Minufiya J. Agric. Res. Vol.37 No. 5(2): 1273-1289 (2012) "http://www.mujar.net"

مدى تأثير الري بالمياه العادمة لفترات طويلة على بعض الخصائص الكيميائية والطبيعية للتربة

أم محمد احمد خفاجى[١] ، محمد عبد الوارث محمود[٢] ، سحر قناوى محمد قناوى[١]

[١] جامعة الأزهر ، كلية العلوم (بنات) القاهرة – مصر

[٢] معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر

الملخص العربي

أجريت دراسات المسح الميداني في ثلاث مناطق ، وكانت أول منطقة ممثلة بمزرعة الجبل الأصفر ، والثانية ممثلة بمزرعة أبو رواش وهاتان المزرعتان ترويان بمياه الصرف الصحى المعالج لفترات طويلة. وأما المنطقة الثالثة فهى منطقة العاشر من رمضان والتى تروى بصرف صناعى .وكان الهدف من الدراسة هو دراسة مدى تأثير الرى لفترات طويلة بمياه الصرف الصحي ومياه الصرف الصناعى على بعض الخواص الكيميائية والفيزيائية للتربة المروية، وعلى محتوى التربة من المعادن الثقيلة والمغذيات

الصغرى. وقد تم جمع عينات التربة والمياه موسمياً لعامين متتاليين من كل منطقة من مناطق الدراسة لاستخدامها في التحليلات. و قد أظهرت النتائج ما يلى:

١ـ دلت النتائج على أن استمرار الرى بمياه الصرف الصحى لفترات طويلة ادى الى زيادة معنوية فى المادة العضوية ، وكذلك المغذيات الكبرى (النتروجين ، الفسفور والبوتاسيوم) فى التربة بينما أدى الى نقص فى قيم pH.

٢. زاد محتوى التربة المروية بمياه الصرف الصناعى من قيم pH ، قيم التوصيل الكهربى، الكاتيونات والانيونات الذائبة ، وكذلك المغذيات الكبرى.

٣– زاد محتوى التربة من المعادن الثقيلة (الكادميوم ،الكوبلت ،الرصاص والنيكل) والمغذيات الصغرى (الحديد ، الزنك ،النحاس و المنجنيز) في كلاً من التربة المروية بمياه الصرف الصحى المعالج وكذلك المروية بالصرف الصناعى ، وقد وجد ان اعلى تركيز لهذه العناصر كان فى التربة المروية بالصرف الصناعى تليها التربة المروية بمياه الصرف الصحى المعالج ، وأوضحت النتائج أن هذه العناصر تميل الى التراكم بالطبقة السطحية تليها الطبقة التحت سطحية .

وقد تعدت تركيزات المعادن الثقيلة والمغذيات الصغرى للتربة المروية بمياه الصرف الصحى المعالج وكذلك المروية بالصرف الصناعى الحدود المسموح بها دوليا طبقا لمنظمة الصحة العالمية.

LONG TERM EFFECT OF WASTEWATER IRRIGATION ON SOME CHEMICAL AND PHYSICAL CHARACTERISTICS OF SOIL

Om Mohamed A. Khafagi[1], M. M. Abdel Warth[2]
and Sahar M. K. Kenawy[1]
[1] Faculty of Science, Al-Azhar University (Girls), Cairo, Egypt
[2] Soils, Water and Environment Research Institute, Agric. Res. Center Giza, Egypt

(Received: Jul. 15, 2012)

ABSTRACT: *In this study, sites irrigated with treated sewage effluent (TSE), industrial effluent (IE) and sites of not irrigated (virgin soil) were sampled for assessing some chemical and physical characteristics to evaluate its long term effect. Seasonal samples of water used in irrigation were also collected. Long term wastewater irrigation increased organic matter and plant nutrients in the soil. The values of soil pH decreased as compared with those of virgin soil. Irrigation with industrial effluent lead to an increase in soil pH, EC, soluble cations and anions and macronutrients (N, P and K) in the soil. Wastewater irrigation had significant effect on soil heavy metals (Cd, Co, Ni and Pb) and micronutrients (Fe, Zn, Cu and Mn). The soil content of these heavy metals and micronutrients increased significantly in soil irrigated with TSE and IE and exceeded the maximum allowable concentration (MAC) ppm according to FAO and WHO (1993). Based on these results, it can be concluded that proper management of wastewater irrigation and periodic monitoring of soil quality parameters are required to ensure successful, safe, long term wastewater irrigation.*

***Key words**: Sewage effluent, Industrial effluent, heavy metals, soil long- term irrigation*

INTRODUCTION

The demand for water is continuously increasing in arid and semi-arid countries. Therefore, water of higher quality is preserved for domestic use while that of lower quality is recommended for irrigation of some restricted crops. Municipal wastewater is less expensive and considered an attractive source for irrigation in these countries (Al-Rashed and Sherif, 2000; Mohammad and Mazahreh, 2003), and any source of water which might be used economically and effectively should be considered to promote further development. (Kiziloglu *et al.* 2008).

The water supply-demand situation in Egypt is changing over time with ever increasing demand and shrinking supply due to climate change, increased withdrawals and pollution. Table 1 shows the current water resources in the year 2006 for Egypt according to Khan *et al.* 2010. As shown, major portion of water resources originates from the Nile River. Egypt is experiencing rapid population and urban growth which lead to additional demand on its limited water resources . The total population has increased from 33 million in 1965 to 76 million in 2007. It is anticipated that by year 2025 Egypt's total population will be about 100 million, thus, increasing the demand for scarce water and arable land. Based on the analysis of the available data, per capital water share has changed from 1,700 cubic meters per year in 1950 to 1.000 cubic meters per year in 2000 (Khan *et al.* 2010).

The most readily available and economic source is the wastewater effluent from Greater Cairo, Alexandria and other major cities. Since 1990, sewage water has been used to cultivate orchards in a sandy soil area at El- Gabal El-Asfar village, near

Cairo (FAO, 2003). The area gradually increased to about 10,000 feddans.

Table1. Water resources in Egypt for the year 2006 (Khan *et al.* 2010)

Water resources	Billion Cubic Meters (BCM)
River Nile	55.5
Agriculture Drainage water reuse in the delta	5.2
Groundwater in the valley and the delta	4.8
Rainfall and Floods	1.0
Treated Wastewater Reuse	0.7
Groundwater in the deserts and Sinai	0.57
Total	67.77

Many farmers, especially those in urban areas, use sewage because it is free of charge and abundant, even during droughts, and, being full of nitrates and water phosphates, acts as an effective fertilizer (Darvishi and Farahani, 2010). The use of wastewater has helped the farmers in different ways such as, increased food and money source (99%), school fees (45%), medication (10%) and clothing (30%). Those that are comfortable in using wastewater (62%), chose it because they thought that the water contains plant nutrients and there would be no need to buy fertilizers (Mutengu *et al.* 2007). The use of wastewater has helped to avoid the disposal of effluent into water bodies and subsequent process of eutrophication (Thomas *et al.* 2007).

