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STUDIES ON DEPOSITION MODE OF SOME SOILS IN THE WESTERN NILE DELTA, EGYPT

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ABSTRACT: This study aims to discrimination between the nature of the depositional media and different mechanisms or processes, deposition environments as well as hydrodynamic conditions for some soils of the western Nile Delta, Egypt.

Soils of western Nile Delta have two main physiographic units namely, the river terraces that differ in their ages and the complex unit of Wadi El-Natrun.

Results of the average median size (Md) for the studied soils showed that, these soils have generally coarse and very coarse sand. Results of their mean size (Mz)indicated that, the coarse sand > medium sand > fine sand. Their sorting values (σ_1) are between poorly and very poorly sorted except soils belong to windblown sand that have moderately well and moderately sorted. Values of skewness (SK_I) tend to be positive to very positive skewed, which have a tail of fine grains. The predominant kurtosis (KG) classes recorded are the lepto and very leptokurtic.

Depositional regime tends to be fluvial (deltaic) environments, while hydrodynamic conditions showed mechanism of rolling and suspension transportation.

Keywords: Statistical size parameter, sorting, skewness, kurtosis, depositional environment, mechanism of transportation

INTRODUCTION

Sedimentary rocks cover about 80 percent of earth's crust. Studies of the composition and properties of sedimentary rocks are vital in interpreting stratigraphy to determine location, lithology, relief, climate and tectonic activity of the source area, to deduce the character of the environment of deposition. Quantitative measurement of such grain size parameters as size and sorting is required for precise work (Folk, 1980).

The studies of Zayed et al. (2021) indicated that the studied soils in the Western Nile Delta (Map 1) are characterized by the presence of two main physiographic units. The first one is the river terraces differ in their ages. These soils have texture classes between sand and sandy loam. Gravel contents differ widely from 5 to 55 %. Total carbonate contents change between 2.11 and 9.30 %. Gypsum contents show values from 0.86 to 12.90 %.

The second unit is Wadi El-Natrun complex unit that including transition, gullies, windblown soils and isolated plateau. These soils have texture classes between sand and sandy clay loam with nil to 40 %gravel contents. Total carbonate contents fluctuate widely from 1.69 to 48.64 %, while gypsum contents are between 0.52 and 6.19%.

The current study includes the common quantitative measurements in sedimentological studies of such grain size parameters of Folk and Ward (1957) which measure median (Md), mean size (M_z), sorting (σ_I), skewness (SK_I) and kurtosis (K_G).

Studying depositional mechanisms were done according to Sahu (1964) and hydrodynamic conditions of sedimentation which are suggested by C-M pattern of Passega (1957 and 1964).

The main goal of the present work is studying the sedimentological characteristic and discrimination between different mechanisms and environments of deposition by using the previous tools and procedures for the studied area of Western Nile Delta.

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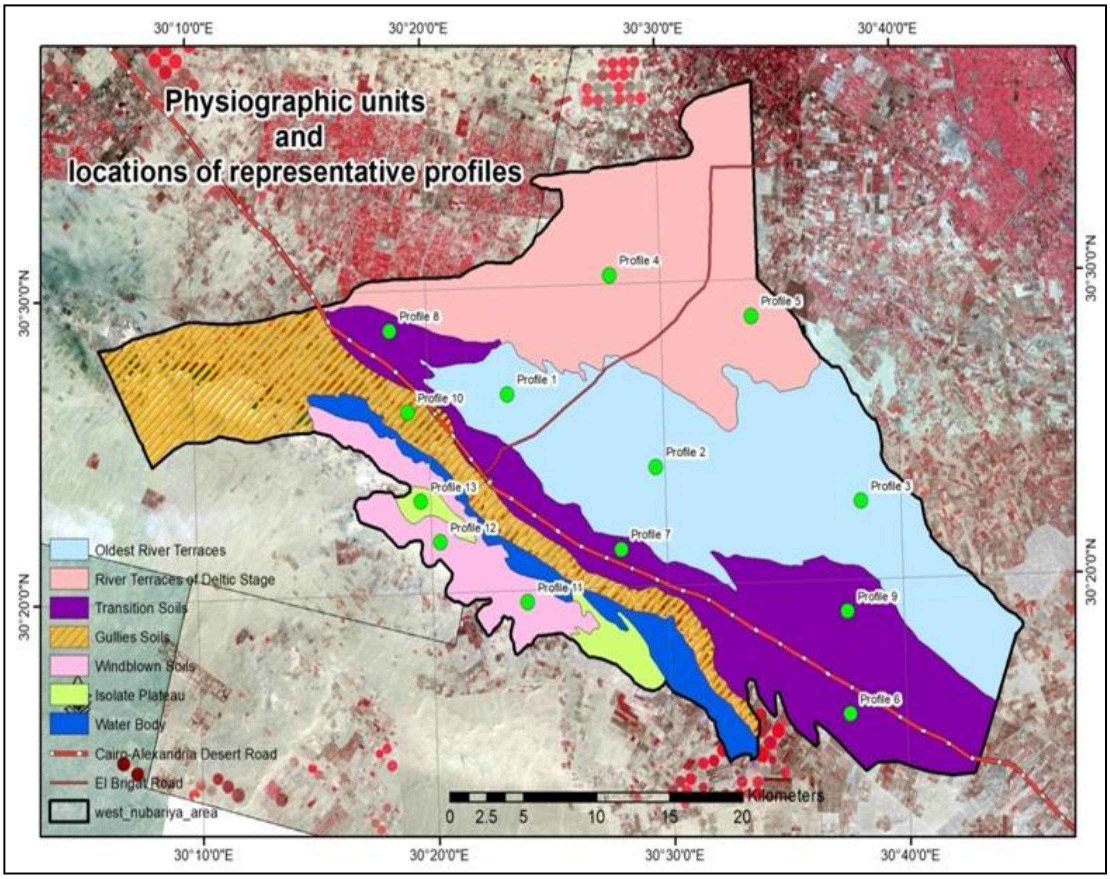


Map (1): Physiographic units and Location of soil profiles in the studied area (Zayed et al., 2021).

