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# THE RELATION BETWEEN THE GEOMORPHOLOGICAL UNITS AND THE CHARACTERISTICS OF SOILS FORMED IN NORTH SINAI, EGYPT

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**ABSTRACT:** *The studied area is considered as one of the most promising area in Egypt. This investigation aimed to perform soil map, classify and evaluate the studied soils. Fiveteen soil profiles represented the different geomorphic units in the studied area were chosen; Alluvial plain, piedmont and windblown sand. The soil surface of the studied Alluvial plain was covered by pavement, on the other hand the surface of the studied piedment soils was had some stone fragment , the elevation ranged from +77 m to 220 m above sea level. The soil color ranged from 5 YR to 10 YR. The studied soils had few to moderate of pedogenic carbonates and gypsum and relatively high contents of lithogenic or primary carbonates. The texture varied between light to medium. The soils were very slightly saline to strongly saline and classified as Typic Torriorthents, Lithic Torriorthents, Typic Haplocalcids, Typic Haplogypsids, Lithic Haplogypsids, Lithic Torriorthents and Typic Torriorthents. The soil capability was S2 in the Alluvial plain, S3pt in the windblown soils. The limitating factors were the light texture (t), Topography (P), Soil depth (d).*

***Key words:*** *Soil Pedology, Land evaluation, geomorphic units, soil classification*

## INTRODUCTION

The area of Sinai is 61000km$^2$ and about 6% of Egypt, the area of North and Middle Sinai is considered the most promising areas in Egypt for Agriculture and encouragement the Egyptian Economic. *Soil Survey Report (2009)* showed that North Sinai included the following geomorphic units:-

1- Wind Blown plain, nearly level, sandy texture, deep soil, non saline and marginally suitable (S3) and classified as Typic Torripsamments.
2- Lacustrine plain, level, clayey texture, deep soil, strongly saline, non suitable (N) and classified as typic Haplosalids..
3- Alluvial plain, nearly level, loamy sand to sandy clay loam texture, very slightly saline to moderately saline, marginally suitable and classified as Typic Haplocalcids and Typic Torripsamments.
4- Sabakha soil, nearly level loamy sand texture, strongly saline, non suitable (N2).

The studied area is considered as one of the most promising areas which are included in the strategy of Egyptian Government up to 2025; the total of the studied area is about 660,000 feddans.

The aim of this investigation is forming a soil map of the studied area, soil classification and evaluating the studied soils

### Climate:-

According to *CLAC (2010)*, the climate of the North Sinai is arid and no rainfall in the summer, cold with few of rainfall in the winter. The maximum temperature is 31$^{o}$C in the August and the minimum is 8.5 $^{o}$C in January as in Table (1). The total rainfall is about 104 mm/year varied from 0.0 in July to 22.2 mm in December, the highest amount in the North, whereas the lowest in the South. The relative humidity varied between 67 % during March to 75 % in August. The wind speed increases in winter and spring seasons and decreases in summer.

**Table (1): Climatic elements from El-Arish station (2005-2009), from central laboratory for Agriculture Climate, Ministry of Agriculture.**

| Month | Temprature C° (T) | | | Mean Rainfall (mm.) | Mean Evaporation (mm./day) (E) | Relative humidity % (Rh) | Wind Speed km./hour (W) |
|---|---|---|---|---|---|---|---|
| | Max. | Min. | Mean | | | | |
| Jan. | 19.2 | 8.5 | 13.6 | 20.3 | 3.6 | 70.0 | 1.3 |
| Feb. | 19.9 | 9.1 | 13.9 | 17.1 | 4.0 | 69.0 | 2.0 |
| March | 21.3 | 10.8 | 16.0 | 12.8 | 4.5 | 67.0 | 2.3 |
| April | 23.7 | 13.3 | 18.7 | 6.1 | 4.7 | 67.0 | 2.1 |
| May | 26.9 | 16.1 | 21.6 | 3.2 | 4.9 | 68.0 | 2.1 |
| June | 28.9 | 18.9 | 24.7 | 0.0 | 4.9 | 72.0 | 2.0 |
| July | 30.6 | 21.3 | 26.2 | 0.0 | 4.8 | 74.0 | 2.0 |
| Aug. | 31.1 | 21.9 | 27.0 | 0.2 | 4.9 | 75.0 | 1.9 |
| Sept. | 29.9 | 20.4 | 25.6 | 0.6 | 5.2 | 71.0 | 2.1 |
| Oct. | 28.5 | 18.0 | 23.2 | 6.0 | 4.8 | 73.0 | 2.0 |
| Nov. | 25.3 | 14.4 | 19.7 | 16.2 | 4.0 | 71.0 | 2.1 |
| Dec. | 21.4 | 10.2 | 15.5 | 22.2 | 3.6 | 69.0 | 2.3 |

## Geology and Geomorphology:-

The area of North Sinai was formed in the geologic periods of Pliocene, Pleistocene and Holocene as shown in Map (1), (*Abdo-Shata 1960).*

Based on the Egyptian Geological Survey (1987), the following geological, formation:

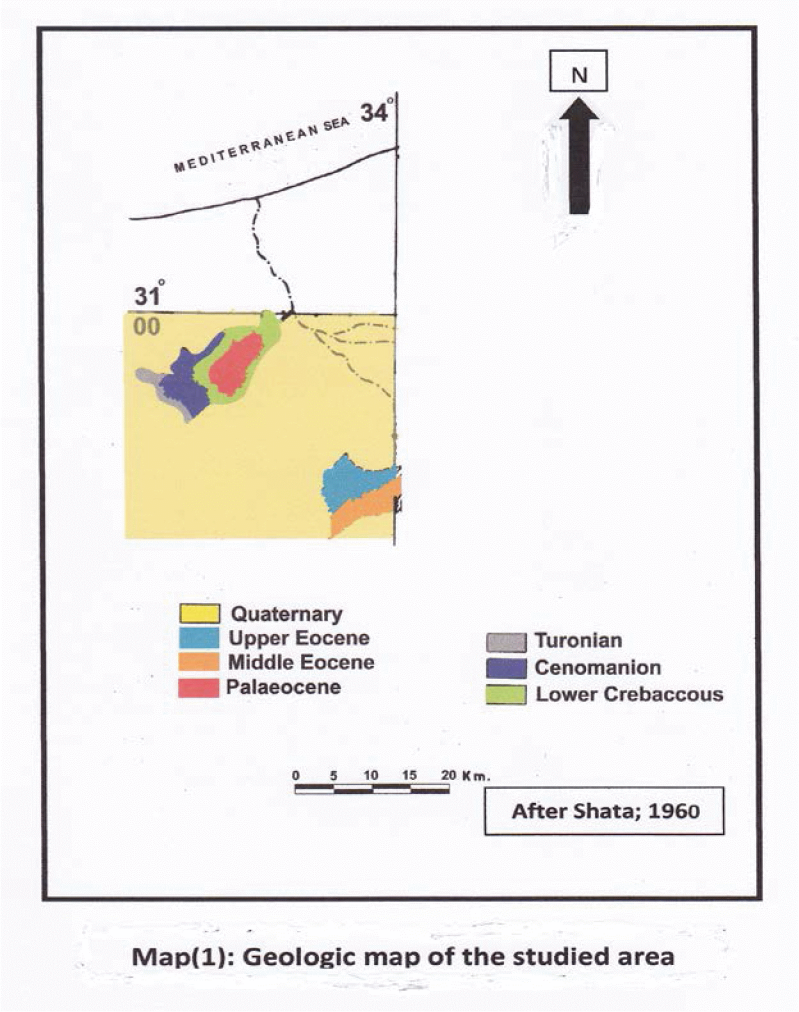
Holocene: - Recent accumulations of quartz with thickness of about 12 m.
- Recent formations of Shell with sand stone.