The irrigation with wastewater has a high nutritive value that may improve plant growth, reduce fertilizer application and increase productivity of poorly fertile soil (Kiziloglu *et al.* 2008). Abd El- Lateef *et al.* (2006) collected irrigation water, soil and plant samples irrigated with secondary treated wastewater from two wastewater treatment plants in Cairo (El Gabal El- Asfar plant and El – Berka plant). They indicated that considerable amounts of macronutrients (NPK) were applied to the grown crops through the treated wastewater irrigation: N(19-79%), P (23-181%) and K (85-357%) of the recommended fertilizer rates according to the crop and experimental site. They cited that treated wastewater would generally provide approximately 50% of N and about 70% of P requirements but about 200 % of K requirements, although this varied widely according to the specific crop and whether this was calculated for a fertile or infertile soil.

Application of wastewater to cropland and forested lands is an attractive option for disposal because it can improve the physical properties and the nutrient content of soils. Wastewater irrigation provides water, N and P as well as organic matter to the soil.

The continuous application of sewage water to soils tended to lower their pH which may due to acidic nature of effluents and loading of organic substances. The variations in the decrease in pH may be due to the chemical characteristics and the amount of effluents used for irrigation. The sewage water used for irrigation is known to contain large amount of organic matter and the release of organic acids during the decomposition of organic matter may also responsible for decrease in pH of sewage irrigated soils (Sikka *et al.* 2009).

Klay *et al.* (2010) mentioned that the pH, organic compounds (C and N), salinity, some major elements (Na, Ca, Mg, K) and the soil EC indicates that the extended irrigation with treated wastewater involves, in our case, the increase of its salinity, which is dependent of the irrigation period. This salinization by Na could be responsible for the change the soil structure. Khan *et al.*

(2008) recorded that the application of wastewater has led to changing in some soil physiochemical characteristics and heavy metals uptake by food crops, particularly vegetables. The soil pH changes depend on pH of the wastewater used for irrigation, and the soil pH has a great influence on the mobility and bioavailability of heavy metals.

The toxicity and the mobility of heavy metals in soils depend not only on the total concentration, but also on their specific chemical speciation, their binding state, the metal properties, environmental factors and soil properties like pH, organic matter content and type, redox conditions and root exudates acting as chelates (Nyamangara, 1998). Heavy metals are generally not removed even after the treatment of wastewater at sewage treatment plants, and thus cause risk of heavy metal contamination of the soil and subsequently to the food chain (Fytianos *et al.* 2001).

This study aimed to assess the impact of irrigation for long term with wastewater on physicochemical characteristics and accumulation of heavy metals and micronutrients in soil .

MATERIALS AND METHODS

The present investigation included the field study which has been carried out in three sites. El- Gabal El- Asfar farm (EGAF), Abu- Rawash farm (ARF) and El-Ashir of Ramadan city (EAR), where soil, treated sewage effluent and industrial effluent samples were collected.

Water samples were taken in summer and winter seasons from the sources of irrigation water from each studied site , and kept in plastic bottles in a cool place. Analyses of water samples were determined according to the standard methods of Chapman and Pratt (1961). The macronutrients of N, P and K were determined according to Chapman and Pratt (1961). The heavy metals (Pb, Cd, Co and Ni) and micronutrients (Fe, Zn, Cu and Mn) were determined using Atomic Absorption Spectrophotometer (Perkin Elmer 3300).The soil samples were collected seasonally in triplicate for two successive years from July 2007- to January 2010 (summer and winter seasons) from the three sites. The soil samples were taken at two depths 0-30 and 30-60 cm using a soil Dutch auger and put in polyethelene bags. Surface litter was first scraped away at each sampling spot to remove plant debris. Samples were collected from twenty two sites, eleven locations from (EGAF), five locations from (ARF), three from (EAR) and three control locations from the three sites (virgin soil or uncultivated soil) as a control. The samples air dried, crushed gently, sieved through a 2mm sieve, mixed thoroughly and stored in polyethylene bags for analysis

Physical and chemical properties of the investigated soil were determined according to the standard methods of Page *et al.* (1982) and Clark *et al.* (1986). The pH was measured using a pH meter in soil suspension (1: 2.5) soil-water ratio, Electrical conductivity (EC) were determined in the saturated soil paste, available macronutrients were determined as outlined by Black (1965).

Available micronutrients were extracted using ammonium bicarbonate-(DTPA) and determined using Inductively Couped Plasma (ICP) Spectrometry model 400, as described by Soltanpour and Schwab (1977).

All obtained data were subjected to statistically analysis according to Sndecor and Cochran (1989), where means value were compared using L.S.D. at 5 % level.

RESULTS AND DISCUSSION

Irrigation Water:

Three sources of irrigation water were used in the present study namely, control (River Nile water , Mansouria canal and Ismailia canal from EGAF, ARF and EAR, respectively), treated sewage effluent (TSE) from both EGAF, ARF and industrial effluent (IE) from EAR . Irrigation water samples were collected during the period of investigation from the different sources and were analyzed in order to determine some of their chemical properties, heavy metals and micronutrients (Tables 2, 3 and 4).

Data in Table 2 showed that the mean values of all the studied parameters (EC, pH, Ca^{++}, Mg^{++}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-}, $SO_4^{=}$ and SAR) of industrial effluent (IE) used in irrigation in EAR recorded higher values than in the control for both summer and winter seasons.

Comparing the present results of irrigation water (Treated sewage effluent) used in EGAF with those used in EAR (Industrial effluent) the data reveal that the mean values of EC, Mg^{++}, Na^{+}, HCO_3^{-}, Cl^{-}, $SO_4^{=}$ and SAR increased by 2.1 folds, 1.4 folds, 3.9 folds, 1.4 folds, 3.8 folds, 1.1 folds and 3.8 folds, respectively in IE as compared with the corresponding ones in TSE used in irrigation in EGAF. Meanwhile the water content of Ca^{++}, K^{+} increased in TSE used in EGAF when compared with those used in EAR (Table 2).

The results of chemical characteristics (EC, Ca^{++}, Mg^{++}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-}, $SO_4^{=}$ and SAR) of TSE used in ARF indicated that the mean values of Ca^{++}, Mg^{++} increased significantly as compared with those used in EAR, meanwhile the mean values of EC, pH, Na^{+}, K^{+}, Cl^{-} and SAR recorded the highest values in IE as compared with those used in TSE used in irrigation in ARF. From the recorded results, it can be concluded that all the studied parameters recorded higher values in IE than that recorded in TSE which used in irrigation in both two farms. The obtained results are in accordance with those obtained by Khafagi *et al.* (2010).

