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IMPACT OF IRRIGATION WITH SEWAGE WATER ON CALCARIOUS SOIL:

1- SOIL PROPERTIES AND HEAVY METALS CONTENT IN SOILS AND PLANTS.

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ABSTRACT

Soil and plant samples were collected from experimental fields at 89 kg Cairo -Alex. desert road ,irrigated with raw sewage water for different periods (3,10,and 30 years)to assess the impact of sewage water On soil properties, distribution of Cu, Zn, Cd, Ni and Pb content in soil profiles and the concentration of the metal in DTPA-extract of the surface soil layer (0-20 cm). Also, the heavy metals concentration in some pastures as well as in leaves, fruits, and oil olives were determined in both plants irrigated with sewage water (30 years)and those irrigated with ground water .irrigation with sewage water increased the levels of heavy metals and O.M. In soils, and decreased the soil pH value as compared with ground water. The relative enrichment for total metals concentration in sewage water irrigated soil (0-20cm)were proportional to the amount of sewage water applied, where Zn had the highest enrichment factor (average EF=16.53), while cu had the lowest value (average EF =1.38).the soil appeared to be very poor in DTPA-extractable metals, which were 0.27 ,0.67 .0.06 ,0.27 and 0.80mg kg-1 for Cu, Zn, Cd, Ni and Pb, respectively. However, these levels had increased with sewage water irrigation. There were significant correlations between DTPA-extractable metals and total metal contents in soil .thirty years period of irrigation with raw sewage water were not sufficient to cause phytotoxic levels of various heavy metals for the plants grown on highly calcareous soil cadmium leaching, in highly calcareous soil is Higher than the other heavy metals (Cu, Zn, Ni and Pb).

INTRODUCTION

Environmental pollution is increasing due to increasing industrial and urban activities in the third world countries. The disposal of municiple sewage, sewage water and industrial effluents is becoming a major problem (Kuhad et al., 1989). Agriculture is the major sink of sewage water and is able to accept even inferior-quality of this water. Hence it is possible to reuse sewage water for irrigating crops. Continuous use of sewage waters may lead to heavy metals accumulation in soils to such extent that may become toxic to soil-plant-animal and human health (Narwal et al.,1993). The mobility of these heavy metals in soils depends on metal concentration, chemical speciation, water movement, and soil properties such as mineralogy, pH, and redox potential (Bang and Hesterberg, 2004). These heavy metals can represent an environmental risk, but absorption by soil renders them less mobile, and therefore less hazardous (Marr et al.,1999). Heavy metals seriously threaten the health of human being when they enter the food chain. Therefore, policy-makers require precise predictions of heavy metal concentrations in agricultural crops(Brus and Jansen,2004). The increasing consumption, production, and exploitation of the earth' s raw materials, coupled with the exponential growth of the world' s population over the past 200 years, have resulted in an environmental buildup of waste products, of which heavy metals are of particular concern (Apple and Ma, 2002).The continued accumulation of heavy metals in the soil with continued sewage water application was also reported by Banin et al.(1981); Cajust et al.(1991) and Flores et al.(1997)

The objectives of the present study were to (i) evaluate the quality of raw sewage water and their effect on the properties of soils irrigated with these waters,. (ii) To study the distribution of total content of Cu, Zn, Ni, and Pb in soil profiles that have been irrigated with raw sewage water for different periods, (iii) Examine the effect of raw sewage water on the amounts of DTPA-extractable metals and (iv) Compare the contents of heavy metals in native pastures and olive plants, grown in irrigated soils with ground water or raw sewage water.

MATERIALS AND MEHODS

1- Studied Area

The studied area is approximately 65 feddans cultivated with olive trees, vegetables, and arable crops. It is located at 89 Km on Cairo-Alexandria desert road. The region has a population of 4000 inhabitants in 1999.

2- Sources of irrigation water:

(i)-Ground water: Ground water is taken from two wells at depths of 80 m. The water taken from the two wells are used for irrigating 50 feddans from the whole area .

(ii)- Sewage water: Raw municipal sewage water is collected in small reservoirs and used for irrigating 15 feddans of the whole area. Irrigation with raw sewage water in this area started in 1968 and continued up to 1999.

