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HYDRO-GEOPHYSICAL PROPERTIES OF SOME SOILS OF WESTERN LIMESTONE PLATEAU AT ASSIUT GOVERNORATE, EGYPT

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By
M. M. El-Sayed, M. A. Gameh*, E. A. Mostafa * and A. A. Abd El-Rhman

Soil and Water Department, Faculty of Agricultural, Al-Azhar University, Assiut
** Soil and Water Department, Faculty of Agricultural, Assiut University, Assiut, Egypt*

ABSTRACT

Field investigations were conducted at the western limestone plateau of Assiut Governorate which is located 300 km south of Cairo between 26° 20⁻ 00⁼ to 27° 40⁻ 00⁼ N latitude and 30° 30⁻ 00⁼ to 31° 40⁻ 00⁼ E longitude. The current work was initiated to recognize the agricultural potentiality of this area. The study aimed to assessing the prevailing hydro-physical soil properties and the suitable management practices for agricultural utilization. The study revealed that Soil texture is mostly coarse (sand, loamy sand and sandy loam). Calcium carbonate content ranges between 13.10 and 85.90% and soil bulk density varies from 1.36 to 1.88 Mg/m^3. The soil salinity (EC_e) differs from non-saline (EC_e = 2.7 dS/m) to extremely saline (EC_e = 86.1 dS/m). The soil reaction could be considered alkaline since the pH values range between7.9 to 8.9. The saturated soil hydraulic conductivity indicated that soils can be categorized between low to excessive permeability. The soil moisture characteristics show a marked decrease in soil moisture content (50%) when the soils were subjected to pressure above one atmosphere. Groundwater salinity ranges between EC .0779 and 1.027 dS/m. Special care would be implemented with respect to agricultural practices. The drainable pores (QDP+SDP) value was about 24.4% representing about 65.59% of the total porosity. The value of capillary pores (WHP+FCP) was about 12.7 % representing about 34.14 % of the total porosity.

Key words: *Limestone plateau, soil texture, soil salinity and alkalinity, hydraulic conductivity, soil moisture characteristic curve.*

1. INTRODUCTION

The limestone plateau in Assiut region is a part of the major Eocene limestone (Thebes formation or its equivalents) plateau that covers major parts of the western desert of Egypt. Eocene rocks constitute the most common outcrops capped by an alluvial cover. This cover consists of relatively flat, poorly consolidated sand, gravel, silt, and clay which belong to the Pleistocene and Holocene epochs. Geo-morphologically, the studied area is a moderately elevated plateau relative to the Nile banks since its elevation ranges between 120 and 300 m ASL (average elevation of the river banks is 35 m ASL), with a gentle slope northward. These characteristics drag this area of the essence for many investors. It is considered as one of the most promising areas for sustainable irrigated agriculture. During the last two decades, some investors dug groundwater wells to cultivate this plateau while others just squat the land as a way of ownership (Abou Heleika and Niesner, 2009). Many important soil processes take place according to soil pores (the air or water-filled spaces). Soil texture and structure influence the porosity considering their size, number and continuity. Coarse-textured soils have many large pores (macro) as a result of the loose arrangement of larger particles with each other (El-Hady *et al*., 2015).

Shawky *et al*. (2004) indicated that the shape of moisture characteristic curves for highly calcareous soils is similar to that of sandy soils where there is a marked decrease in the moisture content with increasing the tension up to 1.0 atm. Abdo (2008) mentioned that the total porosity, void ratio and air porosity of calcareous soils decreased with soil depth. Gamie (2008) found that the total porosity of New Valley soils was low variable with depth and space and was 44.68% as a mean value. Moreno *et al*. (2014) mentioned that the soil water retention values at lower pressure heads showed unusually high values compared to soils from temperate regions. El-Hady *et al*. (2015) found that the available water increased whenever the increase in water retained at soil field capacity (FC) is far beyond that at wilting percentage.

Abdel-Mawgoud *et al*. (1998) mentioned that the presence of calcium carbonate in the clay and silt fraction tends to decrease the hydraulic conductivity. Total carbonates of sandy desert soils of Egypt were reported to be relatively high and differed from site to another as well as with depth (Amira and Ibrahim, 2000; Zaki, 2004). Soil pH values of Assiut desert soils were reported to be in the range of 7.1 to 8.8 (Faragallah and Essa, 2006). Al-Qinna *et al*. (2008) studied the effect of carbonates and gravel contents on hydraulic properties of gravely-calcareous soils. They found that the soil saturated hydraulic conductivity (K_s) varied from 7.2 mm hr^{-1} to 159.3 mm hr^{-1} indicating that the studied soils can be categorized between medium to excessive permeability class. Gamie (2008) reported that the hydraulic conductivity for almost all samples of the New Valley soils was low with a minimum value of 0.1 cm/h and a maximum value of 6.94 cm/h with a mean value of 0.57 cm/h. The $CaCO_3$ content of wadi Abu Shih, Assiut, ranged from 21.10 to 71.40%. High $CaCO_3$ content in the soil causes many difficulties, *e.g*., surface crusting, cracking and susceptibility to erosion (Faragallah *et al*., 2011).

The current work was initiated to recognize the agricultural potentiality of the above-mentioned area by assessing the prevailing hydro-physical soil properties and the suitable management practices for agricultural utilization.

2. MATERIALS AND METHODS

The study area (Assiut Governorate) is located 300 km south of Cairo between 26° 20^{-} 00$^{=}$ to 27° 40^{-} 00$^{=}$ N latitude and 30° 30^{-} 00$^{=}$ to 31° 40^{-} 00$^{=}$ E longitude. Its total area is about 1558 km2, representing 0.15% of the total area of Egypt. The studied area represented the limestone plateau that exposes shallow or stony loamy sand to sandy loam soils of the pane plains with hill remnants and sand dunes stands (Hammad, 2011). In order to represent the investigated area, a transect extended 22 km parallel to the western road of Assiut to Cairo (northern west of Assiut city) was chosen with an absolute altitude varied from 143 to 222m. Eleven soil profiles were selected along this transect (Fig. 1). The soil profiles were situated using the global positioning system (GPS). The distance between two successive soil profiles differed from 5 to 8 km. The soil profiles were dug down to the parent material and their features were morphologically described as shown in Table (1).

