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ENVIRONMENTAL RISKS ASSESSMENT FOR SOILS AND PLANTS IRRIGATED FROM El-MARIOUTEYA AND EL-RAHAWY DRAIN

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ABSTRACT

The objective of this study was to evaluate the environmental risks of water, soils, and plants from the El-Mariouteya Canal and El-Rahawy drain. To achieve this aim, 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 water; soils and plants. In addition to calculation of contamination factor (CF), degree of contamination (Cd), modified degree of contamination (mCd); pollution load index (PLI) and bio-accumulation factor of elements in plants. The obtained results indicated that the values of pH and (SAR) in the water were different from season to another season. (EC) values were very high and unsuitable for irrigation in summer season; while they were suitable for irrigation in winter season according to FAO. Regard to soil pH values tend to be normal, slightly and moderately alkaline and (EC) was ranged between 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 was found in Wheat yield. Manganese and nickel were found in the fruits of Eggplant, zinc and copper were found in Cabbage. While the highest concentrations of iron, manganese, copper, cobalt, chromium and nickel were found in Okra. Zinc was found in Spinach and boron was found in Watercress. BCF indicates that the most plants have more than 1 and showed high concentrations of heavy metals. The values of (CF) were low for both zinc, boron and lead for all sites 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 season.

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

INTRODUCTION

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 (Mohamed. 2014). 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 that Fe to be the most abundant element in water whereas Cd got the least concentration (Gaber *et al.*, 2013).

The application of wastewater increased the soil salinity, available micro-elements and decreased the soil pH. 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 wastewater (Rusan *et al.*, 2007). 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 (Ene *et al*, 2009). Elevated levels of heavy metals in irrigation water led to significantly higher concentrations of heavy metals in the soil compared to those obtained from clean water irrigated site (Singh *et al*., 2010).

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 (Fytianos *et al*., 2001). 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 (Kiziloglu *et al.*, 2007).

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 (Kapourchal *et al.*, 2009). 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 (Khan *et al.*, 2012). The concentrations of heavy metals in edible part of Spinach vary from metal to metal. 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 with cadmium being the lowest of all the metals analyzed (Mustapha and Adeboye. 2014).

The overall contamination of soils based on the CF values which 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) (Likuku *et al.,* 2013). 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 (Omotoso and Ojo. 2015). 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) (Ali *et al.,* 2016). 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 (Tang *et al.*, 2013). 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 (Ekengele *et al.*, 2017).

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

MATERIALS AND METHODS

1. The study area: El- Mariouteya canal (El-Moheet drain) 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. (1a). It extended from the south Giza to north El-Riah El-Naseri.

2. Water, soils and plants sampling: Samples of water, (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. Sites along (El-Moheet and El-Rahawy drains) are selected Fig. (1b). Surface water samples were collected from different sites according to (EPA, 2007 and 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.

