

## CONTAMINATION OF THE AGRICULTURAL LAND DUE TO INDUSTRIAL ACTIVITIES IN KAFR EL-ZEIYAT AREA, EGYPT

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### ABSTRACT:

The main objective of this study was concentrated in monitoring the harmful impacts of industrial liquid wastes released from the industrial activity of Misr Company for oil and soap at Kafr EL-Zeiya city, EL-Gharbia Governorate, Egypt, that are directly through an outlet into an adjacent irrigation canal on some soil physico-chemical properties of the irrigated agricultural areas due to the possible chemical pollution of such effluent wastes. Such polluted effluent chemical-wastes that discharged from the performed industrial activity are not only directly contaminated the neighbourhood irrigation water but also indirectly contaminated the irrigated agriculture land. To achieve this target, samples of either irrigation water or irrigated agriculture land were taken at distances 500, 1000 and 2000 m from the main pollution source, comparing with unpolluted water-sample, for monitoring the chemical changes in irrigation water as well as soil physico-chemical properties of irrigated agriculture land.

The chemical analytical data of the available irrigation water source along the different studied distances within the irrigation canal of Neanaiya, reveal that the released liquid-wastes of the industrial activity are negatively affected irrigation water quality, where its chemical characteristics as represented by the values of water pH,  $EC_{iw}$ , soluble ions (especially  $Na^+$ ,  $Cl^-$  and  $HCO_3^-$ ) and sodium adsorption ratio (SAR), which showed a pronounced tendency to increase. That was true, since the suitability criteria of irrigation water resources showed that the studied irrigation water samples could be categorized into three classes, *i.e.*, third class ( $C_5S_2$ , water salinity of  $EC_{iw} > 3.00 \text{ dS m}^{-1}$  and sodicity of  $SAR > 9$ ), second class ( $C_4S_1$ ,  $EC_{iw}=0.75-3.00 \text{ dS m}^{-1}$  and  $SAR=6-9$ ) and first class ( $C_2S_1$ ,  $EC_{iw} < 0.75 \text{ dS m}^{-1}$  and  $SAR < 6$ ) for the water samples that were taken at distances of 500, 1000 and 2000 m from the main pollution source, respectively. Such chemical irrigation water criteria were also associated with a parallel increase in soil chemical properties, *i.e.*, pH, ECe and exchangeable sodium percent (ESP) as well as soil physical ones, *i.e.*, fine aggregates, fine capillary pores, bulk density, penetration resistance and saturated hydraulic conductivity (Ks). The reverse was true for each of total aggregates, coarse diameter aggregates, mean weight diameter, stability index and water holding pores, which showed pronounced decreases.

**Key words:** Industrial liquid wastes, industrial activity, contaminated irrigation water and irrigated agriculture land, degradation of water and soil properties.

**INTRODUCTION:**

The effluents discharged from industrial activity have contaminated the adjacent soil and water resources, hence the degradation of these natural resources is not only negatively affect agricultural production but also the national income. **Cheremisonoff et al. (1979)** estimated that 90 % by weight of industrial wastes are produced as liquids, and according to **U.S. Environmental Protection Agency (1974)** 40 % of these liquids are inorganic and 60 % organic. Such liquids may be available water and nutrient resources for crops or pollutants to agricultural land and irrigation water (**Samuel et al., 1985**).

Industrial wastes carrying heavy metals to the soils are adsorbed and retained by the organic and inorganic soil colloids (**Bride, 1986**). Plants absorb these metals from the soil in which some are essential for metabolic processes and other enzymatic reactions (**Adrian, 1986**). The excessive uptake may causes phytotoxicity, and consequently human toxicity as envisaged by the processes of bio-accumulation and bio-magnifications. Industrial waste containing toxic heavy metals are real problem to the environment, since they are not degraded like organic matter and persist in the ecosystem heaving accumulated in different tropic levels of the food chain (**Smejkalova et al., 2003 and Igew et al., 2005**). The damage caused by pollution is difficult to be evaluated accurately. This is due to the fact that there is such a wide range of waste materials with different physical, chemical and biological characteristics (**Tantawy, 2004**).

Industrial wastes application to the soil is becoming more widespread usually as means of disposal rather than as aid to agricultural production. The composition of these industrial wastes varies according to the industrial structure of country or region. Also, the chemical composition of these wastes not only varies with time of derived various wastes, but also with treatment of individual industrial waste (**Me Laren and Simith, 1996**).

This study was carried out to evaluate the effect of industrial activity and its released liquid wastes on the local environment such as characteristics of either adjacent water or soil sources in the industrial area of Kafr El-Zeyyat.

**MATERIALS AND METHODS**

To achieve the aforementioned target, a field work was carried out on both soil and water resources adjacent to Misr Company for Oil and Soap at Kafr El-Zeyyat city, El-Gharbia Governorate, Egypt during a year of 2009 to identify the changes in their characteristics due to daily supply of industrial liquid wastes erected in the studied area. Furthermore, the degradation processes of the adjacent irrigation water and agricultural land to Oil and Soap factory are expected to be affected due to the usage of polluted water for irrigation.