MATERIALS AND METHODS

Thirteen soil profiles were dug to represent the different physiographic units (Map 1). These profiles are 1, 2, 3, 4 and 5 that represented the soils of river terraces and 6, 7, 8, 9, 10, 11, 12, and 13representing the soils of Wadi EL-Natrun. Thirty-four soil samples were collected to analyses the different studied features of profiles.

The collected samples were air-dried, crushed and sieved through 2-mm sieve. Mechanical analysis was carried out according to Burt (2004). Grain size distribution of sand fraction was separated for five fractions, i.e., very coarse sand 2.0 – 1.0 mm, coarse sand 1.0 – 0.5 mm, medium sand 0.5 – 0.25 mm, fine sand 0.25 – 0.1 mm and very fine sand 0.1- 0.05 mm, according to Piper (1950) and Soil Survey Staff (1993) as showed in Table (1).

Cumulative percentages were plotted against phi-diameter on arithmetic probability paper, according to Folk (1980). The results had perfectly straight line whose position depends on the average particle size and whose slope depends on the sorting.

Particle size distribution were plotted as cumulative curves using φ unite, where:

$\varphi = -\log_2(d)$, and (d) being the diameter in mm.

Eight diameters were estimated against plotted percentile φ1, φ5, φ16, φ25, φ50, φ75, φ84 and φ95% from cumulative curves (Fig.1) for each sample, according to Griffiths (1967).

The statistical grain size parameters are calculated according to formula of Folk and Ward (1957), as follows:

1- Graphic mean: $M_z = (\phi16 + \phi50 + \phi84)/3$.

2- Inclusive Graphic Standard Deviation: $\sigma_I = (\phi84 - \phi16)/4 + (\phi95 - \phi5)/6.6$

3- Inclusive Graphic Skewness: $Sk_I = (\phi16 + \phi84 - 2\phi50)/2(\phi84 - \phi16) + (\phi5 + \phi95 - 2\phi50)/2(\phi95 - \phi5)$.

4- The Graphic Kurtosis: $K_G = (\phi\ 95 - \phi\ 5) / 2.44(\phi\ 75 - \phi\ 25)$.

The depositional mechanisms and differentiation between the environments of soil depositions were studied according to Sahu (1964), through the following equations:

$$Y_1 = -3.5688\ M_z + 3.7016\ \sigma_1^2 - 2.0766\ Sk_I + 3.1135\ K_G$$

Values of Y_1 less than (- 2.7411) indicate aeolion deposition.

$$Y_2 = 15.6534\ M_z + 65.709\ \sigma_1^2 + 18.1071\ Sk_I + 18.5043\ K_G$$

Table (1): Particle size distribution of the studied soil profiles.

Physiographic unit	Profile No.	Depth cm.	Particle size distribution (%)						
			Sand fractions (mm.)					Silt (mm)	Clay (mm)
			V.C.S 2.0-1.0	C.S 1.0-0.5	M.S 0.50-0.25	F.S 0.25-0.10	V.F.S 010-0.05	0.05-0.002	<0.002
River Terraces									
Oldest river terraces	1	0 - 25	17.27	33.04	13.35	8.03	1.21	15.12	11.99
		25 - 60	26.79	35.09	11.01	2.71	2.05	13.08	9.27
		60 - 100	39.36	28.20	9.27	2.74	1.42	10.87	8.14
	2	0 - 50	39.99	28.38	6.45	5.53	0.65	9.13	9.87
		50 - 110	49.52	27.53	9.51	1.19	0.40	9.97	1.89
	3	0 - 50	52.04	33.79	2.42	4.74	2.12	3.77	1.12
		50 - 100	21.19	44.31	15.38	8.45	4.79	3.87	2.01
River terraces of deltaic stage	4	0 - 20	38.80	36.27	7.19	3.65	2.03	8.89	3.17
		20 - 40	54.63	27.86	9.22	1.20	1.60	3.27	2.21
		40 - 60	1.13	12.48	35.91	29.16	15.04	3.32	2.96
		60 - 100	64.51	21.90	6.40	1.90	1.40	1.88	2.01
	5	0 - 20	49.62	39.92	5.35	0.50	0.59	2.01	2.01
		20 - 55	28.03	50.63	12.86	1.61	1.91	3.19	1.77
		55 - 120	39.82	45.32	8.50	2.20	0.50	2.52	1.14
Wadi EL-Natrun									
Transition soils	6	0 - 45	44.44	28.59	12.44	2.71	4.82	3.88	3.12
		45 - 100	50.43	28.08	8.66	3.93	3.72	3.02	2.16
	7	0 - 20	21.94	35.55	17.77	11.27	6.80	2.92	3.74
		20 - 70	16.05	36.90	20.85	13.08	7.97	1.95	3.19
		70 - 120	39.41	22.91	14.00	6.90	2.80	8.11	5.87
	8	0 - 20	42.03	34.97	10.78	5.14	2.12	2.77	2.19
		20 - 100	49.21	30.87	9.78	3.06	1.73	4.26	1.09
	9	0 - 12	10.96	31.06	15.94	4.65	9.80	14.95	12.64
		12 - 35	8.26	30.53	20.78	4.27	5.85	16.18	14.14
		35 - 95	44.37	32.08	3.18	1.41	0.44	13.40	5.11
		95 - 150	17.60	36.48	12.78	0.00	0.64	18.20	14.30
Gullies soils	10	0 - 30	38.79	22.06	11.08	4.94	7.15	11.76	4.22
		30 - 100	55.54	21.60	8.78	4.04	2.27	4.64	3.12
Windblown Soils	11	0 - 40	75.16	17.15	1.21	1.41	0.50	3.12	1.44
		40 - 120	81.06	9.44	2.36	0.89	0.39	2.77	3.09
	12	0 - 50	52.09	31.04	8.78	3.09	1.70	1.59	1.71
		50 - 120	47.19	10.23	32.29	4.67	2.38	1.22	2.01
Isolated plateau	13	0 - 40	46.07	33.14	11.54	4.08	2.89	1.14	1.14
		40 - 55	10.58	38.70	21.65	1.18	2.45	15.24	10.21
		55 - 100	4.63	17.42	17.82	9.74	8.17	21.78	20.44

