EFFECT OF INDUSTRIAL LIQUIED WASTES ON MAIZE PLANTS AND SOME SOIL PHYSIO-CHEMICAL PROPERTIES

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ABSTRACT: *The theme of this study was to detect the impact of some different industrial wastewater on maize plants and some soil physical and chemical properties. To achieve these objectives, one industrial area was selected at Mostorod, Kalubia governorate, Egypt, where wastewater is loaded with high amounts of fine suspended matter accumulated on the soil surface layer and negatively affected soil properties according to chemical composition of suspended matter. The ceramic industrial wastewater loaded with clay minerals, mainly kaolinite, led to an increase in clay content. Plugging the conducting pores, increasing fine capillary pores, soil bulk density and penetration resistance. Subsequently, quickly drainable pores and saturated hydraulic conductivity (Ks) were decreased.*

Regarding the heavy metal (Cd, Ni, Co, and Pb) contents uptake by maize plants decreased with increase of the distance from pollution source. The roots had higher levels of heavy metal than shoots. The contents of heavy metal in both (shoots and roots) remained higher than the toxic levels, and consequently negatively affected food chain as well as human and animal health.

Key words: Industrial wastewater, maize, heavy metals, soil pollution and soil properties.

INTRODUCTION

Today, the progress in standards of living has been too quick in many aspects, and often wrong with respect to the dynamic equilibrium of the biosphere. The emphasis has been focused on the goods produced and not enough on the wastes always accompanies production process. More of exotic materials are more likely to become pollutants rather than decompose into harmless chemicals. Land and water application of industrial wastes is also becoming more widespread as the extensive developing of industry. It is clear that, however, that soil is an appropriate dumping ground for industrial wastes. 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 are a main source of pollution for all environments. However, it requires on-site treatment before discharging on land the problems of disposal (Emongor *et al.*, 2005). Industrial waste either solid, liquid or gas, all three types of wastes have the potential of ultimately polluting water. This polluted water, in addition to other effects, directly affects soil not only in industrial areas but also in agriculture fields (Kisku *et al*, 2000 and Barman *et al.,* 2000). 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 industrial wastes varies according to the industrial structure of country or region. The chemical composition of these wastes not only varies with time of derived various wastes but also with treatment of individual industrial wastes (Mc Laren and Simith, 1996).

Soil ecosystems all over the world have been infected by various anthropogenic actions resulting in health hazard through food chain (Tu *et al.*, 2000; Dahmani-Mueller *et al.*, 2001 and Mc Grath *et al.*, 2002).

In the production process of industries, a lot of solids, semi-solid and liquid wastes are generated that may contain substantial amount of toxic organic and inorganic pollutants and if dumped in the environment without treatment then this may lead to serious environmental consequences. This will also undoubtedly deteriorate soil productivity and adversely affect crop production in the surrounding lands (Islam *et al.*, 2006). 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: Igwe *et al*,. 2005).

This study was carried out to evaluate the effect of industrial activity and wastes on the local environment such as physical and chemical properties of the soil in the industrial areas, the chemical composition of irrigation water and also the control of some trace elements and heavy metals grows in this area.

MATERIALS AND METHODS

The present study was carried out on a year of 2008 at Mostorod, El-Qalubia governorate to identify the changes in the characteristics of a clayey soil receives daily supply of industrial wastes water derived from several factories erected in the studied area such as Company for Ceramic and Chaina (Chainy) (CCC), as well as the grown plants of maize. Therefore, soil and water samples were taken at different distances from pollution source.

Water sampling

Four water samples numbered by 1, 2, 3 and 4 were taken according to APHA (1985) from the factories outlet at Mostorod (No.1) and. Water samples (Nos. 2 and 3) were taken at certain sites from El-Khsous main drain, parallel

to the soil sampling locations which were at distance of 500 and 1000 m distance from the pollution source. The fourth water sample namely control was taken from the Ismailia irrigation canal. The suspended matters of water sample number 1 were determined according to Jackson (1973) where it was 6080 mg/L. The chemical composition of these suspended matter and also for the tested water samples were carried out according to Cottenie *et al.,* (1982) and Page *et al.* (1982). The chemical composition of the suspended matter was listed in Table (1).

