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RELATIONSHIP BETWEEN LANDFORMS AND SOIL CHARACTERISTICS IN BAHARIYA OASIS, EGYPT

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ABSTRACT

Bahariya Oasis is a natural depression located in the western desert of Egypt. The whole region is under hot arid condition. The images and GIS capabilities were used to generate soil maps. Six landforms were identified and soils availability of groundwater in the depression initiated cultivation of date palms and the associated industrial and economic activities. Due to abundant groundwater, the lands there gave indications of promising agricultural expansion. Study of the landforms and soils associated with them can give a general survey of soil characteristics. Landsat occupying are studied. The landforms include; plains, depression floor with low, moderately high and high lands, Mesa and plateau, and pediplains. Studying their morphological, chemical and physical characteristics, the soils were classified under the following taxa; Haplogypsids, Haplosalids, Calcisalids, Gypsisalids, Calcigypsisalids, Torriorthents and Torripsamments. Calcium and gypsum accumulations are found in saline soils in most of the soils. In the low lands, drainage may have serious problems. The presence of groundwater and the problem of drainage are common in most of the depressions. The challenge is to be aware of the problem and to design a proper and appropriate soil and water management system.

Keywords: Landforms, plains, Mesa, pediplains, Bahariya Oasis, Egypt.

INTRODUCTION

The western desert depressions generally called as Oases are excavated from south to north in cretaceous (Dakhla, Kharga, Bahariya and Farafra), and Eocene - Miocene (Wadi El Nartun, Siwa and Qattara). The bottom elevation of most of these depressions reach the Cretaceous, composed essentially of sandstone which is in most locations below sea level. The Cretaceous sandstone locally named Nubian sandstone is the richest groundwater aquifer in Egypt and North Africa. Groundwater is tapped from wells and springs and is generally fresh. The soils there, though highly saline could be reclaimed, desalinized and cultivated using the available groundwater for irrigation. Drainage in these depressions becomes a problem. Consequently, many sabkhas and highly saline lakes are generally formed in the mot deepest areas. These lakes are generally used as drainage basins (CONCO).

Arid conditions are prevailing under this environment, not only the easily soluble and slightly soluble salts become mobile but also some silicates slightly weathered and their constituents also become relatively mobile, especially in the alkaline media. Accordingly some translocation processes take place partially in the top most layers. Parent materials differ in composition from one place to another because of the variations in their geological origin and their position in the landforms. These materials reflect their characters on the formed soils. As a consequence of the rapid rate of evaporation, salts sometimes do not penetrate deep but accumulate on the surface forming crust or just below the surface.

Hammad *et al.* (1977) showed that, the soils of Natrun - Maryout area are characterized by the formation of an evaporite horizon. This horizon is differentiated to sub horizons. In the soils of the old deltaic plain, the presence of calcium carbonate and gypsum accumulations also evidences of chemical weathering in such desert soils, indicating certain chemical reaction processes where Ca^{++} can be provided by the dissolution of calcium bearing minerals and CO_2 is supplied from atmosphere or plant roots.

They studied two profiles formed under arid conditions, one of them is a weathering profile and the other is stratified, due to its high water table, where leaching is impeded. However the favorable oxidizing condition at the surface can explain the abundant weathering of minerals at that horizon. They also noticed that anhydrite is only found in the soils of depressions irrespective of the presence of gypsum in both depression and old deltaic plain, a case which could point out direct precipitation of anhydrite in a hyper saline solution rather than as accumation in a Gypsic horizon.

Hammad and Abdel Salam (1968) stated that the only prominent feature of development of calcareous soils of the western coast of Egypt is the formation of different types of calcium carbonate accumulation genes (Calcic horizon).They concluded that the position of profiles in landforms have direct bearing of the type of horizon as it controls the relation between evaporation of the received rain water. In general they found that according to the postion in the landforms, the Calcic horizon vary in position, thickness and type.

Hammad (1976) studied the soil landscapes and sedimentary history of the Natrun, Maryut Area, Egypt. He concluded that aridity conditions have resulted in the degradation and aggradations of the old sur faces in that area. Exposition of lime crustes at surfaces its silicification in the top. The previously lake environment is responsible for the presence of evaporates and paleogley layers in the old deltaic plain. He arrived at the conclusion that the major soil processes are the leaching and deposition of lime, gypsum and soluble salts in a composite layer designated as evaporitic horizon.

Khresat (2001) found a relationship between the landscape and the depth of Calcic horizon and found that the Calcic horizon in the concave landscape is deeper than the other sites. The concave landscape position increases the amount of effective precipitation and consequently leads to higher leaching of carbonates. Emadi *et al.* (2008) stated that, calcium carbonate content and landscape physiography indicated that the lower the physiography conditions, the deeper the calcium carbonate accumulation in soils.

Vieillefon (1976) mentioned that, gypsum can be transported by water or wind and re-deposited in new locations forming individual gypsum dunes or becoming incorporated with the soil. Eolian deposits of gypsum are well known in the south-western United States, North Africa, Asia and south-east Australia.

Topography has been recognized as an important factor. In soil formation since the earliest scientific consideration of soils (Jenny, 1980). According to Joffe (1949) the formations of soil in a region can occur within a certain period of time depending on the parent material, climate, topography and vegetation (Buol *et al.,*1980; Dinc *et al.*,1987).A soil landscape pattern generally reflects the original parent material; however saprolite was highly weathered prior to soil formation(wysocki et al.,1988).

The uniformity and weathering sequence of the present sediments were also examined according to the ration suggested by Hasseman and Marshall (1945) as well as by Hammad (1968). (Phillip *et al.,* 1987) defined most of the examined soils as derived from the clay and sandy members of Bahariya formation.

Hanna (1977) found that the virgin soils of Bahariya Oasis have great changes in their mechanical fractions throughout the different layers of profiles. The cultivated soils also showed significant changes in texture among the profile layers.

The study area covers nine landforms, and different ages with various locations in Bahariya Oasis. The objective of this study was to examine the relationship and effects of landforms on the physical, chemical and morphological characteristics of soils of Bahariya Oasis of Egypt and the relationships between soil characteristics and environmental variables including physiographic features. Also the study aims to relate different features of soils derived from various parent rocks with landforms.

MATERIALS AND METHODS

Location and environmental setting

Bahariya Oasis is a natural depression in the southern portion of the Egyptian desert located some 130Km west of Samalot in the Nile valley and about 300 km southwest of Cairo between latitudes 27° 48´ and 28° 30´ N and longitudes 28° 35´ and 29° 10´ E . The value of aridity degree for El-Bahariya Oasis (0.30) as determined by the application of Embergers formula (1955). Q = 100R/ (M*m) (M-m). Is reflecting well a desert condition according to the classification posted by Emberger where values of aridity between (0-20) reflect desert condition. The very low values also indicate extreme aridity condition, assuming yearly precipitation a total of approximately 0.36 mm and a mean evaporation of 10.50 mm. The mean annual temperature is 14.25.The area is one of the well known features in the western desert. It attracted the attention of geologists and some soil scientists, and gained special interest in recent years as a result of containing iron ore deposits of economic importance. The Bahariya Oasis forms a large elliptical depression in the northern part of the western desert trending NE-SW direction for nearly 95 km. The width ranges from 3 Km to about 45 km. The greatest width is near latitude 28° 10´.

Soil mapping and sampling

Twenty soil profiles were selected according to differences in geomorphic units. The soil profiles were described in the field according to Soil Survey Staff (1993) and were classified according to soil taxonomy (Soil Survey Staff, 2006). The location of these profiles is demonstrated Fig 1.

Digital elevation model (DEM) of the study area has been generated from the elevation points (recorded during the field survey by GPS), and the the victor contour lines were plotted; Arc-Vew GIS 9.2 softwere was used for this function. Landsat ETM imges (2001) and digital elevation model (DEM) were used in ENVI 4.5 software to produce the physiographic map of the study area.