Table(2). Chemical characteristics of irrigation water used in the studied locations (mean values)

Site	Type of water	Season	EC dS/m	pH	Soluble cation meq/l				Soluble anion meq/l				SAR
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	
EGAF	Control	summer seasons	0.72	7.12	2.49	2.20	2.28	0.25	0.00	3.24	1.60	2.38	1.49
	TSE		1.22	7.50	4.70	2.90	4.19	0.35	0.00	3.66	3.12	5.36	2.14
	LSD at 0.05		0.13		0.21	0.30	0.37	0.07		0.99	0.39	0.85	0.27
	Control	winter seasons	0.59	8.24	1.69	1.46	2.51	0.24	0.00	2.13	1.99	1.78	2.09
	TSE		1.12	7.26	4.27	2.29	4.05	0.42	0.00	2.09	3.70	5.23	2.23
	LSD at 0.05		0.11		0.97	0.16	0.41	0.16		0.39	0.66	0.72	0.60
ARF	Control	summer seasons	0.78	7.37	2.73	2.25	2.52	0.24	0.00	2.92	1.81	3.00	1.59
	TSE		1.45	7.38	5.05	4.44	3.58	0.33	0.00	3.73	3.75	5.91	1.64
	LSD at 0.05		0.23		0.14	0.30	0.23	0.09		0.54	0.34	0.74	0.13
	Control	winter seasons	0.58	7.36	1.78	1.61	1.80	0.34	0.00	1.82	1.55	2.16	1.43
	TSE		1.24	7.29	4.34	4.32	3.27	0.26	0.00	2.57	2.67	6.98	1.57
	LSD at 0.05		0.07		0.38	0.77	0.49	0.11		0.59	0.65	1.19	0.47
EAR	Control	summer seasons	0.60	7.15	1.86	1.56	2.25	0.27	0.00	1.85	1.69	2.40	1.77
	IE		2.51	8.42	4.17	3.79	16.64	0.43	0.00	3.65	15.71	5.68	8.37
	LSD at 0.05		0.15		0.58	0.56	1.03	0.09		0.55	0.32	0.50	0.90
	Control	winter seasons	0.57	7.24	2.08	1.90	1.49	0.18	0.00	2.41	1.37	1.88	1.05
	IE		2.36	8.62	3.86	3.26	16.06	0.36	0.00	3.07	14.37	6.10	8.53
	LSD at 0.05		0.17		0.29	0.27	1.28	0.06		0.28	0.84	0.32	0.92
Summer seasons													
LSD at 0.05													
EGAF & ARF			0.24		0.17*	0.31*	0.30*	0.08		0.51	0.44*	0.62	0.15*
EGAF & EAR			0.12*		0.50*	0.17*	1.03*	0.09		0.47	0.47*	0.44	0.83*
ARF & EAR			0.25*		0.50*	0.31*	1.03*	0.10*		0.69	0.36*	0.76	0.83*
Winter seasons													

LSD at 0.05											
EGAF & ARF	0.08*		0.40	0.57*	0.30*	0.16*		0.49	0.64*	1.19*	0.16*
EGAF & EAR	0.13*		0.38*	0.15*	1.27*	0.16		0.28*	0.84*	0.48*	0.91*
ARF & EAR	0.12*		0.42*	0.58*	1.29*	0.07*		0.55	1.05*	1.16	0.92*

EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm, EAR: El- Ashir of Ramadan,
TSE: Treated sewage effluent IE: Industrial effluent * : Significant at LSD 0.05%

Table 3. Nitrogen, phosphorus and potassium content (ppm) of irrigation water used in the studied locations (mean values)

Site	Type of water	Season	Macronutrients (ppm)		
			N	P	K
EGAF	Control	summer seasons	2.31	0.71	7.15
	TSE		3.74	1.15	11.73
	LSD at 0.05		0.86	0.22	0.73
	Control	winter seasons	3.62	0.66	6.43
	TSE		5.46	0.83	8.95
	LSD at 0.05		0.55	0.22	0.60
ARF	Control	summer seasons	2.04	0.75	6.93
	TSE		3.51	1.27	12.33
	LSD at 0.05		0.70	0.28	0.54
	Control	winter seasons	2.64	0.81	7.35
	TSE		4.53	1.14	11.75
	LSD at 0.05		0.69	0.27	1.20
EAR	Control	summer seasons	1.55	0.55	6.85
	IE		9.54	3.61	15.15
	LSD at 0.05		2.35	0.51	0.76
	Control	winter seasons	1.79	0.55	5.89
	IE		12.16	2.50	12.94
	LSD at 0.05		2.98	0.39	0.61
Summer seasons					
LSD at 0.05					
EGAF & ARF			0.73	0.27	0.38*
EGAF & EAR			2.41*	0.49*	0.61*
ARF & EAR			2.35*	0.50*	0.62*
Winter seasons					
LSD at 0.05					

EGAF & ARF	0.53*	0.30*	1.05*
EGAF & EAR	2.95*	0.39*	0.43*
ARF & EAR	2.97*	0.43*	1.03*

EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm, EAR: El- Ashir of Ramadan,
TSE: Treated sewage effluent IE: Industrial effluent * : significant at LSD 0.05%

Table 4. The mean values of heavy metals and micronutrients content (mg/l) of irrigation water used in the studied locations compared with permissible limits

Site	Type of water	Season	Heavy metals (mg/l)				Micronutrients (mg/l)			
			Cd	Co	Ni	Pb	Fe	Zn	Cu	Mn
EGAF	Control	summer seasons	0.005	0.015	0.050	0.290	0.792	0.300	0.035	0.012
	TSE		0.020	0.300	0.250	0.495	1.275	0.745	0.165	0.265
	LSD at 0.05		0.010	0.120	0.070	0.110	0.250	0.130	0.060	0.080
	Control	winter seasons	0.004	0.035	0.025	0.290	0.650	0.380	0.035	0.005
	TSE		0.015	0.365	0.110	0.425	1.215	0.710	0.125	0.280
	LSD at 0.05		0.010	0.130	0.11	0.140	0.320	0.290	0.050	0.110
ARF	Control	summer seasons	0.002	0.003	0.014	0.105	0.860	0.310	0.115	0.070
	TSE		0.030	0.135	0.245	0.290	1.310	0.900	0.785	0.145
	LSD at 0.05		0.01	0.04	0.07	0.10	0.25	0.17	0.10	0.05
	Control	winter seasons	0.003	0.002	0.019	0.140	0.922	0.340	0.480	0.075
	TSE		0.027	0.070	0.235	0.415	1.355	0.780	0.670	0.165
	LSD at 0.05		0.01	0.01	0.07	0.10	0.16	0.17	0.23	0.07
EAR	Control	summer seasons	0.001	0.035	0.140	0.055	0.195	0.775	0.060	0.015
	IE		0.065	0.890	0.660	0.880	2.380	2.510	1.360	0.395
	LSD at 0.05		0.02	0.13	0.10	0.07	0.21	0.27	0.10	0.09
	Control	winter seasons	0.002	0.055	0.185	0.055	0.275	0.650	0.120	0.025
	IE		0.065	0.785	0.635	0.750	2.515	2.590	0.735	0.380
	LSD at 0.05		0.03	0.19	0.17	0.20	0.42	0.15	0.52	0.15
Permissible limits			0.010	0.050	0.200	5.000	5.000	5.000	0.200	0.200
Summer seasons										
EGAF	TSE		0.020	0.300	0.250	0.495	1.275	0.745	0.165	0.265
ARF			0.030	0.135	0.245	0.290	1.310	0.900	0.785	0.145
EAR	IE		0.065	0.890	0.660	0.880	2.380	2.510	1.360	0.395
LSD at 0.05										
EGAF & ARF			0.02	0.13*	0.10	0.13*	0.28	0.17	0.11*	0.09*
EGAF & EAR			0.02*	0.18*	0.12*	0.12*	0.27*	0.26*	0.12*	0.12*
ARF & EAR			0.02*	0.14*	0.12*	0.11*	0.29*	0.28*	0.14*	0.10*
Winter seasons										
EGAF	TSE		0.015	0.365	0.110	0.425	1.215	0.710	0.125	0.280
ARF			0.027	0.070	0.235	0.415	1.355	0.780	0.670	0.165
EAR	IE		0.065	0.785	0.635	0.750	2.515	2.590	0.735	0.380
LSD at 0.05										

