Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-3, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

Environmental Assessments of Soils and Water in an Area of Western Desert, Egypt

El-Sayed, M.I.[1], Abdel Ghaffar, M.K.[2], El-Kammar, A.M.[3], and El-Shawadfi, T.M.[2]
[1]Faculty of science, Beni-Suief Univ., [2]Soil, water and Environmental Inst., ARC.
[3]Faculty of science, Cairo University.

Abstract:*The purpose of this paper is to study the geoenvironmental characteristics of an area northeast of Western Desert, Egypt to give an idea about their classification and suitability limits for agricultural trends and other useful purposes.The study area can be divided into four main geomorphlgical units; namely, terraces,scarpment,structural platform and sand accumulation.Guided by the identified geomorphological units; 63 soil profiles were selected, morphologically describedand 176 representative soil samples have been collected from them according to the morphological variations.The laboratory investigations include grain size distribution, chemical analyses of the soil saturation extract and water samples (SP, pH, EC and soluble ions); $CaCO_3$, gypsum and organic matter contents.*

Two soil orders are identified in the study area i.e. Aridisols and Entisols. Aridisols can be differentiated into three suborders i.e. Calcids,Gypsids and Calcigypsids. Two Entisols suborders are identified in the study area, namely; Orthents and Psamments.

Regarding the capability of soils for agriculture, the study area could be classified into three current capability classes: marginally suitable land (S3), currently not suitable land (N1) and permanently not suitable land (N2).Potential suitability of the studied soils could ameliorate to highly suitable (S1), moderately suitable (S2) and marginally suitable (S3).

The main water resource in Egyptian Western Desert (including the study area) is the underground water. The majority of water samples are moderate suitable with minor of marginally suitable for agriculture use.

Key words: *Environmental Assessment, Soil, Water, Western Desert, Egypt.*

1. Introduction

The desert area extends to about 94% of the total area of Egypt. The residual area which devoted for agriculture and foundation represents only about 6% of the total area. According to overcrowded annual increasing of the Egyptian population in Nile Valley and Delta, the government of Egypt decided to get out from the narrow valley and searching for other areas for food production. The government looked toward the vast desert especially the Western Desert which represents the great majority of the total area of Egypt for invasion due to its suitability, flatness, smoothing and extension.

Location of the study area:

The study area occupies a portion of the Western Desert of Egypt (Fig. 1). It is located north-east of Bahariya Depression between longitudes °28 '58 "19.2and °29 '30 "28.8E and latitudes °28 '44 "16.8and °29 '1 "22.8N and it extends in northeast-southwest direction with total area of 945 km^2 (Fig. 1).

The climatic conditions of the study area are typically arid to semi-arid, characterized by a long hot dry summer, mild winter with little rainfall, high evaporation with moderately to high relative humidity.

Geologically,the study area is covered by extensive exposures of sedimentary successions ranging in age from Eocene to Quaternary. The oldest sedimentary rocks are represented by late folded structure. The surface stratigraphic succession includes sequences of Middle Eocene, Upper Eocene, Lower Miocene, Oligoceneand Quaternary sediments.

There are some fractures and/or faults extent mostly NW-SE and NE-SW.

Geomorphologically,landsat ETM^+ image, triangulated irregular network (TIN map), digital elevation model (DEM map), geological map and data verification by in situ observation were used for delineating the main geomorphologic units. The study area can be divided into four units; namely, terraces, scarpment, structural platform and sand accumulation. The terraces can be distinguished into four subunits: high, medium, low and very low terraces (Fig. 2).

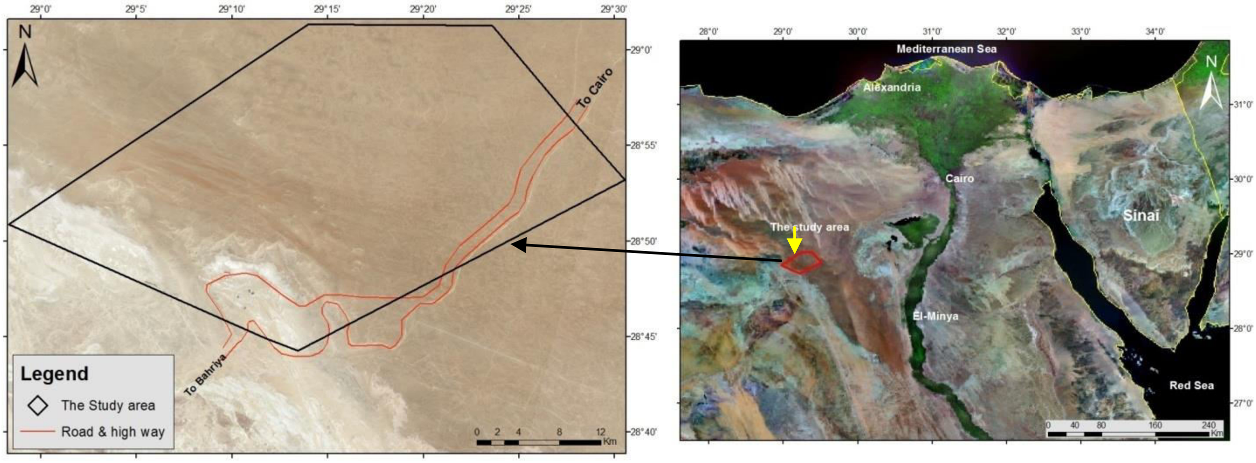

Fig. (1): Location of the study area on Egypt image and on subset landsat ETM8image (acquired in 2012).

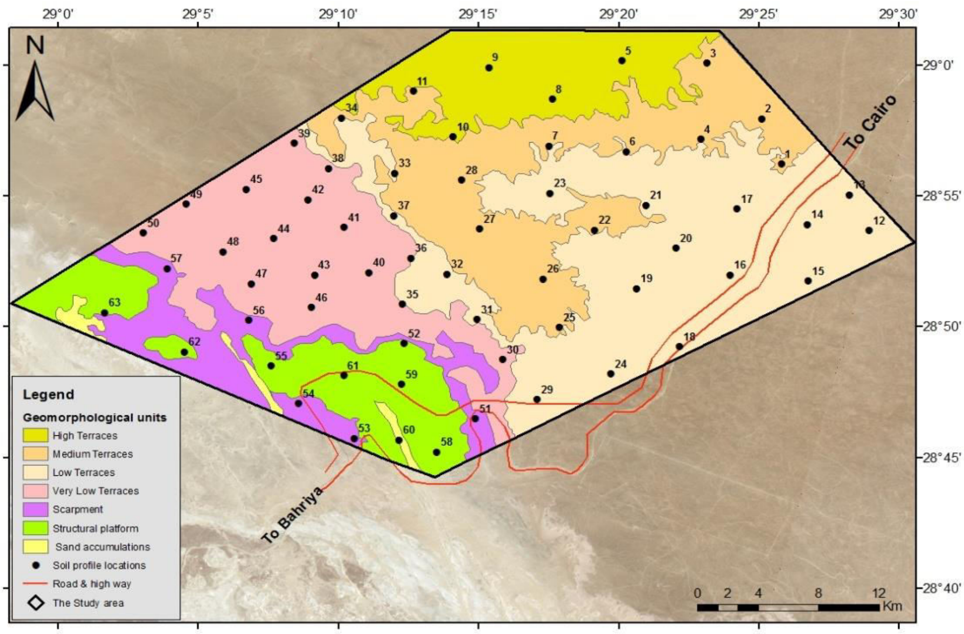

Fig. (2): Geomorphological units and soil profile locations in the study area.

2. MaterialsandMethods

2.1. Field work:

Field investigations were carried out in the study area using geological map (1:100,000), topographic map (1:50,000) and landsat TM image. Different geomorphologic units were identified in the study area. Guided by the identified geomorphological units; 63 soil profiles were selected and allocated by the portable global positioning system (GPS). Morphological description of the soil profiles was undertaken according to the criteria established by Field Book for describing sampling soils, FAO [1,2]. 176 representative soil samples have been collected from the studied soil profiles according to the morphological variations. Soil color for both moist and dry conditions was determined by the aid of Munsell soil chart color, USDA [3]. Distribution of the studied soil profiles in the study area is shown in Fig. (2).The depth of digging in the studied profiles was usually about 150 cm except when met bed rock to locate the type of boundaries and general lithology.Six groundwater samples were examined and collected, from selected water wells; two of them represent wells inside the study area and four outside the study area.

2.2. Laboratory analyses:

Soil samples, which collected to represent the different variations of soil profiles, were air dried, crushed and sieved through a 2 mm sieve, coarse fragments (>2 mm) were determined by weight and volumetrically to measure their sizes and percentages, while the fine earth (<2 mm) was used for physical, chemical and mineralogical studies.

