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MONITORING THE CHANGES IN SOME SOILS PROPERTIES IRRIGATED WITH SEWAGE WATER FOR LONG PERIODS

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ABSTRACT: ***The major goal of this study was to evaluate the impact of using sewage water effluent as a source of irrigation for different periods on some chemical and physical properties of sandy and clayey soils. To fulfill this study, two locations were chosen. The first location was at Abou - Rawash farm, Giza governorate, Egypt where, the soil is sandy. The second location was chosen at Bahr El -Bakar, (Sharkia governorate), Egypt to represent clayey texture. Twelve soil profiles were chosen from each location to representative the three application periods (10 and 30) years and virgin soils.***

The obtained data showed that the salinity expressed as (EC) which increased to reach about of (2.20, 1.45 dS/m) and (5.22, 4.19 dS/m) in the surface and subsurface layers after 30 years of usage sewage water for irrigation at Abou- Rawash and Bahar El – Bakar areas respectively, The soil pH ranged from (6.20 to 7.50) and (6.60 to 8.15) at Abou- Rawash and Bahar El – Bakar areas respectively, availability of Fe, Mn, Zn, Cu and Pb were increased. The most accumulation of Fe, Mn, Zn, Cu and Pb was recorded for clay soil and increased more than the permissible limit. Organic matter content (%) increased and reached about of (5.73, 9.75) and (4.24, 5.78) times for surface layers of the irrigated soils than that of virgin soils in Abou- Rawash and Bahr El – Bakar areas respectively. The total calcium carbonates tend to decrease to reach (0.63%, 1.92%) for surface layers of sandy and clayey soils ,respectively after 30 years of irrigation with sewage water was leached from the surface layers and precipitated in the sub surface layers in the treated soils. The soil texture changed from sand in the virgin soils to loamy sand and sandy clay loam in the irrigated one in Abou – Rawash area. While, it changed from clay loam to clay in Bahr EL- Bakar area.

Data showed also, that in Abou-Rawash area the quickly drainable pores (QDP) and slowly drainable pores (SDP) decreased while, water holding pores (WHP) and fine capillary pores (FCP) and total porosity increased, The bulk density decreased from (1.70 g/cm^3 to 1.30 g/cm^3) after 30 years of utilization. Treated clayey soil had reverse effect where total porosity, (QDP) and (WHP) decreased then (BD) increased to reach about of (1.40 g/cm^3) after 30 years of sewage water utilization. Data showed that the hydraulic conductivity in clay soil was reduced in comparison with sandy soils. Soil

moisture constants as; Field capacity (FC), Wilting point (WP) and available water (AW) are high in the irrigated soil, the (AW) increased from 4.21% in the virgin soils to 6.77% and 11.52% in the irrigated soil in Abou-Rawash area after 10 and 30 years of treatment. In clayey soil, available water capacity tends to decrease as the period of utilization of sewage water effluent for irrigation increased. The lowest values of (AW) were (9.88% and 7.66%) for surface and subsurface layer after 30 years of irrigation with sewage water. This is due to the accumulation of suspended materials in the soil surface and clogging of the soil porosity. It can be concluded that, land application of sewage water effluent can have many beneficial effects such as increasing organic matter content, improving soil physical properties for sandy soils. The most commonly voiced concerns include: 1) the potential for damage to soils especially clay soils. 2) The potential for toxic metal applications.

Key words***: Sewage water, sandy, clayey, soils, physical, chemical, properties***

INTRODUCTION

Water in scarcity is one of the most critical problems that confront the world particularly in the arid and semi arid regions. Reuse of sewage water outlines is the most substantial and self- controllable resource so far despite many obstacles and limitations to be retrieved.

Sewage farming is meditated as one of the most environmentally sound mode for disposing of sewage effluent. Areas irrigated with sewage are extensive all over many parts of the world. On the other hand, it is yet practiced at small scale in most developing countries. It is generally recognized that sewage effluent reuse in agriculture is merited on agronomic and economic ground, but care must be fulfilled to minimizing inauspicious health and environmental impacts.

Effluent differs from fresh water by higher contents of electrolytes, dissolved organic matter, suspended solids *(Feigin et al., 1991)*. These varied constituents in effluent can affect soil chemical and physical properties. *(Levy et al., 1999 and Tarchitzky et al., 1999)*. Consequently, prolonged use of these effluents for irrigation could increase the ESP and OM content and the changes in these parameters could affect the chemical and physical properties of the treated soils. (*Mamedov et al., 2001; Agassi et al., 2003; Ben-Hur, 2004)*.

***Malik et al. (2000)* found that the soluble salts are accumulated because of sewage sludge application. *Marcos Lado and Meni Ben-Hur (2009)* reported that irrigation of semiarid clay and sandy soils with secondary effluent increased the salinity at depths down to 1.5m, and the sodicity down to 1.5 and 4 m, respectively. *El-Gindi et al. (1997) and Abd El- Hady (2007)* fond that the adding sewage sludge increased the pH values with the depth in the treated soils while there was no change in the virgin ones. Organic matter**

content increased than that virgin soil by the increasing of the treatment time. Theynoticed also, that the $CaCO_3$ was leached from surface layers and precipitated in the sub surface layers in the treated soils with waste water.

The soluble cations, anions, and molecules found in effluents and sludge, and which are of concern in agricultural operations, generally include potassium, sodium, calcium, magnesium, chloride, sulfate, nitrate, bicarbonate, selenate, and boron (as boric acid and borate) in lesser concentrations. All of the above are absorbed by plants and those which are essential contribute to the nutrient-supplying power of effluents and sludge. (*Keren and Bingham, 1985)*.