3-Sampling:

(i)-Water Sampling: Samples of ground water and raw sewage water were collected from the irrigation outlet three times during 1998 (January, April, and August). Composite samples were taken from the ground water or from the raw sewage water. Each composite sample was placed in 2000-ml plastic bottles, preserved according to APHA (1985), transported to the laboratory, and analyzed immediately.

(ii)- Soil Sampling: The experimental area was divided into three field treatments which have different periods of raw sewage water irrigation(3, 10 and 30 years). Each field treatment has a corresponding adjacent control of the same soil type, which is representing background concentrations of heavy metals (soil irrigated by ground water).

Thirty pits from the three fields were sampled in March 1997 (10 pits from each field).Soil samples were collected from the upper soil layer (0-20 cm).

Tow surface soil samples (0-20 cm) were taken from each pit, air-dried, ground, passed through a 2-mm sieve and stored in plastic bags for analysis. In addition, soil profiles (to 150 cm depth) in both sewage and ground water-irrigated fields were prepared and samples were taken at different depths (20-40, 40-60, 60-100 and100-150cm).

(III)-Plant Sampling: Native plant species and cultivated olive plant samples were collected during August-September, 1998.These plant species included, wild mallow (Malva *parviflora),* lamb's quartet (Chenopodium murale) ,sedge *(Cyprus rotandus), jimson* weed *(Solanum nigrum),* olive leaves *(Olea europea) and* olive fruits. Composite samples were collected, placed in polyethylene bags and prepared for analysis according to Chapman and Pratt (1963).

4-Analysis

(i)- Water Analysis: The pH and EC values were measured immediately (APHA, 1985) in ground and sewage water and the data obtained are given in Table (1). Sample of raw sewage water were filtered through Whatman No. 42 filter paper. The residues were dried at 60°C for 12 hours and the metals in the residue were determined after digestion in a 2:1 mixture (v/v) of 70% $HClO_4$ and concentrated HNO_3 at 70°C overnight (Le Claire et al., 1984). The concentration of heavy metals in the filterate and in the aliquot of the digested residue were measured by AAS. The total concentration of metals in raw sewage water was the sum of the total in the filterate and in the residue (Vergara et al.,1986).

(ii)-Soil Analysis: Soil pH was measured in 1:2.5 soil-water ratio, and the electrical conductivity was measured in a 1:2.5 soil-water extract. Organic matter (O.M.) was determined by using Walkley-Black method and the cation exchange capacity (CEC) was determined by Na saturation (Black, 1965). The determination of calcium carbonate percentage was done by using a simple calcimeter according to the method described in Page et al. (1982). Particle size distribution of the soil was done by using the hydrometer method and the texture of the soil was determined according to the American classification system (Black, 1965) .DataTobtained are given in Table 2.

The amount of heavy metals in soil were determined according to Jeng and Bergseth (1992), where two grams of soil were treated with 25 ml aqua regia. The samples were kept over night, digested, and filtered through Whtman No. 42 filter paper.The concentrations of Cu, Zn, Cd, Ni and Pb were measured in the filtrate by using atomic absorption spectrophotometer (AAS), Perkin Elemer model 5000.

The amount of DTPA extractable elements were determined according to Lindsay and Norvell (1978). The filterate was analyzed for Cu, Zn, Cd, Ni, and Pb by AAS.

Table (1):The range and average values of pH, EC and the concentration of heavy metals of raw sewage water and ground water (well water) (mg L^{-1}) used for irrigation.

