Sustainable reclamation of newly reclaimed sandy soil through local marine deposits application: I- Improvement of hydrophysical characteristics

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ABSTRACT

The study aim to investigate some characteristics of marine deposits and soil amended with in Regwa region, Wadi Al Fareg, Egypt, in order determine the improvement of soil. Four samples representing the dominant sediments types in the study area have been selected, applied and very well mixed with sandy soil which sprinkler irrigated and planted by onion crop. At the end of the growing season, surface soil samples were collected and some hydrophysical soil characteristics were determined. The data shows that these deposits are thick, clayey, loamy and/or silty loam textured, extremely affected by salts, natural in reaction and have low content of calcium carbonate and slightly high content of gypsum in some of the studied samples. The main results obtained in this study concluded that the physical characteristics vary according to texture of soil and added marine deposits type. Clay content in marine deposits increased in soil treated with and play an important role in improve soil water characteristics. Regression equation of field capacity, wilting point and available water as affected by fine particles were strongly positive correlated except with the last one, where no clear correlation was noticed and the opposite was true in case of the coarse particles. Obtained result pointed out that exponential equation was more fit than other to expressing the relation between water content at field capacity from side and fine particles and coarse one. This correlation was positive in the 1st case and negative with the other one. The reduction in HC consider as an improvement of soil water movement especially if the soil is sandy in texture. So, the reduction in HC was 23.1, 41.3, 61.2 and 51.2 % for MD 1, 2, 3 and 4 as compared with untreated plot. It is well known that the addition of the marine deposits to the sand must be preceded by knowledge of the type of marine deposits added that greatly improve the qualities.

Key words: Newly reclaimed soils; marine deposits, sandy soils, hydrophysical charactereristics

Introduction

Egypt is among the semiarid countries that are affected by climatic changes leading to an ecological mutation of ecosystems. The sandy soils are very exposed to this degradation strongly marked by drought aggressively, which returns them in water deficit and poor fertilizing (Goa et al., 1998) on account of a weak capacity to keep back water, not existing water absorbents materials such as clay and organic matter, a high infiltration (Wierda and Veen 1992) and a weak cation exchange capacity (CEC). So, the characterization of soils like natural resources is one of important data, principally in the project of durable development of countries (Carter, 1993).

Soils of Wadi El-Faregh (Western desert of Nile Delta), Behera Governorate, Egypt, covered 80 % of sandy soils (USDA, 1991) exposed by degradation. The prevention against this natural phenomenon requires various techniques to improve these soils and one of them is maximum utilization from local marine deposits as a natural soil amendments to fulfill the abovementioned improvement especially hydrophysical ones. Marine deposits in Egypt cover a considerable area. The surface outcrops of this deposits form about 414848 km (Ageeb1999), which have a relatively high capacity to retain water and nutrients and mainly located in the desert expansion parts of the country about 60 cm from soil surface. So they considered as important amendment resources from agriculture point of view. Therefore, in the perspective to rehabilitate the sandy soils in the studied site, the use of the natural resources that consider one of the eco-physiological approaches to payback first the fertility of soils and later to recommend a companion crops system. Shale deposits at western desert of Egypt, contain quartz, feldspars, muscovite and heavy minerals (Boulis and Attia 1994).

Many authors (i.e. El Sherif and El Hady 1986; El-Sherif, 1987; Benkhelifa 1997; Benkhelifa 1998) mentioned that bentonite as a marine deposits ameliorates the properties of sandy soil by increasing their wealth clay and its adding to sandy soils allow to improve the physio-chemical characteristics (Petr 1985) and to increase the agricultural yield (Abdel Aleem et al., 2000).
Al-Omran, et al (2002) studied the effect of two natural bentonite clay deposits on water movement in a sandy calcareous soil. They found that available water content increased with increasing concentrations of bentonite. This is attributed to its higher clay content and the water absorbance characteristics which more effective in controlling water movement in the soil and markedly increased the available water content of a sandy soil.

The aim of this study is to evaluate the physio-chemical responses of sandy soil amended by different local types of marine deposits.