Oil and Soap industry constitute another category of industrial liquid wastes, which are characterized by high pH and monovalent cation concentrations, where sodium hydroxide is used in processing or for cleaning purposes (**Liffering and Mc Lay, 1996**). So that, a special attention was focused in this study to investigate the potential  $\text{Na}^+$  hazardous when soils are irrigated with a high  $\text{Na}^+$  concentration water, especially under arid and hot climate. Therefore, three water samples were taken from irrigation canal (Neanaiya) at different distances of 500, 1000 and 2000 m from the pollution source (Oil and Soap factory), besides a fourth water sample

was chosen as a control from the un-polluted part of Neanaiya canal, according to APHA (1996). In addition, soil samples were also taken at certain sites parallel to the water sampling. Some physico-chemical properties of the studied soil are presented in Table (1).

**Table (1): Particle size distribution, CaCO<sub>3</sub> % and organic matter of the studied soil.**

Particle size distribution %				Textural class	CaCO <sub>3</sub> %	Organic matter %
C. sand	F. sand	Silt	Clay			
2.4	25.3	26.50	46.07	clay	3.45	1.68

Disturbed and undisturbed soil samples were taken from the selected soil sites at different depths of 0-10, 10-20, 20-40 and 40-60 cm. These samples were air dried, crush, sieved through a 2 mm sieve and prepared for the different physical and chemical properties according to the standard methods described by the different Publishers, as follows in Table (2).

**Table (2): Soil properties as determined by the standard methods described by the different Publishers.**

Soil properties	Publishers
Particle size distribution (%)	Gee and Bauder (1986)
Bulk density (g cm <sup>-3</sup> )	Vomocil, (1965)
Penetration resistance	Davidson (1965)
Pore size distribution (μ)	De Leenheer and De-Boodt (1965)
Saturated hydraulic conductivity (m h <sup>-1</sup> )	Klute and Dirksen (1986)
Total calcium carbonate %	Page <i>et al.</i> (1982)
Organic matter content %	
Soil reaction (pH) and electrical conductivity (dS m <sup>-1</sup> )	
Soluble cations and anions (m mole L <sup>-1</sup> )	
Cations exchange capacity (c mole kg <sup>-1</sup> soil)	Jackson (1967)
Water stable aggregates %	Kember and Rosenau (1986)
Dry aggregates	De Leenheer and Deboodt (1959)

**RESULTS AND DISCUSSION:**

***I. Chemical characteristics of irrigation water source:***

The chemical characteristics of irrigation water samples collected from El-Neanaia canal at different distances from the oil and soap factory are shown in Table (3).

**Table (3): Water pH, electrical conductivity, soluble ions and SAR of irrigation water at different distances from pollution source.**

Distance (m)	pH	EC (dS/m)	Soluble cations (m mole L <sup>-1</sup> )				Soluble anions (m mole L <sup>-1</sup> )				SAR
			Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	CO <sub>3</sub> <sup>=</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>=</sup>	
500	8.60	4.73	4.01	7.40	34.40	0.96	0.00	10.49	26.80	9.48	14.39
1000	8.10	2.90	7.90	3.30	17.0	0.40	0.00	7.65	17.35	3.60	7.17
2000	7.50	0.66	3.00	1.10	2.05	0.20	0.00	2.45	2.70	1.20	1.43
Neanaia water	7.45	0.49	2.36	0.83	0.96	0.23	0.00	1.90	1.42	1.06	0.76

The obtained data clarify that the electrical conductivity (EC) of irrigation water reached a greatest value at a distance of 500 m from the pollution source, and then it tends to decrease with increasing the distance faraway the pollution source of the factory. EC value begins with a value of 4.73 dS/m at water source closed to pollution source, and then it tendency to gradual decrease up to a minimum value of 0.66 dS/m at a distance of 2000 m faraway the pollution source as compared to a value of 0.49 dS/m in original fresh water of Neanaiya canal before pollution point source. A parallel similar trend was found for each of water pH and SAR values, where their maximum values were beginning with 8.60 and 14.39 at the pollution source and greatly decreased to minimum values of 7.50 and 1.43 at 2000 m from the pollution source, respectively.

It is noteworthy to mention that the distribution pattern of soluble cations and anions indicate that the soluble cations are dominated by  $\text{Na}^+$  followed by  $\text{Mg}^{2+}$  and the  $\text{Ca}^{2+}$ , however, soluble  $\text{Na}^+$  constitutes 73.55 % of the total salts at 500 m from the outlet of the factory (pollution source). Concerning the distribution pattern of soluble anions, it was noticed that the dominance of any of soluble anion depends on the EC value, where at a high EC value  $\text{Cl}^-$  represents the dominant anion vs  $\text{HCO}_3^-$  that was the dominant anion at a low EC. That means that discharged industrial liquid wastes of Oil and Soap factory into irrigation canal resulted in high values for pH, EC and SAR of irrigation water.