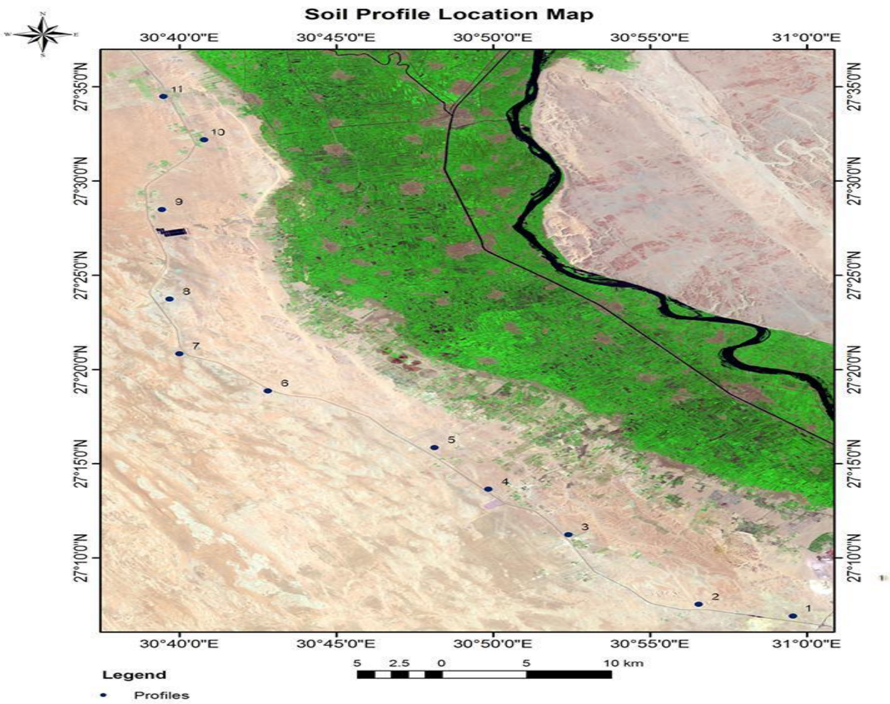

Fig. (1). A map showing the locations of the investigated soil profiles in Assiut Governorate, Egypt.

Table (1): Some morphological features of the studied soil profiles of limestone plateau, at Assiut, Egypt.

Profile No.	location Lat.	location Long.	Elevation (m.asl)	Parent material	Relief	Slope (%)	Soil depth (cm)		Soil structure
1	27° 06′ 55.4″	30° 59′ 33.6″	209	Lim	Almost flat	4%	0 - 20	M	single grains
							20 - 40		Weak, fine, subangular blocky
							40 – 100		Moderate, very fine, subangular blocky
2	27° 07′ 32.4″	30° 56′ 33.2″	222	Lim	Almost flat	3%	0 - 40	D	single grains
							40 - 55		Moderate, fine, subangular blocky
							55 – 105		Weak, fine, subangular blocky
3	27° 11′ 14.2″	30° 52′ 23.9″	177	Lim	Almost flat	3%	0 - 30	M	Weak, very fine, subangular blocky
							30 - 80		moderately fine subangular blocky
4	27° 13′ 38.7″	30° 49′ 51.4″	166	Lim	Almost flat	2%	0 - 40	D	Weak, very fine, subangular blocky
							40 - 70		Moderately, fine, angular blocky
							70 – 110		Strong, medium, angular blocky
5	27° 15′ 51.3″	30° 48′ 8″	169	Lim	Undulating	6-8%	0 - 40	D	Weak, very fine, subangular blocky
							40 - 60		Moderate, fine, subangular blocky
							60 – 110		Moderate, medium, subangular blocky
6	27° 18′ 51.7″	30° 42′ 49.2″	157	Lim	Almost flat	2%	0 - 40	D	single grains
							40 - 50		Weak, fine, subangular blocky
							50 – 80		Weak, very fine, subangular blocky
							80 - 120		Moderate, fine, subangular blocky
7	27° 20′ 50.1″	30° 39′ 59.7″	143	Lim	Almost flat	3-5%	0 - 30	D	Weak, very fine, subangular blocky
							30 - 60		Weak, fine, subangular blocky
							60 – 70		Moderate, fine, subangular blocky
							70 - 130		Weak, very fine, subangular blocky
8	27° 23′ 43.9″	30° 39′ 41.2″	171	Lim	Undulating	6-8%	0 - 40	D	Weak, fine, subangular blocky
							40 - 60		Moderate, very fine, angular blocky
							60 – 75		Weak, very fine, angular blocky
							75 - 110		Moderate, fine, subangular blocky
9	27° 28′ 28.9″	30° 39′ 26.8″	152	Lim	Undulating	3-5%	0 - 30	D	Weak, very fine, subangular blocky
							30 - 55		Strong, medium, subangular blocky
							55 – 110		Moderate, fine, subangular blocky
10	27° 32′ 10.6″	30° 40′ 47.6″	149	Lim	Almost flat	2%	0 - 30	D	Weak, very fine, subangular blocky
							30 - 45		Moderate, medium, angular blocky
							45 – 75		Strong, medium, angular blocky
							75 - 120		Weak, fine, subangular blocky
11	27° 34′ 28.4″	30° 39′ 29″	164	Lim	Almost flat	2%	0 - 30	D	Weak, very fine, subangular blocky
							30 - 60		Moderate, medium, subangular blocky
							60 – 80		Strong, medium, subangular blocky
							80 - 120		Weak, fine, subangular blocky

Lim = Limestone **D = Deep** **M = Moderate**

Disturbed and undisturbed soil samples were collected from each layer according to the difference in the morphological features. The disturbed samples were air-dried crushed sieved through a 2 mm sieve and kept for soil analysis. The relevant soil chemical analysis of the tested area as well as the groundwater analyses were preformed according to Page (1982) and shown in Table (2).

Soil particle-size distribution was performed using pipette method according to Jackson (1973). Particle and bulk density (Dp & Db) were determined according to Klute (1986). Total porosity was calculated according to the method described by Danielson and Sutherland (1986). Void ratio (e) was calculated using total porosity values according to Klute (1986). Water retention was determined according to Kulte (1986) using pressure plates in a cooker

Table (2): Some soil chemical properties of the investigated area.

