Cairo Univ. Stud. Rev. 26 (2004) : 1 - 12

Influence of Waste Water on Soil Texture , CEC and Organic Matter Content in Arid Environments.

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ABSTRACT

Effluent discharge from Makkah wastewater treatment plant was analyzed to assess the effects of inland disposal of conventionally treated wastewater on soil texture ,CEC and organic matter .

Results revealead that the percentage of clay and sand increased while the percentage of silt decreased along the wastewater stream . However , no significant changes were recoreded in textural classes over a period of ten years . Meanwhile, CEC and soil organic matter increased along the wastewater stream .As for sampling side , the percentages of clay and organic matter were higher at the right side than at the left side of the wastewater stream . CEC was not affected regarding the effect of soil depth . No significant changes were recorded with soil sampling depth . However , CEC and soil organic matter decreased with sampling depth .

Treated wastewater is usually disposed of by dilution in rivers and natural lakes . This is not the case in Saudi Arabia where in – land wastewater disposal simply means discharge into dry wadis .Under arid land conditions , such method results in concentration of pollutants due to the high rate of evaporation . Furthermore , the hot cli-

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mate increases bacterial activities which will result in higher rate of removal for the biodegradable matters .

Addition of sewage water remarkably improves soil structure and sewage increases soil water holding capacity (Greenberg , 1952; Lunt, 1953) . Water and compost tend to increase the water holding capacity and improve the physical conditions of most soils (Hortenine and Rothwell, (1968).Mays at al (1973) and Shahalam et .al,(1998) found that incoroporation of compost made from municipal refuse and sewage sludge over two – year period to the soil exhibited no significant effect on soil physical properties . Epstein (1975) and Epstein et .al. (1978) found that sludge and sludge compost were beneficial as organic amendmants for improving the physical properties of marginal soils .Gupta et.al.(1977) concluded that application of sewage sluge increased soil aggregation,decreased bulk density and improved water holding capacity and hydraulic conductivity .Abdul El-Naim (1988) reported that the increase of fine soil particles in the top layer reached 40 to 55% .Soil aggregation increased in sandy soil due to increasing their organic matter content (Dimian,1983) .A highly significant relationship between soil organic carbon and percentage of reduction in bulk density was obtained by kolsheans and Grielich (1981) and kealeel et.al .(1981). Swartzenduber and Uebler (1982) observed that the addition of sewage water to fine quartz sand and sand silt (95% fine quartz and 5% quartz silt) caused a reduction in the soil hydraulic condutivity. A decrese in bulk density was reported by Hulugalle (1996) ,Cox et .al .(1997) and Lindsay (1998) .On the other hand , Lindsay (1998) noticed an increase in porosity , moisture retention ,soil aggregtion and mean weight diameter of aggregates due to the addition of sewage sludge to soil .There was an increase in microbial soil biomass (Goyal et .al . ,1995, Banerjee et .al .,1997) .

MATERIALS AND METHODS

The wastewater effluent from Makkah sewage treatment plant is being disposed of in a dry wadi bed , which is a tributary of wadi Naaman , located to the south of the city .The effuent runs as a natural open channel flow , towards the Red Sea for about 20 km , crossing the road Taif through a bridge .

Camels , herds of sheep and birds have a free access to stream and its vicinity .Wild vegetation is growing on the banks of the stream. Organic matters precipitate during over – flooding were observed on the banks of the stream .

Towards the end of the main stream , the flow of wastewater was still relatively high. The stream breaches into several shallower , yet wider channels . The width of the main stream varies from about one and half to several meters .

In the vicinity near the termination of the stream , there are several farms in which agricultural activities are taking place . Water supply for these farms are from wells dug out in the alluvium . Also, a new farm is being constructed . It is believed that wells are in hydraulic connection with the stream .

Soil sampling :

Five trips were made for sampling , however , the last soil samples were used to determine organic matter (O.M) , cation exchange capacity (CEC) and soil texture , because the expected changes in these soil parameters during such a short time (time of the study) was minimum .

Soil samples from the five specified cross sections along the sewage stream (Fig .1) at four points (two on each side , 3 m apart) were collected at three different depths (0-30, 30-60 and 60- 90cm) .