The remotely sensed data and soil maps were geometrically rectified to the projection of Universal Transverse Mercator (UTM) coordinate system optimally enhanced and histogram matched to be compared during the visual interpretation through Arc GIS software. The root mean square error (RMSE) for the rectified image was less than 0.4 pixels. The DEM generated and the slope class map of the study area are merged with color the composite Landsat image of the studied area to delineate soil boundaries and other land features by visual interpretation. A 3D perspective view map and a hill shade relief map were generated using the DEM where the 3D presentation of the landscape is required to detect the soil and landform relationships.

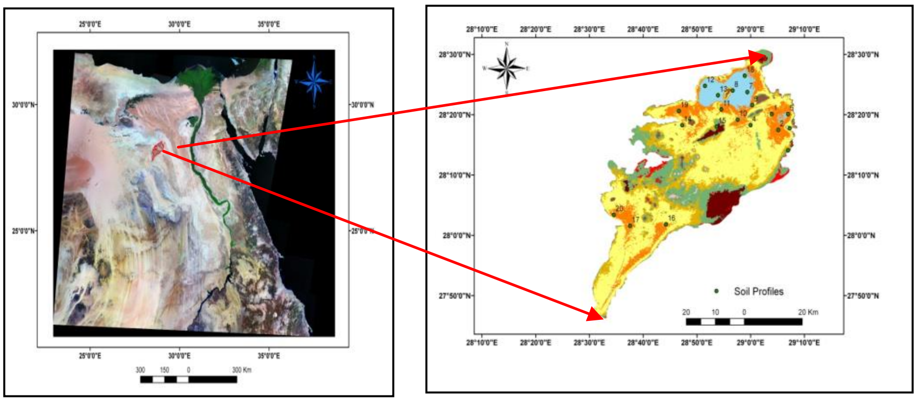

Fig. 1: Location map of Bahariya Oasis showing sites twenty representative soil profiles.

Laboratory analysis

Soil samples were air-dried and sieved through a 2mmseive. Particle – size distribution analysis was carried out by sieving and sedimentation, using the pipette method (Day 1965). Prior to dispersion, samples were treated to remove carbonates ((dissolution by 2N HCL), organic matter (oxidation by 30% H_2O_2) and soluble salts (by leaching). Sodium Hexametaphosphate was added to prevent re-flocculation of colloidal material. The pH was measured in the saturated paste with a glass electrode using (Jenway manufactured in USA). The salt content (electrical conductivity, EC) was measured in saturation. Extracts (HANNA, HI 99301 made in Romania). Cation exchange capacity (CEC) was determined using sodium acetate (NaoAc) at a pH of 8.2 (Chapman 1965). Organic matter in the soil was determined following Walkely and Black rapid titration method, Jackson (1975). Gypsum ($CaSO4.H2O$) was determined by precipitation with acetone (Salinity laboratory staff, (1954). Total carbonates were determined using the Collines Calcimeter method, (Salinity laboratory staff, 1954). Soluble cation and anions in the saturation extracts were determined according to the procedures described by Jackson (1975).

Table 1: Stratigraphic correlation, landforms, soil taxonomy, Geological formation and location of soil profiles.

Region	Landforms		Soil profile	Soil Tax. Of great group	Geological formation	Age	location	Area Km^2
Bahariya oasis	plains		5	Torripsamments	Bahariya Formation	Cenomanian	Ain saad	141 Km^2
			7	Haplogypsids			Ain Guffara	
			12	Torriorthents	Naqb Formation	Early to middle Eocene	Side of Gabel El-Dist	
			13	Haplogypsids	Bahariya Formation	Cenomanian	Ain El-gazzarin	
			18	Torriorthents	Hefhuf formation	Campanian Lat Cretaceous	Ezbit El-Ris	
	Depression Floor	Lowland	1	Gypsisalids	Bahariya Formation	Cenomanian	El-Harra side in way	300 Km^2
			2	Torripsamments			Ain-clite	
			9	Haplosalids			Kabala	
			10	Torripsamments			El-Agous	
			19	Torripsamments	Hiz Formation		Ain Madi	
		Moderately High land	4	Haplosalids	Bahariya Formation		Ain El-wadi	953 Km^2
			11	Torripsamments	Ghorabe Iron Ore Member	Oligocene	El-zabu	
			14	Haplosalids	Radwan Formation		Side of Gabale Hammade	
			16	Calcigypsisalids	Bahariya Formation	Cenomanian	Table Amon	
		High land	3	Torripsamments	Hamra formation	Middle and Upper Eocene	Ain Haswi	332 Km^2
			17	Haplosalids	Hiz Formation	Cenomanian	Ain El-Izza	
			20	Torripsamments	Khoman Chalk	Lat Cretaceous Maostrichtion	Side of gabal El-Hize	
	Mesa and Plateau		8	Calcisalids	Naqb Formation	Early to middle Eocene	Qassa	88 Km^2
			15	Gypsisalids	Plateau Limestone	Middle Eocene	Sid of Gabel El-Hafhuf	
	Pediplains		6	Torripsamments	Qazzun formation	Middle Eocene	Ain Gidid	291 Km^2

Physiographic Feature

Geomorphology of Bahariya Depression

According to Metwally (1953) and Said (1962), the major part of the oasis floor is a flat or gently undulating ground of sandstone and layers of clay, strewn with fragments of rocks derived from the hills. The lowest part of the oasis floor appears to be in the neighborhood of El-Qasr and El-Bawiti, where the altitude is about 113 m. above sea level;

The most important geomorphic features include:

- The alternating weak and strong beds and their influence on topography.
- The marked parallelism of NE-SW ridges.
- Geologic structure and its control of the small wadis.
- The position and outlines of the folds, exemplified in the ridges formed by the alternating weak and strong beds.

The most striking feature in the geomorphology of Bahariya is the large number of hills within the depression. Most parts of these hills have a black shape due to the nature of the rock capping them. The darkness of Gebel Mandisha is due to the eruptive rocks that cap its flat top. Similar hills are found in Gebel Mayesara to north of Gebel Mandisha. Gebel Ghorabi in the north of the oasis is black because of the presence of considerable quantities of iron. Gebel El-Hufhuf has a narrow ridge similar to that of the hills in the center of the Oasis. It also has a black appearance as it is composed of dolerite. However, the rest areas are entirely capped with brown limestone. The most strongly marked group of hills is extending from north to east in a nearly straight direction across the center of the Oasis.

Geology of Bahariya Depression

The geological section in Bahariya Oasis and its surroundings comprises the following units from the oldest to the youngest.

Bahariya Formation:

This formation covers the floor of the oasis and the major part of the scarp and the isolated hills in the depression. The exposed thickness of the Bahariya Formation varies from few meters at the western scarp to more than 170 m at Gebel El Dist in the north central part of the depression, mostly formed of friable, false-bedded, variegated sandstones with harder dark brown ferruginous quartzitic sandstone beds. Fluviatile sandstone and siltstone in the lower part grading upward into alternating beds of estuarine sandstone and shale in the essential composition.

Heiz formation:

The Heiz marks the first carbonate deposits in Bahariya Oasis, made of 30m thick clastics with carbonate interbeds and dolostone member at top. Basal and upper members of reddish brown dolomatic sandstone and siliceous dolostone, enclosing a middle member of sandy clay and calcareous grit, varicolored, with ironstone concretions and flint. They represent shallow marine deposits.

Hefhuf Formation:

The formation is exposed on both the eastern and western scarps of the Bahariya Oasis, and also in almost all the northerly isolated hillocks especially these well developed at Gebel Hefhuf. Dolostone with sandstone and sandy clay interbeds, occasional thin gritty phosphatic beds in the upper part is the general composition.

Khoman Chalk: of this formation.

The khoman consists of 50 m thick chalk and limestone beds with hard dolomitic limestone band at top. Snow-white to light tan, chalky calcilutite, moderately hard, fractured and with calcite fillings.