That was true, since the suitability criteria of irrigation water resources according to **Ayers and Westcot (1985)** limits, show that the studied irrigation water samples could be categorized into three classes, *i.e.*, third class ( $\text{C}_3\text{S}_3$ , water salinity of  $\text{EC}_{\text{iw}} > 3.00 \text{ dS m}^{-1}$  and sodicity of  $\text{SAR} > 9$ ), second class ( $\text{C}_2\text{S}_2$ ,  $\text{EC}_{\text{iw}} = 0.75\text{-}3.00 \text{ dS m}^{-1}$  and  $\text{SAR} = 6\text{-}9$ ) and first class ( $\text{C}_1\text{S}_1$ ,  $\text{EC}_{\text{iw}} < 0.75 \text{ dS m}^{-1}$  and  $\text{SAR} < 6$ ) for the water samples that were taken at distances of 500, 1000 and 2000 m from the main pollution source, respectively.

## **II. Effect of industrial liquid-wastes of Oil and Soap Company on soil properties:**

### **a. Soil chemical properties:**

It is well known that the quality of irrigation water is considered one of the main factors that affecting chemical properties of the soil, mainly due to a high salt concentration of the applied saline water precipitates and accumulates through evaporation from the soil under arid and hot climate. Soil pH, EC and soluble ions of the studied soil profiles are presented in Table (4). The obtained data show that the studied soil profiles are suffering from salts built up, especially those adjacent to the pollution source, where the EC value is greater than 4 dS/m (**U.S. salinity Laboratory Staff, 1954**) as compared to the soil irrigated from the unpolluted irrigation water (control) of Neanaiya canal ( $\text{ECe} = 2.99 \text{ dS/m}$  as an average value).

Among the studied soil profiles, it can see that soil profile lies adjacent to the factory (pollution source) has a greatest  $\text{ECe}$  value of 5.75 dS/m (as an average value), and then it decreases with increasing the distance faraway the source of pollution up to a minimum value of 4.20 dS/m at a distance of 2000 m. Concerning the soluble ions, data reveal that at a low  $\text{ECe}$  value the  $\text{Ca}^{2+}$  is the dominant cation, whereas at a high  $\text{ECe}$  value (adjacent to the factory)  $\text{Na}^+$  is the dominant one. A similar trend was found for soluble anions, where at a low  $\text{ECe}$  value  $\text{HCO}_3^-$  and  $\text{SO}_4^{2-}$  were the dominant anions, while at a high EC value  $\text{Cl}^-$  was the dominant one.

Concerning soil pH value, data show that the soils of the studied area are characterized by alkaline conditions, where the pH values were ranged between 8.55 and 7.93. These results are in agreement with **Lifferring and Mc Lay (1996)** and **Shalaby et al. (1996)**.

**Table (4): Soil pH, ECe, soluble ions and SAR values of the studied soils at Kafr El-Zeyyat area.**

Distance (m)	Depth (cm)	pH	EC (dS/m)	Soluble cations (m molc L <sup>-1</sup> )				Soluble anions (m molc L <sup>-1</sup> )				SAR
				Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	CO <sub>3</sub> <sup>-</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>-</sup>	
500	0-10	8.32	6.40	13.14	12.42	49.10	1.34	0.00	6.50	48.00	21.50	13.75
	10-20	8.55	7.14	11.53	13.90	58.20	1.45	0.00	7.00	55.72	22.36	16.34
	20-40	8.40	4.40	9.05	10.36	22.37	1.72	0.00	5.80	24.05	13.65	7.17
	40-60	8.46	5.07	8.56	12.20	28.91	0.60	0.00	6.00	27.95	16.32	8.98
	Mean	7.86	5.75	10.57	12.22	39.64	1.27	0.00	6.32	28.93	18.45	11.56
1000	0-10	8.00	6.05	13.8	9.14	46.05	0.56	0.00	4.29	43.06	22.2	13.50
	10-20	7.93	6.31	10.16	11.2	46.1	0.54	0.00	3.8	42.1	27.1	12.8
	20-40	7.96	4.38	9.8	8.9	23.9	0.40	0.00	3.4	26.2	13.4	7.8
	40-60	7.99	4.49	9.9	8.9	24.4	0.5	0.00	3.4	26.9	13.7	7.9
	Mean	7.84	5.32	11.93	9.73	35.17	0.59	0.00	3.72	34.6	19.1	10.6
2000	0-10	7.96	3.95	17.43	7.66	13.30	0.54	0.00	3.00	15.95	19.88	3.75
	10-20	7.93	5.07	19.50	13.76	16.40	0.56	0.00	4.00	28.62	17.60	4.02
	20-40	8.05	4.41	16.11	8.14	18.80	0.54	0.00	3.50	23.52	16.57	5.40
	40-60	8.05	3.38	16.20	9.45	7.55	0.20	0.00	3.50	16.02	13.88	2.11
	Mean	7.40	4.20	17.31	9.75	14.01	0.46	0.00	3.52	21.02	16.98	3.82
Nenaya water	0-10	7.19	1.92	9.70	5.56	3.14	0.30	0.00	2.40	8.48	7.82	1.14
	10-20	7.29	2.60	11.00	6.96	7.19	0.33	0.00	2.50	12.54	10.44	2.40
	20-40	7.34	4.08	18.06	10.13	11.80	0.56	0.00	2.70	17.85	20.00	3.15
	40-60	7.26	3.38	13.18	8.14	11.48	0.14	0.00	2.90	15.40	14.64	3.52
	Mean	7.27	2.99	12.98	7.69	8.40	0.33	0.00	2.62	13.57	13.23	2.55

In regard of cation exchangeable capacity and exchangeable cations, data in Table (5) showed that the studied soil profiles are characterized by a relatively high CEC value accompanied to fine texture grade. Concerning the exchangeable sodium percent ESP value, data showed that the soil profiles are characterized by alkali soil media in the area adjacent to the pollution source, since the ESP value exceeds the arbitrary limit of 15 % (**U.S. Salinity Laboratory Staff, 1954**). Whereas, those are located faraway of 2000 m are non-alkali ones, due to the ESP value reached 13.30 as an average for soil profile layers.