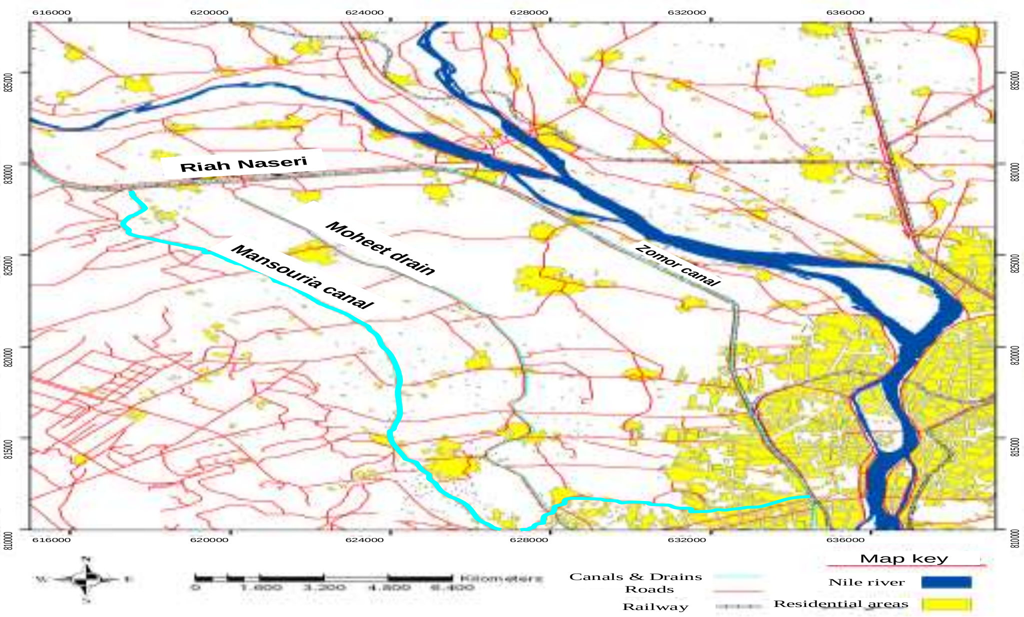

Fig. (1a): Location of the study area (El-Moheet drain).

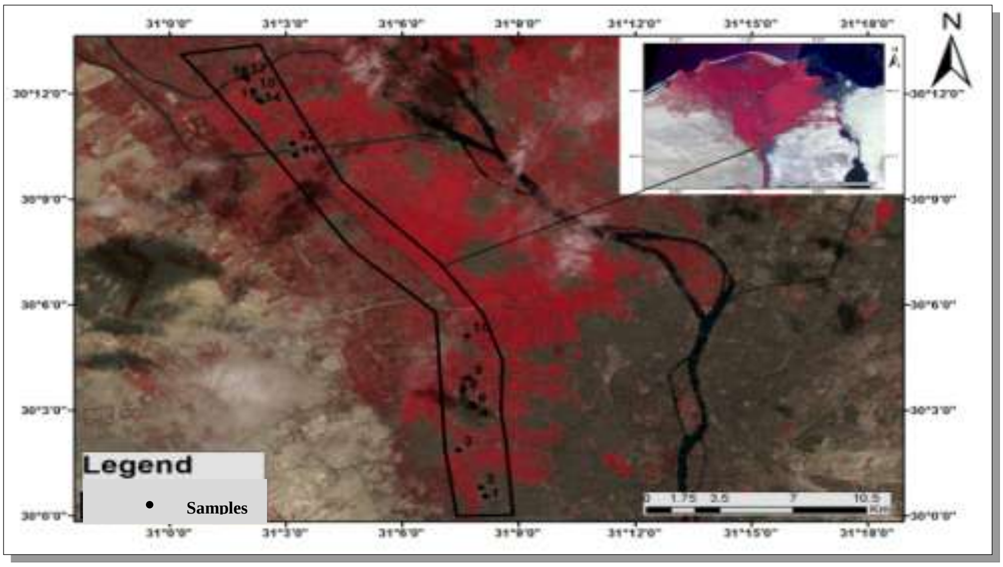

Fig. (1b): Map of the study area and sampling sites.

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; 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, finally washed with tap water to remove any kind of contamination like soil particles then placed in drying oven for 72 hours at

70 ºC after the dryness of the sample, it was completely grinded by using the stainless mill and digestion according to Adepetu *et al.*, (1996).

3. 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 are extracted according to AB-DTPA (Soltanpour and Schwab, 1991). For total elements, samples (water, soil and plants) were digested by aqua regia according to (Cottenie *et al.*, 1982; ICARDA. 2013). Different micro and heavy metals in water, soils and plants are determined according to (EPA, 1991) using Inductively Coupled Plasma (ICP) Spectrometry (*Ultima 2 JY Plasma*).

4. Data analysis:

<u>4.1. Contamination Factors (CF):</u> The contamination factor (CF) is used to determine contamination status in the studied surface soil samples (Liu *et al.*, 2005). The contamination factor is calculated according to Equation No. (1).

$$CF = \frac{\text{Measured concentration}}{\text{Background concentration}} \qquad (1)$$

The background concentrations of different elements under study in mg kg^{-1} in the Earth's crust were 37.001 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; Bradford *et al.*, 1996). The significance of contamination factor and the level of contamination values are described according to Hakanson (1980).

