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Pedomorphic Features and Soil Classification of Gharb El-Mawhob area, El-Dakhla Oasis, Western Desert, Egypt.

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ABSTRACT

The mean object of the current study is to asses soil morphological and physico-chemical properties as well as soil classification in order to establish guide parameters for land utilization types on a basis of sustainable agricultural. This study was carried out at Gharb El-Mawhob area which is located at the North-Western part of Dakhla Oasis, between longitudes 28° 26 00″ - 28° 40 00″ E and latitudes 25° 44 00″ – 25°56 00″ N. Twelve soil profiles (44 samples) were dug according to soil morphological observations and their sites to 150 cm depth or to the hard layer or to the parent rock. The soil profiles were morphologically described in the field and soil samples were taken for physical and chemical analysis. The obtained results show that soil moisture regime is aridic and the soil temperature regime is hyperthermic. Soils color is almost light brownish gray (10YR 6/2 dry) turned to brown (10YR 5/3 moist). The color of surface horizon was brighter than lower horizons. Solum was found to be a function of the topography, type of basement rock and configuration of the landscape. Soil texture ranges widely from coarse and moderately coarse to fine texture. Soil structure of most soil layers is massive. The consistence varies from hard and very hard to extremely hard (dry). The boundary differs from clear distance to gradual one and its topography varies from smoothing to wavy. Gypsum and calcium carbonate content vary widely from 1.10 to 8.10% and from 2.70 to 83.50%, respectively. The studied soils are considered salt-affected soils (EC > 4 dS/m) and the pH values ranges from 7.20 to 8.17 indicating that the soils are near neutral to slightly alkaline. Organic matter (OM) content was very low varied from 0.05 to 1.41%. Soil cation exchange capacity (CEC) found to be closely related to the clay content. The soil with the highest CEC was the vertic torriorthents which had the highest clay content, while Typic torripsamment soil had the lowest clay content. Three suborders could be distinguished under Aridisols order, namely Argids, Salids and Calcids and two suborder Psamments and Orthents are related to Entisols order. At the great group level under Aridisols order, three categories could be distinguished, namely; Natrargids, Haplosalids and Haplocalcids. Under these three great groups, the identified subgroups are Typic Natrargids, Salic Natrargids, Sodic Haplosalids and Sodic Haplocalcids. At the great group level under Entisols order, two categories could be distinguished, namely; Torriorthents and Torripsamments. Under these two great groups, the identified sub groups are Vertic Torriorthents, Typic Torripsamments, Typic Torriorthents and Sodic Torriorthents.

Key words: Gharb El-Mawhob area, El-Dakhla Oasis,Morphological description, Physico-chemical properties, Soil classification.

Introduction

Egypt is considered a desert area (about 94% of its total area), which pull our attention to desert reclamation and to the utilizing of its own natural resources. Egypt is an imperative need to increase both the productivity of existing agricultural land and in meanwhile expand the cultivated area. Therefore, locating new areas having agricultural potential is a highly priority task for the government to narrow the gap between food consumption and its production. The national strategy of Egypt for horizontal expansion of agricultural lands until year 2017 aims at adding about 4.5 million feddans in different regions, depending on land suitability and water resources (Abdel-kader *et al*., 2004). South Western Desert is considered as one of the promising regions that have the potentialities to share in producing food and life requirements.

The New Valley Governorate occupies huge area of the south western desert representing 43.6% of the total area of Egypt underlie by high ground water potentiality; accordingly it is included in the agricultural expansion for Egypt Land Master Plan. The New Valley consists of three oases, Kharga, Dakhla, and Farafra (Allam *et al* 2002). Dakhla Oasis is located at the heart of the Western Desert of Egypt between latitudes 28º30′ and 29º 22′ East and longitudes 25º29′ and 25º 55′ North. It is 190 km to the West of the Kharga Oasis where it extends 155 km from the Teneida village in the east to the Mawhoob village in the West with an area suitable for agriculture of about 9300 km^2 (155× 60 km). Dakhla Oasis contains highly fertile lands supplemented by good quality groundwater in surplus amount. The groundwater is the only water resource for all activities in this Oasis.

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However, the potentiality of this water resource is very promising. The general geology of the Dakhla Oasis as outlined in the geology of Egypt (Said, 1961) is essentially a plateau with vast flat extensions of rock deep closed in depressions (Fig 1).

Gharb El-Mawhob area represents a part of the geological formation of the western desert. It includes two main formations : 1) Dawi formation belongs to the Maasterichtion period (Hermina, 1990) and contains laminates of phosphate that interfere with successive layers of sandstone, claystone , silt and conglomerate. The phosphatic sediments are found in three layers where overlapping shale layers separate between them. 2) Dakhla formation spreads in the northern part of the depression where its front edge represents an area of 888.7 Km^2 . Its layers have a large thickness ranging between 170 and 250 m (Hermina *et al*., 1989). Dakhla formation, dark-grey oscillating marine shale with calcareous, sandy and phosphatic intercalations rich in pelecypods. Soils of the study area are developed during pluvial times and preserve the present desert condition. Therefore, these soils display different depositional environments, mostly of Aeolian, alluvial and lacustrine nature (Rahim and Ageeb, 2003).

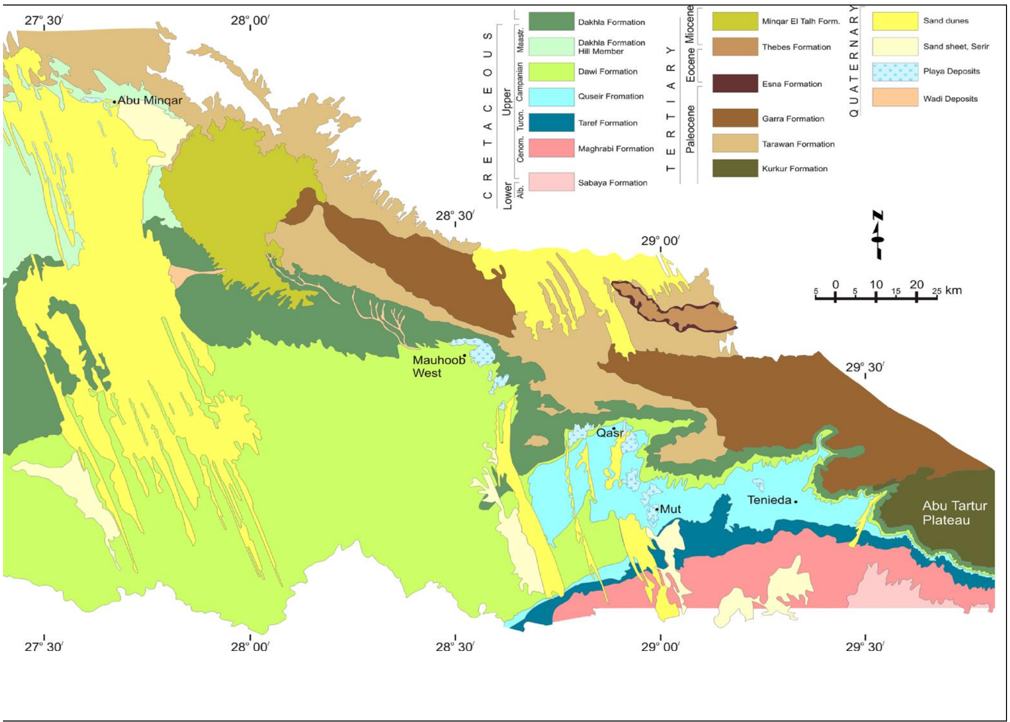

Fig. 1: Geological map of Dakhla oasis, digitized from CONOCO (1987), showed lithostratigraphic units (adopted from El Khawaga *et al*., 2005).