2.2.1. Grain size analysis:

The grain size analysis was carried out for all soil samples (176 samples) using the methods of [4]. The gravel contents (> 2 mm diameter) were separated from the sample using 2 mm diameter screen. Silt and clay were separated from sand by wet sieving using 0.063 mm diameter screen and determined by the pipette method. Sand was fractionated by dry sieving using 2, 1, 0.5, 0.25, 0.125 and 0.063 mm diameter screens.

2.2.2. Chemical analyses:

The chemical analyses of soil paste extract and water as well as the determination of calcium carbonate, gypsum and organic matter contents in all the studied soil samples were carried out according the methods described by [5] as follows:

1- Water saturation capacity or saturation percentage (SP) was determined by adding distilled water to a 100g dry soil and stirring with spatula until the saturation point is reached.

SP= (volume of distilled water/weight of air dry soil) x 100.

2- The pH value was determined in saturated soil paste after 24 hours using pH meter by inserting the pH electrode repeatedly until a representative pH value is obtained.

3- Soil water extract was obtained using a vacum to filtrate the soil paste.

4- The electrical conductivity (EC) was determined using the conductivity meter and the values were corrected at 25^{o}C.

5- The soluble cations were determined for the soil paste extract as follow:

a- Determination of Ca^{2+} and Mg^{2+} was carried out by titration.

b- Determination of Na^{+} and K^{+} was carried out using flame photometer.

6- The soluble anions were determined for the soil paste extract as follow:

a- Carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{-}) were carried out by titration with HCl acid using phenolphthalein as indicator for the former and methyl orange for the latter.

b- Chloride (Cl^{-}) was determined by titration against silver nitrate.

c- Sulphate (SO_4^{2-}) was determined by precipitation as barium sulphate using barium chloride.

d- Sodium adsorption ratio (SAR) was determined using the following equation:

$$SAR= Na^{+}/1/2\ (Ca^{2+}+Mg^{2+})^{0.5}$$

7- Calcium carbonate content was determined volumetrically using Collin's calcimeter.

8- Gypsum content was determined by precipitation with acetone.

9- Organic matter content (O.M.) was determined using ferrion as indicator.

2.3. Geoenvironmental evaluation:

2.3.1. Soil classification: The soils were classified to the great group levels, based on the American soil Taxonomy [6] and its keys [7].

2.3.2.Land evaluation: Soil under investigation was evaluated using the parametric system under taken by [8] and [9].

2.3.3.Water quality: The quality ofunderground water for drinking use was determined according to [10]. However, the classification of water for irrigation was determined according to [11], [12] and the diagram of U.S. Salinity Lab [13].

3. Results and Discussions

3.1. Physical properties of soils:

The physical properties of the study soils include the morphological description of profiles in the field and the grain size distribution as well as calcium carbonate, gypsum and organic matter contents.

3.1.1. Soil profile descriptions:

- The surface is almost flat to slopingand covered by different size gravel; mostly were originated and transported from the surrounding sedimentary rocks. The dominant desert feature is the presence of pavement surface gravel (lag deposits) shaped by the wind and showing desert varnish. The soil depths in most of the studied profiles are deep (> 100 cm) with some profiles which are moderate or shallow depth.
- The dominant soil color in the studied soil profiles is mostly yellowish brown (10 YR5/6, dry) to dark brown (10YR 3/4, moist) or yellow (10 YR7/ 6; dry) to brownish yellow (10YR6/6; moist), however, yellow orange (10YR 8/6; dry) to dull yellow orange (10YR 6/4; moist) is also detected. In general, the soil color is seemingly affected by calcium carbonate content and soil depth.
- Soil structure is different with depth, being massive or weak angular blocky in the top surface layers of all soil profiles and massive to single grain in the subsoil layers. Dry consistence of soils is ranging from loose to slightly hard, while wet consistence agrees well with soil texture, being non-sticky and non-plastic for sand to slightly sticky and slightly plastic for loamy sand. Wavy boundary is common between soil layers of the study profiles indicating recent and undeveloped soils. However, smooth boundary is present in some soil profiles.

3.1.2. Soil texture:

Soil texture is considered one of the most important soil criteria affecting soil behavior and land management, and it influences a number of physical and chemical soil characteristics. Also, growth and development of the plant is primarily based on the soil texture and root penetration, nutrition absorption through soil particles, water holding capacity, water infiltration and percolation.

Generally, soil texture throughout the entire depth of these soil profiles are mostly coarse-textured where the sand textures constitute more than 85% of the studied samples. Sand fractions are dominated by medium and fine sand (more than 50%, Table 1).

According to the [2], soil components larger than 2.0 mm are considered as gravel and can be included in textural class. The textural classes of the geomorphic units can be described as follows (Table 1):

- In high terraces unit, about half of the soil samples are sand texture followed by gravelly sand and loamy sand texture.
- In medium terraces unit, the texture are loamy sand followed by sand and gravelly sand.
- In low terraces unit, about half of the samples are sand followed by loamy sand texture.
- In very low terraces unit, the texture are sand and slightly gravelly sand followed by slightly gravelly loamy sand.
- In scarpments unit, loamy sand is adominant texture followed by slightly gravelly sand and slightly gravelly loamy sand.
- In structural platform unit, the texture are slightly gravelly sand and gravelly sand followed by loamy sand and slightly gravelly loamy sand.

3.1.3. Calcium carbonate content:

Soil $CaCO_3$ is identified as an important soil criterion for agricultural crops in Mediterranean region.Calcium carbonate accumulation depend on a balance among, geomorphic age or landscape stability, soil water movement at both profile and landscape scales, soil texture, and vegetation type and quantity. These accumulations follow a sequence of morphologic development starting as horizon features such as carbonate coats, masses, and fine nodules [14]. Calcareous soils originate mainly from carbonate-rich parent materials such as limestone.

In the study area, soils adjacent to the Eocene limestone have high calcium carbonate content (escarpment and structural platform units), where the weight mean values of $CaCO_3$ content in soil profiles (15.1-45.0%) indicate an extremely calcareous nature. Carbonate contents in the surface layers of this area are formed from calcareous parent materials through the weathering of high tableland formations (Eocene plateau) in the west and the re-precipitations of carbonate.

3.1.4. Gypsum Content:

Gypsum formation is influenced by many climatological factors as temperature, precipitation and pressure. Other local conditions in the soil as type of minerals, salt concentration, fluctuation of water table, organic acids, evaporation and oxidation-reductionprocesses are important factors of gypsum formation in most soils [1].In gypsiferous soils of Egypt,[15] have introduce three categories of soils according to gypsum content as: low gypsum content soils (< 5%); moderate gypsum content soils (5.10%) and high gypsum content soils (>10%). [16]Stated that the gypsum percentage is not the most important factor that affects soil characteristics but also special attention must be given to the form of gypsum crystals. The content of gypsum in the study area occurs as cemented fine particles between the sand grains originate from the sedimentary parent rocks and/or as pedogenic origin of soft and hard aggregation. It is generally low (< 5%) and the distribution in the study area and soil profiles have no significance. The weight mean values of gypsum content in soil profiles range from 0.1 to 5.8%.

3.1.5. Organic matter content:

Soil organic matter is considered the main source for many elements in soil and helps to maintain the aggregates of soils and increase resistance to erosion. Increasing organic matter in soils will increase the amount of water for plant growth.

Organic matter contents are very low owing to its occasioned by very small inputs of litter and the rapid decomposition rate of the vegetative residues as affected by aridity prevalence. The study soils have organic matter content fluctuated between 0.0 and 0.86%, the surface and subsurface layers have almost relatively the highest values of organic matter. Weight mean values of organic matter are very low (0.01 and 0.54% organic matter).

Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-3, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

Table (1): Mean of grain size distribution and textural classes as well as $CaCO_3$, gypsum andorganic matter contents in the studied soil profiles.

