THE LEVEL OF ORGANIC POLLUTANTS IN SOME PLANTS IRRIGATED WITH TREATED SEWAGE WATER

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Abstract

This experiment was conducted to study the effect of irrigation with treated sewage water (TSW) on the levels of pesticide residues in plants cultivated in loamy sandy or silty loam soil.

The results indicated that an increase of organochlorine (OC) level when the two soil types were irrigated with agriculture drainage water (ADW) and ground water (GW) compared with sewage water (SW), at the 1st and 2nd growing seasons. Lower pesticide residues were found when the soils were irrigated with TSW.

Also, water source affects greatly the level of pesticide residues observed by plants. According to the total detected pesticide residues, GW caused high contamination in wheat grains or radish leaves, followed by SW, while TSW caused the lowest. However, all detected pesticide residues in wheat grains or radish leaves did not exceed the MRLs contamination of Codex, 2000.

Key words: Treated sewage water, Soil, Plant, Pesticide contamination.

INTRODUCTION

The demand for water increases each year as urban and natural development countries. In the past focus has been on providing fresh groundwater and surface water for domestic, industrial and agricultural purposes. Opportunities for ecologically sustainable development can be pursued by the more efficient use of traditional sources of fresh water and by the increased used of alternative resources such as reclaimed water. There are no comprehensive figures of the wastewater used for irrigation but the available estimates indicate that about 900,000 hectares of farmland in developing countries are irrigated with wastewater, and globally 20 million hectares producing nearly 4 % of food are irrigated with wastewater (Muhammad Abbas, 2006).

But some scientific articles raise questions about possible health and the environmental effects of sewage water uses. Recent studies support long standing concerns about possible public health effects of reclaimed water. However, the use of raw or treated sewage water in agriculture is not without danger. The major risk is food contamination by pathogenic microorganisms and organic chemicals.

Therefore, this research aims to study the effect of irrigation with treated sewage water (TSW) on organic pesticides contamination levels in plants cultivated in different soil types which have been irrigated for many years with SW comparing to various irrigation water sources.

MATERIALS AND METHODS

I- Experiment design:

Two soil types (have been irrigated from many years ago with sewage water), loamy sand and silty loam soil were collected from the rhizosphere zone of El-Gabal El-Asfar and Tahanoub agricultural area, Qualubia governorate. Each soil type was air dried ground and passed through 2-mm sieve to remove rocks, plant residues, and other large particles. Soil sample of 5.0 kg was sub-divided and placed in polyethylene bags. Some physical, chemical properities, soil texture and organic matter percentage of the investigated soils are presented in Tables 1 and 2.

Table 1. Chemical characteristics of soil samples

Soil type	pH (1:2.5) Suspen	EC dsm^{-1} at 25 C	Soluble cations (meq/l)				Soluble anions (meq/l)			O.M* %	SP** %
			Ca^{++}	Mg^{++}	K^+	Na^+	HCO_3^-	Cl^-	SO_4^{--}		
Silty loam	7.5	2.1	2.43	4.43	0.4	21.2	7.75	14.79	5.92	3.27	60.00
Loamy sand	7.5	1.31	7.03	2.27	0.78	3.91	5.75	3.36	4.88	1.97	19.33

* Organic matter ** Saturation percentage

Table 2. Particle size distribution of soil samples (mm).

Soil sample	Particle size distribution of the studied soil		
	Clay (<0.002)	Silt (0.002-0.02)	Sand (>0.02)
Silty loam	23.10	65.70	11.20
Loamy sand	10.42	5.98	83.60

Wheat (*Triticum aestivum*) and radish (*Raphanus sativus*) was seeded in winter and in summer, respectively, during 2004-2007. Wheat and radish were thinned to 3 and 5 plants per pot after 21 or 15 d from sowing, respectively.

Different irrigation water sources, Nile water (NW), ground water (GW), and agricultural drainage water (ADW) were collected monthly during winter and summer seasons from Tahanoub, while sewage water (SW) and treated sewage water (TSW) were collected from El-Gabal El - Asfar Station . The pesticide contamination levels of the collected water are shown in Table 3. During the experiment, fertilizers (urea 46 %, and super- phosphate 16 %) were added to the pots with the rate of 0.6 and 0.35 g/pot of wheat and 0.6 and 0.9 g/ pot of radish, respectively. Irrigation was practiced to keep soil almost at their field capacity for a period of growing season.

Table 3. Mean concentration of detected pesticides in different irrigation water sources at Qualubia governorate during winter and summer season, 2005 & 2006.