Plateau Limestone:

A succession of limestone beds with few marly and clayey interbeds uncomfortably overlies different Cretaceous rocks at different parts of the Bahariya area. To the north of the depression the limestones on top of the Bahariya belong to the middle Eocene. At the Bahariya northern plateau and farther northeast at El Bahr depression and its surrounding plateau, the limestones include both Midlle and Upper Eocene fauna. Here Said and Isswi (1965) classified the section into the following units, from base to top:-**Naqb formation:**

The Naqb forms the lower unit of the Plateau group, a name introduced by Said and Issawi (1965) to replace the Plateau Limestone. The formation attains a characteristic dark grey to pink color which contrasts with the white or pale color of the overlying formations. The upper part of the Naqb assumes at the present stage of geomorphic development a characteristic mature landscape composed chiefly of many widely spaced conical hills with steep slops.

- Lower member: dark gray to pink, non-fossiliferous dolomitic and siliceous limestone.
- Upper member: Fossiliferous limestone beds with minor clay and conglomeratic intercalations.

The Ghorabi Iron Ore Member:

The origin of this important economic deposits has stirred much dispute among several workers from lacustrine deposits of Oligocene age (Ball and Beadnell, 1903) to replacement in post Midlle Eocene time (Gheith, 1959) to metasomatic replacement of Lower Eocene limestone's as well as precipitation from colloidal solution and by cavity filling (Nakhla, 1961) and diagenetic replacement (El akkad and Issawi, 1963 and Said and Issawi, 1965).

The presence of clay, sandstone, conglomerate and other clastics within the iron ore succession and also below it showing no signs of ferruginous, indicate deposition during minor episodes of water climates in the evolution of these emphemeral lagoons. This process explains,(1) the shape of the deposit (2) the sharp lower contact of the ore (3) the lateral pinching out of the Naqb beds (4) the correlatability of the Naqb beds and the Ghorabi Iron member (5) the presence of non ferruginated coarse and fine clastics within the iron beds and also below them (6) the presence of replaced marine fossils and oolites (7) the recurrent presence of diastems and (8) the association of halite, barite and gypsum in the ore.

The Qazzun Formation:
This Formation covers a large tract of the plateau surface north and northwest of the Bahariya Oasis. Lagoonal limestone: white to gray to yellowish, thinly-bedded, partly crystalline, partly chalky, occasionally siliceous and/or dolomitic, common calcite pockets. The limestone includes characteristic melon-shaped concretions of siliceous limestone.

The Hamra Formation:
The hamra makes many of the hills and ridges of the Bahariya northern and western plateaus. Shore line, partly algal reef limestone, yellowish-brown, abundant detrital grains, numerous skeletal remains, intraformational conglomerates.

The Radwan formation:
The formation is 40m at its type section in Gebel Radwan located at the central west part of the depression. Lithologically, the Radwan is formed of dark brown non-fossiliferous ferruginous grits and sandstones. The formation was probably formed in connection with an Oligocene sinous river system which flowed over the Bahariya area before the depression was formed.

The Volcanic Rocks:
These rocks occur in the Bahariya Oasis mainly as capping Gebel Maysera, Gebel Mandisha, the northern part of gebel Hefhuf, the Basalt Hill and small conical hill to the west of Qala Siwa. The volcanic cover of the Bahariya Formation and the sandstones at the contact are altered by the eruptions.

RESULTS AND DISCUSSION

1.Geomorphological units (landforms) geological maps of the Oasis together with the generated digital elevation modal were used identify the exiting landforms. Field work verified the presence of these units and enabled the description of these units. Location of soil profiles were preliminary determined to characterize the soils occupying the surfaces of these units. However the field conditions decided their locations (fig.2).The landforms identified are given in Table 1, where four major geomorphic units were formed.These are;

Plains. These areas occupy extended almost flat terrain in the northern east and west (141 km^2) considerably; they are the best suitable lands for traditional crops. Their elevations lower than their surroundings impede natural drainage and hence encourage water table rising. Isolated small sabkhas exist within shallow deflational depressions. Aeolian sand deposits cover more than half of the surface in the form of sand sheets, dunes and hummocks.

Depression floor. According to the elevations encountered in these major units, three submits were recognized. Those are, low lands, moderately high land, and high lands. (300 km^2, 953km^2 and 332km^2 respectively)The topography in general is undulating, locally hilly. This major landform is covering most of the depression surface. The high lands are located in the center of the depression separating the northern territories from the southern ones. The general prominent features in these are is salinity. Water table is generally higher. Due to excessive evaporation, salinity deteriorates and salts are noticed on the surface of the low and the relatively moderately high lands. Shale deposits in the layers of the prevailing formations developed loamy to clay loamy soils covering these units.

Mesa and erosion remnants. These are essentially eroded remnants above the surrounding country. They dominant the eastern pastes of the oasis where they caver an area of about 88Km^2. Exposed rocks of these units. Salinity and gypsum formations are secondary accumulations.

Pediplains. The pediplains are rock lands at the foot of scarps of the high lands and the oasis depression steep slopes (291km^2). They are rocky in general covered with a desert pavement of rock of rock fragments. These fragments are silicified and ferrogenated at the surface.

Soils in the landforms. Using the digital elevation model (DEM Fig 2) generated from topographic and contour maps was merged with the unsupervised landsat image (2010), a soil map was elaborated (Fig 3). The field work a chivvied and representing the soil mapping units and describing soil profiles Table (1). Soil mapping units identified are described in the following

Soils of the plains. The formation dominating this unit is composed of fluviatile sandstone overlain by alternating beds of estuarine sandstone and shale. The soils therefore might have been developed or originated from these rocks (Table 1). The soils are generally sandy to sandy loam, occasionally sandy clay loam (Table2). With regard to the surrounding limestone of the plateau, the soils containing calcium carbonate relatively little amounts ranging between 0.0 to 12.90. Gypsum is not found except in profiles 7 and 13. Gypsic horizon is only horizon developed in the soils developed probably on Bahariya rock formation. The soils in this unit is classified as; (Table 6) and Fig 3.

Aridisols

Haplogypsids

Entisols

Torripasmments *Torriorthents*

Soils of the depression floor. These are soils developed from Bahariya and Hiz formations. Hiz formation in particular, is formed essentially of reddish brown dolomitec sandstone and siliceous dolostone. The formation is rich in ironstone concretions. Hamra formation is essentially reef and algal limestone and hence contributing to calcareousness of these soils. The soils are color between reddish brown, reddish yellow and brownish yellow. Due to higher iron oxide contents the color of the soils are generally reddish yellow, Table (3). The field texture in generally sandy reflecting texture composition of their parent rocks. Most of the soils of this unit are saline. The lower the elevation is the higher salinity is recorded (Table 3). The soils are classified as bllows; (Table 6).

Aridisols

Haplosalids *Haplogypsids*

Entisols

Torripasmments

Table 2 : Some Morphological, physical and chemical characteristics of the studied soil profiles.

Morphological description of the studied soils (plian)										
Profile No.	Depth Cm	Mynsell color		Field texture	Structure	Consistence			Boun-dary	location
		Dry	Moist			Dry	Stick	Plastic		
5	0 -15	10YR 8/6	10YR 5/6	S	M A	L O	SST	NPL	C S	28º 20' 5.2" N 29º 06' 58.5" E
	15 - 50	10YR 8/4	10YR 5/4	S	M A	L O	SST	NPL	D W	
	50 - 90	10YR 8/6	10YR 5/6	S	M A	L O	SST	NPL	A S	
	90 - 150	10YR 7/6	10YR 4/6	S	M A	L O	SST	NPL		
7	0 - 37	10YR7/6	10YR 5/6	S C L	A B	S O	SST	SPL	G W	28º 17' 44.3" N 29º 57' 16.3" E
	37 - 65	10YR 7/4	10YR 5/6	S C L	M A	L O	SST	SPL	A S	
	65 - 115	10YR 7/4	10YR 4/4	S C L	M A	L O	SST	SPL	C S	
	115- 150	10YR 7/4	10YR 5/6	S	M A	L O	SST	NPL		
12	0 - 37	10YR4/3	10YR 3/3	S L	W E P L	S H A	S S T	S P L	A S	28º 24' 46.9" N 28º 51' 30.9" E
	37 - 85	10YR4/4	10YR 2/3	S L	M O S B	H A	S S T	S P L	C S	
	85 - 150	10YR 5/3	10YR 4/3	S C L	P L	H A	S T	P L		
13	0 - 30	10YR 7/6	10YR 6/6	L S	M A	L O	N S T	N P L	C S	28º 23' 13.0" N 28º 53' 56.3" E
	30 - 65	10YR 7/4	10YR 5/4	S L	W E P L	S O	S S T	S P L	A S	
	65 - 120	10YR 7/4	10YR 5/4	S	S G	L O	N S T	N P L	A S	
	120- 150	10YR 7/6	10YR 4/4	L S	M A	L O	N S T	N P L		
18	0 - 25	10YR 8/4	10YR 5/6	S	S G	L O	N S T	N S T	C S	27º 59' 13.0" N 28º 43' 38.2" E
	25 - 80	10YR 8/6	10YR 6/6	S	S G	L O	N S T	N S T	C S	
	80 - 150	10YR 8/6	10YR 8/3	SL	M O S B	S H A	S S T	S P L		