Pleistocene: - Formations of car car with thickness of 60-70 m.
- Marine cacao with thickness of 5-40 m with formations consolidated of Shell and calcareous formations.
- Conglomerate with thickness of 2-5 m concocted of rounded rock ferments of yellow marl calcareous rock with small shell.

## Geomorphology.

*Abd Allatif (1968)* showed that North Sinai region included the following main geomorphic Units:-

- El-Halal upland in the south up to more than 200 m above the level of the adjacent plain.
- Foot Hill slopes between El-Hall Mountain and the lowest plain with Height of 123-200 m and width of about 15 km.
- Foreshore plain located between El-Halal Mountain and El-Maghara Mountain.
- Coastal plain between El-Arish and Rafah.




Map(1): Geologic map of the studied area

## MATERIALS AND METHODS

### Location:

1- The studied area is located between Latitude of 30° 30\ to 31° 0\ N and Longitude of 33° 30\ to 34° 0\ E . the Arish city far from it about 20 km in the North side , the Kasma city is located in the West side , both Kosima and the Halal montain in the East and the El-Maghara mountain in the West, Map (2).

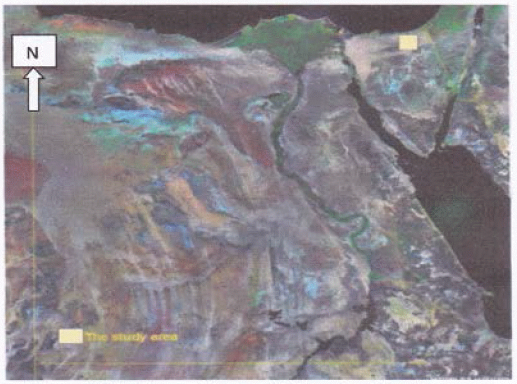
2- Two high ways passes throw the middle of the studied area. One from the North started from El-Arish city goes to El-Ismailia city in the South. The other passes from the East to the West.

Using land Sat, Topographic and geologic maps of the studied areas (El-Ser and El-Qawarir) located between 30° 30- to 30° 0- N and 33°30- to 34° 0- E (Map, 2). The studied area includes the following for geomorphological units, Map (3):-

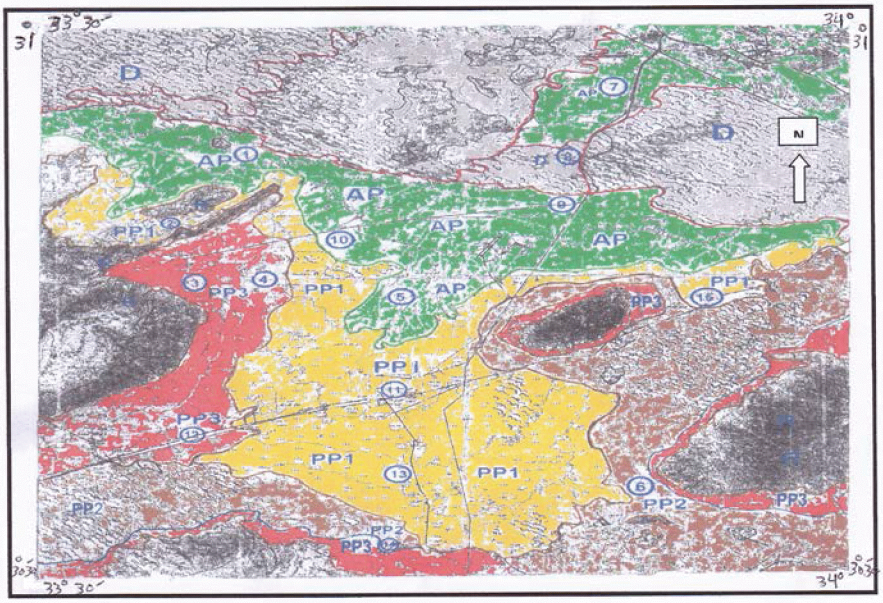
1- Alluvial plain (AP).
2- Piedmont plain (PP).
3- Sand Dunes (D).
4- Rock of Mountains.

The boundaries between the geomorphological units of the base map was corrected in the field.

Fiveteen soil profiles represented the different geomorphological units were chosen and described in the field according to *FAO (2010)* and soil sample for laboratory analysis were collected, soil color was determined using *Munsell color (1975).*




Map (2) : Location of the studied area




PP = Piedmont plain

| | | | |
|---|---|---|---|
| | **PP1**<br>Nearly level, deep soil, gravelly sand to gravelly sandy loam, Typic Torriorthents & Typic Haplocalcids | | **AP = Alluvial plain**<br>Nearly level , deep soil, loamy sand to clay loam , Typic Torriorthent and Typic Haplogypsids |
| | **PP2**<br>Gently undulating, deep soil , shallow, gravelly sandy loam , gravel & stone fragments on the surface, Typic Torriorthents & Lithic Torriorthents | | **D = WindBlown sands**<br>Undulating, deep soil, sandy, Typic Torripsamments |
| | **PP3**<br>Gently undulating , deep soil to shallow, gravelly loamy sand, gravel & some stone on the surface. | | |

Map (3) : Geomorphic map of the studied area. Location of the studied profiles.

## Laboratory Analysis:-

The particle size distribution was done according to *Page et.al, (1982).* The texture classification and namely texture were derived from the American texture Triangular chart based on the percentage of clay, silt and sand. Soil pH was determined in the soil paste. Soil ions, electrical conductivity (ECe) were determined in soil paste extract, calcium carbonate and gypsum contents were determined according to *page et al., (1982).* Soil salinity was performed using *Soil Survey staff (1993).* Soil Classification was done according to *Soil Survey Staff (2010).*

The land capability classification was achieved according to the system of *Sys et al. (1991).* The weighted mean values of soil profiles properties to namely texture , depth , $CaCO_3$ and gypsum contents, salinity and alkalinity, drainage and soil surface slope were used for defined as in Table (2) .