Table (1): Chemical composition of the suspended matter

Chemical characters and units	Values
Organic matter content (%)	0.05
Total CaCO$_3$ (%)	14.40
Soluble Ca (meq L^{-1})	10.00
Soluble Mg (meq L^{-1})	26.70
Soluble Na (meq L^{-1})	6.80
Soluble K (meq L^{-1})	1.70
Heavy metals content (mg kg^{-1})	
Zn	664.50
Fe	507.50
Cd	0.34
Pb	0.20
Co	73.97
Ni	12.15
Mn	26.00
Cr	12.70
Cu	13.20
B	13.60

Soil sampling:-

Disturbed and undisturbed soil samples where taken from three location sites namely, 0, 500 and 1000 m distance from the pollution point source with different depths i.e. 0-10, 10 -20, 20-40 and 40-60 cm. These samples were air

dried and prepared for different physical and chemical properties as following Table (2).

Table (2): Soil properties and their determination references.

Soil properties	References
Particle size distribution (%)	Gee and Bauder, 1986
Bulk density (g cm^{-3})	Vomocil, 1965
Penetration resistance	Davidson, 1965
Pore size distribution (μ)	De Leenheer and De-Boodt, 1965
Saturated hydraulic conductivity (m h^{-1})	Klute and Dirksen, 1986
Total calcium carbonate (%)	Page *et al.,* 1982.
Organic matter content (%)	Page *et al.,* 1982.
Soil reaction (pH) and electrical conductivity(dS m^{-1})	Page *et al.,* 1982.
Soluble cations and anions (meq L^{-1})	Page *et al.,* 1982.

Qualitative Clay Mineralogical Analyses:

Clay fraction (<0.002mm) was separated from the studied soil samples and prepared for X-ray diffraction analyses according to Black *et al.* (1965). Each oriented clay samples was subjected to X-ray after the treatments with Mg-saturated (air dried), Mg-saturated treated with glycerol 10%, K-saturated (air dried) and K-saturated heated to 550 ºC for 4 hours. X-ray analyses were carried out using a Philips PW1140/90, X-ray diffraction apparatus Ca-K∞ radiation. The identification of the clay minerals from the X-ray diffractograms was done according to Brindley and Brown (1980).

Plant analysis:

The collected plants were divided to shoots and roots, washed separately with tab water and two times with distilled water, then air dried, ground and kept for chemical analysis. A 0.5 g of each ground plant sample was digested in a mixture of H_2SO_4+$HClO_3$ at ratio of 3:1. The clear digestion was diluted by distilled water up to 50 ml. Then the digestion content of Fe, Zn, Cd, Pb, Ni, Mn, Cr, Cu, and B were determined using atomic absorption spectrophotometer according to the methods described by Cottenie *et al.* (1982).

The obtained data were subjected to the statistical analysis where the correlation coefficient (r) was calculated according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION
Chemical analyses of irrigation water

Chemical analyses of water samples collected from the factory outlet and at different distances from the outlet are shown in Table (3). The obtained data show that the values of pH, EC, soluble cations and anions, SAR and total suspended matter in the Ismailia irrigation canal (control) are highly favorable and dramatically increased towards the factor's outlet. This fact reveals that wastewater disposed from such factories could be negatively affecting the neighboring soils.

According to the U.S Salinity Laboratory Staff (1954), electrical conductivity (EC) of water samples collected from the factory's outlet and Ismailia irrigation canal and that collected at different distances of outlet are in the normal rang (<2.25 dS/m), whereas the relative increase in EC values reached to 145.6, 59.6 and 35.1% for the samples taken from the factory outlet, 500 and 1000 m distance, respectively as compared with irrigation canal. In respect of soluble cations, Ca^{2+} is the dominate ion followed by Na^+ and Mg^{2+} ions. While, HCO_3^- is the dominant anion followed by $SO_4^=$ and Cl. The irrigation water in such area could be classified as slight saline-non alkali. No clear differences were observed in pH values of the investigated water samples.

Table (3): Changes in chemical compositions of wastewater collected from factory outlet and from different distances from the factory as compared to the canal water sample.