Total $Caco_3$ and Bulk real density practical size distribution of the studied soils (plian)													
Profile No.	Depth Cm	$Caco_3$ %	Sand %					Sand %	Silt %	Clay %	Texture class	Bulk density	Real density
			V.C	C	M	F	V.F						
5	0 -15	2.60	7.67	24.84	20.61	17.17	21.81	92.1	3.30	4.60	S	1.55	2.57
	15 - 50	4.90	6.50	24.46	18.23	19.26	23.15	91.6	5.20	3.20	S	1.53	2.63
	50 - 90	5.20	6.15	24.58	19.16	21.76	20.0	91.65	4.95	3.40	S	1.53	2.61
	90 - 150	2.20	7.14	27.73	24.5	8.88	25.65	39.90	3.00	3.10	S	1.50	2.65
7	0 - 37	6.50	3.42	5.11	6.70	20.17	18.6	54.00	20.0	26.0	SCL	1.37	2.45
	37 - 65	5.70	3.55	6.60	14.1	20.25	12.5	57.00	23.0	20.0	SCL	1.41	2.50
	65 - 115	5.10	8.73	13.72	9.41	15.99	28.15	76.00	16.0	8.00	SL	1.34	2.47
	115 - 150	ND	8.10	30.65	15.17	16.78	20.6	91.30	3.20	5.50	S	1.45	2.39
12	0 - 37	2.30	7.5	8.00	10.70	26.95	12.5	65.65	23.15	11.2	S L	1.40	2.60
	37 - 85	ND	8.20	8.60	14.00	23.50	13.50	67.80	21.5	10.7	S L	1.42	2.65
	85 - 150	0.65	5.30	15.60	16.20	10.50	15.60	73.60	23.6	20.8	S C L	1.50	2.62
13	0 - 30	10.2	9.42	11.72	15.41	15.50	26.15	78.20	12.3	9.50	L S	1.41	2.60
	30 - 65	9.50	8.41	10.32	19.3	16.90	17.81	72,74	14.7	12.56	S L	1.43	2.55
	65 - 120	8.90	6.05	24.58	19.16	21.76	20.0	91.55	4.50	3.95	S	1.50	2.70
	120 - 150	12.6	6.46	12.32	20.3	16.80	21.97	77.58	10.15	12.0	L S	1.55	2.68
18	0 - 25	12.5	9.31	23.84	20.61	19.17	18.81	91.74	4.41	3.85	S	1.50	2.65
	25 - 80	3.25	8.64	24.90	18.50	18.00	21.81	91.85	4.65	3.50	S	1.45	2.60
	80 - 150	9.15	9.73	13.62	10.40	14.95	19.10	67.80	16.5	15.7	S L	1.42	2.66

Some chemical properties of the studied soils (plian)														
Profile No.	Depth Cm	S.P %	pH in past	EC dsm^{-1}	Gyp-sum %	Soluble cation mq^{-1}				Soluble anion mq^{-1}			CEC meq/ 100g soil	O.M %
						Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3^-	Cl^-	SO_4^{--}		
5	0 -15	22	7.45	16.6	ND	30	37	110	0.08	S L	2.3	165	9.78	1.7
	15 - 50	20	7.5	7.75	ND	15	18	48.2	0.03	M O	2.2	75.2	3.83	1.62
	50 - 90	19.5	7.6	3.6	ND	10.5	7.7	20	0.01	M O	2.52	33	2.69	1.35
	90 - 150	20	7.5	2.9	ND	11.11	6.8	14	0.01	S L	2.3	26.8	2.81	1.3
7	0 - 37	46.5	7.35	16.2	6.3	45.2	30.75	100	0.1	2.5	130	43.55	20.3	0.38
	37 - 65	42	7.4	9.18	2.5	30.63	10.25	60.1	0.15	2.3	70	28.83	18.9	0.32
	65 - 115	38.2	7.3	6.5	1.4	15.7	13.5	36.5	0.12	2.4	50.6	12.82	10.2	0.2
	115 - 150	30.15	7.25	11.3	ND	30.63	20.25	70.2	0.1	2.1	109.9	9.17	2.1	0.18
12	0 - 37	32.5	7.35	1.25	ND	3.5	2.1	8.32	0.02	2.7	8.6	2.64	12.6	1.7
	37 - 85	33.8	7.5	1.5	ND	3.2	4.8	7.3	0.02	2.5	10	2.82	8.2	1.4
	85 - 150	42.2	7.45	5.15	ND	9.62	15.55	26.9	0.13	2.4	40.2	9.6	18.7	1.05
13	0 - 30	26.5	7.2	20.5	6.5	56.5	52.78	98.63	0.12	2.6	130.17	75.26	2.7	0.5
	30 - 65	28.25	7.15	15.2	4.2	45.6	31.54	78.2	0.12	2.65	106.5	46.31	3.5	0.51
	65 - 120	23.5	7.15	7.18	3.0	20.41	15.62	40.5	0.05	2.3	40.78	33.5	2.1	0.42
	120 - 150	27.8	6.8	25.6	2.3	35.5	18.35	200	0.1	2.25	195.3	56.4	2.5	0.35
18	0 - 25	23.45	7.2	13.2	ND	30.35	22.7	82.5	0.02	2.2	95.3	38.07	2.75	0.25
	25 - 80	20.5	7.2	8.5	ND	20.2	20.7	48.85	0.01	1.9	63.7	24.16	2.5	0.12
	80 - 150	32.11	7.5	4.4	ND	8.65	5.4	32.15	0.01	1.8	36.5	7.91	3.1	0.15

Table 3: Some Morphological, physical and chemical characteristics of the studied soil profiles. (depression floor)

Morphological description of the studied soils (High land)

Profile No.	Depth Cm	Mynsell color		Field texture	Structure	Consistence			Boundary	location
		Dry	Moist			Dry	Stick	Plastic		
1	0 - 25	2.5YR 6/6	2.5YR 6/6	SL	MA	LO	NST	NPL	CS	28º 20' 05.2" N 29º 03' 56.3" E
	25 - 55	2.5YR 5/4	2.5YR 5/4	SCL	MA	SO	SST	SPL	AS	
	55 - 75	2.5YR 7/2	2.5YR5/2	SL	MA	LO	NST	NPL	AS	
	75 - 110	5YR 3/2	5YR 5/3	SL	MA	SO	SST	SPL	AS	
	110 -150	10YR 8/2	10YR7/3	SCL	PL	VHA	ST	PL		
2	0 - 30	10YR 8/6	10YR 5/4	S	MA	LO	NST	NPL	DW	28º 17' 28.7" N 29º 05' 09.4" E
	30 - 70	10YR 6/4	10YR 5/4	S	MA	LO	NST	NPL	AS	
	70 - 90	10YR 7/3	10YR 4/3	S	MA	LO	NST	NPL	CS	
	90 - 130	10YR 8/4	10YR 5/4	S	MA	LO	NST	NPL	DW	
	130 - 150	10YR 7/6	10YR 4/6	S	MA	LO	NST	NPL		
9	0 - 40	10YR 8/4	10YR 5/6	LS	WEPL	SO	SST	SSP	CS	28º 21' 23.5" N 29º 00' 18.2" E
	40 -90	10YR6/4	10YR 6/5	LS	PL	SHA	SST	SSP	DW	
	90 - 110	10YR 8/4	10YR 4/4	LS	MA	LO	NST	NSP	AS	
	110 -150	10YR 8/6	10YR 5/6	SCL	SB	SHA	SST	SSP		
10	0 - 30	10YR 8/4	10YR 6/4	S	SG	LO	NST	NSP	AS	28º 19' 10.4" N 28º 57' 34.5" E
	30 - 60	10YR 8/3	10YR 5/4	S	SG	LO	NST	NSP	AS	
	60 - 80	10YR 7/6	10YR 4/6	S	MA	LO	NST	NSP		
19	0 - 40	10YR 8/4	10YR 5/4	S	SG	LO	NST	NPL	CS	28º 20' 36.5" N 28º 46' 40.0" E
	40 - 120	10YR 8/4	10YR 4/4	LS	MA	LO	NST	NPL	AS	
	120 - 150	10YR 5/6	10YR 4/4	S	SG	LO	NST	NPL		

