The Agricultural Investments of Some Shale Deposits in Egypt

*Wahab M.A., G. W. Ageeb and F. Labib

Soils and Water Use Dept. National Research Centre, El Buhouth St., 12311,Giza,Egypt
* mohamedwahab@yahoo.com

Abstract: The investigation deals with shale deposits, cover a considerable area in Egypt, in order to clarify their capability and suitability for agricultural purposes. Twenty-four soil profiles representing nine types of the most dominant shale deposits in Egypt, named: Qasr El Sagha, Wadi Rayan, Maadi, Mokattam groups(Maghagha, Qarara, Beni Suef Formations), Dakhla, Quseir, Esna, Wadi Abbad and Lower Esna Formations(pale grey and dark grey shale members).Automated Land Evaluation System "ALES"(Rossiter and Van Wambeke, 1995) have been used in order to identify the suitability of this shale derived soils for agriculture investment. The following eight parameters are comprised, using a new model proposed with the code SHALE-EGYPT build in the model of ALES: slope, plant- available soil water, Thermic and/ or Hyperthermic conditions, soil depth, chemical properties, salinity, alkalinity and the dominant clay type. The obtained results showed that : the highly suitable areas for agricultural purposes covered about 1192 Km^2, 488 km^2 are moderately suitable areas, 8653 km^2 are low to very low suitable and 9648 km^2 are not suitable for agricultural purposes since investment of industrial use and/ or urbanization are recommended in this areas. [Journal of American Science 2010;6(9):201-207]. (ISSN: 1545-1003).

Keywords: shale deposits, soil evaluation, Egypt

1. Introduction

Shale derived soils in Egypt form about 9,956,160 fed. These soils have a relatively high capacity to retain water and nutrients and mainly located in the desertic parts of the country. For that they considered as a precious natural resource from agriculture point of view, with the aim of increasing the agricultural lands as a partial resolution of the overwhelming problem of over population. The inventory of such land resources is rather essential to help the decision makers in propose planning. This inventory could be achieved throughout an integrated soil survey, classification and evaluation.

Nowadays, the national expansion plan of Egypt till the year of 2017 (El Ganzory, 1998) includes 400,000 fed.in Sinai, 12,000 fed. in Wadi Rayan, 15,000 fed. In Dakhla oasis, 6000 fed. in Beni Suef and 200,000 fed. in Tushka basin area. The studied shale derived soils form considerable parts in these areas. There is several land evaluation methodologies have been published throughout the world. USDA methodology (Klingebiel and Montgomery, 1966) illustrated a land capability classification. It is general evaluation method based on limitations of the land characteristics. Van Ranst et al (1991) applied the fuzzy set theory to the field of land evaluation. The result of land suitability classification for defined land utilization type applied to a land unit. The classification results obtain with the fuzzy set method show a closer relationship with observed yield than previously proposed suitability classification methods.

Abdel Rahman and El Taweel (1994) applied SAADA model using 15 factors to evaluated and classified Qimen El Arus area in Beni Suef. These factors are climate, water quality, soil physical properties, fertility and management.

2 - Materials and Methods

To evaluate the shale derived soils properties and the limitation affecting their potentialities for agricultural purposes, twenty-four soil profiles were selected represent the main nine shale types in Egypt. These nine types of shale deposits in Egypt, named: Qasr El Sagha, Wadi Rayan, Maadi, Mokattam groups (Maghagha, Qarara, Beni Suef Formations), Dakhla, Quseir, Esna, Wadi Abbad and Lower Esna Formations(pale grey and dark grey shale members). The selection of the representative profiles was based on the previously geological studies (El Shazly et al, 1977) and maps (CONOCO geological maps, 1987) scale 1:500,000. These soil profiles were morphologically described and the samples were collected for the following analyses. Electrical conductivity pH of soil paste was determined following the method described by Roads (1982). Calcium carbonate was determined by Black et al (1982). Gypsum content was determined according to methods of Nelson (1982). ECE was carried out according to Richards (1954) method. Particle size distribution was done after Gee and Bander(1986).