Sampling time	Sources* of Irrigation Water	Pesticide (ppb)										
		α-HCH	β-HCH	D-HCH	p,p-DDD	O,P-DDT	P,P-DDT	P,P-DDE	endrin	*trans*-chlordan	choro-thalonil	Total OC**
winter season	N.W	0.12	0.01	ND	ND	0.06	ND	ND	0.01	ND	ND	0.20
	G.W.	0.01	ND	0.19	ND	0.40	0.18	ND	ND	0.03	ND	0.81
	A.D.W.	0.23	0.09	0.05	ND	0.30	0.19	ND	0.02	ND	ND	0.88
	S.W.	0.13	0.05	ND	ND	0.26	0.05	ND	ND	ND	ND	0.49
	T.S.W.	ND	ND	ND	ND	0.16	ND	ND	ND	ND	ND	0.16
summer season	N.W	ND	0.02	0.04	0.06	0.59	0.06	0.12	3.66	ND	0.43	4.98
	G.W.	ND	0.02	0.02	ND	1.66	0.13	0.14	3.62	ND	0.45	6.04
	A.D.W.	ND	ND	0.05	ND	0.54	ND	0.25	3.88	ND	0.40	5.12
	S.W.	ND	ND	0.02	ND	0.40	ND	0.11	4.00	0.02	0.25	4.80
	T.S.W.	ND	ND	0.02	ND	0.21	ND	0.11	3.19	0.02	0.17	3.72

* NW= Nile water, GW= Ground water, ADW= Agricultural drainage water, SW= sewage water and TSW= treated sewage
** Total organochlorine pesticide residues ND = not detected

2- Sampling:

Soil samples were collected after of the growing season from irrigated pots, air dried, and ground and sieved through 2 mm, while wheat grains and radish leaves were collected at the harvest stage of each season. The ground soil, wheat grains and radish leaves samples were kept in refrigerator at 4 °C for pesticide residue analysis.

3- Pesticide residue analysis

3-1-Extraction

3-1-1 Soil: -

Residue analysis was carried out according to the multi-residue method recommended by Pesticide Analytical Manual, 1978. In such method, 50g soil was placed in 250-ml Stoppard flask containing 100 ml of 50% acetone in n-hexane (analytical grade) overnight. The slurry was shacked for 4 h and filtered through Whatman No. 1 filter paper. After filtration, soil was re-washed with an additional amount of 50 % acetone/n-hexane. The extracted filtrate was transferred into 500 ml separatory funnel containing 200 ml distilled water with slight amount of saturated sodium chloride solution, and then shacked vigorously for 2min. After separation, the lower aqueous layer was drained off and re-extracted in a second 500ml separatory funnel with 20ml of 15 % methylene chloride / n-hexane mixture (15 + 85). The solvent layers were combined and washed with additional amount (100 ml) of distilled water in 500 ml separatory funnel (two times).

The extract was drained off into 250ml spherical flask through Whatman No.1 filter paper with a moderate amount of anhydrous sodium sulfate and activated Celite (30 ~ 80 mesh), and evaporated under vacuum at 40 °C to dryness. Then, the extracts were kept in refrigerator for clean – up.

3-1-2 Plant:-

3-1-2-1- Leaves: -

According to Health and Welfare Canada, 1990, 50 g sample were blended with 100 ml acetonitrile at high speed for 3 min. Ten grams of sodium chloride were added, and the sample were blended for another 3 minutes. The slurry was filtered through Whatman No. 1 filter paper. Extract was evaporated to 10 ml and decanted into 15 – ml centrifuge tube containing anhydrous sodium sulphate to bring the liquid to 15-ml volume. Tube was centrifuged at 5000 rpm for 5 min. Aliquot of 10 ml (equivalent to 50 gm sample) was transferred to second tube and evaporated to 0.5 ml for clean – up.

3-1-2-2- Wheat grains:

Ground grain was extracted for pesticide residue analysis according to the previous mentioned method, (II-3-1-1).

II-3-2-Clean – up: -

The previous extract was cleaned – up according to Thompson (1974) method. Fifteen grams of florisil (60 – 100 mesh) activated at 130 °C over night were introduced over a piece of cotton into chromatographic glass column (250 × 22mm id.). Anhydrous sodium sulfate was then added to the top of the column with 2-cm thickness. The column was pre-washed with 15-ml n-hexane. Sample extract was gently transferred to the top of the column and the solvent was allowed to move until the extract just reaches the surface of sodium sulfate. The column was re-washed with 100 ml of eluting mixture, petroleum ether / diethylether (94 + 6) followed by same volume of 85 % (85 + 15) and 50 % (50 + 50) petroleum ether / diethylether solution solvents (analytical grade).

The filtrate was evaporated under vacuum in rotary evaporator to dryness at about 40 °C. The residue was dissolved with 1 ml of n-hexane for GLC analysis.