Some chemical properties of the studied soils (High land)

Profile No.	Depth Cm	S.P %	pH in past	EC dsm^{-1}	Gypsum %	Soluble cation mq^{-1}				Soluble anion mq^{-1}			CEC meq/100g soil	O.M %
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}		
1	0 - 25	32.15	7.78	41.63	1.12	15.87	18.55	385.25	0.92	2.6	380	37.99	3.1	0.73
	25 - 55	48.07	8	40.3	5.2	13.3	19.5	377.27	0.51	2.6	375	32.98	7.63	0.52
	55 - 75	45.2	7.75	28.15	2.13	15	14.1	253.5	0.75	2.53	261	19.82	6.85	0.41
	75 - 110	45.87	7	60.13	ND	16	18	590.1	0.92	2.1	570	53.02	6.71	0.25
	110 - 150	47.24	7.25	27.55	1.3	15.2	14	235.17	0.87	2.1	230	33.14	10.35	0.2
2	0 - 30	24.2	7.9	1.00	ND	2.5	2.9	4.18	0.12	2.2	6.16	1.34	3.6	0.98
	30 - 70	23.16	7.9	1.6	ND	3.6	4.8	7.4	0.11	2.5	11.9	1.51	2.72	0.6
	70 - 90	22.51	7.8	1.42	ND	3.15	3.01	8.16	0.11	2.1	10.5	1.83	2.1	0.39
	90 - 130	21.32	7.8	1.36	ND	3.1	2.55	7.85	0.1	2.05	9.8	1.75	2	0.33
	130 - 150	25.9	7.9	1.22	ND	2.2	2.75	7.2	0.1	2.1	7.95	2.2	3.17	0.3
9	0 - 40	24.5	7.8	16.72	2.3	30.5	20.1	125	0.25	2.3	122.5	51.05	2.8	0.36
	40 -90	25	7.8	16.25	2.5	32.3	25.72	111.7	0.25	2.2	130.7	41.47	3.1	0.34
	90 - 110	26	7.6	37.78	1.0	28.3	37.15	330.5	0.3	2.35	280	113.9	3.17	0.25
	110 - 150	41	7.5	45.65	ND	35.75	55	370	0.35	2.1	370	89	15.5	0.2
10	0 - 30	23.23	7.35	4.9	1.3	14.2	10.15	25.6	0.02	2.5	41.15	6.32	3.2	0.81
	30 - 60	28.5	7.75	4.3	1.1	13.7	8.8	23.6	0.02	2.3	38.8	5.02	4.6	0.65
	60 - 80	38.78	7.7	4.1	ND	11.5	8.5	22.7	0.03	2.3	38.9	1.53	9.7	0.37
19	0 - 40	27.5	7.4	1.5	ND	6	4.25	6.1	0.01	2.5	10.23	3.63	5.1	1.5
	40 - 120	32.76	7.6	1.2	ND	3.15	2.35	6.5	0.01	2	7.95	2.06	5.3	1.65
	120 - 150	26.64	7.45	1	ND	4.1	2.2	3.8	0.05	2	6.47	1.68	2.24	0.46

Total $Caco_3$ and Bulk real density practical size distribution of the studied soils (High land)

Profile No.	Depth Cm	$Caco_3$ %	Sand %					Sand %	Silt %	Clay %	Texture class	Bulk density	Real density
			V.C	C	M	F	V.F						
1	0 - 25	13.22	8.55	16.2	10.17	20.5	25.26	80.68	5.12	14.2	SL	1.44	2.55
	25 - 55	7.81	3.81	5.5	18.6	13.2	24.94	66.50	9.8	24.15	SCL	1.48	2.57
	55 - 75	1.34	3.5	5	17.87	9.53	18.88	54.78	25.17	20.05	SL	1.52	2.58
	75 - 110	0.13	3.46	5.32	20.3	16.9	21.81	67,79	10.11	22.1	SL	1.38	2.61
	110 - 150	0.1	3.67	4.36	8.84	19.2	31.03	67.50	9.32	23.18	SCL	1.56	2.58
2	0 - 30	3.6	7.56	20.1	12.7	18.9	27.51	86.77	7.08	6.15	S	1.55	2.56
	30 - 70	3.8	13.75	25.7	13.28	15.47	22.22	90.42	3.58	6.00	S	1.57	2.59
	70 - 90	4.4	10.15	40.62	25.8	5.6	8.63	90.80	4.40	4.80	S	1.58	2.66
	90 - 130	9.16	7.1	30.8	12.5	20.78	18.22	89.40	5.50	5.10	S	1.60	2.66
	130 - 150	6.05	9.2	26.3	9.7	25.1	19.8	90.00	2.70	7.30	S	1.63	2.67
9	0 - 40	4.65	6.54	19.68	12.50	18.70	23.58	82.00	8.50	9.50	LS	2.52	1.26
	40 -90	3.93	8.29	20.1	11.7	19.9	23.51	83.50	7.80	8.70	LS	2.58	1.35
	90 - 110	4.17	7.56	20.1	12.7	18.9	20.39	79.65	11.2	9.15	LS	2.62	1.40
	110 - 150	5.75	3.67	4.36	10.84	19.41	22.03	60.31	15.42	24.27	SCL	2.70	1.46
10	0 - 30	5.4	10.95	20.62	25.8	15.6	18.63	91.60	4.10	4.30	S	2.51	1.40
	30 - 60	12.9	4.81	7.75	19.6	14.2	22.94	71.30	15.2	13.5	SL	2.57	1.48
	60 - 80	18.5	3.5	3.01	17.87	9.53	18.88	52.79	20.71	26.5	SCL	2.67	1.60
19	0 - 40	4.6	9.2	26.3	11.7	25.55	18.4	91.15	4.35	4.50	S	1.45	2.40
	40 - 120	14.5	6.54	19.68	12.88	18.70	24.50	82.3	9.20	8.50	LS	1.45	2.45
	120 - 150	13.45	8.29	20.70	16.7	19.4	26.56	91.65	3.15	5.20	S	1.49	2.47

