

## 5. SUMMARY

This study points to the evaluation of the pedochemical characteristics of some soils representing the main geomorphic units in the eastern and western sides of the Nile Delta. Accordingly twenty soil profiles were chosen to represent the different geomorphic units encountered in the eastern and western sides of the Nile Delta. These profiles were morphologically described their physical, chemical and mineralogical properties were evaluated. The obtained data could be summarized in the following:

### 1. Physical and chemical properties:

#### a) Soils of the eastern Nile Delta (region 1):

##### 1- Soils of the young deltaic plain:

These soils have clay texture class throughout the entire profile depths with an apparent increase of clay content with depth.  $\text{CaCO}_3$  and gypsum contents is very low and ranges from 2.16 to 4.74 % and from .81 to 2.0 %, respectively. Organic matter content is generally low and does not exceed 2.05 %. Soil reaction of these soils are mildly alkaline to moderately alkaline. Soils are non-saline as indicating by EC values which ranges from 0.64 to 1.7  $\text{dSm}^{-1}$ . The soluble cations are dominated by  $\text{Ca}^{+2}$  and  $\text{Na}^{+}$  followed by  $\text{Mg}^{+2}$  and  $\text{K}^{+}$ , where  $\text{HCO}_3^{-}$  ions is the predominant anions followed by  $\text{Cl}^{-}$  and  $\text{SO}_4^{=}$ .

##### 2- Soils of the old deltaic plain:

Soil texture of this geomorphic unit ranges from sand in profiles 5 and 8 to sandy clay loam in profile 7. Calcium

carbonate content is commonly low and ranges from 0.86 to 4.74 % with no specific distribution pattern with depth. Organic matter content is very low and does not exceed 0.89 %, gypsum content is very low ranging from 0.4 to 1.89 %. pH values range from 7.03 to 8.86 indicating that the soils are natural to strongly alkaline. EC values range from 0.95 to 4.88 dSm<sup>-1</sup> indicating that the soils are non-saline to slightly saline. Soluble cations are in the order: Na<sup>+</sup> > Ca<sup>++</sup> > Mg<sup>++</sup> > K<sup>+</sup> while in some layers Ca<sup>++</sup> ion exceeds Na<sup>+</sup>. Soluble anions have the order SO<sub>4</sub><sup>=</sup> > HCO<sub>3</sub><sup>-</sup> > Cl<sup>-</sup>.

### **3- Soils of fluvio marine plain:**

Soil texture varies from clay in the surface layers to loamy sand and sandy clay loam in the deepest layers. CaCO<sub>3</sub> content is less than 7.76 % with an irregular distribution pattern with depth. Organic matter and gypsum contents is very low and range from 0.02 to 1.06 % and from 0.31 to 1.86 %, respectively. Soils are mildly alkaline to moderately alkaline (pH 7.48 to 8.2). Soils are non-saline and the soluble cations are characterized by the dominance of Ca<sup>++</sup> followed by Mg<sup>++</sup> and /or Na<sup>+</sup>, which K ions are the least abundant soluble cations, while the dominant anions are HCO<sub>3</sub><sup>-</sup> followed by SO<sub>4</sub><sup>=</sup> and Cl<sup>-</sup>.

### **4- Soils of wadi El-Tumulat:**

These soils are characterized by sand textural classes in profile 4, while in profile 6, the texture is sandy clay loam in the top layer and clay in the deepest layers. CaCO<sub>3</sub> content ranges from 0.86 to 15.09 %. Gypsum and organic matter contents are extremely low being in the range 0.27 to 0.93 % and 0.01 to 1.02 %, respectively. Soil reaction is mildly alkaline to moderately

alkaline (pH: 7.74 to 8.12). EC (saturating extract) ranged from 1.01 to 3.64 dSm<sup>-1</sup> (non-saline). Soluble cations have the order Na<sup>+</sup> > Ca<sup>++</sup> > Mg<sup>++</sup> > K<sup>+</sup>, soluble anions have the order HCO<sub>3</sub><sup>-</sup> > SO<sub>4</sub><sup>=</sup> > Cl<sup>-</sup>, while CO<sub>3</sub><sup>=</sup> was absent.