Parameter	Raw Sewage water	Ground water (Well water)	Permissible* Water
PH	4.77-7.08 5.93	6.90-7.47 7.13	6.50-8.40
EC (dSm^{-1})	1.02-2.37 1.40	0.37-1.53 0.98	0.75-3.00
Cu	0.36-0.65 0.51	0.01-0.06 0.030	0.2
Zn	3.92-5.23 4.08	0.01-0.03 0.02	2.0
Cd	0.15-0.20 0.18	0.01-0.07 0.04	0.01
Ni	0.45-0.79 0.57	0.03-0.25 0.13	0.2
Pb	0.97-1.34 1.11	0.12-0.69 0.36	5.0

*Ayers and Westcot (1985)

(iii)- Plant Analysis: The leaves of native plants and olive were rinsed with tap water then with distilled water. The plant samples were placed in paper bags, dried at 65° C for 48 hours and ground to pass through 1-mm sieve. Two hundred mg plant samples were digested in 5.0ml of 2:1 mixture (v / v) of 70% $HClO_4$ and concentrated HNO_3 at 70° C overnight (LeClaire et al., 1984). The concentration of Cu , Zn, Cd, Ni and Pb in the filtrate was measured by using AAS.

The fruit and oil olive were analyzed after removal of seeds from olive fruits. Five grams of the edible component and 10 gm of the olive oil were dried then ashed at 450°C for 16hrs, dissolved in 10 ml 50% (v/v) HCl and diluted to 50 ml with distilled water (Chlopecka,1993) and the concentrations of trace elements were measured by using AAS.

5-Statistical Analysis

In order to define the relationships between the soil and plant variables, correlation analyses were performed on the data (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Quality of the Irrigation Waters

The average values of pH and EC of the two waters used for irrigation are given in Table 1. It is clear that the raw sewage water has an average low pH value as compared with the permissible value (Table 1). However, the EC of the raw sewage water is within the permissible level (Table 1) and is higher than that of the ground water. The metals content in the raw sewage water specially Cu, Zn, Cd and Ni were higher than the permissible levels, while Pb was only an exception (Table 1). On the other hand, water of wells contained lower amounts of Cu, Zn, Ni and Pb than the permissible level except Cd which was higher (Table 1).

The source of the raw sewage water is local small rural community and is discharged from domestic daily life. The variations of metal contents among the water sampling seasons are found to be rather narrow. This raw sewage water contained relatively higher metal contents than those of wells water, or relative to the permissible levels for irrigation (Table 1). Similar findings were also found by Anderson and Nilsson (1973) and Gupta et al. (1986). Shalaby et al. (1996) found that sewage water collected from Tanta City contained concentrations of 28, 7.8, 12.5, 2.7, 6.2, 0.8 and 2.4 ppm, for Fe, Mn, Zn, Cu, Pb, Cd and Ni, respectively. Narwal et al. (1993) reported similar values of metal concentrations in sewage waters. The concentration of Pb in the raw sewage water (Table 1) was found to be suitable for irrigation purposes, since the sewage water has Pb ranging from 0.97-1.24mg L^{-1} ,whereas the permissible concentration level for irrigation water is 5mg L^{-1}.

Soil Characteristics

Data in table 2 showed that continuous irrigation by raw sewage water has slightly decreased soil pH after 30 years of irrigation with sewage water. This decrease in pH may be attributed to both low pH of the sewage water (average, 5.93) and the production of organic acids during decomposition of organic matter added with sewage water (Simard et al.,1999) However, it has been found that the higher the carbonate content, the higher the buffering capacity of the soil (Cabral and Lefebvre, 1998).In the present case, the $CaCO_3$ represents about 20% of the bulk soil. So, the soil showed a good buffering capacity and soil pH did not differ widely in the two fields (3 and 10 years of irrigation with sewage water).

There were increases in both organic matter and cation exchange capacity (CEC) as a result of sewage water irrigation with its component of organic residues. Robertson et al. (1982) found that liquid sludge application, over a 6-years period, increased soil organic matter to a depth of 90 cm in fine sandy loam soil.

Table (2): Some chemical and physical properties soils irrigated with ground water or with raw waste water.