Clay minerals identifications carried out using General Electric Diffractometer (Siemens D500) x-rays. An oriented separated clay samples (>2µ) were prepared in the following order of pretreatment: Mg, Mg+ glycerol, K and heat at 550C treatment according to Millot (1970). Soil moisture retention curves: The saturated soil samples in cores exposed to the pressures at 0.33 Atm in the pressure cooker and for 15.0 Atm in the pressure membrane. The attained moisture percentage expressed on volume basis by using the value of bulk density (Klute, 1986). Land evaluation methodology new model proposed with the code *SHALE-EGYPT* using Automated Land Evaluation System (*ALES*) (Rossiter and Van Wambeke, 1995 the guidelines given by Sys et al.,(1993), USDA land capability classification(Klingebiel and Montgomery, 1966) and the modified land evaluation methodology for Mediterranean environment (Ano et al.,1998) to particular environmental characteristics of Egypt and more specifically of the shale deposits. According to the value resulting from application of capability index the author assignees the land use recommendations. Final proposal that sets up the most suitable kind of land use for every shale type of areas under investigation.

The base of this evaluation model is the selection of a group of soil characteristics in order to assess the soil capability. Intervals for every parameter have established according to the peculiar characteristics of the Egyptian environment. Thermic and/or hyperthermic conditions(C) and plant-available soil water (W) are two parameters that directly affect plant growth. The first parameter appraised according to the mean annual temperature and the precipitation value comes from the climatological data of Egyptian Meterological Authority (1996).

Thermic and/or hyperthermic conditions(C*)*

C1. Very Appropriate thermic conditions
The mean annual temperature is 22C° or higher Completely dry during the whole year
C2. Moderately appropriate thermic conditions
The mean annual temperature is more than 15 C°but lower than 22C° Precipitation less than 150 mm/year

In the second parameter the water holding capacity which varies among different shale types, by establishing the field capacity and the wilting point for every shale type.

Plant-available soil water (W)

W1.High plant-available soil water
Available water storage capacity is >30%, if there are soil water deficit it is mitigated by plenty of surface or ground water resources
W2.Moderate plant-available Ssil water
Available water storage capacity is 20-30 %, or surface or ground water resources are limited or they are moderately difficult to be used
W3.Low plant-available soil water
Available water storage capacity is <20%, or surface or ground water are limited with very difficult use or with a low profitable economic access

Slope parameter (P) has a strong influence on many edaphic properties. Slope characteristics either allow or prevent mechanization and irrigation practices.

Slope (P)

P1	Flat. Intensive mechanization and irrigation. No limitation	<2%
P2	Gentle. High potential of mechanization. Moderate capability for irrigation	2-4%
P3	Moderate. Medium potential of mechanization. Low capability for irrigation	4-8%
P4	Moderately steep. Low potential of mechanization. Very low capability for irrigation	8-16%
P5	Steep. Very low potential of mechanization. Very severe limitation	>16%

The effective soil depth (X) parameter refers to the soil depth at which root growth is strongly inhibited.

The effective soil depth (X)

X1	Very deep. No limitations	>150
X2	Deep. No limitations	150-100
X3	Slightly deep. Slight limitations	100-80
X4	Moderately deep. Moderate limitations	80-60
X5	Shallow. Severe limitations	<60

The chemical properties (Q) parameter indicates the fertility level of the shale, showing the facility of the soil to supply mineral nutrients to the roots. This aspect does not depend so much on the nutrients quantity but on certain characteristics difficult to be modified, and directly affect the availability. The availability depends on the cation exchange capacity, pH and the proportions of both calcium carbonate and gypsum. These characteristics are assessed together.