Profile No.	Gravel %	Sand fractions %						Mud %		Textural classes	$CaCO_3$ %	Gypsum %	Organic matter %
		Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Total sand	Silt	Clay				
High Terrace													
5	4.1	11.8	30.1	30.1	11.5	5.2	92.8	5.1	2.1	sgS	4.8	1.9	0.02
8	15.1	10.1	12.2	19.6	21.1	9.6	87.7	8.4	4.0	gS	11.8	1.6	0.2
9	12.7	5.8	8.5	22.5	32.4	8.9	90.8	6.3	2.9	sgLs	16.9	1.3	0.02
10	12.0	24.5	21.6	18.1	9.9	3.8	89.9	7.1	3.0	sgS	15.0	2.6	0.50
Medium Terraces													
1	5.2	15.4	24.5	28.0	17.3	3.2	93.6	4.7	1.7	sgS	4.0	1.4	0.65
2	3.4	4.1	10.4	31.2	35.2	9.8	94.1	6.7	2.7	S	7.8	0.1	0.08
3	17.6	7.9	12.5	21.3	23.0	6.8	89.1	7.7	3.2	gS	10.8	4.4	0.54
4	15.6	12.2	11.4	22.1	20.2	8.0	89.5	7.7	2.8	gS	8.9	0.5	0.4
6	2.9	11.4	19.8	37.5	15.8	3.7	91.1	6.4	2.4	S	6.0	1.6	0.1
7	4.1	9.0	12.1	17.9	25.4	14.6	83.1	13.0	4.0	LS	9.2	5.5	0.01
11	13.3	23.1	16.7	12.8	14.4	9.8	90.1	6.7	3.3	gS	3.9	4.3	0.49
22	12.4	8.1	12.5	19.9	26.0	9.4	88.3	7.9	3.8	gS	6.6	1.1	0.1
25	7.3	14.9	25.2	23.0	13.1	5.8	89.3	7.9	2.7	sgS	7.0	1.7	0.02
26	3.4	9.1	21.5	25.0	19.0	10.0	88.0	8.5	3.5	S	7.2	0.9	0.02
27	2.3	14.2	19.6	27.0	14.6	8.0	85.7	10.7	3.6	LS	10.7	2.6	0.03
28	8.5	11.9	12.7	18.5	20.9	8.3	80.8	15.9	3.4	sgLS	9.3	0.4	0.01
Low Terrace													
12	6.9	16.7	23.9	26.8	13.5	4.3	92.1	6.1	1.9	S	4.6	3.2	0.03
13	2.8	7.2	13.8	17.2	28.6	13.9	83.5	10.8	5.7	LS	10.0	4.8	0.07
14	10.9	7.2	11.0	30.1	23.8	5.9	88.9	7.5	3.6	sgS	8.8	0.8	0.1
15	8.1	11.0	17.5	28.7	16.4	9.8	91.5	6.0	2.5	sgS	6.1	2.6	0.17
16	7.3	8.3	14.9	25.0	19.1	8.5	83.1	12.8	4.3	sgLS	7.3	5.2	0.04
17	6.9	5.3	8.4	26.0	26.6	11.3	84.5	11.4	3.9	sgLS	7.6	2.3	0.13
18	20.3	16.4	18.3	23.2	8.7	3.3	90.2	7.3	2.5	gS	8.6	0.4	0.03
19	12.6	21.8	13.8	15.6	10.4	4.1	78.3	15.1	6.6	sgLS	14.1	2.9	0.13
20	1.9	6.2	11.7	31.3	18.9	7.5	77.5	14.5	8.1	Ls	6.6	2.0	0.16
21	3.9	6.5	14.3	37.0	16.6	6.5	84.8	11.9	3.3	LS	6.0	1.4	0.02
23	3.7	8.7	15.6	30.5	19.8	3.2	81.5	12.9	5.7	LS	11.8	5.8	0.22
24	19.9	17.9	18.0	20.3	9.0	4.6	89.7	7.3	2.9	gS	6.8	1.5	0.32
29	12.8	5.1	10.9	19.1	26.9	10.0	84.8	8.8	6.3	gS	8.2	0.6	0.3
31	8.0	8.1	23.9	35.4	15.0	3.9	94.3	4.4	1.4	sgS	3.5	2.3	0.1
32	3.9	4.1	6.0	24.7	35.2	7.1	81.0	15.6	3.4	LS	4.7	5.9	0.1
33	1.6	11.9	25.7	44.6	9.9	1.5	95.2	3.5	1.4	S	3.8	0.3	0.0
34	3.7	8.2	13.9	29.0	31.6	3.9	90.3	7.3	2.4	S	5.0	3.1	0.04
37	4.4	9.7	23.5	24.3	24.5	7.5	93.9	4.2	2.0	S	8.5	1.2	0.02
Very Low Terraces													
30	10.3	13.2	11.0	16.5	23.6	12.4	87.0	9.0	3.9	sgS	7.0	3.3	0.03
35	3.0	5.8	28.1	43.4	11.4	3.4	95.1	3.6	1.4	S	2.5	1.0	0.01
36	3.9	24.5	12.1	14.9	23.7	9.1	88.2	8.4	3.2	S	8.1	0.1	0.2
38	1.0	7.0	44.0	34.7	6.3	0.7	93.7	4.8	1.4	S	3.4	4.5	0.01
39	13.8	9.4	15.0	28.2	21.5	4.5	92.4	5.4	2.3	sgS	4.8	2.0	0.01
40	4.7	11.3	24.8	26.5	13.3	7.9	88.5	7.7	3.9	sgS	4.0	4.3	0.06
41	10.5	5.5	14.5	17.2	26.9	13.4	88.0	8.3	3.7	sgS	11.4	2.7	0.01

42	10.1	9.7	12.3	17.7	24.3	14.2	88.3	7.4	4.3	sgS	5.8	0.6	0.1

Table (1): Cont

Profile No.	Gravel %	Sand Fractions %						Mud %		Textural classes	$CaCO_3$ %	Gypsum %	Organic matter %
		Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Total sand	Silt	Clay				
Very Low Terraces													
43	7.4	5.3	6.8	12.8	20.4	9.5	62.2	25.1	12.5	sgSL	39.5	5.1	0.01
44	6.8	16.0	15.5	18.6	27.3	8.9	93.1	4.4	2.6	sgS	5.2	0.0	0.02
45	9.7	23.4	13.2	11.0	18.1	14.5	89.9	7.1	3.0	sgS	23.4	13.2	11.0
46	13.8	8.9	10.4	8.4	12.9	8.5	62.9	25.1	12.1	sgSL	45.4	6.4	0.13
47	19.9	7.1	11.8	13.3	21.0	9.0	82.1	12.8	5.0	sgLS	25.5	7.9	0.09
48	8.9	9.5	11.4	14.4	27.6	12.5	84.3	11.7	4.1	sgLS	7.9	1.5	0.0
49	4.0	12.2	11.2	22.6	38.6	5.2	93.8	4.6	1.6	S	4.0	0.5	0.0
50	7.7	24.9	26.2	20.7	15.2	4.4	99.1	0.7	0.2	sgS	4.3	0.3	0.01
Scarpments													
51	8.8	9.5	13.4	19.2	28.4	12.2	91.5	6.2	2.2	sgS	7.1	1.2	0.02
53	4.8	15.2	11.8	13.7	21.6	16.2	83.3	13.0	3.7	LS	6.9	5.3	0.04
54	4.7	3.2	4.5	9.9	50.0	13.0	85.3	11.3	3.4	LS	7.4	0.7	0.34
56	10.0	5.1	13.7	11.3	16.1	12.0	68.2	23.6	8.1	sgSL	32.8	5.8	0.23
57	19.0	5.8	4.9	5.2	34.9	26.0	95.8	2.8	1.5	gS	7.0	1.3	0.22
	Structural platform												
52	19.9	2.2	9.4	22.2	25.8	6.9	86.4	9.4	4.3	gLS	11.5	4.8	0.02
55	6.5	5.4	14.3	13.7	25.2	17.6	82.7	12.8	4.5	sgLS	12.2	2.5	0.03
58	13.0	4.8	5.9	15.3	30.6	18.8	88.4	9.2	2.4	sgS	14.0	0.2	0.2
59	2.2	15.4	16.8	6.3	12.7	7.4	60.8	28.6	10.7	SL	36.8	0.5	0.0
60	11.5	5.2	24.6	23.4	19.3	4.7	88.7	9.5	1.7	sgS	20.3	0.4	0.1
61	29.6	4.3	11.2	18.9	19.4	5.4	88.8	8.9	2.3	vgS	15.9	0.8	0.1
62	15.2	5.8	32.8	12.4	14.8	8.0	89.0	8.8	2.2	gS	33.1	0.2	0.00
63	20.5	5.1	20.9	12.4	20.9	8.4	88.2	9.7	2.1	gS	27.8	0.1	0.10

Note: sg: Slightly gravelly g: Gravelly vg: Very gravelly
S: Sand LS: Loamy sand SL: sandy loam

3.2.Chemical analyses of soil paste extracts:

3.2.1. Saturation percent (SP):

Soil saturation percentage values (SP) are mainly textural classes dependent. The SP values of the studied soils are generally low and fluctuate between 16 and 33 with an average of 21.6%. The low SP values can be interpreted to the sandy coarse texture of these soils.

3.2.2. Soil reaction (pH):

The pH value is one of the main factors affecting the physiochemical characteristics of the soil. The mobility and bioavailability of nutrients and toxic elements in soils depends principally on the pH value of the soil [17].

The data presented in this study propose that soil reaction occurred at pH varies considerably between 6.9 and 8.8 with an average of 7.7, indicating neutral to moderately alkaline soil reaction (Table 2). The dominant part of the investigated soils has pH values in the range of 7.1 to 8.0. The high pH values are due to the abundance of $CaCO_3$and presence of $MgCO_3$ or other carbonate phases.