Irrigation Period (years)	Irrigation water	Depth Cm	PH (1:2.5)	EC dSm^{-1}	O.M. %	CEC meq100g^{-1}	CaCO3 %	Sand %	Silt %	Clay%	Texture
3	SW	0 – 20	8.1	2.3	0.7	8.7	14.8	76.2	14.4	9.4	*Loamy sand*
		20 – 40	7.9	1.7	0.4	-	20.1	71.9	23.3	4.8	
	GW	0 – 20	8.1	4.3	0.3	7.7	21.3	72.6	21.7	5.7	*Loamy sand*
		20 – 40	7.9	3.9	0.2	-	22.7	73.7	20.2	6.1	
10	SW	0 - 20	7.8	0.2	1.4	10.5	21.7	73.2	19.4	7.4	*Loamy sand*
		20 – 40	7 .9	0.3	0.8	-	21.2	80.6	13.6	5.8	
	GW	0 – 20	7.8	2.3	0.8	9.6	24.8	74.1	17.3	8.6	*Loamy sand*
		20 – 40	8.0	0.6	0.4	-	25.4	76.3	13.9	9.8	
30	SW	0 – 20	7.8	0.7	4.8	13.1	14.7	48.4	34.7	16.9	*Sandy Loam*
		20 – 40	7.9	0.8	1.4	-	21.4	53.1	33.2	13.7	
	GW	0 – 20	8.2	4.6	0.2	8.5	18.4	48.7	32.9	18.4	*Sandy Loam*
		20 – 40	8.1	3.7	0.1	-	20.1	52.4	32.8	14.8	

G W :Ground water irrigated soil
S W: Sewage water irrigated soil

Total Heavy Metals Contents In Soil.

The total amounts of heavy metals in soil irrigated with raw sewage water or with ground water (whell water) are presented in Tables 3 and 4. The total metals content in the soil irrigated with raw sewage water were higher than that irrigated with ground water (control soil). The highest values of Cu, Zn and Ni metal contents were 51.8, 291.0 and 47.1 mgkg^{-1} respectively, at upper soil layer (0-20cm).

It is clear that the levels of total metal in the control surface soil layer (0-20 cm) are within the normal ranges of agricultural soils as reported by Kabata-Pendias and Pendias (1992). It is reported that the native distribution of the metals in the soil was largely dependent upon the nature of the metal and the soil properties (Han and Banin, 1999).

Table (3): The amounts of total Cu, Zn, Cd, Ni and Pb (mgkg^{-1}) in sewage water irrigated soil for 3, 10 and 30 years.

Soil depth, cm	Cu	Zn	Cd	Ni	Pb
3 Years					
0-20	18.5	41.60	2.60	22.00	20.50
20-40	14.3	37.50	3.80	21.00	20.2
40-60	11.1	14.60	2.80	15.00	12.70
60-100	11.7	8.90	3.70	14.70	7.30
100-150	8.5	10.40	4.00	11.10	9.90
10 Years					
0-20	30.50	162.0	3.20	27.70	38.50
20-40	15.90	29.50	4.80	21.60	24.00
40-60	10.10	22.00	3.20	15.80	14.90
60-100	9.30	10.80	5.80	10.40	16.90
100-150	8.60	12.00	3.10	5.30	14.40
30 Years					
0-20	51.80	291.0	4.10	47.10	40.20
20-40	24.90	112.0	4.00	44.30	46.80
40-60	13.70	45.80	5.00	19.90	15.50
60-100	12.20	19.60	7.90	16.20	7.10
100-150	8.90	10.70	5.20	9.10	13.20

The distribution of total metals with soil depth (Tables 3 and 4) indicates that most metasl had accumulated in the upper soil layer (0-20 cm). This is due to natural cycling of metals to the surface soil by vegetation (Schirado et al., 1986). However, it is reasonable to assume that a part of the metal enrichment the surface soil layer because of anthropogenic activities (Mermut et al., 1996).

Also, within the soil profile, heavy metals tend to be concentrated in the O. M.- rich- top soil due to the strong adsorptive capacity of soil complex (Singh et al. 1987).

Table (4): The amounts of total Cu, Zn, Cd, Ni and Pb (mgkg^{-1}) in ground water irrigated soil for 3, 10 and 30 years.