V.C.S: Very coarse sand., C.S: Coarse sand., M.S: Medium sand., F.S: Fine Sand., V.F.S : Very fine sand.

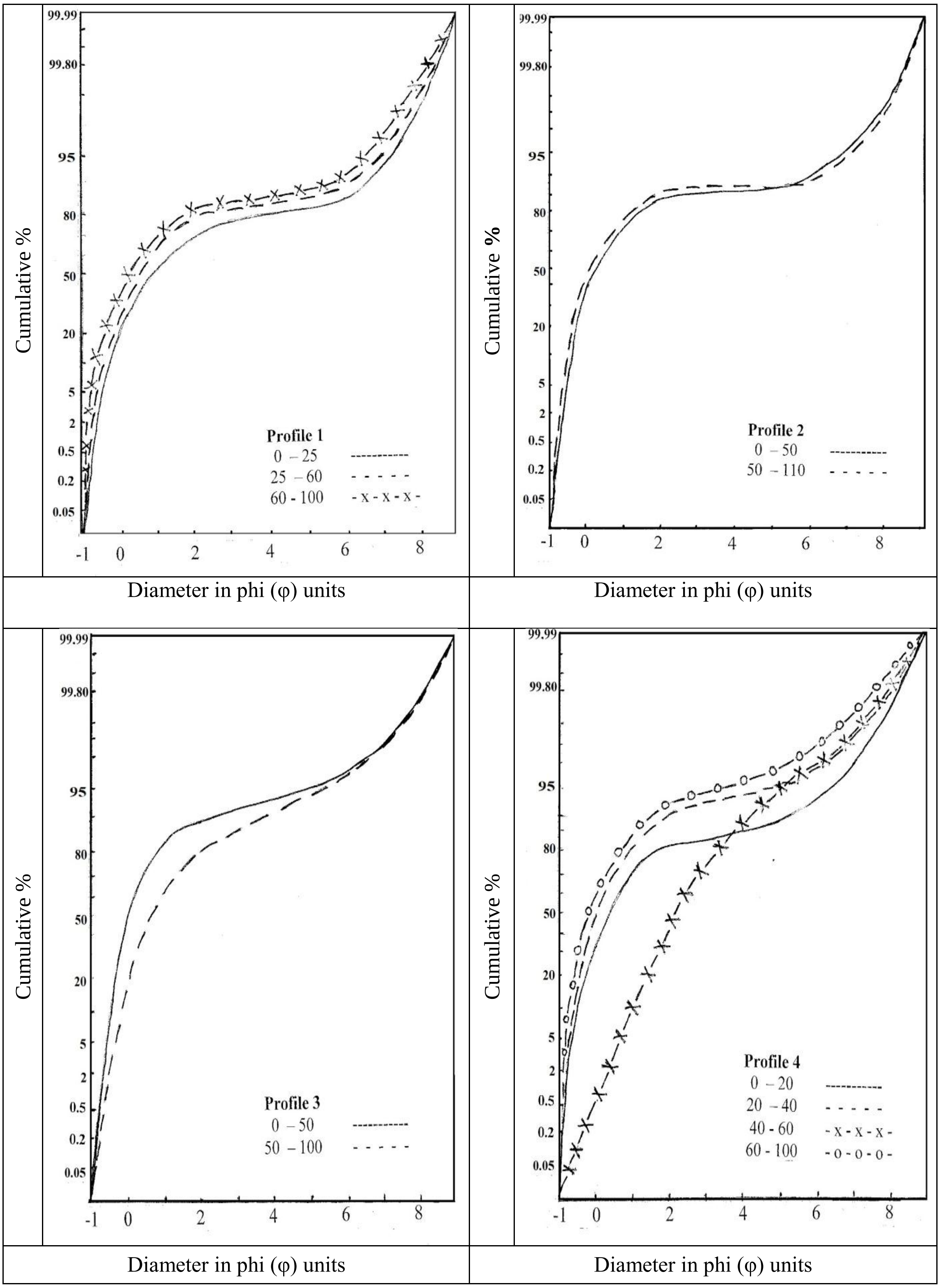


Fig (1): Cumulative frequency curves of the sand and silt fractions of the studied soil profiles.

