Zn and Cu respectively, in Spinach ; (18.3 mg kg^{-1}) for B in Parsley. Also highest content values were (1.5 and 0.13 mg kg^{-1}) for Co and Ni in Cabbage at site 15.

Generally, the sequence of micro- nutrients and heavy metals in the studied plants were as follows: - Fe > Mn > Cu > Zn > B > Co > Cr > Ni > Pb at winter season; as well as in summer the sequence were as follows: - Fe > Mn > Zn > B > Cu > Co > Cr > Ni. It is clear from the previous results that Cd not found at summer and winter seasons. The Pb content at summer season found in Okra fruits at site 2; Elephant forage at site 3; and Molokhia at site 15 were respectively; whereas Pb was not found in all growing plants at winter season.

Table 11: Micro nutrients and heavy metal content in different plants grown in soil irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites and seasons.

Season	Site No.	Plants namely	Concentration mg kg^{-1} Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
Summer season	1	Arugula	1257	58.0	94.0	44.0	22.0	0.00	0.80	3.28	0.08	0.00
	2	Okra fruits	5857	117.0	46.2	109.8	11.2	0.00	8.60	2.26	0.72	3.00
	3	Elephant forage	3476	77.6	57.0	63.6	8.8	0.00	3.80	1.47	0.32	0.20
	8	Elephant forage	1352	23.2	32.6	29.6	8.0	0.00	0.60	0.69	0.08	0.00
	10	Eggplant fruits	535	13.2	30.8	20.8	15.2	0.00	0.00	0.44	0.01	0.00
	11	Maize	519	44.6	15.9	13.5	3.8	0.00	0.60	0.24	0.07	0.00
	15	Molokhia	4357	79.2	34.8	90.2	10.0	0.00	4.40	2.27	0.48	0.60
Minimum			519	13.2	15.9	13.5	3.8	0.00	0.00	0.24	0.01	0.00
Maximum			5857	117.0	94.0	109.8	22.0	0.00	8.60	3.28	0.72	3.00
Average			2479	59.0	44.5	53.1	11.3	0.00	2.69	1.52	0.25	0.54
Winter season	1	Cabbage	516	32.8	23.2	9.0	16.5	0.00	0.30	0.14	0.03	0.00
	2	Parsley	496	30.9	26.1	14.2	18.3	0.00	0.80	0.15	0.04	0.00
	3	Wheat	99	29.1	18.5	4.9	1.9	0.00	0.20	0.04	0.02	0.00
	8	Mallow	649	44.3	42.7	11.7	11.4	0.00	0.50	0.09	0.04	0.00
	10	Onion	866	41.3	22.5	10.6	5.6	0.00	1.20	0.35	0.08	0.00
	11	Spinach	515	71.6	54.5	15.4	14.2	0.00	0.90	0.20	0.07	0.00
	15	Cabbage	478	26.6	12.9	3.7	3.8	0.00	1.50	0.34	0.13	0.00
Minimum			99	26.6	12.9	3.7	1.9	0.00	0.20	0.04	0.02	0.00
Maximum			866	71.6	54.5	15.4	18.3	0.00	1.50	0.35	0.13	0.00
Average			517	39.5	28.6	9.9	10.2	0.00	0.77	0.19	0.06	0.00
Critical levels*			50-250	20-300	20-50	5-20	--	0.02-1.2	--	--	0-4	0.1-30

*Bennett (1993), Adriano (1986); Misra and Mani (1991).