The investigated area lies within the extremely arid belt, having long hot summer and short warm winter, where the mean monthly minimum temperature values range from 4.30 to 9.90 C° in winter while the mean maximum values range from 28.50 to 32.30 C° in summer (Table 1). According to the meteorological data of Egyptian Meteorological Authority (1996), the soil moisture regime is aridic, while the soil temperature regime is hyperthermic (Hussein, 1993). Dakhla oasis belongs to the rainless part of Egypt (Brookes 1993 and Kleindienst *et al*., 1999). The hottest months are June, July, August and September with a mean maximum temperature of 31.48°C. January and February are considered the coldest months with a mean minimum temperature of 4.5°C (Table 1).

The northwestern and the northern wind blow from the Mediterranean toward Western Desert with fallen speed south wards. The wind is the major factor of erosion and deposition processes (UNCCD Egypt Office, 2005). The study area is distinguished by dry desert climate. Sustainable land use planning of Dakhla oasis involves making knowledgeable decisions about land use and the environment. Holistic planning involves input from multiple interrelated data sources and types. In order to accomplish this feat, a great deal of information must be considered simultaneously. Soil information, water resources and socio-economic conditions work together playing a vital rule in the planning process and reflecting directly upon land use suitability. Study on soil characteristics in particular morphological, physico-chemical properties will provide basic information for better plant growth and management of the soil resources. The mean object of the current study is to asses soil morphological and physico-chemical properties as well as soil classification in order to establish guide parameters for land utilization types on a basis of sustainable agricultural.

Table 1: Some meteorological data of Dakhla Oasis (Data is average of a period from 1980 – 2010)

Month	Rainfall (mm)	Temperature (C°) Max.	Min.	Mean	Evaporation (mm/day)	Relative Humidity %
January	0.01	23.90	4.30	14.10	8.80	35.40
February	0.20	26.80	4.70	15.80	11.40	29.60
March	0.10	31.50	8.40	20.00	17.70	22.80
April	0.10	37.00	12.20	24.60	24.40	19.50
May	0.10	39.00	17.00	28.50	30.40	18.50
June	0.00	39.90	21.50	30.30	37.20	17.00
July	0.00	41.70	21.50	31.60	37.60	17.70
August	0.00	41.40	22.00	31.70	36.80	18.90
September	0.00	39.60	25.00	32.30	31.40	20.70
October	0.00	35.50	16.00	25.60	21.90	25.80
November	0.00	29.10	9.90	19.50	14.00	30.70
December	0.00	25.30	6.00	15.70	10.00	34.90
average	0.50	34.20	14.04	24.10	23.50	24.30

Materials and Methods

Study area:

The studied area named Gharb El-Mawhob and it is located at the North-Western part of Dakhla Oasis, between longitudes 28° 26 00″ - 28° 40 00″ E and latitudes 25° 44 00″ – 25°56 00″ N. The studied area is about 236 Km^2 representing about 23557 hectares (Fig 2).

Field studies and soil sampling:

Twelve soil profiles according to the morphological observations of the soils and their sites have been conducted using Global Position System (GPS). Each soil profiles has been dug to150 cm depth or to the hard layer or to the parent rock. Profile descriptions included observation on land surface, identification of horizons, boundaries, soil texture, structure and consistency. Soil profiles were morphologically described in the field according to FAO (2006) and Schoenberger *et al*. (2012). Forty four soil samples of the various layers have been collected for laboratory analyses.

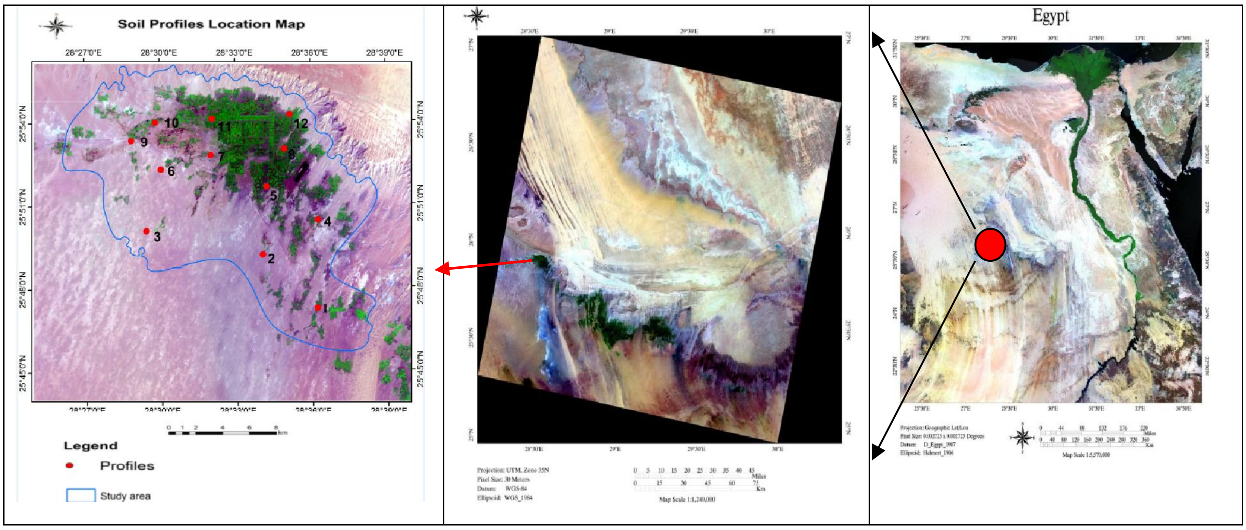

Fig. 2: Location of the studied area and soil profiles location of the investigated area.