Profile No.	Soil depth (cm)	$CaCO_3$ %	pH (1:1)	EC_e (dS/m)	Soluble Cations (meq /l)				Soluble Anions (meq /l)			SAR
					Ca^{+2}	Mg^{+2}	K^{+1}	Na^{+1}	SO_4^{-2}	Cl^{-1}	HCO_3	
1	0 - 20	49.0	8.9	11.4	40.0	12.0	1.3	55.5	47.7	50.2	14	10.88
	20 - 40	68.8	8.7	36.4	96.0	28.0	1.3	216.4	32.1	283.9	12	27.48
	40 – 100	85.9	8.3	34.6	140.0	48.0	3.8	126.0	1.1	321.4	12	13.00
2	0 - 40	22.7	8.5	25.9	123.6	36.0	1.7	79.6	1.1	224.5	14	8.91
	40 - 55	36.9	8.0	86.1	372.9	111.5	3.2	323.9	109.2	701.8	20	20.81
	55 – 105	46.7	7.9	82.0	216.0	222.0	1.7	345.3	16.6	749.5	14	23.33
3	0 - 30	40.2	8.6	29.1	121.5	40.0	1.8	96.3	6.2	261.0	10	10.72
	30 - 80	48.9	8.8	40.9	168.5	32.0	1.6	181.9	11.4	364.7	10	18.17
4	0 - 40	33.8	8.7	16.2	76.0	12.0	1.8	59.4	58.0	89.0	12	8.95
	40 - 70	33.8	8.8	25.1	101.3	20.0	1.6	113.6	42.5	182.5	14	14.59
	70 – 110	55.4	8.8	35.7	111.6	32.0	1.4	194.5	1.1	308.5	10	22.95
5	0 - 40	20.8	8.7	5.3	20.0	11.0	0.6	19.4	15.8	27.9	9	4.93
	40 - 60	78.4	8.7	28.3	98.3	16.0	1.2	146.4	11.4	236.7	16	19.37
	60 – 110	82.1	8.5	17.1	48.0	20.0	1.3	85.5	1.1	142.8	10	14.66
6	0 - 40	29.6	8.8	2.7	13.5	5.0	0.2	7.4	7.3	16.3	3	2.43
	40 - 50	29.4	8.8	5.1	24.0	7.0	0.6	19.5	11.9	32.4	6	4.95
	50 – 80	40.2	8.7	7.7	42.0	10.0	0.7	22.8	10.9	57.5	5	4.47
	80 - 120	51.1	8.6	17.5	67.8	28.0	0.8	71.6	8.3	154.3	8	10.35
7	0 - 30	35.6	8.9	10.8	41.0	16.0	1.0	45.1	21.2	73.6	11	8.45
	30 - 60	21.6	8.6	30.7	114.0	44.0	2.0	129.1	6.2	274.3	12	14.52
	60 – 70	18.1	8.7	27.1	97.5	40.0	1.6	119.4	88.5	143.8	14	14.40
	70 - 130	45.3	8.4	28.2	108.0	24.0	1.1	118.0	32.1	214.4	10	14.52
8	0 - 40	40.5	8.3	45.3	158.0	28.0	2.0	237.0	1.1	420.0	14	24.58
	40 - 60	30.4	8.3	52.2	194.0	52.0	2.1	253.7	1.1	488.1	8	22.88
	60 – 75	18.4	8.8	21.4	68.0	16.0	1.2	118.0	1.1	178.9	14	18.21
	75 - 110	47.7	8.6	24.2	86.0	20.0	1.1	115.2	6.2	220.5	12	15.82
9	0 - 30	20.3	8.6	3.5	20.0	7.0	0.5	7.2	1.6	29.2	4	1.96
	30 - 55	34.2	8.6	19.4	88.0	20.0	2.0	76.6	16.6	153.0	12	10.42
	55 – 110	41.6	8.4	27.9	86.0	28.0	2.1	140.8	16.6	219.4	14	18.65
10	0 - 30	13.1	8.4	5.6	34.0	4.0	0.6	16.1	8.0	41.3	5	3.69
	30 - 45	14.1	8.7	31.9	118.0	48.0	2.0	133.8	47.7	237.6	16	14.69
	45 – 75	17.5	8.6	47.2	132.0	84.0	1.8	224.0	26.9	389.9	14	21.55
	75 - 120	26.3	8.5	29.9	84.0	38.0	1.9	163.6	47.7	217.2	12	20.95
11	0 - 30	20.8	8.5	10.3	42.0	6.0	1.1	51.6	12.7	80.4	7	10.53
	30 - 60	22.9	8.8	39.6	156.0	35.0	2.5	169.6	37.3	318.6	20	17.35
	60 – 80	22.7	8.6	43.1	128.0	34.0	2.2	233.3	11.4	391.3	10	25.92
	80 - 120	23.1	8.5	50.5	164.0	72.0	2.5	238.9	16.6	458.7	14	21.99

apparatus and undisturbed samples (cores of 2.5cm in height and 4.5 cm in diameter). The samples were water saturated and placed in the pressure plate at 0.10, 0.33, 1.00, 5.00 and 15.00 bars, and left until equilibrium then weighed at each pressure stage and then water content was gravimetrically determined by oven drying.

Pore size distribution was calculated from the soils moisture retention curve and classified according to De-Leenheer and De-Boodt (1965) as follows:

$$h = \frac{2\delta \cos \beta}{pgr}$$

Saturated hydraulic conductivity was measured in the undisturbed soil cores using the constant head method according to Kulte and Dirksen (1986).

Where h is the matric potential (m)
δ is the surface tension (N m-1)
r is the pore radius (m)
β is the contact angle (o)
ρ is the specific water mass (Mg m-3) and
g is the acceleration of gravity (m s-2).

It was calculated by using the following equation:

$$Ks = VL / [At (H2\text{-}H1)]$$

Where Ks = saturated hydraulic conductivity (cm/h)
V= volume of water that flows through the sample (cm^3)
L = length of sample (cm)
A = cross-sectional area of the sample (cm^2)
T = time at the collected volume (h) and
H_1= the hydraulic head at zero time (cm) and
H_2 = the hydraulic head after certain time (cm)

3. RESULTS AND DISCUSSION

3.1. Soil salinity and Sodicity

Soil salinity data as electrical conductivity (EC_e) are presented in Table (2). In general, the data show that soil salinity is quite very high and it is widely differed from place to another. It varied from 2.70 to 86.10 dS/m with an average value of 28.54 dS/m. The soil salinity increased with soil depth which is complied with the inherent parent material ($CaCO_3$) that also increases with soil depth.