Materials And Methods

Four local marine deposits have been selected from experimental site to present the most dominant types of marine deposits in Regwa region, Wadi El-Faregh (Western desert of Nile Delta), Behera Governorate, Egypt (Fig.1). The collected samples were subjected to the following determinations: Chemical composition of saturated soil extract (Roades 1982); organic matter and calcium carbonate content (Black et al. 1982); gypsum content (Nelson 1982); cation exchange capacity (USDA 1991); particle size distribution (Gee and Bander 1986), and soil classification (Soil Survey Staff 2003).

Soil treated by different marine deposits 1, 2, 3 and 4 at ratio of 60 m³/fed and well ploughed to get the best mixture with the upper layer of the soil (30 cm). Sprinkler irrigation was used. Treated soils were irrigated by 20 mm/fed weekly three times before planting to leach salts out root zone. Seeds of onion plant were sown at 10 November 2011 and harvested at 5 May 2012. Recommended doses of the P and K fertilizer were added before and during soil preparation and N fertilizer was added in Ammonium sulphate (21.5 % N) in three equal doses through used irrigation system. Surface soil samples (0–20 cm) from experimental site were collected after the growing season of the onion crop. The soil as sampled in the field was air-dried and passed through a 2 mm opening sieve before use in determination.

Fig. 1: The Location of the study area.

Hydraulic conductivity (HC) was measured in the laboratory under a constant head technique (Klute and Dirksen, 1986) using the following formula: \[ HC = \frac{QL}{At \Delta H} \]
Where: HC: water quantity flowing through saturated soil sample/area / unit time, Q: volume of water flowing through saturated soil sample per unit time (L³/t), A: cross sectional flow area (L²), L: length of the soil sample and ΔH: differences in hydraulic head across the sample (L) and t: time (hr). Soil water retention at 0.1 bar for field capacity (FC) and 15.0 bar for wilting point (WP) were estimated after Klute (1986). Soil available water (AW) was calculated by subtracting FC – WP. Differences in soil properties in response to the effects of marine deposits (MD) application were analyzed using an Analysis of Variance model procedure (SAS Institute, 2001). Treatment means and interactions were separated by a LSD multiple comparison procedure at p 0.05.

Results and Discussion

The texture classes of these marine deposits are clay in samples 3 and 4, silty loam and loam in samples 1 and 2, respectively (Table 1). Soil structures are coarse platy, hard in samples 3 and 4, while it is soft blocky and sub-angular blocky in samples 1 and 2. Values of the bulk densities ranged between 1.32 (sample 4) and 1.68 g cm⁻¹ (sample 3). Whereas, variation in bulk density (BD) could be attributed to the compaction effect by weight of the upper layer and to the increase clay content in the sample and also to decrease the pores in samples. Same trend was observed in saturation % which affected by BD from side and increase salt content in the studied samples.

Table 1: Particle size distribution and texture class of the studied samples.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>SP %</th>
<th>BD (g cm⁻¹)</th>
<th>Particle size distribution %</th>
<th>Texture class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>1.49</td>
<td>24.6</td>
<td>Silty loam</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>1.41</td>
<td>30.0</td>
<td>Loam</td>
</tr>
<tr>
<td>3</td>
<td>83</td>
<td>1.68</td>
<td>6.9</td>
<td>Clay</td>
</tr>
<tr>
<td>4</td>
<td>72</td>
<td>1.32</td>
<td>36.5</td>
<td>Clay</td>
</tr>
</tbody>
</table>

The studied marine deposits samples are mostly saline. The higher values of salinity have been found in sample 1 (EC=30.4 dS/m), while the lowest one was recorded in sample 2 (EC=19.1 dS/m). Calcium chloride is the dominant soluble salt, followed by gypsum in samples 1 and 2 Table (2). Values of pH is the index to the neutral soil reaction in the studied marine deposits samples. It is ranged between 6.8 and 7.59 in Sample 2 and 4 got the highest and lowest pH values, respectively. Calcium carbonate content is relatively low. Cation exchange capacity (CEC) values are high and correlated with clay content and the highest values were observed in sample 3 and sample 4, while the lowest ones were recorded in other samples, which ascribed on base the light texture class and low organic matter (OM) content (Table 2). This phenomena was in harmony with obtained by El Sherif and El Hady (1988) and Abdel-Hady (2005).