4.2. Contamination Degree (Cd): The Cd is the sum of the contamination factors of all the elements examined according to **Hakanson (1980)**.

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

4.3. Modified degree of contamination (mCd):

The (mCd) was defined as the sum of all contamination factors Abrahim (2005) and calculated as follows:

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

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). 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
CF > 6	Cd ≥ 36	8 ≤ mCd < 16	Very high contamination
—	—	16 ≤ mCd < 32	Extremely high contamination
—	—	mCd ≥ 32	Ultra-high contamination

4.4. The pollution load index (PLI):

The PLI proposed by Tomlinson *et al.*, (1980) is calculated using the following equation and level index tabulated in Table (2).

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

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

4.5. Bio concentration factor (BCF): The BCF is calculated according to Liu *et al.,* (2006) using the following equation

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

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

1. Assessment of irrigation water for EL-Mariouteya canal 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 are listed 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 dSm^{-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. Samples are 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 dSm^{-1}) and (1.26 to 6.72 dSm^{-1}) in winter and summer seasons, respectively. On the other hand, EC indicates 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 this wastewater for irrigation purposes.

Table (3): Assessment of chemical analysis in irrigation water for El-Mariouteya canal.

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
Min.	6.10	0.49	1.02	7.71	0.37	0.42
Max.	8.49	9.24	7.57	8.86	3.80	4.49

- RSC is zero in summer and winter seasons.

2. Micro-nutrients and heavy metals in irrigation water: The results of Tables (4 and 5) revealed that the concentrations (mg l^{-1}) of micro-nutrients and heavy metals in El-Mariouteya canal water during summer and winter seasons. Also, 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 showed that the mean heavy metal concentrations displayed the following decreasing order: Zn > Mn > Fe > B > Pb > Ni > Co ≈ Cr. Regarding the concentration of Cd, Co, Cr, Ni and Pb are very low compared with standard limits for irrigation water (FAO 1985 and 1992). As shown from Tables (4 and 5), the average micro-nutrients and heavy metal concentrations in summer season are higher than the average values in winter season. However, none of the heavy metals exceeded the recommended maximum concentrations of trace elements in irrigated water (Ayers and Westcot, 1985; FAO, 1992; Row and Abdel-Majid, 1995). This is mainly due to the clay texture of the sediment which can accumulate excessive amounts of elements on the surface. These results are in a good agreement with (El-Kholy *et al.,* 2015; Sherif *et al.*, 2015) which reported that the values of trace elements are considerably below the permissible limits.

Table (4): Assessment of micro-nutrients in irrigation water for El-Mariouteya canal.

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
Min.	0.105	0.035	0.088	0.004	0.032	0.050	0.016	0.025	0.003	0.002
Max.	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 (Ayers and Westcot, 1985).

Table (5): Assessment of heavy metals in irrigation water for El-Mariouteya canal.

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
Min.	0.000	0.000	0.000	0.001	0.006	0.000	0.000	0.000	0.000	0.000
Max.	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 (Ayers and Westcot, 1985).

3. pH and salinity in soils irrigated from El-Mariouteya canal at different sites during summer and winter seasons:

Soil pH values in different sites are listed in Table (6). The pH values for sites tend to be normal and slightly alkaline in all sites. 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. Results in Table (6) 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.

Table (6): Assessment of chemical analysis in surface and sub-surface soil irrigated from El-Mariouteya canal 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

Increasing in soil salinity may be due to high concentration of salts in agricultural drainage water used in irrigation as well as the untreated domestic wastewater and human activities which discharge along El-Moheet and El-Rahawy drains. High temperature in summer season leads to high evaporation from soil surface. Using this type of water which contains high salts and evaporation water from soil surface leading to drying then rise of salts by the poetic property to surface soil, leading to the increase of concentration of salts in the soil.

4. Available micro-nutrients and heavy metal contents in soils: Available concentrations of micro-nutrient and heavy metals in surface and sub-surface soils irrigated from El-Mariouteya canal 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 season are very high concentration 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; Michael *et al.,* 2007). The averages of available elements 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) and (17.512, 6.230, 3.282, 5.508, 0.068, 0.01, 0.035, 0.013, 0.307 and 0.830) for Fe, Mn, Zn, Cu, B, Cd, Co, Cr, Ni and Pb, respectively.