VII. Bio concentration factor (BCF) for plants irrigated from El-Mohett drain:

Plants may represent an important source of elements for humans as it is well known that metals in soil may be taken up by plants and enter the food chain. The BCR of different plants tissues grow in soil irrigated from (El-Mohett and El-Rahawy drains) at different sites during summer and winter seasons are presented in Table (12). Data showed that, each plant has specified capability to accumulate elements in their tissue *i.e.* generally most plants were considered hyper-accumulator for (Fe, Mn, Zn, Cu, B, Co, and Cr); as well as Cd was not hyper-accumulator at summer and winter seasons. In summer season; Eggplant fruits with Co; Arugula, Elephant feed at sites 3 and 8, Maize with Ni and Pb; it considered not hyper-accumulator. Concerning winter season; Cu was not hyper-accumulator with Wheat, Mallow and Onion, also Cd, Ni and Pb were not hyper-accumulator with all plants under studied. Cabbage in site 15 was not hyper-accumulator with all elements this may be do you to irrigation water source not polluted it's irrigated from Nile river. This behavior could be attributed to one or more of the following processes: (1) plant adsorb heavy metals, translocate them through tonoplast and accumulate in vacuoles, thereby, protecting cell metabolism from metal toxicity; (2) binding of the cationic element form to the anionic sites in the cell wall; (3) binding to non-proteinaceous polypeptides (Phyto 12 chelati and ons) and accumulate in the vacuole. Sekar *et al.* (2004) and Zhu *et al.* (1999). The advantage of high biomass productive and easy disposal makes plants most useful to remediate heavy metals on site.

Based on knowledge of the heavy metal accumulation in plants, it is possible to select those species of crops and pasturage herbs, which accumulate fewer heavy metals, for food cultivation and fodder for animals, and to select those hyper accumulation species for extracting heavy metals from soil and water.

Table 12: The BCR of different plants tissues grow in soil irrigated from El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites.

Sites No.	Plants namely	Contents (mg kg^{-1})									
		Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
						Summer season					
1	Arugula	72.03	9.34	27.98	7.17	244.44	0.00	30.77	234.29	0.32	0.00
2	Okra fruits	608.84	13.19	13.92	22.97	86.15	0.00	100.00	225.60	2.10	2.12
3	Elephant feed	216.17	9.57	19.79	13.45	44.00	0.00	82.61	73.65	0.93	0.34
8	Elephant feed	135.61	2.28	8.45	5.56	100.00	0.00	15.79	19.17	0.21	0.00
10	Eggplant fruits	11.29	1.62	3.64	2.14	253.33	0.00	0.00	27.50	0.01	0.00
11	Maize	25.73	5.75	4.95	2.04	47.50	0.00	13.64	12.05	0.20	0.00
15	Molokhia	273.85	19.46	18.81	26.14	333.33	0.00	220.00	378.67	1.69	1.90
						Winter season					
1	Cabbage	21.26	4.29	6.17	1.36	165.00	0.00	7.89	6.90	0.10	0.00
2	Parsley	38.72	2.48	7.05	2.97	101.67	0.00	7.02	8.50	0.07	0.00
3	Wheat	4.02	2.74	3.71	0.84	23.75	0.00	3.13	0.85	0.04	0.00
8	Mallow	12.27	5.20	4.49	0.95	98.28	0.00	8.06	5.00	0.10	0.00
10	Onion	16.37	4.85	2.37	0.86	48.28	0.00	19.35	19.67	0.19	0.00
11	Spinach	30.80	9.36	23.19	3.06	322.73	0.00	45.00	25.38	0.31	0.00
15	Cabbage	0.01	0.04	0.23	0.08	0.29	0.00	0.08	0.01	0.00	0.00