According to the texture class for the soil treated by examined marine deposits (MD), one can notice that fine particles were increased and fine ones were decreased according to the MD types 3 and 4 comparing to the control plot (untreated). There are no changes in texture classes of the plots treated with the studied MD, except MD3. The low clay content of samples 1 and 2 is responsible of weakly developed massive microstructure, while the opposite was true with high clay content of samples 3 and 4. While sand is the dominant coarse fraction in samples 1 and 2 (Table 1). This finding described on base of high content of fine fraction of the applied MD 3 and 4 more than others. Also, plot treated with MD4 although its texture class is sandy loam, it is close to loam one. With respect to the coarse /fine fraction ratio, data revealed that the ratio increased by about 84, 65, 52 and 51 % over control resulted from MD 1, 2, 3 and MD, respectively. Also, there is no significant difference between soils treated by MD3 and MD4.

According to the water content in the treated soils at different water suction such as, saturation percent (SP), field capacity (FC), wilting point (WP) and available water (AW), obtained results showed that SP increased as a result of application of MD at all and the highest values were recorded with MD1 and MD2, and the lowest ones were observed with MD3 and MD4. This result could explain by the salt content in MD 1 and 2 and to the fine fraction content in the others MD (Table 3).

But in case of FC the increase was slightly with MD1 (5.5 %) and MD2 (16.7 %) that reflect MD components from coarse fractions in MD1 and MD2, while the increase were 44.4 % (D3) and 27.8 % (D4) which related mainly to fine fractions content. The previous obtained results attributed to the water content at WP and AW. Regarding to the importance of the AW for plant, the change in water content at AW as affected by application of MD were 10, 10, 30 and 20 % under MD 1, 2, 3 and MD, respectively. Also, there is no significant difference between MD3 and MD4.

The reduction in BD and consequently the increase in total porosity (TP) were expected under MD application regardless the types. Results revealed that the changes in BD were highly with MD 3 and 4 by about -11.7 and -9.3%, respectively. Whereas, the reduction in BD values by MD 1 and 2 applications compare to the control plot were 2.5 and 6.2 %, respectively. The opposite was true in case of TP which represents mainly on
its role on soil aeration and its ability to retain water relative to the pore size distribution. This finding agreed with those obtained by El Hady et al. (1987).

According to the water movement in soil under saturated condition expressed in hydraulic conductivity (HC) values improved that MD 3 and 4 were better than the others on base of reduction in HC. Classification of HC were very high (control), high (soil treated with MD2) and moderate (MD1, 3 and 4). These descriptions would help in the following: i) very high for led to runoff only occasional and soil is suitable for irrigation, ii) high led to runoff rarely occurs and soil is becoming too permeable for irrigation, and iii) moderate led runoff less regular and soil is becoming suitable for irrigation (Hazelton and Murphy, 2007).

The reduction in HC consider as an improvement of soil water movement especially if the soil is sandy in texture. So, the reduction in HC was 23.1, 41.3, 61.2 and 51.2 % for MD 1, 2, 3 and 4 as compared with untreated plot.

Both swelling and clay dispersion approved by Summer (1993) to be responsible for the reduction of HC in fine textured soils. This may suggest that either swelling or dispersion of aggregate due to sodium domination on clay surfaces would have an influence on hardening the soil even with relatively high EC values. Reduction in hydraulic conductivity in soil treated with MD 3 and 4 may be attributed to the increasing of penetrability with decreasing solute concentration resulting from fine particles (El Kholi et al., 1994 and Emdad et al, 2004).