Soil reaction (pH) is one of the most important parameters which reflects the overall change in soil chemical properties. Data in Table (2) revealed that the pH values changed from 7.9 to 8.9 which are considered alkaline. In general pH values decreased with the soil depth which is commonly happened in the dry and hot conditions in the limestone plateau.

3.2. Total calcium carbonate

Since the parent material of the investigated soils is limestone, calcium carbonate is a dominant component of the soil matrix. Data in Table (2) revealed that the calcium carbonate ($CaCO_3$) content varied from 13.10 to 85.90% with an average value of 36.97%. It was noticed that the $CaCO_3$ content increased with soil depth. The high content of $CaCO_3$ in these soils was mainly attributed to the pedogenic calcium carbonate inherited from limestone parent material. Thus, these soils are classified as strongly calcareous in terms of $CaCO_3$ content according to FAO (2006).

Data in Table (3) show the correlation between total $CaCO_3$ content and some soil properties. There were positive significant correlation between $CaCO_3$ and silt, clay content, void ratio, WHP,FCP and total pores. There were negative significant correlations between total $CaCO_3$, sand, bulk density, hydrolic conductivity. The obtained results agreed with those of Shawky *et al*. (2004), Al-

Table (3): Correlation coefficients between total $CaCO_3$ and some soil properties.

Sand %	Silt %	Clay %	Db Mg/m^3	DP Mg/m^3	Void ratio	Ks cm/h	QDP %
-0.449**	0.370**	0.365**	-0.317**	-0.069	0.302**	-0.226*	-0.162
SDP %	**WHP %**	**FCP %**	**T.P %**	**Gravel %**	**pH**	**ECe (dS/m)**	
0.154	0.199*	0.225*	0.314**	0.109	0.008	0.037	

Qinna *et al*. (2008 & 2013) and Sağlam & Dengiz (2015).

3.3. Soil texture and structure

Data in Table (4) show that the soils of the

Table (4): Soil particle size distribution and their densities and organic matter content of the studied soil.

Profile No.	Soil depth (cm)	Gravel (%)	Particle size distribution (%)			Texture class	Density (M g/m^3)		Void ratio	O.M.%
			Clay	Silt	Sand		Dp	Db		
1	0 - 20	7.63	9.72	13.9	76.38	S. loam	2.63	1.55	0.70	0.30
	20 - 40	1.65	8.61	27.26	64.14	S. loam	2.51	1.48	0.69	0.26
	40 – 100	32.53	22.08	28.11	49.81	Gravelly loam	2.46	1.52	0.63	0.24
2	0 - 40	25.71	9.00	6.65	84.35	Gravelly L. sand	2.55	1.68	0.52	0.81
	40 - 55	41.46	6.85	14.9	78.26	Gravelly L. sand	2.55	1.49	0.71	0.75
	55 – 105	61.00	10.55	13.06	76.38	V. Gravelly S. loam	2.51	1.61	0.55	0.42
3	0 - 30	11.13	16.42	5.78	77.80	S. loam	2.68	1.68	0.60	0.34
	30 - 80	17.33	5.99	22.52	71.49	S. loam	2.52	1.43	0.76	0.4
4	0 - 40	17.97	11.78	9.89	78.33	S. loam	2.47	1.77	0.39	0.38
	40 - 70	25.64	9.39	11	79.61	Gravelly L. sand	2.56	1.54	0.66	0.44
	70 – 110	27.59	8.08	26.2	65.72	Gravelly S. loam	2.58	1.52	0.69	0.17
5	0 - 40	15.70	9.19	8.56	82.25	L. sand	2.62	1.68	0.56	0.52
	40 - 60	5.73	8.84	23.88	67.28	S. loam	2.43	1.60	0.52	0.28
	60 – 110	21.82	9.47	29.02	61.51	Gravelly S .loam	2.59	1.57	0.65	0.27
6	0 - 40	13.24	8.02	10.85	81.13	L. sand	2.67	1.88	0.42	0.31
	40 - 50	3.64	6.38	23.45	70.17	S. loam	2.73	1.70	0.60	0.29
	50 – 80	12.11	6.14	15.83	78.02	L. sand	2.72	1.74	0.56	0.26
	80 - 120	11.19	10.15	7.21	82.64	L. sand	2.62	1.62	0.61	0.26
7	0 - 30	4.85	20.15	13.19	66.66	S. C. loam	2.58	1.69	0.53	0.83
	30 - 60	3.27	5.48	1.63	92.89	Sand	2.68	1.66	0.62	0.65
	60 – 70	10.51	5.56	17.42	77.02	L. sand	2.66	1.78	0.49	0.23
	70 - 130	8.41	6.98	4.16	88.86	Sand	2.51	1.51	0.66	0.07
8	0 - 40	50.54	9.02	18.1	72.87	V. Gravelly S. loam	2.53	1.78	0.43	0.53
	40 - 60	57.82	7.82	13.02	79.16	V. Gravelly L. sand	2.60	1.72	0.51	0.54
	60 – 75	26.02	6.52	16.22	77.26	Gravelly L. sand	2.56	1.61	0.58	0.52
	75 - 110	19.29	8.86	7.95	83.18	L. sand	2.48	1.56	0.59	0.3
9	0 - 30	12.36	7.12	1.35	91.53	Sand	2.57	1.81	0.42	0.37
	30 - 55	59.39	5.57	5.85	88.58	V. Gravelly Sand	2.61	1.72	0.51	0.32
	55 – 110	51.13	7.42	4.78	87.80	V. Gravelly Sand	2.64	1.77	0.50	0.32
10	0 - 30	32.21	6.55	3.4	90.05	Gravelly Sand	2.73	1.80	0.52	0.4
	30 - 45	11.27	8.11	10.61	81.28	L. sand	2.41	1.35	0.79	0.35
	45 – 75	25.72	6.76	8.78	84.46	Gravelly L. sand	2.57	1.61	0.60	0.27
	75 - 120	46.02	0.70	12.43	86.87	Gravelly Sand	2.44	1.69	0.44	0.13
11	0 - 30	32.03	2.18	9.6	88.22	Gravelly Sand	2.61	1.80	0.44	0.69
	30 - 60	14.55	6.46	10.09	83.45	L. sand	2.66	1.62	0.64	0.74
	60 – 80	29.31	2.09	22.32	75.59	Gravelly L. sand	2.59	1.61	0.61	0.3
	80 - 120	25.09	2.90	8.91	88.18	Gravelly Sand	2.51	1.66	0.51	0.28