EGAF & ARF	0.01	0.13*	0.13	0.14	0.260	0.240	0.10*	0.13
EGAF & EAR	0.03*	0.23*	0.19*	0.23*	0.47*	0.26*	0.52*	0.18
ARF & EAR	0.03*	0.19*	0.17*	0.22*	0.43*	0.16*	0.52	0.16*

EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm, EAR: El- Ashir of Ramadan,
TSE: Treated sewage effluent IE: Industrial effluent * : significant at LSD 0.05%
Permissible limit according to FAO (1992) and Egyptian code 2004 (ppm)

In thise concern, Nazif *et al.* (2006) stated that waters having electrical conductivity of 1.5dSm^{-1} were safe for irrigation, those having up to 1.5 to 3.0dSm^{-1} were marginal and waters having EC values more than 3.0 dSm^{-1} were unsafe.

Results in Table 3 show the content of N, P and K in irrigation water used in irrigation of the studied sites during the period of investigation (Summer and Winter seasons). The irrigation water content of macronutrients (N, P and K) increased significantly in TSE of both EGAF and ARF and IE used in EAR as compared with the control, with the exception of the concentration of P in irrigation water collected from EGAF during winter seasons which increased insignificantly as compared with the control. With respect to the IE content of macronutrients the results indicated that the mean values of N, P and K increased significantly in IE as compared with TSE used in both ARF and EGAF.

Considering the irrigation water used during winter season the data showed that the nitrogen content of TSE used in EGAF increased significantly as compared with those used in ARF. On the other hand, the mean values of P and K recorded the opposite direction. Generally, the mean values of N, P and K of IE used in irrigation in EAR during winter seasons recorded the highest values in IE more than that recorded in TSE which used in irrigation in both two farms.

Generally the concentration of macronutrients N, P and K in IE used in EAR increased significantly as compared with the corresponding ones in TSE used in irrigation in both of EGAF and ARF (khafagi *et al.* 2001).

Rusan *et al.* (2007) reported that the wastewater contains considerable amount of nitrate, phosphate and potassium which are considered essential nutrients for improving plant growth and soil fertility and productivity levels.

The content of irrigation water of tested heavy metals and micronutrients increased significantly in all samples of TSE and IE than in the control except in a few cases which increase insignificantly (Table 4). El – Gendi (2003) showed that the levels of Zn, Fe, Ni, Cd in Nile water (0.012, 0.02, 0.001 and 0.001 ppm), respectively, are below the critical levels reported for these metals in waters for irrigation use. Meanwhile, the sewage effluent water contains measurable quantities of Zn (0.70 ppm), Fe (1.05 ppm), Ni (0.40) and Cd (0.12 ppm).

Chemical and some physical characteristics of the studied soil

All soil chemical characteristics were carried out for the surface and subsurface layers (0 - 30 cm and 30-60 cm). Soil samples analyzed in order to determine some of their chemical, physical properties, heavy metals and some micronutrients (Tables 5, 6, 7, 8, 9 and 10).

The results in Tables 5 & 6 show the mean values of the studied chemical parameters of soil samples collected from the three sites. The data declared that the mean values of EC decreased significantly in soil samples collected from EGAF and ARF during summer and winter seasons as compared with the virgin soil (uncultivated soil). These may be due to continuous cultivation and irrigation which lead to leaching of soluble cations and soluble anions from the soil (Khalil 1990). It can be clearly obvious that the pH values of soil irrigated with TSE decreased as compared with the control. In this concern, Mohammad and Mazahreh (2003) mentioned that the soil pH values were significantly decreased when wastewater used in irrigation, and they attributed this decrease to high content of ammonia in wastewater, which its nitrification would serve as a source of hydrogen ions thus causing a decrease in soil pH. Generally pH values decreased with soil depth increased.

Comparing the present results (EC, pH, Ca^{++}, Mg^{++}, Na^{+}, K^{+}, HCO^{-}, Cl^{-}, $SO_4^{=}$ and SAR) of EGAF with the corresponding ones in EAR, the data indicated that with respect to both soil depths 0-30 and 30-60 cm the mean values of EC, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-} increased significantly in the soil samples collected from EAR as compared with those tested in EGAF. It was detected that the mean values of Mg^{++}, and $SO_4^{=}$ for both the surface and subsurface layers and Ca^{++} (at the deepest layer only) increased significantly in EGAF as compared with that of soil collected from EAR. Comparing the present results from the chemical analysis of soil collected from EAR with the corresponding ones collected from ARF it can be observed that for both soil depth (0-30 and 30-60 cm) the mean values of EC, Ca^{++} (at the surface layer only) Na^{+}, K^{+}, HCO_3^{-} (in the surface layer only) and Cl^{-} recorded the highest significant values in the soil collected from EAR than that collected from ARF. Generally pH values decreased in soil irrigated with TSE as compared with those irrigated with IE, moreover pH values decreased in most of the studied locations with depth increased. Nyamangara and Mzezewa (1999) cited that the decrease in pH in the subsoil was attributed to the effects of organic acids produced during the degradation of sewage sludge that are translocated to the subsoil.

Table 5. Chemical characteristics of soil in the studied locations during summer seasons (mean values)

Sites	Depth cm	EC dS/m	pH	Soluble cation meq/l					Soluble anion meq/l		
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
EGAF											
control	0-30	1.90	7.65	3.78	5.40	8.96	0.72	0.00	3.75	7.22	7.89
soil sites		1.23	6.82	3.99	3.26	4.47	0.41	0.00	1.94	4.66	5.44
LSD at 0.05		0.24		1.15	1.29	1.05	0.15	0.00	0.62	1.55	2.21
control	30-60	1.48	7.53	3.22	4.11	6.97	0.56	0.00	1.02	6.07	7.77
soil sites		1.13	6.72	3.78	3.04	4.08	0.34	0.00	1.87	3.91	5.48
LSD at 0.05		0.29		0.93	1.1	1.09	0.15	0.00	0.78	1.03	1.99
ARF											
control	0-30	2.23	7.78	4.14	2.56	14.84	0.42	0.00	1.32	15.04	5.60
soil sites		1.36	7.88	4.44	3.29	5.60	0.35	0.00	2.54	5.27	5.87
LSD at 0.05		0.5		1.5	1.2	2.53	0.17		0.90	2.69	2.26
control	3٠-60	1.62	7.73	2.26	1.12	12.14	0.30	0.00	2.10	12.11	1.61
soil sites		0.84	7.75	2.72	2.06	3.21	0.29	0.00	1.68	3.03	3.56
LSD at 0.05		0.18		0.79	0.97	1.23	0.1		0.69	1.04	1.52
EAR											
control	0-30	1.91	7.73	3.43	3.26	11.76	0.38	0.00	3.76	10.87	4.20
soil sites		3.03	8.03	4.77	3.17	21.41	0.85	0.00	5.11	20.18	4.59
LSD at 0.05		0.24		0.63	0.48	0.90	0.13		1.02	2.75	2.58
control	30-60	1.79	7.69	3.96	2.06	11.21	0.29	0.00	2.17	9.16	6.19
soil sites		2.68	7.86	4.67	2.98	18.30	0.66	0.00	4.78	18.17	3.66
LSD at 0.05		0.33		1.00	0.25	2.17	0.22		0.58	2.55	1.41
LSD at 0.05											
EGAF&	0-30	0.17		0.59	0.57	0.84*	0.06		0.32*	0.97	1.00