Soil depth, cm	Cu	Zn	Cd	Ni	Pb
3 Years					
0-20	13.8/0	34.50	1.90	21.00	17.70
20-40	13.80	15.30	2.60	17.70	14.30
40-60	11.80	13.00	2.60	13.00	13.2
60-100	11.20	7.40	3.30	12.90	6.50
100-150	8.30	9.90	4.00	10.0	10.50
10 Years					
0-20	19.70	33.50	2.10	22.00	20.50
20-40	12.00	12.00	3.00	13.80	10.70
40-60	9.60	13.60	2.30	12.60	14.90
60-100	9.50	8.40	5.20	9.30	18.60
100-150	8.40	9.60	2.70	5.10	15.60
30 Years					
0-20	18.10	17.60	2.90	20.50	25.30
20-40	15.00	13.50	2.40	16.70	14.10
40-60	13.50	17.10	3.20	16.50	12.90
60-100	10.40	8.60	2.90	12.90	5.90
100-150	7.40	9.00	4.20	6.20	11.30

It is reported that the stability of heavy metals complexes with organic ligands decreases with relative electronegativity of the metals, i.e. Pb> Cu>Zn>Cd (Tyler et al., 1989). In case of cadmium, the highest level (7.9 mg kg^{-1}) was found in soil depth of 60-100 cm, where Cd was the most mobile heavy metal. This implys that Cd is more leachable than the other metals under conditions of different soils (Kabata-Pendias and Pendias,1992 and Jeng and Singh, 1993). According to Laxen (1985), as alkalinity increases Cd adsorption decreases, probably due to the competition from Ca^{2+} and Mg^{2+} ions.

It is also clear that continuous irrigation with raw sewage water for 30 years increased the amounts of total metals. The enrichment factor (EF) in surface soil layer irrigated with sewage water (Table 5) was proportional to the amount of applied sewage water. Chirenje and Ma (1999) mentioned that under alkaline conditions (pH 8-9), most Cu and Pb in solution were probably associated with dissolved humic acid and were relatively mobile. Zou and Wong (2001) concluded that in the presence of dissolved organic matter (DOM), Cu sorption decreased markedly in calcareous soil. Among all studied metals, it was found that Zn represented, the highest EF in the soil surface (EF= 16.53) after 30 years of sewage water irrigation. This may be due to the relatively high concentration of Zn in sewage water (Table 1). According to the conditions of the experimental field study, it should be expected that the large pores, long time of sewage water application, and hydraulic loading would increase heavy metal leaching through the soil profile. These observations are in agreement with those found by Mattigod et al.(1985). Dowdy and Volk (1983) suggested that movement through open soil channels or cracks might explain longer-range translocation of heavy metals.

Organic matter is of importance in the translocation, and subsequent leaching, and accumulation of heavy metals (Kabata-Pendias and Pendias, 1992).

Stevenson (1982) showed that under alkaline conditions, humic substance molecules are in their fully expanded state because of mutual repulsion of charged acidic groups (e.g.COO^-). Humic and fulvic acids are anionic polyelectrolytes with a degree of ionization that depend on pH. Their potentiometric titration indicates two inflection points; characteristics of carboxylic groups (pH 4.6-4.9) and of phenol-OH groups (pH 8.0-8.2). So, the complexing of metal ions with humic substances led to the solubilization at high pH (Almås et al.,2000). Since soil pHs, in the present study were of average 8.0, the complexing formation of the studied heavy metals with the organic matter led to solubilization and, as a result, downward of heavy metals through the soil profile. According to Phillips and Chapple (1995), the presence of dissolved organic carbon (DOC) could increase metal mobility via organo-metal complexes.

Table (5): Values of enrichment factors EF* in soils irrigated by sewage water for 30 years.

Depth Comparison (cm)	Sewage water Application period (year)	Elements				
		Cu	Zn	Cd	Ni	Pb
0-20	3	1.34	1.21	1.37	1.05	1.16
	10	1.55	4.84	1.52	1.26	1.88
	30	1.38	16.53	1.62	2.12	1.59
20-40	3	1.04	1.06	1.46	1.19	1.41
	10	1.33	1.08	1.60	1.57	2.24
	30	3.45	1.54	1.63	2.54	3.32
40-60	3	0.94	1.12	1.08	1.15	0.96
	10	1.05	1.62	1.39	1.25	1.00
	30	1.01	2.68	1.47	1.13	1.20
60-100	3	1.04	1.20	1.12	1.14	1.12
	10	0.98	1.29	1.12	1.12	0.91
	30	1.17	2.28	3.10	1.18	1.27
100-150	3	1.02	1.05	1.00	1.11	0.94
	10	1.02	1.25	1.15	1.04	0.92
	30	1.20	1.19	1.10	1.24	1.17

$$EF^{*} = \frac{\text{The mean metal in irrigated soil}}{\text{The metal concentration of background soil}}$$

(EF, Kim and Kim ,1999).