Chemical properties (Q)

Q1. Very appropriate chemical properties			
$CaSO_4.2H_2O$%	$CaCO_3$%	CEC(cmol(+)/Kg	pH(H_2O)
≤15	≤15	≥50	6.5-7.5
Q2. Appropriate chemical properties			
$CaSO_4.2H_2O$%	$CaCO_3$%	CEC(cmol(+)/Kg	pH(H_2O)
15-20	15-30	50-30	7.5-8.5
Q3. Inappropriate chemical properties			
$CaSO_4.2H_2O$%	$CaCO_3$%	CEC(cmol(+)/Kg	pH(H_2O)
20-30	30-50	<30	>8.5

The Dominant clay minerals (D) parameter reflects the shale and soil characteristics (i.e. higher or low nutrient-holding capacity; water holding capacity; its influence on the infiltration rate and soil micro-relief) which determine the soil behavioa.

Dominant clay mineral (D)

D1	Montmorillonite clay
D2	Vermiculite clay
D3	Illite clay
D4	Kaolinite clay and other clay minerals

The salinity (S) and alkalinity (N) parameters have been considered. Salt concentration is expressed in terms of the electrical conductivity (at 25 C°) of the solution extracted from a saturated soil paste.

Salinity (S)

S1	Low. Slight limitations. Yield of very sensitive crops may be restricted	<4 dS/m
S2	Moderate. Moderate limitation. Yield of many crops are restricted	4-8 dS/m
S3	High. Severe limitations. Only tolerant crops are satisfactory	8-16 dS/m
S4	Very high. Very severe limitation. Only a few tolerant crops are satisfactory	>16 dS/m

Alkalinity (N)

N1	Very low. No limitations	ESP<10
N2	Low. Slight limitations	10-15
N3	Moderate. Moderate limitations	15-20
N4	High. Severe limitations	20-25
N5	Very high. Very severe limitations	>25

3. Result and Discussion

The analytical data of twenty-four soil profiles representing different shale types (Fig.1) used as basic characteristics for the evaluation of the investigated shales. Information on effective soil depth and slope obtained directly from the field description. The surface layer values of pH and ESP have been considered. The other characteristics recalculated for the upper 100 cm depth by using weight factors for the different profiles section (Sys *et al.*, 1993).