From the previous discussion of chemical properties of the studied soil profiles, it can be concluded that, as a result of irrigation with water contaminated with industrial liquid wastes of Oil and Soap factory, the irrigated agriculture soils are suffering from salinity and sodicity conditions of ECe and ESP values that are greater than 4 dS/m and 15%, respectively. The corresponding ECe and ESP values ranged between 5.75-7.50 dS/m and 24.56-32.09 % at distances of 500 and 1000 m from the [pollution source, respectively (**U.S. Salinity Laboratory Staff, 1954**).

*b. Soil physical properties:***III. Effect of industrial wastewater effluents on soil structure:**

Soil structure is an important soil property to be evaluated, because it mediates many biological and physical processes in soils. Soil structure can be evaluated by determining the extent of aggregation and the stability of aggregates. These characteristics play a significant role in affecting soil-plant relationships.

**Table (5): Cation exchange capacity and exchangeable cations of the studied soils at Kafr El-Zeiyat area.**

Distance (m)	Depth (cm)	CEC (c mole kg <sup>-1</sup> soil)	Exchangeable cations (meq 100 g <sup>-1</sup> soil)				Exchangeable cations %			
			Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>
500	0-10	38.60	15.01	10.19	9.05	3.75	39.50	26.82	23.82	9.87
	10-20	41.00	13.05	11.65	14.02	2.28	31.833	28.41	34.20	5.56
	20-40	43.70	13.76	14.00	14.78	1.16	31.49	32.04	33.82	2.65
	40-60	45.10	13.98	13.90	16.47	0.75	30.82	30.82	36.52	1.66
	Mean	41.96	13.95	12.44	13.58	1.99	33.41	29.52	32.09	4.94
1000	0-10	46.60	14.41	20.70	9.42	2.07	30.931	44.42	20.21	4.44
	10-20	45.50	12.98	18.30	13.07	1.15	28.53	40.22	28.73	2.53
	20-40	48.10	11.60	25.13	10.48	0.89	24.12	52.25	21.79	1.85
	40-60	47.60	9.82	24.00	13.10	0.68	20.63	50.42	27.52	1.43
	Mean	46.95	12.20	22.03	11.52	1.20	26.05	46.83	24.56	2.56
2000	0-10	40.10	24.23	9.14	5.85	0.88	60.42	22.79	14.59	2.19
	10-20	37.80	20.51	21.05	4.55	0.79	54.26	55.69	12.04	2.09
	20-40	40.90	20.52	25.45	5.66	0.59	50.17	62.22	13.84	1.44
	40-60	46.00	22.02	17.57	5.86	0.55	47.87	38.20	12.74	1.20
	Mean	41.20	21.82	18.30	5.48	0.70	53.18	44.73	13.30	1.73
Nenaya water	0-10	41.90	26.97	9.91	3.90	1.12	64.37	23.65	9.31	2.67
	10-20	42.30	24.63	11.7	4.94	1.03	58.23	27.66	11.68	2.43
	20-40	40.10	21.46	12.45	5.44	0.75	53.52	31.05	13.57	1.87
	40-60	41.10	26.97	8.10	5.26	0.77	65.62	19.71	12.80	1.87
	Mean	41.35	25.01	10.54	4.89	0.92	60.44	25.52	11.84	2.21

Understanding the soil degradation and structure stabilizing processes affected by irrigation water quality is a better management of soil and water resource. The use of polluted water with high total salt concentration, SAR and pH for irrigation leads to an increase in the ESP of the soil, which can significantly affect soil susceptibility to deteriorate soil structure. In this connection, data presented in Table (6) show the percentages of water stable aggregate sizes distribution, total aggregates and mean weight diameter. The studied water stable aggregate fractions could be recognized under four sizes, as follow: (4-2 mm), (2-1 mm), (1-0.5 mm) and (<0.25 mm).