Classification of capability soil grades *(Sys et al., 1991)*

| Capability Index | Class | Capability Grade |
|---|---|---|
| >80 | I | Excellent |
| 60-79 | II | Good |
| 45-59 | III | Fair |
| 30-44 | IV | Poor |
| <30 | V | Very Poor |

## RESULTS AND DISCUSSION

The investigation of the studied area in the field and the description of the profiles results in the correction of the boundaries between the obtained geomorphical units in the base Map. Therefore, the piedmont plain (PP) unit was divided into three subunits: (PP1), (PP2) and (PP3) as shown in the geomorphologic Map (3). The Alluvial plain (Ap) is represented by the studied soil profiles No.s 1, 5, 7, 9 and 10. The piedmont plain (PP1) represented by studied soil profiles No.s 2 , 11, 13 and 15. The piedmont plain (PP2) is represented by studied soil profiles No 6 and 14, whereas Piedmont plain (PP3) represented by studied soil profiles No 3, 4 and 12. The sand dunes (D) are represented by studied soil profile No 8, Map (3).

## Morphological Description:

## Surface Features:

The soils of the alluvial plain are mainly covered by desert pavements of different sizes of gravel related to the nature of these alluvial deposits. Similar description was reported by ***High*** *Dam soil survey (1964)* and *Al-Sharif et al. (2013)* in the old alluvial soils in Nile Valley. On the other hand, the piedmont plain soils had some stones and rock fragments on their surface especially (PP3) this is represented by profiles No.s 3, 4, and 12, Table (2) due to their colluviums deposition nature.

The studied area is nearly level to gently sloping and elevation ranged from 77 m to 220 m. above, sea level, Table (2). The studied Alluvial plain soils (AP) are nearly level surface and developed on the lowest elevation ranged from 77 m to 100 m. above sea level. Also, the piedmont plain (PP1) is developed on nearly level surface and relatively moderate elevation ranged from 132 m to 168 m. above sea level. On the other hand, the piedmont plain (PP2) and (PP3) are developed on nearly level to gently sloping surface and the highest elevation reached to 220 m above sea level. The studied sand dunes, soil profile No. 8 were developed on gently sloping depressions low elevation of 88 m above sea level.

## Physiographic Features:

The nature of the parent material inherited of the alluvial deposition in the area under investigation affected the characteristics of the soil profiles, as following:

Soil color of the horizons of the alluvial plain had moisted color Hue varied from 5YR to 10 YR.

The substratum horizons had contents of fine and medium gravels and few to moderate pedogenic accumulation of both $CaCO_3$ and gypsum accumulations. All of these features were related to the Alluvial material as mentioned above. The piedmont soils (PP2) and (PP3) , this is represented by soil profiles No.s 14 , 3 and 4 are lithic,

Table 2

Table 2

TABLE 2

whereas the depth of the soil profiles are very shallow to shallow ranged from 25-40 cm, reflecting the undeveloping of these soils. Also, the dominant of massive structure is related to the low contents of clay and un-development conditions of these soils.

The studied area has a medium to light texture varied between sandy clay loam to sandy texture. The soils of Alluvial plain (AP) have the medium texture of sandy loam to sandy clay loam due to their development on the lowest elevation which allowed to the deposition of the fine particles as in the studied soil profiles No.s 1, 5, 7 and 10, this is agree with *Al-Sherif et al., (2013).* The sandy texture of the other soils due to their high elevation.

The abrupt wavy boundary between the surface A horizon and the subsoil C horizon in the studied soil profile No. 7, of the Alluvial plain (AP) soil indicated the occurrence the lithologic discontinuity in these soils due to the difference in the deposition environmental of their Alluvial materials. On the other hand, all other soils have clear to gradual transition boundary and similar or close texture between their horizons reflecting similar or close environmental conditions of the deposition.

## Analytical Data

The area under investigation have clay contents ranged from 2.35 % to 24.79%, Table (3), the highest content is detected in the subsoil of the Alluvial plain, C horizon of studied soil profile No. 10. On the other hand the lowest value was in the subsoil of the piedmont (PP1). Soil profile No. 11 due to the deposition on the high elevation which allowed to the deposition of the coarse particles, and the windblown sand, soil profile No. 8. *El-Demerdash (1970).*

$CaCO_3$ content ranged from 1.61 to 46.23 %. The highest value was in A horizon of alluvial plain (Ap), studied soil profile No. 7. The field description (Table 3) indicated that most of this carbonates were lithogenic or primary. On the other hand the lowest content was in C horizon of the windblown sand soils, studied soil profile No. 8 This is related to their sandy nature poorly in lime.

The electrical conductivity values (ECe) (Table 4) ranged from 0.51 to 56.5 dS/m. The lowest values were in the Windblown sand soils in the C horizon of soil profile No. 8 this is due to their sandy nature, whereas the highest values were in the A horizon of the piedmont plain soil profile No. 4 (PP3); salinity classes were non saline (Windblown sand soil profile No. 8 and the surface horizons of the piedmont plain, soil profiles No.s 2 and 15) which had ECe lower than 2 dS/m, Table (4).

Very slightly saline (subsurface of (PP2), studied soil profile No. 2 and the soil of (PP3) of the piedmont plain which had ECe values varied between 2.0 and 4.0 dS/m).

Slightly saline (the surface A horizon of the alluvial plain (AP) soils which had Ece values between 5.22 to 6.91 dS/m.

Moderately saline (the middle C2 horizon of studied soil profiles No. 1 and 10 of the alluvial plain ; middle and subsurface of studied soil profiles No 11 and 12 the piedmont soils respectively which had ECe values ranged from 8.52 to 15.2 dS/m .

Strongly saline (studied soil profile No. 9 of the Alluvail plain, studied soil profiles No. 4 and 6 and C horizon of the soil profile No. 13 of the piedmont soil which had ECe values ranged between 20.5 to 56.6 dS/m. However, this relatively high salinity is considered as false saline.

The order of the dominant soluble cations as : $Na^{+}$ >$Ca^{+2}$ >$Mg^{+2}$> $K^{+}$ , the highest content of Na+ cation was 544 meq/L in the studied soil profile No. 4 of the piedmont plain, and the lowest content was 3.3 meq/L in the A horizon of the windblown soil profile No. 8.

The order of the dominant soluble anions as: $Cl^{-}_2$ >$SO_4^{-2}$ > $HCO_3^{-}$ whereas, the highest value of $Cl_2$ content was 700.0meq/L in the above studied profile No. 4.