***Silver and Sommers (1977)* showed that the application of wastewater with low pH causes a faster movement of the Cd and Pb to lower depths. The results also showed that the concentrations of Pb and Cd in the soil irrigated with wastewater effluent and groundwater were almost similar. *Abd El – Hady (2007)* reported that the soil fertility as macronutrients (NPK) and micronutrients (Fe,Mn,Zn and Cu) increased to more than soils critical levels in the treated soils.**

***El - Amir et al. (1997); El - Motaium & Badawy (2002); El Gindi (2003) and Abd El- Hady (2007)* studied the effect of wastewater on the physical soil properties and found that the amending soil with sewage water induced an increase of the fine particles percentages. The increase become significant with increasing the rates and the period of application as the texture changed from sandy to sandy loam after seven years and to clay loam after twelve years of using sewage water. The texture changed from sand in the virgin soil to clay loam in the soil treated with sewage sludge effluents.**

***Abd El - Naim et al. (1997)* found that the addition of sewage sludge improved the porosity and pore size distribution of the treated soils. According to *Mc Bride (1995), Logan et al. (1999) and Ibrahim (1998)*, the application of the sewage sludge by the rate of 60 ton/fedan to the soil caused a decrease of soil bulk density.**

Many soil properties are known to influence soil hydraulic conductivity (Ks) such as organic matter content, soil texture, salt concentration of leaching solution. Numbers of researchers found a reduction in (Ks) of the soils treated with sewage water effluents, the causes of such changes may be physical or chemical mechanisms. *Vinten et al. (1983)* and *Marcos Lado and Meni Ben-Hur (2009)* found that the hydraulic conductivity in silty loam was reduced in comparison with sand and sandy loam soils as aresult of waste water irrigation. This is due to the physical mechanisms which include the accumulation of suspended materials in the soil surface, release of entrapped air babbles, and filtration activity of solid in the percolating liquid particles suspended matter. They also stated that wastewater irrigation would increase ESP and clogging of the soil porosity. The decreased the soil hydraulic conductivity because of plugging of pores with suspended solids,

whereas soil hydraulic conductivity of a sandy soil was not affected because of its large average pore size.

While, the chemical processes include the dissolved organic matter in wastewater even with low ESP had negative effect on hydraulic conductivity. The reduction in hydraulic conductivity is due to the retaining of the organic matters during infiltration and the change of pore size distribution because of expansion and dispersion of soil particles. Also, the changes in swelling properties of the soils and dispersion of colloidal particles

***Abd El - Naim et al. (1997) and Tarchitzky et al. (1999)* showed that one of the important effects of adding sewage sludge effluents to soil is the increase of moisture retention capacity, which is due to reduction of the soil bulk density, increase of soil porosity and the specific surface area of soil particles. *Abd El- Hady (2007)* stated that the soil water properties as; filed capacity, wilting point and available water are high in the soil treated with sewage sludge effluent and increased 1.7,1.3 and 2.5 times than that of the virgin soils by the increasing of the treatment time from 5,15 and 20 years, respectively.**

Therefore, the objective of this study was to determine the changes on some physical and chemical properties of sandy and clayey soils as a result of sewage water application for long periods..

MATERIALS AND METHODS

Two locations varied in their textural classes were chosen to represent the soils irrigated with sewage water. The first location was at Abou - Rawash farm, Giza Governorate, Egypt where, the textural class of the soil is sandy. While, the second one was at Bahr El -Bakar, Sharkia Governorate, Egypt to represent clayey soil texture. These areas are well characterized by using sewage water as a source of irrigation. Three sites were chosen from each location to representative the three periods of sewage water utilization. The first site of each location had not been irrigated and assumed virgin. The second and third sites were selected to represent area, which irrigated continuously with sewage water for 10 and 30– years, respectively. Twelve soil profiles were chosen from each location to representative the three periods. Soil samples were taken down to the depth of 100 cm, from layers (0-15 cm) and (15-50 cm).

In this connection, the disturbed and undisturbed soil samples were collected from the chosen profiles. The disturbed soil samples air-dried and ground to pass through a 2 mm screen and kept for determine some chemical properties of the studied soils. In addition, samples of sewage water were collected from irrigation source. Soils and water samples were subjected to the following analyses:

1-Sewage water analyses:

A sample of sewage effluent water, which was used for irrigation, was filtrated for chemical analyses, according to Page et al., (1982) Fe, Mn, Zn, Cu

and Pb were determined in DTPA extract according to Lindsay and Novel (1978). Some characteristics of sewage water are presented in Table (1).

Table (1): Chemical analyses of used sewage water effluent in irrigation

Components	Water source		Permissible limit*
	Abou-Rawash	Bahr EL - Bakar	
EC (dS\m)	1.79	2.49	
pH	7.65	7.20	
Soluble Cations (meq\l)			
Ca++	6.00	3.80	
Mg++	4.29	3.45	
Na+	7.29	16.40	
K+	0.20	1.05	
Soluble Anions (meq\l)			
HCO-3	8.73	7.70	
Cl-	5.40	6.50	
SO4--	3.65	10.50	
SAR	3.20	8.63	
Adj SAR	9.00	21.60	
Nutrients contents (ppm)			
N	14.50	8.52	
P	4.52	1.52	
K	0.20	0.48	
Fe	14.18	5.65	*5.00
Mn	1.02	0.187	*0.20
Zn	2.42	0.054	*2.00
Cu	0.59	0.180	*0.20
Pb	0.47	2.612	*5.00