VIII. Contamination Factors; Degree of Contamination, Modified Degree of Contamination and Pollution Load Index:

Soils irrigated from (El-Mohett and El-Rahawy drains) are assessed for contamination factors (CF), degree of contamination (Cd), modified degree of contamination (mCd) and the pollution load index (PLI). The results are shown in Table (13). It is obvious from these results that (CF) values indicated that soils were (CF) low with Zn, B and Pb for all sites; (CF) moderately with Cu and Co in all sites, (CF) low to moderate with Fe, Mn, Cr and Ni; (CF) low in for Fe in sites 2, 8, 11 and 15; and (CF) moderate at summer season in sites 1, 3 and 10. As well as in winter season was (CF) low in all sites except sites 1 and 3. With regard to Mn (CF) was a moderate in all sites except site 2; low at summer; but in winter season , considered was low in sites 2, 11 and 15 only and was moderate in sites 1, 3, 8 and 10. Concerning contamination factor for Cr was low in sites (2, 8 and 11) and (1 and 3) at summer and winter seasons respectively, and other sites was moderately. With regard to Ni (CF) was low in sites (8, 10, 11 and 15); and moderate in sites 1, 2 and 3 at summer season; while in winter season (CF) was low for all sites except site 1 was moderate; but showed very high with Cd. The contamination factor for the different metals generally followed the sequence Cd > Cu >Fe > Ni > Co > Mn > Cr > Pb > Zn > B. On the other hand, in winter season it can be concluded form these results that the highest contamination was for Cd in site 3 in winter and summer seasons.

In case of degree of contamination (Cd), soils at summer season considered high considerable (Cd) in sites (2, 10, 11 and 15) and high concentration, indicating serious anthropogenic pollution very high contamination in sites (1, 3 and 8); also (Cd) of soils at winter season was considerable in all sites except sites (1 and 3) (Cd) was very high, indicating serious anthropogenic pollution.

Table 13: Contamination factor, contamination degree, and modified degree of contamination and pollution load index of heavy metals in soil at El-Mariouteya canal (El-Mohett and El-Rahawy drains) at different sites during summer and winter seasons.

Seasons	Sites No.	Concentration of contamination factor (mg kg-1)										Contamination degree	Modified degree of contamination	Pollution load index
		Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb	Cd	mCd	PLI
Summer	1	1.98	1.37	0.49	1.84	0.22	28.06	1.46	1.21	1.88	0.925	39.44	3.94	1.47
	2	0.84	0.99	0.45	1.68	0.14	18.06	1.18	0.99	1.05	0.874	26.25	2.63	1.05
	3	1.58	1.36	0.50	2.39	0.19	48.61	1.70	1.29	1.36	0.803	59.78	5.98	1.50
	8	0.97	1.20	0.47	1.92	0.14	33.89	1.34	0.79	0.75	0.686	42.13	4.21	1.10
	10	1.05	1.27	0.61	2.37	0.14	21.11	1.40	0.89	0.91	0.770	30.51	3.05	1.18
	11	0.94	1.24	0.60	2.24	0.13	18.33	1.30	1.07	0.81	0.782	27.44	2.74	1.13
	15	0.96	1.50	0.51	1.61	0.07	17.50	1.20	0.49	0.87	0.766	25.47	2.55	0.95
Winter	1	1.91	1.09	0.45	1.80	0.21	26.39	1.47	1.18	2.82	0.820	38.13	3.81	1.43
	2	0.74	0.92	0.42	1.65	0.12	17.50	1.14	0.96	0.93	0.841	25.23	2.52	0.98
	3	1.45	1.14	0.41	1.81	0.15	39.44	1.52	1.25	0.85	0.770	48.80	4.88	1.25
	8	0.92	1.12	0.45	1.55	0.11	23.33	1.21	0.51	0.61	0.640	30.45	3.05	0.92
	10	0.99	1.26	0.59	1.75	0.12	17.50	1.32	0.63	0.84	0.762	25.76	2.58	1.03
	11	0.90	0.90	0.43	1.51	0.08	16.39	1.23	0.76	0.59	0.699	23.49	2.35	0.88
	15	0.91	0.98	0.38	1.52	0.07	14.72	1.20	0.47	0.82	0.594	21.66	2.17	0.82

The mCd suggested that the studied soil showed moderate degree of (mCd) in sites (1,2, 10, 11 and 15) and high degree of (mCd) in sites (3 and 8) at summer season; while in winter season, the values of (mCd) varied from 2.166 to 4.880. These values indicating moderate degree of (mCd) in all studied sites except site 3 showed high degree of (mCd). Pollution severity and its variation along the sites were determined with the use of pollution load index. This index is used to compare pollution status of different places (Tomlinson *et al.* 1980). In summer season, the values of pollution load index are found to be generally high (> 1) in all sites except site 15 was moderate (0.948). Consequently, the pollution load index suggested deterioration of site quality in all sites except site 15 showed base line pollution level of pollution level. These results confirmed that long term irrigation with polluted water might increase the accumulation of heavy metals in soil. Whereas, the values of PLI in winter season are found to be low (< 1) in sites (2, 8, 11 and 15), these values indicating perfection; whereas, and other sites (1, 3 and 10) showed PLI equal to 1.