Soil analysis:

Soil color in both dry and moist conditions was measured with the aid of Munsell soil color Charts of Soil Survey Staff (1951). Particles size distribution was determined by using the pipette method, as described by to Piper (1950) and Jackson (1973)**.** Saturation Percentage (SP) was estimated according to Richards, (1954). Soil reaction (pH) has been measured in 1:2.5 soil to water suspension at 25 C° using pH-meter, (Alvarenga *et al.*, 2012). Organic matter (OM) content was determined according to Jackson (1973). Soil calcium carbonate

($CaCO_3$) content was measured using Scheibler's calcimeter according to Nelson (1982). Gypsum content was determined using precipitation by acetone according to Hesse, (1998). Soil salinity was determined in soil – paste extract according to Bashour and Sayegh, (2007). Cation Exchange Capacity (CEC) was determined by using sodium acetate (NaOAC) at pH 8.2 according to Black (1982). Exchangeable Sodium Percentage (ESP) was calculated according to Richard, (1954).

Soil classification:

Soil Taxonomy was used to classify different soil profiles under this study into taxonomic units starting from soil order level down to the soil family level according to soil taxonomy manual of the United States Department of Agriculture (USDA, 2014). This classification is based on field survey, morphological description, chemical and physical analyses.

Results and Discussion

Soil morphological properties:

The morphological description of the investigated soil profiles is presented in (Table 2). In general, topography of the landscape is almost flat of its relief with level to nearly level sloping, and its geomorphology is considered as depression inheriting shale (profile No. 1, 4, 5, 8, 10, 11 and 12) or lime stone (profile No.3, 6 and 7) or sand stone (profile No. 2 and 9) as parent materials with elevation ranges from 102 and 163m above sea level (Table 2). In case the parent material is the dominant factor in soil formation, the most obvious way in which it affects the soil is through similarity in color and texture (Mahajan *et al*., 2007). The results showed that, some of the studied soil profiles surfaces were covered with drift sand or varnished gravels (stoniness), or both especially in profile No. 3, 6, and 9. All studied soils are considered slightly eroded with permeability differed from very slow to very rapid which is congruent with drainage class. Therefore, the land use is common for crop. Soils color in dry condition ranges between light brownish gray (10YR 6/2) in profiles No. 5, 8, 10 and 12 to light gray (10YR 6/1) in profile No. 1 to pale brown (10YR 6/3) in profiles No. 2, 4 and 11 to very pale brown in profiles No. 3, 6, 7 and 9 (Table 2). While soils color in moist condition ranged between brown (10YR 5/3) in profiles No. 1, 2, 4, 5 and 11 to yellowish brown (10YR 5/6) in profiles No. 3, 6, 7 and 12 to grayish brown (10YR 5/2) in profile No. 8 to dark brown in profile No. 10. Also it was found that the color of surface horizon was brighter than lower horizons. Solum thickness is a combined expression of pedogenetic horizons and the depth of the studied soil profiles varied from 110 to 150 cm indicated that all sites have deep soils.

Therefore, the depth of soils was found to be a function of the topography, type of basement rock and configuration of the landscape (Table 2). The differentiation of profile layers is not an easy task and subdivisions are largely based on variation in structure and or color. Therefore, A/C horizon sequence is most common in virgin shales (Rahim and Ageeb, 2003).

The soil texture throughout the entire depth of soil profiles is variable according to the sediments origin, i.e., lacustrine, alluvial and aeoline sand deposits, and ranges widely from coarse and moderately coarse to fine texture (Table 2). Soil texture varies from clay in profiles No. 1,5, 8, 10 and 12 to sandy clay loam in profile No. 4 and 11 to very gravelly sandy loam in profiles No. 6 and 9 to loam in profile No. 2.

Regarding soil structure, the grade is moderate to strong, the size is medium to fine and the type is angular to sub-angular blocky for most layers. Soil structure is massive in profiles No. 3, 4, 9, 10, 11 and 12. The consistence varies from hard and very hard to extremely hard (dry), but it changes from firm and very firm to extremely firm (moist) and it is sticky to very sticky and plastic to very plastic (wet). Soil boundaries differs from clear distance to gradual one and its topography varies from smoothing to wavy.

Physical and chemical properties:

Soil physical and chemical properties show variability as a result of dynamic interactions among environmental factors such as climate, parent material, topography and land cover/land use (Dengiz *et al* 2006). The organic matter (OM) content in the soil profiles was very low varied from 0.05 to 1.41% (Table 3). No specific trend of distribution has emerged out with respect to the topography in the selected soils for the study. In general the content of organic matter is higher at the surface, decreasing down the depth in soil profile. This was mainly due to accumulation of plant residues on the soil surface and very less opportunity to move it down the depth due to rapid decomposition at higher temperature and inadequate pedoturbation. Data in table (3) showed that gypsum and calcium carbonate content vary widely from 1.10 to 8.10% and from 2.70 to 83.50%, respectively.

Table 2: Soil profiles description of the investigated area.

Profile No.	Horizon	Depth of Layer (cm)	Position		Topography		Parent material	Stoniness %	Land use	Drainage Class	Classification	Colour		Texture	Structure			Consistence			CaCO3 reaction	Boundary	
			E	N	Elevation a.s.l	Slope						dry	moist		siza	Grade	Type	dry	Stickiness	Plasticity		Dist (cm)	Topo
1	Ap	0 - 20	28° 36′ 09.9″	25° 47′ 05.1″	118 m	Nearly level	Shale	None	Crop land	Weak drained	Typic Natrargids	Light gray (10YR 6/1)	Brown (10YR 5/3)	C	Fi	Mo	Sb	Ha	Vst	Vpl	Mo	C	S
	C2	20 - 40										Light gray (10YR 6/1)	Brown (10YR 5/3)	C	Vf	St	Sb	Ha	Vst	Vpl	Mo	G	I
	C3	40 - 70										Light gray (10YR 6/1)	Brown (10YR 5/3)	C	Vf	St	Sb	Vha	Vst	Vpl	Mo	C	S
	C4	70 - 120										Pale brown (10YR 6/3)	Brown (10YR 5/3)	Sic	Vf	Mo	Sb	Eha	Vst	Vpl	Mo		
2	C1	0 - 10	28° 33′ 34″	25° 49′ 06″	115 m	Nearly level	Sand stone	None	Bare land	Well drained	Salic Natrargids	Pale brown (10YR 6/3)	Brown (10YR 5/3)	Scl	Fi	We	Sb	Ha	St	Pl	St	C	S
	2C2	10 - 30										Pale brown (10YR 6/3)	Brown (10YR 5/3)	L	Me	Mo	Sb	Vha	St	Spl	St	G	W
	2C3	30 - 70										Pale brown (10YR 6/3)	Brown (10YR 5/3)	L	Me	Mo	Co	Vha	St	Spl	St	G	W
	3C4	70 - 120										Pale brown (10YR 6/3)	Brown (10YR 5/3)	Sl	-	-	Ma	Ha	Sst	Spl	St		
3	Ap	0 - 25	28° 29′ 00″	25° 50′ 00″	163 m	Nearly level	Lime stone	Very fine pebbles 60-70 %	Bare land	Well drained	Sodic Haplosalids	Very pale brown (10YR 7/4)	Light yellowish brown (10YR 6/4)	G - Sl	-	-	Ma	Ha	Sst	Spl	Ex	C	S
	2C2	25 - 40										Very pale brown (10YR 7/4)	Yellowish brown (10YR 5/6)	Sl	-	-	Ma	Ha	Sst	Spl	Ex	C	S
	3C3	40 - 110										Very pale brown (10YR 7/4)	Yellowish brown (10YR 5/6)	Scl	-	-	Ma	Vha	St	Pl	Ex		
4	Ap	0 - 25	28° 36′ 01.0″	25° 50′ 13.7″	119 m	Level	Shale	None	Crop land	Moderate drained	Typic Natrargids	Light brownish gray (10YR 6/2)	Brown (10YR 5/3)	Scl	-	-	Ma	Ha	St	Pl	Mo	C	S
	C2	25 - 30										Pale brown (10YR 6/3)	Brown (10YR 5/3)	Scl	-	-	Ma	Vha	St	Pl	Mo	A	S
	C3	30 - 45										Pale brown (10YR 6/3)	Brown (10YR 5/3)	Scl	-	-	Ma	Vha	St	Pl	St	C	S
	C4	45 - 130										Pale brown (10YR 6/3)	Brown (10YR 5/3)	Scl	-	-	Ma	Vha	St	Pl	St		