II-3-3- Determination: -

Determination and quantification of pesticide residues were carried out using gas liquid chromatography (HP 5890 II, chromatographic capillary columns). Conformation was carried out by injection into two different columns. Detected pesticides were calculated relative to aldrin as internal standard to avoid deviation in Rt_s.

Calibration Standard Curve: -

Single analytical standard of α-HCH, β-HCH, δ-HCH, HCB, *p,p*′-DDD, *p,p*′-DDE, *o,p*′-DDT, *p,p*′-DDT, aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, alachlor, chlorothalonil, *trans*-chhlordane, *cis*-chlordane, and dicofol, were obtained from Central LAB of Residue Analysis of Pesticides and Heavy Metals in Foods , Agricultural Research Center, Ministry of Agriculture, Giza, Egypt. The pure samples were mixed at concentration of 0.1, 0.5, 1.0, and 2.0 µg / ml in n-hexane and injected into GC. Calibration curve was established. Chromatogram of the monitored pesticides is shown in Fig_s. 1 and 2.

Recovery: -

Known concentration of the mixed standard of analytical pesticides were added to virgin soil, leaves, grains and distilled water. The same procedures as used in the samples were essentially followed. Recovery percentage of the compounds was calculated by the following equation and represented in Table 4.

$$\% \text{ Recovery} = \frac{\text{Concentration of sample (mg/l)}}{\text{Concentration of standard (mg/l)}} \times 100$$

Table 4. Recovery of standard pesticides (%).

Pesticide	Soil			
	Silty Loam	Loamy Sandy	wheat G*	Radish L**
a-HCH	75	83	85	90
b-HCH	80	91	80	94
d-HCH	83	94	90	94
HCB	85	95	80	86
alachlor	87	96	93	83
heptachlor	86	95	92	82
H.epoxide	78	87	88	89
dieldrin	69	86	95	87
endrin	71	82	86	86
cis-chlordane	78	84	88	83
trans-chlordane	78	84	88	83
p,p-DDE	82	91	90	91
p,p-DDD	88	93	80	83
o,p-DDT	81	89	96	88
p,p-DDT	80	89	84	86
chlorothalonil	80	89	93	88
dicofol	86	85	92	82

*G= Grains

**L= Leaves

RESULTS AND DISCUSSION

III -1- Soil:

At the beginning of the experiment, soil pre-irrigated with SW was analyzed to determine the existed pesticide residues. The organochlorine (OC) pesticides, *β*-HCH, *p,p'*-DDE and endrin, and chlorothalonil, being 0.05, 0.131, 0.276 and 0.156 ppb, respectively. In loamy sand soil *p,p'*-DDE, endrin, and chlorothalonil were found with different concentrations reaching, 0.08, 0.10 and 0.202ppb, respectively.

III -1- 1- Wheat pots: -

After harvesting the analyzed soil samples of the grown pots showed that ADW and GW irrigation sources increased the total detected OC pesticide residues in the grown soil compared to SW, at the end of the 1st and 2nd season in silty loam and loamy sand soil, while, irrigation with TSW decreased the total pesticide residues in silty loam soil (0.59 and 3.60 ppb) and loamy sand soil (0.45 and 3.09 ppb) than soil irrigated with SW at the 1st and 2nd seasons, respectively.

At the end of the 1st wheat season (Table 5), the major detected pesticide residues were *o,p'*-DDT, *p,p'*-DDE and endrin, which were detected in silty loam or loamy sand soil when irrigated with all irrigation water sources. *o,p'*-DDT and *p,p'*-DDE reached its peak in the soils when irrigated with GW and ADW, and endrin residue reached its peak in soils irrigated with ADW. The lowest contamination with endrin, *p,p'*-DDE and *o,p'*-DDT was detected in silty loam soil irrigated with TSW. These results showed that all detected pesticide residues in the grown soil were readily correlated with the contamination concentration of endrin, *p,p'*-DDE and *o,p'*-DDT in irrigation water during wheat season and soil type. The organochlorine *p,p'*-DDT was not detected in soils irrigated with NW and TSW, while, the amounts of 0.41, 0.39 and 0.11 ppb or 0.31, 0.30 and 0.08 ppb were found in silty loam and loamy sand soil irrigated with GW, ADW and SW, respectively. This because of *p,p'*- DDT was not detected in NW or TSW as well as the cultivated soil at the beginning of the season. Chlorothalonil was not detected in silty loam or loamy sand soil when irrigated with all irrigation water sources, because of its absence in the irrigation waters.