The aggregate size of (4-2 mm) is chosen because it is the accepted break between fine and medium granular structure (**Agriculture Canada Expert Committee on Soil Survey, 1987**). Aggregate size greater than (0.84 mm) is

generally considered resistant to wind erosion (Chepil, 1958). Aggregate size of (0.84-0.25 mm) contains water conducting and aeration pores, therefore, it is necessary for proper water and air movement through the soil (Oades, 1984). Aggregate size less than (0.25 mm) reflects the micro aggregates that contain the important water retention pores (Oades, 1984). From these information about the classification of soil aggregate, it can be concluded that aggregate fractions of (0.50-0.25 mm) and (<0.25 mm) are found to be the abundant sizes in the soil irrigated with polluted water, where their corresponding value percentages (as an average) reached 20.84 and 68.66 %, respectively in the soil profile close to the pollution source. Meanwhile, the average percentages of the intermediate and large aggregate sizes reached 1.22 and 2.22 %, respectively. That was true, since soil aggregate sizes of (4-2 mm), (2-1 mm) and (1-0.50 mm) tended to decrease. The corresponding relative decrease percentages were 87.32, 87.18 and 66.68 %, respectively. On the other hand, the corresponding relative decrease percentages in soil profile lies at a distance of 2000 m from the pollution were 28.48, 55.66 and 21.17 %, respectively as compared to the control. This means that, the use of polluted water for irrigation causes a marked decrease in the large water stable aggregate sizes, which districted to smaller ones.

**Table (6): Water stable aggregate size distribution, total aggregates, mean weight diameter and stability index of the studied soils.**

Distance (m)	Depth (cm)	Water stable aggregate distribution %					Total aggregates %	Mean weight diameter (mm)	Stability index (mm)
		>2.0 mm	2.0-1.0 mm	1.0-0.5 mm	0.5-0.25 mm	< 0.25 mm			
500	0-10	1.31	1.11	2.13	21.12	74.33	25.67	0.34	0.30
	10-20	1.20	1.56	1.59	22.60	73.05	26.65	0.34	0.23
	20-40	1.05	4.95	11.50	19.28	63.32	36.78	0.42	0.30
	40-60	1.36	1.28	13.01	20.39	63.96	36.04	0.39	0.25
	Mean	1.22	2.22	7.05	20.84	68.66	31.28	0.37	0.26
1000	0-10	1.41	2.46	2.58	24.08	69.47	30.53	0.36	0.32
	10-20	0.98	1.82	3.18	24.35	69.67	30.33	0.35	0.28
	20-40	1.77	4.74	6.44	18.10	68.95	31.05	0.41	0.21
	40-60	0.99	6.49	5.69	21.33	65.50	34.60	0.41	0.28
	Mean	1.54	4.87	8.28	18.04	67.26	33.98	0.41	0.28
2000	0-10	9.65	7.39	10.02	18.84	54.10	45.90	0.68	0.42
	10-20	9.84	6.94	15.07	14.85	53.30	46.70	0.70	0.30
	20-40	2.75	7.83	20.75	12.70	56.00	44.0	0.54	0.27
	40-60	5.30	8.60	20.90	12.35	52.85	47.15	0.62	0.24
	Mean	6.88	7.68	16.88	14.68	46.06	45.93	0.63	0.30
Control	0-10	13.64	15.75	19.67	6.53	44.41	55.59	0.93	0.97
	10-20	10.85	18.61	13.53	15.41	41.60	58.40	0.87	0.61
	20-40	8.83	15.05	26.65	10.40	39.07	60.93	0.83	0.71
	40-60	5.19	19.88	24.80	11.50	38.63	61.37	0.78	0.81
	Mean	9.62	17.32	21.16	10.96	41.92	59.07	0.85	0.77

Moreover, the obtained data reveal that, a marked decrease in total aggregates was detected in the soil profile adjacent to the pollution source, where the relative decrease percentage was 47.04 % as compared to the control. While, its values reaches 22.24 % in the soil profile lies at a distance of 2000 m faraway the pollution source. The aforementioned data of water stable aggregate size distribution and total aggregates are emphasized that their values are considered as a measure of the stability state of soil structure. Thus, the soil structure stability appears a pronounced decrease as a result of the use of increasingly lower qualities of irrigation water, which subsequent cause salinization and alkalinization processes for the irrigated soil.

The mean weight diameter (MWD) fluctuates between a minimum value of 0.37 mm in the soil profile closed to the pollution source and a maximum one of 0.63 mm in the soil profile lies at a distance of 2000 m faraway from the pollution source. On the other hand, stability index (SI) tends to decrease in the soil profile closed to the pollution source of pollution (0.26 mm), and then it increases to reach 0.30 mm in the soil profile located at 2000 m from the pollution source.

In conclusion, the obtained results indicate that, structure stability of soil described by the amount of total water stable aggregates and mean weight diameter showed significant and negative changes when soil salinity and sodicity increased, due to the use of progressively polluted irrigation water that falls in the very high salinity and sodicity class ( $C_3S_3$ ), as mentioned before. Sodidity may be the more obscure problem, but it is a more widespread of land degradation, especially in clay soils because clays are inherently more prone to dispersion. More salts, including sodium, will accumulate in clay soils because of clay's inherent greater surface area. High levels of sodium make the clay particles less sticky, so, they do not adhere, or hold together so well (**Quirk, 2002**).