Distance from outlet (m)	PH	EC (dS/m)	Soluble cations (meq/L)				Soluble anions (meq/L)				SAR	Suspended matter (mg/L)
			Ca^{2+}	Mg^{2+}	Na^+	K^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$		
0	7.47	1.40	6.16	2.35	5.17	0.2	-	4.05	4.67	5.16	2.06	6080
500	7.45	0.91	4.56	1.35	3.34	0.36	-	3.56	3.00	3.05	1.72	3420
1000	7.40	0.77	3.58	1.33	2.00	0.44	-	3.30	1.80	2.25	1.57	2500
Control	7.51	0.57	1.96	1.73	1.59	0.36	-	3.00	1.08	1.56	1.36	18

High content of total suspended solids (TSS) are found in the water samples taken from the factory outlet. These high concentrations decreased as the increase in distance from the factory. Suspended solid transport is dynamic phenomenon. Some of extreme variability in suspended solid transport is particle size and composition of total suspended solids (Verbavichus, 1990 and Jamie and Richard, 1996).

Data in Table (3) also reveal that the (TSS) at just factory outlet is 6080 mg/L, and then it decreases by getting away to reach 3420 and 2500 mg/L at a

distance of 500 and 1000 m from the pollution source, respectively. These values are highly exceeding the accepted level (30mg/L) according to (APHA, 1996).

Mineralogical composition of suspended solids:

The semi quantitative mineralogical composition of the suspended solids and soil profile at different distance from the point source of pollution was carried out using the X-ray diffractometer (Table 4 and Fig. 1). It is based on the presence of characteristics diffraction for each mineral in the suspended soild and soil samples.

Table (4): Mineralogical composition of ceramic suspended solid and polluted soil profile of the studied soils. (Semi-quantitative level)

| Sample No.	Distance (m)	Montmorillonite	Illite	Kaolinite	Vermculonite	Quartz	Feldspars
1	Susp. solid	---	10	40	-	25	25
2	500	40	7	24	4	15	10
3	1000	42	6	19	5	18	10
4	Control	50	10	15	5	13	7

Data presented in Table (4) and illustrated in Fig (1) show that, the clay fraction of the ceramic suspended solids was dominated with kaolinite followed by illite and then quartz and feldspars as accessory minerals, which constitute about of 25% of the sample. However, montmorillonite constitutes about of 40-50% of the other studied samples.

Effect of ceramic industrial wastewater effluents on some soil chemical properties
Soil salinity:

Values of soil salinity as expressed with electrical conductivity (EC) are shown in Table (5). Data reveal that soil samples under investigation have low values of electrical conductivity. The mean values of EC are 0.96dS/m, 0.77 dS/m and 0.57dS/m for soil sites at 500, 1000 m and control, respectively. Within soil profiles layers, the EC values are in general irregularly distributed with a tendency to decrease in the deeper layers. This finding may be attributed to the nature of irrigation water.

The distribution of individual soluble cations of the investigated soil samples is shown in Table (5). Data indicate that, the soluble calcium dominates the other soluble cations in the soils.
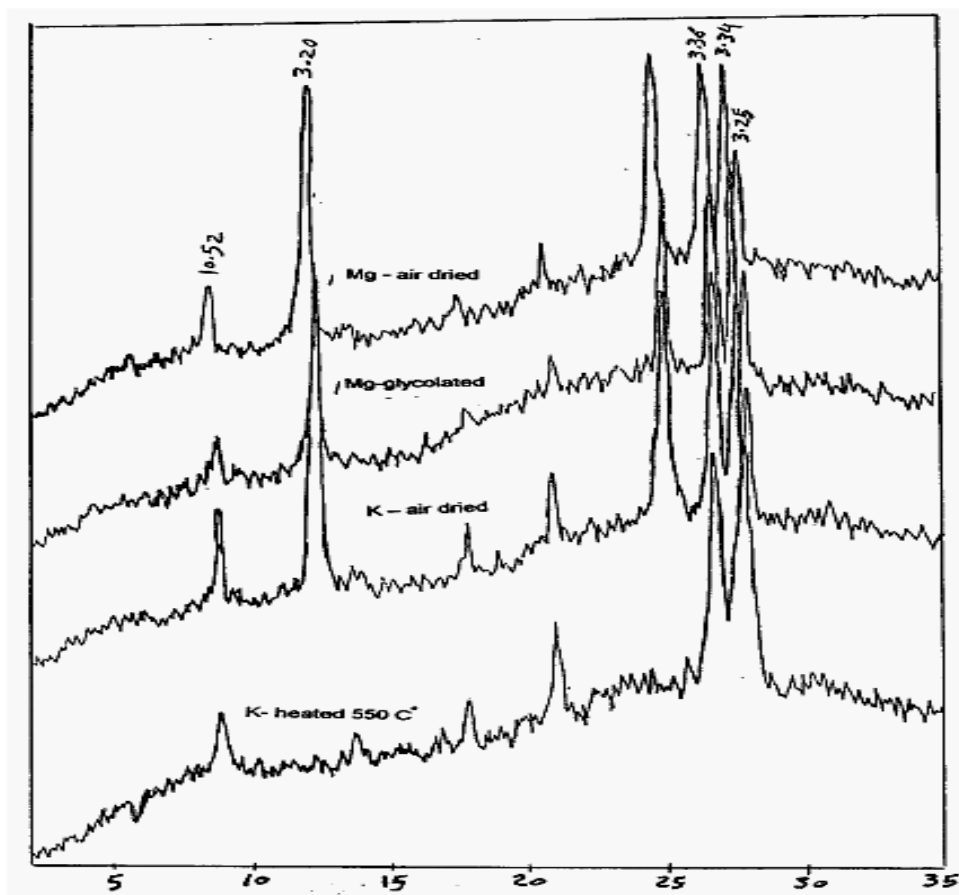
Degree 2θ