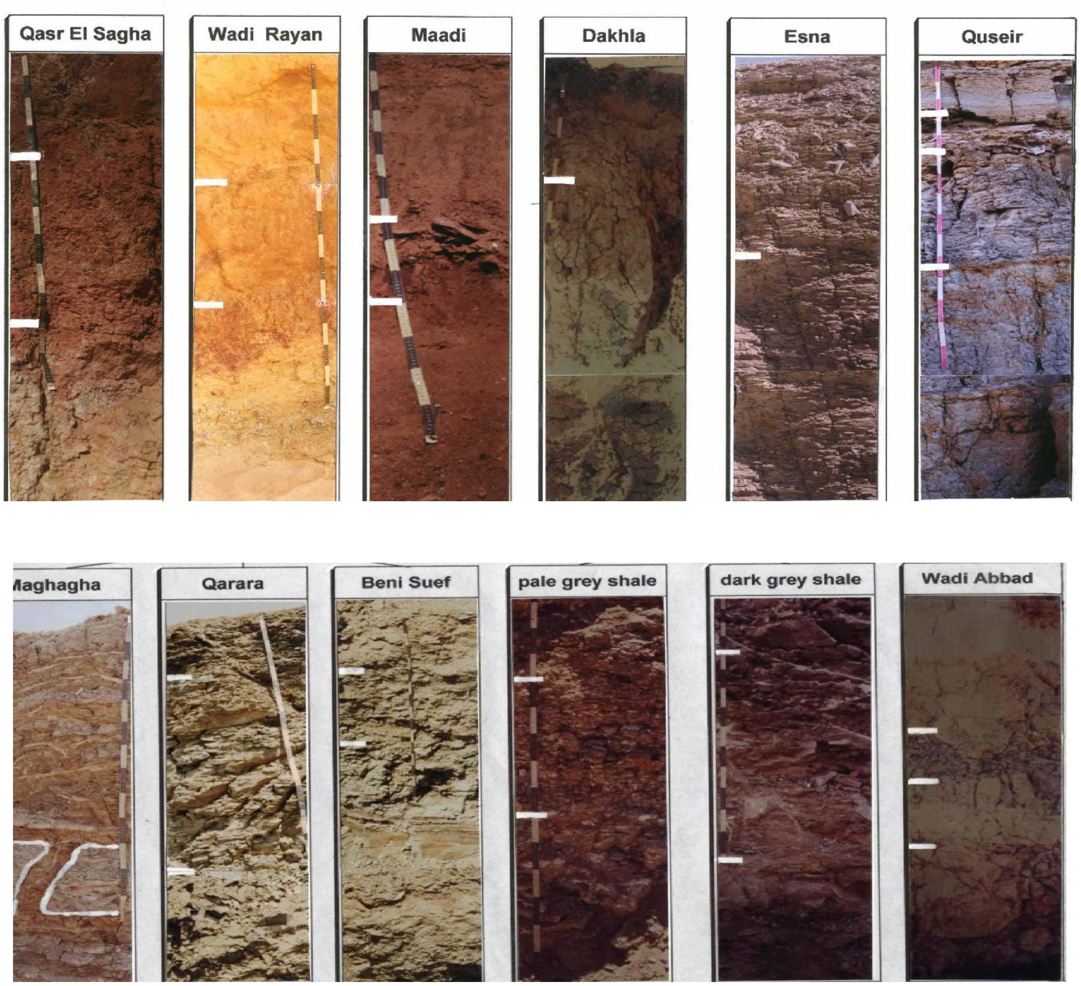


Fig.(1) Soil morphology of shale derived soil profiles.

Values of land characteristics and land qualities used in shale evaluation are given in Table1.In the capability classification using *SHALE-EGYPT* build in the model of *ALES* land evaluation system, the following parameters are comprised: slope (P), plant-available soil water (W), Thermic and /or Hyperthermic conditions(C), effective soil depth (X), chemical properties (Q), salinity (S), alkalinity (N) and the dominant clay type (D). According to the assigned values to each of the above mentioned parameters the following different degrees of capabilities are distinguished.

3.1- shale properties

These shales are mostly saline, particularly the surface layers. The higher salinity have been found in Maadi Formation. (EC=175 dS/m). However lower value was indicated in Quseir and Maghagha Formation, where EC=5 dS/m. Calcium chloride is the dominant soluble salt in these shales, followed by gypsum in some other types Beni Suef, Maadi, Maghagha and Qarara Formations. pH values indicate the neutral soil reaction in the majority of the samples. It is ranged between 6.8 (Quseir and Esna Formation due to its high content of amorphous iron) and 8.1(Quseir Formation). Calcium carbonate content is relatively low. The lower value is 1% (which indicated in Dakhla, Quseir, Esna and Tushka basin Formations). While the calcareous shales (up to 25%) were in Maadi ; Dakhla; Quseir, Esna and Beni Suef Formations. Gypsum precipitations are associated with the high salinity. Gypsum is present in most samples. The gypsum could be rendered as secondary formation (evaporitic) from gypsum saturated water at the time of sedimentation (Abu Zied, 1974). Gypsum contents are ranged between 3% (Qasr El Sagha and Wadi Rayan Formation) and 23% (Esna Formation) Some others are gypsum free as Dakhla, Quseir and Esna Formations. The values of cation exchange capacity are high. The increase of its values are corresponds to increase in the clay content (mostly fine clay, predominant clay mineral and the presence of high content of amorphous iron and manganese). The high values of CEC were detected with Dark grey shale member; Esna and Wadi Abbad Formations which are 79, 78 and 77 cmol(+)/kg soil respectively. While the lower values are 31 and 32 cmol(+)/kg soil in Dakhla and Quseir Formations due to the type of dominant clay mineral and the light texture class (silty clay) respectively.

3.2- Capability classification of the studied shale deposits (Fig.2)

No limitations class (C_1): the total area of this class is 1192 Km^2 (3% of the total investigated shale areas) presented by 2.1% of Dakhla shale (28.5% of Maghagha shale and 100% of Wadi Abbad shale areas.