**Table (3): Particle size distribution, texture class and $CaCO_3$% of the studied soil profiles.**

| Horizon | Prof. No. | Depth (Cm) | Gravel % | Partical size destribution % | | | | Text. Class | CaCO3 % |
|---|---|---|---|---|---|---|---|---|---|
| | | | | C.S | F.S | Silt | clay | | |
| Alluvial Plain | | | | | | | | | |
| A | 1 | 0-20 | - | 39.48 | 24.92 | 13.52 | 12.08 | SL | 24.12 |
| C | | 20-50 | 2 | 60.01 | 17.48 | 10.45 | 12.06 | SL | 11.26 |
| $C_1$ | | 50-100 | 4 | 76.06 | 13.44 | 6.43 | 4.07 | S | 11.26 |
| A | 5 | 0-15 | - | 76.05 | 3.96 | 11.62 | 16.37 | SL | 20.10 |
| C | | 15-35 | 2 | 65.80 | 8.31 | 25.13 | 0.76 | LS | 17.28 |
| C1 | | 35-100 | 8 | 59.91 | 8.52 | 17.50 | 14.07 | SL | 18.89 |
| A | 7 | 0-25 | | 45.50 | 3.81 | 27.54 | 23.15 | SCL | 46.23 |
| C | | 25-100 | - | 82.40 | 6.56 | 4.53 | 6.51 | LS | 2.81 |
| A | 9 | 0-10 | - | 73.02 | 7.58 | 11.35 | 8.05 | LS | 20.50 |
| C | | 10-60 | - | 72.77 | 7.02 | 11.43 | 8.78 | LS | 13.27 |
| A | 10 | 0-25 | - | 79.74 | 5.38 | 7.89 | 6.99 | LS | 8.44 |
| C | | 25-45 | - | 51.94 | 6.65 | 19.33 | 22.08 | SCL | 23.72 |
| $C_y$ | | 45-100 | - | 40.51 | 5.49 | 20.21 | 24.79 | SCL | 19.69 |
| Piedmont Plain | | | | | | | | | |
| A | 2 | 0-10 | 5 | 80.46 | 6.49 | 3.65 | 9.37 | LS | 20.10 |
| C | | 10-30 | 20 | 87.64 | 5.23 | 3.81 | 3.32 | GS | 14.07 |
| $C_1$ | | 30-100 | 40 | 81.82 | 12.08 | 3.72 | 2.38 | GS | 13.27 |
| A | 3 | 0-30 | 45 | 71.76 | 13.51 | 5.13 | 9.60 | GLS | 25.60 |
| $A_y$ | 4 | 0-40 | 40 | 72.64 | 11.08 | 10.04 | 6.24 | GLS | 27.60 |
| A | 6 | 0-35 | 13 | 48.47 | 8.18 | 26.16 | 17.19 | SL | 20.91 |
| C | | 35-100 | 65 | 44.06 | 6.01 | 26.84 | 23.09 | GSCL | 27.60 |
| A | 11 | 0-35 | 55 | 81.88 | 3.25 | 8.82 | 6.05 | GLS | 13.27 |
| C | | 35-60 | 20 | 71.31 | 2.92 | 22.72 | 3.05 | GLS | 10.05 |
| $C_1$ | | 60-100 | 13 | 80.15 | 1.12 | 16.38 | 2.35 | LS | 8.44 |
| A | 12 | 0-45 | 35 | 76.57 | 5.15 | 11.71 | 6.57 | GLS | 10.05 |
| C | | 45-100 | 20 | 82.79 | 5.80 | 7.69 | 3.72 | GS | 8.44 |
| A | 13 | 0-25 | 3 | 83.25 | 2.29 | 8.71 | 5.75 | LS | 5.27 |
| C | | 25-100 | 9 | 84.51 | 1.37 | 8.30 | 5.82 | SL | 26.58 |
| A | 14 | 0-25 | 50 | 60.85 | 20.90 | 16.11 | 12.14 | GSL | 27.58 |
| A | 15 | 0-20 | 3 | 73.16 | 12.51 | 8.24 | 6.09 | LS | 9.25 |
| $C_k$ | | 20-100 | 20 | 54.48 | 6.22 | 26.72 | 12.58 | GSL | 16.85 |
| Wind Blown Sand | | | | | | | | | |
| A | 8 | 0-30 | - | 82.22 | 5.79 | 7.46 | 4.53 | S | 2.01 |
| C | | 30-100 | - | 85.86 | 3.84 | 6.17 | 4.13 | S | 1.61 |

SCL = Sandy Clay Loam GLS = Gravely Loamy Sand S = Sandy SL = Sandy Loam
GSL = Gravely Sandy Loam LS = Loamy Sand GSCL = Gravely Sandy Clay Loam GS = Gravely Sand