Abbreviations:
C= Clay Sic = Silt clay Scl= Sandy clay loam L= Loam Sl= Sandy loam G-Sl= Gravelly sandy loam Fi= Fine Vf= Very fine Me= Medium Mo= Moderate
St= Strong We= Weak Sb= Sub angular blocky Co= Columnar Ma= Massive Ha= Hard Vha= Very hard Eha= Extremely hard Vst= Very sticky Sst= Slightly sticky St= Sticky Vpl= Very plastic
Pl= Plastic Spl= Slightly plastic Ex= Extremely C= Clear G= Gradual A= Abrupt S= Smooth I= Irregular W= Wavy.

Table 2: Continued

Profile No.	Horizon	Depth (cm)	Position		Topography		Parent material	Stoniness %	Land use	Drainage Class	Classifcation	Colour		Texture	Structure			Consistence			CaCO3 reaction	Boundary	
			E	N	Elevation a.s.l	Slope						dry	moist		siza	Grade	Type	dry	Stickiness	Plasticity		Dis (cm)	Topo
5	Ap	0 - 30	28° 34′ 19.3″	25° 51′ 32.2″	102 m	Level	Shale	None	Crop land	weak drained	Vertic Torriorthents	Light brownish gray (10YR 6/2)	Brown (10YR 5/3)	C	Fi	St	Ab	Vha	Vst	Vpl	Mo	C	W
	C2	30 - 50										Light brownish gray (10YR 6/2)	Brown (10YR 5/3)	C	Fi	Mo	Ab	Vha	Vst	Vpl	Mo	C	S
	C3	50 - 110										Light brownish gray (10YR 6/2)	Brown (10YR 5/3)	C	-	-	Ma	Eha	Vst	Vpl	Mo		
6	Ap	0 - 35	28° 30′ 00″	25° 52′ 00″	129 m	Nearly level	Lime stone	Small cobbles 50-60 %	Bare land	Very well drained	Typic Torripsamments	Very pale brown (10YR 7/4)	Yellowish brown (10YR 5/6)	Ls	Me	Mo	Sb	So	Sst	Npl	St	C	S
	2C2	35 - 50										Very pale brown (10YR 7/4)	Yellowish brown (10YR 5/6)	V.G-s	-	-	Sg	Lo	Nst	Npl	Ex	C	S
	3C3	50 - 120										Pale brown (10YR 6/3)	Yellowish brown (10YR 5/4)	V.G-ls	Fi	Mo	Ma	Ha	Sst	Spl	Ex		
7	C1	0 - 15	28° 32′ 00″	25° 53′ 00.7″	109 m	Nearly level	Lime stone	None	Bare land	Well drained	Typic Torriorthents	Very pale brown (10YR 7/4)	Light yellowish brown (10YR 6/4)	Sl	Fi	We	Sb	Sha	Sst	Spl	St	G	W
	C2	15 - 35										Light yellowish brown (10YR 6/4)	Yellowish brown (10YR 5/6)	Sl	Fi	We	Sb	Sha	Sst	Spl	St	C	W
	2C 3	35 - 150										Very pale brown (10YR 8/3)	Pale brown (10YR 6/3)	V.G-ls	-	-	Ma	Vha	Sst	Npl	Ex		
8	C1	0 - 30	28° 35′ 03.3″	25° 53′ 03.9″	104 m	Level	Shale	None	Crop land	Weak drained	Vertic Torriorthents	Light brown ish gray (10YR 6/2)	Grayish brown (10YR 5/2)	C	Fi	Mo	Gr	Ha	Vst	Vpl	Mo	C	S
	C2	30 - 65										Light brownish gray (10YR 6/2)	Grayish brown (10YR 5/2)	C	Fi	Mo	Gr	Ha	Vst	Vpl	Mo	C	S
	C3	65 - 140										Light brownish gray (10YR 6/2)	Grayish brown (10YR 5/2)	C	-	-	Ma	Vha	Vst	Vpl	Mo		

Abbreviations:
C= Clay Ls= Loamy sand V.G-s= Very gravelly sand V.G-ls= Very gravelly loamy sand Sl= Sandy loam Fi= Fine Me= Medium St= Strong Mo= Moderate We= Weak
Ab= angular blocky Ma= Massive Sb= Sub angular blocky Sg= Single grains Gr=Granular Vha= Very hard Eha= Extremely hard So=Soft Lo=Loos Ha=Hard Sha=Slightly hard
Vha= Vey hard Vst= Very sticky Sst= Slightly sticky Nst= Non-sticky Vpl= Very plastic Npl=Non-plastic Spl= Slightly plastic Ex= Extremely C= Clear G= Gradual W= Wavy S= Smooth