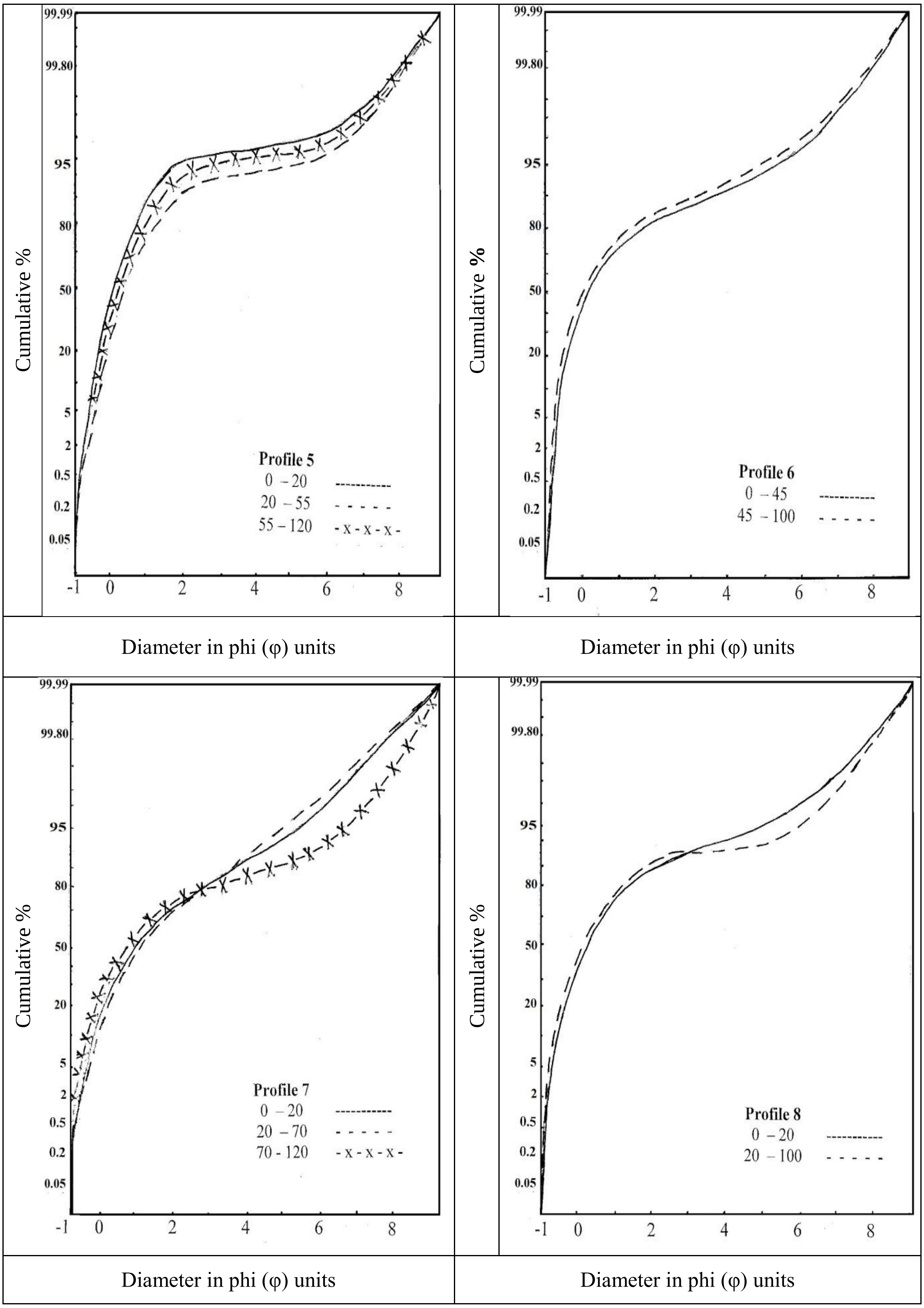
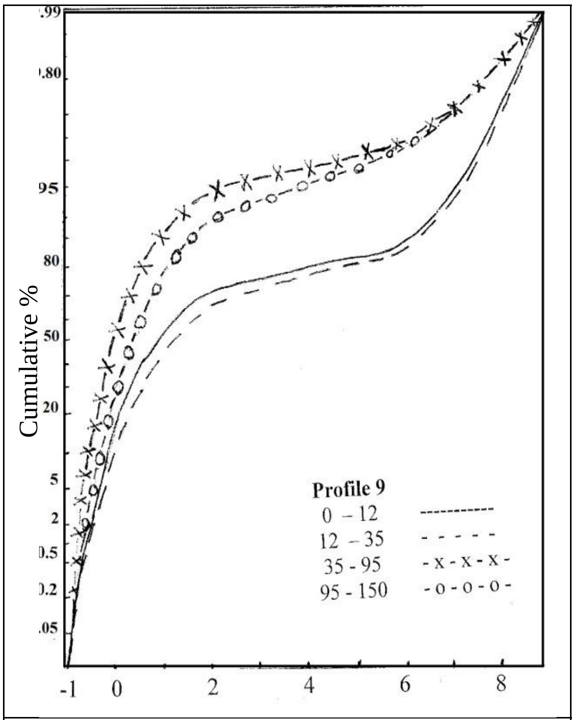
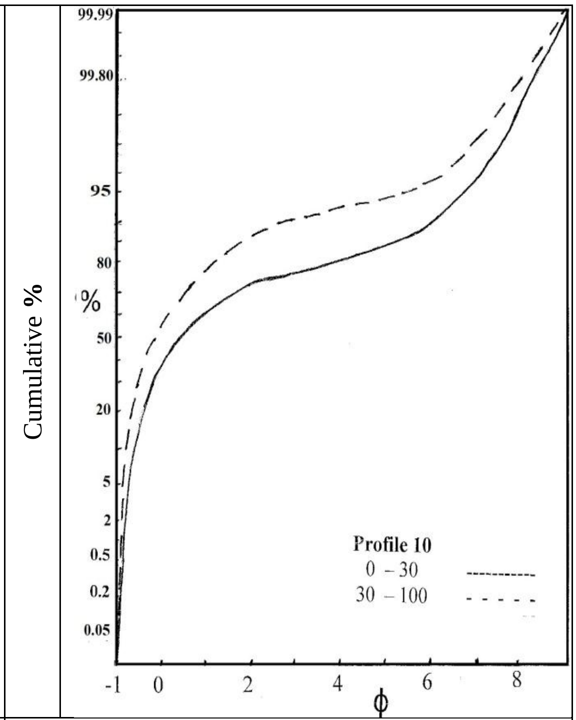