ARF	30-60	0.10*		0.40*	0.48*	0.52*	0.06*		0.34	0.47*	0.82*
EGAF& EAR	0-30	0.13*		0.58*	0.64	0.57*	0.07*		0.37*	1.09*	1.28
	30-60	0.15*		0.53*	0.54	0.80*	0.09*		0.42*	0.88*	1.05*
ARF & EAR	0-30	0.25*		0.76	0.61	1.28*	0.09*		0.55*	1.59*	1.38
	30-60	0.13*		0.50*	0.48*	0.92*	0.08*		0.39*	0.96*	0.87

EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm, EAR: El- Ashir of Ramadan,
* : significant at LSD 0.05%

Table 6. Chemical characteristics of soil in the studied locations during winter seasons (mean values)

Sites	Depth cm	EC dS/m	pH	Soluble cation meq/l				Soluble anion meq/l			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
EGAF											
control	0-30	1.90	7.65	3.78	5.40	8.96	0.72	0.00	3.75	7.22	7.89
soil sites		1.39	6.92	4.83	3.44	5.33	0.43	0.00	2.27	5.03	6.59
LSD at 0.05		0.43		1.74	1.46	1.75	0.23		0.96	1.56	3.31
control	30-60	1.48	7.53	3.22	4.11	6.97	0.56	0.00	1.02	6.07	7.77
soil sites		1.22	6.81	4.27	3.09	4.22	0.46	0.00	2.03	4.09	5.94
LSD at 0.05		0.33		1.22	1.53	1.53	0.48		0.85	1.37	2.46
ARF											
control	0-30	2.23	7.78	4.14	2.56	14.84	0.42	0.00	1.32	15.04	5.60
soil sites		1.17	7.67	3.49	2.70	4.67	0.35	0.00	2.22	4.46	4.53
LSD at 0.05		0.34		0.98	1.18	1.11	0.13		0.58	0.92	2.13
control	30-60	1.62	7.73	2.26	1.12	12.14	0.30	0.00	2.10	12.11	1.61
soil sites		0.96	7.61	2.80	2.23	3.94	0.36	0.00	1.55	4.15	3.65
LSD at 0.05		0.20		0.82	0.81	1.05	0.29		0.59	0.98	1.29
EAR											
control	0-30	1.91	7.73	3.43	3.26	11.76	0.38	0.00	3.76	10.87	4.20
soil sites		2.86	7.91	4.83	2.83	19.81	0.90	0.00	3.72	18.99	5.65
LSD at 0.05		0.43		1.14	0.66	3.44	0.21		1.02	3.05	2.59
control	30-60	1.79	7.69	3.96	2.06	11.21	0.29	0.00	2.17	9.16	6.19
soil sites		2.41	7.79	3.66	2.19	17.08	0.67	0.00	2.40	16.60	4.60
LSD at 0.05		0.40		0.79	0.80	4.04	0.28		0.89	3.74	1.88
LSD at 0.05											
EGAF& ARF	0-30	0.15*		0.58*	0.52*	0.60*	0.07*		0.31	0.53*	1.13*
	30-60	0.10*		0.42*	0.51*	0.530	0.160		0.29*	0.480	0.82*

EGAF& EAR	0-30	0.30*		0.80	0.62*	1.89*	0.12*		0.51*	1.78*	1.44*
	30-60	0.24*		0.57*	0.63*	1.72*	0.20		0.42	1.64*	1.08*
ARF & EAR	0-30	0.36*		0.73*	0.57	2.45*	0.13*		0.55*	2.31*	1.25
	30-60	0.30*		0.56	0.45	2.25*	0.15*		0.43*	2.16*	0.88

EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm,
EAR: El- Ashir of Ramadan, * : Significant at LSD 0.05%

Table 7. Some physical and chemical characteristics of soil in the studied locations during summer seasons (mean values)

Sites	Depth cm	Particle size distribution%				Texture class	$CaCO_3$ %	OM %	Macronutrients (ppm)		
		Coarse sand	Fine Sand	Silt	Clay				N	P	K
EGAF											
Control	0-30	28.00	56.00	10.00	6.00	sandy	2.33	0.99	33.00	1.14	32.30
soil sites		20.40	40.40	22.60	16.60	sandy loam	2.18	2.70	62.44	2.86	68.61
LSD at 0.05		1.66	10.06	8.06	3.55		0.53	0.45	9.69	0.64	18.81
Control	30-60	28.00	60.00	6.00	6.00	sandy	2.05	0.84	24.00	0.83	17.03
soil sites		29.41	54.30	9.10	7.20	sandy	1.58	2.41	59.15	3.23	58.35
LSD at 0.05		3.79	5.93	5.70	2.64		0.38	0.58	8.82	0.61	12.07
ARF											
Control	0-30	68.00	28.00	2.00	2.00	sandy	1.96	0.44	34.12	1.14	35.32
soil sites		20.87	43.12	20.37	15.62	sandy loam	1.77	1.91	55.81	2.44	61.16
LSD at 0.05		3.90	7.02	6.28	4.43		0.66	0.81	12.37	0.57	4.29
Control	30-60	62.00	35.00	2.00	1.00	sandy	1.85	0.31	26.04	1.06	39.11
soil sites		21.50	42.75	20.50	15.25	sandy loam	1.51	1.23	53.86	3.24	57.11
LSD at 0.05		5.57	6.01	5.47	1.87		0.48	0.33	16.19	0.47	7.43
EAR											
Control	0-30	20.00	35.00	25.00	20.00	Sandy clay	4.74	0.56	85.23	2.22	203.08
soil sites		15.50	37.25	25.75	21.50	Sandy clay	5.14	1.17	165.53	24.14	341.23
LSD at 0.05		3.12	3.87	2.93	4.02		0.71	0.35	20.49	1.00	31.85
Control	30- 60	27.00	54.00	9.93	9.00	Loamy sand	3.10	0.39	73.70	1.48	193.22
soil sites		30.75	56.00	6.08	7.00	Loamy sand	4.08	0.85	171.38	24.08	323.93
LSD at 0.05		1.85	2.14	1.20	1.39		0.35	0.26	3.99	1.01	12.65
LSD at 0.05											
EGAF&	0-30	1.30	4.04	3.34	1.80		0.25*	0.28*	4.98*	0.28*	7.74

ARF	30-60	2.12*	2.72*	2.55*	1.06*		0.18	0.22*	5.73	0.25	6.67
EGAF& EAR	0-30	1.20*	5.06	4.05	2.08*		0.28*	0.24*	7.48*	0.42*	12.89*
	30-60	1.93	2.98	2.82*	1.35		0.21*	0.29*	4.47*	0.41*	6.92*
ARF & EAR	0-30	2.16*	3.66*	3.22*	2.52*		0.33*	0.40*	8.93*	0.43*	12.37*
	30-60	2.80*	3.03*	2.71*	1.02*		0.24*	0.16*	8.05*	0.40*	9.46*

EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm,
EAR: El- Ashir of Ramadan, * : Significant at LSD 0.05%

Table 8. Some physical and chemical characteristics of soil in the studied locations during winter seasons (mean values)

Sites	Depth cm	Particle size distribution%				Texture class	$CaCO_3$ %	OM %	Macronutrients (ppm)		
		Coarse sand	Fine Sand	Silt	Clay				N	P	K
EGAF											
Control	0-30	28.00	56.00	10.00	6.00	sandy	2.33	0.99	33.00	1.14	32.30
soil sites		18.50	39.44	25.61	16.44	Sandy loam	2.30	2.77	63.39	2.88	142.97
LSD at 0.05		4.81	12.44	8.28	8.84		0.74	0.56	13.89	0.48	33.72
Control	30-60	28.00	60.00	6.00	6.00	sandy	2.05	0.84	24.00	0.83	17.03
soil sites		21.55	48.22	15.61	14.61	Sandy loam	1.57	2.39	53.19	3.22	144.22
LSD at 0.05		6.14	14.55	6.76	10.60		0.64	0.48	6.38	1.06	34.18
ARF											
Control	0-30	68.00	28.00	2.00	2.00	sandy	1.96	0.44	34.12	1.14	35.32
soil sites		18.40	41.60	26.00	14.00	sandy loam	1.67	2.33	55.15	2.99	77.72
LSD at 0.05		3.60	6.46	5.58	3.25		0.60	0.54	16.30	0.67	9.87
Control	30-60	62.00	35.00	2.00	1.00	sandy	1.85	0.31	26.04	1.06	39.11
soil sites		19.00	46.80	21.30	12.90	sandy loam	1.51	1.50	53.35	3.00	74.16
LSD at 0.05		3.89	6.95	3.61	1.65		0.48	0.61	11.34	0.71	6.08
EAR											
Control	0-30	20.00	35.00	25.00	20.00	sandy loam	4.74	0.56	85.23	2.22	203.08
soil sites		19.17	34.50	27.00	19.11	sandy	4.77	1.28	172.09	23.95	342.29
LSD at 0.05		4.64	5.27	4.44	3.24		0.82	0.22	16.00	2.98	64.10
Control	30-60	27.00	54.00	9.93	9.00	sandy loam	3.10	0.39	73.70	1.48	193.22
soil sites		28.33	49.50	10.50	11.67	sandy	4.00	1.04	168.56	23.98	279.62
LSD at 0.05		6.69	12.77	9.19	10.35		0.64	0.17	10.43	1.76	78.86
LSD at 0.05											
EGAF&	0-30	1.70	4.13	2.86	2.85		0.26*	0.21*	5.66*	0.21	10.72*

ARF	30-60	2.10*	4.79	2.26*	3.32		0.22*	0.20*	3.22	0.37	10.75*
EGAF& EAR	0-30	2.59	5.63*	3.96	3.78		0.50*	0.24*	15.42*	2.06*	33.52*
	30-60	3.57*	7.35	3.31*	4.66		0.43*	0.21*	14.19*	2.04*	30.89*
ARF & EAR	0-30	2.84	4.78*	3. 87	2.62*		0.60*	0.25*	20.67*	2.81*	42.38*
	30-60	3.95*	7.07	3.12*	3.22		0.50*	0.25*	19.54*	2.74*	38.28*

EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm,
EAR: El- Ashir of Ramadan, * : Significant at LSD 0.05%

Table 9. Heavy metals and micronutrients concentration of soil in the studied locations during summer seasons (mean values)

Sites	Depth cm	Heavy metals (ppm)				Micronutrients (ppm)			
		Cd	Co	Ni	Pb	Fe	Zn	Cu	Mn
EGAF									
Control	0-30	0.040	0.040	0.160	0.557	4.373	0.910	0.493	3.970
soil sites		0.244	0.210	2.108	5.431	81.357	58.193	24.783	45.422
LSD at 0.05		0.060	0.150	0.430	1.070	15.520	3.870	2.230	5.810
Control	30-60	0.020	0.020	0.150	0.243	3.763	0.960	0.390	3.397
soil sites		0.158	0.116	1.626	3.685	66.110	55.300	23.819	41.575
LSD at 0.05		0.120	0.070	0.540	1.480	14.960	3.970	1.160	6.050
ARF									
Control	0-30	0.033	0.027	0.173	0.940	2.453	1.463	0.137	0.373
soil sites		0.230	0.512	1.516	2.479	92.985	54.309	23.026	80.464
LSD at 0.05		0.13	0.26	0.46	0.94	6.31	2.8	2.85	6.14
Control	30-60	0.013	0.060	0.023	0.147	1.643	0.533	0.030	0.227
soil sites		0.070	0.206	0.719	1.513	77.880	50.960	22.778	77.570
LSD at 0.05		0.07	0.14	0.7	1.12	21.51	12.77	3.36	10.15
EAR									
Control	0-30	0.070	0.043	0.387	1.400	11.713	3.657	0.470	5.413
soil sites		0.825	1.548	8.103	16.508	185.648	137.930	101.319	170.008
LSD at 0.05		0.21	0.44	1.34	2.36	20.71	5.78	7.50	9.43
Control	30-60	0.047	0.027	0.173	0.670	9.620	1.610	0.730	3.043
soil sites		0.447	0.970	6.845	12.685	169.883	129.493	97.009	162.893
LSD at 0.05		0.24	0.21	0.99	2.24	2.46	6.68	4.83	6.71
EGAF& ARF	0-30	0.04	0.09*	0.20*	0.46*	5.64*	1.57*	1.15*	2.71*
	30-60	0.05*	0.05*	0.28*	0.61*	8.25*	4.08*	1.090	3.69*
EGAF& EAR	0-30	0.07*	0.14*	0.43*	0.85*	9.61*	2.50*	2.38*	3.90*
	30-60	0.09*	0.07*	0.39*	0.96*	7.38*	2.71*	1.48*	3.52*

ARF& EAR	0-30	0.09*	0.19*	0.48*	0.88*	7.32*	2.30*	2.78*	4.27*
	30-60	0.08*	0.10*	0.47*	0.90*	10.58*	6.62*	2.26*	5.43*
Maximum allowable concentration		0.03		0.04	0.25		0.05	0.05	

Maximum allowable concentration (MAC) according to to FAO and WHO 1993
EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm,
EAR: El- Ashir of Ramadan, * : Significant at LSD 0.05%

Table 10. Heavy metals and micronutrients concentration of soil in the studied locations during winter seasons (mean values)