Slendered deviation (SD) in Table (1) showed how much variation or "dispersion" exists from the average (expected value). A low standard deviation indicates that the data points tend to be very close to the mean, whereas the high standard one indicates that the data points are spread out over a large range of values. This means that the determined soil characteristics recorded in Table (1) were more convinced to interpretation the obtained results.

### Table 2: Some chemical properties of the studied samples.

<table>
<thead>
<tr>
<th>Sample No</th>
<th>pH</th>
<th>EC dS/m</th>
<th>Ca2+</th>
<th>Mg2+</th>
<th>Na+</th>
<th>K+</th>
<th>CO3</th>
<th>HCO3</th>
<th>Cl-</th>
<th>SO4</th>
<th>OM</th>
<th>CaCO3</th>
<th>K2O</th>
<th>ESP</th>
<th>CEC *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.05</td>
<td>30.4</td>
<td>68.4</td>
<td>37.2</td>
<td>196.5</td>
<td>1.9</td>
<td>0.0</td>
<td>2.6</td>
<td>206.4</td>
<td>95.0</td>
<td>0.2</td>
<td>3.0</td>
<td>6.0</td>
<td>54</td>
<td>32.3</td>
</tr>
<tr>
<td>2</td>
<td>7.59</td>
<td>19.1</td>
<td>29.4</td>
<td>12.9</td>
<td>147.8</td>
<td>0.9</td>
<td>0.0</td>
<td>0.6</td>
<td>117.9</td>
<td>72.5</td>
<td>0.2</td>
<td>2.2</td>
<td>9.0</td>
<td>20</td>
<td>14.5</td>
</tr>
<tr>
<td>3</td>
<td>7.08</td>
<td>25.9</td>
<td>42.0</td>
<td>8.0</td>
<td>206.0</td>
<td>3.0</td>
<td>0.0</td>
<td>1.2</td>
<td>192.0</td>
<td>65.8</td>
<td>0.3</td>
<td>2.0</td>
<td>0.0</td>
<td>41</td>
<td>62.3</td>
</tr>
<tr>
<td>4</td>
<td>8.83</td>
<td>29.5</td>
<td>62.7</td>
<td>32.9</td>
<td>195.9</td>
<td>3.5</td>
<td>0.0</td>
<td>1.8</td>
<td>194.7</td>
<td>98.5</td>
<td>0.3</td>
<td>2.0</td>
<td>0.0</td>
<td>58</td>
<td>49.0</td>
</tr>
</tbody>
</table>

SD: standard deviation, soil pH in 1:2.5, EC in soil paste extract, OM: organic matter, ESP; exchangeable sodium percentage, CEC: cation exchange capacity cmol/kg soil = meq/100g soil

### Table 3: Effect of marine deposits application on different hydro-physical characteristics.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sand Coarse</th>
<th>Silt Fine</th>
<th>Clay</th>
<th>Texture class</th>
<th>C/F</th>
<th>TP %</th>
<th>BD g cm⁻¹</th>
<th>Soil water content at (cm³ water/cm³ soil)</th>
<th>HC cm⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>21.7</td>
<td>46.7</td>
<td>24.3</td>
<td>6.8</td>
<td>Sandy loam</td>
<td>2.16</td>
<td>38.9</td>
<td>1.62</td>
<td>0.39</td>
</tr>
<tr>
<td>MD1</td>
<td>20.1</td>
<td>44.3</td>
<td>26.9</td>
<td>8.7</td>
<td>Sandy loam</td>
<td>1.81</td>
<td>40.4</td>
<td>1.58</td>
<td>0.51</td>
</tr>
<tr>
<td>MD2</td>
<td>21.3</td>
<td>38.5</td>
<td>28.4</td>
<td>11.8</td>
<td>Sandy loam</td>
<td>1.49</td>
<td>42.6</td>
<td>1.52</td>
<td>0.48</td>
</tr>
<tr>
<td>MD3</td>
<td>16.6</td>
<td>36.3</td>
<td>27.5</td>
<td>19.6</td>
<td>Loam</td>
<td>1.12</td>
<td>46.0</td>
<td>1.43</td>
<td>0.47</td>
</tr>
<tr>
<td>MD4</td>
<td>14.2</td>
<td>39.4</td>
<td>25.2</td>
<td>15.3</td>
<td>Sandy loam</td>
<td>1.10</td>
<td>44.5</td>
<td>1.47</td>
<td>0.45</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>0.3</td>
<td>0.8</td>
<td>0.9</td>
<td>0.7</td>
<td></td>
<td>0.04</td>
<td>1.1</td>
<td>0.01</td>
<td>0.02</td>
</tr>
</tbody>
</table>