Chengqing et al. (1999) showed that organic matter enhances metal leachability when present in dissolved form under alkaline conditions. Thus, organic matter tends to be more soluble at neutral or alkaline pH and therefore the potential for leaching of metals in the studied soil may be the highest as they are irrigated with raw sewage water and maintained high pH (Japenga et al., 1992).

The occurrence of $CaCO_3$ in soil (20%) and pH values about 8.0 (Table 1) would favor the solubility of organic matter and consequently, heavy metals movement could be reached. McBride et al. (1999) considered that DOM could act as a vehicle for leaching heavy metals in soils. Thus, metal leaching could be expected to be at the highest immediately after raw sewage water irrigation. Dorronsoro et al.(2002) reported that metals can be arranged according to migration index (MI) as Cd> Zn> Cu> Pb. So, they divided MI values into three subsets. Elements with high mobility (Cd and Zn) with moderate mobility (Cu) and with low mobility (Pb). Comparable results were reported by Vidal et al, (1999). Accordingly, we can hypothesize that factors that may explain the movement or leaching of the studied heavy metals in our case could be: (i) the quantity of irrigation sewage water applied or the time involved for movement to take place, (ii) low clay and organic contents and subsequently low CEC of the studied soil, and (iii) the coarse texture of the soil.

DTPA-Extractable Heavy Metals

As shown in Table 6, the soil samples appear to be very low in DTPA extractable heavy metals, since. DTPA extracted small portions of the total metal contents in soil. The amounts varied from 1.9 to of DTPA extractable Zn, Cu, Cd, Pb, and Ni, as a percentage of total metal, 7.9, 1.1 to 1.9, 2 to 9.4, 1 to 5.5, 4.3 to 5.6, and 1.2 to 1.7%, respectively. These low levels of the DTPA extractable metals obtained in this study could be due to the small quantities of organic matter, high $CaCO_3$ content, and high pH values of the soils. Flores et al.(1997) and. Lake et al. (1984) reported that application of sewage sludge to soils may alter the distribution of metal cations between the physicochemical forms and thus may increase its availability.

Table (6): The amounts of metal extracted from soil by DTPA ($mgkg^{-1}$) from soils of the top layer (0-20cm) and irrigated for different periods with sewage water and ground water.

Irrigation Periods (year)		Cu	Zn	Cd	Ni	Pb
3	S. W.*	0.91	3.18	0.05	0.33	1.02
	G.W.**	0.27	0.67	0.06	0.27	0.80
10	S. W.	2.20	12.83	0.06	0.56	1.82
	G. W.	0.62	0.64	0.06	0.35	1.04
30	S. W.	2.16	13.12	0.07	0.62	1.70
	G. W.	0.42	0.34	0.04	025	1.21

* Sewage water- irrigated soil

** Ground water -irrigated soil

As shown in Table 6, Cd-DTPA extracted from soil was not apparently affected by sewage water treatment at the top soil layer. This behavior reflects the character of Cd as it has a very high migration rate. El-motaium and Badawy (2000) showed that DTPA-extractable heavy metals increased as the irrigation period of sewage water increased.

A positive relationship between the increasing DTPA extractable metal and the period of sewage water irrigation was observed. The concentration of Zn extracted by DTPA from soils irrigated by raw sewage water for 3, 10 and 30 years were 4.7, 20.0 and 38.6 times, respectively, more than their corresponding controls (ground water irrigated soil).So, these results indicated that metal availability, measured by DTPA, had increased with time of sewage water application. Lake et al. (1984) mentioned that the apparent increase in DTPA-extractable metals from sludge-soil mixtures with time was ascribed to dissolution of metal precipitates such as carbonates, hydroxides, and phosphates through changes in pH or gas composition of the soil resulting from microbial activity; oxidation of metal sulfides by autotrophic sulfur-oxidizing bacteria; and microbial release of metals complexed with sludge organic matter.