*** National Academy of science and National Academy of Engineering, Washington, D. C.USA. (1972)**

2-Soil Analysis

- **General characteristics of the tested soils were carried out in disturbed soil samples, i.e. Particle size distribution was carried out by pipette method by *Gee and Bander (1986)*, organic matter (OM %) and calcium carbonate ($CaCO_3$ %) were described by *Jackson (1973).***
- **Soil chemical analyses were carried out according to *Page et al. (1982)*.**
- **DTPA –Extractable metals: Available Fe, Mn, Zn, Cu and Pb were determined for all soil samples using 0.005 M DTPA (Diethylene Triamine Penta Acidic) as outlined by *Lindsay and Norvell (1978).***
- **The undisturbed soil samples were used to determine some soil physical properties. Soil bulk density was determined using the core method technique according to *Blacket al., (1982)*.**

- **Saturated hydraulic conductivity (Ks) was determined using the falling head method as described by *Black (1982)*.**
- **Soil moisture characteristics were determined according to *Stakman (1966)*.**
- **Pore size distribution was calculated from the soil moisture retention curve according to *De-Leenheer and De-Boot (1965)*.**

RESULTS AND DISCUSSION

Characteristics of sewage water used

The chemical analyses of the sewage water, which used for irrigation in both studied locations is presented in table (1). The data refer that, the electrical conductivity (EC) values for used irrigation water are higher than the normal range according to U.S. Salinity Laboratory Staff. Hand book (1954). Sewage water for irrigation at Abu-Rawash area can be classified as (C3 S1) having high salinity hazard and low alkalinity hazard. The dominant cations are Na^+, Ca^{++}, Mg^{++} and K^+. The dominant anion are HCO^-_3,Cl^- and $SO^=_4$. While, irrigation water used in Bahr El- Bakar area can be classified as (C4 S1) having very high salinity hazard and low alkalinity hazard. The chemical composition of irrigation water indicates that the decreasing order for dominant anions are HCO^-_3, $SO^=_4$ and Cl^-. While, the dominant cations are Na^+,Ca^{++},$Mg^{++}$and then K^+. Also data show that the essential nutrients present in a high content N (14.50, 8.52 ppm), P (4.52, 1.52 ppm) and K (0.20, 0.480 meq/l) for both studied areas. Data indicated that, the sewage water was rather high in Fe, Mn, Zn, and Cu and their values were greater than the maximum permissible limits recommended by the National Academy of science and National Academy of Engineering as shown in table (1)

Impact of sewage water on some properties

1. Soil chemical properties

The changes in soil salinity expressed as electrical conductivity (EC) due to irrigation with sewage water are listed in table (2).In general, data referred that using sewage water for irrigation increased the soil salinity compared to that virgin soil. The (EC) values of the treated soils tend to increase as the period of utilizing sewage water for irrigation increase. On the other hand the (EC) values tend to decrease by increasing the soil depth. Data presented in table (2) show that the distribution of cations and anions differed among sandy and clayey soils and among virgin soils and soils that irrigated with sewage water for different irrigation periods. The distribution of soluble cations in sandy and clayey soils shows that the dominant cation is Na^+ followed by Ca^{++}, Mg^{++} and K^+ especially after 30 years of irrigation. Concerning the distribution of soluble anions in sandy soils i.e Abu- Rawash area, data show that the dominant anion is $SO_4^=$, Cl^-, and then HCO_3^-. While, in clayey soil i.e.Bahr El – Bakar area the dominant anion is Cl^-, $SO_4^=$ and then HCO_3^-especially after 30 years of irrigation. Sulphate ion concentration

increases in clayey soils than sandy one with increasing the period of sewage water utilization. This is mainly attributed to biological activities. The oxidation of the protein sulpher in the sewage could account for increase in the concentration of sulphate ions. The chloride ions behaved similar to sulphate ions. On the other hand HCO_3^- ions tend to increase as the period of irrigation increased. This trend is holding true for clayey soil than sandy one. This increase could be attributed to the breakdown of organic matter compound to carbon dioxide and water, as well as the encouraging of organic acids on the solubility of $CaCO^3$. *(EL Amir et al., 1997)*.

Data also, shown that the soil reaction (pH) was slightly alkaline in virgin soil and changed to slightly acidic after consecutive use of sewage water application. The soil pH ranged from (6.20, 7.20) with surface layers to (6.45, 7.50) in the deep layers for treated soils.

Table (2): Chemical analysis of the soil paste extract of the studied soils

Area	Period of cultivation	Soil Depth (cm)	EC (ds/m)	pH	Soluble Cations (meq/l)				Soluble anions (meq/l)			
					Ca++	Mg++	Na+	K+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
Abou-Rawash	Virgin	0-15	0.77	7.50	2.85	1.95	2.15	0.55	-	1.60	2.25	3.65
		15-50	0.67	7.20	2.60	1.41	2.25	0.25	-	1.25	2.16	3.10
	10-years	0-15	1.71	6.55	3.82	1.65	9.15	1.43	-	2.65	3.95	9.45
		15-50	1.10	6.80	3.95	2.50	2.95	0.55	-	1.35	3.75	4.85
	30-years	0-15	2.20	6.20	5.60	2.80	10.90	1.70	-	2.90	6.20	11.90
		15-50	1.45	6.45	4.81	2.85	4.50	0.89	-	2.15	4.95	5.95
Bahr El - Bakar	Virgin	0-15	1.69	8.15	3.20	2.10	9.10	0.45	-	3.20	6.70	4.95
		15-50	1.45	8.10	3.80	2.20	7.20	0.35	-	2.60	6.20	4.75
	10-years	0-15	3.78	7.20	12.50	3.70	18.50	1.90	-	3.90	16.60	16.10
		15-50	2.96	7.50	10.50	3.00	13.80	0.70	-	3.30	12.40	12.30
	30-years	0-15	5.22	6.60	16.50	6.60	24.30	2.60	-	4.60	24.60	20.80
		15-50	4.19	7.35	14.50	4.30	20.20	1.00	-	3.80	19.30	16.90