At the end of the second wheat season (Table 5), endrin, *o,p'*-DDT, *p,p'*-DDE and chlorothalonil residues were found in the two soils irrigated with all tested irrigation water sources. *p,p'*-DDT and *α*-HCH were detected when irrigated with all irrigation waters, except of that irrigated with TSW in silty loam or loamy sand soil. The highest concentrations of *α*-HCH, *β*-HCH and *p,p'*-DDE were found in ADW irrigated soils. *p,p'*-DDT and ρ,p'-DDT reached its peak in soil irrigated with GW. The highest value of endrin was found in soils irrigated with NW being 2.45 and 2.10 ppb, respectively. In contrast, the lowest soil contamination with *o,p'*-DDT, *p,p'*-DDE, and endrin pesticide residues were found in soils irrigated with TSW, while, *α*-HCH, *β*-HCH and *p,p*'-DDT were not detected.

In comparison with the 1st wheat season, the concentration of detected organochlorine pesticide residues at the 2nd season were much higher, due to that wheat was planted in consequence with radish plant, grown in the same pots during the summer season and irrigated with different irrigation water sources. These waters sources were highly contaminated with different organochlorine pesticides during summer than winter season.

III -1- 2- Radish pots: -

In pots where radish was consequent to wheat, the results showed the same pattern of wheat pots. Data in Tables 6 showed that GW and ADW irrigation sources increased the total OC pesticide residues in the grown soil compared with SW being 7.84 and 7.17 or 5.95 and 5.44 ppb at the end of the 1st season, and 12.37 and 11.06 or 10.76 and 9.62 ppb at the end of the 2nd season in silty loam and loamy sand soil, respectively. Irrigation with TSW decreased the total pesticide residues in silty loam soil (4.08 and 5.99 ppb) or loamy sand soil (3.10 and 5.22 ppb) than soil irrigated with SW at the 1st and 2nd season.

Also, results showed that, at the end of 1st growing season, residue of chlorothalonil, endrin, and *p,p*'-DDE, *o,p*'-DDT, *p,p*'-DDT and *β*-HCH was higher in the soil irrigated with all water sources than TSW. The major detected pesticide residues were endrin, *o,p*'-DDT, *p,p*'-DDE and chlorothalonil reaching its high peak in soil irrigated with SW, GW, ADW and GW, respectively. The highest concentration of α-HCH and β-HCH was found in soil irrigated with ADW. Irrigation with TSW showed the lowest pesticide contamination level, and *p, p*'- DDT, *α* - HCH and *β* - HCH were not detected in the two soil types. Similar to the previous wheat season, pesticide contamination of radish pots depends essentially on water contamination levels.

At the end of the 2nd radish season (Table 6), the detected pesticides showed that irrigation with GW represent the highest contamination level of chlorothalonil, *o,p*'-DDT and *p,p*'-DDT residues. Also, irrigation with ADW caused the highest content *p,p*'-DDE and β-HCH in addition to α-HCH. Soil irrigated with SW containing the highest endrin concentration, while, Irrigation with TSW represents the lowest contamination level of all detected pesticide residues.

Reviewing the obtained results of mean pesticide residues in wheat and radish showed that the soil contamination with organochlorine pesticides was readily influenced with irrigation water source according to the contamination level (Ni *et al.*, 2002). Although trans-chlordane was detected in GW, no residue level was found in the soil. This is because of its faster breakdown compared to other organochlorine pesticides, (EPA, 1999).

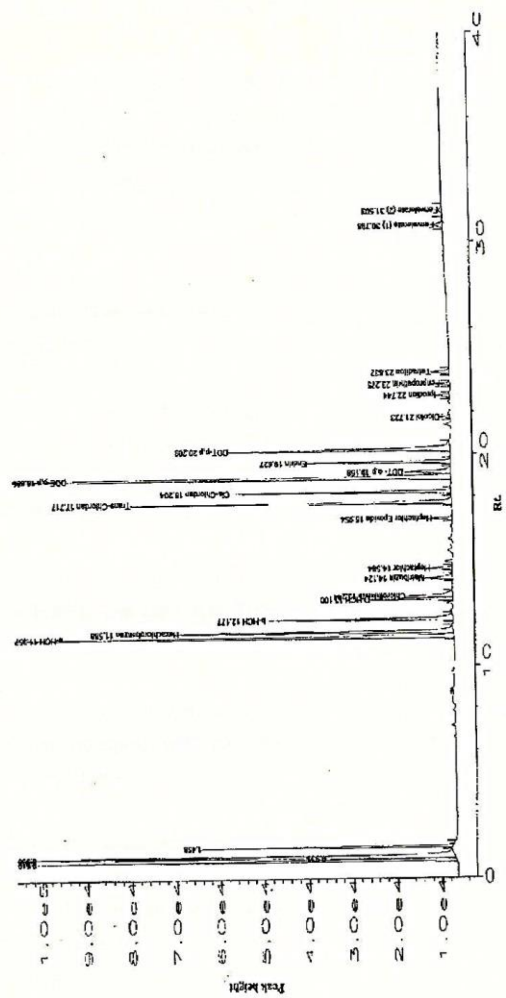

Fig. (1) : Chromatogram of monitored pesticides (Column 1).