investigated areas are typically desert land. They were characterized by variability in their components and soil texture that could be described as non-homogenous soils. The gravel content varied from 1.65 to 61.00 %, while sand fraction ranged from 49.81 to 92.89%. The silt fraction varied from 1.35 to 29.02% and clay content changed from 0.70 to 22.08%. Data illustrated that sand content is the dominant fraction followed by a minor amount of silt or clay. The results indicated that the studied soils were mostly coarse in texture and the soil texture changes from sand to sandy loam to sandy clay loam with obvious gravel content. This behavior reflected the physical erosion factors that took place under the arid and semi-arid conditions. Soil structure was considered single grains and its grade is weak with fine to very fine size and angular to sub-angular type (Table 1). The soil structure is a sign of soil texture that shows individual and course particles.

3.4. Particle and bulk densities and void ratio

Soil particle density (D_p) values in the different layers of the studied soil profiles showed irregular trend and they ranged from 2.23 to 2.75 Mg/m^3 with an average value of 2.56 Mg/m^3 (Table 4). Most of the studied soil samples had higher D_p values than 2.60 Mg/m^3. This may be due to their relatively high sand content that dominated the other fractions (silt and clay). These results are consistent with those of Abdo (2008) and Gamie (2008).

Soil bulk density (D_b) is a function of different factors, *i.e*., particle size distribution, specific ions, total salts, soil compaction, total porosity and moisture content. The data presented in Table (4) revealed that the bulk density values displayed no trend and they varied from 1.35 to 1.88 Mg/m^3 with an average value of 1.64 Mg/m^3. It was noticed that the D_b values in the surface layers were higher than those in the underneath layers. This may be attributed to the pore spaces in the surface layers which are filled with eroded soil particles. Hence, porosity was reduced and bulk density turned out to be higher than those in the subsurface layers (Sayed, 2012).

Void ratio is usually used in parallel with soil porosity (n) , which is defined as the ratio of the volume of voids to the total volume of the soil. The porosity and the void ratio are inter-related. The value of void ratio depends on the consistence and packing of the soil. It is directly affected by compaction. Void ratio values of the tested soil showed irregular trend and they differed from 0.39 to 0.79 with an average value of 0.57 (Table 4). The low values of void ratios indicated that most soil layers are considered compacted which comply with soil bulk density values. Das (2008) stated that the minimum void ratio for a soil was commonly recognized with a wide range of particle size. Also, that in poorly graded sands, gravelly sands, with little or no fine particles, the void ratios varied from 0.30 to 0.75.

3.5. Soil moisture characteristics

Soil moisture characteristic is used to predict the soil water storage, water supply to the plants (field capacity) and soil aggregate stability. The geology of limestone plateau is mainly characterized by quaternary sediments and calcareous sedimentary rocks also occur. The high water content values observed at the dry ends of the water retention curves of the investigated soil profiles suggested that the different hydrological behavior could be attributed to mineralogical and pedogenic factors (Table 5). The high carbonates content at the study area showed no effect on storing soil water capacity rather being a major factor controlling water movement (Al-Qinna *et al*., 2013; Chaudhari *et al*., 2013; Moreno *et al*., 2014 and El-Hady *et al*., 2015). Data in Table (5) showed that the maximum water contents ranged from 48.7 to 32.4 v/v % under zero pressure while the minimum one varied from 8.8 to 4.5 v/v % under 15 bar pressure. It was noticed that there are wide variations among the maximum and minimum soil water contents. These wide variations might be due to the variations in soil textures and CaCO3 content (Moreno *et al*., 2014).

At potentials close to zero, a soil is close to saturation, and water is held in the soil primarily by capillary forces. As water content (θ) decreases, binding of the water becomes stronger, and at small potentials (more negative, approaching wilting point) water is strongly bound in the smallest pores, at contact points between grains and as films bound by adsorptive forces around particles. Under these conditions, sandy soils will involve mainly capillary binding, and will therefore release most of the water at higher potentials (Seki, 2007).

3.6. Soil moisture constants

Soil moisture constant is the imaginary concept of soil moisture content that is named according to its availability for the plant. Therefore, it represents definite soil moisture relationship and retention of soil moisture in the

Table (5):Soil moisture characteristics and constants of the investigated area.