**Table (4): Chemical Analysis of the Saturation extract Soils and gypsum contents of the studied soil profiles.**

| HorNo | Prof No | Depth Cm | pH | ECe (dS/m) | Anions (meq/L) | | | | Cations (meq/L) | | | | Gyp. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $CO^{=}_3$ | $HCO^{-}_3$ | $Cl^-$ | $SO^{2-}_4$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ | $K^+$ | |
| Alluvial Plain | | | | | | | | | | | | | |
| A | 1 | 0-20 | 7.64 | 5.22 | - | 0.95 | 43.0 | 22.68 | 18.58 | 9.92 | 37.43 | 0.70 | 0.52 |
| C | | 20-50 | 7.73 | 10.14 | - | 1.22 | 75.0 | 47.06 | 44.87 | 5.75 | 72.31 | 0.35 | 0.97 |
| $C_1$ | | 50-100 | 7.81 | 8.52 | - | 1.90 | 70.0 | 41.43 | 33.33 | 14.2 | 65.50 | 0.30 | 0.51 |
| A | 5 | 0-15 | 7.49 | 9.08 | - | 2.04 | 63.0 | 49.04 | 51.28 | 22.79 | 39.13 | 0.88 | 1.3 |
| C | | 15-35 | 7.55 | 19.20 | - | 0.95 | 190.0 | 35.74 | 61.54 | 26.11 | 137.8 | 1.23 | 1.0 |
| $C_1$ | | 35-100 | 7.53 | 15.0 | - | 1.09 | 164.0 | 8.81 | 65.40 | 33.36 | 74.86 | 0.28 | 0.7 |
| A | 7 | 0-25 | 7.66 | 6.86 | - | 1.15 | 42.0 | 25.21 | 41.05 | 19.45 | 6.81 | 0.60 | 3.5 |
| C | | 25-100 | 7.92 | 3.70 | - | 0.81 | 15.0 | 53.35 | 33.33 | 12.34 | 23.14 | 0.35 | 1.0 |
| A | 9 | 0-10 | 7.33 | 29.4 | - | 0.81 | 168.0 | 158.8 | 76.92 | 21.48 | 227.9 | 1.35 | 0.5 |
| C | | 10-60 | 7.43 | 28.0 | - | 0.81 | 556.0 | 32.13 | 261.5 | 108.8 | 217.8 | 0.77 | 1.0 |
| A | 10 | 0-25 | 7.78 | 6.91 | - | 1.22 | 55.0 | 62.19 | 44.87 | 4.51 | 68.05 | 0.98 | 1.1 |
| C | | 25-45 | 7.52 | 15.20 | - | 1.76 | 150.0 | 153.5 | 87.74 | 107.7 | 107.1 | 0.58 | 0.8 |
| $C_y$ | | 45-100 | 7.50 | 9.75 | - | 0.95 | 84.0 | 47.61 | 71.79 | 8.46 | 51.89 | 0.42 | 7.1 |
| Piedmont Plain | | | | | | | | | | | | | |
| A | 2 | 0-10 | 8.17 | 1.74 | - | 2.04 | 7.0 | 14.0 | 8.97 | 2.14 | 8.17 | 3.76 | 0.36 |
| C | | 10-30 | 7.82 | 3.73 | - | 1.09 | 20.0 | 29.82 | 24.36 | 5.27 | 20.42 | 0.86 | 0.41 |
| $C_1$ | | 30-100 | 7.91 | 2.52 | - | 1.22 | 15.0 | 14.8 | 14.74 | 4.40 | 11.23 | 0.65 | 0.40 |
| A | 3 | 0-30 | 7.96 | 2.42 | - | 1.22 | 17.0 | 12.66 | 10.26 | 7.02 | 12.76 | 0.84 | 0.5 |
| $A_y$ | 4 | 0-40 | 7.28 | 56.50 | - | 0.95 | 700.0 | 337.2 | 333.3 | 160.5 | 544.4 | 1.11 | 6.4 |
| A | 6 | 0-35 | 7.43 | 20.5 | - | 0.95 | 214.0 | 28.86 | 89.74 | 63.34 | 90.17 | 0.56 | 0.4 |
| C | | 35-100 | 7.66 | 17.68 | - | 0.68 | 184.0 | 40.48 | 51.30 | 32.65 | 141.2 | 0.62 | 1.0 |
| A | 11 | 0-35 | 7.73 | 5.23 | - | 1.36 | 33.0 | 35.1 | 26.28 | 8.28 | 34.59 | 0.31 | 4.0 |
| C | | 35-60 | 7.70 | 11.65 | - | 1.49 | 98.0 | 75.84 | 62.82 | 23.6 | 88.47 | 0.44 | 1.0 |
| $C_1$ | | 60-100 | 7.77 | 8.55 | - | 1.08 | 65.0 | 88.18 | 46.15 | 19.25 | 88.46 | 0.40 | 1.0 |
| A | 12 | 0-45 | 8.02 | 8.07 | - | 1.49 | 75.0 | 90.48 | 12.82 | 6.93 | 69.75 | 0.97 | 3.5 |
| C | | 45-100 | 7.99 | 10.70 | trace | 1.49 | 100.0 | 12.45 | 18.59 | 11.04 | 83.36 | 0.95 | 5.0 |
| A | 13 | 0-25 | 7.82 | 9.55 | - | 1.36 | 93.0 | 117.6 | 39.7 | 15.8 | 62.09 | 0.90 | 0.6 |
| C | | 25-100 | 7.83 | 18.20 | - | 1.49 | 180.0 | 51.1 | 51.30 | 32.65 | 148.0 | 0.63 | 1.5 |
| A | 14 | 0-25 | 6.95 | 64.3 | - | 0.68 | 950.0 | 370.7 | 660.3 | 203.9 | 455.9 | 1.26 | 1.8 |
| A | 15 | 0-20 | 7.93 | 1.84 | - | 2.04 | 3.00 | 18.36 | 11.54 | 1.42 | 9.53 | 0.91 | 3.0 |
| $C_k$ | | 20-100 | 7.80 | 15.0 | - | 1.36 | 128.0 | 67.79 | 41.03 | 35.51 | 119.1 | 1.51 | 9.3 |
| Windblown Sand | | | | | | | | | | | | | |
| A | 8 | 0-30 | 8.5 | 0.6 | - | 1.63 | 4.0 | 2.89 | 3.85 | 1.09 | 3.30 | 0.28 | 0.7 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | | 30-100 | 8.65 | 0.51 | - | 2.04 | 4.0 | 1.76 | 2.56 | 1.14 | 3.81 | 0.29 | 0.7 |

## Soil Classification

As shown in the field description the studied soil profile No. 10 of the Alluvial plain and soil profile No 4 of piedmont plain (PP3) had crystal accumulations of the pedogenic (secondary) gypsum in the subsurface horizon Cy their content of gypsum ranged from 7.1 to 9.3%, therefore , this horizon was considered as gypsic according to *Soil Survey Staff (2010),* and can be classified as Fine loamy , Mixed , Thermic, Typic , Haplogysids (soil profile 10) , related to its texture was sandy clay loam (fine loamy), their mineralogy was mixed and the soil temperature regime is thermic , whereas their soil temperature ranged between (15$^{o}$C - 21$^{o}$C) Table (5) . For studied soil profile No. 4 , due to its texture was sandy and its mineralogy was dominant by quartz (Siliceous), and soil depth was shallow lower than 50 cm considered as lithic, classified as Sandy, Siliceous, thermic, lithic, Haplogypsids .

The studied soil profile No. 15 of the piedmont soil (PP1) had a pedogenic carbonates shown in the field description Table (2) as many soft lime accumulations in C k horizon which qualified as a Calcic horizon and classified this soil as Coarse loamy, Mixed, Thermic, Typic Haplocalcids. Due to the texture in the control section (20-100 cm depth from the surface), is sandy loam, it is considered as Coarse loamy.

On the other hand, the other studied soil profiles not had any diagnostic horizons. Therefore, it classified as typic Torriorthents (soil profiles No.s 1, 5, 7 and 9 of the alluvial plain profiles No.s 2, 11 and 13 of the piedmont plain (PP1), and profile No. 12 of the piedmont plain (PP3) . Lithic Torriorthents (soil profile No 14 of the piedmont plain (PP2) and No. 3 and 4 of the piedmont plain (PP3). Typic Torripsamments (soil profile No. 8 of Wind blown soils.

## Land Capability:

Using the soil parameter of *Sys et al. (1991)* method for land capability ; Topography (p); slope (l); drainage status (f), salinity & Alkalinity (s), gypsum content , $CaCO_3$ content , soil depth (d) and soil texture (t). The studied area included moderately suitable soil (S2), marginally suitable (S3), moderately to marginally S2-S3, marginally to non suitable in current and non suitable in current, Map (4) and Table (6).