Fig. (1): X-ray diffraction patterns of suspended matter of ceramic industrial wastes

Regarding the anions distribution pattern, data in Table (5) show that, soil samples under investigation exhibit high values of bicarbonate, especially in the soil sample at 500m distance from the pollution source (3.56 meq/L), followed by sulphates and chlorides at a distance of 500 and 1000 m from the pollution source, respectively.

Table (5): Soil pH, electrical conductivity, soluble cations and anions (meq/L) and SAR of the studied sites as affected by ceramic industrial wastewater at Mostorod area.

Distance (m)	Depth (cm)	pH	EC (dS/m)	Cations (meq/L)				Anions (meq/L)				SAR
				Ca^{2+}	Mg^{2+}	Na^+	K^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	
500	0-10	7.39	0.71	3.69	1.26	1.79	0.19	-	4.79	1.67	0.47	1.14
	10-20	7.58	0.65	3.49	1.06	1.61	0.17	-	3.65	1.90	0.78	1.07
	20-40	7.42	0.68	3.95	0.59	1.74	0.13	-	4.10	2.14	0.17	1.15
	40-60	7.34	0.67	3.79	1.06	1.71	0.10	-	3.42	2.38	0.86	1.10
	Mean	7.43	0.73	3.73	0.99	1.71	0.14	-	3.99	2.02	0.56	1.11
1000	0-10	7.95	0.71	3.59	1.72	1.48	0.15	-	2.96	1.90	2.08	0.91
	10-20	7.45	0.76	4.75	1.13	1.52	0.15	-	4.46	2.38	0.61	0.89
	20-40	7.48	0.66	3.49	1.62	1.22	0.04	-	2.74	2.38	1.25	0.76
	40-60	7.48	0.59	3.59	0.87	1.12	0.14	-	2.56	2.14	1.02	0.75
	Mean	7.59	0.68	3.85	1.33	1.33	0.12	-	3.18	2.20	1.23	0.83
Control	0-10	7.21	0.65	4.15	1.10	0.91	0.16	-	3.42	1.46	1.44	0.56
	10-20	7.34	0.87	4.07	2.74	1.47	0.06	-	3.19	2.62	2.53	0.80
	20-40	7.36	0.67	2.91	1.92	1.22	0.06	-	2.96	1.90	1.25	0.79
	40-60	7.36	0.66	2.91	1.92	1.52	0.11	-	2.96	1.67	1.33	0.98
	Mean	7.31	0.71	3.51	1.92	1.28	0.09	-	3.13	1.91	1.63	0.78

Soil reaction (PH)

The pH values of the soil profiles under investigation are shown in Table (5); data reveal that they, generally range between 7.21-7.59.The mean values of pH tend to increase in polluted soil samples than the control. These findings are in harmony with that obtained by Tantawy (2004).