Table 2: Continued

Profile No.	Horizon	Depth (cm)	Position		Topography		Parent material	Stoniness %	Land use	Drainage Class	Classification	Colour		Texture	Structure		Consistence				CaCO3 reaction	Boundary	
			E	N	Elevation m a.s.l	Slope						dry	moist		siza	Grade	Type	dry	Stickiness	Plasticity		Dist (cm)	Topo
9	Ap	0- 25	28° 28' 45"	25° 53' 31.5"	119 m	Nearly level	Sand stone	Medium pebbles 80-90 %	Crop land	Well drained	Sodic Haplocalcids	Very pale brown (10YR 8/3)	Very pale brown (10YR 7/4)	V.G-sl	-	-	Ma	So	Sst	Spl	Ex	C	S
	2C2	25 - 50										Very pale brown (10YR 7/3)	Brown (10YR 5/3)	V.G-ls	-	-	Ma	So	Sst	Npl	St	C	W
	3C3	50 - 80										Very pale brown (10YR 7/3)	Light yellowish brown (10YR 6/4)	V.G-s	-	-	Sg	Lo	Nst	Npl	St	C	S
	4C4	80 - 150										Very pale brown (10YR 7/3)	Light yellowish brown (10YR 6/4)	G-ls	-	-	Ma	Vha	Sst	Spl	St		
10	C1	0 -30	28° 29' 40"	25° 54' 00"	111 m	Nearly level	Shale	None	Crop land	Weak drained	Sodic Torriorthents	Light brownish gray (10YR 6/2)	Dark brown (10YR 4/3)	C	Fi	Mo	Gr	Ha	Vst	Vpl	Mo	G	I
	C2	30 - 75										Light brownish gray (10YR 6/2)	Dark brown (10YR 4/3)	C	-	-	Ma	Vha	Vst	Vpl	Mo	C	W
	C3	75 - 125										Light brownish gray (10YR 6/2)	Dark brown (10YR 4/3)	C	-	-	Ma	Vha	Vst	Vpl	Mo		
11	Ap	0 - 10	28° 32' 01.0"	25° 54' 03.1"	110 m	Nearly level	Shale	None	Crop land	Moderate drained	Typic Natrargids	Pale brown (10YR 6/3)	Brown (10YR 5/3)	Scl	Fi	Mo	Sb	Ha	St	Pl	St	G	W
	C2	10 - 25										Pale brown (10YR 6/3)	Brown (10YR 5/3)	Scl	Fi	St	Sb	Ha	St	Pl	St	C	W
	C3	25 - 40										Pale brown (10YR 6/3)	Brown (10YR 5/3)	Scl	-	-	Ma	Vha	St	Pl	St	C	S
	2C4	40 - 60										Pale brown (10YR 6/3)	Yellowish brown (10YR 5/4)	Cl	-	-	Ma	Vha	St	Pl	St	C	S
	C5	60 - 120										Pale brown (10YR 6/3)	Yellowish brown (10YR 5/4)	Scl	-	-	Ma	Vha	St	Pl	St		
12	Ap	0 - 25	28° 35' 04.4"	25° 54' 11.2"	103 m	Level	Shale	None	Crop land	Weak drained	Vertic Torriorthents	Light brownish gray (10YR 6/2)	Yellowish brown (10YR 5/4)	Cl	Me	Mo	Gr	Ha	St	Pl	St	C	W
	C2	25 - 40										Light brownish gray (10YR 6/2)	Yellowish brown (10YR 5/4)	Cl	-	-	Ma	Ha	St	Pl	St	C	W
	2C3	40 - 75										Light brownish gray (10YR 6/2)	Grayish brown (10YR 5/2)	C	-	-	Ma	Vha	Vst	Vpl	St	C	S
	C4	75 - 130										Light brownish gray (10YR 6/2)	Grayish brown (10YR 5/2)	C	-	-	Ma	Vha	Vst	Vpl	St		

Abbreviations:
V.G-sl= Very gravelly sandy loam V.G-ls= Very gravelly loamy sand V.G-s= Very gravelly sand G-ls= Gravelly loamy sand C=Clay Scl= Sandy clay loam Cl=Clay loam
Fi=Fine Me= Medium Mo= Moderate St= Strong Ma= Massive Sg= Single grains Gr= Gr=Granular Sb= Sub angular blocky So=Soft Lo=Loos Vha= Very hard Ha=Hard Sst= Slightly sticky
Nst= Non-sticky Vst= Very sticky St=Sticky Spl= Slightly plastic Npl=Non-plastic Vpl= Very plastic Pl=Plastic Ex= Extremely C= Clear G= Gradual S= Smooth W= Wavy I= Irregular.