Data in table (3) indicated that the availability of Fe, Mn, Zn, Cu and Pb increased by irrigation with sewage water compared to virgin soil. The highest accumulation was found in the surface layers in the irrigated soil with sewage water for studied areas. The accumulation rate depends on the duration of sewage water utilization for irrigation. These results may be attributed to the increasing of organic matter, which retain heavy metals and to the high content of heavy metals in the sewage water .However, the highest availability of Fe, Mn, Zn, Cu and Pb was more obvious in the surface layers (0-15cm) than that the subsurface ones especially in the soil irrigated with sewage water for 30 years. While, the most accumulation of Fe, Mn, Zn, Cu and Pb was recorded for clayey soils and increased than the permissible limits according to National Academy of science (1972)

Table (3): Available DTPA extractable heavy metals from the studied soils

Area	Period of cultivation	Soil depth (cm)	Available Heavy metals mg/Kg soil				
			Fe	Mn	Zn	Cu	Pb
Abou-Rawash	Virgin	0-15	1.70	0.70	0.85	0.20	0.55
		15-50	1.18	0.20	0.23	0.10	0.13
	10-years	0-15	48.60	5.10	46.43	9.67	7.98
		15-50	12.50	0.86	2.20	1.51	1.43
	30-years	0-15	63.09	7.20	53.60	12.80	9.34
		15-50	15.40	1.17	4.37	1.82	2.36
Bahr El - B akar	Virgin	0-15	9.60	7.80	0.53	0.39	0.33
		15-50	8.30	3.90	0.290	0.26	0.19
	10-years	0-15	206.3	45.1	19.80	3.88	3.46
		15-50	123.7	12.1	4.66	1.84	0.76
	30-years	0-15	337.7	53.90	23.40	7.22	4.82
		15-50	236.1	21.60	10.40	3.18	1.70

2. Soil physical properties

2.1 Soil organic matter content

Data in table (4) depict the effect of sewage effluent utilization for irrigation on organic matter content (%). Organic matter content (%) increased by increasing the duration of sewage effluent utilization. It reached about (5.73, 9.75) and (4.24, 5.78) times for surface layers of the treated soils than that of virgin soils in Abou-Rawash and Bahr El – Bakar areas respectively. This due to the effect of suspended materials existed in the sewage effluent water by appreciable amounts. These materials are rich in organic matter content. Hence, and deposit mainly on the soil surface.

2.2 Total calcium carbonate

Data in table (4) also show that the total calcium carbonates decreased as the period of application increase. This hold true for both studied areas. The relative decrease was (53.93%, 87.91%) and (9.35%, 38.06%) for surface layers in Abou -Rawash and Bahr El – Bakar areas respectively after 10 and 30 years of sewage water utilization. Total calcium carbonate tends to increase in the subsurface layers than the surface ones. This increase reached about (17.74%, 50.70%) and (6.43%, 61.07%) for Abou- Rawash and Bahr El – Bakar areas respectively after 10 and 30 years of sewage water utilization when compared with virgin soils. The calcium carbonate was leached from the surface layers and was precipitated in the sub surface layers in the irrigated soils. This could be referred to the acid effect of sewage water in lowering soil pH values and the dissolution action of organic acids presented in sewage water. *(Abd El- Hady, 2007)*.

2.3 Soil Texture

The particle size distribution in table (4) showed that there is a change in soil texture. The soil texture changed from sand in the virgin soils to loamy sand and sandy clay loam in Abou – Rawash area. While, It changed from clay loam to clayey in Bahr EL- Bakar area. These changes depend on the period of irrigation with sewage water for and the soil depth. The changes in soil texture are more pronounced in the surface layers than the subsurface ones.

Table (4): Particle size distribution, Organic matter content (%) and CaCO3 (%) of the studied soils

Area	Period of cultivation	Soil depth (cm)	Particle size distribution				Soil Texture	OM %	$CaCO_3$ %
			Sand		Silt %	Clay %			
			Coarse %	Fine %					
Abou - Rawash	Virgin	0-15	77.20	22.50	0.20	0.10	Sandy	0.55	5.21
		15-50	75.40	24.40	0.15	0.05	Sandy	0.34	3.55
	10-years	0-15	62.30	23.80	1.40	12.50	Loamy sand	3.15	2.40
		15-50	77.60	19.90	1.18	1.32	Sandy	1.25	2.92
	30-years	0-15	60.50	16.50	2.30	20.70	Sandy clay loam	5.36	0.63
		15-50	74.20	15.60	1.30	8.90	Loamy Sand	1.10	1.75
Bahr El- bakar	Virgin	0-15	18.10	20.40	22.40	39.10	Clay Loam	0.85	3.10
		15-50	17.90	21.60	21.10	39.40	Clay Loam	0.60	2.80
	10-years	0-15	17.00	22.30	18.60	42.10	Clay	3.60	2.81
		15-50	17.10	22.10	20.20	40.60	Clay	1.75	2.62
	30-years	0-15	10.20	18.00	33.20	48.60	Clay	4.91	1.92
		15-50	13.10	12.10	28.90	45.90	Clay	2.25	1.09

In Abou – Rawash area, the clay content increased from 0.1% in the virgin soils to (12.5%, 20.70%) after 10 and 30 years of application sewage water. While, in Bahr EL- Bakar area, the soil texture changed from clay loam to clayey. The clay content increased from 39.10% in virgin soils to (42.10%, 48.60%) for the surface layers (0 -15cm) after 10 and 30 years of sewage water utilization, respectively. This changes can be attributed to the settlement of the suspended mater existed in the sewage water, especially before the development of purification technique. *(EL Amir et al., 1997)*.