Cumulative %
99.99
99.80
95
80
50
20
5
2
0.5
0.2
0.05
-1
0
2
4
6
8
Profile 5
0 – 20
20 – 55
55 – 120
- x - x - x -
Diameter in phi (φ) units
Profile 6
0 – 45
45 – 100
Profile 7
0 – 20
20 – 70
70 - 120
Profile 8
0 – 20
20 – 100

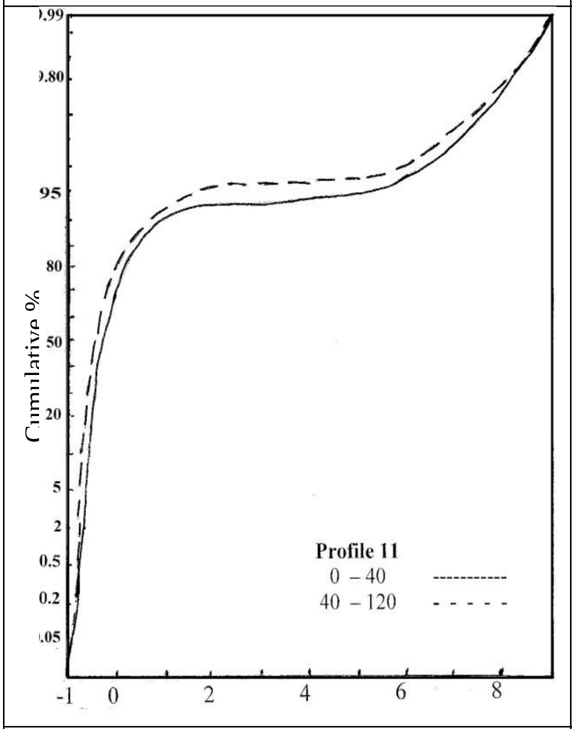
Fig 1: Cont.

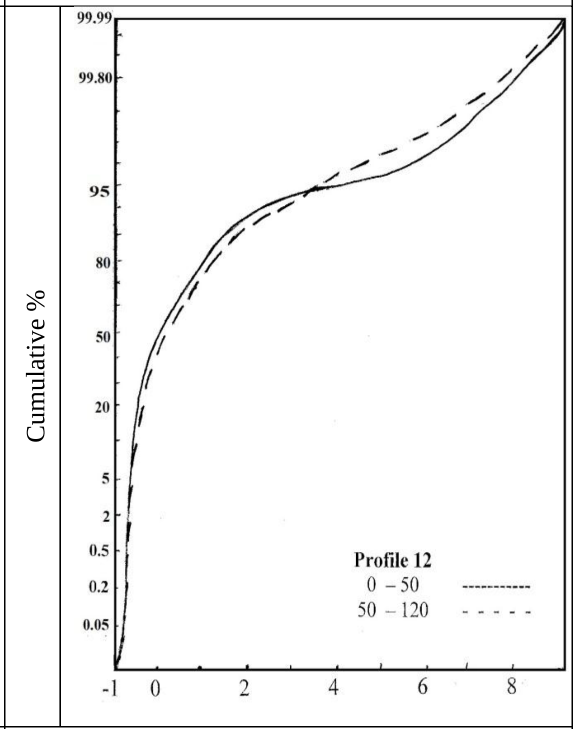




Diameter in phi (φ) units

Diameter in phi (φ) units





Diameter in phi (φ) units

Diameter in phi (φ) units

Fig 1: Cont.

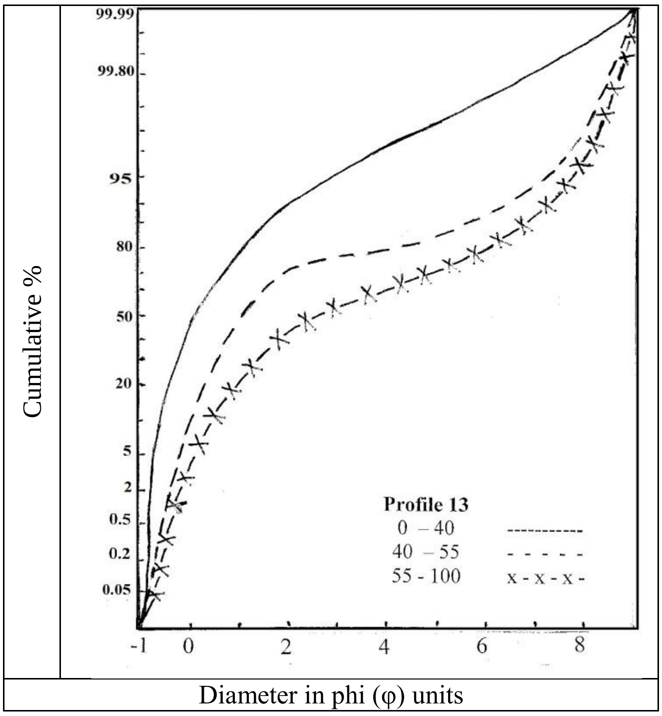


Fig 1: Cont.

Values of Y_2 less than (65.3650) indicate beach deposition, and the greater than this limit indicate shallow agitated marine.

$Y_3 = 0.2852\ M_z - 8.7604\ \sigma_1^2 - 4.8932\ Sk_I + 0.0482\ K_G$

Values of Y_3 less than (-7.4190) indicate fluvial deltaic deposition, and the greater than this limit indicate shallow agitated marine.

$Y_4 = 0.7215\ M_z - 0.4030\ \sigma_1^2 + 6.7322\ Sk_I + 5.2927\ K_G$

Values of Y_4 less than (9.8433) indicate turbidity current deposition, and the greater than (9.8433) indicate fluvial deposition.