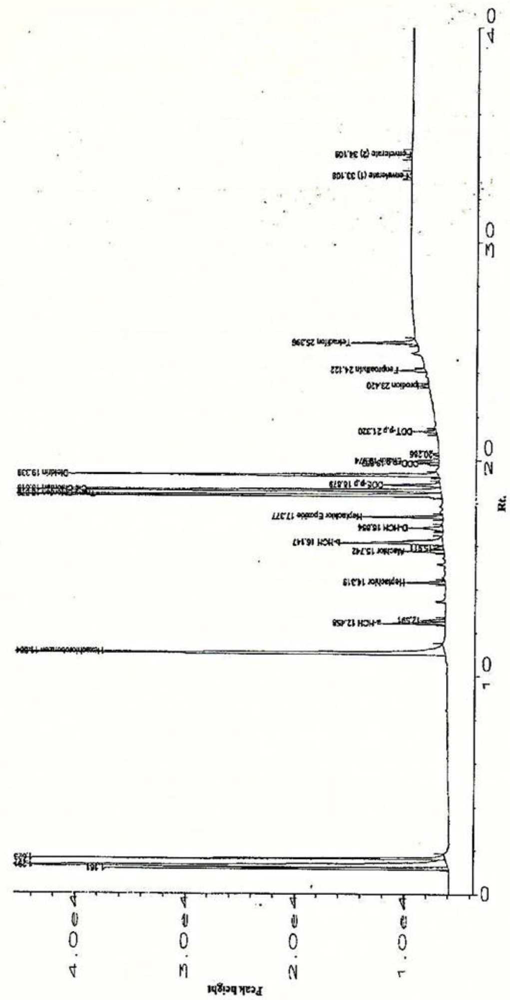

Fig. (2) : Chromatogram of monitored pesticides (Column 2).

Table 5. Effect of irrigation water sources on pesticides contamination in different soil types at the end of wheat 2004-2005 and 2005-2006 growing seasons.

Season	Soil type	Irrigation* water sources	α-HCH	β-HCH	P,P-DDT	O,P-DDT	P,P-DDE	endrin	choro-thalonil	Total OC**
2004 - 2005	Silty Loam	NW	0.18	0.06	ND	0.12	0.16	0.13	ND	0.65
		GW	0.01	0.03	0.41	0.88	0.36	0.11	ND	1.80
		ADW	0.30	0.25	0.39	0.64	0.38	0.16	ND	2.12
		SW	0.15	0.15	0.11	0.52	0.27	0.09	ND	1.29
		TSW	ND	ND	ND	0.38	0.14	0.07	ND	0.59
		Mean	0.13	0.10	0.18	0.51	0.26	0.11	ND	1.29
	Loamy sand	NW	0.14	0.05	ND	0.09	0.12	0.10	ND	0.50
		GW	0.01	0.02	0.31	0.67	0.27	0.09	ND	1.37
		ADW	0.23	0.19	0.30	0.49	0.29	0.12	ND	1.62
		SW	0.11	0.11	0.08	0.40	0.20	0.07	ND	0.97
		TSW	ND	ND	ND	0.29	0.11	0.05	ND	0.45
		Mean	0.10	0.07	0.14	0.39	0.20	0.09	ND	0.98
2005-2006	Silty Loam	NW	0.39	0.15	0.10	1.39	0.41	2.45	0.56	5.45
		GW	0.03	ND	0.84	3.60	0.58	2.05	0.59	7.69
		ADW	0.64	0.47	0.80	2.21	0.80	2.37	0.56	7.85
		SW	0.36	0.31	0.23	1.85	0.45	2.32	0.29	5.81
		TSW	ND	ND	ND	1.12	0.37	2.07	0.04	3.60
		Mean	0.28	0.19	0.39	2.03	0.52	2.25	0.41	6.08
	Loamy sand	NW	0.34	0.13	0.08	1.19	0.35	2.10	0.48	4.67
		GW	0.02	ND	0.73	3.10	0.50	1.76	0.51	6.62
		ADW	0.55	0.41	0.69	1.90	0.68	2.04	0.48	6.75
		SW	0.31	0.26	0.20	1.59	0.38	2.00	0.25	4.99
		TSW	ND	ND	ND	0.96	0.32	1.78	0.03	3.09
		Mean	0.24	0.16	0.34	1.75	0.45	1.94	0.35	5.22

Pesticide concentration (ppb)

* NW= Nile water, GW= Ground water, ADW= Agricultural drainage water, SW= sewage water and TSW= treated sewage water

** Total organochlorine pesticides residues. ND = Not detected

Table 6. Effect of irrigation water sources on pesticides contamination in different soil types at the end of radish 2005-2006 and 2006-2007 growing seasons.