Soil texture:

From the previous discussion, it could be observed that the polluted irrigation water contains suspended solid may be in turn, affect soil texture. Therefore, a detailed investigation of soil texture of the various soil profile samples were carried out and are presented in Table (6). The particle size distribution shows that fine particle (clay) increased in the soil irrigated with such polluted water. The magnitude of increase depends on the depth and location of soil profiles. Therefore, the longer the distance from the point source, the higher is the clay content mainly in the surface layer. This could be rendered to the fact that the fine particles remain suspended in water for

longer distance than the coarse particles, and then it is accumulated especially in the soil surface. On the other hand, despite the increase in clay content, the texture class is not changed.

Organic matter and calcium carbonate contents:

Regarding soil organic matter and calcium carbonate contents of the investigation sites, data presented in Table (6) show that all soil profiles under investigation exhibited low contents of organic matter. It ranges between 0.41% and 1.49%.The organic matter content tend to be high in the upper layer and low in the deeper ones. Calcium carbonate content reveals that all soil samples under study have low content of $CaCO_3$ carbonate with a maximum value of 2.08%, which attained for control. Also, there is no regular pattern of $CaCO_3$ % content within soil profiles

Table (6): Particle size distribution, calcium carbonate ($CaCO_3$%) and organic matter content (O.M%) of the studied soil under the effect of Ceramic industrial wastes at Mostorod.

1Distance (m)	Depth (cm)	Particle size distribution (%)				Textural class	$CaCO_3$ (%)	O.M (%)
		C. Sand	F. Sand	Silt	Clay			
500	0-10	7.33	13.44	28.55	50.68	Clay	1.60	1.01
	10-20	12.31	15.79	25.40	46.50	Clay	1.40	0.98
	20-40	5.53	19.25	24.14	51.08	Clay	1.76	0.68
	40-60	7.52	12.56	28.13	51.79	Clay	1.68	0.41
1000	0-10	4.73	20.08	20.11	55.08	Clay	1.76	1.15
	10-20	3.37	18.97	23.34	54.32	Clay	1.53	1.02
	20-40	13.62	9.22	22.07	55.09	Clay	1.67	0.74
	40-60	10.80	10.64	25.47	53.09	Clay	1.68	0.85
Control	0-10	13.79	14.60	31.06	40.55	Clay	2.08	1.43
	10-20	8.92	20.41	28.80	41.87	Clay	2.06	1.49
	20-40	7.10	18.38	25.47	49.05	Clay	2.14	1.10
	40-60	4.62	16.94	27.25	51.19	Clay	2.05	0.95

Total porosity:

Total porosity is presented by moisture content at saturation Table (7). It is pointed out that, total soil porosity is mainly affected by soil texture, soil structure and partly by both organic matter and soil compaction. Generally, total porosity increases with increasing clay content. This means that, total porosity at 1000 m distance is higher than that at 500 m distance from the pollution source. Moreover, total porosity tends to be higher in the surface layers than in the deeper one. It is noticed that, in the soil sample which represents control, in spite of its low content of clay fraction, the soil total

porosity tend to be higher than the others polluted ones. This is may be due to decreasing of soil bulk density, soil compaction and increasing of organic matter content which in turn led to increase total soil porosity. Statistical analyses show a positive highly significant correlation between total porosity and OM% content with "r" value of 0.91[**]. Whereas a negative highly significant correlation was attained with bulk density (r = -0.95[**]). Also, a negative highly significant correlation is obtained between total porosity and the amount of suspended matter (r =-0.93[**]).

Pore size distribution

Pore size distributions presented in Table (7) show that quickly drainable pores (QDP) with a diameter of (> 28.8u) are mainly affected by industrial waste effluent which is loaded with suspended solid. It is filtered through the soil pore, therefore, the lowest values of QDP is mainly found in the soil profile at 1000 m from the point source and reaches about of 5.67% in the surface layer. Also, the obtained results show clearly that the surface layers have the highest values of QDP than the deepest ones. This behavior of (QDP) pores is more evident in fine textured soil. This distribution pattern of (QDP) pores may be interpreted as a result from accumulation of suspended solid in the percolating waste water progressive disintegration of soil aggregates and clog the conducting pores. This behavior is clear in the surface layer at 1000m distance from the point source (Agassi *et al.*, 1981 and Tarchitzky *et al.*, 1998).