References

Abrahim, G. and R. Parker, 2008. Assessment of heavy metal enrichment factors and the degree of contamination in marine sediments from Tamaki Estuary. Auckland, New Zealand. Envir. Monit. and Assess., 136 (1-3): 227 - 238.

Abrahim, G. M. S., 2005. Holocene sediments of Tamaki Estuary, characterization and impact of recent human activity on an urban estuary in Auckland, New Zealand, PhD Thesis Univ. of Auckland: Auckland, New Zealand, 5 - 275. P361.

Adepetu, J. A., H. Nabhan and A. Osinubi, 1996. Simple soil, water and plant testing techniques for soil resource management. Proceedings of a training course held in Ibadan, Nigeria, 16-27.

Adriano, D. C., 1986. Trace elements in the Terrestrial environment. Spring – Verlage.

Ali, M. M., M. L. Ali, S. Islam and Z. Rahman, 2016. Preliminary assessment of heavy metals in water and sediment of karnaphuli river, Bangladesh. Envir. Nanotechn., Monit. and Manag., 5: 27-35.

Ayers, R. S. and D. W. Westcot, 1985. Water quality for agriculture. FAO Irrigation and drainage paper 29 Rev. 1. Food and Agric. Org. Rome, 1, 74.

Balkhair, K. S. and M. A. Ashraf, 2016. Field accumulation risks of heavy metals in soil and vegetable crop irrigated with sewage water in western region of Saudi Arabia. Saudi J. of biological sciences, 23 (1): 32-44.

Bennett, W. F., 1993. Nutrient deficiencies and toxicities in crop plants. College of Agric. Sci. Nautural Resources, Texas Tech Univ., Lubbock, Berlin, Heidelberg, New York, p.536.

Bradford, G. R., A. C. Change, A. L. Page, D. Bakhtar, J. A. Frapton and H. Wright, 1996. Background concentrations of Trace and Major Elements in California Soils. Dr. Andrew C. Chang, Department of Environmental Sciences University of CA, Riverside, CA 92521.p 1-32.

Cottenie, A., M. Verloo, L. Kiekens, G. Velghe and R. Camerlynck, 1982. Chemical analysis of plants and soils. Lab. of Analyt. and Agro. State, Univ. Ghent. Belgium.

Ekengele, L. N., A. Blaise and M. C. Jung, 2017. Accumulation of heavy metals in surface sediments of lere lake, Chad. Geosciences Journal, 21 (2): 305-315.

El Tohamy, S. A., Y.I. Mahmoud, M. M. I. Afifi and Wafaa A. Hafez, 2015. Environmental impact of using low quality water in irrigation. J. Soil Sci. and Agric. Eng., Mansoura Univ., 6 (9): 1029 – 1052.

El-Kholy, M. M., A. E. A. Sherif, Y. I. Mahmoud and G.A.M.El-Sayed, 2015. Evaluation of the contamination caused by human activities on EL-Zomor canal, EL-Giza Governorate. J. Soil Sci. and Agric. Eng., Mansoura Univ., 6 (2): 323 – 336.

Elrashidi, M. A., M.D. Mays and C.W. Lee, 2003. Assessment of Mehlich3 and Ammonium Bicarbonate-DTPA Extraction for Simultaneous Measurement of Fifteen Elements in Soils. Communications in Soil Science and Plant Analysis, 34(19-20).

Ene, A., I.V. Popescu, and C. Stihi, 2009. Applications of proton-induced X-ray emission technique in materials and environmental science. Ovidius Univ Ann Chem, 20, (1): 35-39.