Season	Soil type	Irrigation* water sources	Pesticide concentration (ppb)							
			α-HCH	β-HCH	P,P-DDT	O,P-DDT	P,P-DDE	endrin	choro-thalonil	Total OC**
2005 - 2006	Silty Loam	NW	0.08	0.15	0.14	1.46	0.54	2.79	0.74	5.90
		GW	0.01	ND	0.49	3.08	0.77	2.71	0.78	7.84
		ADW	0.13	0.30	0.47	1.80	1.05	2.68	0.74	7.17
		SW	0.07	0.22	0.14	1.44	0.59	3.07	0.38	5.91
		TSW	ND	ND	ND	0.81	0.49	2.73	0.05	4.08
		Mean	0.06	0.13	0.25	1.72	0.69	2.80	0.54	6.18
	Loamy sand	NW	0.06	0.11	0.10	1.11	0.41	2.12	0.57	4.48
		GW	ND	ND	0.38	2.34	0.58	2.06	0.59	5.95
		ADW	0.10	0.22	0.36	1.36	0.80	2.03	0.57	5.44
		SW	0.05	0.16	0.10	1.09	0.45	2.33	0.29	4.47
		TSW	ND	ND	ND	0.61	0.37	2.08	0.04	3.10
		Mean	0.04	0.10	0.19	1.30	0.52	2.12	0.41	4.69
2006 - 2007	Silty Loam	NW	0.22	0.17	0.22	2.52	0.62	4.25	1.46	9.46
		GW	0.02	0.05	0.74	5.35	0.81	3.87	1.53	12.37
		ADW	0.36	0.33	0.56	3.10	1.17	4.08	1.46	11.06
		SW	0.20	0.21	0.16	2.54	0.63	4.41	0.75	8.90
		TSW	ND	ND	ND	1.42	0.56	3.93	0.08	5.99
		Mean	0.16	0.15	0.34	2.99	0.76	4.11	1.06	9.56
	Loamy sand	NW	0.19	0.15	0.19	2.19	0.54	3.70	1.27	8.23
		GW	0.01	0.04	0.64	4.66	0.71	3.37	1.33	10.76
		ADW	0.31	0.29	0.49	2.69	1.02	3.55	1.27	9.62
		SW	0.17	0.19	0.14	2.21	0.55	3.84	0.65	7.75
		TSW	ND	ND	ND	1.24	0.49	3.42	0.07	5.22
		Mean	0.14	0.13	0.29	2.60	0.66	3.58	0.92	8.32

* NW= Nile water, GW= Ground water, ADW= Agricultural drainage water, SW= sewage water and TSW= treated sewage water

** Total organochlorine pesticides residues. ND = Not detected

Generally, soil irrigated with GW or ADW was highly contaminated with the total organochlorine pesticide residues either in the 1st or 2nd season. That may be due to its high organochlorine pesticide residues content, and to the high salinity of these sources which decreased plant uptake, (Romero *et al.*, 2001). Conversely, TSW was less contaminate soils compared with other sources, because of lower organochlorine pesticide residues and the surfactants contents of TSW, which reduces the accumulation of organochlorine pesticide residues and enhances the biodegradation, (Walters and Aitken, 2001).

Concerning the total pesticide residues, it could be concluded that, irrigation with ADW or GW caused the highest pesticides contamination level in irrigated silty loam or loamy sand soil. That was in related with irrigation water source according to the contamination level (Ni *et al.*, 2002). In addition, the high salinity of ADW and GW, reduces plant uptake, (Romero *et al.*, 2001), and consequentially pesticide accumulation. Conversely, TSW irrigation showed the lowest pesticide contamination in the growing soil that may be due to the microbial content of TSW which induces pesticide biodegradation, (Edwards *et al.*, 1992 and Buyanovsky, *et al.*, 1995).

Also, the surfactants content reduces the accumulation of organochlorine pesticide residues and elevates the biodegradation, (Walters and Aitken, 2001). The lowest pH value of TSW induces plant uptake, (Alloway, 1995). In addition, SW or TSW contains the lowest total pesticide residues during summer and winter seasons comparing with ADW, GW or NW (Marzouk, 2003**)**.

III -2-Plant:-

Data presented in Tables 7 and 8 show that *β*-HCH, HCB, lindan, *cis* chlordane, *p,p'*-DDE ,endrin , chlorothalonil and heptachlor were detected in wheat grains and radish leaves .

III -2- 1- Wheat grains: -

Data of total contaminated pesticides in Table 7 Show that irrigation with GW highly contaminates wheat grains more than other water sources, being 9.95 and 11.44 ppb at the 1st season and 16.65 and 19.16 ppb at the 2nd season; in silty loam and loamy sand pots, respectively. Conversely, irrigation with TSW showed the lowest pesticide contamination reaching 2.11 and 4.25 ppb in that grown in silty loam soil and 2.80 and 4.88-ppb in loamy sand pot at the 1st and 2nd seasons, respectively.