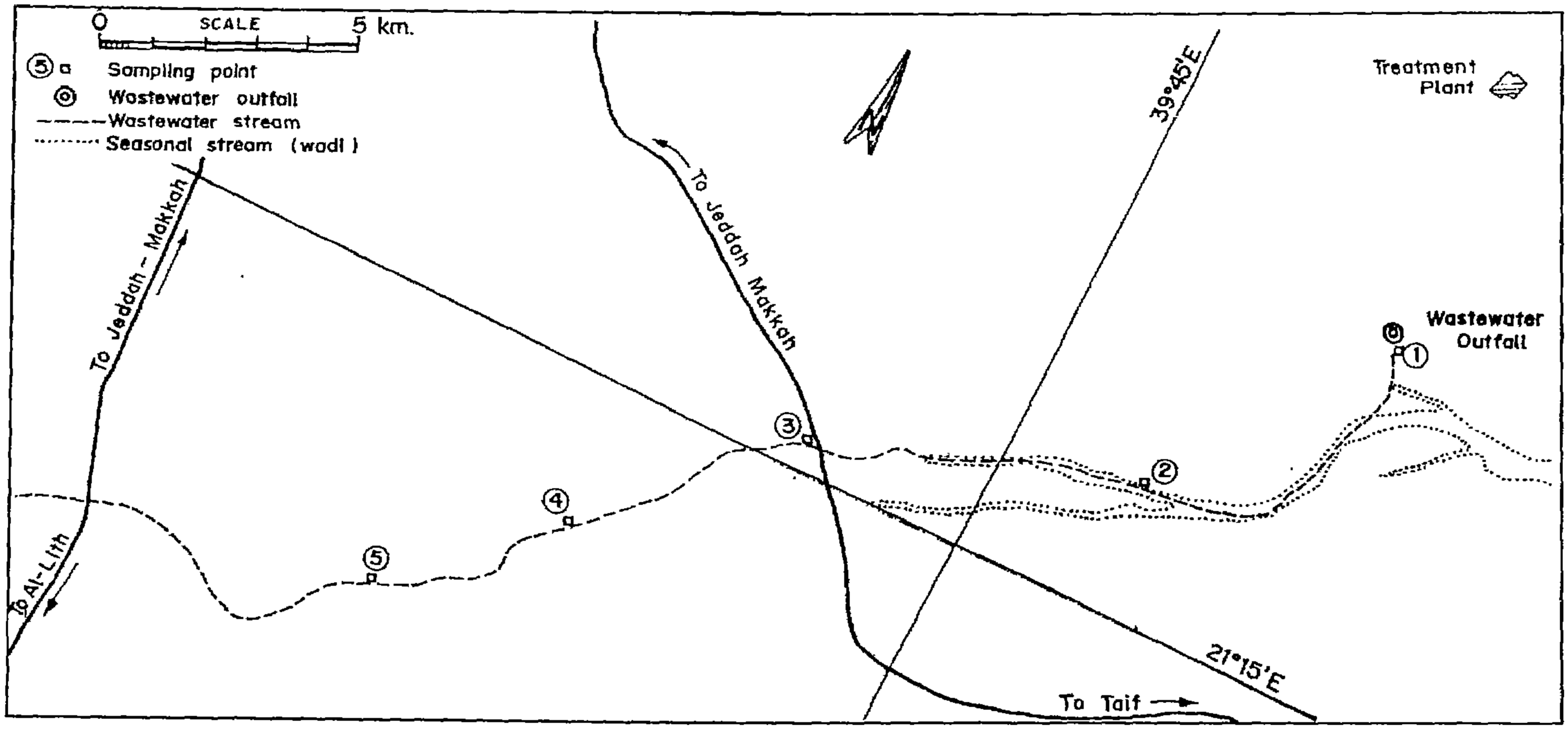

Fig (1) : A map of the waste water and soil sampling points along the waste water stream.

The sixty soil samples were air dried , crushed , sieved through a 20-mesh sieve, mixed thoroughly and stored for laboratory analysis .

Total organic matter (OM) in the soil was determined by the procedure described by Walkeley and Black method (Jackson , 1973) . Soil texture was determined by the hydrometer method as described by Day (1956) at 255C using pyrophosphate as a dispersing agent . Cation exchange capacity (CEC) was determined using NaOAC-NH4 OAC method (Richards , 1954).The soil analysis for the virgin control sample is shown in Table 1.