### **5- Soils of the structural plain:**

These soils are characterized by coarse texture classes (sandy to sandy loam). CaCO<sub>3</sub> content ranges from 8.62 to 26.72 % with an increase in the uppermost surface layers. Gypsum content ranges from 0.48 to 5.29 % with an irregular distribution pattern with depth. Organic matter is extremely low, it is not exceeding 1.06 %. Soil reaction lies in the natural to strongly alkaline side. Soils are strongly saline as the EC values varies between 19.29 and 56.68 dSm<sup>-1</sup>. Soluble cations are in the order Na<sup>+</sup> > Ca<sup>++</sup> > Mg<sup>++</sup> > K<sup>+</sup>, while soluble anions have the order Cl<sup>-</sup> > SO<sub>4</sub><sup>=</sup> > HCO<sub>3</sub>.

### **b) Soils of the western Nile Delta (region 2):**

#### **1- Soils of the young deltaic plain:**

These soils have clay textural class throughout the entire profile depth. CaCO<sub>3</sub> content is very low and ranges from 4.31 to 5.6 % with an irregular distribution pattern with depth. Regarding gypsum soil profile is considered low gypsum content. Organic matter content ranges from 0.34 to 2.86 %. Soil reaction is mildly alkaline and the soils are slightly saline. The dominant soluble cations are Na<sup>+</sup> followed by Ca<sup>++</sup>, Mg<sup>++</sup> and K<sup>+</sup>, while soluble anions dominated by SO<sub>4</sub><sup>=</sup> followed by Cl<sup>-</sup> and HCO<sub>3</sub><sup>-</sup>.

## **2- soils of old deltaic plain:**

These soils are characterized by the coarse textural classes (sand, loamy sand and sandy loam).  $\text{CaCO}_3$  content is very low due to the nature of parent material and ranges from 0.86 to 5.17 %. Gypsum content ranges from 0.08 to 5.17, while organic matter content is extremely low (not exceed 0.34 %). Soil reaction is mildly alkaline to moderately alkaline (pH 7.55 – 8.26). EC values range from 0.72 to 17.12  $\text{dSm}^{-1}$  (non-saline to strongly saline).  $\text{Ca}^{++}$  ion and /or  $\text{Na}^+$  dominate soluble cations followed by  $\text{Mg}^{++}$  and  $\text{K}^+$ ,  $\text{SO}_4^{=}$  and  $\text{Cl}^-$  ions dominate soluble anions followed by  $\text{HCO}_3^-$ .

## **3- Soils of fluviomarine plain:**

The soils of this geomorphic unit have clayey textural classes throughout the entire profile depth.  $\text{CaCO}_3$  content varies from 8.02 to 13.36 % and tends to decrease with depth. Gypsum and organic matter contents are very low and range from 0.46 to 2.14 % and 0.24 to 2.01 %, respectively. Soil reaction is moderately alkaline (pH 7.83 to 8.15). Soils are non-saline to moderately saline (EC 2.15 – 8.71  $\text{dSm}^{-1}$ ). Soluble cations follow the descending order  $\text{Na}^+ > \text{Mg}^{++} > \text{Ca}^{++} > \text{K}^+$ , while soluble anion dominated by  $\text{SO}_4^{=}$  followed by  $\text{Cl}^-$  and  $\text{HCO}_3^-$ .