Table (7): Total porosity and pore size distribution of the studied soil samples at Mostorod

Distance (m)	Depth (cm)	Total Porosity (%)	QDP >0.28.8 μ	SDP 0.28.8-8.6 μ	WHP 8.6-0.19 μ	FCP <0.19 μ
500	0-10	52.90	11.83	13.83	13.46	13.78
	10-20	45.65	10.00	10.34	11.05	14.26
	20-40	53.29	5.00	11.17	8.07	29.05
	40-60	54.35	5.51	11.16	14.96	22.72
	Mean	51.54	8.08	11.62	11.88	19.95
1000	0-10	59.29	11.04	16.85	15.58	15.82
	10-20	48.86	11.37	7.89	15.46	14.14
	20-40	60.38	7.45	14.30	18.26	20.37
	40-60	57.60	6.02	13.11	16.71	21.76
	Mean	55.58	8.97	13.04	15.58	18.22
Control	0-10	70.93	15.53	19.58	17.22	18.60
	10-20	66.31	13.12	14.55	19.52	19.12
	20-40	62.29	5.70	17.16	17.82	21.61
	40-60	59.07	5.23	12.90	15.96	24.98
	Mean	64.65	9.89	16.04	17.63	21.07

The previous interpretation are ascertained by the statistical analyses where positive highly significant correlation between (QDP) and either OM% or $CaCO_3$% (r=0.96[**] and 0.93[**], respectively). There is also a negative and highly significant correlation between QDP and BD (r= -0.99[**]) and the QDP with amount of suspended matter (r= -0.92[*]).

The values of (SDP) of a diameter 28.8-8.62u is, generally, higher than that of (QDP). This hold true for all soil samples under investigation. Also both (QDP) and (SDP) behaved a similar way, since they tend to be higher in the soil profile adjacent the factory at 500m distance from the point source, especially in the surface layer. The distribution pattern of (SDP) within soil profile is regular, where the maximum values of (SDP) pores are exist in the surface layers and gradually decrease with depth. The statistical correlations between (SDP) and soil components are approximately similar to those attained for (QDP).

The water holding pores (WHP) having diameter of (8.62-0.19u) of the soil under consideration are mainly affected by soil texture and $CaCO_3$ content, since the highest values of (WHP) are attained for soil profile at 500 m distance from the point source, but they still less than control. On the other hand, (WHP) pores reach their maximum values, generally, at surface layers. Since the simple correlation coefficient reveals a positive significant correlation between (WHP) and total porosity (r=0.59[*]). While a positive highly significant correlation between (WHP) and silt fraction (r=0.74[**]) was occurred.

On the other hand, there is a negative highly significant correlation between (WHP) and clay content (r=-0.82[**]) and positive and significant correlation is obtained for $CaCO_3$ % (r =0.57[*]).

The fine capillary pores (FCP) having diameter of (<019u), reach their maximum value in the soil profile at 1000m distance from the point source, where it reaches about of (29.52%) with relative mean increase 40.10% as compared to control. Additionally, the (FCP) are generally higher in sub surface than surface layers. The statistical correlation between (FCP) and either BD or clay content shows a positive highly significant correlation (r =0.74[**] and 0.89[**], respectively. Whereas, a negative highly significant correlation is found between (FCP) and silt fraction (r=-0.84[**]),

In this connection, it is obvious that, the fine capillary pores are the predominant pores. Additionally, the pattern of pore distribution is mainly dependant on soil suspended solid settlement. On the other hand, suspended solid present in wastewater effluent may accumulate and physically block water conducting pores. Blocking of pores occurs mostly in the upper layer. The degree of blocking depends on the load of suspended solid in the wastewater effluent (Ventin *et al*, 1983). Also, the physicochemical dispersion and the continues disposal of wastewater effluent with higher rate allowed the dispersion clay to migrate through the large pore, which led to plug the pores by dispersed clay particles and

suspended solid, and lead also to squeeze the large pores to form fine capillary pores.

Soil bulk density and soil compaction:

Data of bulk density of the soil under consideration are shown in Table (8). From these data it is obvious that the highest bulk density values of (1.36 g/cm^3 and 1.35 g/cm³) were attained for the soil samples at 500 m and 1000 m distances from the point source. The relative mean of increases as compared to control are 13.33% and 12.5%, respectively. Within soil profile, the bulk density values, in general, tend to increase in the subsoil layers.

Table (8): Soil bulk density, penetration resistance, and saturated hydraulic conductivity of the studied soil under the effect of ceramic industrial wastes.