RESULTS AND DISCUSSION

The summary of analysis of variance for soil texture, organic matter (OM) and cation exchang capacity (CEC) of soil along the wastewater stream is presented in Table 2.

The effect of soil sampling locations was significant for the percentage of sand , silt and clay , OM and CEC.However , the effect of soil sampling side was significant only for organic matter (OM) .The effect of soil sampling distance was significant for the percentage of

Table (1) : Soil analysis for control sample located at 900-1000 m from the main wastewater stream .

Soil depth (cm)	Particle size distribution			Soil texture	Organic matter %	Cation Exchange Capacity (CEC) mg / 100 g soil
	Sand%	Silt%	Clay%			
0-30	76	23	1	Sandy loam	0.0	2.8
30-60	76	23	1	Sandy loam	0.0	2.8
60-90	77	22	1	Sandy loam	0.0	2.7

sand and silt and CEC.On the other hand , the effect of soil sampling depth was significant for the percentage of sand and silt , organic matter (OM) and cation exchang capacity (CEC) .

Data of soil texture , organic matter and cation exchange capacity of soil are presented in Table (3). It is obvious that the virgin soil (control soil profile) is sandy loam in texture through the different layers . Also , continuous water flow of the sewage stream for more than ten years did not exhibit recent changes in the soil texture .

Table (2) : Summary of analyis of variance for soil texture , organic matter and cation exchange capacity (CEC) of soils along the wastewater stream.

Source	DF	Particle size distribution			Organic matter(%)	Cation exchange capacity (CEC) Meq/100g
		Sand %	Silt%	Clay%		
Side	1	0.029*	0.134		0.025*	0.297
Location(L)	4	0.000**	0.000**	0.000**	0.003**	0.000**
Depth D	2	0.000**	0.000**	0.252	0.002**	0.001**
LX D	8	0.001**	0.028*			0.456
Distance DS	1	0.000**	0.000**			0.013
LX D S	4	0.000**	0.000**			0.379
LX D S	2	0.033*	0.313			
LX D X DS	8	0.003**	0.029**			0.319
EMS	59	2.480	3.411	2.598	0.005	0.454

* Significant at 0.005 level DF = Degrees of freedom

** Significant at 0.01 level EMS = Error mean square

Table (3): Variation in soil texture ,organic matter (OM) and cation exchange capacity (CEC) due to soil sampling location , direction, distance and depth of the wastewater stream and their tests of Significance.

Variable	Particle size distribution			Soil texture	Organic matter %	CEC meq /100 soil
	Sand%	Silt%	Clay%			
Location						
1	59.583 D	38.667 A	1.250 B	Sandy loam	0.261 A	4.345 B
2	64.500 C	33.083 BC	1.250 B	Sandy loam	0.201 AB	4.408 B
3	65.583 BC	33.917 B	1.000 B	Sandy loam	0.227 AB	4.875 B
4	65.833 B	32.250 C	2.167 B	Sandy loam	0.194 BC	4.758 B
5	68.500 A	15.583 D	15.833B	Sandy loam	0.135 C	9.742 A
L.S.D	1.315	1.542	1.345		0.059	0.592
Side						
1	62.267 A	30.333 A	4.0467A	Sandy loam	0.225 A	5.718 A
2	64.333 B	31.067 A	4.133A	Sandy loam	0.182 B	5.533 A
L.S.D	0.588	0.689	0.601		0.027	0.251
Distance						
1	63.00 B	32.733 A	4.333 A	Sandy loam	0.209 A	5.853 A
2	66.600 A	28.667 B	4.267 A	Sandy loam	0.194 A	5.398 B
L.S.D	0.588	0.689	0.601		0.027	0.251
Depth						
1	63.050 C	32.250 A	4.800 A	Sandy loam	0.252 A	6.128 A
2	65.150 B	30.600 B	4.050 A	Sandy loam	0.192 B	5.469 B
3	66.200 A	29.250 C	4.050 A	Sandy loam	0.167B	5.280 B
L,S .D	1.018	1.194	1.042		4.573	0.436
Overall Mean	64.800	30.700	4.300	Sandy loam	0.203	5.625

L.S.D = Least significant difference at 5%
A = 1st highest category
B = 2nd highest category
C = 3rd highest category

However , the percentage of clay and silt increased from 1 and 22% (control soil profile) to 4.3 and 30.7% , respectively . On the other hand , the percentage of sand decreased from 76% to 64.8% .Also ,the organic matter (%) and CEC increased from 0.0% and 2.8 meq /100 g soil (control soil .) to 0.203% and 5.623 meq /100 g soil , respectively .