The changes in the soil aggregation in the current work occur as a result of the changes in the chemical properties of the soil, which follow the use of increasingly reduced irrigation water quality. An preliminary attempt to study the factors affecting the amount and size distribution of water stable aggregates was done by using statistical analysis of simple correlation coefficient, as follows: Increasing E<sub>c</sub>, SAR and ESP values have the adverse significant effects on total aggregates with "r" values of -0.81<sup>\*\*</sup>, -0.76<sup>\*\*</sup> and -0.77<sup>\*\*</sup>, respectively. The corresponding negative highly significant simple correlations "r" were -0.77<sup>\*\*</sup>, -0.64<sup>\*\*</sup> and -0.76<sup>\*\*</sup> water stable aggregate size of (4-2 mm), -0.67<sup>\*\*</sup>, -0.71<sup>\*\*</sup> and -0.74<sup>\*\*</sup> for aggregate size of (2-1 mm) and -0.69<sup>\*\*</sup>, -0.77<sup>\*\*</sup> and -0.66<sup>\*\*</sup> for aggregate size of (1.0-0.5 mm), respectively. A similar way and a parallel trend were observed with mean weight diameter, where "r" values were -0.80<sup>\*\*</sup>, -0.61<sup>\*\*</sup> and -0.89<sup>\*\*</sup>, respectively.

Soil salinity and sodicity encourage soil disaggregation and increase fine aggregate sizes of <0.25 mm diameter, where highly significant positive correlations are obtained between E<sub>c</sub>, SAR, ESP on one hand and aggregate size of <0.25 mm on the other hand, with "r" values of 0.81<sup>\*\*</sup>, 0.76<sup>\*\*</sup> and 0.77<sup>\*\*</sup>, respectively.



**IV. Effect of industrial wastewater effluents on soil porosity:**

Soil porosity and pore size distribution were calculated from the moisture retention curves, the results are presented in Table (7). Data show that total porosity of soil profiles under consideration appears to fluctuate between 69.43 % in the soil profile closed to the pollution source and 68.89 % in the soil profile located at 2000 m distance from the pollution source. Nevertheless, the two values are higher than the control, mainly due to an almost similar of soil texture grade. Concerning pore size distribution, data reveal a marked decrease of quickly drainable pores (QDP) and water holding pores (WHP) in the soil profile at 500 m distance from the pollution source, and then their values tendency to increase up to a distance of 2000 m distance and the control. The fine capillary pores have an opposite trend, where its value found to occupy a considerable volume (49.62 % of total porosity) under the effect of industrial waste effluents at 500 m distance.

**Table (7): Total porosity and pore size distribution of the studied soils at Kafr El-Zeiyat area.**

Distance (m)	Depth (cm)	Soil total Porosity %	Quickly drainable pores (>0.28.8 $\mu$ )	Slowly drainable pores (0.28.8-8.6 $\mu$ )	Water holding pores (8.6-0.19 $\mu$ )	Fine capillary pores (<0.19 $\mu$ )
500	0-10	73.76	7.01	10.90	17.48	38.37
	10-20	74.93	4.02	15.51	16.29	39.11
	20-40	63.73	2.46	16.30	15.00	29.97
	40-60	65.32	1.86	18.80	14.31	30.35
	Mean	69.43	3.83	15.37	15.77	34.45
1000	0-10	70.75	6.31	12.75	16.59	35.10
	10-20	74.06	7.53	14.52	12.94	39.07
	20-40	74.26	6.18	18.50	15.28	34.30
	40-60	74.13	6.89	17.16	15.09	34.99
	Mean	73.29	6.73	15.73	14.97	35.86
2000	0-10	64.70	14.48	5.29	20.93	24.00
	10-20	63.45	12.60	6.03	19.63	25.19
	20-40	70.08	10.10	10.96	19.58	29.44
	40-60	70.04	11.30	10.59	19.65	28.50
	Mean	67.06	12.12	8.21	19.95	26.78
Control	0-10	66.95	15.63	9.28	22.94	19.10
	10-20	63.09	13.54	8.82	22.23	18.50
	20-40	69.60	12.00	10.14	20.00	27.46
	40-60	68.19	110.66	9.88	19.65	28.00
	Mean	66.95	12.95	9.53	21.20	23.26

By increasing the distance from the pollution source, the values of fine capillary (FCP) and water holding (WHP) pores tend to increase. A more pronounced change was found with each of water holding and slowly drainable pores, which form 29.75 and 39.93 % of the total porosity vs 18.07 and 12.24 % for fine capillary and quickly drainable pores, respectively in the soil profile at

2000 m distance from the pollution source. These results are more obvious by applying the statistical analysis of simple correlation, which show that ECe affect greatly soil total porosity ("r" 0.71\*\*).

A sharply reduction in soil porosity, due to the effect of industrial waste effluents, is found for each of quickly drainable and water holding pores, where highly significant and negative correlations are found between pore size (>28.0-0.19 $\mu$ ) and each of ECe, SAR and ESP (r = -0.60\*\*, -0.81\*\* and -0.88\*\*, respectively). The reverse was true for fine capillary pores (< 0.19 $\mu$ ), which exhibited positive highly significant correlations with corresponding "r" values of 0.89\*\*, 0.47\* and 0.72\*\*, respectively.

In this connection, the aggregates formation affect greatly the soil porosity, hence the quickly drainable and water holding pores are significantly increased with increasing the large and intermediate aggregate sizes of (4-2 and 1-0.50 mm, respectively). Positive and highly significant correlations are also found between both the quickly drainable and water holding pores on one hand and each of total aggregates and mean weight diameter (r = 0.69\*\* and 0.80\*\*, respectively). Whereas, the fine capillary pores has a reverse situation, where negative highly significant correlations were occurred with total aggregates and mean weight diameter (r=-0.79\* and -0.85\*\*, respectively).