MD: marine deposit, SP: saturation percent, FC: field capacity, WP: wilting point, AW: available water, TP: Total porosity (cm³ voids/cm³ soil), HC: hydraulic conductivity.

### Table 4: Simple correlation between main soil constituents and some soil physical properties.

<table>
<thead>
<tr>
<th>soil properties</th>
<th>Coarse sand %</th>
<th>Fine sand %</th>
<th>Silt %</th>
<th>Clay %</th>
<th>C/F</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC</td>
<td>-0.753</td>
<td>-0.917</td>
<td>0.513</td>
<td>0.999</td>
<td>-0.919</td>
</tr>
<tr>
<td>WP</td>
<td>-0.710</td>
<td>-0.924</td>
<td>0.493</td>
<td>0.988</td>
<td>-0.900</td>
</tr>
<tr>
<td>AW</td>
<td>-0.799</td>
<td>-0.861</td>
<td>0.526</td>
<td>0.974</td>
<td>-0.911</td>
</tr>
<tr>
<td>BD</td>
<td>-0.788</td>
<td>-0.963</td>
<td>0.655</td>
<td>0.997</td>
<td>-0.976</td>
</tr>
<tr>
<td>HC</td>
<td>0.482</td>
<td>-0.329</td>
<td>-0.079</td>
<td>0.019</td>
<td>-0.051</td>
</tr>
</tbody>
</table>

SP: saturation %, FC: field capacity, WP: wilting point, AW: available water, TP: total porosity (cm³ voids/cm³ soil), HC: hydraulic conductivity.

Data on hand revealed that both coarse and fine sand highly negative correlated with soil water constant (FC, WP and AW) and TP (Table 4). While they positively correlated with BD and HC at significant level 1%. The opposite was true in case of fine fractions (silt and/or clay). This finding agreed with those obtained by El Sherif and El Hady (1988) and Abdel-Hady (2005), who reported that soil particles especially coarse one has a negative effect on the soil water constant. They also added that effect of these coarse particles play an important role in the soil water movement ion soil to fulfill good aeration and increase drainage state of the treated soil.

Fig. (1) showed the regression equations which assess the close correlations between water content at different water constant such as FC, WP and AW as dependant variable and fine or coarse particles as independent ones. Regression equation of FC, WP and AW as affected by fine particles were strongly positive correlated except with AW, where no clear correlation was noticed and the opposite was true in case of the coarse particles (Fig. 1). Also, exponential equation was more fit than other to expressing the relation between
water content at FC from side and fine particles and coarse one. This correlation was positive in the 1st case and negative with the other one. This finding is described on base of the important role of the fine particles than coarse one on the increasing soil content from water at FC due to mainly clay and silt characteristics as an absorbent materials (Abd El-Hady, 2005 and Tayel and Abd El-Hady 2005).

Fig. 2: Relations between fine or coarse soil particles and soil water content.

Conclusion:

The main results obtained in this study concluded that the physical characteristics vary according to the texture of the studied soil and added marine deposits type. Clay content in marine deposits increased in soil treated with and play an important role in improve soil water characteristics. Addition of the marine deposits to the sandy soils is not too bad but it must be preceded by knowledge of the type of marine deposits added as preferred types. More importantly, the marine deposits should be, rather it must be added crushed to the point of strength of clay and silt so that it can penetrate the pores different in sandy soil to mix with the mixing homogeneous through the mix quite a depth of soil to be reclaimed.

References