III -2- 2- Radish leaves: -

Data of total contamination organochlorine pesticides in Table 8 showed that irrigation with GW caused high contamination of radish leaves over the other irrigated water sources, being 17.24 and 19.84 ppb at the 1st season and 18.80 and 21.62 ppb at the 2nd season, in silty loam and loamy sand pots, respectively. Conversely, as wheat trend, irrigation with TSW showed the lowest pesticide contamination to radish leaves, reaching 4.71 and 5.20 ppb in that grown in silty loam soil and 5.42 and 5.98 ppb in loamy sand pot at the 1st and 2nd seasons, respectively.

The above mentioned results clear that GW highly contaminated wheat grains and radish leaves, followed by SW, while TSW caused the lowest. That could be related to the contamination status of irrigation water, water salinity, organic wastes content of irrigation water and soil as mentioned before, as well as, physical and chemical properties of soil, pH, temperature, aeration and humidity, (Buyanovesky *et al.*, 1995 and Tarek and Osama, 2008).

However, all detected pesticide residues did not exceed the MRLs (Codex, 2000).

Though this study confirms that the treated sewage water can effectively increase water resource for irrigation especially in light soil, but there is a need for continuous monitoring of the concentration of potentially toxic elements in soil, plants and ground water.

Table 7. Effect of irrigation water sources on pesticides contamination in wheat grains planted in different soil types at 2004-2005 and 2005-2006 growing seasons.

Season	Soil type	Irrigation* water sources	Pesticide concentration (ppb)								
			α-HCH	HCB	lindane	*cis* chlordane	*P,P*-DDE	endrin	choro-thalonil	hepta-chlor	Total OC**
2004 - 2005	Silty Loam	NW	0.90	0.97	0.41	0.14	0.76	0.56	ND	2.05	5.79
		GW	ND	1.73	3.12	1.33	2.31	0.50	ND	0.96	9.95
		ADW	1.55	0.32	0.64	0.80	1.62	0.67	ND	0.75	6.35
		SW	1.07	0.39	2.35	0.22	1.29	0.41	ND	0.67	6.40
		TSW	ND	ND	ND	0.15	1.03	0.35	ND	0.58	2.11
		Mean	0.70	0.68	1.30	0.53	1.40	0.50	ND	1.00	6.12
	Loamy sand	NW	1.03	1.12	0.47	0.16	0.84	0.65	ND	2.36	6.62
		GW	ND	1.99	3.59	1.53	2.65	0.58	ND	1.10	11.44
		ADW	1.78	0.45	2.70	0.92	1.86	0.77	ND	0.86	9.35
		SW	1.23	0.37	0.74	0.25	1.49	0.47	ND	0.77	5.32
		TSW	ND	ND	ND	0.54	1.19	0.40	ND	0.67	2.80
		Mean	0.81	0.78	1.50	0.68	1.61	0.57	ND	1.15	7.10
2005-2006	Silty Loam	NW	1.08	1.12	0.62	0.15	1.53	0.84	0.83	2.30	8.46
		GW	ND	1.99	4.68	1.46	4.61	0.75	1.30	1.86	16.65
		ADW	1.86	0.37	0.96	0.88	3.24	1.01	0.93	1.05	10.29
		SW	1.28	0.45	3.53	0.24	2.59	0.62	1.65	0.95	11.30
		TSW	ND	ND	ND	0.17	2.06	0.53	0.66	0.84	4.25
		Mean	0.84	0.78	1.96	0.58	2.81	0.75	1.07	1.40	10.19
	Loamy sand	NW	1.24	1.28	0.71	0.18	1.76	0.97	0.95	2.64	9.73
		GW	ND	2.29	5.38	1.68	5.30	0.86	1.50	2.14	19.16
		ADW	2.14	0.42	1.10	1.01	3.73	1.16	1.07	1.21	11.84
		SW	1.48	0.52	4.05	0.28	2.98	0.71	1.90	1.09	12.99
		TSW	ND	ND	ND	0.19	2.37	0.60	0.75	0.97	4.88
		Mean	0.97	0.90	2.25	0.67	3.23	0.86	1.23	1.61	11.72
	MRL***		--	--	500.00	20.00	100.00	--	100.00	20.00	

* NW= Nile water, GW= Ground water, ADW= Agricultural drainage water, SW= sewage water and TSW= treated sewage water

** Total organochlorine pesticides residues. *** Maximum residues limit (according to Codex, 2000).

ND = Not detected (--) = not listed

Table 8. Effect of irrigation water sources on pesticides contamination in radish leaves planted in different soil types at 2005-2006 and 2006-2007 growing seasons.