The representative profiles are: profile no. 5 (Dakhla shale from East Bulaq, Kharga oasis), profile no. 17(Maghagha shale from El-Sheikh Fadl, El Minia) and profile no. 24 (Wadi Abbad shale from Bir Abu El-Hussein, Tushka basin). These profiles, except profile no. 24, are cultivated with field crops and vegetables.

Moderate limitations class (C_2): the total area of this class is 488 Km^2 (1.2% of the total investigated shale areas), including 15.6% of Quseir shale area. This type is presented by: profile no. 9 (El Gidida, Dakhla) and profile no. 11 (Nagh Shehata Abu El Quasem, Idfu).

High limitations class (C_3): the total area of this class is 8653 Km^2 (20.9% of the total investigated shale areas), including 100% of Wadi Rayan, 71.3% of Maadi, 16.0% of Esna, 71.5% of Maghagha and 100% of Dark grey shale areas. The represented profiles are: profile no. 2 (Gehannam village, Fayoum), profile no. 4 (Ain Soukhna road, Km55), profile no.13 (El Hasnah village, Sinai), profile no.14 (Metmatny village, Sinai), profile no. 16 (El Sheikh Fadl, El Minia) and profile no. 23 (Bir Kiseiba, Tushka).

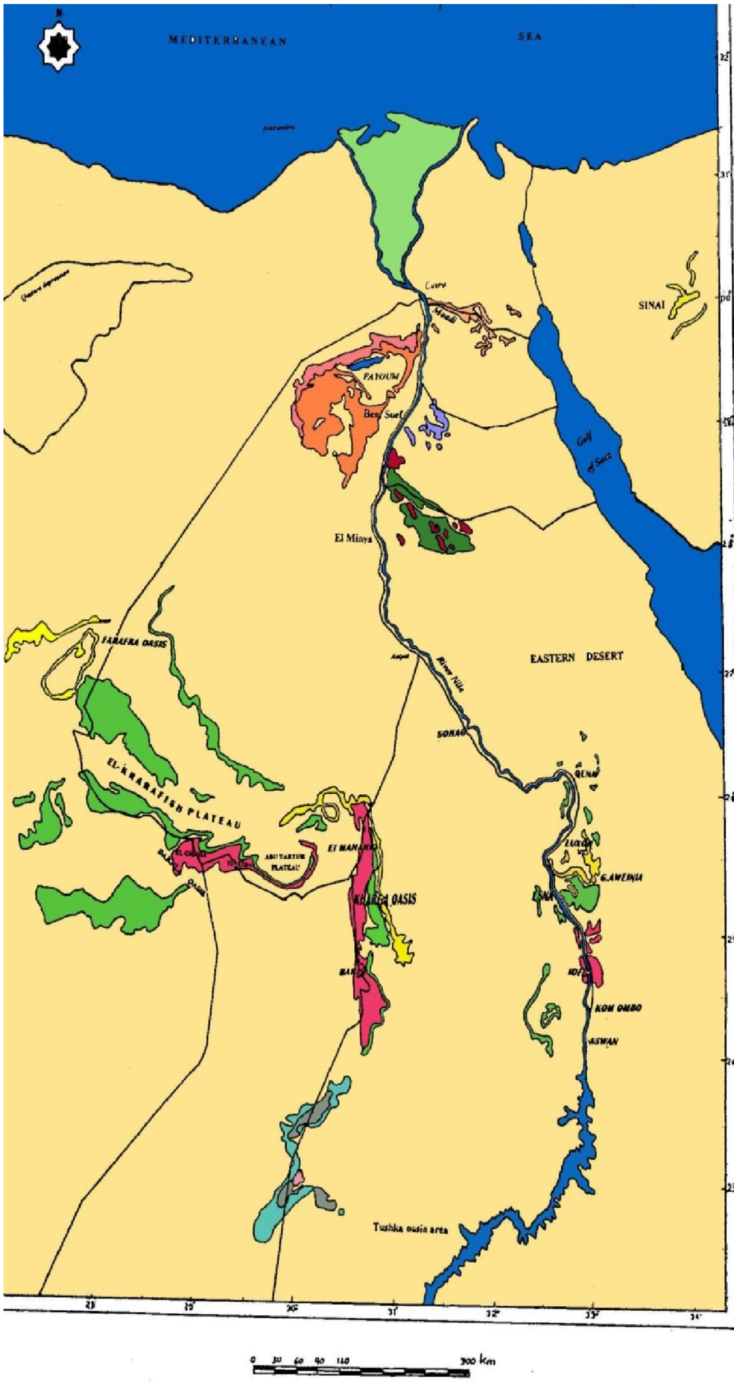
Very high limitations class (C_4): the total area of this class is 4560 Km^2 (11.0% of the total investigated shale areas), including 100% of Qasr El Sagha, 76.3% of Quseir, 52.0% of Esna and 7.0% of Qarara shale areas and represented by: profile no. 1 (El Ginidi village, Fayoum), profile no. 8 (El Maks El Qibli, Baris), profile no. 12 (Bagdad-Luxor road) and profile no. 21 (East El Minia).