Significant correlations were found between the amounts of total metals and DTPA extractable metals (r^2 = 59.1**, 86.4**, 82.6**and 50.1** for Cu, Zn, Ni and Pb, respectively) However, in case of Cd, no significant correlation was found. This is probably because of the low binding energy of that metal consequently its migration to the deepest layer. Li and Shuman (1996) concluded that no significant relationship was found between DTPA extraction and total concentration of Cd. The significant correlations between total and DTPA-extractable metals suggest that the DTPA soil test could be used as a reliable index for the total metal concentrations of a soil (Valdares et al., 1983, and He and Singh, 1994).Singh and Karthikeyan (2003) reported that trace element of the soils and plants are substantial higher in sewage water-irrigated fields.

Heavy Metal in Plants.

The amounts of Zn, Cu, Cd, Pb, and Ni in the native pastures and leaves, fruits, and oil of olive plants are presented in Table 7. The order of the metal concentrations in these vegetations was Zn>Cu>Pb>Ni>Cd. There was little increase of metal concentrations in organs of plants grown on sewage water- irrigated soil compared to the control. In the other studies, Badawy and Helal, (1997) and Selem et al.(2000) showed that heavy metals contents in plants had increased with sewage water application. In respect to fruits and oil of olive, there was no increase in metals concentration as a result of sewage water applications. Concentrations of Zn, Cu, and Ni in most of the pastures and olive leaves had increased with the irrigation with sewage water, whereas the concentrations of Cd and Pb did not increase. Chaney et al. (1976) found that increased levels of heavy metals in soils from sewage applications, while there were very little increases in plant tissues.

Table (7): The amounts of metals (mgkg^{-1}) in the leaves of native pastures plants and leaves, and fruits of olive plant and its oil, grown on soil irrigated by sewage water for 30 years.

Plant material	Treatment	Cu	Zn	Cd	Ni	Pb
Wild Mallow *(Malva porviflora)*	S.W.	24.5	43.7	0.30	0.87	2.50
	G.W	15.7	33.7	0.32	0.76	2.15
	L.S.D.(1)	11.66	12.69	0.11	0.40	1.12
Lamb' s quartet *(Chenopodium murale)*	S.W.	17.70	28.7	0.22	1.02	3.50
	G.W.	10.50	16.00	0.20	0.65	1.50
	L.S.D.	5.32	7.03	0.07	0.35	1.20
Sedge *(Cyprus rotandus)*	S.W.	20.00	28.50	0.20	2.10	5.82
	G.W.	13.20	17.00	0.17	1.04	6.00
	L.S.D.	7.49	7.79	0.10	0.65	4.94
Jimson weed (*Solanum nigrum)*	S.W.	16.20	27.50	0.17	1.45	5.75
	G.W.	17.40	15.20	0.27	0.95	4.00
	L.S.D.	8.86	10.32	0.11	1.29	4.41
Oliveleaves (*Olea Europea*)	S.W.	22.20	25.70	0.30	1.50	2.00
	G.W.	12.20	13.20	0.28	1.12	2.02
	L.S.D.	7.48	9.85	0.11	0.86	0.71
Olive fruits I	S.W.	1.00	12.00	0.02	0.01	0.09
	G.W.	0.700	9.00	0.02	0.01	0.10
	L.S.D.	0.94	9.80	0.02	0.02	0.10
Olive fruits II	S.W.	0.90	13.00	0.02	0.01	0.13
	G.W.	1.00	8.00	0.02	0.01	0.12
	L.S.D.	0.80	5.95	0.02	0.02	0.08
Olive Oil	S.W.	0.10	1.00	0.01	0.01	.05
	G.W.	0.10	1.00	0.01	0.01	0.06
	L.S.D.	0.12	0.60	0.02	0.02	0.06

(1): Least significant difference at level 5%
I& II: Tow different olives species