Cont. Table 3

Morphological description of the studied soils (moderately high Land)										
Profile No.	Depth Cm	Mynsell color		Field texture	Structure	Consistence			Boundary	location
		Dry	Moist			Dry	Stick	Plastic		
4	0 -38	10YR 8/6	10YR 5/6	SL	AB	SO	NST	NPL	AS	28º 18' 15.6" N 29º 00' 00.0" E
	38 - 60	10YR 8/4	10YR 5/4	SL	MA	LO	NST	NPL	CS	
	60 - 80	10YR 8/6	10YR 6/6	S	MA	LO	NST	NPL	CS	
	80 - 125	10YR 7/6	10YR 5/6	SL	MA	LO	NST	NPL	AS	
	125 - 150	10YR 8/4	10YR 5/3	S	MA	LO	NST	NPL		
11	0 - 30	10YR 8/4	10YR 6/4	S	SG	LO	NST	NSP	AS	28º 20' 52.2" N 28º 54' 32.7" E
	30 - 60	10YR 8/3	10YR 5/4	S	SG	LO	NST	NSP	AS	
	60 - 80	10YR 7/6	10YR 4/6	S	MA	LO	NST	NSP	AS	
	80 - 150	5YR 2/3	10YR 2/2	SL	MA	LO	NST	NSP		
14	0 - 40	10YR 8/6	10YR 6/6	S	SG	LO	NST	NPL	CS	28º 18' 15.6" N 28º 47' 16.3" E
	40 - 90	10YR 5/6	10YR 4/4	S	MA	LO	NST	NPL	AS	
	90 - 150	10YR9/6	10YR 5/6	SL	MOSB	SHA	SST	SPL		
16	0 -35	10YR 4/1	10YR 2/1	S	SG	LO	NST	NST	DW	28º 01' 49.5" N 28º 44' 14.5" E
	35 -85	10YR 8/6	10YR 5/6	SL	VWPL	SO	SST	SST	CS	
	85 -150	10YR 7/6	10YR 5/6	SL	MOPL	SO	SST	SST		

Some chemical properties of the studied soils (moderately high Land)														
Profile No.	Depth Cm	S.P %	pH in past	EC dsm^{-1}	Gypsum %	Soluble cation mq^{-1}				Soluble anion mq^{-1}			CEC meq/100g soil	O.M%
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^-		
4	0 -38	35	7.8	12.5	1.12	25	45	65.8	0.03	2.5	110.3	23.03	3.5	0.7
	38 - 60	26.5	7.8	30.2	3.6	36	17.5	250	0.02	2.2	270.15	31.17	2.7	0.65
	60 - 80	20	7.6	3.5	**ND**	13	6.2	17.5	0.02	2.3	29.7	4.72	1.5	0.3
	80 - 125	24.7	7.45	6.6	**ND**	26	12.5	27.5	0.01	2.3	55.8	7.91	2.2	0.4
	125 - 150	21.5	7.35	2.9	**ND**	19	6.5	15.5	0.03	2.1	23.5	5.43	1.4	0.22
11	0 - 30	22.5	7.6	3.88	3.5	10.3	7.62	23.5	0.01	2.23	26.1	13.1	2.5	0.4
	30 - 60	21.2	7.7	6.5	3.1	22.76	12.5	33	0.02	2.51	40.78	24.99	2.1	0.32
	60 - 80	23.7	7.3	6	2.1	19.11	15.17	28.41	0.02	2.5	43.35	16.86	1.8	0.1
	80 - 150	25.11	7.5	12.75	2	33.5	18.73	75.1	0.1	2.46	110.52	14.45	3	0.15
14	0 - 40	22.2	7.2	16.5	2.5	39.7	20.15	115.18	0.08	2.4	109.5	63.21	1.82	0.3
	40 - 90	23.5	7.5	18.2	1.7	40.2	18.5	125.72	0.09	2.6	120.6	60.71	2	0.31
	90 - 150	25	7.4	11.7	0.65	31.32	20.17	66.5	0.1	2.2	70.5	45.39	2.65	0.21
16	0 -35	19.5	7.1	43.1	5.75	55.11	110.15	290.2	0.17	2.7	310.35	142.58	2.6	0.9
	35 -85	20.19	7.5	10.6	2.25	29.41	26.42	45.81	0.08	2.4	80.65	18.67	11.5	0.85
	85 -150	35.7	7.3	6.5	1.2	30.62	20.67	110.3	0.06	2.4	46.24		12.95	0.43

Total $Caco_3$ and Bulk real density practical size distribution of the studied soils (moderately high Land)													
Profile No.	Depth Cm	$Caco_3$%	Sand %					Sand %	Silt %	Clay %	Texture class	Bulk density	Real density
			V.C	C	M	F	V.F						
4	0 -38	6.5	3.27	15.64	8.52	17.2	24.17	68.80	15.7	15.5	SL	1.44	2.55
	38 - 60	4.2	2.63	13.87	14.85	17.15	20.95	69.45	18.35	12.2	SL	1.5	2.57
	60 - 80	2.35	4.44	25.17	20.16	19.91	21.32	90.00	5	5	S	1.52	2.5
	80 - 125	4.5	12.25	11.17	9.15	30.87	8.26	71.70	16.8	11.5	SL	1.53	2.6
	125 - 150	5.11	10.2	32.75	31.65	9.2	7.2	91.00	2.5	6.5	S	1.5	2.66
11	0 - 30	3.6	5.60	22.67	23.13	19.30	22.50	92.80	4	3.8	S	2.6	1.5
	30 - 60	10.58	5.47	25.80	21.27	18.50	19.36	90.40	3.5	6.1	S	2.36	1.4
	60 - 80	8.9	5.68	23.44	20.13	19.60	21.15	90.00	4.2	5.8	S	2.6	1.44
	80 - 150	12.5	13.25	11.25	11.90	26.90	18.20	81.00	11.5	7.5	SL	2.55	1.45
14	0 - 40	13.5	4.50	24.39	19.65	17.73	25.56	91.85	3.95	4.2	S	1.6	2.62
	40 - 90	12.2	6.30	20.40	23.56	20.77	21.32	92.35	3.5	4.15	S	1.65	2.5
	90 - 150	10.15	2.63	12.90	14.07	10.65	20.95	61.20	26.5	12.3	SL	1.71	2.62
16	0 -35	9.5	5.55	23.66	20.16	20.91	20.32	90.60	4.2	5.2	S	1.5	2.58
	35 -85	9	6.15	14.50	15.15	8.80	22.20	66.80	14.7	18.5	SL	1.6	2.6
	85 -150	12.3	8.37	12.45	10.22	14.16	18.20	63.40	20.25	16.35	SL	1.65	2.67

Cont. Table 3

Morphological description of the studied soils (High Land)										
Profile No.	Depth Cm	Mynsell color		Field texture	Structure **	Consistence			Boundary	location
		Dry	Moist			Dry	Stick	Plastic		
3	0 - 20	10YR6/4	10YR 4/4	LS	MA	LO	NO	NO	CS	28° 14' 05.2" N 29° 06' 58.2" E
	20 - 60	10YR 8/4	10YR 5/4	S	SG	LO	NO	NO	AS	
	60 -	10YR 7/6	10YR 6/6	S	SG	LO	NO	NO		
17	0 -20	10YR 8/6	10YR 6/6	S	SG	LO	NST	NST	CS	28° 01' 33.9" N 28° 37' 34.5" E
	20 -60	10YR 7/6	10YR 5/6	S	SG	LO	NST	NST	DW	
	60 - 100	10YR 7/6	10YR 5/6	LS	MA	LO	NST	NST	AS	
	100 - 150	10YR 8/6	10YR 5/6	LS	MA	SO	NST	NST		
20	0 - 30	10YR 6/8	10YR 6/4	LS	MA	LO	NST	NPL	CS	28° 03' 23.5" N
	30 - 95	10YR 6/4	10YR 5/4	C	STSB	VHA	VST	VPL	CS	28° 34' 32.7" E
	hard pane									

Some chemical properties of the studied soils (High Land)														
Profile No.	Depth Cm	S.P %	pH in past	EC dsm^{-1}	Gypsum %	Soluble cation mq^{-1}				Soluble anion mq^{-1}			CEC meq/100g soil	O.M %
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{-}		
3	0 - 20	31.35	7.6	1.3	ND	4.2	4.7	5.1	0.1	2	10.78	1.32	2.41	0.98
	20 - 60	28.5	7.8	1.1	ND	3.15	4.2	4.5	0.05	2	8.2	1.7	2	0.4
	60 -	22.19	7.8	0.9	ND	2.5	3.1	4.6	0.05	2	7.12	1.13	1.75	0.15
17	0 -20	18.5	7.5	25.5	ND	45.5	33.2	186.52	0.05	2.5	210.5	52.27	2.49	0.45
	20 -60	18	7.3	23.2	ND	46.32	40.42	155.71	0.06	2.2	199.11	41.2	1.9	0.22
	60 - 100	20.3	7.2	6.2	ND	24.46	13.11	27.62	0.05	2.1	42.53	20.6	2.7	0.2
	100 - 150	21.5	7.3	3.6	ND	10.5	8.3	19.5	0.1	2	27.75	8.65	3.5	0.23
20	0 - 40	25.3	7.1	22.75	3.5	21.16	51.6	157.1	0.1	2.1	160.4	67.46	3.92	0.36
	40 - 120	60.65	7.8	11.65	2.76	20.3	42.7	60.35	0.1	2	82.6	38.85	28	0.18
	120 - 150	hard pane												