Table (7): Assessment of available micro nutrients in surface and sub-surface soil irrigated from El-Mariouteya canal.

Sites No.	Soil depth (cm)	Concentration 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): Assessment of available heavy metals in surface and sub-surface soil irrigated from El-Mariouteya canal.

Sites No.	Soil depth (cm)	Concentration 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 [b]	0.31[b]	-- [b]	8.0 [b]	8.1 [b]	13 [b]

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

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

Table (9): Assessment of total micro nutrients and heavy metals in surface and sub-surface soil irrigated from El-Mariouteya canal.

Sites No.	Soil depth (cm)	Concentration 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	4.1	70470	705.2	67.3	51.7	3.9
	20-40	67920	642.0	66.6	50.8	3.5	65655	641.2	51.8	50.9	3.4
2	0-20	30899	643.5	67.5	48.2	2.6	27466	597.8	62.8	47.3	2.2
	20-40	27299	545.5	53.0	42.5	2.2	25023	590.1	52.5	41.9	2.1
3	0-20	58620	875.7	74.6	68.6	3.6	53591	734.0	61.2	52.0	2.9
	20-40	58410	832.2	72.8	53.3	3.6	52591	733.0	57.3	48.2	2.3
8	0-20	35775	773.5	69.5	55.0	2.6	34073	722.4	67.1	44.4	2.1
	20-40	32600	534.6	49.0	55.0	2.5	32382	699.1	48.8	43.6	2.0
10	0-20	38831	818.6	90.4	68.0	2.7	36855	816.5	87.8	50.2	2.2
	20-40	36475	674.0	81.2	54.7	2.2	33767	695.7	83.0	49.4	1.8
11	0-20	34812	802.8	89.2	64.2	2.5	33333	582.2	64.1	43.3	1.6
	20-40	32664	642.9	73.3	50.3	2.2	31452	547.5	51.8	43.4	1.5
15	0-20	35335	968.6	75.2	46.3	1.4	33668	634.0	56.6	43.6	1.3
	20-40	32507	823.3	65.0	45.0	1.2	30276	551.9	53.4	43.5	1.3
Minimum		27299	534.6	49.0	42.5	1.2	25023	547.5	48.8	41.9	1.3
Maximum		58620	968.6	90.4	68.6	3.6	70470	816.5	87.8	52.0	3.9
Average		37852	744.6	71.7	54.3	2.4	40043	660.8	61.8	46.7	2.2
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 Pendieas (1992), b- ISI. (1983).

The studied elements are toxic with respect to the total form of cadmium element only in all sites at two seasons; and total iron in sites No. 1 and 3 in summer season, but the other elements were 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 (37852.0, 744.6, 71.7, 54.3, 2.4, 8.9, 19.2, 94.7, 50.1 and 17.6) and (40040.0, 660.8, 61.8, 46.7, 2.2, 7.4, 18.4, 82.7, 50.0 and 16.6) for Fe, Mn, Zn, Cu, B, Cd, Co, Cr, Ni and Pb, respectively.

Table (10): Assessment of total heavy metals in surface and sub-surface soils irrigated from El-Mariouteya canal.

Sites No.	Soil depth (cm)	Concentration 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- (EU, 2002).

6. Micro-nutrients and heavy metals contents in different plants irrigated for El-Mariouteya canal at different sites during summer and winter seasons: The irrigation with low quality water generally leads to change in chemical properties of soil and consequently micro-nutrients and heavy metals contents in growing plants. The concentrations of Fe, Mn, Zn, Cu, B, Cd, Co, Cr, Ni and Pb in plants grown in soils irrigated from at different sites during summer and winter seasons are showed in Table (11).