Table (3): Some physical and chemical properties of the studied soil profiles

Profile No.	soil depth (cm)	OM %	$CaCO_3$ %	Gypsum %	EC_e dS/m	SP %	pH (1:2.5)	CEC cmol (+)/kg	ESP %	Gravel %	Sand %	Silt %	Clay%	Texture class
1	0 - 20	0.62	7.0	2.5	8.4	104.0	7.77	40.06	18.82	0.2	24.70	35.10	40.20	clay
	20 - 40	0.53	6.4	2.0	11.0	84.0	7.75	43.06	22.51	0.0	28.13	29.76	42.11	clay
	40 - 70	0.51	7.4	1.6	11.4	84.5	7.72	44.79	26.03	0.0	23.96	32.88	43.16	clay
	70 - 120	0.41	6.4	2.2	9.5	73.5	7.75	32.14	20.37	0.0	18.14	41.71	40.15	silty clay
2	0 - 10	0.12	11.0	1.8	15.2	63.5	7.51	22.29	16.96	0.5	53.23	25.56	21.21	sandy clay loam
	10 – 30	0.07	12.0	1.4	10.7	52.0	7.76	27.35	25.06	0.0	44.23	29.67	26.10	loam
	30 - 70	0.05	13.2	5.0	38.4	51.0	7.79	21.59	41.17	0.0	45.42	30.44	24.14	loam
	70 - 120	0.05	13.8	3.0	23.3	42.0	7.81	21.33	31.10	0.0	59.10	21.77	19.13	sandy loam
3	0 - 25	0.16	38.2	1.8	42.7	29.0	7.79	16.47	31.87	21.6	63.14	22.76	14.10	Gravelly sandy loam
	25 - 40	0.14	37.5	1.2	74.1	39.0	7.59	21.01	43.75	0.0	55.99	26.05	17.96	sandy loam
	40 - 110	0.16	48.9	1.4	23.7	44.0	7.67	24.19	24.86	2.5	52.21	24.67	23.12	sandy clay loam
4	0 - 25	1.11	2.7	4.0	15.4	68.0	7.46	31.13	46.44	1.0	51.30	22.50	26.20	sandy clay loam
	25 - 30	0.30	9.8	2.6	13.1	76.5	8.13	31.78	25.89	0.8	50.20	19.70	30.10	sandy clay loam
	30 - 45	0.22	13.2	1.3	10.5	77.5	8.11	19.85	27.21	0.4	55.10	12.50	32.40	sandy clay loam
	45 - 130	0.37	12.5	1.9	9.7	81.0	8.17	30.18	26.49	0.0	49.70	22.10	28.20	sandy clay loam
5	0 - 30	1.77	7.8	3.3	4.4	90.5	7.62	54.09	8.80	0.0	17.91	30.13	51.96	clay
	30 - 50	0.81	7.5	3.4	7.9	91.0	7.42	53.85	14.65	0.0	16.22	27.62	56.16	clay
	50 - 110	0.81	9.4	4.0	4.7	102.5	7.50	59.15	15.51	0.0	14.09	24.05	61.86	clay
6	0 - 35	0.08	12.0	2.2	6.0	27.0	8.03	8.09	7.27	0.5	87.13	6.76	6.11	loamy sand
	35 - 50	0.07	65.4	1.1	3.0	21.0	7.75	7.44	1.34	45.8	89.11	5.72	5.17	Very gravelly sand
	50 - 120	0.07	83.5	2.3	5.1	30.0	7.78	7.45	3.13	46.7	84.15	8.75	7.10	Very gravelly loamy sand
7	0 - 15	0.16	15.3	6.3	5.2	40.5	7.88	14.32	8.34	5.4	67.15	21.71	11.14	sandy loam
	15 - 35	0.07	11.0	4.6	4.2	33.0	7.74	8.44	1.42	0.0	75.10	16.79	8.11	sandy loam
	35 - 150	0.13	67.6	5.2	5.6	34.5	7.71	6.79	1.47	53.2	82.13	13.74	4.13	Very gravelly loamy sand
8	0 - 30	1.41	9.0	3.6	2.8	86.0	7.27	42.09	2.44	0.0	30.15	16.72	53.13	clay
	30 - 65	0.86	8.3	5.1	4.4	87.0	7.45	47.40	6.45	0.0	28.14	19.76	52.10	clay
	65 - 140	0.55	6.9	5.5	6.7	93.5	7.55	56.89	9.55	0.0	19.98	19.86	60.16	clay
9	0 - 25	0.16	49.2	6.5	11.2	33.5	7.76	16.79	9.49	57.4	76.13	9.73	14.14	Very gravelly sandy loam
	25 - 50	0.08	22.4	3.7	13.1	26.5	7.50	6.34	18.09	42.6	86.13	5.65	8.22	Very gravelly loamy sand
	50 - 80	0.16	23.7	4.0	7.8	21.0	7.58	5.17	3.65	45.6	92.08	1.82	6.10	Very gravelly sand
	80 - 150	0.08	22.4	1.6	16.9	23.0	7.57	9.32	10.46	33.9	88.17	4.72	7.11	Gravelly loamy sand
10	0 - 30	1.24	8.3	8.1	21.1	61.5	8.02	41.06	13.13	1.2	43.96	14.07	41.97	clay
	30 - 75	0.79	9.7	6.1	20.8	72.0	8.04	38.80	20.85	0.0	34.62	21.61	43.77	clay
	75 - 125	0.48	6.7	5.4	18.4	69.0	8.12	42.20	16.14	0.0	29.42	26.57	44.01	clay
11	0 - 10	0.81	11.7	5.8	31.6	54.0	7.20	18.57	11.65	0.2	62.11	15.75	22.14	sandy clay loam
	10 - 25.	0.96	13.1	5.5	47.4	52.0	7.32	31.24	29.78	0.0	53.16	19.69	27.15	sandy clay loam
	25 - 40	0.81	11.5	5.3	13.8	57.0	7.66	25.74	32.37	0.0	49.10	19.71	31.19	sandy clay loam
	40 - 60	0.52	12.5	3.5	14.1	66.5	7.77	36.05	32.17	0.0	43.98	21.90	34.12	clay loam
	60 - 120	0.44	12.8	3.5	9.4	64.0	7.78	22.66	26.85	0.0	47.08	23.67	29.25	sandy clay loam
12	0 - 25	0.47	12.3	4.8	6.1	62.5	7.58	27.28	17.06	0.0	41.50	22.30	36.20	Clay loam
	25 - 40	0.55	10.8	6.1	15.4	62.5	7.47	31.49	21.31	0.0	42.30	22.50	35.20	Clay loam
	40 - 75	0.16	13.7	5.9	11.9	68.0	7.54	38.32	20.93	0.0	37.50	21.10	41.40	Clay
	75 - 130	0.31	12.0	5.8	15.2	75.0	7.58	42.93	18.19	0.0	28.10	26.70	45.20	Clay

The surveyed soils show that gypsum content decreases with soil depth with low content since its value less than 7%. It is noteworthy to mention that the gypsum accumulation in surface layer could be mixed or over lined by accumulation salts zone. These features have direct effect on percolating water, which accumulate above these layers with low permeability, where salts precipitation occurs in most cases. Then water table rises and evaporates leaving the salts on the soil surface consequently inhibit plant growth (Wahba *et al*., 2004). The accumulation of pedogenic calcite is a common feature in the studied soil profiles of this arid area (table 3). The various climatic conditions have resulted in a variety of forms and content of calcite precipitation at various depths in the soil profiles. From several macro forms of pedogenic carbonate in the studied profiles, two types are observed namely; 1) round to sub-round calcite concretions of small to medium size, 0.5- 1.0 cm, and 2) angular to subangular lime concertinos about (2.5 cm).

The changes from a soft diffuse nodule to hard is due to churning or desiccation and these conditions are concordant with climate of Dakhla Oasis. Total carbonates content are generally high and either accumulates on the subsurface layer or decreases with soil depth. These soils can be grouped in four classes according to FAO (2006) depend on $CaCO_3$ content as follows:

1- Slightly calcareous soils, $CaCO_3$ content 0- 2 %
2- Moderately calcareous, $CaCO_3$ content 2- 10 %
3- Calcareous soils (strong), $CaCO_3$ content 10- 25 %
4- Extremely calcareous soils, $CaCO_3$ content > 25%.

Pal *et al*. (2001) mentioned that in semi-arid climate, remover of Ca^{++} ions from the soil solution occurs by precipitating carbonate and also causes the ESP and SAR to increase with soil depth. In general, the accumulation of calcium carbonate in the soils depends on the position pf the area, evaporation rates and the depth of percolating rainwater.

The electrical conductivity rannges between 3.0 and 74.1 dSm^{-1}. Soil salinity decreases with soil depth in profiles No. 4 and 10 while opposite direction is found in profile No. 8. Soil salinity in other profiles shows irregular trend with soil depth (Table 3). In general, the studied soils are considered salt-affected soils. The highest value of EC regarding the second layer of soil profile No.3 meets the requirements of salic horizon that could be classified as sodic haplosalids. The general trend of soluble salt distribution was found increasing from upper rolling topographic position to lower elevation, indicates that the appreciable amount of salts moved down the slope along with water flow.

In the present investigation the pH values of the studied soils ranges between 7.20 to 8.17 indicating that the soils are near neutral to slightly alkaline (Table 3). A critical examination of data indicates that soil pH in most cases was found to increase with depth in most of the studied soils. This increase level of pH down the depth of pedons was mainly due to movement of soluble salts and increased content of calcium carbonate. The higher pH values in soils of lower slopes and its increased value with soil depth could be attributed to the deposition of illuviated bases from surrounding upper slopes.