The C-M pattern was used as a tool for indicating the hydrodynamic condition of sedimentation for the studied soils as suggested by Passega (1957 and 1964).

RESULTS AND DISCUSSION

The sedimentological studies used methods involves plotting the cumulative curves of the samples (Fig, 1) and reading the diameter by various cumulative percentages according to Folk (1980) are illustrated in Table (2). These are a base for interpretation the sedimentological properties of sediments and their environments, on the other hand, studying the hydrodynamic conditions. Four statistical parameters (MZ, σ_1, Sk_I and K_G) are calculated using the formula of Folk and Ward (1957). The results could be discussed as in follows.

Soils of river terraces: This unit included young and old Nile sediments which represented by soil profiles 1, 2, 3, 4 and 5. Moreover, these soils are subjected to strong wind erosion, therefore, they are covered in some localities with drift sand, Sandford and Arkell (1939), El-Fayoumy (1968) and Elwan, et al. (1980).

I) Statistical Size parameters: According to Folk and Ward (1957) and Folk (1980), they included four parameters:

1- Measures of average size: Including median and graphic mean

A-Median (Md):

This measure expresses which about half of the particles by weight are coarser than the median and half are finer. It is the diameter corresponding to the 50% mark on the cumulative curve (Folk 1980). Data in Table (2) showed that soils of river terraces correspond to coarse sand except for the surface layer of profile 3 and the deepest layer of profile 4which have very coarse sand as median diameter.

B-Mean Size (M_Z):

According to Folk and Ward (1957), the ϕ 16 may be considered roughly as the average size of the course third of the sample, and the ϕ 84 as the average size of the finest third; the addition of the ϕ 50 (the average of the middle third) thus completes the picture and gives a better overall representation of the true phi mean. So, the median is very misleading value, where, it is based on only one point of the cumulative curve. Soils of river terraces (Table 3), show that, these soils have coarse and very coarse sand predominant mean size (M_z) while, fine sand is observed inthe surface layer of profile 1 and the 40 – 60 cm layer of profile 4.

Table (2): Phi-diameters (Φ)again steight percentiles on arithmetic probability paper.

Physiographic unit	Profile No.	Depth cm.	Φ 1	Φ 5	Φ 16	Φ 25	Φ 50	Φ 75	Φ 84	Φ 95
River Terraces										
Oldest river terraces	1	0 - 25	-0.80	-0.55	-0.10	0.15	0.85	2.85	5.75	7.25
		25 - 60	-0.85	-0.65	-0.25	-0.05	0.45	1.60	4.20	6.90
		60 - 100	-0.90	-0.85	-0.55	-0.35	0.20	1.25	3.20	6.60
	2	0 - 50	-0.80	-0.60	-0.40	-0.30	0.15	1.00	1.65	6.65
		50 - 110	-0.85	-0.70	-0.50	-0.40	0.00	0.85	1.45	6.85
	3	0 - 50	-0.80	-0.60	-0.40	-0.30	-0.05	0.50	1.05	5.00
		50 - 100	-0.70	-0.40	-0.15	0.05	0.55	1.50	2.35	5.20
River terraces of deltaic stage	4	0 - 20	-0.90	-0.65	-0.35	-0.20	0.30	1.25	3.10	6.35
		20 - 40	-0.90	-0.75	-0.55	-0.40	0.00	0.70	1.15	5.00
		40 - 60	0.10	0.60	1.20	1.50	2.10	3.00	3.55	5.00
		60 - 100	-0.95	-0.90	-0.70	-0.60	-0.30	0.40	0.90	3.60
	5	0 - 20	-0.80	-0.60	-0.40	-0.30	0.00	0.45	0.70	1.65
		20 - 55	-0.80	-0.60	-0.30	-0.20	0.15	0.70	1.10	4.55
		55 - 120	-0.80	-0.60	-0.35	-0.25	0.10	0.50	0.85	2.00
Wadi EL-Natrun										
Transition soils	6	0 - 45	-0.85	-0.70	-0.50	-0.35	1.10	1.15	2.05	5.10
		45 - 100	-0.90	-0.80	-0.60	-0.50	-0.05	0.90	1.65	4.70
	7	0 - 20	-0.80	-0.60	-0.25	-0.10	0.60	2.00	2.95	5.00
		20 - 70	-0.80	-0.55	-0.20	0.05	0.75	2.20	3.00	4.65
		70 - 120	-0.85	-0.65	-0.35	-0.15	0.50	1.85	3.55	6.40
	8	0 - 20	-0.90	-0.70	-0.40	-0.25	0.20	1.00	1.65	4.70
		20 - 100	-0.90	-0.85	-0.60	-0.40	0.00	0.75	1.30	5.70
	9	0 - 12	-0.60	-0.30	0.00	0.25	0.85	3.10	5.65	7.05
		12 - 35	-0.55	-0.20	0.20	0.45	1.20	3.75	5.80	7.20
		35 - 95	-0.75	-0.60	-0.30	-0.20	0.05	0.50	0.80	2.00
		95 - 150	-0.65	-0.45	-0.15	0.00	0.35	0.95	1.35	3.45
Gullies soils	10	0 - 30	-0.90	-0.80	-0.50	-0.30	0.35	2.60	4.55	6.70
		30 - 100	-0.90	-0.85	-0.75	-0.60	-0.15	0.80	1.45	5.55
Windblown Soils	11	0 - 40	-0.90	-0.60	-0.55	-0.50	-0.35	0.00	0.25	4.40
		40 - 120	-0.90	-0.85	-0.75	-0.70	-0.50	-0.20	0.00	1.45
	12	0 - 50	-0.85	-0.70	-0.60	-0.55	-0.20	0.55	0.90	2.80
		50 - 120	-0.85	-0.75	-0.60	-0.50	-0.15	0.65	1.00	2.70
Isolated plateau	13	0 - 40	-0.90	-0.75	-0.50	-0.40	0.00	0.80	1.20	2.60
		40 - 55	-0.50	-0.20	0.10	0.40	0.95	2.45	4.90	7.10
		55 - 100	-0.35	0.10	0.70	1.15	2.35	5.30	6.30	7.60

Table (3): Statistical size parameters of the studied soils according to Folk and Ward (1957).