Total $Caco_3$ and Bulk real density practical size distribution of the studied soils (High Land)													
Profile No.	Depth Cm	$Caco_3$%	Sand %					Sand %	Silt %	Clay %	Txture class	Bulk denstiy	Real denstiy
			V.C	C	M	F	V.F						
3	0 - 20	7.5	5.82	12.37	20.35	25.11	16.65	80.30	11.5	8.2	LS	1.42	2.44
	20 - 60	1.1	3.8	25.89	19.48	13.5	25.62	88.39	4.11	7.5	S	1.5	2.5
	60 -	ND	5.33	27	13.15	16.82	30.2	92.50	3.5	4	S	1.52	2.52
17	0 -20	3.6	7.82	13.37	20.35	26.86	22.50	90.90	4.95	4.15	S	1.6	2.7
	20 -60	2.5	5.8	25.89	19.48	17.91	22.62	91.64	3.16	5.2	S	1.5	2.63
	60 - 100	2.38	5.33	28.94	13.15	14.78	28.20	90.40	3.5	6.1	S	1.65	2.6
	100 - 150	1.22	5.82	12.37	20.85	22.66	26.65	88.35	3.15	8.5	LS	1.65	2.65
20	0 - 40	15.2	7.60	17.45	16.36	18.75	22.14	82.30	8.5	9.2	LS	1.55	2.67
	40 - 120	10.18	3.14	4.85	5.18	4.91	10.62	28.70	27.8	43.5	C	1.48	2.43
	120 - 150	hard pane											

** According to FAO guide lines (1990)

Soils of the Pediplain. These soils are occupying the foot slopes of the depression margins and rims, shallow and highly calcareous in general. They are covered with aeolian sand in some parts. The terrain is hilly and dominantly rocky. The soils of appreciable depth is; (Table 6).

Entisoils

Torripsamment .

Table 4: Some Morphological, physical and chemical characteristics of the studied soil profiles.

Some chemical properties of the studied soils (Mesa and Plateau)														
Profile No.	Depth Cm	S.P %	Ph in past	EC dsm^{-1}	Gypsum %	Soluble cation mq^{-1}				Soluble anion mq^{-1}			CEC meq/ 100g soil	O.M %
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}		
8	0 -25	22	8.6	40.25	4.6	110.5	80.13	260	0.1	2.5	350	98.23	3.15	0.47
	25 - 60	23.8	8.4	34.4	3.75	32.57	13.52	305	0.1	2.4	250	98.79	2.6	0.4
	60- 85	25.2	8.1	6.21	1.5	15.7	12.5	36.42	0.05	2.3	41.5	20.77	2.9	0.31
	85 - 105	33.3	8.9	2.5	1.3	12.08	6.5	9	0.05	2.4	18.9	6.33	3.5	0.22
	105-150	40.5	8.9	1.7	1.0	6.2	4.5	8	0.02	2.4	9.85	6.47	23.4	0.35
15	0 - 25	45.1	6.7	50.2	8.5	120.32	75.36	320.78	0.13	2.5	410.2	103.91	22.5	0.71
	25 - 60	43.7	6.5	70.11	3.6	82.54	220.22	430.62	0.13	2.5	555.81	175.2	20.7	0.32
	60 - 90	46.11	6.1	88.5	5.2	72.61	300.35	520.4	0.2	2.32	700.74	190.5	23.17	0.15
	90-150	33.9	5.5	38.75	2.75	39.51	120.17	240.2	0.2	2.1	352.61	45.37	16.5	0.17

Morphological description of the studied soils (Mesa and Plateau)										
Profile No.	Depth Cm	Mynsell color		Field texture	Structure	Consistence			Boundary	location
		Dry	Moist			Dry	Stick	Plastic		
8	0 -25	10YR 8/4	10YR 6/4	S	MA	LO	NST	NSP	CS	28º 24' 00.0"N 28º 56' 40.0" E
	25 - 60	10YR 8/6	10YR 6/4	S	MA	LO	NST	NSP	DW	
	60- 85	10YR 8/6	10YR 5/6	S	MA	LO	NST	NSP	CS	
	85 - 105	10YR 8/6	10YR6/4	SL	MA	LO	SST	SPL	CS	
	105 - 150	10YR 6/3	10YR 5/4	SCL	SB	SHA	SSS	SPP		
15	0 - 25	10YR 5/6	10YR 4/6	SCL	WEPL	MA	SST	SPL	CS	28º 18' 00.0" N 28º 53' 40.0" E
	25 - 60	10YR5/6	10YR 4/4	SCL	MOSB	SHA	SST	SPL	CS	
	60 - 90	10YR 5/4	10YR 4/4	SCL	STSB	HA	ST	PL	CS	
	90 - 150	10YR 7/3	10YR 5/4	SIC	STSB	HA	ST	PL		

Total $Caco_3$ and Bulk real density practical size distribution of the studied soils (Mesa and Plateau)													
Pro-file No.	Depth Cm	$Caco_3$ %	Sand %					Sand %	Silt %	Clay %	Texture class	Bulk density	Real density
			V.C	C	M	F	V.F						
8	0 -25	19.5	6.62	15.57	23.45	24.83	22.25	92.72	3.2	4.08	S	2.58	1.6
	25 - 60	17.35	5.84	25.85	14.44	13.73	32.62	92.48	4.17	3.35	S	2.63	1.61
	60- 85	18.9	4.43	18.90	11.183	17.89	39.2	92.25	3.5	4.25	S	2.67	1.61
	85-105	22.2	6.86	14.33	19.35	20.00	21.50	82.04	8.15	9.81	L S	2.6	1.61
	105-150	7.15	5.85	6.85	11.18	8.91	18.62	49.35	21.2	29.45	S C L	2.62	1.63
15	0 - 25	3.6	5.83	28.94	13.15	14.78	28.20	90.90	4.95	4.15	S	1.6	2.7
	25 - 60	2.5	5.82	12.66	23.85	22.66	26.65	91.64	3.16	5.2	S	1.5	2.63
	60 - 90	2.38	5.82	25.12	19.48	14.36	25.62	90.40	3.5	6.1	S	1.65	2.6
	90-150	1.22	5.38	26.92	17.15	12.82	26.08	88.35	3.15	8.5	L S	1.65	2.65

Table 5: Some Morphological, physical and chemical characteristics of the studied soil profiles.

Total $CaCO_3$ and Bulk real density practical size distribution of the studied soils (Pediplains)														
Profile No.	Depth Cm	$CaCO_3$ %	Sand %					Sand %	Silt %	Clay %	Texture class	Bulk density	Real density
			V.C	C	M	F	V.F						
6	0 -40	5.35	14.05	28.79	13.11	21.2	15.1	92.25	3.7	4.05	S	1.45	2.5
	40 - 75	5.1	13.62	32.17	10.81	23.5	13.2	93.30	3.5	3.2	S	1.5	2.62
	75-150	6.2	10.34	30.21	9.78	25.62	16.45	92.40	4.1	3.5	S	1.65	2.6

Some chemical properties of the studied soils (Pediplains)														
Profile No.	Depth Cm	S.P %	pH in past	EC dsm^{-1}	Gyp-sum %	Soluble cation mq^{-1}				Soluble anion mq^{-1}			CEC meq/ 100g soil	O.M %
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{--}		
6	0 -40	23.5	7.9	0.92	**ND**	2.3	3.1	5.1	0.01	2.1	6.7	1.71	3	0.5
	40 - 75	22	7.85	1.1	**ND**	3.1	2.75	6.2	0.01	2.2	8.5	1.36	2.8	0.42
	75-150	22.5	7.85	1.08	**ND**	2.7	2.65	6.8	0.01	2.2	8	1.96	2.69	0.31

Morphological description of the studied soils (Pediplains)										
Profile No.	Depth Cm	Mynsell color		Field texture	Structure	Consistence			Boundary	location
		Dry	Moist			Dry	Stick	Plastic		
6	0 -40	10YR 8/6	10YR 5/4	S	M A	L O	NST	NPL	D W	28º 19' 18.2" N 29º 07' 16.3" E
	40 - 75	10YR 8/4	10YR 5/6	S	M A	L O	NST	NPL	D W	
	75 - 150	10YR 8/4	10YR 5/4	S	M A	L O	NST	NPL		

Table 6: Soil classification according to key to soil Taxonomy (2006) and FAO (1998).