Sites	Depth cm	Microelements (ppm)				Micronutrients (ppm)			
		Cd	Co	Ni	Pb	Fe	Zn	Cu	Mn
EGAF									
Control	0-30	0.040	0.040	0.160	0.557	4.373	0.910	0.493	3.970
soil sites		0.226	0.344	1.874	5.687	72.531	54.496	27.400	44.544
LSD at 0.05		0.08	0.23	0.76	1.44	12.71	6.73	3.1	5.27
Control	30-60	0.020	0.020	0.150	0.243	3.763	0.960	0.390	3.397
soil sites		0.088	0.156	1.357	2.811	62.893	46.459	21.853	39.697
LSD at 0.05		0.08	0.10	0.77	1.61	11.89	14.42	7.04	10.71
ARF									
Control	0-30	0.033	0.027	0.173	0.940	2.453	1.463	0.137	0.373
soil sites		0.276	0.393	1.634	1.335	61.071	53.704	25.133	53.894
LSD at 0.05		0.12	0.23	0.41	0.48	4.52	2.52	2.04	3.74
Control	30-60	0.013	0.060	0.023	0.147	1.643	0.533	0.030	0.227
soil sites		0.103	0.145	0.892	1.168	55.663	49.927	20.290	51.155
LSD at 0.05		0.11	0.19	0.67	0.25	3.95	12.28	7.30	17.18
EAR									
Control	0-30	0.070	0.043	0.387	1.400	11.713	3.657	0.470	5.413
soil sites		0.834	1.829	6.986	15.692	195.541	134.650	97.051	163.930
LSD at 0.05		0.20	0.21	1.76	1.90	4.04	14.33	3.83	4.81
Control	30-60	0.047	0.027	0.173	0.670	9.620	1.610	0.730	3.043
soil sites		0.647	0.910	6.123	13.057	191.813	130.772	94.422	170.172
LSD at 0.05		0.15	0.61	0.77	0.74	12.90	11.89	2.72	21.76
EGAF& ARF	0-30	0.04*	0.090	0.250	0.46*	4.08*	2.170	1.07*	1.84*
	30-60	0.03	0.050	0.28*	0.50*	3.80*	5.260	2.730	5.09*
EGAF&	0-30	0.08*	0.18*	0.74*	1.45*	16.76*	11.70*	8.08*	13.62*

EAR	30-60	0.07*	0.15*	0.60*	1.24*	55.66	12.29*	8.21*	15.20*
ARF& EAR	0-30	0.12*	0.23*	0.94*	1.84*	21.96*	15.60*	10.93*	18.43*
	30-60	0.09*	0.21*	0.76*	1.48*	21.79*	15.68*	10.93*	20.98*
Maximum allowable concentration		0.03		0.04	0.25		0.05	0.05	

Maximum allowable concentration (MAC) according to to FAO and WHO 1993
EGAF: El- Gabal EL- Asfar farm, ARF: Abu- Rawash farm,
EAR: El- Ashir of Ramadan, * : significant at LSD 0.05%

Rusan *et al.* (2007) worked in sites irrigated with wastewater for 10, 5, and 2 years and site not irrigated. He recorded that long term wastewater irrigation increased salts and organic matter in the soil. He concluded that proper management of wastewater irrigation and periodic monitoring of soil and plant quality parameters are required to ensure successful and safe use of long-term wastewater irrigation.

Tables 7 & 8 show the mean values of OM and macronutrient in the studied soil. Soil organic matter (OM) significantly increased with wastewater irrigation application and with increasing the period of application, which is attributed directly to the contents of the nutrients and organic compounds in the applied wastewater. The OM concentration accumulated more in the top soil in all the studied locations. However, in soil irrigated with IE lower concentrations of OM were recorded than that in soil receiving TSE. Ramadan (2000) stated that the soil content of OM was significantly affected with the interaction of solid and liquid dying waste, as the OM content increased with increasing soild dying waste rates and irrigated with liquid waste. Considering the soil content of macronutrients the results indicated that TSE and IE irrigation increased significantly the soil N, P and K. This increase was the highest in the top soil (0-30 cm), and decreased with depth increased. The highest values of these nutrients were reported in soil irrigated with IE. Several researchers reported on the accumulation of N, P and K in the soil with wastewater application which was attributed to the original contents of these nutrients in the wastewater applied.

Soil heavy metals and micronutrients content

The results revealed significant variations in the concentration of heavy metals in soil among sites and between seasons inside the same site. This trend may be correlated with the soil properties that influence heavy metal availability at different sites. As shown in Tables 9 & 10, the mean values of heavy metals and micronutrients increased by many folds in soil irrigated with IE as compared with that in the virgin soil. Also when compared with those irrigated with TSE. As expected the tested heavy metals and micronutrients recorded significant values in soil collected from EAR than that collected from both EGAF and ARF. In this concern, Xiao-Li *et al.* (2010) mentioned that the toxicity and the mobility of heavy metals in soils depend not only on the total concentration, but also on their specific chemical speciation, their binding state, the metal properties, environmental factors and soil properties like pH, organic matter content , redox conditions and root exudates acting as chelates.

It was detected that the mean values of all tested heavy metals and micronutrients of all the studied soils exceeded the maximum allowable concentration according to FAO and WHO 1993.

Conclusion

Based on these results it can be concluded, that proper management of wastewater irrigation and periodic monitoring of soil fertility and quality parameters are required to ensure successsful and safe long term reuse of wastewater for irrigation. The long term wastewater irrigation has led to contamination of soils and food crops in the study area. The authors strongly recommended that it must be do not use the industrial effluent in irrigation the crops that eaten by human or animals because these lead to bioaccumulation of heavy metals that cause risks to the consumers, scince dietary of food results in long- term low body accumulation of heavy metals and detrimental impact becomes apparent only after several years of consumed these food.

REFERENCES

Abd El Lateef, E. M., J. E. Hall, P. C. Lawrence and M. S. Negm (2006). Cairo-East Bank effluent re-use study 3 – Effect of field crop Irrigation with secondary treated wastewater on biological and chemical properties of soil and groundwater. J. Biologia, Bratislava, 61/ 19: 240-245.

Al- Rashed, M. F., and M. M. Sherif (2000). Water resources in the GCC countries: An overview. Water Resour. Manag. 14: 59-75.

Black, C. A. (1965). Methods of soil analysis, (I and II). Amer. Soc. Agron. Inc., Madison, Wisc. U.S.A.

Chapman, H. D. and P. E. Pratt (1961). Methods of Analysis for Soil, Plant and Water. Univ. of California, Division of Agric. Sci., USA.

Clark, F. E., D. D. Evans, L. E. Ensunger and J. L. White (1986). "Methods of Soil Analysis." Amer. Soc. Agron. Inc. Ser. No. 9 Madison, Wisc. U.S.A.

Darvishi, H. H. and H. A. Farahani (2010). Economical value of irrigation with wastewater instead of agronomical water at Iran. J Economical theory 2 (1): 8-10

El- Gendi, S. A. M. (2003). Speciation of some of heavy metals in some waters of Egypt. J. Soil Sci. 43(2): 211-221.

Food and Agricultural Organization (FAO) and World Health Organization (WHO) (2003). Expert consultations for launching the regional Network on wastewater Re- use in the Near East. Regional Office for the Near East. World Health Organization. Regional Office for the Eastern Mediterranean. Cairo, 2003.

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. Bull. Environ. Contamin. Toxicol. 67: 423-430.

Khafagi, O. A., A. A. M. Ragab, S. M. I. Marie and A. A. Mohsen (2010). Effect of wastewater irrigation on some chemical characteristics of soil and plant. Egypt. J. of App. Sci. 25 (4A) : 1-18.