## Moderately Suitable Soil (S2):

The studied area of class (S2) is about to 101000 feddans in the Alluvial plain presented by soil profiles No.s 1, 5, 7, 9 and 10, their limiting factor was soil texture (t) in the current time. Its subclass was (S2t).

## Marginally Suitable (S3):

The studied area of class (S3) is about to 96000 feddans in the Sand Dunes , the limiting factors were soil texture (t) and Topography (p), their subclass was (S3pt), represented by studied soil profile No. 8.

## Moderately to Marginally Suitable S2-S3:-

The studied area of class (S2-S3) is about to 205000 Feddans in the piedmont plain (pp1), the limiting factors were soil texture (t) and salinity & alkalinity (s), its subclass represented by soil profiles No.s 2, 11, 13 and 15.

## Marginally to Non Suitable in current time:

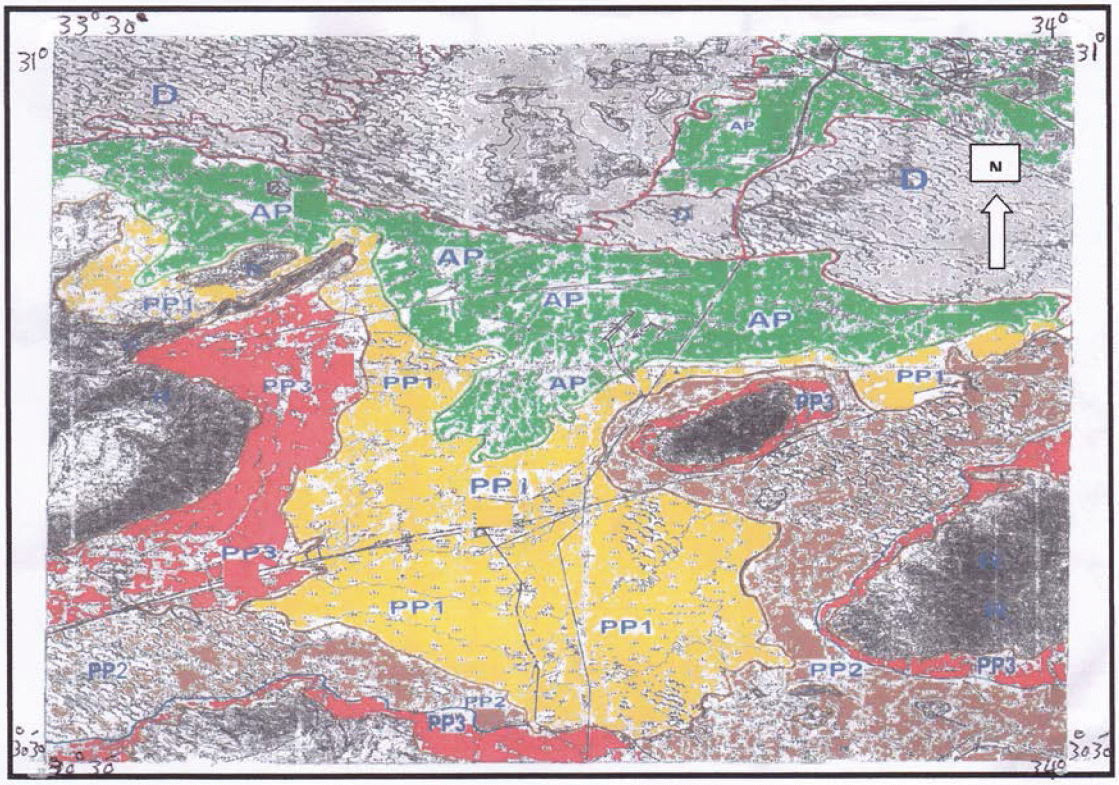
The studied area of class (S3-N) is about to 123000 feddans in the piedmont (PP2) the limiting factors were the gravelly texture (t), in addition to moderately deep soil profile (d).

## Non Suitable in current time:

The studied area of class (N) is about to 60000 feddans in the piedmont (PP3) the limiting factors were sandy texture (t), shallow deep soil profile and relatively high of the stone fragments on the soil surface. These limiting factors can be overcome; the texture can be improved by addition of organic matter, the soil salinity can be

leached from the area zone, the limited soil depth can be overcome by cultivation of surface root crops. Therefore these soils can reach moderately to high suitable in the potential.

Table 5




| | | | |
|---|---|---|---|
| | PP1 = Moderately Suitable to Marginelly Suitable $S_{II}$-$S_{III}$<br>Shallow to deep soil, sandy , Nearly level | | AP = Moderately Suitable $S_{II}$<br>Deep soil, sandy loam, slightly saline |
| | PP2 = Marginally to Non Suitable in currently time , shallow soil, sandy | | D = Marginally Suitable $S_{III}$<br>Deep soil, sandy , undulating |
| | PP3 = Non Suitable Soil N1 in currently time.<br>Shallow soil, gravelly sand , some stones on the surface | | |

**Map (4): Land capability classification of the studied area.**

**Table (6): Rating Factors and Sutability Clases of the Studied Soils.**

| Factors | Texture (A) | Soil Depth (B) | $CaCO_3$ (C) | Gypsum status (D) | Salinity & Alkalinity (E) | Drainage (F) | Slope (G) | Capability Index |
|---|---|---|---|---|---|---|---|---|
| Soil profile: 1 | | | | | | | | |
| Ratings | 55 | 100 | 90 | 100 | 100 | 100 | 100 | 55 |
| Survey area: Alluvial Plain | | | | | | Capability class: II<br>Capability subclass: IIt | | |
| Soil profile: 2 | | | | | | | | |
| Ratings | 35 | 100 | 90 | 100 | 100 | 100 | 100 | 35 |
| Survey area: Piedmont Plain | | | | | | Capability class: III<br>Capability subclass: IIIt | | |
| Soil profile: 3 | | | | | | | | |
| Ratings | 30 | 40 | 80 | 100 | 90 | 100 | 100 | 10 |
| Survey area: Piedmont Plain | | | | | | Capability class: N<br>Capability subclass: $N_t$ d | | |
| Soil profile: 4 | | | | | | | | |
| Ratings | 27 | 40 | 80 | 100 | 75 | 100 | 100 | 11 |
| Survey area: Piedmont Plain | | | | | | Capability class: N<br>Capability subclass: $N_t$ d | | |
| Soil profile: 5 | | | | | | | | |
| Ratings | 70 | 100 | 90 | 100 | 80 | 100 | 100 | 56 |
| Survey area: Alluvial Plain | | | | | | Capability class: II<br>Capability subclass: $II_t$ | | |
| Soil profile: 6 | | | | | | | | |
| Ratings | 67 | 100 | 100 | 100 | 75 | 100 | 100 | 51 |
| Survey area: Piedmont Plain | | | | | | Capability class: II<br>Capability subclass: IIt5 | | |
| Soil profile: 7 | | | | | | | | |
| Ratings | 73 | 100 | 90 | 100 | 85 | 100 | 100 | 62 |
| Survey area: Alluvial Plain | | | | | | Capability class: II<br>Capability subclass: $II_t$ | | |
| Soil profile: 8 | | | | | | | | |
| Ratings | 40 | 100 | 90 | 100 | 100 | 100 | 80 | 30 |
| Survey area: Wind Blown Sand | | | | | | Capability class: III<br>Capability subclass: IIIt | | |
| Soil profile: 9 | | | | | | | | |
| Ratings | 60 | 60 | 95 | 100 | 75 | 100 | 100 | 28.5 |
| Survey area: Alluvial Plain | | | | | | Capability class: III<br>Capability subclass: IIItds | | |