2.4 Pore size distribution

The results will be devoted for the changes of particle size distribution and organic matter content due to different period of sewage water utilization and their effects on some soil physical properties of the studied areas. These physical properties are pore size distribution, total porosity, soil bulk density and saturated hydraulic conductivity. Hence, data in table (5) show that using sewage water for irrigation is associated with an increase in total porosity especially in the surface layers of sandy soils compared to virgin soils. Total porosity also, increased as the period of usage increase. Its values have

been increased from 37.41% in the surface layer (0-15cm) in the virgin soils to about 42.28% and 43.57% in the soils irrigated with sewage water for 10 and 30 years respectively. The same trend is found in the subsurface layer (15 -50 cm). Generally, the increase in total porosity can be explained by the increase in both fine particles and organic matter contents which helps in forming soil aggregation.

The changes in soil total porosity are accompanied by the changes in pore size distribution. As a general, trend quickly drainable pores (QDP) and slowly drainable pores (SDP) decreased in treated soils compared to virgin soils. Data show also, that (QDP) decreased with increasing the period of sewage water utilization in both studied areas. However, Water holding pores (WHP) and fine capillary (FCP) were increased in the irrigated soils than virgin. The maximum increase is noticed in the irrigated soils with sewage water after 30 years of utilization. The changes are more pronounced in the surface layers than the subsurface ones. These results are expected because the coarse sand causes an increasing value of the macro pores and the slipping of fine sand causes decreasing in the macro pores. Furthermore, the presence of clay fraction and organic matter decrease the macro pores presence i.e. Abou – Rawash area. *(EL Amir et al., 1997)*.

Table (5): Total porosity, Pore size distribution, bulk density and saturated hydraulic conductivity

Area	Period of cultivation	Soil depth (cm)	Total porosity %	Pore size distribution				BD (g/cm^3)	Ks (cm/h)
				QDP %	SDP %	WHP %	FCP %		
Abou- Rawash	Virgin	0-15	37.41	21.58	8.84	4.21	2.78	1.70	25.50
		15-50	32.29	23.25	3.95	2.76	2.33	1.79	20.10
	10-years	0-15	42.28	17.01	5.61	6.77	12.89	1.48	15.41
		15-50	35.08	19.12	3.54	4.38	8.04	1.70	18.57
	30-years	0-15	43.57	8.46	6.36	11.52	17.23	1.30	9.77
		15-50	38.15	13.68	5.50	6.29	12.68	1.50	14.12
Bahr El - Bakar	Virgin	0-15	60.01	14.58	9.05	17.58	18.80	1.14	2.55
		15-50	58.89	8.33	10.01	12.82	27.73	1.21	1.50
	10-years	0-15	57.13	9.15	9.94	14.32	23.72	1.33	0.77
		15-50	56.61	5.78	5.49	14.97	30.37	1.35	0.58
	30-years	0-15	53.34	4.51	5.21	9.88	33.74	1.40	0.49
		15-50	48.53	2.16	3.55	7.66	35.16	1.47	0.39

In clayey soils, i.e. Bahr El- Bakar area, clay can play an important role in caused a reduction in the soil porosity. The average soil total porosity, at surface layer (0-15 cm) depth (57.13%, 51.34%) after (10 and 30) years of utilization, respectively compared to (65.01%) in the virgin soil.

The data presented in table (5) referred the effect of sewage water on pore size distribution in clayey soils. In general, using sewage water for irrigation decreased (QDP), (SDP) and (WHP) and consequently increased (FCP) in the

surface layers especially after 30 years of utilization compared to virgin soils. These results can be explained by different mechanisms are blocking of the inter-soil spaces by suspended materials such as colloidal clay, biological clogging including microbial extracellular *(McAuliffe et al. 1982)*, collapse dissolution *(Lieffering and Mclay, 1996)*

2.5 Soil bulk density

The obtained results presented in table (5) showed the effect of sewage water application on soil bulk density. It is obvious that soil bulk density decreased with sewage water utilization in sandy soils (i.e Abou – Rawash) area. The magnitude of decrease depends on the duration of sewage water utilization. The longer the period the less is the soil bulk density. Where it is values (g/cm^3) were (1.70, 1.48 and 1.30) for virgin, 10 and 30 years of application. The decrease in soil bulk density is more related to the increase in soil organic matter content. Sewage effluents application led to a dilution effect resulting from the mixing of the added organic matter with more dense mineral fraction of the soil. This is may be attributed to the binding effect of organic matter exist, producing a more structured soil, consequently decreasing soil bulk density. (McBride, 1995).