EPA Guidelines, 2007. Regulatory monitoring and testing water and wastewater sampling.

EPA., 1991. Methods for the Determination of Metals in Environmental Samples. Office of research and development Washington DC 20460 pp. 23 - 29 and 83 -122.

European Union Standards EU, 2002. Heavy metals in wastes, European commission on environment.

FAO., 1985. Water quality for agriculture. Paper No. 29 (Rev. 1) UNESCO, Publication, Rome Italy.

FAO., 1992. Wastewater Treatment and use in Agriculture. Pescod MB. Irrigation and Drainage Paper 47. Food and Agricultural Organization (FAO), Rome.

Fatih, M. K., T. Metin, S. Ustun, A. Ilker and A. Omer, 2007. Effects of wastewater irrigation on soil and Cabbage-plant (*Brassica olerecea* var. capitate cv. yalova-1) chemical properties and Mustafa Okuroglu1 J. Plant Nutr. Soil Sci., 170: 166–172.

Fytianos, K., G. Katsianis, P. Triantafyllou and G. Zachariadis, 2001. Accumulation of heavy metals in vegetables grown in an industrial area in relation to soil. Bulletin of environmental contamination and toxicology, 67 (3): 0423-0430.

Gaber, H. S., M. A. El-Kasheif, S. A. Ibrahim and M. M. N. Authman, 2013. Effect of Water Pollution in El-Rahawy Drainage Canal on Hematology and Organs of Freshwater Fish *Clarias gariepinus.* World Appl. Sci. J., 21 (3): 329-341.

Hakanson, L., 1980. Ecological risk index for aquatic pollution control: Sediment logical approach, Water Res., 14: 975–1001.

ICARDA, "International Center for Agricultural Research in the Dry Areas" 2013. Methods of soil, Plant, and water analysis: A manual for the West Asia and North Africa region. Estefan, G., Sommer, R. and Ryan, J. 3th edition. Box 114/5055, Beirut, Lebanon.

ISI (Indian Standard Institution), 1983. Specifications for drinking and irrigation waters. IS: 10500. New Delhi, India.

Kabata-Pendias and Pendieas, 1992. Trace elements in soil and plants-CRC Press. inc., Boca Raton, Florida.

Kapourchal, S. A., S. A. Kapourchal, E. Pazira and M. Homaee, 2009. Assessing radish (*Raphanus sativus* L.) potential for phytoremediation of lead-polluted soils resulting from air pollution. Plant Soil Environ., 55 (5): 202-206.

Khan, H. A., I. A. Arif and A. A. Al Homaidan, 2012. Distribution pattern of eight heavy metals in the outer and inner tissues of ten commonly used vegetables. Intern. J. of food properties, 15 (6): 1212-1219.

Kiziloglu, F., M. Turan, U. Sahin, I. Angin, O. Anapali, and M. Okuroglu, 2007. Effects of wastewater irrigation on soil and Cabbage-plant (*Brassica olerecea* var. capitate cv. yalova-1) chemical properties. J. of Plant Nutr. and Soil Sci., 170 (1): 166-172.

Lei, M., B. H. Liao, Q. R. Zeng, P. F. Qin, and S. Khan, 2008. Fraction Distributions of Lead, Cadmium, Copper, and Zinc in Metal Contaminated Soil before and after Extraction with Disodium Ethylenediaminetetraacetic Acid. Communi. in Soil Sci. and Plant Analy., 39 (13-14): 1963 - 1978.

Likuku, A. S., K. B. Mmolawa and G. K. Gaboutloeloe, 2013. Assessment of heavy metal enrichment and degree of contamination around the copper-nickel mine in the selebi phikwe region, eastern Botswana. Envir. and Ecol. Res.,1 (2): 32-40.

Liu, W. H., J. Z. Zhao, Z. Y. Ouyang, L. Soderlund and G. H. Liu, 2005. Impacts of sewage irrigation on heavy metal distribution and contam. in Beijing, China. Envir. Intern., 31 (6): 805 - 812.