Season	Soil type	Irrigation* water sources	Pesticide concentration (ppb)								
			α-HCH	HCB	lindane	cis chlordane	P,P-DDE	endrin	chorothalonil	heptachlor	Total OC**
2005 - 2006	Silty Loam	NW	1.71	1.34	0.64	0.34	2.87	0.88	0.94	1.85	10.57
		GW	1.66	2.39	4.82	1.21	3.33	0.72	1.44	1.67	17.24
		ADW	1.48	0.44	0.99	0.53	3.91	0.70	1.08	0.95	10.08
		SW	1.42	0.54	3.63	0.94	3.18	0.78	0.75	0.72	11.96
		TSW	0.43	ND	0.18	0.18	2.26	0.66	0.45	0.55	4.71
		Mean	1.34	0.94	2.05	0.64	3.11	0.75	0.93	1.15	10.91
	Loamy sand	NW	1.97	1.54	0.73	0.40	3.30	1.01	1.08	2.12	12.15
		GW	1.91	2.75	5.54	1.39	3.83	0.83	1.66	1.93	19.84
		ADW	1.70	0.51	1.14	0.61	4.50	0.81	1.24	1.09	11.60
		SW	1.63	0.62	4.18	1.09	3.66	0.90	0.86	0.83	13.77
		TSW	0.50	ND	0.21	0.21	2.59	0.76	0.52	0.63	5.42
		Mean	1.54	1.08	2.36	0.74	3.58	0.86	1.07	1.32	12.56
2006-2007	Silty Loam	NW	1.80	1.39	0.67	0.35	2.98	0.97	1.22	2.41	11.79
		GW	1.74	2.49	5.01	1.26	3.46	0.79	1.87	2.17	18.80
		ADW	1.55	0.46	1.03	0.55	4.07	0.77	1.40	1.24	11.07
		SW	1.49	0.56	3.78	0.98	3.31	0.86	0.98	0.94	12.88
		TSW	0.45	ND	0.19	0.19	2.35	0.73	0.59	0.72	5.20
		Mean	1.41	0.98	2.13	0.67	3.23	0.82	1.21	1.49	11.95
	Loamy sand	NW	2.06	1.60	0.77	0.41	3.43	1.11	1.41	2.77	13.56
		GW	2.00	2.86	5.76	1.45	3.98	0.91	2.15	2.50	21.62
		ADW	1.79	0.53	1.18	0.63	4.68	0.89	1.61	1.42	12.73
		SW	1.71	0.65	4.34	1.12	3.80	0.99	1.12	1.08	14.81
		TSW	0.52	ND	0.22	0.22	2.70	0.83	0.67	0.82	5.98
		Mean	1.62	1.13	2.45	0.77	3.72	0.95	1.39	1.72	13.74
	MRL***		--	--	100.00	20.00	--	50.00	--	--	

* NW= Nile water, GW= Ground water, ADW= Agricultural drainage water, SW= sewage water and TSW= treated sewage water

** Total organochlorine pesticides residues. *** Maximum residues limit (according to Codex, 2000).

ND = Not detected (--) = not listed

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مستوى الملوثات العضوية فى بعض النباتات المروية بمياة الصرف الصحى المعالج

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أجريت هذه التجربة لدراسة فاعلية استخدام مياة الصرف الصحى المعالج فى أغراض الــرى وتقدير مستوى متبقيات المبيدات فى الأرض المروية (الطمييه و الرملية) وكذلك النباتات المزروعة.

أوضحت النتائج زيادة مستوى المبيدات الكلورونية بكل من نوعى التربة التى تم ريهــا بميــاه الصرف الزراعى ومياه الآبار مقارنة بمياه الصرف الصحى المعالج خلال موسمى التجريب الأول والثانى. بينما وجد أقل مستوى من متبقيات المبيدات الكلورونية بالأراضى التــى تــم ريهــا بميــاه الصرف الصحى المعالج.

كما أوضحت النتائج أن مصدر الرى يؤثر بدرجة كبيرة على مستوى متبقيات المبيدات الممتصة بالنبات. من خلال نتائج متبقيات المبيدات الكلية وجد أن مياه الآبار أحدثت أعلى مستوى للتلوث فى حبوب القمح وأوراق الفجل يليها مياه الصرف الصحى، بينما كــان التلــوث بمتبقيــات المبيــدات الكلورونية فى أدنى مستوياته عند الرى بمياه الصرف الصحى المعالج. كمــا إن مســتوى التلــوث بمتبقيات جميع المبيدات التى تم تقديرها فى حبوب القمح أو أوراق الفجل لم يتعدى الحدود المسموح بها وفقاً لقيم الكودكس لسنة ٢٠٠٠.