The effect of using sewage water for irrigation on soil bulk density for clayey soils (Bahr El- Bakar) area is listed in table (5). Data showed that the soil bulk density increased as the period of irrigation increased. Hence, the maximum values of soil bulk density is recorded (1.40, 1.47 g/cm^3) for surface and subsurface layers after 30 years of application sewage effluent. This was due to clay dispersion and sedimentation of clay particles which, clogging the pores. *(Lieffering and Mclay, 1996)*

2.6. Saturated soil hydraulic conductivity (Ks)

As shown in table (5) percolation of sewage water through the soil profile can reduce its saturated hydraulic conductivity (Ks) to an extent that depends on the sewage water quality, soil chemical properties, and the pore size distribution in the soil. The decrease in (Ks) is more pronounced at depths of (0-15 cm) and (15- 50 cm) especially, in the sites irrigated for 30 years with sewage water application. Data also, show that the hydraulic conductivity in clay soil was reduced in comparison with sandy soil. This is may be due to the accumulation of suspended materials in the soil surface, release of entrapped air babbles, and filtration activity of solid in the percolating liquid particles suspended matter. Suspended materials in irrigation water can be clogging of the soil porosity which led to increase soil bulk density, micro pores in the expense of macro pores. An increase in soil sodicity, caused by sewage water irrigation, decreased the (Ks) of clayey soil as a result of enhanced clay swelling and dispersion. *(Marcos Lado and Meni Ben-Hur, 2009)*

2.7. Moisture constants

The effect of sewage water on soil moisture constant i.e field capacity (FC), Wilting point (WP) and consequently available water (AW) is presented in table (6). The moisture constants are strongly affected by soil texture and organic matter content. In general, the greater the clay content the higher the water content at any particular suction. The soils with high content of clay exhibit high (FC) and (WP) values.

Table (6): Moisture constants of the studied soils

	Period of cultivation	Depth (cm)	FC (%)	WP (%)	AW (%)
Abou- Rawash	Virgin	0-15	6.99	2.78	4.21
		15-50	5.09	2.33	2.76
	10-years	0-15	19.66	12.89	6.77
		15-50	12.42	8.04	4.38
	30-years	0-15	28.75	17.23	11.52
		15-50	18.97	12.68	6.29
Bahr El – Bakar	Virgin	0-15	36.38	18.8	17.58
		15-50	40.55	27.73	12.82
	10-years	0-15	38.04	23.72	14.32
		15-50	45.34	30.37	14.97
	30-years	0-15	43.62	33.74	9.88
		15-50	42.82	35.16	7.66

The data show that the moisture retained in the soil irrigated with sewage water is always higher than that in virgin soil. The magnitude of the increase depends on the period of using the sewage water for irrigation. The values of (FC) and (WP) tend to increase as the period of utilization increased. Data also show that the values of (FC) of the surface layers of the studied soils are higher than that in the subsurface layers for both locations.

Moisture constant at field capacity (FC) in the surface layers (0 – 15 cm) wasincreased from (6.99%, 36.38%) in the virgin sandy and clayey soils to (19.66%, 28.75%) and (38.04%, 43.62%) in the soils irrigated with sewage water for 10 and 30 years in both locations, respectively.

The lower limit of available water content was also increased with prolonged sewage water utilization. The maximum increased in wilting point are detected after 30 years of irrigation with sewage water. The values reach about of (33.74% and 35.16%) in the surface and subsurface layers respectively. This increased is rendered to the accumulation of organic matter and fine particles presented in sewage water. The organic matter may affect water retention either through the direct effect of organic particles themselves and its ability to absorb and store water or through its indirect effect on other physical properties (such as bulk density, porosity and pore size distribution).

Data also shows that available water capacity in sandy soils increases as the periods of sewage water utilization for irrigation increases. In the surface layers (0-15 cm) the (AW) increased from 4.21% in the virgin soils to 6.77% and 11.52% in the soil irrigated with sewage effluent for 10 and 30 years respectively. In sub surface layers (15 -50 cm), the (AW) was increased from 2.76% to 4.38% and 6.29% after 10 and 30 years of treatment, respectively. In clayey soil, available water capacity tends to decrease as the period of utilization of sewage water for irrigation increased. Also it's noticed that (AW) decreased by increasing the soil depth. These results could be attributed mainly to the presence of soluble salts, i.e., the high electrical conductivity causes an increase in osmotic pressure which represent one of the total moisture stress. The effect of different cations on soil properties such as Na^+ which is a dispersing agent because of its relatively large size, single electrical charge and hydration status, adsorbed sodium tend to cause soil physical separation of soil particles. *(Balks et al., 1998)*

CONCLUSIONS

Based on the obtained results these conclusions can be achieved:

- **Land application of sewage water effluent can have many beneficial effects such as increasing organic matter content, improving soil physical properties for sandy soils.**
- **Although these are obvious benefits, there are also concerns that must be addressed to insure a safe and environmentally sound approach to applying sewage water to the soil. The most commonly voiced concerns include: 1) the potential for damage to soils especially clay soils. 2) The potential for toxic metal applications.**
- **Sandy soil was better than clay soil for utilization of sewage water effluents for irrigation because of improving soil physical properties, the soil texture changed from sandy to loamy sand and to sandy clay loam after10 and 30 years of utilizing sewage water for irrigation. The soil bulk density and hydraulic conductivity were decreased. The total porosity was increased with the dominancy of fine and water holding pores on the expense of quickly and slowly drainable pores. This means enhancing the ability of sandy soil to retain water and decreasing its ability to conduct water.**
- **Gradual adverse changes in soil physical properties, e.g., hydraulic conductivity, soil porosity and bulk density in clayey soils may not be noticed until some time well after soil degradation occurs. Identifying the soil properties that are sensitive to such changes will help predict long –term sustainability of effluent disposal areas.**
- **Due to the interaction between effluent irrigation and soil properties, it is necessary to identify sensitive regions and soils prior to irrigation with effluents, to prevent possible deleterious effect on soil physical properties. These conclusions are supported by *Dawes and A. Goonetilleke (2003)***

REFERENCES

Abd El- Hady, A. A. (2007). Using the sewage sludge and effluent for reclamation of Calcareous soils in the Eastern side of the Nile valley, Giza Governorate. I. The effects on the soil characteristics and development of the soil profile. Egypt. J. Soil. Sci. 47, No.2. pp. 181 – 194.