Profile No.	Soil depth (cm)	Retained moisture content (v/v %) Pressure (atm.)							Soil moisture constants (v/v %)		
		0.00	0.10	0.33	1.00	3.00	5.00	15.00	F.C	W.P	A.W.C
1	0-20	34.7	16.1	12.4	9.8	8.1	6.5	5.9	16.1	5.9	10.2
	20-40	34.6	21.3	15.3	10.6	9.4	8.3	7.9	21.3	7.9	13.4
	40-100	42.6	25.2	17.9	12.2	10.6	10.0	8.7	25.2	8.7	16.5
2	0-40	33.6	15.9	12.2	8.5	7.0	6.6	6.2	15.9	6.2	9.7
	40-55	26.8	14.0	10.3	6.9	6.7	5.6	4.9	14	4.9	9.1
	55-105	33.8	15.1	11.6	8.8	7.9	6.4	5.9	15.1	5.9	9.2
3	0-30	33.3	16.4	12.4	9.6	8.1	7.4	6.1	16.4	6.1	10.3
	30-80	34	18.7	14.8	11.4	10.7	9.4	7.4	18.7	7.4	11.3
4	0-40	37.2	16.0	11.5	9.1	8.0	7.1	5.9	16	5.9	10.1
	40-70	34.8	16.4	11.7	9.3	8.6	7.8	6.2	16.4	6.2	10.2
	70-110	35.3	20.3	14.3	9.6	9.1	8.3	6.9	20.3	6.9	13.4
5	0-40	38	15.9	12.7	9.9	9.0	7.0	6.5	15.9	6.5	9.4
	40-60	34.6	16	12	9.6	8.3	7.4	6.3	16	6.3	9.7
	60-110	35.8	16.2	12.5	9.9	8.7	7.9	6.8	16.2	6.8	9.4
6	0-40	38.4	15.9	11.9	9.5	8.0	7.3	5.8	15.9	5.8	10.1
	40-50	38.8	17	12.5	10.1	9.2	8.1	6.9	17.0	6.9	10.1
	50-80	36.5	15.5	11	9.4	8.2	7.2	5.7	15.5	5.7	9.8
	80-120	32.4	16.4	12.12	10.3	8.7	7.1	6.3	16.4	6.3	10.1
7	0-30	33.8	16.6	12.2	9.6	8.3	7.5	6.4	16.6	6.4	10.2
	30-60	34.9	16.9	12.5	9.8	8.6	7.9	6.5	16.9	6.5	10.4
	60-70	29.9	15.2	9.5	6.5	5.8	4.8	4.5	15.2	4.5	10.7
	70-130	35.0	17.9	13.1	9.12	8.5	7.9	6.2	17.9	6.2	11.7
8	0-40	36.0	17.0	13.1	9.2	8.1	7.1	6.7	17	6.7	10.3
	40-60	36.8	14.9	11.5	9.3	7.8	6.9	5.6	14.9	5.6	9.3
	60-75	43.5	14.3	10.3	7.9	7.7	6.6	5.9	14.3	5.9	8.4
	75-110	39	16.9	12.5	9.3	8.5	7.1	6.4	16.9	6.4	10.5
9	0-30	38	15.4	11	9.4	8.3	7	5.3	15.4	5.3	10.1
	30-55	45.4	17.9	12.8	9.1	8.4	7.6	6.5	17.9	6.5	11.4
	55-110	46	18.2	13.2	9.6	9.1	8.3	6.8	18.2	6.8	11.4
10	0-30	38.2	17.4	12.3	8.9	8.2	6.6	5.9	17.4	5.9	11.5
	30-45	44.3	22.2	19.2	15.6	13.1	10.3	8.8	22.2	8.8	13.4
	45-75	43.5	18.1	14.1	11.2	10.5	8.4	7.4	18.1	7.4	10.7
	75-120	48.7	21.4	15.3	10.3	8.4	7.9	7	21.4	7.9	14.4
11	0-30	37.8	16.5	12.5	9.7	8.3	6.1	5.6	16.5	5.6	10.9
	30-60	32.4	17.2	13.2	10.1	8.5	7.1	6.5	17.2	6.5	10.7
	60-80	37.7	16.5	12	9.6	8.1	7.4	6.3	16.5	6.3	10.2
	80-120	41.2	16.9	12.3	9.8	8.15	7.6	6.7	16.9	6.7	10.2

field. Hence two soil moisture constants (field capacity and wilting point) have been introduced to express the soil-plant-water relationships as it is found to exist under field conditions.

Field capacity is the capacity of the soil to retain water against the downward pull of the force of gravity and it is readily available to plants and microorganism. The field capacity of the investigated area varied from 14.0 to 25.2 v/v % with an average value of 17.2 v/v % (Table 5). The changes in field capacity values might be due to the difference in soil texture and structure. The finer the texture is, the higher is the FC, the slower is its attainment, and the less distinct is its value. Again, the term field capacity is of questionable value for soils having layers of widely differing in hydraulic conductivities (Hillel, 1982).

Wilting point is reached when the water is so firmly held by the soil particles that plant roots are unable to draw it. The wilting point of the investigated area varied from 4.9 to 8.8 v/v % with an average value of 6.4 v/v % (Table 5). Again, the changes in wilting point values might be due to the different in soil texture and structure. These lower values of wilting point are commonly found in desert area (coarse texture).

Plant available water is the difference in the amount of water at field capacity (- 0.1 bar) and the amount of water at the permanent wilting point (- 15 bars). The available water values of the investigated area differed from 8.4 to 16.5 v/v % with an average value of 10.8 v/v % (Table 4). Soil texture can have a large effect on soil water availability. Similar results are reported by Moreno *et al*. (2014) and Karahan & Erşahin (2016).

There are several factors can affect soil moisture constants. These factors include soil texture, organic matter, and mineral composition among others. In the present study, the soil texture and calcium carbonate could be the dominant factors that enhanced / reduced the soil moisture constants. Since the soil textures are mostly coarse ones (low clay and organic matter contents), the retained moisture at tensions greater than one bar is low. One factor that has adverse effects on the agricultural potentialities of coarse textured soils is the little water amount storage in soils and great water loss by fast deep percolation.

3.7. Total porosity and pore-size distribution

Soil porosity refers to the space between soil particles, which consists of various amounts of water and air. Porosity depends on both soil texture and structure. The results revealed that total soil porosity differed from 26.8 to 46% with an average value of 37.2% (Table 6). In general, it was noticed that total soil porosity decreased with soil depth. This might be due to effect of the weight of overlying soil layers (Bakry, 2001). However, the total soil porosity is considered relatively low. This might be due to

Table (6): Total soil porosity, pore size distribution and saturated hydraulic conductivity of the investigated area.