Hinesly et.al (1979) indicated that application of municipal sewage sludge increased soil content of organic matter and cation exchange capacity . El- Gamal (1980) reported that prolonged use of sewage water markedly increased soil organic matter .

Effect of sampling location on soil texture along the wastewater stream was presented in Table (3) .It showed that the percentage of clay and sand increased but the percentage of silt decreased along the wastewater stream (from location one through five). These limited small changes in the soil texture along the wastewater stream were mainly related to the suspended colloidal materials floating away with sewage water ,nevertheless , no significant changes in the textural classes were recorded (Abd Elnaim , 1988; Labib et , al . 1992). On the other hand , cation exchange capacity (CEC) increased but the soil organic matter (OM%) decreased along the wastewater stream (Table 3) . Obviously , this increase in CEC values was mainly associcated with tremendous increase in clay content of soil along the wastewater stream .

Effect of soil sampling side (1 : Right , 2 : Left) on soil texture (Table 3) showed that the percentages of silt and sand were not affected by the side . However, the percentage of clay was higher in the right side than in the left side of the wastewater stream . On the other

hand , CEC was not affected by side of soil sampling . However, organic matter percentage was higher in the right side than the left side of the wastewater stream .

Effect of soil sampling depth on soil texture (Table 3) showed that the percentage of sand increasesd and the percentage of silt decreased with increasing soil depth . However , the percentage of clay was not affected by soil sampling depth .On the other hand , no significant changes in the textural classes of different depths are recoded .The organic matter (%) and CEC were affected by soil sampling depth (Table 3) .It showed that the OM and CEC decreased with increasing soil depth .

The data revealed considerable accumlation of organic matter in soil due to continuous water flow of the sewage stream ; of course , these accumulations were more pronounced in the surface layers . This basically was due to continuous addition of organic materials in sewage water which deposits on the surface layers (Gupta et al.1977 , Dimian 1983 and Abdul Naim ,1988) . As expected , CEC of the subsurface layers were affected to , a lesser extent , by the flow of sewage stream which was anticipated due to the lack of the subsurface layers to both organic matter and clay content .

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تأثير مياه الصرف الصحى على قوام التربة والسعة التبادلية الكاتيونية والمادة العضوية فى البيئات الجافة

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ملخص

يهدف هذا البحث إلى دراسة تأثير مياه الصرف الصحى من محطة المعالجة بمكة المكرمة على قوام التربة والسعة التبادلية الكاتيونية والمادة العضوية تحت ظروف البيئات الجافة .

أظهرت النتائج حدوث زيادة فى النسبة المئوية للطين والرمل بينما نقصت النسبة المئوية للسلت على طول امتداد مجرى المياه ، وعلى امتداد عشر سنوات يمكن القول أنه لم يحدث تغيير معنوى فى رتبة القوام Textural Class ، وفى نفس الوقت حدثت زيادة معنوية على طول امتداد مجرى مياه الصرف الصحى فى نسبة المادة العضوية والسعة التبادلية الكاتيونية ، وبالنسبة تأثر الجانب الذى أخذت منه عينات التربة sampling side ، كانت نسبة الطين والمادة العضوية فى الجانب الأيمن أعلى منها فى الجانب الأيسر لمجرى المياه ، ولوحظ عدم تاثير السعة التبادلية الكاتيونية .

أما بالنسبة لعمق عينات التربة soil sampling، فلم يعطى العمق تأثيراً معنوياً فيما يخص الخصائص الثلاث المدروسة ، إلا أنه بطبيعة الحال حدث نقص ملحوظ فى نسبة المادة العضوية والسعة التبادلية الكاتيونية .