Distance (m)	Depth (cm)	BD (g cm^{-3})	PR (Dyne cm^{-2})	K$_s$ (cm h^{-1})
	0-10	1.27	128.19	2.03
	10-20	1.34	146.00	0.30
500	20-40	1.39	152.00	0.54
	40-60	1.45	170.60	0.21
	Mean	1.36	149.19	0.77
	0-10	1.32	138.00	1.12
	10-20	1.35	145.60	0.47
1000	20-40	1.36	130.00	0.80
	40-60	1.39	158.00	0.65
	Mean	1.35	142.90	0.72
	0-10	1.09	105.00	5.44
	10-20	1.15	112.30	3.93
Control	20-40	1.27	112.00	1.66
	40-60	1.32	125.00	1.04
	Mean	1.20	113.57	3.01

BD: Bulk density (g cm^{-3}), PR: Penetration resistance (Dyne cm^{-2}), Ks: Saturated hydraulic conductivity (cm h^{-1})

Statistical analyses show that soil bulk density is mainly related to soil texture, organic matter and calcium carbonate contents. In this connection, a positive highly significant correlation is found between clay content and soil bulk density (r= 0.82**). Also, a positive highly significant correlation

between (BD) and FCP with (r=0.74**) is found. Also, a positive significant correlation is found between the amount of suspended matter and BD (r=0.89[*]). While, a negative highly significant correlations are attained for (QDP), (SDP) and total porosity (r=-0.96, -0-89** and -0.95**), respectively.

Concerning soil penetration resistance (PR), data presented in Table (8) show that, soil penetration resistance (PR) is affected by soil physical properties such as soil porosity and soil bulk density. Therefore, soil resistance shows the same behavior like that attained for soil bulk density. The highest value of (PR) is attained for surface layer of soil sample at 1000 m distance from the pollution source. This is due to the accumulation of soil suspended solids which clog the pores to form fine pores which increase soil bulk density and consequently increase soil resistance. However, some of relations were ascertained by statistical analyses. There are positive significant correlations between (PR) and (BD), clay content and the amount of suspended matter (r=0.84*, 0.65[*] and 0.85[**], respectively. On the other hand, negative and highly significant correlation are attained for (QDP), (SDP) and total porosity (r=-0.76**, -0.91** and -0.85, respectively.

Saturated hydraulic conductivity (Ks):

Data of Ks are shown in Table (8), which show that the lowest value of Ks (0.79 cm/h) is recorded in surface layer of soil samples located at 1000m distances from the pollution source, and then it increases in the soil profile at 500m distance from the point source of pollution but still lower than control. The distribution pattern of Ks within soil profile is irregular, where its values tended to decrease in the subsurface layers. These results confirmed that the reduction in Ks values is accompanied by the increase of clay content and soil bulk density. This would be expected because smaller pores and increase of tortuosity make soils of higher clay content and bulk density more susceptible to blockage and constriction of transmitting pores by load agreement of dispersed and suspended particles (Kristansen, 1981).

In this connection, the effect of compaction is more evident in the soil, where Ks values are inversely related to soil depth, and consequently with soil compaction. These results are mostly expected, since the compaction reduces mostly the large rather than the narrow soil pores. The causes of such changes in soil compaction, and consequently pore size distribution may be physical mechanisms include entrapped air bubbles. Filtration activity of solid particles suspended in the percolating liquid and the disintegration of soil aggregates, clogging of the soil surface layer as a result of accumulation of suspended solid. The degree of blocking depends on the load of suspended solid in wastewater effluent and on the environmental condition (Levy *et al.,* 1999 and Tarchitzky *et al.,* 1998).

The simple correlation coefficient analyses confirmed these results, where a negative highly significant correlation is obtained between clay content and Ks (r= -0.84**).While, a positive highly significant correlation is

attained for OM content (r= 0.80). In this connection, it is noticed that, positive and highly significant correlations are obtained between Ks and QDP (r= 0.97**), SDP (r= 0.83**) and total porosity (r= 0.88**). While, negative and highly significant correlations are found for FCP (r=-0.78**), soil balk density (r= -0.96**) and the amount of suspended matter(r= -0.87[*]).

Effect of irrigation with industrial wastes effluent on some heavy metal content in the tested maize plants:

The factors affecting the amounts of metal absorbed by plant are those controlling:

1- The concentration and speciation or the metal in the soil solution.
2- The movement of the metal from the bulk soil to the root surface.
3- The transport or the metal from the root surface into the root.
4- Translocation from the root to the shoot (Alloway, 1995).