The Pb concentration in summer season in Okra fruits in site 2; Elephant forage in site 3; and Molokhia in site 15 were (3.00, 0.20, and 0.60 mg kg^{-1}), respectively; whereas Pb was not found in all growing plants at winter season. It is clear from the previous results that cadmium not found in detectable concentrations in summer and winter seasons. Generally, the sequence of heavy metals in the studied plants were as follows Fe > Cr > Ni > Mn > Zn > B > Cu > Co. In winter season results showed that the lowest concentration values were (99.0; 1.9, 0.20, 41.1 and 16.5 mg kg^{-1}) for Fe, B, Co, Cr and Ni found in Wheat yield; and Cabbage 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 concentration values were (866.0 and 354.0 mg kg^{-1}) for Fe and Cr were found in Onion; (71.6; 54.4 and 15.4 mg kg^{-1}) for Mn, Zn and Cu were found in Spinach; B was 18.3 mg kg^{-1} was found in Parsley; (1.50 and 129.1 mg kg^{-1}) for Co and Ni .

Table (11): Assessment of micro nutrients and heavy metals in different plants grown in soil irrigated from El-Mariouteya canal.

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	328.0	80.4	0.00
	2	Okra fruits	5857	117.0	46.2	109.8	11.2	0.00	8.60	2256.0	719.4	3.00
	3	Elephant forage	3476	77.6	57.0	63.6	8.8	0.00	3.80	1473.0	318.4	0.20
	8	Elephant forage	1352	23.2	32.6	29.6	8.0	0.00	0.60	69.0	81.6	0.00
	10	Eggplant fruits	535	13.2	30.8	20.8	15.2	0.00	0.00	44.0	6.0	0.00
	11	Maize	519	44.6	15.9	13.5	3.8	0.00	0.60	241.0	69.9	0.00
	15	Molokhia	4357	79.2	34.8	90.2	10.0	0.00	4.40	2272.0	483.8	0.60
Minimum			519	13.2	15.9	13.5	3.8	0.00	0.00	44.0	6.0	0.00
Maximum			5857	117.0	94.0	109.8	22.0	0.00	8.60	2272.0	719.4	3.00
Average			2479	59.0	44.5	53.1	11.3	0.00	2.69	954.7	251.4	0.54
Winter season	1	Cabbage	516	32.8	23.2	9.0	16.5	0.00	0.30	138.0	30.0	0.00
	2	Parsley	496	30.9	26.1	14.2	18.3	0.00	0.80	153.0	40.9	0.00
	3	Wheat	99	29.1	18.5	4.9	1.9	0.00	0.20	41.0	16.5	0.00
	8	Mallow	649	44.3	42.7	11.7	11.4	0.00	0.50	90.0	42.0	0.00
	10	Onion	866	41.3	22.5	10.6	5.6	0.00	1.20	354.0	76.6	0.00
	11	Spinach	515	71.6	54.5	15.4	14.2	0.00	0.90	203.0	72.4	0.00
	15	Cabbage	478	26.6	12.9	3.7	3.8	0.00	1.50	341.0	129.1	0.00
Minimum			99	26.6	12.9	3.7	1.9	0.00	0.20	41.0	16.5	0.00
Maximum			866	71.6	54.5	15.4	18.3	0.00	1.50	354.0	129.1	0.00
Average			517	39.5	28.6	9.9	10.2	0.00	0.77	188.6	58.2	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).7. Bio concentration factor (BCF):

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-Mariouteya canal 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 all plants were hyper-accumulator for (Fe, Mn, Zn, B, Co, Cr and Ni) at summer and winter seasons except Eggplant fruits with Co and Wheat plant with Cu were influences. As well as this the BCF for all plants with Cd and Pb; the plants can be an excluder except with Okra fruits and Molokhia. 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, **Sekar *et al.,* (2004)**, (2) binding of the cationic element form to the anionic sites in the cell wall **Zhu *et al.,* (1999)**, (3) binding to non-proteinaceous polypeptides (Phyto 12 chelations) and accumulate in the vacuole **Sacchi *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.