Profile No	Depth (cm)	Total porosity (%)	Pore size distribution (%)				HC (cm/h)
			QDP >28.8µ	SDP 28.8-8.68µ	WHP 8.68-0.19µ	FCP <0.19µ	
1	0-20	34.7	18.6	3.70	6.5	5.9	1.2
	20-40	34.6	13.3	6.00	7.4	7.9	0.3
	40-100	42.6	17.4	7.30	9.2	8.7	0.5
2	0-40	33.6	17.7	3.70	6	6.2	13.4
	40-55	26.8	12.8	3.70	5.4	4.9	2.1
	55-105	33.8	18.7	3.50	5.7	5.9	31.6
3	0-30	33.3	16.9	4.00	6.3	6.1	38.2
	30-80	34.0	15.3	3.90	7.4	7.4	0.3
4	0-40	37.2	21.2	4.50	5.6	5.9	1. 8
	40-70	34.8	18.4	4.70	5.5	6.2	19.5
	70-110	35.3	15.0	6.00	7.4	6.9	1.30
5	0-40	38.0	22.1	3.20	6.2	6.5	52
	40-60	34.6	18.6	4.00	5.7	6.3	1.6
	60-110	35.8	19.6	3.70	5.7	6.8	2.0
6	0-40	38.4	22.5	4.00	6.1	5.8	18.2
	40-50	38.8	21.8	4.50	5.6	6.9	17.8
	50-80	36.5	21.0	4.50	5.3	5.7	0.3
	80-120	32.4	16.0	4.28	5.82	6.3	7.9
7	0-30	33.8	17.2	4.40	5.8	6.4	6.3
	30-60	34.9	18.0	4.40	6	6.5	12.2
	60-70	29.9	14.7	5.70	5	4.5	40.2
	70-130	35.0	17.1	4.80	6.9	6.2	11.5
8	0-40	36.0	19.0	3.90	6.4	6.7	0.14
	40-60	36.8	21.9	3.40	5.9	5.6	0.5
	60-75	43.5	29.2	4.00	4.4	5.9	4.2
	75-110	39.0	22.1	4.40	6.1	6.4	11.3
9	0-30	38.0	22.6	4.40	5.7	5.3	13.3
	30-55	45.4	27.5	5.10	6.3	6.5	2.0
	55-110	46.0	27.8	5.00	6.4	6.8	3.2
10	0-30	38.2	20.8	5.10	6.4	5.9	5.2
	30-45	44.3	22.1	3.00	10.4	8.8	3.3
	45-75	43.5	25.4	4.00	6.7	7.4	1.3
	75-120	48.7	27.3	6.10	7.4	7.9	2.5
11	0-30	37.8	21.3	4.00	6.9	5.6	3.9
	30-60	32.4	15.2	4.00	6.7	6.5	4.5
	60-80	37.7	21.2	4.50	5.7	6.3	3.8
	80-120	41.2	24.3	4.60	5.6	6.7	7.3

QDP= quickly drainable pores SDP= slowly drainable pores WHP= water holding pores
FCP= fine capillary pores HC= hydraulic conductivity

that Porosity is inversely related to bulk density depending on particle size and aggregation. A large number of small particles in a volume of soil produce a large number of soil pores (clay soil). Fewer large particles can occupy the same volume of soil so there are fewer pores and less porosity (sand soil). Water retention capacity depends primarily on total porosity and pore size distribution, which are related to texture, bulk density and secondary structure.

The stability and arrangement of aggregates delimits soil total porosity and pore size distribution. Pore size distribution depends mainly on the way in which soil particles are arranged because soil structure has a great influence on this parameter. Pore size distributions also delimit the air/water balance of soils. (El-Samnoudi *et al*., 1991 and Mecke *et al*., 2002).

Water flow in soil pedality depends on many factors, especially the volume of drainable pores. The pore size distribution show that the values of quickly drainable pores (QDP) differed from 12.8 and 29.2 % with an average value of 20.0 % while slowly drainable pores (SDP) values ranged between 3.0 and 7.30 % with a mean value of 4.43% (Table 6). The values of water holding pores (WHP) ranged between 4.40 and 10.4 % with a mean value of 6.44% and fine capillary pores (FCP) values varied from 4.50 to 8.80 % with an average value of 6.31% (Table 6). In general, it was noticed that the drainable pores (QDP+SDP) value was about 24.4% as an average value representing about 65.59% of the total porosity. The value of capillary pores (WHP+FCP) was about 12.7 % as an average value representing about 34.14 % of the total porosity. This might be attributed to the relatively coarse texture and high $CaCO_3$ content in the investigated soils.

3.8. Saturated hydraulic conductivity

The flow of water under saturated conditions is a function of two opposing factors, namely, the effective pore size and the continuity of water films in the conducting pores. At a given suction, the decrease in pore size facilitates the flow of water by increasing the continuity of the water films in the water conducting pores (Amer 2003). The results of soil saturated hydraulic conductivity (Ks) in all layers of the studied soil profiles are shown in Table (6). The soil saturated hydraulic conductivity (Ks) varied from 0.14 to 51.97 cm/h with a mean value of 9.37 cm/h. According to the hydraulic conductivity values the studied soils can be categorized between very slow to very rapid permeability classes (Soil Survey Staff, 1993). Freez and Cherry (1979) reported wide range for the hydraulic conductivity for different soil textures.

3.9. Water resources

The groundwater is the only water resource for all activities in this area and it is as deep as 270- 300 m (Table 7). The pH values of the groundwater samples ranged from 6.39 to 7.82 which are considered neutral. According to the WHO (2004) the range of desirable pH values of water prescribed for human purposes is 6.5 – 9.2. In the investigated area, groundwater salinity ranges between EC 0.779 and 1.027 dS/m which are considered good quality water (Table 7). Piper diagram was used to classify the groundwater quality of different wells served in the investigated area.

The water type quality is found under the area of:

1) S7 which were characterized by a non carbonate alkali, primary salinity, that exceeds 50% and chemical alkalies and strong acids dominate properties and
2) S9 which were marked by strong acid (SO_4+Cl)> (HCO_3+CO_3) and non cation-anion pair that exceeds 50%. Accordingly, sulphate water type exists with Ca, Mg, Na and K (Fig.2).

Table (7): Some chemical properties of the analyzed groundwater sample.