The negative response of some metal concentrations, in the olive plant and grass grown on soil receiving sewage water, was most likely for the result of a combination of different factors. The differences in metal uptake due to the difference between plants grown on both the treated and control soils. Pasture grasses and olive trees, from plots of sewage water irrigation, were green and actively growing, while native plants and olive samples taken from the control plots were growing poorly in a dry and nutrient-deficient soil. Because of the slow growth habits of the native pasture and olive tree in the control soil, the decrease in metal content of plants grown in the treated soil may have been a dilution effect rather than an actual decrease in plant availability of soil metal (Baxter et al., 1983). Also, soil containing sludge residue (the treated soil) possess a higher capacity to immobilize metals against plant uptake relative to the control soil. So, the protective effect of sludge against metals uptake from the treated soil can be attributed to the large difference in organic matter content between the treated (2.8%) and control (0.2%) soils. McBride (1995) concluded that the adsorptive properties of sludge, themselves, often prevent excessive uptake of many of heavy metals into crops, a protection attributable largely to the added organic matter. He also concluded that this protection could not be considered to be permanent or effective for all toxic metals. Also, he observed that the differences in degree of protection are largely attributed to different rooting patterns and degree of organic matter decomposition.

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تأثير الرى بمياه الصرف الصحي على الأرض الجيرية:

١- خواص الأرض ومحتوى الأرض والنبات من العناصر الثقيلة

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جمعت عينات الأرض والنبات من مواقع الحقول التجريبية التى تقع عند الكيلو ٨٩ طريق مصر – إسكندرية الصحراوى والتى رويت بمياه الصرف الصحى الخام لمدد مختلفة (٣، ١٠، ٣٠ سنة) وذلك لتقييم تأثير الرى بتلك المياه على الخواص الكيميائية للأرض وكذا توزيع محتوى عناصر النحاس، الزنك، الكادميوم، النيكل والرصاص فى القطاع الأرضى، وقياس تركيز العناصر المستخلصة بواسطة محلول DTPA من الطبقة السطحية للأرض (صفر – ٢٠ سم). وكذا تقدير تركيز العناصر الثقيلة فى بعض النباتات الطبيعية وأوراق وثمار وزيت أشجار الزيتون والتى رويت بمياه الصرف الصحى (لمدة ٣٠ سنة) وتلك التى رويت بالمياه الجوفية (مياه آبار). وأوضحت النتائج أن الرى بمياه الصرف الصحى أدى إلى زيادة مستوى العناصر الثقيلة والمادة العضوية فى الأرض وانخفاض قيم الـ pH وذلك بالمقارنة بالرى بالمياه الجوفية وقد وجد أن الإثراء النسبى لتركيز العناصر الثقيلة فى الأراضى (صفر – ٢٠سم) المروية بمياه الصرف الصحى تتناسب مع كمية المياه المضافة، حيث أعطى الزنك أعلى معامل إثراء (فى المتوسط = ١٦,٥٣)، بينما أعطى النحاس أقل معامل (فى المتوسط = ١,٣٨). وقد أوضحت النتائج أيضا أن الأرض فقيرة فى العناصر المستخلصة بمحلول DTPA وقد بلغ محتواها من هذه العناصر ٠,٢٧، ٠,٦٧، ٠,٠٦، ٠,٢٧، ٠,٨٠ ملليجرام لكل كيلو جرام لكل من النحاس، الزنك، الكادميوم، النيكل، الرصاص على التوالى ومع ذلك فإن تلك المستويات حدث لها زيادة بالرى بمياه الصرف الصحى. وقد وجد أن هناك تلازم معنوى بين العناصر المستخلصة بواسطة محلول DTPA وكذا محتواها الكلى فى الأرض. وقد بينت النتائج أن ثلاثون عاما من الرى بمياه الصرف الصحى لم تكن كافية لإحداث مستويات سامة بالعناصر الثقيلة للنباتات النامية بالأرض الجيرية وكان غسيل الكادميوم فى الأراضى ذات المحتوى المرتفع من الجير أعلى من العناصر الأخرى مثل النحاس، الزنك، النيكل والرصاص.