Sites No.	Plants namely	Concentration mg kg^{-1}									
		Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
Summer season											
1	Arugula	51.8	7.6	25.0	6.6	220.0	0.0	20.0	16400.0	277.2	0.0
2	Okra fruits	457.2	9.4	12.5	23.0	62.2	0.0	78.2	112800.0	1308.0	1.8
3	Elephant forage	187.7	11.0	16.2	10.3	40.0	0.0	63.3	73650.0	860.5	0.2
8	Elephant forage	55.0	2.2	6.5	5.1	100.0	0.0	10.0	1380.0	189.8	0.0
10	Eggplant fruits	10.1	1.5	3.2	1.7	126.7	0.0	0.0	2200.0	15.0	0.0
11	Maize	16.4	4.0	1.9	1.8	34.5	0.0	8.6	8033.3	92.0	0.0
15	Molokhia	260.6	10.4	14.8	17.9	250.0	0.0	220.0	227200.0	2015.8	1.4
Winter season											
1	Cabbage	29.6	5.3	6.9	1.5	183.3	0.0	10.0	13800.0	120.0	0.0
2	Parsley	51.6	3.5	7.9	3.0	140.8	0.0	8.9	15300.0	120.3	0.0
3	Wheat	6.2	3.6	6.4	1.0	9.5	0.0	4.0	2050.0	48.5	0.0
8	Mallow	65.1	4.3	11.1	2.2	142.5	0.0	12.5	2250.0	105.0	0.0
10	Onion	18.3	5.1	2.7	1.1	93.3	0.0	24.0	17700.0	117.8	0.0
11	Spinach	25.5	9.2	17.0	2.3	177.5	0.0	22.5	10150.0	206.9	0.0
15	Cabbage	30.0	6.5	7.0	1.1	126.7	0.0	75.0	34100.0	445.2	0.0

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

Soils irrigated from (El-Moheet 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 low in (CF) with Zn, B and Pb for all sites; moderately (CF) with Cu and Co in all sites, low to moderate (CF) with Fe, Mn, Cr and Ni;

low in (CF) for Fe in sites 2, 8, 11 and 15; and moderate (CF) at summer season in sites 1, 3 and 10. As well as in winter season was low (CF) in all sites except sites 1 and 3. With regard to Mn was a moderate (CF) in all sites except site 2 was low (CF) at summer; but in winter season was low (CF) in sites 2, 11 and 15 only and was moderate in sites 1, 3, 8 and 10. Concerning contamination factor for Cr was low (CF) in sites (2, 8 and 11) and (1 and 3) at summer and winter seasons respectively and other sites were moderately (CF). With regard to Ni was low (CF) in sites (8, 10, 11 and 15); and moderate (CF) in sites 1, 2 and 3 at summer season; while in winter season was low (CF) for all sites except site 1 was moderate; but showed very high (CF) 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 fall under considerable (Cd) in sites (2, 10, 11 and 15) and very high (Cd), indicating serious anthropogenic pollution in sites (1, 3 and 8); also (Cd), soils at winter season was fall under considerable (Cd) in all sites except sites (1 and 3) was very high (Cd), indicating serious anthropogenic pollution. 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 ($_m$Cd) 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.

Table (13): Contamination factor, contamination degree, and modified degree of contamination and pollution load index of heavy metals in soil at El-Mariouteya canal 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	28.056	1.46	1.21	1.88	0.925	39.436	3.944	1.466
	2	0.84	0.99	0.45	1.68	0.14	18.056	1.18	0.99	1.05	0.874	26.252	2.625	1.053
	3	1.58	1.36	0.50	2.39	0.19	48.611	1.70	1.29	1.36	0.803	59.784	5.978	1.498
	8	0.97	1.20	0.47	1.92	0.14	33.889	1.34	0.79	0.75	0.686	42.133	4.213	1.100
	10	1.05	1.27	0.61	2.37	0.14	21.111	1.40	0.89	0.91	0.770	30.512	3.051	1.175
	11	0.94	1.24	0.60	2.24	0.13	18.333	1.30	1.07	0.81	0.782	27.436	2.744	1.127
	15	0.96	1.50	0.51	1.61	0.07	17.500	1.20	0.49	0.87	0.766	25.466	2.547	0.948
Winter	1	1.91	1.09	0.45	1.80	0.21	26.389	1.47	1.18	2.82	0.820	38.125	3.812	1.433
	2	0.74	0.92	0.42	1.65	0.12	17.500	1.14	0.96	0.93	0.841	25.225	2.523	0.981
	3	1.45	1.14	0.41	1.81	0.15	39.444	1.52	1.25	0.85	0.770	48.800	4.880	1.249
	8	0.92	1.12	0.45	1.55	0.11	23.333	1.21	0.51	0.61	0.640	30.451	3.045	0.923
	10	0.99	1.26	0.59	1.75	0.12	17.500	1.32	0.63	0.84	0.762	25.759	2.576	1.033
	11	0.90	0.90	0.43	1.51	0.08	16.389	1.23	0.76	0.59	0.699	23.490	2.349	0.880
	15	0.91	0.98	0.38	1.52	0.07	14.722	1.20	0.47	0.82	0.594	21.661	2.166	0.823