#### ***V. Effect of industrial waste effluents on soil bulk density and penetration resistance:***

Data presented in Table (8) showed indicate different soil bulk density values were associated with penetration resistance ones in the soil profiles under consideration. However, a general trend to increase bulk density (BD) with increasing ESP value, especially in soil profile adjacent to pollution source at 500 m distance, where the mean average of BD reached a maximum value of 1.43 g/cm<sup>3</sup>. That was true, since the maximum value of BD was accompanied with a maximum one of penetration resistance (379 dyne/cm<sup>2</sup>).

Data also reveal that soil bulk density (BD), and consequently penetration resistance (PR) values tendency to decrease as the distance from the pollution source increase. Therefore, the lowest mean values of BD and PR of about 1.22 g/cm<sup>3</sup> and 253.22 dyne/cm<sup>2</sup>, respectively, are associated with soil profile at 2000 m distance from the pollution source, which are still higher than those of the control (1.17 g/cm<sup>3</sup> and 202.03 dyne/cm<sup>2</sup>, respectively). Among the studied soil profiles, it is noticed a general increase in soil BD value depth wise is accompanied with increasing soil material weight load, indicating a general tendency to increase soil compaction towards soil depth. Generally, it can be concluded that increasing the ESP value leads to increase both of BD and PR in the surface and subsurface layers, especially in the soil profile closed to the pollution source of industrial waste effluents (**Rashed, 2004**). This condition leads to increase fine capillary pores due to the deterioration of soil structure, and then total porosity is reduced and the soil is being compacted.

Statistical analysis shows that, there are positive highly significant correlations obtained between BD and each of ECe (r=0.77\*\*), SAR (r=0.62\*\*) and ESP (r=0.88\*\*). The reverse was true between ECe and each of BD (r=-0.80\*\*) and MWD (r=-0.87\*\*).

Table (8): Soil moisture content, bulk density, penetration resistance and saturated hydraulic conductivity of the studied soils.

Distance (m)	Depth (cm)	Moisture content ( $\theta$ ) %	Bulk density ( $\text{g cm}^{-3}$ )	Penetration resistance ( $\text{dyne cm}^{-2}$ )	$K_s$ ( $\text{cm h}^{-1}$ )
500	0-10	33.04	1.35	310.00	0.94
	10-20	32.64	1.45	446.00	0.05
	20-40	31.85	1.45	360.0	0.43
	40-60	30.22	1.50	400.00	0.35
	Mean	31.93	1.43	379.00	0.44
1000	0-10	33.34	1.33	300.01	0.79
	10-20	31.55	1.44	460.00	0.09
	20-40	29.30	1.45	356.80	0.44
	40-60	28.66	1.46	363.81	0.25
	Mean	30.71	1.41	370.15	0.39
2000	0-10	34.00	1.19	229.50	1.85
	10-20	33.50	1.23	233.65	1.24
	20-40	38.98	1.24	276.74	1.33
	40-60	40.00	1.23	273.00	1.33
	Mean	36.62	1.22	253.22	1.43
Control	0-10	35.63	1.13	110.00	2.63
	10-20	34.98	1.15	190.50	2.48
	20-40	41.67	1.20	262.00	1.53
	40-60	41.00	1.23	245.63	1.43
	Mean	38.31	1.17	202.03	2.02

#### VI. Effect of industrial waste effluents on saturated hydraulic conductivity:

The hydraulic conductivity values ( $K_s$ ) of the soils under investigation, which characterized by saline- sodic condition, are presented in Table (8). The obtained data show that  $K_s$  values tend to a general decrease with increasing the ESP values. This behavior is clear in the soil profile closed to the pollution source at a distance of 500 m, where the mean value of  $K_s$  reached 0.44 cm/h, with a relative decrease percentage of 78.74 % as compared to the control. Then, the values of  $K_s$  tend to increase gradually as the distance from the pollution source increases, where the ESP value shows a parallel decrease. At 2000 m distance from the pollution source, the  $K_s$  value was 1.43 cm/h, with a relative decrease percentage of 29.2 0% as compared to the control. On the other hand, data reveal that  $K_s$  are inversely related to soil depth (**Mansour et al., 2010**).

In conclusion, the saturated hydraulic conductivity of the saline-sodic soils is greatly hindered by increasing weight load and exchangeable sodium percentage. The larger values of sodium in the soils like one treated with irrigation water with high SAR, swelling and dispersion are expected to be the main mechanisms responsible for reducing soil  $K_s$  (**Lima et al., 1990**). Swelling reduces the soil pore sizes where dispersion clogs soil pore. Statistically, factors affecting the  $K_s$  are studied by simple correlation analysis, which shows that structural parameters of

total aggregates, mean weight diameter and stability index all cause significant increases in Ks ( $r=0.84^{**}$ ,  $0.86^{**}$  and  $0.93^{**}$ , respectively). On the other hand, ECe, SAR, and ESP, as factors negatively affecting water flow and subsequent internal swelling, have significant reverse effects on Ks ( $r=-0.85^{**}$ ,  $-0.70^{**}$  and  $-0.84^{**}$ , respectively).