Abdel – Naim, M., M. El Hoseni, N. Kandil and M. Abdel- Gany (1997) Effects of sewage sludge utilization on crop production in sandy soil of Egypt. Congn. of Yugoslavian Sci. Soc.380-386.

Agassi,M., J. Tarchitzky, R. Keren, Y. Chen, D. Goldstein and E. Fizik (2003). Effects of prolonged irrigation with treated municipal effluent on runoff rate. J. Environ. Qual. 32:1053–1057.

Balks, M. R., W. J. Bond and C. J. Smith (1998). Effects of sodium accumulation on soil physical properties under an effluent-irrigated plantation. Aust. J. Soil Res. 36:821–830.

Ben-Hur, M. (2004). Sewage water treatments and reuse in Israel. p. 167–180. *In* F.

Black, C. A. (1982). “Methods of Soil Analysis”. Soil Sci. Soc. Amer., Inc. Pub. Madison, Wisconsin, USA.

Dawes, L., and A. Goonetilleke. (2003). An investigation into the role of site and soil characteristics in onsite sewage treatment. Environmental Geology 44 (4): 467-477.

De-Leenheer, L. and M. De-Boodt (1965). "Soil Physics". International Training Center for Post gradual Soil Scientist Ghent, Belgium.

El – Motaium, R. A. and S.H. Badawy (2002). Heavy metals accumulation in tomato plants and soils amended with irradiated and non irrtadiated sewage sludge. Egypt. J. Soil Sci. 42:517 – 532.

El- Amir, S., M. M. Selem, M. F. Kandil and S. F. Mansour (1997). Potential effects of using sewage water for sandy soil irrigation. Fayoum J. Agric. Res. & Dev. 11:92 – 101.

El- Gindi, S. A. (2003). fractionation and mobility of some heavy metals in soil amended with sewage sludge. J. Agric. Sci. Mansoura Univ.18:95-114.

El- Gindi, S. A., S. H. Badawy and M. I. D. Helal (1997) Mobility of some heavy metals nutrients in sandy soil irrigated with sewage sludge effluent. J. Agric. Sci. Mansoura Univ. 22:3535 – 3552.

Feigin, A., I. Ravina, and J. Shalhevet (1991). Irrigation with treated sewage effluent. Management for environmental protection. Adv. Ser. Agric. Sci., Vol. 17. Springer-Verlag, Berlin.

Gee, G. W. and J. W. Bander (1986). “Particle size analysis” .In methods of soils analysis, Part I. Klute, A.edt. Agronomy No.9.

Ibrahim S. B. (1998). Sewage sludge as amendment for soil .M.Sc. Thesis, Fac. Agric., Monofiya Univ., Egypt.

Jackson, M. L. (1973). “Soil chemical analyses”. Prentice Hall, Inc. Englewood cliffs, N.J., New Delhi, India

Keren, R. and F. T. Bingham (1985). Boron in water, soils, and plants. p.229 - 275 in Advances in Soil Science. Volume 1. New York: Springer-Verlag.

Levy, G. J., A. Rosenthal, J. Tarchitzky, I. Shainberg and Y. Chen. (1999). Soil hydraulic conductivity changes caused by irrigation with reclaimed waste water. J. Environ. Qual. 28:1658–1664

Lieffering, R. E. and C.D. A. McLay (1996). The effects of strong hydroxide solutions on the stability of aggregates and hydraulic conductivity of soil. Eur. J. Soil Sci., 47:43 50.

Lindsay, W. L. and W. A. Norvell (1978). Development of DTPA test for Zinc, iron, manganese and cupper. Soil Sci. Am. J. 42: 421 – 428.

Logan, T.C., B. T. Harrison, D. C. McAvoy and J. A. Greff (1999). Effect of olestra in sewage sludge on soil physical properties. J. Environ. Qual. 25: 153 – 161.

Malik, R. S., N. E. Bassam and S. Haneklous (2002). Effect of high and low input nutrient system on soil properties and their residual effect on sweet corn. J. Soil Properties, Landbauforschung Volkenrode 5:24 – 31.

Mamedov, A. I., I. Shainberg and G. J. Levy (2001). Irrigation with effluents: Effects of prewetting rate and clay content on runoff and soil loss. J. Environ.

Marcos Lado and Meni Ben Hur (2009). Treated domestic sewage irrigation effects on soil hydraulic properties in arid and semi arid zones. Soil and Tillage research 106: 152 – 163.

McAuliffe K. W., D. R. Scotter, A. N. McGregor, K. D. Earl (1982). Casein whey wastewater effects on soil permeability. J. Environ. Qual., 11: 31–34.

Mc Bride, M. B. (1995). Toxic metal accumulation from agricultural use of sludge: Are USEP A Regulation Protective. J. Environ. Qual. 24: 5 – 18.

National Academy of Science and National Academy of Engineering (1972). Water Quality Criteria. NAS/NAE Environmental Studies Board. Washington, D.C, USA.

Page A. L., R. H. Miller and D. R. Jkeeney (1982). “Methods of soil analyses part 2. Chemical and Microbiological properties.” Second Edition. Agronomy monograph, No.9, Madison Wisconsin.

Silver D. J., L. E. Sommers (1977). Extractability of Cu, Zn, Cd and Pb in soils incubated with sewage sludge. J. Environ. Qual., 6: 47–52.

Stakman, W. P. (1966)."Determination of soil water retention curves I. Sand – box method .II. Pressure membrane methods". ICW, Wageningen, the Netherlands.