Khafagi, O. A., W. I. El-Lewendy and H. Abdel- Aal (2001). Effect of irrigation with treated sewage effluent on the accumulation of Cd, Cr, Cu, Pb and Zn in some vegetables. Al- Azhar, J, Agric Res, 33: 171-187.

Khalil, M. E. A. (1990). Accumulation of some nutrients and heavy metals in Abu-Rawash area, Giza Governorate. M.Sc. Thesis Fac. of Agric., Zagazig Univ.

Khan, S., L. Aijun, S. Zhang, Q. Hu and Y. Zhu (2008). Accumulation of polycyclic aromatic hydrocarbons and heavy metals in lettuce grown in the soils contaminated with long- term wastewater irrigation. J. Hazardous Material 152: 506-515.

Khan, S., S. Rehman, A. Z. Khan, M. Khan and A. Shah (2010). Soil and vegetables enrichment with heavy metals from geological sources in Gilgit, northern Pakistan . J. Ecotoxicology and Environmental Safety 73: 1820- 1827.

Kiziloglu, F. M., M. Turan, U. Sahin, Y. Kuslu and A. Dursun (2008). Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (*Brassica olerecea* L. *var. botrytis*) and red cabbage (*Brassica olerecea* L. *var. rubra*) grown on calcareous soil in Turkey. J. AgriculturalWater Management 95: 716-724.

Klay, S., A. Charef, L. Ayed, B. Houman and F. Rezgui (2010). Effect of irrigation with treated wastewater on geochemical properties (saltiness, C, N and heavy metals) of isohumic soils (Zaouit Sousse perimeter, Oriental Tunisia). J. Desalination 253: 180- 187.

Mohammad, M. J. and N. Mazahreh (2003). Changes in soil fertility parameter in response to irrigation of forage crops with secondary treated wastewater. Comm. Soil Sci. Plant Anal. 34: 1281-1294.

Mutengu, S., Z. Hoko and F. S. Makoni (2007). An assessment of the puplic health hazard potential of wastewater reuse for crop production. Acase of Bulawayo city, Zimbabwe. J. Physics and Chemistry of the Earth 32: 1195-1203.

Nazif, W., S. Perveen and S. A. Shah (2006). Evaluation of irrigation water for heavy metals of Akbarpura area. J. Agricultural and Biological Science 1 (1): 51-54.

Nyamangara, J. (1998). Use of sequential extraction to evaluate zinc and copper in a soil amended with sewage sludge and inorganic metal salts. J. Agric Ecosyst Environ 69 (2): 135-141.

Nyamangara, J. and J. Mzezewa (1999). The effect of long- term sewage sludge application on Zn, Cu, Ni and Pb levels in a clay loam soil under pasture grass in Zimbabwe. J. Agricultural, Ecosystem and Environment 73: 199-204.

Page, A. I., D. R. Miller and D. R. Keeny (1982). "Methods of Soil Analysis part II second ed. Chemical and Microbiological properties", 2nd ed, American Society of Agronomy Madison, Wisconsin, U. S. A.

Ramadan, W. F. (2000). Effect of some industrial wastes of 10th of Ramadan city on soil and plant. M.Sc. Thesis, Cairo Univ., Egypt.

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. J. Desalination 215: 143-152.

Sikka, R., V. Nayyar and S. S. Sidhu (2009). Monitoring of Cd pollution in soils and plants irrigated with untreated sewage water in some industrialized cities of Punjab, India. J. Environ Monit Assess 154: 53-64.

Sndecor, G. W. and W.G. Cochran (1989). Statistical Methods, 8th ed. Low State Univ., Press Ames Iowa, USA., 325-330.

Soltanpour, P. N. and A. P. Schwab (1977). A new soil test for simultaneous extraction of macro and micro nutrients in alkaline soils. Community of Soil Science, Plant Annals, 3: 195-207.

Thomas, V. G., M. C. Forti, Y. Lucas, C. R. Montes, R. A. B. Goncalves, U. Herpin and A. J. Melfi (2007). Soil solution chemistry of a Barazilian Oxisol irrigated with treated sewage effluent. J. Agricultural Water Management. 88: 119-131

Xiao-Hu, Z. L., F. Y. Tang, L. Chu and Y. Yang (2010). Characteristics of distribution and chemical speciation of heavy metals in environmental mediums around Jinchang mining city, northwest China. J. Environ Earth Sci. 10: 1007/s 12665.

مدى تأثير الري بالمياه العادمة لفترات طويلة على بعض الخصائص الكيميائية والطبيعية للتربة

أم محمد احمد خفاجى(١) ، محمد عبد الوارث محمود(٢) ، سحر قناوى محمد قناوى(١)

(١) جامعة الأزهر ، كلية العلوم (بنات) القاهرة – مصر

(٢)معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر

الملخص العربي

أجريت دراسات المسح الميداني في ثلاث مناطق ، وكانت أول منطقة ممثلة بمزرعة الجبل الأصفر ، والثانية ممثلة بمزرعة أبو رواش وهاتان المزرعتان ترويان بمياه الصرف الصحى المعالج لفترات طويلة. وأما المنطقة

الثالثة فهى منطقة العاشر من رمضان والتى تروى بصرف صناعى .وكان الهدف من الدراسة هو دراسة مدى تـأثير الـرى لفترات طويلـة بمياه الصرف الصحي ومياه الصرف الصناعى علـى بعض الخواص الكيميائيـة والفيزيائية للتربة المروية، وعلى محتوى التربة من المعادن الثقيلة والمغذيات

الصغرى. وقد تم جمع عينات التربة والمياه موسمياً لعامين متتاليين من كل منطقة من مناطق الدراسة لاستخدامها في التحليلات. و قد أظهرت النتائج ما يلى:

١ـ دلت النتائج على أن استمرار الرى بمياه الصرف الصحى لفترات طويلة ادى الى زيادة معنوية فى المادة العضوية ، وكذلك المغذيات الكبرى (النتروجين ، الفسفور والبوتاسيوم) فى التربة بينما أدى الى نقص فى قيم pH.

٢. زاد محتوى التربة المروية بمياه الصرف الصناعى من قيم pH ، قيم التوصيل الكهربى، الكاتيونات والانيونات الذائبة ، وكذلك المغذيات الكبرى.

٣- زاد محتوى التربة من المعادن الثقيلة (الكادميوم ،الكوبلت ،الرصاص والنيكل) والمغذيات الصغرى (الحديد ، الزنك ،النحاس و المنجنيز) في كلاً من التربة المروية بمياه الصرف الصحى المعالج وكذلك المروية بالصرف الصناعى ، وقد وجد ان اعلى تركيز لهذه العناصر كان فى التربة المروية بالصرف الصناعى تليها التربة المروية بمياه الصرف الصحى المعالج ، وأوضحت النتائج أن هذه العناصر تميل الى التراكم بالطبقة السطحية تليها الطبقة التحت سطحية .

وقد تعدت تركيزات المعادن الثقيلة والمغذيات الصغرى للتربة المروية بمياه الصرف الصحى المعالج وكذلك المروية بالصرف الصناعى الحدود المسموح بها دوليا طبقا لمنظمة الصحة العالمية.