Table (2): Mean values of chemical analysis of soil paste extract in the studied soil profiles.

Profile No.	SP	pH	E.C ds/m	Anions ($cmol_c\ kg^{-1}$)			Cations ($cmol_c\ kg^{-1}$)				SAR
				HCO^-_3	Cl	$SO^=4$	Ca^{++}	Mg^{++}	Na^+	K^+	
High Terraces											
5	19.8	7.6	20.9	3.4	212.3	89.5	120.8	39.8	142.5	2.0	17.1
8	21.7	7.5	29.7	9.4	386.3	102.4	91.3	94.1	309.7	3	34.1
9	22.2	7.6	21.2	4.9	269.6	72.5	133.2	44.9	167.3	1.5	18.1

10	18.5	7.4	33.2	5.1	245.9	436.7	179.0	103.7	402.5	2.5	32.0
Medium Terraces											
1	18.8	7.5	20.4	4.1	224.3	66.4	89.2	59	145.5	1.6	16.6
2	21.4	7.6	7.4	2	29.4	57.3	22.1	8.1	57.8	0.8	14.8
3	21.8	7.7	13.8	4.6	106.3	71.9	61.6	22.0	97.2	2.1	15.0
4	20.8	7.7	21.3	5.5	123.9	185.4	80.2	40.7	192.8	1.1	24.7
6	21.5	7.3	23.4	4	255.7	57.2	151.6	56.5	107.6	1.2	13.5
7	20.6	7.7	20.7	4.9	191.8	118.8	64.4	16.8	232.8	1.5	36.6
11	21.9	7.5	34.7	5.2	477.5	109.1	168.3	23.6	351.1	1.1	37.3
22	23.2	7.8	18	4.8	212.3	76.3	89.7	29	173.4	1.4	23.8
25	21.4	7.9	10.8	5.1	85.3	41.4	34.5	6.1	89.1	2.0	16.9
26	21.8	7.9	12.9	2.4	46.6	104.5	41.8	15.7	93.6	2.4	15.9
27	21.0	7.8	33.3	9.5	430.4	38.7	138.3	54.6	282.5	3.3	29.3
28	21.0	7.3	31.5	7.6	425.1	71.2	142.1	18.9	340.0	2.9	38.9
Low Terraces											
12	19.8	7.7	18.1	2.7	199.6	70.4	86.8	46.2	138.6	1.1	17.1
13	21.2	7.8	39.3	7.1	518.0	99.3	94.3	58.0	469.4	2.8	52.2
14	21.1	7.6	18.5	4.3	215.4	51.1	74.3	34.5	160.4	1.6	20.3
15	19.9	7.8	11	2.2	75.9	41.6	35.3	6	76.6	1.7	16.2
16	21.4	7.9	33	7.2	356.8	51.7	65.5	13.3	333.9	3.1	49.7
17	21.6	7.9	22.3	5.4	273.6	47.4	71.8	32.8	220	1.8	31.4
18	20.1	7.7	15.9	2.1	155.5	38.8	50.0	21.0	123.8	1.7	21.0
19	21.2	7.8	40.9	5.2	471.2	42.5	190.6	138.5	186.9	2.9	21.2
20	26.8	7.8	17.3	2.7	173.6	40.2	38.4	38.5	137.8	1.7	25.3
21	22.1	7.9	25.9	3.0	335.5	140.2	64.2	167.2	244.4	2.9	23.0
23	21.6	7.9	18.9	3.9	210.4	55.8	71.1	42.5	154.4	2.1	20.0
24	19.2	7.8	5.7	1.9	60.2	16.3	28.3	5.1	46	1.5	10.9
29	23.5	7.5	26.4	3.4	270.4	134.6	103.7	29.9	272.3	2.5	31.3
31	20.6	7.7	19.5	4.3	218.3	29.1	63.1	31.7	155.6	1.4	22.2
32	21.4	7.9	17.1	5.7	156.4	145.7	49	11.3	159.3	2.1	24.9
33	18.3	7.5	21.4	6.9	272.3	78.2	56.2	22.7	277.7	0.8	37.3
34	22.1	7.5	20.6	4.8	249.6	13.7	67.3	32.6	184.6	1.4	24.9
37	22.2	7.8	18.4	3.4	168	74	61.7	34.3	148.1	1.2	21.8
Very Low Terraces											
30	22.3	7.7	33.8	5.9	312.7	435.4	114.9	61.4	576.1	1.6	57.9
35	21.2	7.8	12.8	3.1	100.8	46.5	57.6	22.7	68.8	1.4	10.6
36	21.0	7.8	26.4	4.8	322.4	67.0	72.9	38.7	281.4	1.1	37.2
38	20.1	7.6	8.1	1.6	64.2	21.8	20.9	3.4	61.7	1.6	17.8
39	21.1	7.5	14.2	3.4	138.3	69.4	42.7	25.7	109.6	1.1	17.3
40	21.4	7.9	8.4	2.0	49.8	40.4	32.3	8.2	50.0	1.7	10.7
41	21.8	7.6	28.3	5.2	261.2	695	104.1	81.0	774.7	1.5	66.3
42	24.6	7.7	21.5	5.1	275.7	82.5	123.1	89.7	149.2	1.3	16.6
43	23.5	7.8	46.1	6.3	315.8	58.4	85.7	75.8	215.6	3.4	21.9
44	21.9	7.7	19.0	2.8	206.4	65.7	93.1	37.2	145.1	1.0	17.5
45	19.4	7.4	16.4	5.7	199.2	49.2	105.8	33.8	113.1	1.4	14.7
46	28.6	7.9	12.6	5.2	13.5	160.8	11.1	3.2	163.5	1.6	75.3
47	22.5	7.8	21.8	4.2	230.7	228.2	164	86.9	222.6	2.8	22.2
48	22.8	7.7	43.4	8.1	1079.2	47.1	435.9	105.5	591	2.1	42.8
49	18.7	7.5	8.5	2.5	100.2	25.6	43.3	29.3	49.4	1.3	8.7
50	19.5	7.7	18.8	2.9	230.5	78.8	127.6	91.9	93.1	1.2	9.0
Scarpments											
51	28.1	7.7	39.2	10.7	514	18.1	202	11.8	326.2	2.7	29.7
53	21.7	7.4	71.1	6.2	946	19.3	182.7	27.8	757.2	3.9	69.8
54	19.7	7.1	87.8	12.5	1401.6	158.1	553.4	299.3	688.3	2.4	33.1

Table (2): Cont'd

Profile No.	SP	pH	E.C ds/m	Anions (cmol$_c$ kg^{-1})			Cations (cmol$_c$ kg^{-1})				SAR
				HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+	
Scarpments											
56	23.2	7.8	15.1	5.1	135.9	8.0	33.2	18.6	106.2	1.3	20.7
57	20.8	7.9	23.4	5.5	211.1	49.8	52.4	18.2	196.3	2.1	32.8
Structural platform											
52	21.4	7.7	30.6	4.1	136.5	371	48.6	53.3	188.5	85	2.6
55	20.0	8.0	18.4	3.5	176.0	123.4	35.6	3.0	177.3	2.3	36.1
58	20.9	7.9	34.7	11.2	371.1	49.9	75.3	4.3	351.7	1.0	53.9
59	19.8	7.7	19.6	5.1	195.7	40.8	55.3	11.1	174.3	0.9	30.9
60	19.7	7.5	30.1	3.7	299.2	117.2	149.1	24.3	245	1.6	28.6
61	21.5	7.6	16.3	4.1	173.8	16.2	58.7	29.3	104.8	1.3	46.7
62	21.6	7.9	9.2	2.3	82.6	27.1	28.1	22.2	61.2	0.5	13.5
63	18.3	7.9	6.5	2.3	56	14.2	14.8	5.8	50.6	1.3	15.8

3.2.3. Soil salinityand soluble ions:

Salt affected soils are widely spread in semi-arid and arid areas such as Egypt. It is a fact that saline soils distribution is closely related to environmental factors such as climate, geology, geochemical and hydrological conditions.

In the study area, soil salinity values ranged widely between 3.0 and 107.8dSm^{-1}, with an average value of 32.6 dSm^{-1}. Most values of soil salinity (EC) indicate very strongly saline soils (> 16 dSm^{-1}). The low precipitation level and the high evaporation rate lead to the accumulation of soluble salt.

The soluble cations are dominated by Na^+ followed by Ca^{++} and Mg^{++}; while K^+ is the least abundant cations. On the other hand, Cl^- is the most dominant anion followed by $SO^=_4$, while HCO^-_3 is the least abundant anion and CO^-_3 is undetectable. Exceptional cases are found in some soil profiles, where $SO^=_4$ exceeds Cl^-.

3.3. Soil Classification:

The soil classification system is used to provide means for understanding the relationships among soils within a given area and among soils in different landforms. It can be used as reference term to identify soil map units [18].