Sample no.	pH	EC (dS/m)	Ca^{++} mg/l	Mg^{++} mg/l	Na^{+} mg/l	K^{+} mg/l	Cl^{-} mg/l	SO_4^{--} mg/l	HCO_3^{-} mg/l
1	7.52	1.009	2.54	1.58	5.77	0.15	6.36	0.05	3.74
2	7.2	1.011	2.03	1.57	6.22	0.16	6.54	0.31	3.49
3	6.80	1.001	2.77	1.60	5.41	0.14	5.41	1.09	4.57
4	6.85	1.027	2.89	1.73	5.32	0.14	6.63	1.50	3.56
5	7.33	1.009	3.05	1.38	5.47	0.14	7.05	1.89	2.91
6	6.73	0.779	2.12	1.82	3.52	0.09	4.65	0.83	2.87

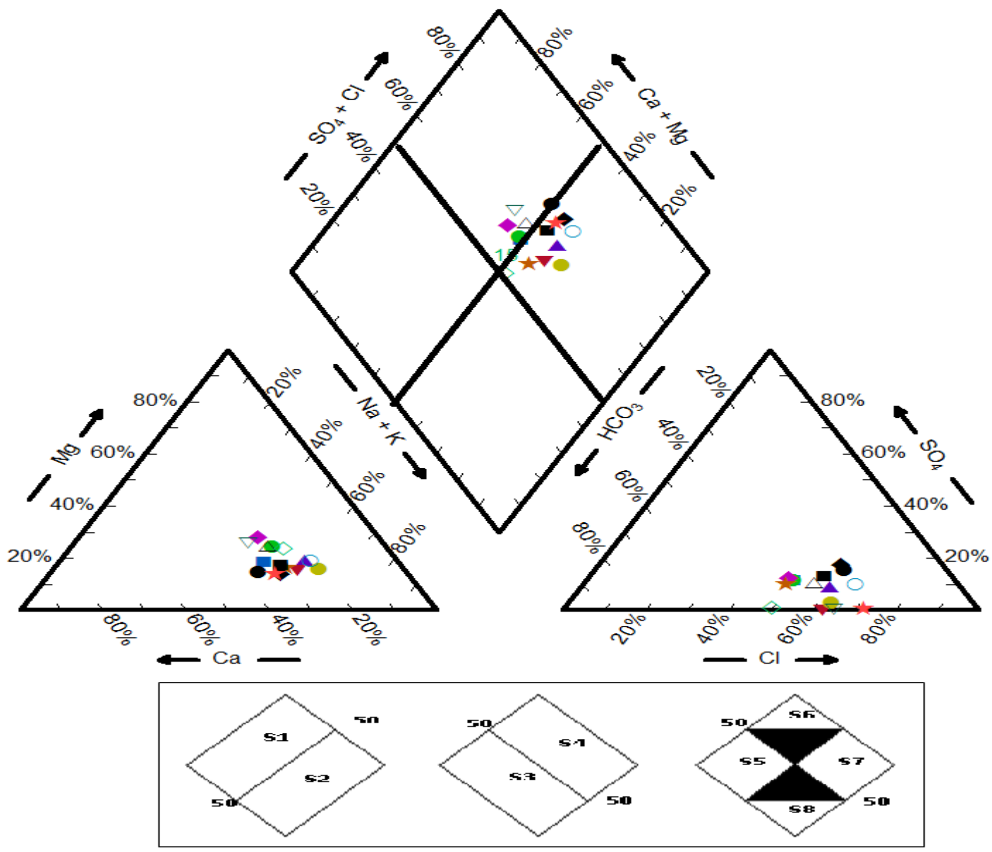

Fig. (2): Piper diagram and subdivisions of diamond-shaped field (after Piper, 1950).

It might be concluded that the investigated area is considered a very promising area for agricultural utilization since it has a good source of irrigation water. Also, it should follow a suitable soil water management and select a proper crop to be cultivated under these conditions. Special care would be implemented with respect to agricultural practices (how and when to irrigate or fertilization).

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الخواص الطبيعيه والهيدرولوجية لأراضى الهضبة الجيرية الغربية بمحافظة أسيوط – مصر

محمود محمد السيد - محسن عبد المنعم جامع* - عزت احمد مصطفى* - احمد على عبد الرحمن

قسم علوم الاراضى والمياه- كلية الزراعة - جامعة الأزهر- أسيوط
* قسم علوم الاراضى والمياه - كلية الزراعة - جامعة أسيوط – مصر

ملخص

أجريت هذه الدراسة على بعض الأراضى الممثلة لأراضى الهضبة الجيرية فى الصحراء الغربية بمحافظة أسيوط، والواقعة على بعد 300كم جنوب القاهرة بين خط عرض N ‾00 ‾40 °27 to ‾00 ‾20 °26 وخط طول ‾30 °30 ‾00 to 31° 40‾ 00‾ E وبدأ العمل الحالي للإعتراف بالإمكانيات الزراعية في هذه المنطقة. تهدف الدراسة الى تقييم الخواص الطبيعية والهيدرولوجية للتربة لتحديد القدرة الزراعية لهذه الأراضى ومعرفة الممارسات المناسبة لاستغلالها زراعيا.

أظهرت النتائج أن اراضى المنطقة يغلب عليها القوام الخشن (رملى –رملى طميى-طميى رملى). تراوح محتوى كربونات الكالسيوم بين 13.10 الى 85.90% وتراوحت قيم الكثافة الظاهرية بين 1.36الي 1.88جم/سم^3 كما لوحظ زيادة طفيفة في الكثافة مع العمق. أظهرت نتائج منحنيات الشد الرطوبى ان هناك انخفاضاً كبيراً (اكثر من 50%) عند تعرض التربة لقوى شد اقل من 1 ض.ج . اوضحت نتائج الخواص الهيدروليكية للتربة ان معامل التوصيل الهيدروليكى المشبع (KS) تراوح بين المنخفض الى السريع جدا، وان التربة ذات محتوى عالى من كربونات الكالسيوم الكلية حيث تراوحت بين 13.10 الى 85.90% . تراوحت قيم رقم حموضة التربة (pH) بين 7.9الى 8.9 وقد لوحظ ان معظم العينات تميل الى القلوية. وتتنوع قيم ملوحة عينات التربة من غير ملحية إلى شديده الملوحة حيث تراوحت قيم التوصيل الكهربى لمستخلص عجينة التربه المشبعه ECe من 2.7 الى 86.10 ديسيمينز/م. وملوحة مياه الآبار تعتبر جيدة للرى حيث تراوحت قيم EC بين 0.779 و 1.027 dS/m. وكانت قيمة مسام الصرف (سريعة الصرف + بطيئة الصرف) حوالى 24.4% لتمثل 65.59% من قيمة المسام الكلية بينما قيمة المسام الشعرية 12.7% لتمثل حوالى 34.14 من قيمة المسام الكلية.

المجلة العلمية لكلية الزراعة - جامعة القاهرة - المجلد (68) العدد الثالث (يوليو 2017) : 345- 357.