## **4- Soils of alluvial deposits of desert wadi:**

Textural class of these soils are sandy clay loam.  $\text{CaCO}_3$  contents are generally high and range from 13.9 to 22.36 % with an increase with depth. Gypsum content is extremely low with percentages not exceed 1.56 %. Organic matter content is very low. pH values range from 7.81 to 7.91 indicating that the soils

are mildly alkaline to moderately alkaline, EC measurements indicate that the soils are slightly saline. Soluble cations are in the order  $\text{Na}^+ > \text{Ca}^{++} > \text{Mg}^{++} > \text{K}^+$ , and soluble anions have the order  $\text{SO}_4^{=}> \text{Cl}^- > \text{HCO}_3^-$ .

## **5- Soils of inland dunes:**

These soils have textural classes varies from sand to sand clay loam.  $\text{CaCO}_3$  content varies in narrow limits from 4.3 to 8.19 %. Gypsum content is very low and not exceeds 0.84 %, and organic matter content is extremely low (0.03 to 0.41 %). Soil reaction is mildly alkaline to strongly alkaline (pH 7.6 –8.46). EC values ranged from 0.59 to 5.79  $\text{dSm}^{-1}$  indicating that the soils are non-saline to slightly saline. Soluble cations are dominated by  $\text{Ca}^{++}$  followed by  $\text{Mg}^{++}$ ,  $\text{Na}^+$  and  $\text{K}^+$ , while soluble  $\text{HCO}_3^-$  and /or  $\text{Cl}^-$  ions are the predominant anions followed by  $\text{SO}_4^{=}$ .

## **2. Grain size analysis:**

From the grain size parameters, the data of sorting, Skewness and Kurtosis reveal that water and wind or both are share together in the sedimentation of the soils under study. Applying the discriminant functions of **Sahu (1964)** reveals that the sediments forming the investigated soils are mostly deposited under aqueous environments.

## **3. Trace elements status:**

### **3.1. Soils of the eastern Nile Delta:**

#### **1- Total iron:**

Total iron content ranges from 5250 to 66500  $\text{mg kg}^{-1}$ . The highest content is detected in the young deltaic plain and old

deltaic plain soils, while the lowest content is formed in the soils of structural plain. Soils of fluvio marine and wadi El-Tumulate exhibit moderate content of total Fe.

## **2- Total Mn:**

Total Mn ranges from 125 to 950 mg kg<sup>-1</sup>. The highest content characterized the soils of young deltaic and old deltaic plain, whereas the lowest content is total of structural plain soils. Fluvio marine and wadi El-Tumulat have intermediate content of total Mn.

## **3- Total zinc:**

Total Zn ranged between 22.5 and 77.5 mg kg<sup>-1</sup>. Soils of wadi El-Tumulat and young deltaic plain attains the highest content of total Zn, while soils of structural plain display the lowest content. Moderate amounts of total Zn are formed in the soils of old deltaic plain and fluvio marine plain.

## **4- Total copper:**

Total Cu ranged from 7.5 to 42.0 mg kg<sup>-1</sup>. The relatively low amounts of total Cu is in the soils of young deltaic plain, fluvio marine and structural plain, while the highest content of total Cu is formed in the soils of wadi El-Tumulat.

### **3.2. Soils of the western Nile Delta:**

#### **1- Total iron:**

Total Fe content ranged from 5000 to 58500 mg kg<sup>-1</sup>. It may be noticed that the total Fe content in the western Delta soils followed the order:

Young deltaic > fluvio marine > old deltaic > aluvial wadi > inland dunes.

## **2- Total manganese:**

Total Mn ranged between 125 to 1125 mg kg<sup>-1</sup>. It can be noticed that the coarse textural soils in inland dunes and desert wadi are characterized by the lowest total Mn content, while the highest amounts of total Mn are obtained in the fine textured soils in young deltaic and fluvio marine plain.

## **3- Total zinc:**

Total Zn content ranges from 9 to 75 mg kg<sup>-1</sup>. The distribution of total Zn can be arranged in the following order:

Young deltaic > fluvio marine > old deltaic > inland dunes > desert wadi.