The classification is carried out of soil under investigation according to theU.S soil Taxonomy System [19]. This system is based on the soil moisture and temperature regime, morphological characteristics, chemical and mineralogical composition and presence or absence of diagnostic horizon.

With regard to the study area, the soils display common features, but differ in one or more of the following characteristics:

- The mean annual soil temperature is about 20°C.
- The soil texture is coarse in all profiles, varying mostly from gravelly coarse sand to sandy loam.
- Depth of soil profiles in the area is dominantly deep but some profiles are moderately deep and shallow.
- Total calcium carbonate content varies between 2.5 and 45.0%.
- Soil salinity mostly ranges from high-saline to extremely high saline.
- Gravel content ranges between non gravel to very gravelly soils.
- Soil alkalinity varying from neutral to strongly alkaline.
- Organic matter ranges from 0.0 to 0.86%.

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 3). Two soil orders are identified in the study area i.e. *Aridisols*and *Entisols* (Fig.3). These orders are differentiated into suborders, greatgroups and subgroups based on criteria outlined in [19]. Subgroups are further differentiated into families taking into account the following classes: particle size, mineralogy, calcareous and reaction, soil temperature, soil depth, soil slope, soil consistence, coating (on sands) and cracks.

Table (3): Classification of soils in the study area [20].

Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-3, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

Names of taxa in each category				
Order	**Suborder**	**Great group**	**Subgroup**	**Profile No.**
Aridisols	*Gypsids*	*Haplogypsids*	*TypicHaplogypsids*	7,11, 13, 16,20, 23, 24, 30, 32, 38, 40, 45, 52, 53, 55
		Calcigypsids	*TypicCalcigypsids*	43, 46, 47, 56
	Calcids	*Haplocalcids*	*TypicHaplocalcids*	9,10, 19, 60, 62, 63
Entisols	*Psamments*	*Torripsaments*	*Typic Torripsaments*	1, 2, 3, ,5,6, 12, 15, 17, 21, 25, 26, 27, 31, 33, 34, 35, 36, 37, 41, 42, 44, 48, 49, 50, 51, 54,58, 59, 61
	Orthents	*Torriorthents*	*TypicTorriorthents*	4, 8, 14, 18, 22, 28, 29, 39, 57

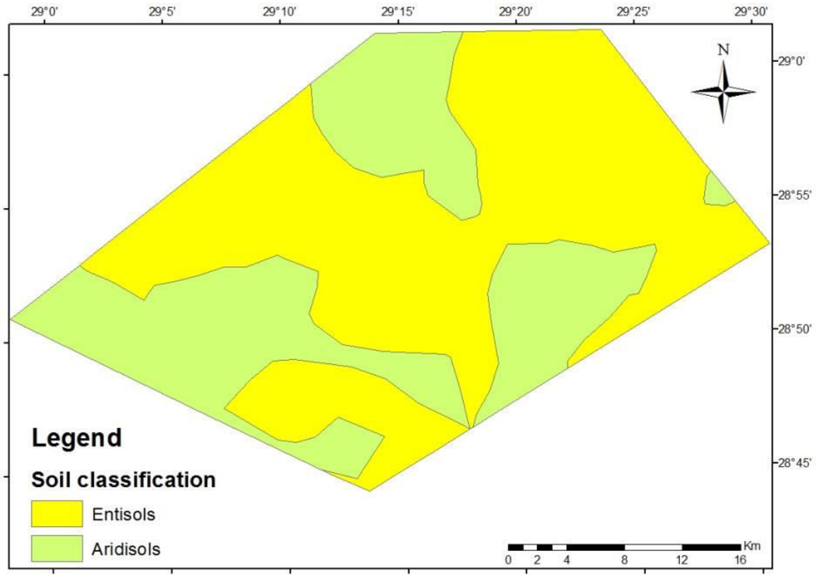

Fig. (3): Distribution of soil classification in the study area.

3.3.1. ***Aridisols*:**
Aridisols are cover 362 km^2 (38.3% of the study area) and differentiated into three suborders i.e. *Calcids, Gypsids* and *Calcigypsids* (Table 3).

A) Calcids:
These soils of *Aridisols* have a calcic or petrocalic horizon that has its upper boundary within 100 cm of the soils surface. One greatgroup is detected under such suborder in the study area, namely; *Haplocalcids*.
Haplocalcids are *Calcids* which have calcic horizon that has its upper boundary within 100 cm of the soil surface. One soil subgroup is included in such greatgroup, namely; *TypicHaplocalcids*. This subgroup includes two soil families:
-*TypicHaplocalcids*, sandy, mixed, hyper-thermic, deep (Profiles Nos. 9, 10, 19, 60 and 62).
-*TypicHaplocalcids*, sandy, carbonatic, hyperthermic, moderately deep (Profile No. 63).

B*) Gypsids*:
Gypsids are *Aridisols* which have a gypsic or petrogypsic that has its upper boundary within 100 cm of the soil surface. One greatgroup has been detected under this suborder, namely; *TypicHaplogypsids*.This subgroup includes two soil families:
-*TypicHaplogypsids*, sandy, mixed, hyperthermic, deep (Profiles Nos. 7, 11, 13, 23, 32, 38, 40, 45, 52, 53 and 55).
- *TypicHaplogypsids*, loamy, mixed, hyperthermic, moderately deep (Profiles Nos.16, 24 and 30).

C) ***Calcigypsids*:**
*Calcigypids*are *Gypsids* that have a calcic horizon that has its upper boundary within 100 cm of the soil surface. One subgroup is identified namely *TypicCalcigypsids*. This subgroup includes two soil families:
-*TypicCalcigypsids*, loamy, mixed, hyperthermic, deep (Profiles Nos. 43 and 47).
-*TypicCalcigypsids*, loamy, mixed, hyperthermic, moderately (Profiles Nos., 46 and 56).

3.3.2. ***Entisols*:**
Entisols are the recent soils that are not exhibiting any sign of parent material maturity under the prevailing arid climate. However, according to [21]*Entisols* lack the subsurface diagnostic horizons. This order is cover about 583 km^2 (61.7% of the studyarea).Two *Entisols*suborders isidentified in the study area, namely *Orthents* and *Psamments*.

A) ***Orthents*:**

These soils are dry most of the year with naturally oriented soil layers, include more than 35% (by volume) of rock fragments and are free of sulfidic materials within 100 cm of the soil surface. One greatgroup have been detected under such suborder, namely; *Torriorthents*.

Torriorthents are *Orthents*, which have a torric moisture regime. One soil subgroup is included in such greatgroup, namely *TypicTorriorthents* that include two soil families:

- *TypicTorriothents*, sandy skeletal, silicieous, hyperthermic, deep (Profiles Nos. 4, 8, 14, 18, 22, 28, 39 and 57).
- *TypicTorriothents*, sandy skeletal, silicieous, hyperthermic, moderately deep (Profile No. 29).

B) ***Psamments*****:**

These soils have less than 35% (by volume) rock fragments and texture of loamy sand or coarser within 100 cm of the soil surface. One greatgroup is detected under such suborder, namely *Torri-psamments*, which are characterized by torric moisture regime. One soil subgroup is included in such greatgroup, namely; *TypicTorripsamments*. This subgroup includes two soil families:

-*TypicTorripsamments*, siliceous, hyper-thermic, deep (Profiles Nos. 1, 2, 3, 5, 6, 12, 17, 21, 26, 27, 31, 33, 34, 35, 36, 37, 42, 48, 49, 50, 58 and 61).

- *TypicTorripsamments*, siliceous, hyper-thermic, moderately deep (Profiles Nos. 25, 41, 51 and 54).

3.4.Soil evaluation for irrigated agriculture:

For the evaluation of land suitability for current and potential capability, the parametric evaluation system was used [8, 9]. This method is based on morphology, physical and chemical properties of soil and the land is evaluated according to numerical indexes. Seven parameters (slope, drainage properties, electrical conductivity of soil solution, calcium carbonates status, gypsum status, soil texture and soil depth) were considered and rates were assigned to each parameter, thus, the capability index for irrigation (Ci) was developed as shown in the equation below:

Ci = A x B/100 x C/100 x D/100 x E/100 x F/100 x G/100.

where A, B, C, D, E, F and G are the rating of soil texture, soil depth, calcium carbonate content, gypsum content, electrical conductivity, drainage and slope, respectively. Suitability classes are defined by considering the value of the capability indices (Table 4).

The results obtained through the land evaluation methods for irrigated agriculture were incorporated into the digital map in the Arc GIS 10.1 software to produce land suitability maps for current and potential capability. Within a particular area, the positive correlation between present land use and potential land capability is very important.

From the agricultural point of view, classification of soils for evaluating their capability for irrigation utilization aims at assessing the degree of limitation or suitability for agriculture use on the basis of their permanent properties.