Extreme limitations class (C_5): the total area of this class is 5088 Km^2 (12.3% of the total investigated shale areas), including 28.7% of Maadi, 5.5% of Dakhla, 8.1% of Quseir, 23.0% of Esna 100% of Beni Suef, 93.0% of Qarara and 100% of pale grey shale. Soils of class (C_5) are not suitable for agriculture proposes, for the following reasons: presence of salt layer on the soil surface as in profiles no. 20 (East El Minia) and 22 (Bir Abu El Hussein, Tushka) and/or, presence of salt or limestone layer in subsurface as in profiles no.10 (El Camp, El Ababd, Idfu) and 3 (Ain Soukhna road, Km5), presence of slope limitations as in profiles no. 7 (Khur El Aweiniya, Esna) and 15 (El Aweiniya village, Esna) and presence of gypsum and/or calcium carbonate limitations as in profiles no. 18, 19 (Ras Zafarana road, Km2 and 15) and 6 (Ezbet Sheikh Mawhub, Dakhla).

Other areas of Dakhla shales cover about 21503 km^2 (51.8% of the total investigated shale areas) not distinguished because we could not reach it.

4. Conclusion: Shale deposits cover considerable areas in Egypt. The area of the surface outcrops of these shales are about ~41484 km^2 (~4 % of total area of Egypt). 3% of the total investigated areas about 1192 Km^2 are highly suitable for agricultural investments, while 12.3% of the total investigated areas, about 5088 Km^2 are not recommended for the agricultural investments.

Responding Author
Wahab M.A
Soils and Water Use Dept. National Research Centre,El Buhouth St.,12311,Giza,Egypt
Email: mohamedwahab@yahoo.com



LEGEND

	SHALE TYPE	LOCATION	AREA, Km² (%)
	Qasr El Sagha	Fayoum Governorate	1,456 (3.5)
	Wadi Rayan	Fayoum Governorate	5,083 (12.3)
	Maadi	South of Cairo	766 (1.9)
	Dakhla	Dakhla, Kharga oases and Esna district	23,259 (56.1)
	Quseir	Quseir, Safaga, Dakhla and Kharga oases and Idfu district	3,137 (7.6)
	Esna	Esna, Dakhla and Kharga oases and Sinai	1,307 (3.2)
	Maghagha	El Shiekh Fadl, El Minia.	2,315 (5.6)
	Beni Suef	East Beni Suef.	54 (0.2)
	Qarara	East El Minia city	517 (1.3)
	Pale grey shale	Bir Abu El Hussien	2,380 (5.7)
	Dark grey shale	Bir Kiseiba, Tushka basin	1,160 (2.8)
	Wadi Abbad	Bir Abu El Hussien, Tushka basin	60 (0.2)

This map is produced in 1999 to identify the geographical distribution and areas of different surface shale outcrops in Egypt, using the available geological maps (CONOCO geological maps, 1987) scale 1:500,000, by GAMIL WAHEEB AGEEB Ph.D. student under the supervision of Prof. Dr. F.Hanna, and Prof. Dr. F. Labib

Fig.(2) Capability classification of the studied shale deposits in Egypt

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