## **4- Total copper:**

Total Cu in the studied soils ranges between 5 and 40 mg kg<sup>-1</sup>. Generally, soils of young deltaic plain and fluvio marine plain attain relatively high content of total Cu, while soils of desert wadi and inland dunes attain the lowest contents.

The vertical distribution of total trace elements is discussed in light of the statistical measures, i.e. weighted mean, trend and specific range, suggested by **Oertel and Giles (1963)**.

#### **4. Mineralogical composition of the studied soils:**

##### **4.1. Mineralogy of the sand fraction:**

###### **4.1.1. Light minerals:**

Quartz predominates the light minerals content with less pronounced amounts of feldspars, of which plagioclase and orthoclase are the principal members, while microcline is the least abundant.

###### **4.1.2. Heavy minerals:**

Heavy minerals are dominated by opaques. Non-opaques are dominated by pyroboles (pyroxenes + amphiboles), garnet, aluminosilicate minerals (zircon, rutile and tourmaline) and Epidote. Kyanite, sillimanite, epidote and biotite are present in moderate amounts, while the remaining minerals are found in less pronounced occurrences.

Index figure ranges from 2.3 to 11.1 %. Moreover, a test of uniformity and development of soil profile leads to the conclusion that the soils constituting each profile are heterogeneous either due to their multi-origin or due to the subsequent variation along the course of sedimentation. Therefore, they are still considered young from the pedological view point.

##### **4.2. Clay mineralogy:**

Mineralogical identification of the clay fraction using X-ray diffraction reveals that the dominance of smectite (montmorillonite) in the young deltaic plain and old deltaic plain soils in the eastern and western sides of the Nile Delta. Soils of fluvio marine plain in the eastern and western sides of the Nile



Delta are characterized by the dominance of kaolinite and /or smectite, while soils of wadi El-Tumulat are characterized by the dominance of illite followed by smectite. Soils of alluvial deposits of desert wadi are characterized by the dominance of palygorslsite minerals followed by kaolinite.

The identified accessory minerals are mainly dominated by quartz and feldspars followed by dolomite, calcite and apatite.

## **5. Soil classification:**

According to the previously mentioned field analytical results on basis of Soil Taxonomy System (USDA, 1975) and Key of Soil Taxonomy (1998). The soils under consideration are generally classified in to three soil order namely, Vertisols, Aridisols and Entisols.

### **1- Order: Vertisols**

a) Suborder: Aquerts

Great group: Endoaquerts

Subgroup: Typic Endoaquerts (profile 12)

b) Suborder: Torrerts

Great group: Haplotorrerts

Subgroup: Typic Haplotorrerts (profile 10 and 11)

### **2- Order: Aridisols**

a) Suborder: Gypsids

Great group: Calcigypsids

Subgroup: Typic Calcigypsids (profile 10)

- b) Suborder: Calcids
- Great group: Haplocalcids
- \* Subgroup: Aquic Haplocalcids (profiles 6 and 13)
- \* Subgroup: Typic Haplocalcids (profiles 14 and 9)

### **3- Order: Entisols**

- a) Suborder: Fluvents
- Great group: Torrifluvents
- Subgroup: Aquic Torrifluvents (profile 2)
- b) Suborder: Psamments
- Great group: Torripsamments
- Subgroup: Typic Torripsamments (profiles 3, 4, 16, 17 and 18).
- c) Suborder: Orthents
- Great group: Torriorthents
- Subgroup: Typic Torriorthents (profiles 7, 15, 19 and 20).

## **6. Land evaluation:**

### **6.1. Land capability classification:**

Application of the capability index for the studied soil profiles reveals that the studied soil profiles are placed between (I) and (VI) grades as follows:

- 1- Grade (I): Excellent soils, represented by profiles 1 and 7.
- 2- Grade (II): Good soils, represented by profiles 3, 5, 2, 4, 11, 20, 12, 13, 14 and 15.
- 3- Grade (III): Fair soils, represented by profiles 8, 6, 16, 19, 17 and 18.

## **SUMMARY**