Table (4): Suitability classes for the irrigation capability indices (Ci) classes.

Soil class	Definition	Land index
S1	Highly suitable	> 75
S2	Moderately suitable	50-75
S3	Marginally suitable	25-50
Nl	Currently not suitable	12.5-25
N2	Permanently not suitable	< 12.5

3.4.1. Current land suitability:

Current land capability refers to the capability for a defined use of land in its present condition, without major improvement [22].The rating values [9]were calculated to express the capability of land characteristics. The rating values and the kind of limitations are presented in Table (5). Accordingly, the studied area could be classified into three current classes (Table 6 and Fig. 4):

- Marginally suitable land (S3): Soils of this class cover 488.0 km^2; about half of the study area (31 soil profiles; 49.2% of all soil profiles).

- Currently not suitable land (N1): This includes land having very severe limitations that are not economically feasible to be corrected with existing knowledge. From the data showed, it is clear that soil represented an area of 418.5 km^2 (27 profiles; 42.9% of all soil profiles).

- Permanently not suitable land (N2): Limitations of this land are so severe limitation as to preclude any possibilities of successful sustained use of the land with an area of 38.3 km^2 (represent 5 profiles; 7.9% of all profiles). These soils have severe andvery severe limitations, e.g., textural, soil depth, calcium carbonate content, gravel content, salinity and fertility.

The soil limiting factors in the study area are texture (t), salinity & alkalinity (n), slope (s) and $CaCO_3$ content with slight to severe and very severe intensity for soil limitations.

3.4.2. Potential land suitability:

Potential capability refers to the capability of units for a defined use, after specified major improvements have been completed where necessary [22]. In the study area the major improvements needed to overcome the current (present) limitations are:

a) Leaching of soils salinity and reclamation of soil sodicity,

b) Continuous application of organic manure to improve soil properties and fertility status, and

c) Application of drip and sprinkler irrigation system.

By applying these practices, potential suitability of the studied soils could ameliorate to highly suitable (S1), moderately suitable (S2) and marginally suitable (S3); (Tables 5 & 6 and Fig. 5).

- Highly suitable land (S1):soils of this class cover a very small area representing 9.5 km^2 (1.6% of all soil profiles).

Moderately suitable (S2): soils of this class cover 435.5 km^2 (31 soil profiles; 42.9% of all soil profiles).

- Marginally suitable land (S3):soils of this class cover 500.0 km^2, i.e more than half of the study area (35 soil profiles; 55% of all profiles).

The limiting factor to this kind of land use is mainly soil texture, soil salinity and calcium carbonate content.

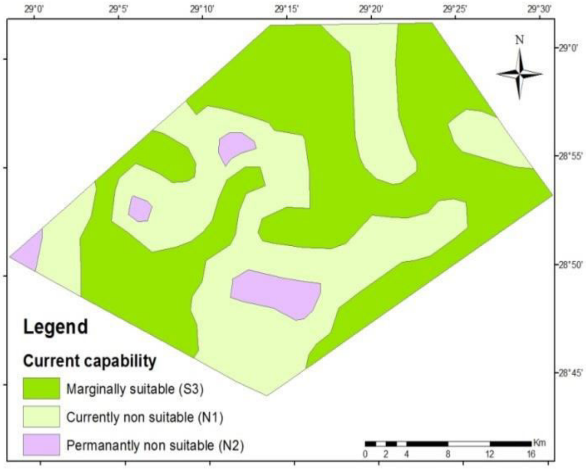

Fig. (4): Spatial distribution of current capability classes for the study area.

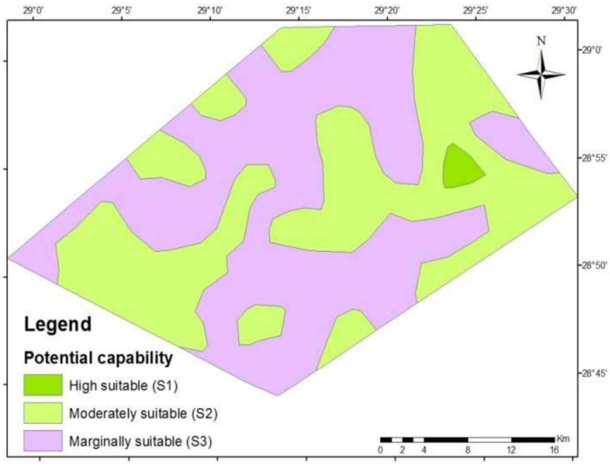

Fig. (5): Spatial distribution of potential capability classes for the study area.

Table (5): Degree of soil limitations and suitability classes of the studied soil Profiles**.**

Profile No.	Slope		Drainage		Depth	Texture		$CaCO_3$	Gypsum	Salinity/ Alkalinity		Current capability		Potential capability	
	C	P	C	P		C	P	S3	S4	C	P	Ci	Class	Ci	class
1	90	100	100	100	100	40	55	100	90	58	85	18.8	N1tn	42.1	S3t
2	90	100	100	100	100	60	70	90	90	85	100	37.2	S3t	56.7	S2t
3	90	100	100	100	100	60	70	90	100	75	95	36.5	S3tn	59.9	S2t
4	90	100	100	100	100	60	70	100	90	58	85	28.2	S3tn	53.6	S2t
5	90	100	100	100	100	40	55	100	100	58	85	20.9	N1tn	46.8	S3t
6	90	100	100	100	100	40	55	100	90	58	85	18.8	N1tn	42.1	S3t
7	90	100	100	100	100	60	70	90	100	58	85	28.2	S3tn	53.6	S2t
8	90	100	100	100	100	60	70	90	90	58	85	25.4	S3tn	48.2	S3t
9	90	100	100	100	100	60	70	90	90	75	95	32.8	S3tn	53.9	S2t
10	90	100	100	100	100	60	70	90	90	58	85	25.4	S3tn	48.2	S3t
11	90	100	100	100	100	60	70	100	100	30	60	16.2	N1tn	42.0	S3tn
12	90	100	100	100	100	40	55	100	100	75	95	27.0	S3tn	52.3	S2t
13	90	100	100	100	100	60	70	90	100	30	60	14.6	N1tn	37.8	S3tn

14	90	100	100	100	100	60	70	90	90	75	95	32.8	S3tn	53.9	S2t
15	90	100	100	100	100	40	55	100	100	75	95	27.0	S3tn	52.3	S2t
16	90	100	100	100	100	60	70	90	100	30	60	14.6	N1tn	37.8	S3tn
17	90	100	100	100	100	70	80	100	100	75	95	47.3	S3tn	76.0	S1
18	90	100	100	100	100	60	70	90	90	75	95	32.8	S3tn	53.9	S2t
19	90	100	100	100	100	60	70	90	100	30	60	14.6	N1tn	37.8	S3tn
20	90	100	100	100	100	70	80	90	90	75	95	38.6	S3tn	61.6	S2t
21	90	100	100	100	100	60	70	100	90	30	60	14.6	N1tn	37.8	S3tn
22	90	100	100	100	100	60	70	100	90	75	95	36.5	S3tn	59.9	S2t
23	90	100	100	100	100	60	70	100	100	75	95	40.5	S3tn	66.5	S2t
24	90	100	100	100	95	40	55	100	90	90	100	27.7	S3t	47.0	S3t
25	90	100	100	100	85	40	55	100	90	80	95	22.0	N1tn	40.0	S3t
26	90	100	100	100	100	60	70	100	90	75	95	36.5	S3tn	59.9	S2t
27	90	100	100	100	100	60	70	90	90	30	60	13.1	N1tn	34.0	S3tn
28	90	100	100	100	100	60	70	90	90	30	60	13.1	N1tn	34.0	S3tn
29	90	100	100	100	95	60	70	100	90	75	95	34.6	S3tn	56.9	S2t
30	75	95	100	100	95	40	55	100	90	30	60	7.7	N1stn	26.8	S3tn
31	75	95	100	100	100	40	55	100	100	58	85	17.4	N1stn	44.4	S3t
32	90	100	100	100	100	60	70	100	100	58	85	31.3	S3tn	59.5	S2t
33	90	100	100	100	100	40	55	100	90	30	60	9.7	N1tn	29.7	S3tn
34	90	100	100	100	100	60	70	100	100	58	85	31.3	S3tn	59.5	S2t
35	75	95	100	100	100	40	55	100	90	75	95	20.3	N1stn	44.7	S3t
36	75	95	100	100	100	60	70	90	90	58	85	21.1	N1stn	45.8	S3t
37	75	95	100	100	100	60	70	90	90	75	95	27.3	S3stn	51.2	S2t
38	75	95	100	100	100	40	55	100	100	80	95	24.0	N1stn	49.6	S3t
39	90	100	100	100	100	40	55	100	90	58	85	18.8	N1tn	42.1	S3t
40	90	100	100	100	100	60	70	100	100	80	95	43.2	S3tn	66.5	S2t
41	90	100	100	100	100	60	70	90	90	30	60	13.1	N1tn	34.0	S3tn
42	90	100	100	100	100	60	70	100	90	58	85	28.2	S3tn	53.6	S2t
43	90	100	100	100	100	70	80	80	100	30	60	15.1	N1tcn	38.4	S3tcn
44	75	95	100	100	100	40	55	100	90	75	95	20.3	N1stn	44.7	S3t
45	75	95	100	100	100	60	70	100	100	75	95	33.8	S3stn	63.2	S2t
46	90	100	100	100	95	70	80	80	100	85	100	40.7	S3tc	60.8	S2tc
47	90	100	100	100	100	70	80	90	100	30	60	17.0	N1tn	43.2	S3tn
48	75	95	100	100	100	60	70	100	90	30	60	12.2	N1stn	35.9	S3tn
49	90	100	100	100	100	40	55	100	90	80	95	25.9	S3tn	47.0	S3t
50	75	95	100	100	100	40	55	100	90	80	95	21.6	N1stn	44.7	S3t
51	75	95	100	100	85	40	55	100	90	58	85	13.3	N1stn	34.0	S3t
52	75	95	100	100	100	60	70	90	90	30	60	10.9	N1stn	32.3	S3tn
53	75	95	100	100	100	60	70	100	100	30	60	13.5	N1stn	39.9	S3tn
54	90	100	100	100	95	60	70	100	90	58	85	26.8	S3tn	50.9	S2t
55	90	100	100	100	100	60	70	90	90	80	95	35.0	S3tn	53.9	S2t
56	75	95	100	100	95	70	80	90	90	80	95	32.3	S3stn	55.6	S2t
57	90	100	100	100	100	70	80	90	90	58	85	29.6	S3tn	55.1	S2t
58	90	100	100	100	85	40	55	90	90	75	95	18.6	N1tn	36.0	S3t
59	75	95	100	100	100	70	80	90	90	58	85	24.7	N1stn	52.3	S2t
60	75	95	100	100	100	40	55	90	90	58	85	14.1	N1stn	36.0	S3t
61	90	100	100	100	100	40	55	90	90	80	95	23.3	N1tn	42.3	S3t
62	90	100	100	100	100	60	70	90	90	75	95	32.8	S3tn	53.9	S2t
63	90	100	100	100	100	40	55	90	90	30	60	8.7	N1tn	26.7	S3tn