| Soil profile: 10 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ratings | 80 | 100 | 100 | 100 | 85 | 100 | 100 | 65 |
| Survey area: Alluvial Plain | | | | | | Capability class: II<br>Capability subclass: IIt | | |

**Table (6): Cont.**

| Factors | Texture (A) | Soil Depth (B) | $CaCO_3$ (C) | Gypsum status (D) | Salinity & Alkalinity (E) | Drainage (F) | Slope (G) | Capability Index |
|---|---|---|---|---|---|---|---|---|
| Soil profile: 11 | | | | | | | | |
| Ratings | 52 | 100 | 100 | 100 | 83 | 100 | 100 | 34 |
| Survey area: Piedmont | | | | | | Capability class: III<br>Capability subclass: $IIIt_t$ | | |
| Soil profile: 12 | | | | | | | | |
| Ratings | 60 | 100 | 100 | 100 | 40 | 100 | 100 | 25 |
| Survey area: | | | | | | Capability class: III<br>Capability subclass: II Its | | |
| Soil profile: 13 | | | | | | | | |
| Ratings | 73 | 85 | 90 | 100 | 80 | 100 | 100 | 53 |
| Survey area: Piedmont Plain | | | | | | Capability class: II<br>Capability subclass: $II_{ts}$ | | |
| Soil profile: 14 | | | | | | | | |
| Ratings | 65 | 25 | 100 | 100 | 85 | 100 | 100 | 11 |
| Survey area: Wind Blown Sand | | | | | | Capability class: N<br>Capability subclass: $N_{tds}$ | | |
| Soil profile: 15 | | | | | | | | |
| Ratings | 65 | 100 | 95 | 100 | 87 | 100 | 100 | 57 |
| Survey area: Piedmont Plain | | | | | | Capability class: II<br>Capability subclass: $II_t$ | | |

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# العلاقة بين الوحدات الجيومورفولوجية وخواص الاراضى المتكونة عليها فى شمال سيناء مصر

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## الملخص العربى

تعتبر الاراضى الواقعة شمال سيناء مصر من اكثر المناطق الواعدة للاستغلال الزراعى فى مصر وتهدف هذة الدراسة الى انتاج خريطة تربة وتقسيم للاراضى وتقييم للقدرة الانتاجية لها.

وقد أختير خمسة عشر قطاعاً أرضياً لتمثل مختلف الوحدات الجيو مورفولوجية بمنطقة الدراسة فى شمال سيناء مصر وهي Alluvial plain ، Piedmont ، Windblown sand .

طبوغرافية سطح هذة الاراضى يتراوح من مستوى الى خفيف التموج ، ومنسوب الارض يتراوح من +٧٧ م الى +٢٢٢ م فوق سطح البحر ، وتتميز سطح أراضى وحدة الـ Alluvial plain بوجود طبقة رصيف صحراوى ، اما سطح اراضى الـ Piedmont فكان مغطى بقطع من الصخور.

وتميزت الاراضى بوجود بعض الافاق الارضية التى تحتوى على كميات قليلة الى متوسطة من كربونات الكالسيوم والجبس. والقوام يتغير من خفيف الى متوسط والملوحة تراوحت من خفيفة جدا الى شديدة الملوحة .

وباستخدام نظام التقسيم الامريكى (USDA 2010) امكن التعرف على الوحدات التقسيمية التالية :

Typic Torriorthents , Lithic Haplogypsids , Tpyic Haplogypsids , Lithic Torriorthents Typic Haplocalcids . , Typic Torripsamments

وبتطبيق نظام Sys *et al* 1991 لتقدير القدرة الانتاجية (درجة الصلاحية) لهذة الاراضى فقد وجد ان هذة الاراضى متوسطة الصلاحية S2t فى الاراضى الـ Alluvial plain ، S3pt فى أراضى Wind Blown sand والعوامل المحددة للزراعة كانت القوام الرملى الخشن ، الطبوغرافية ، عمق القطاع الارضى ، والملوحة والقلوية.

**Table (2) : Morphological Description of the Studied Soil Profile**

| Profile No. | Surface features | Horizon | Depth (cm) | Soil color (Moist) | Texture | Coarse fragment | Stucture | Pedogenic features | Efferscence | Boundary | Taxonomic units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alluvial plain (Ap)** | | | | | | | | | | | |
| 1 | 77 m avove sea level , Nearly level, Natural plants, covered by gravel with different sizes | A | 0-20 | (10YR5/6) | SCL | - | w.f.sb | Few soft lime | st | c / w | Typic Torriorthents |
| | | C | 20-50 | (10YR6/6) | SL | Few fine gravel | m | Few soft lime & gypsum crystals | st | c.w | |
| | | $C_2$ | 50-100 | (10YR5/6) | LS | Few fine gravel | m | | st | | |
| 5 | 110 m above sea level | A | 0-15 | (10YR7/4) | SL | | m | | st | c.w | Typic Torriorthents |
| | | C | 15-35 | (7.5YR6/6) | SL | Few fine gravel | m | | st | c.w | |
| | | $C_2$ | 35-100 | (7.5YR6/6) | SL | moderate fine gravel | m | | st | | |
| 7 | 78 above sea level nearly level, few natural plants, covered by sands | A | 0-25 | (10YR 7/4) | LS | | mo f sb | few soft lime | st | d.w | Typic Torriorthents |
| | | C | 25-100 | (10YR 7/6) | S | | m | | st | | |
| 9 | Nearly level to nearly undulating , few natural plants light collor gravel with different sizes | A | 0-10 | (7.5YR6/6) | SL | | wc sb | | st | c./.w | Typic Torriorthents |
| | | C | 10-60 | (7.5YR5/6) | LS | few medium gravel | ma | Few soft lime | st | c.w | |
| 10 | 104 m above sea level , Nearly level, few natural plants, moderate small and medium gravel | A | 0-25 | (7.5YR6/6) | S | | | | | | Typic Haplogypsids |
| | | Cy | 25-45 | (7.5YR6/6) | SCL | few fine gravel | ma | moderate gypsum crystals | mod | c./.w | |
| | | $Cy_2$ | 45-100 | (7.5YR6/4) | SCL | few fine gravel | ma | moderate gypsum crystals | st | c.w | |
| **Piedmont plain (P1P1)** | | | | | | | | | | | |
| 2 | 130 m above sea level , nearly level, few natural plants, moderate small and medium light color gravel and some stones | A | 0-10 | (7.5YR6/6) | LS | few fine gravel | ma | | st | | Typic Torriorthents |
| | | C | 10-30 | (7.5YR5/8) | S | many fine gravel | ma | | st | c./.w | |
| | | $C_2$ | 30-100 | (7.5YR6/6) | S | many fine gravel and stones | ma | | st | g.w | |