Data presented in Table (9) show the heavy metal contents (Cd, Co, Ni and Pb) in maize plants irrigated with industrial wastewater at two different distances. Generally, the studied heavy metals concentrations (mg/kg) in the different parts of maize plants contained different concentrations of heavy metals. The heavy metals content in roots is always higher than that in the other parts of plant. Nevertheless, the content of heavy metals in the roots and shoots are above the requirement ranges and could be considered as toxic to the growing plants. These high concentrations in the tasted maize plants markedly decreased with the increase in distance from pollution source. Regarding the contents of heavy metal in different parts of plants they are above the level that may be toxic (Kabata Pendias and Pendias, 1992). However, the continuous application of industrial wastewater in irrigation may cause heavy metals build up in soils to undesirable and phyto-toxic levels. So, the longer term effluents irrigation would be risky from environmental point of view.

Table (9): Influence of irrigation with industrial wastes on some heavy metal content in the tested plants.

Distance from pollution sources	Element	Plant part		* Toxic limit
		Shoots (mg/kg)	Roots (mg/kg)	
500 m	Cd	16.00	18.7	5- 30
	Ni	60.2	75.7	10 -100
	Co	73.5	80.8	1 – 32
	Pb	509.5	660.7	30 – 300
1000 m	Cd	15.5	16.1	
	Ni	49.6	65.2	
	Co	53.1	66.4	
	Pb	419.6	561.4	

* Toxic limits in plant according to Kabata Pendias and Pendias (1992)

Based on the aforementioned discussion, it could be concluded that the use of waste industrial water for irrigation purposes could be negatively affect on some soil physio-chemical properties. The highly content of suspended matter in such water may be raised the clay content, slow drainable pores, penetration resistance and water holding pores. Also, the values of electrical conductivity and heavy metal contents for both of water and the corresponding soil samples would increase. On contrary, soil bulk density, quickly drainable pores and saturated hydraulic conductivity were decreased. On the long term, it is expected undoubtedly to deteriorate soil productivity and adversely affect crop production in the surrounding lands. In addition, the excessive uptake of heavy metals may cause phytotoxicity and consequently human toxicity as envisaged by the processes of bioaccumulation and biomagnifications.

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تاثير المخلفات الصناعية السائلة على نبات الذرة وبعض خواص التربة الفيزيوكيميائية

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الملخص العربي

أجريت هذه الدراسة بهدف تتبع تأثير المخلفات الصناعية السائلة الناتجة عن مصانع السيراميك على بعض خواص التربة وذلك فى منطقة مسطرد بمحافظة القليوبية - مصر، كأحد المناطق الصناعية حيث تم أخذ عينات من التربة وماء الرى والصرف الصناعى وكذا نباتات الذرة النامية بالمنطقة على مسافات صفر و ٥٠٠ و ١٠٠٠ متر من مصدر التلوث ويتحليلها كانت النتائج كالتالى :–

ان المواد المعلقة تتراكم على سطح التربة وتؤثر سلبا على خواص الارض حيث وجد ان معدن الكاؤولينيت هو المكون السائد فى المواد المعلقة الناتجة من صناعة السيراميك والذى يؤدى الى زيادة المحتوى الطينى للتربة مما يؤدى الى زيادة نسبة المسام الضيقة على حساب النقص فى المسام الواسعة والمسام الحافظة للمياه. كما يزيد من قيمة الكثافة الظاهرية ومقاومة التربة للاختراق ويخفض من قيمة معامل التوصيل الهيدروليكى المشبع.

وبتحليل أجزاء نباتات الذرة المأخوذة (مجموع خضرى – مجموع جذرى) لتقدير محتواها من العناصر الثقيلة (كادميوم – نيكل – كوبلت – رصاص)، تبين إرتفاع محتوى الجذور من تلك العناصر مقارنة بالمجموع الخضرى وإنخفاض هذا المحتوى بزيادة المسافة من مصدر التلوث. إلا أن محتوى كل منهما بتلك العناصر وصل الى حدود السمية للنباتات ولكنه لم ينهى حياتها، مما قد يؤدى الى تسمم للحيوانات التى تتغذى عليها.