Note: C: Current P: Potential Ci: Capability Index
Limitations (t: texture n: salinity s: slope c: $CaCO_{3)}$
Intensity of limitations: no (95-100), slight (85-95), moderate (60-85) severe (45-60), very severe (<45).

Table (6): Suitability index distribution of the current and potential capability of the studysoil profiles.

Suitabilityclasses	Current capability	Potential capability
Highly suitable (S1)	-	17
Moderately suitable (S2)	-	2,3,4,7,9,12,14,15,18,20,22,23,26,29, 32,34,37,40,42,45,46,54,55,56,57,59, 62
Marginally suitable (S3)	2,3,4,7,8,9,10,12,14,15,17,18,20,22,23, 24,26,29,32,34,37, 40,42,45,46,49,54,56,57,62	1,5,6,8,10,11,13,16,19,21,24,25,27,28,30,31,3 3,35,36,38,39,41,43,44,47,48,49,50,51,53,58, 60,61,63
Currently not suitable (N1)	1,5,6,11,13,16,19,21,25,27,28,31,35,36 ,38,39,41,43,44,47, 50,51,53,58,59,60,61	-
Permanently not suitable (N2)	30,33,48,52,63	-

3.5. Water quality:

The main water resource in Egyptian Western Desert (including the study area) is the underground water.

3.5.1. Hydrochemical characteristics of groundwater in the study area:

For evaluating the water of the studied wells for drinking and irrigation, a numerous attributes have been measured and quantified as follows:

A) pH value:

The pH values of the studied water samples are slightly alkaline to alkaline (where it's ranged from 7.40 to 8.80) (Table 7).

B) Electrical conductivity (EC):

The water salinity of the study area ranged from 0.36 to 1.81 dS/m which correspond to slightly saline and moderately saline [23]. The salinity values decreased with increasing the depth of water well (Table 7).

Table (7): Chemical analysis of water sample of the study water samples**.**

Well No.	Depth (m)	pH	EC dS/m	TDS	Cations (mgL^-)				Anions (mgL^-)				SAR
					Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^-	HCO_3^-	Cl^-	$SO_4^=$	
1	870	7.4	0.43	275.2	0.53	0.21	3.28	0.04	0.00	0.85	1.63	1.59	5.41
2	400	8.5	1.81	1158.4	0.35	0.38	16.52	0.11	0.94	3.21	5.88	7.34	27.25
3	880	8.5	0.36	230.4	0.35	0.68	2.30	0.08	0.57	0.38	1.25	1.21	3.20
4	650	8.8	0.70	448.0	0.26	0.91	4.70	0.13	0.94	0.85	2.25	1.96	6.12
5	600	7.5	0.60	384.0	1.23	1.71	2.37	0.05	0.00	0.09	1.38	3.89	1.95
6	860	8.1	0.42	268.8	0.53	0.65	2.58	0.10	0.00	0.85	1.38	1.63	3.36

C) Total dissolved salts (T.D.S):

The salinity of the groundwater samples (indicated as TDS) ranged from 230 to 1158 mgL^- (Table 7). The shallower horizons register high salinity which may be due to increased groundwater discharge. The relatively high values of TDS and EC also associated mostly with the salts existence in the upper geological beds in particular.

D) Sodium adsorption ratio (SAR):

The SAR is mostly low except well No. 2. The two most common water quality factors which influence the normal infiltration rate are the salinity of the water and it's SAR. High salinity water will increase infiltration. Low salinity water or water with a high SAR will decrease infiltration [11].

E) Major soluble cations: The sodium content of the groundwater samples ranges from 2.30 to 16.52 meq/l. The source of sodium content in water is greatly dependent on the rock type of the reservoir where sodium may be present as impurity or readily soluble sodium salts. Some salty sediments as evaporites or soils contain minerals rich in sodium.Calcium content of the groundwater samples ranges between 0.26 and 1.23 meq/l. Carbonate rocks are the principle source for calcium in the study area. The magnesium content of the groundwater samples ranges from 0.21 to 1.71 meq/l. The source of magnesium in the study area is dolomite and magnesite. Potassium content ranges from 0.04 to 0.13 meq/l.

F) Major soluble anions:

The chloride content of the groundwater samples of the study area ranges from 1.25 to5.88 meq/l.They are present in high content in marine sediments, such as shales in the study area. The carbonate and bicarbonate contents of the sampled wells range from 0.00 to 0.94 and 0.09 to 3.21 meq/l,respectively. It is well known that carbonate ions are mainly derived in the study area from calcium carbonate rocks. The sulphate content of the groundwater ranges from 1.21 to 7.34 meq/l.

G) Trace Elements:

Eleventrace elements (Iron, manganese, copper, zinc, phosphorous, lead, boron, cobalt, nickel, cadmium and cromium) are detected in the sampled wells (Table 8). Only well No. 5 has high content of Fe (15.27 mgL$^-$) and Mn (2.0mgL$^-$).The relatively high content of iron and manganese is related to the geological nature of this area which enriched by these elements in their sedimentary succession [24].

Table (8): Chemical analysis of some trace elements in the study water samples (mg/kg).

Well No.	Fe	Mn	Cu	Zn	P	Pb	B	Co	Ni	Cd	Cr
1	0.10	0.03	0.02	0.00	0.10	0.06	0.08	0.03	0.03	0.00	0.00
2	0.22	0.02	0.03	0.01	0.11	0.07	0.34	0.05	0.05	0.01	0.00
3	0.10	0.01	0.03	0.00	0.04	0.05	0.05	0.03	0.03	0.00	0.00
4	0.10	0.01	0.03	0.01	0.07	0.05	0.10	0.04	0.04	0.00	0.00
5	15.3	2.00	0.03	0.42	0.07	0.06	0.01	0.04	0.02	0.00	0.00
6	0.18	0.01	0.02	0.01	0.04	0.04	0.04	0.03	0.04	0.00	0.00

3.5.2. Water quality:

In order to assess the suitability of the groundwater of the area under consideration, the former measured groundwater attributes have been compared with the standard guideline values issued by [11,25,12 and10].

3.5.2.1. Suitability of water for drinking:

The TDS and major ions content of thesampled wells (except sample No. 2) arebelow the critical limits for drinking according to[10]. The trace element contents are mostly below the critical limits of such use except Fe and Mnin well No.5 (Tables 8 and 9). Therefore, the groundwater of the study water samples is suitable for drinking usage except wells Nos. 2 and 5.