Tarchitzky, J., Y. Golobatin, R. Veren, Y. Chen (1999). Waste water effects on montmorilli- onite suspensions and hydraulic properties of sandy soil. Soil Sci. Am. J., 63: 554–560

U.S. Salinity Laboratory Staff, U.S.D.A. Hand book 60.(1954)."Diagram for determining the quality rating of an irrigation water from its sodium adsorption ratio and electrical conductivity".In : F. E. Bear(ED).Chemistry of the soil P.316.Oxford & IBH, publishing Co. New Delhi.

Vinten A.J., H. Mingelgrin, B. Yaron (1983). The effect of suspended soils in wastewater on soil hydraulic conductivity and vertical distribution of suspended solids. Soil Sci. Soc. Am. J., 47: 408–412.

متابعة التغيرات في بعض خواص الأراضي المروية بمياه الصرف الصحي لفترات طويلة

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الملخص العربي

إن الهدف الرئيسي من هذه الدراسة تقييم تأثير إستخدام مياه الصرف الصحي كمصدر للري ولمدد مختلفة على بعض الخواص الكيماوية والطبيعية للأراضي الرملية والطينية. ولذلك تم اختيار منطقتين للدراسة، الأولى مزرعة أبو رواش ، محافظة الجيزة ، مصر ، ممثلة للتربة الرملية والثانية منطقة بحر البقر ، بمحافظة الشرقية ، مصر ، ممثلة للتربة الطينية. وقد تم اختيار إثنا عشرة قطاعا في كلتا المنطقتين التي شملتهما الدراسة تمثل فترات زمنية مختلفة لاستخدام مياه الصرف الصحي (١٠ سنوات) ،(٣٠ سنة) والأرض البكر .

أوضحت النتائج أن استخدام مياه الصرف الصحي أدى إلى زيادة الملوحة إلى (٢,٢٠و ١,٤٥ ديسمنز/م) و(٤,١٩ و ٥,٢٢ ديسمنز/م) للطبقات السطحية وتحت سطحية فى منطقة أبو -- رواش و بحر البقر على التوالي. انخفاض رقم حموضة الأرض (pH) وتراوحت قيمته من (٦,٢٠ و ٧,٥٠) إلى (٦،٦٠ ، ٨,١٥) للأراضي في منطقة أبو -- رواش و بحر البقر على التوالي نتيجة للرى بماء الصرف الصحي لمدة ٣٠ سنه كما أظهرت النتائج زيادة فى تيسر العناصر الصغرى والثقيلة خاصة فى الطبقة السطحية كما أنها تقل بالعمق.كما زاد تراكم (Fe, Mn, Zn, Cu and Pb) في الأراضي الطينية مقارنة بالرملية.

كما أظهرت النتائج زيادة محتوى الأرض من المادة العضوية كنتيجة لاستخدام مياه الصرف الصحي وذلك بزيادة مدة الاستخدام ليصل معدل الزيادة إلى حوالي (٥،٧٣ ، ٩,٧٥) و (٤,٢٤ و ٥،٧٨) مرة بالنسبة للكنترول وذلك في مزرعة أبو رواش و منطقة بحر البقر على التوالي . بينما انخفضت نسبة كربونات الكالسيوم إلى (٠,٦٣٪) مقارنة بالكنترول (٥,٢١٪) في مزرعة أبو رواش وإلى (١,٩٢٪) مقارنة بالكنترول (٣,١٠٪) في منطقة بحر البقر بعد (٣٠)

سنة من الري بماء الصرف الصحي نتيجة عمليات الإذابة ونقل وترسيب في الطبقات التحت سطحية.

تغير القوام من الرملي في الأرض البكر إلى القوام الطمي طيني وطمي طيني رملي في منطقة استخدام مياه مخلفات الصرف الصحي و إلى القوام الطيني في منطقة بحر البقر وذلك بعد مدة (١٠) و (٣٠) سنة من الاستخدام.وفى منطقة أبو رواش انخفضت نسبة مسام الصرف السريعة والبطيئة مع زيادة نسبة المسام الحافظة للماء ومسام الصرف البطيئة وزيادة المسامية الكلية. كما انخفضت قيم الكثافة الظاهرية لتصل إلى (١،٣٠ جم/سم^{٣}). بينما في منطقة بحر البقر انخفضت نسبة مسام الصرف السريعة والبطيئة والمسام الحافظة للماء. وذات نسبة المسام الشعرية الدقيقة كما انخفضت المسامية الكلية وزادت الكثافة الظاهرية لتصل الى (١،٤٠جم/سم^{٣}) بعد (٣٠) سنة من استخدام مياه الصرف الصحي.

أوضحت النتائج انخفاض قيم التوصيل الهيدروليكى في الأراضي الطينية مقارنة بالأراضي الرملية. وذلك لترسيب وتراكم المواد العلقة من ماء مخلفات الصرف الصحي على سطح التربة مما يؤدى إلى سد المسام. بالإضافة إلى زيادة كلا من السعة الحقلية ونقطة الذبول وكذلك زيادة الماء الميسر للنبات ليصل إلى (٦,٧٧٪) و (١١,٥٢٪) بعد (٣٠) سنة من استخدام مياه الصرف الصحي في مزرعة أبو رواش.بينما في الأراضي الطينية (بحر البقر) على الرغم من زيادة نسبة الرطوبة عند كلا من السعة الحقلية ونقطة الذبول إلا أنه يلاحظ انخفاض في نسبة الماء الميسر . لذا نستنتج من هذه الدراسة أن استخدام ماء الصرف الصحي في الري له بعض التأثيرات المختلفة على خواص الأراضي فهو يحسن من الخواص الطبيعية للأراضي الرملية بينما يؤدى إلى تدهور الخواص الطبيعية للأراضي الطينية مع تراكم العناصر الثقيلة في التربة بمستويات تجاوزت حد السمية.