Cation exchange capacity in different profiles found to vary between 5.17 to 59.15 C mol $^{(+)}$ kg^{-1}. The CEC values decreases with soil depth in profiles No. 8 and 12 while opposite direction is found in profiles No. 3, 5, 6 and 7 (Table 3). The CEC values in other profiles shows irregular trend with soil depth. A critical examination of data indicated that the cation exchange capacity of soils was found to be closely related to the clay content and for some extend to organic matter content. The soil with the highest CEC was the vertic torriorthents which had the highest clay content (profile No. 5), while Typic torripsamment soil had the lowest clay content (profile No. 6). The drifting of clay along with the bases down the slope might be the factor for the increased level of cation exchange capacity in subsurface layer of soils. It can be inferred that increase in clay content provide more exchange sites to get the cations adsorbed on it (Bhatia *et al*., 2005 and Maji *et al*., 2005).

The values of exchangeable sodium percentage (ESP) ranges from 1.34 to 46.44. The highest value of exchangeable sodium percentage (46.44) was found in the surface layer of profile No. 4 while the lowest value (1.34) was recorded in subsurface layer of profile No.6 (Table 3). In general, the soil profiles are considered very sodic soil since the ESP > 15 in most soil layers.

Sand content of the studied soil profiles ranges from 14.09 to 92.08 % and it decreases with soil depth (Table 3). Generally, soil texture was coarser on the higher landforms or sloping landforms, because the fine materials like silt and clay are removed from the relatively higher location to those portion where slopes become gentler attain heavily level relief. The silt content of the studied soil profiles varies from 4.72 to 41.71 % with a weighted mean value of 20.74% (Table 3). The highest value of silt fraction (41.71%) was recorded in the deepest layer of profile No. 1 while the lowest one (4.72%) was observed in the deepest layer of profile No. 8. An increasing trend of higher silt content from elevated topographic position to lower topographic position as well as down soil depth of studied profiles was observed which could be attributed to the movement of silt particles along with downward movement of water as well as due to erosion agents. The clay content varies from 4.13 to 61.86 % with a mean value of 30.1% (Table 3). The highest value of clay fraction (61.86%) was recorded in the deepest layer of profile No. 5 while the lowest one (4.13%) was observed in the deepest layer of profile No. 7.

- *Soil classification:*

The taxonomic classification of the studied soil profiles has been worked out based on morphological, physical and chemical properties and climatic data according to Soil Taxonomy (USDA, 2014). On basis of the soil properties within the profile control section, soils belonging to the taxonomic units could be differentiated into orders, suborders, great groups and subgroups (Table 4). In the light of the relevant soil properties, the studied soil profiles could be differentiated into the order Entisols (profiles No. 5, 6, 7, 8, 10 and 12) and aridisols (profiles No. 1, 2, 3, 4, 9 and 11) as they have an aridic soil moisture regime, an argillic, cammbic, nitric and salic horizons. The soil orders are further taken down to the suborder level, using the other differential characteristics. Since the soil profiles No. 1, 2, 3 and 4 could be represented argids suborder. The soil profiles No. 5, 7, 8, 9 and 12 represents orthents suborder. The soil profiles No. 3, 6 and 9 represents salids, psamments and calcids suborder, respectively. The great groups which belong to the suborders in the investigated area are Natrargids (profiles No. 1, 2, 4 and 11), Haplosalids (profile No. 3), Torriorthents (profiles No. 5, 7, 8, 10 and 12), Torripsamments (profile No. 6) and Haplocalcids (profile No. 9). The subgroups which belongs to those great groups in the investigated area are Typic Natrargids ((profiles No. 1, 4 and 11), Salic Natrargids (profile No. 2), Sodic Haplosalids (profile No. 3), Vertic Torriorthents (profiles No. 5, 8 and 12), Typic Torripsamments (profile No. 6), Typic Torriorthents (profile No. 7), Sodic Haplocalcids (profile No. 9) and Sodic Torriorthents (profile No. 10).

Table (4): Soil taxonmic units of the studied soil profiles.

Profile no.	Order	Suborder	Great group	Subgroup	Family
1	Aridisols	Argids	Natrargids	Typic Natrargids	Fine-clayey , mixed, hyperthermic, Typic Natrargids
2	Aridisols	Argids	Natrargids	Salic Natrargids	Fine-loamy, mixed, hyperthermic, Salic Natrargids
3	Aridisols	Salids	Haplosalids	Sodic Haplosalids	Loamy, mixed, hyperthermic, Sodic Haplosalids
4	Aridisols	Argids	Natrargids	Typic Natrargids	Fine-loamy, mixed, hyperthermic, Typic Natrargids
5	Entisols	Orthents	Torriorthents	Vertic Torriorthents	Fine-clayey, mixed, hyperthermic, Vertic Torriorthents
6	Entisols	Psamments	Torripsamments	Typic Torripsamments	Sandy, mixed, hyperthermic, Typic Torripsamments
7	Entisols	Orthents	Torriorthents	Typic Torriorthents	Loamy, mixed, hyperthermic, Typic Torriorthents
8	Entisols	Orthents	Torriorthents	Vertic Torriorthents	Fine-clayey, mixed, hyperthermic, Vertic Torriorthents
9	Aridisols	Calcids	Haplocalcids	Sodic Haplocalcids	Loamy, mixed, hyperthermic, Sodic Haplocalcids
10	Entisols	Orthents	Torriorthents	Sodic Torriorthents	Fine-clayey, mixed, hyperthermic, Sodic Torriorthents
11	Aridisols	Argids	Natrargids	Typic Natrargids	Coarse-loamy, mixed, hyperthermic, Typic Natrargids
12	Entisols	Orthents	Torriorthents	Vertic Torriorthents	Fine-loamy over clayey, mixed, hyperthermic, Vertic Torriorthents

Conclusion:

The climatic normals of the studied area can be defined as hyperthermic and torric. Sand, silt and clay content of the studied soil profiles ranges from 14.09 to 92.08 %, from 4.72 to 41.71 % and from 4.13 to 61.86 %, respectively. Soil texture was coarser on the highly landforms or steep landforms. Topography of the landscape is almost flat of its relief with level to nearly level sloping, and its geomorphology is considered as depression inheriting shale or lime stone or sand stone as a parent material with elevation ranges from 102 and 163m ASL. The studied soils are considered salt-affected soils (EC > 4 dS/m). The pH values of the studied soils ranges between 7.20 to 8.17 indicating that the soils are near neutral to slightly alkaline. The organic matter (OM) content in the soil profiles was very low varied from 0.05 to 1.41%. The cation exchange capacity of soils was found to be closely related to the clay content and for some extend to organic matter content. The soil with the highest CEC was the vertic torriorthents which had the highest clay content, while Typic torripsamment soil had the lowest clay content. In the light of the relevant soil properties, three suborders could be distinguished under the order Aridisols, namely Argids, Salids and Calcids and two suborder Psamments and Orthents are related to the order Entisols. At the great group level under Aridisols order, three categories could be distinguished, namely; Natrargids, Haplosalids and Haplocalcids. Under these three great groups, the identified subgroups are Typic Natrargids, Salic Natrargids Sodic Haplosalids and Sodic Haplocalcids. At the great group level under Entisols order, two categories could be distinguished, namely; Torriorthents and Torripsamments. Under these two great groups, the identified subgroups are Vertic Torriorthents, Typic Torripsamments, Typic Torriorthents and Sodic Torriorthents. It is worth to mention that the area under investigation has a high potentiality for agricultural utilization.