Table (9): Guidelines values of water components for drinking and irrigation usages.

Inorganic chemical parameters	Drinking water Guidelinesvalues *1	Drinking water Guidelines values *2	Irrigation water Guidelines values*3	Irrigation water Guidelines values *4
Temperature	-	-	-	35 ^{o}C
pH	6.5 - 8.0	6.5 - 9.2	6.5 – 8.4	5 - 9
Aluminum (mgL$^-$)	-	0.2	5.0	5.0
Antimony (mgL$^-$)	0.002	-	-	-
Arsenic (mgL$^-$)	0.01	0.05	0.1	0.1
Barium (mgL$^-$)	0.7	-	-	-
Bicarbonate (mgL$^-$)	-	-	520	-
Boron (mgL$^-$)	0.5	-	2.0	0.75
Cadmium (mgL$^-$)	0.003	0.005	0.01	0.01
Calcium (mgL$^-$)	200	200	-	-
Chloride (mgL$^-$)	250	500	-	250
Chromium (mgL$^-$)	0.05	0.05	0.10	0.1
Copper (mgL$^-$)	5.0	1.0	0.2	0.2
Fluoride (mgL$^-$)	1.5	0.8	1.0	1.0
Iron (mgL$^-$)	0.3	0.3	5.0	5.0
Lead (mgL$^-$)	0.01	0.05	5.0	2.0
Magnesium (mgL$^-$)	150	150	-	-
Manganese (mgL$^-$)	0.4	0.1	0.2	0.2
Mercury (mgL$^-$)	0.006	0.001	0.02	0.02
Nitrate (mgL$^-$)	50 (as NO_3^-)	40 (as NO_3^-)	15 (as N^-)	15 (as N^-)
SAR	-	-	3 - 9	< 6
Selenium (mgL$^-$)	0.01	0.01	0.02	0.02
Sodium (mgL$^-$)	200	200	-	-
Sulphate(mgL$^-$)	250	400	500	500
TDS(mgL$^-$)	1000	1200	2000	2000
Zinc (mgL$^-$)	5.0	5.0	2.0	2.0

*1 [10] *2 [25]

*3 [11] *4[12].

3.5.2.2.Suitability of water for irrigation:

The current investigation, partially classified the water of the sampled wells for irrigation uses with respect to TDS, EC, SAR and trace elements according to [26, 11 and 12].

A-Classification according to salinity content:

In the present study, the U.S. Salinity Laboratory classification [13]has been used with slight modification in the high salinity levels [26]as in Table (10). The data declare that wells Nos. 1, 3, 4, 5, 6 have medium saline, whereas Well No. 2 has high saline.

B-Classification according to EC and SAR:

As for classifying the sampled waters according to their EC and SAR values, plotting EC vs SAR values of such water show that its possess C1-S1and C3-S4, respectively.

Table (10): Water classification according to TDS and EC [26].

Salinity classes	TDS (mg/kg)	EC (dS/m)	Well No.
Low saline	< 160	< 0.25	-
Medium saline	160-480	0.25- 0.75	1, 3, 4, 5, 6
High saline	480- 1440	0.75-2.25	2
Very high saline	1440-3200	2.25-5.0	-
Excessive saline	> 3200	> 5.0	-

The data depicted in Table(11) summarized the suitability classes of the sampled water for crop irrigation according to [13]. The data indicate that the majority of sampled waters are moderate suitable with minor of marginally suitable.

Table (11): EC and SAR values of the sampled wells and their water suitability for irrigation according to [13]

Well No.	EC dS/m	SAR	Suitability for irrigation	
			Order	Class
1	0.43	5.41	C2-S1	Moderately Suitable
3	0.36	3.20		
4	0.70	6.12		
5	0.60	1.95		
6	0.42	3.36		
2	1.81	27.25	C3-S4	Marginally Suitable

EC = Electrical Conductivity SAR = Sodium Adsorption Ratio

C-Classification according to EC, TDS, SAR, major ions and trace elements:

According to [11 and 12], the studied water samples properties are mostly under the critical levels of irrigation use except for iron and manganese elements in sample No.5 (Tables 8, 10and 11). Iron is not toxic to plants in aerated soils, but can contribute to soil acidification and loss of essential phosphorus and molybdenum [11]. Manganese is toxic to a number of crops at few-tenths to a few mg/L in acid soils. In this connection, [11]postulated that the quality of the water does not present special problems when used in irrigation for a short-term.

4. References:

[1] FAO (1990) Guidelines for Soil Description. 3rd(Ed.) Revised, Soil Resources, Management and Conservation Service. Landand Water Development Division, Rome, Italy.

[2] FAO (2006) Guidelines for Soil Description. Food and Agriculture Organization of the United Nations, Rome, Italy.

[3] USDA (United State Department of Agriculture, Natural Resources Conservation Service) (2010) Field Indicator of hydric soils for the United States, Version 7.0.USDA, NRCS, in cooperation with the Natural Technical Cmmittee for Hydric Soils.

[4] Folk Folk, R. L. (1980) Petrology of sedimentary rock; Sylabus, Hamphill's publishing company, Austin,Texas.

[5] Issam, I. B. and Antoine, H. S. (2007) Methods of analysis for soils of arid and semi-arid regions, FAO, Rome, 128 pp.

[6]Soil Survey Staff (1975)SoilTaxonomy: a basic system of soil classification for making and interpreting soil survey. United States Department of Agriculture (USDA), Handbook 436. U.S. Gov. Print. Off., Washington, D.C., USA.

[7] Soil Survey Staff (2014) Keys to Soil Taxonomy; USDA, Twelfth Edition, Soil Cons Serv. Washington, USA, 372 pp.

[8] Sys, C., and Verheye, W. (1978)An attempt to the evaluation of physical land characteristics for irrigation according to the FAO framework for land evaluation. Int. Train Course for Post Grad.Soil, Sci. Univ., Ghent, Belgium.

[9] Sys, C., Ranst.V, and Debaveye, J. (1991) Land evaluation, part I and II, Lecture Notes. Ghent Univ. Ghent, Belgium.

[10] World Health Organization (WHO) (2008) Guidelines for drinking water quality (electronic resource): incorporating first addendum. Vol.1, Recommendations.3rd ed., Geneva, Switzerland, 595pp.

[11] Ayers, R. S. and Westcot, D. W. (1985) Water quality for agriculture. FAO Irrigation and Drainage Paper, 29 Rev.1. FAO, Rome.

[12] Ministry of the Environment (1999) Guidelines for irrigation water quality. Human resource development andemployment, department of environment.
[13] Richards, L. A., (1954), Diagnosis and improvement of saline and alkali soils. USDA. Hand Book No. 60.

[14] Schoeneberger, P. J., Wysocki, D. A. and Benham, E. C. (2011) Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

[15]Labib, F. B., Hamdi, M. A., and El- Taweel, M. A.(1999) Genesis and classification of some gypsiferous soils in Egypt, Annals of Agric. Sci., Moshtohor, Vol. 25.

[16] Beshay, N. F. (2001) Gypsum forms in relation to soil characteristics in some western desert depressions, Egypt. M.E.R.C. Ain Shams Univ. Earth Sci. Ser., 15: 119-134.

[17]Schroeder, D., and Blum, W. H. (1992) Bodenkunde in Stichworten, 4th ed. Hirt, Berlin.

[18] Soil Survey Staff (1983) National soil handbook. USDA Agric. Handbook USDA Agric. Handbook.
[19] Soil Survey Staff (2010) Keys to soil taxonomy. United State Department of Agriculture, Natural Resources, Conservation Service (NRCS), Eleventh Edition.

[20] Soil Survey Staff (2014) Keys to Soil Taxonomy; USDA, Twelfth Edition, Soil Cons. Serv. Washington, USA, 372 pp.

[21] Smith, G. (1986) Rationale for concepts in soil taxonomy. USDA- SMSS. Tech. Monograph No., 11, Washington, D.C., USA.

[22] FAO (1976) A framework for land evaluation. IIRI,Wagningen, pub.No., 32.Soil survey investigation for irrigation. Soil Bull. 42, Rome, Italy.

[23] Ministry of Public Works and Water Resources (MPWWR), National Water Research Center (1993) National level strategies and policies for utilizing Egypt's Water Resources.WRSR publication series.

[24] CONCO (1987) Geological map of Egypt, Scale 1:500,000, Nile Delta, NH-36. Egyptian General Petroleum Corporation.

[25] Egyptian Ministry of Health (1995) Standards and specifications of water quality for drinking and domestic uses.

[26] El-Ghandour, M. F., Hefny, K., Khalil, J. B. and Atta, S. A. (1983) Suitability of groundwater in the Nile Delta region (Egypt) for irrigation. Middle East Water Sewage, 7(2),Fuel Metallurgical Jour, Ltd. U.K.