Data also reveal that soil bulk density (BD), and consequently penetration resistance (PR) values tendency to decrease as the distance from the pollution source increase. Therefore, the lowest mean values of BD and PR of about  $1.22 \text{ g/cm}^3$  and  $253.22 \text{ dyne/cm}^2$ , respectively, are associated with soil profile at 2000 m distance from the pollution source, which are still higher than those of the control ( $1.17 \text{ g/cm}^3$  and  $202.03 \text{ dyne/cm}^2$ , respectively). Among the studied soil profiles, it is noticed a general increase in soil BD value depth wise is accompanied with increasing soil material weight load, indicating a general tendency to increase soil compaction towards soil depth. Generally, it can be concluded that increasing the ESP value leads to increase both of BD and PR in the surface and subsurface layers, especially in the soil profile closed to the pollution source of industrial waste effluents (**Rashed, 2004**). This condition leads to increase fine capillary pores due to the deterioration of soil structure, and then total porosity is reduced and the soil is being compacted.

Statistical analysis shows that, there are positive highly significant correlations obtained between BD and each of ECe ( $r=0.77^{**}$ ), SAR ( $r=0.62^{**}$ ) and ESP ( $r=0.88^{**}$ ). The reverse was true between ECe and each of BD ( $r=-0.80^{**}$ ) and MWD ( $r=-0.87^{**}$ ).

#### **CONCLUSION:**

Based on the aforementioned discussion, it could be concluded that the usage of contaminated water with industrial waste effluents for irrigation purposes could be negatively affect soil physio-chemical properties, where high values of ECe, pH, SAR, ESP, bulk density and penetration resistance were achieved. On contrary, total aggregates, mean weight diameter, stability index and saturated hydraulic conductivity (Ks) were decreased. Furthermore, soil structure degradation, so the longer term effluents irrigation would be risky from environmental point of view.

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#### تلوث الأراضي الزراعية الناتج من النشاط الصناعي في منطقة كفر الزيات - مصر

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الهدف الرئيسى من هذه الدراسة يتركز فى تتبع التأثيرات الضارة للمخلفات الصناعية السائلة الناتجة من النشاط الصناعى لمصنع مصر للزيوت والصابون بمدينة كفر الزيات - محافظة الغربية - مصر، والمنطلقة مباشرة من خلال منفذ إلى قناة الري المتاخمة للمصنع على بعض الخواص الفيزيو-كيميائية للأراضي الزراعية المروية كنتيجة للتلوث الكيميائى المحتمل لتلك المخلفات. وهذه المخلفات الملوثة كيميائيا والناتجة من النشاط الصناعى القائم لا تلوث مباشرة مياه الري المجاورة فقط، بل أيضا تلوث بطريقة غير مباشرة الأراضي الزراعية المروية. ولتحقيق هذا الهدف، تم أخذ عينات من كلا مياه الري والأراضي المروية على أبعاد صفر، 500، 1000، 2000 متر من مصدر التلوث الرئيسى لمتابعة التغيرات الكيميائية فى مياه الري، وكذلك صفات التربة الفيزيو-كيميائية فى الأراضي المروية.

وتشير نتائج التحليل الكيميائى لمياه مصدر الري المتاحة على إمتداد مختلف المسافات المدروسة داخل قناة رى النعناعية إلى حدوث تأثير سلبى للمخلفات السائلة الناتجة من النشاط الصناعى على نوعية مياه الري، حيث أن صفاتها الكيميائية ممثلة فى قيم الرقم الهيدروجينى للمياه، التوصيل الكهربى، الأيونات الذاتية خاصة الصوديوم والكلوريد والبيكربونات، والنسبة الإلمصاصة للصوديوم قد أظهرت ميل واضح إلى الزيادة. وهذا حقيقى، حيث توضح معايير صلاحية المصادر المائية للرى تبعا لمستويات الملوحة والصودية، أن عينات مياه الري تحت الدراسة تنتمى إلى ثلاث رتب هي: (9)  $(C_4S_1, EC_{iw}=0.75-3.00 \text{ dS/m and SAR}=6-9)$ ،

(6)  $(C_2S_1, EC_{iw} < 0.75 \text{ dS/m and SAR} < 6)$ ، وذلك بالنسبة لعينات المياه المأخوذة على أبعاد 500، 1000، 2000 متر من مصدر التلوث الرئيسى على التوالى.

ومثل هذه المعايير الكيميائية لمياه الري كانت أيضا مصاحبة بزيادة موازية فى صفات التربة الكيميائية ممثلة فى قيم الرقم الهيدروجينى للمياه، التوصيل الكهربى، نسبة الصوديوم المتبادل، وكذلك الفيزيائية ممثلة فى تجمعات التربة الدقيقة، المسام الشعرية، الكثافة الظاهرية، مقاومة التربة للاختراق، معامل التوصيل الهيدرولى المشبع، والعكس صحيحا بالنسبة لكل من التجمعات الكلية، التجمعات الكبيرة، متوسط اوزان الأقطار المكافئة، مؤشر الثبات، المسام الحاملة للماء، والتي أظهرت تناقضا ملحوظا.