References

Abdel-Kader, F.H., W.F. Erian and R.K. Yacoub, 2004. Evaluation of land degradation severity by using the ordinary kriging in west Nubariya region, Egypt. Egypt. J. Soil Sci., 44(3): 407-427.

Allam, A., E. Saaf and M. Dawoud, 2002. Desalination of brackish groundwater in Egypt. Desalination, 152: 19-26.

Alvarenga, P., P. Palma, A. de Varennes and A.C. Cunha-Queda, 2012. A contribution towards the risk assessment of soils from the São Domingos Mine (Portugal): Chemical, microbial and ecotoxicological indicators, Environ. Pollut., 161: 50-56.

Bashour, I. and A. Sayegh, 2007. Methods of Analysis for Soil in Arid and Semi-Arid Regions FAO, Roma, p: 119.

Bhatia, A., G.B. Roy and D. Saha, 2005. Study on soils of Budhabudhaiani irrigation project in Nayagarh district of Orissa : 1. Characteristics and classification of soils and their productivity potential. J. Indian Soc. Soil Sci., 53: 163-171.

Black, C., 1982. "Methods of soil analysis". 2nd edition. Chemical and microbiological properties. Agronomy series no. 9, ASA, SSSA, madison, Wis., USA 1982.

Brookes, I.A., 1993. Geomorphology and Quaternary Geology of the Dakhla Oasis Region, Egypt. Quaternary Science Reviews, 12: 529-552.

CONOCO, 1987. Geologic map of Egypt. Egyptian general authority for petroleum (UNESCO joint map project), 20 sheets, scale1:500000.Cairo,Egypt.

Dengiz, O., C. Göl, S. Karaca and M. Yüksel, 2006. Effects of different landscape position and parent material on soil variability and land use in both sides of Acicay River-Çankırı. International Soil Meeting on Soil Sustaining Life on Earth, Managing Soil and Technology Proceedings, II: 745-751, Sanlıurfa, Turkey.

Egyptian Meteorological Authority, 1996. Climatic Atlas of Egypt. Published Arab Republic of Egypt, Ministry of Transport, Cairo, Egypt, p: 157.

ElKhawaga, M.L., E.R. Philobbos, S. Riad, 2005. Stratigraphiclexicon and explanatory notes on the geological map of the South Western Desert, Egypt, 81 sheets, scale 1:250,000. UNESCO, Cairo.

FAO, 2006. Guidelines for soil description. Food and Agriculture Organization of the United Nations. Rome, Italy.

Hermina, M., 1990. The Surrouding of Kharga , Dakhla and Farafra. In :Said , R. ZAd. The Geology of Egypt. AA. Balkema, Rotterdam.

Hermina, M., E. Klitzsch and F.K. List, 1989. Stratigraphic Lexicon and Explanatory Notes to the Geological Map of Egypt. 1:500,000 Conoco Inc., Cairo.

Hesse, P.R., 1998. A Textbook of soil chemical analysis. CBS Publishers & Distributors. Delhi,India.

Hussein, A.M., 1993. Characterization of some soil families in Dakhla Oasis. Al-Azhar J. Agric. Res.,18: 339-352.

Jackson, M.L., 1973. Soil chemical analysis. Prentice-Hall of India Private limited New Delhi.

Kleindienst, M.R., C.S. Churcher, M.M.A. Mcdonald and H.P. Schwarcz, 1999. Geography, geology, geochronology and geoarchaeology of the Dakhleh region: An interim report. In C. S. Churcher and A. J. Mills (Eds), Reports from the survey of the Dakhleh Oasis 1977-1987 (pp.1-54). Oxford: Oxbow Books.

Maji, A.K., R.G.P. Obi, S. Thayalan and N.J. Walke, 2005. Characteristics and classification of landforms and soils over basaltic terrain in sub-humid tropics of central India. J. Indian Soc. Soil Sci., 53: 154-162.

Mahajan, A., S.K. Sharma, D. Gupta and R. Sharma, 2007. Morphological, physical and chemical properties of soils from North West Himalayas. Bulgarian J. of Agric. Sci., 13: 607-618.

Nelson, R.E., 1982. Carbonate and Gypsum. In Page, A. L., R. H. Miller and D. R. Keeney (eds.) Methods of soil analysis. Part 2 – Chemical and microbiological properties. (2nd Ed.) pp: 181-197.

Pal, D.K., S.S. Balpande and P. Srivastava, 2001. Polygenetic Vertisols of the Purna Valley of central India. Catena, 43: 231-249.

Piper, C.S., 1950. Soil and Plants analysis. Inter. Science, Inc., New York.

Rahim, I.S. and G.W. Ageeb, 2003. Influence of land use in some Quseir shale derived soils in Dakhla and Kharga Oasis, Egypt. Egypt. J. Soil Sci., 43(3): 377- 387.

Richards, L.A., 1954. Diagnosis and Improvement of Saline and alkali Soils. United States Salinity Laboratory Staff, Department of Agriculture, Hand Book, No.60.California, USA.

Said, R., 1961. Tectonic framework of Egypt and its influence on distribution of foraminifera. Bull. Am. Assoc. Petrol. Geologists., 45: 198-218.

Schoenberger, P.J., D.A. Wysocki, E.C. Benham and W.D. Broderson, (editors), 2012. Field Book for Describing and Sampling Soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Soil Survey Staff, 1951. Soil Survey Manual, U.S. Dept. Agric., Handbook No. 18, government printing office, Washington, D.C.

UNCCD (United Nation Convention to Combat Desertification) Egypt Office. 2005. Egyptian National Action Program to Combat Desertification. Ministry of Agriculture & Land Reclamation and Desert Research Center.

USDA, 2014. Keys to Soil Taxonomy. United State Department of Agiculture, Natural Resourcess, Conservation Service (NRCS), Eleventh Edition.

Wahba, M.M., G.W. Ageeb, I.S. Rahim and F. Awad, 2004. Lime and gypsum accumulation as important parameters in the classification of the soils of Sahl Baraka, Farafra Oasis. Egypt. J. Soil Sci., 44(2): 159-169.