Order	Suborder	Great group	Subgroup	Temperature Regime	Representative profiles
Aridisols	Salids	Haplosalids	*Typic haplosalids*	***Hyper thyrmic***	4,9,14,17
			Calcic-haplosalids		8
			Gypsic-haplosalids		1,15,16
	Calids	Haplocalcids	*Typic Haplocalcids*		8
	Gypsids	Haplogypsids	*Typic Haplogypsids*		1,7,13,15,16
Entisols	Psamments	Torripsamments	*Typic Torripsamments*		2,3
					5,6,19
					10,11,12,18,20

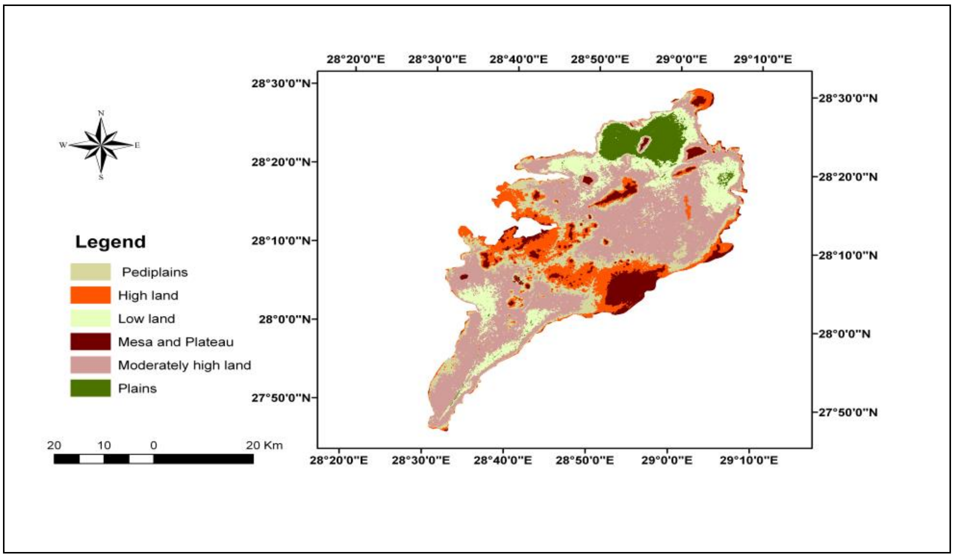

Fig (2) Geomorphic units recognized in Bahariya Oasis

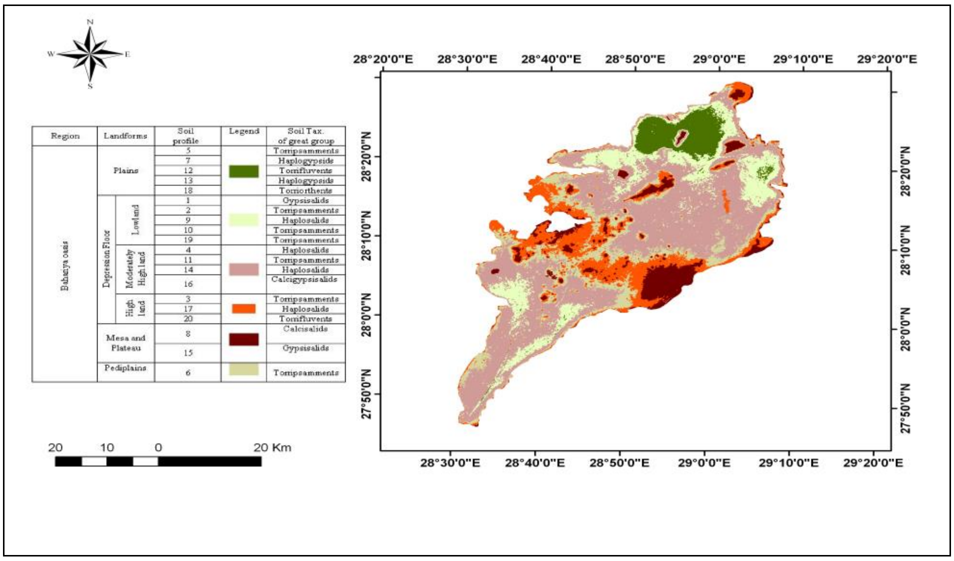

Fig (3). Soil landscape map of Bahariya Oasis

CONCLUSION

Field observation and laboratory analysis support the following conclusions:

Recognizing land forms helped in understanding of the intrelations between morphological, physical and chemical characteristics of soil attributes in different periods of the year. Some physical and chemical characteristics of the soils were affected by location on landforms.

The differences in physical and chemical properties of the soils were reflecting the conditions of the landforms. Varying degrees of pedogenic features are tied to the relationship between the soil and age of the landform. Most of the examined soil profiles are derived from the clayey and sandy members of Bahariya formations, overlying hard calcareous beds and in places on the basaltic rocks. The high $CaCo_3$ content of some profiles were associated was calcareous parent material.

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علاقة الأشكال الأرضية بخصائص التربة فى الوحات البحرية – مصر

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**** الهيئة القومية للأستشعار من البعد وعلوم الفضاء – القاهرة - مصر**

تمثل الواحات البحرية احدى المنخفضات الطبيعية فى الصحراء الغربية بمصر، يهدف هذا البحث الى دراسة العلاقة بين الأشكال الأرضية وخواص التربة السائدة فى تلك المنطقة الجافة, حيث يشغل منخفض الواحات بتكوينات رسوبية تنتمى الى الباليوسن المتأخر وبداية الأيوسين - Campanian Late Cretaceous - Early to middle Eocene-Cenomanian) Late Cretaceous Maostrichtion -Oligocene) وتختلف هذه الترسيبات على اى حال من الأحوال على حسب المواقع نتيجة لأختلاف التكوينات المكونة لنوع وبيئة الترسيب0 أجريت هذه الدراسة على 20 قطاع تربة تمثل 6 وحدات جيمورفولوجية من أصل 9 وحدات فى منخفض الواحات البحرية وهى كالتالى:- السهول plains ويمثلها (القطاعات 5- 7 -12 -13 - 18) Depression Floor ويندرج تحتها Lowland (القطاعات 1-2-9-10- 19) Moderately high land ويمثلها (القطاعات 4-11-14-16) Highland ويمثلها (قطاعات 3-17- 20) Mesa and Plateau ويمثلها (القطاعات 8-15) Pediplains ويمثلها(قطاع 6) ويوجد ثلاث وحدات لم تمثل وهى Hill, Hillocks and scarps وذلك بهدف ربط هذه الوحدات landforms بخواص التربة حيث ان الأتجاه العام فى التنمية يتجه بقوه نحو الوحات بصفة خاصة والصحراء الغربية بصفة عامة وعليه تم استخدام صور لاند سات وبرامج GIS لأنتاج خرائط التربة وتم تصنيف الأراضى حسب التقسيم الى : Haplogypsids, Haplosalids, Calcisalids, Gypsisalids, Calcigypsisalids, Torriorthents and Torripsamments. ووجدت تراكمات من الجبس والكالسيوم فى معظم الأراضى الملحية0

قام بتحكيم البحث

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