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تقييم المخاطر البيئية للتربة والنبات المروى من ترعة المريوطية ومصرف الرهاوى.

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المستخلص

لقد أجريت هذه الدراسة بهدف تقييم المخاطر البيئية للمياه والتربة والنباتات التى تروى من ترعة المريوطية ومصرف الرهاوى. ولتحقيق هذا الهدف تم تقدير الأس الهيدروجينى ودرجة التوصيل الكهربى EC في المياه والتربة وكذالك نسبة الصوديوم المدمص (SAR) فى المياه كما تم تقدير بعض العناصر الصغرى والثقيلة فى كلاً من المياه والتربة والنباتات بالإضافة إلى حساب معامل التلوث (CF) ودرجة التلوث (Cd) ودرجة التلوث المعدلة (mCd) ومؤشرحمل التلوث (PLI) فى التربة ومعدل التراكم الحيوى للعناصر فى النبات.

تشير النتائج التى تم الحصول عليها إلى أن قيم الأس الهيدروجينى ونسبة الصوديوم المدمص فى المياه كانت تختلف من موسم لآخر. كانت قيم درجة التوصيل الكهربائى عالية جداً وغير صالحة للرى في فصل الصيف بينما كانت صالحة للرى فى فصل الشتاء طبقاً لمنظمة الأغذية والزرعة.

تراوحت درجة الأس الهيدروجينى في التربة بين المعتدل إلى القلوى المعتدل كما تراوحت قيم التوصيل الكهربائى بين تربة غير مالحة إلى تربة شديدة الملوحة بينما كان المحتوى الميسر للحديد والنمجنيز والنحاس بالتربة فى فصلى الصيف والشتاء مرتفع جداً.ولكن البورون والكادميوم والكوبالت والكروم والنيكل والرصاص كانت ضمن الحدود الآمنة.تجاوز المحتوى الكلي للكادميوم الحدود الآمنة فى كلا الموسمين، ولكن العناصر الأخرى كانت ضمن الحدود الآمنة.

وجد أن تركيزالحديد والبورون والكوبالت والكروم أقل فى محصول القمح كما وجد المنجنيز والنيكل في ثمار الباذنجان والزنك والنحاس في الكرنب. بينما أعلى تركيز لكلاً من الحديد والمنجنيز والنحاس والكوبالت والكروم والنيكل وجد فى ثمار البامية.أما الزنك وجد فى السبانخ والبورون وجد في الجرجير.يشير معامل التراكم الحيوى (BCF) إلى أن معظم النباتات أكثر من ١ وأظهرت تراكمًا عاليًا للعناصر الثقيلة.

كانت قيم معامل التلوث (CF) منخفضة لكلا من الزنك والبورون والرصاص لجميع المواقع ومتوسطة للنحاس والكوبالت في جميع المواقع ومنخفضة إلى متوسطة مع كلاً من الحديد والمنجنيز والكروم والنيكل مما يدل إلى أن هذا التلوث راجع إلى الأنشطة البشرية. درجة التلوث المعدلة (mCd) متوسطة إلى عالية فى بعض المواقع ومؤشر حمل التلوث (PLI) بشكل عام مرتفع (> ١) في جميع المواقع باستثناء موقع واحد كان متوسط فى حمل التلو. كان مؤشر حمل التلوث منخفض (<١) في بعض المواقع فى فصل الشتاء.

الكلمات المفتاحية: المياه، التربة، النبات، التلوث، تقييم مخاطر التراكم الحيوى.