Liu, W. X., H. H. Li, S. R. Li, and Y. W. Wang, 2006. Heavy metal accumulation of edible vegetables cultivated in agricultural soil in the suburb of Zhengzhou City, People's Republic of China. Bulletin of Enviro. Contami. and Toxico., 76: 163–170.

Michael, C. A., K. P. O'Neil, and C. H Perry, 2007. Soil vital signs: A new Soil Quality Index (SQI) for assessing forest soil health. Res. Pap. RMRS-RP-65WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 12 p.

Misra, S. G. and D. Mani, 1991. Soil Pollution. Ashish Publishing House, New Delhi, India.

Mohamed, M. S., 2014. Geophysical and geochemical method in the detection of ground water contamination zones, El-Minia district, Egypt. M.S. degree, Fac. of Sci. Minia Univ.

Mustapha, H. I. and O. B. Adeboye, 2014. Heavy metals accumulation in edible part of vegetables irrigated with untreated municipal wastewater in tropical savannah zone, Nigeria. African J. of Envir. Sci. and Technology, 8 (8): 460-463.

Omotoso O.A. and O.J. Ojo, 2015. Assessment of some heavy metals contamination in the soil of river Niger floodplain at Jebba, central Nigeria. Water Utility J., 9: 71-80.

RMRS "Mountain Research Station, 2012. Sampling Procedure for Lake or Stream Surface Water Chemistry. United States Department of Agric., Forest Service, Rocky Mountain Res. Station, Res. Note RMRS-RN - 49.

Rowe, D. R. and I. M. Abdel-Magid, 1995. Handbook of Waste Water Reclamation and Reuse. Edition: 1 Publisher: CRC Press\Lewis Publishers.

Rusan, M. J. M., S. Hinnawi and L. Rousan, 2007. Long term effect of wastewater irrigation of forage crops on soil and plant quality parameters. Desalination, 215 (1): 143-152.

Sekar, K.C., N.S. Chary, C.T. Kamala, and Y. Amjaneyulu, 2004. Utilization of plant metal interactions for environmental management. Proceedings of Indian National Science Academy, Part B, Reviews and Tracts Biolo. Sci., 70: 1 pp. 13-30.

Sherif, A. E. A., M. M. El-Kholy and T. M. Salem, 2015. Risk assessment of trace elements toxicity through contaminated edible plants from polluted irrigation canal at Giza governorate, Egypt. Iranica J. of Energy and Envi., 6 (1): 47 - 55.

Singh, A., R. K. Sharma, M. Agrawal and F. M. Marshall, 2010. Health risk assessment of heavy metals via dietary intake of foodstuffs from the wastewater irrigated site of a dry tropical area of India. Food and Chem. Toxic., 48 (2): 611-619.

Soltanpour, P. N. and A. P. Schwab, 1991. Determination of nutrient availability element toxicity by AB-DTPA. Soil Test ICPS Adv. Soil Sci., 16: 165 - 190.

Tang, W. Z., Y. Zhao, C. Wang, B. Q. Shan, and J. G. Cui, 2013. Heavy metal contamination of overlying waters and bed sediments of Haihe Basin in China. Ecotox. Environ. Safe., 98: 317-323.

Tomlinson, D., J. Wilson, C. Harris and D. Jeffrey, 1980. Problems in the assessment of heavy-metal levels in estuaries and the formation of a pollution index. Helgolander Meeresuntersuchungen, 33 (1 - 4): 566 - 575.

Turekian, K. K. and K.H. Wedepohl, 1961. Distribution of elements in some major units of the earth's crust. Geolo. Soc. of Amer., Bulletin., 72: 175-192.

Zhu, Y.L., A. A. M. Zayed, J.H. Qian, M. Desoura, and N. Teery, 1999. Phytoaccumulation of trace elements by wetland plants: 11. water hyacinth. J. Environ. Qual. 23: 339-344.