**Table (2) : Cont.**

| Profile No. | Surface features | Horizon | Depth (cm) | Soil color (Moist) | Texture | Coarse fragment | Stucture | Pedogenic features | Efferscence | Boundary | Taxonomic units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 132 m above sea level, nearly level , few natural plants, many different sizes gravel covered with stones | A | 0-35 | (7.5YR7/4) | S | many fine and stones | ma | | st | c./.w | Typic Torriorthents |
| | | C | 35-60 | (7.5YR5/6) | LS | many fine and medium gravel and stones | ma | few soft lime and gypsum accumulation | st | c./.w | |
| | | $C_2$ | 60-100 | (7.5YR6/4) | LS | moderate fine and medium gravel | ma | few soft lime and gypsum accumulation | st | | |
| 13 | 168 m above sea level , nearly level, few natural plants, many gravel, stones and rock fragments | A | 0-25 | (7.5YR6/4) | S | few fine gravel | ma | | st | c.w | Typic Torriorthents |
| | | C | 25-100 | (7.5YR5/6) | LS | moderate different size gravel | ma | moderate soft lime accumulation | st | | |
| 15 | 145 m above sea level , | A | 0-20 | (5YR5/6) | LS | few fine gravel and stones | ma | | st | c.w | Typic Haplogypsids |
| | | C | 20-100 | (7.5YR6/6) | SL | many different size gravels | ma | many soft lime accumulations | st | | |
| 6 | 210 m above sea level , nearly level , few natural plants, block color gravel of different sizes | A | 0-35 | (5YR5/8) | SL | moderate fine and medium gravels | ma | few soft lime and gypsum accumulations | st | c.w | Typic Torriorthents |
| | | C | 35-100 | (7.5YR6/3) | SCL | many gravel of different size | ma | few soft lime accumulations | st | | |
| 14 | 220 m above sea level , gently sloping , few natural plants, different sizes of gravel and some rock fragments | A | 0-25 | (7.5YR6/6) | SL | many gravell of different size | ma | | st | | Lith Torriorthents |
| | | | 25- | **Rock Fragments** | | | | | | | |
| 3 | 165 m above sea level , gently sloping, few natural plants, many gravels and rock fragments | A | 0-30 | (10YR7/6) | S | many gravel of different size | ma | | st | | Lithic Torriorthents |
| | | | 30- | **Rock Fragments** | | | | | | | |

**Table (2) : Cont.**

| Profile No. | Surface features | Horizon | Depth (cm) | Soil color (Moist) | Texture | Coarse fragment | Stucture | Pedogenic features | Efferscence | Boundary | Taxonomic units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 125 m above sea level , gently sloping , few nature plants, many light color, gravel and stones | Ay | 0-40 | (7.5YR6/6) | LS | many gravel of different size | ma | moderate soft lime and gypsum accumulations | st | | Lithic Haplogypsids |
| | | | 40- | **Rock Fragments** | | | | | | | |
| 12 | 175 m above sea level, nearly level, few natural plants, many gravels, stones and rock fragments | A | 0-45 | (7.5YR6/4) | LS | many gravel of different size | ma | moderate soft lime accumulations | st | c.w | Typic Torriorthents |
| | | C | 45-100 | (7.5YR5/6) | LS | many gravel of different size | ma | few soft lime accumulations | st | | |
| 8 | 88 m above sea level , gently sloping, few natural plants, depressions of sand dunes spots of alluvail plain | A | 0-150 | (7.5YR6/6) | S | | sg | | w | d.w | Typic Torripsamments |

| **Texture** | **Structure** | **Effervescence** | **Boundary** |
|---|---|---|---|
| **C = Clay** | **w.f.sb = weak Fine sub angular** | **st = strong** | **cw = clear weavy** |
| **S = Sand** | **m.f.sb = moderate fine sub angular** | **mod = moderate** | **aw = abrupt waevy** |
| **S.L = Sany loam** | **w.c.sb = weak coarse sub angular** | **w = weak** | **cls = clear smoth** |
| **L.S = Loamy sand** | **ma = massive** | | **gw = gradual waevy** |
| **SCL=sandy clay loam** | **sg = single grain** | | **dw = diffuse weavy** |

**Table (5): Soil classification of the studied soil profiles (according to *Soil Survey Staff, 2010*).**

| Profile No | Order | Sub-Order | Great Group | Subgreat Group | Famaily |
|---|---|---|---|---|---|
| 1 | Entisols | Orthents | Torriorthents | Typic Torriorthents | Coarse loamy over sandy loam, mixed, thermic, Typic Torriorthent |
| 2,7,9,11,12,13 | | Orthents | Torriorthents | Typic Torriorthents | Sandy, Siliceous,thermic, Typic Torriorthent |
| 5 | | Orthents | Torriorthents | Typic Torriorthents | Coarse loamy, mixed, thermic, Typic Torriorthents |
| 6 | | Orthents | Torriorthents | Typic Torriorthents | Coarse loamy over fine loamy, mixed, thermic, Typic Torriorthents |
| 3 | | Orthents | Torriorthents | Lithic Torriorthents | Sandy, Siliceous, thermic, lithic Torriorthents |
| 14 | | Orthents | Torriorthents | Lithic Torriorthents | Coarse loamy, mixed, thermic, lithic Torriorthents |
| 8 | | Psamments | Torripsamments | Typic Torripsamments | Sandy, siliceous, thermic, Typic Torripsamments |
| 15 | Aridisols | Calcids | Haplocalcids | Typic Haplocalcids | Coarse loamy, mixed, thermic, Typic Haplocalcids |
| 10 | | Gypsids | Haplogypsids | Typic Haplogypsids | Fine loamy, mixed, thermic, Haplogysids |
| 4 | | Gypsids | Haplogypsids | Lithic Haplogypsids | Sandy, Silicous, thermic, lithic Haplogysids |