Physiographic units	Profile No.	Depth Cm.	Mean size M_z	Mean size Class	Sorting σ_I	Sorting Class	Skewness Sk_I	Skewness Class	Kurtosis K_G	Kurtosis Class
River Terraces										
Oldest river terraces	1	0 - 25	2.167	Fine sand	2.644	Very poorly sorted	0.658	Strong fine skewed	1.184	Leptokurtic
		25 - 60	1.467	Medium sand	2.256	Very poorly sorted	0.697	Strong fine skewed	1.875	Very leptokurtic
		60 - 100	0.950	Coarse sand	2.066	Very poorly sorted	0.659	Strong fine skewed	1.908	Very leptokurtic
	2	0 - 50	0.467	Coarse sand	1.611	Poorly sorted	0.628	Strong fine skewed	2.286	Very leptokurtic
		50 - 110	0.317	Coarse sand	1.631	Poorly sorted	0.651	Strong fine skewed	2.475	Very leptokurtic
	3	0 - 50	0.200	Coarse sand	1.211	Poorly sorted	0.660	Strong fine skewed	2.869	Very leptokurtic
		50 - 100	0.917	Coarse sand	1.473	Poorly sorted	0.550	Strong fine skewed	1.583	Very leptokurtic
River terraces of deltaic stage	4	0 - 20	1.017	Medium sand	1.923	Poorly sorted	0.676	Strong fine skewed	1.979	Very leptokurtic
		20 - 40	0.200	Coarse sand	1.296	Poorly sorted	0.546	Strong fine skewed	2.142	Very leptokurtic
		40 - 60	2.283	Fine sand	1.254	Poorly sorted	0.276	Fine skewed	1.202	Leptokurtic
		60 - 100	0.033	Very coarse sand	1.082	Poorly sorted	0.617	Strong fine skewed	1.844	Very leptokurtic
	5	0 - 20	0.100	Coarse sand	0.616	Moderately sorted	0.370	Strong fine skewed	1.230	Leptokurtic
		20 - 55	0.317	Coarse sand	1.130	Poorly sorted	0.533	Strong fine skewed	2.345	Very leptokurtic
		55 - 120	0.200	Coarse sand	0.694	Moderately sorted	0.356	Strong fine skewed	1.421	Leptokurtic
Wadi EL-Natrun										
Transition soils	6	0 - 45	0.883	Coarse sand	1.516	Poorly sorted	0.062	Nearly symmetrical	1.585	Very leptokurtic
		45 - 100	0.333	Coarse sand	1.396	Poorly sorted	0.619	Strong fine skewed	1.610	Very leptokurtic
	7	0 - 20	1.100	Medium sand	1.648	Poorly sorted	0.520	Strong fine skewed	1.093	Mesokurtic
		20 - 70	1.183	Medium sand	1.588	Poorly sorted	0.453	Strong fine skewed	0.991	Mesokurtic
		70 - 120	1.233	Medium sand	2.043	Very poorly sorted	0.619	Strong fine skewed	1.445	Leptokurtic
	8	0 - 20	0.483	Coarse sand	1.331	Poorly sorted	0.541	Strong fine skewed	1.770	Very leptokurtic
		20 - 100	0.233	Coarse sand	1.467	Poorly sorted	0.554	Strong fine skewed	2.334	Very leptokurtic
	9	0 - 12	2.167	Fine sand	2.526	Very poorly sorted	0.693	Strong fine skewed	1.057	Mesokurtic
		12 - 35	2.400	Fine sand	2.521	Very poorly sorted	0.632	Strong fine skewed	0.919	Mesokurtic
		35 - 95	0.183	Coarse sand	0.669	Moderately sorted	0.432	Strong fine skewed	1.522	Very leptokurtic
		95 - 150	0.517	Coarse sand	0.966	Moderately sorted	0.462	Strong fine skewed	1.682	Very leptokurtic
Gullies soils	10	0 - 30	1.467	Medium sand	2.399	Very poorly sorted	0.678	Strong fine skewed	1.060	Mesokurtic
		30 - 100	0.183	Coarse sand	1.520	Poorly sorted	0.618	Strong fine skewed	1.874	Very leptokurtic
Windblown Soils	11	0 - 40	-0.217	Very coarse sand	0.958	Moderately sorted	0.700	Strong fine skewed	4.098	Extremely leptokurtic
		40 - 120	-0.417	Very coarse sand	0.536	Moderately sorted	0.514	Strong fine skewed	1.885	Very leptokurtic
	12	0 - 50	0.033	Coarse sand	0.905	Moderately sorted	0.590	Strong fine skewed	1.304	Leptokurtic
		50 - 120	0.083	Coarse sand	0.923	Moderately sorted	0.545	Strong fine skewed	1.230	Leptokurtic
Isolated plateau	13	0 - 40	0.233	Coarse sand	0.933	Moderately sorted	0.482	Strong fine skewed	1.144	Leptokurtic
		40 - 55	1.983	Medium sand	2.306	Very poorly sorted	0.665	Strong fine skewed	1.459	Leptokurtic
		55 - 100	3.117	Very Fine sand	2.536	Very poorly sorted	0.405	Strong fine skewed	0.741	Platykurtic

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2-Standard Deviation:

Cumulative curves of river terraces soils which are represented by profiles 1, 2, 3, 4 and 5 are illustrated in Fig. (2) and their computed statistical size parameter are given in Table (3). Sorting data show that the sediments constituting for these profiles fall in very poorly, poorly and moderately sorted sediments. In this accord, profiles 2, 3 and 4 constitutes poorly sorted sediments throughout their entire depths, while profile 1 have very poorly sorted sediments in its all layers. On the other hand, profile 5 is characterized by moderately sorted sediments in the top and deepest layers, sandwiching one of poorly sorted layer in between. According to Folk (1980), the sediments transported by water or weathered in situ are usually poorly and very poorly sorted, while the sediments transported by wind and water are moderately well sorted. Folk and Ward (1957) stated that it may be argued that any attempt to set verbal limits on sorting values is foolish because sorting is rather closely controlled V-shaped or sinusoidal function of mean size; hence about the only sediments falling in the "well sorted" category would be the medium and fine sands, while all clays, silts and most gravel would be poorly sorted to very poorly sorted.

3-Skewness:

A better measure of skewness is Inclusive Graphic Skewness (SK_I), which is the average of two measures of Inman (1952). One to measure the asymmetry of the central part of the distribution and the other to measure the extremes. Using this measure skewness is geometrically independent of sorting, perfectly symmetrical curves have SK_I= 0.00 and the absolute mathematical limits are – 1.00 to + 1.00, however, very few curves have SK_I beyond –0.80 or +0.80 (Folk and Ward, 1957).

Data in Table (3) showed that skewness values reveal to strongly fine skewed except for the 40 -60 cm layer of profile 4 which has fine skewed. This indicates that all samples of river terraces have a "tail" of fines.

4- Kurtosis:

It measures the ratio of the sorting in the extremes of the distribution compared with the sorting in the central part and as such is a sensitive and valuable test of the normality of a distribution. In normal curve, the spread in the phi units between the 5th and 95th percentiles should be 2.44 times the spread between the 25th and 75th percentiles. Thus, the normal curves have K_G = 1.00 (Folk and Ward, 1957).

Data in Table (3) clear that soils of river terraces have kurtosis values between 1.184 and 2.869φ, which indicate that soils of most samples have very leptokurtic level except for the top layer of profile 1, 40 – 60 cm layer of profile 4, and the surface and deepest layers of profiles 5 which attain leptokurtic sediments.

II) Depositional environments or mechanisms:

According to Sahu (1964) it is possible to distinguish between aeolian, marine, fluvial and turbidity current mechanism and between littoral (beach) and shallow agitated water environments within the spectrum of marine depositional processes. Inman's (1952) statistics are theoretically independent for normal distributions, but these have been modified by Folk and Ward (1957), which are mutually independent and can be applied to normal as well as non-normal distribution.

Whereas, every environment of deposition can be assumed to have its characteristic energy conditions and energy fluctuations through space and time. The preservation of these fluctuations is subject to the availability of sufficient amounts of source material of all sizes. If so, then size distribution would indicate the environment of deposition. Four equations discriminate functions are used for classification purposes, which were illustrated in Table (4). Soils of river terrace are deposited under aqueous environment mainly fluvial (deltaic) conditions, except for the surface and deepest layer of profile 5, which is formed by beach deposition.

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Table (4): The depositional environments of the studied area according to Sahu (1964).

Physiographic units	Profile No.	Depth cm.	Y_1	Y_2	Y_3	Y_4
River Terraces						
Oldest river terraces	1	0 - 25	20.4704	527.2064	-63.8017	9.4423
		25 - 60	18.0039	404.8394	-47.5056	13.6241
		60 - 100	16.9867	342.6641	-40.2649	13.5018
	2	0 - 50	13.7529	231.5077	-25.5666	15.6175
		50 - 110	15.0776	237.4391	-26.2919	16.6393
	3	0 - 50	12.2754	164.5362	-15.8832	19.1833
		50 - 100	8.5506	196.2680	-21.3755	11.8689
River terraces of deltaic stage	4	0 - 20	14.8181	307.7780	-35.3208	14.2650
		20 - 40	11.0418	163.0622	-17.2305	14.4819
		40 - 60	0.8432	166.3432	-14.4215	9.2352
		60 - 100	8.9126	121.6724	-13.1907	13.4170
	5	0 - 20	4.1077	55.9370	-5.0444	8.9156
		20 - 55	9.7940	141.9517	-13.5966	15.7138
		55 - 120	4.7535	67.5052	-5.8339	9.8650
Wadi EL-Natrun						
Transition soils	6	0 - 45	10.1628	195.3510	-20.1174	8.5169
		45 - 100	9.7496	174.2472	-19.9255	12.1455
	7	0 - 20	8.4561	225.4240	-25.9849	8.9842
		20 - 70	7.2552	210.7462	-23.9201	8.1345
		70 - 120	14.2639	331.5542	-39.1783	11.0205
	8	0 - 20	9.2193	166.4692	-17.9345	12.6456
		20 - 100	13.2545	198.3797	-21.3980	15.3878
	9	0 - 12	17.7404	485.3374	-58.6259	9.2517
		12 - 35	16.5126	483.7027	-58.0505	8.2904
		35 - 95	4.8449	68.2604	-5.9074	10.9158
		95 - 150	5.8896	108.8832	-10.2032	12.0088
Gullies soils	10	0 - 30	17.9582	432.9804	-53.2621	8.9157
		30 - 100	12.4446	200.4804	-23.1129	13.2774
Windblown Soils	11	0 - 40	15.4741	145.3727	-11.3224	25.8781
		40 - 120	7.3517	56.5558	-5.0622	13.0253
	12	0 - 50	5.7487	89.1971	-9.9967	10.5708
		50 - 120	5.5509	89.8675	-10.0418	9.8924
Isolated plateau	13	0 - 40	4.9479	90.6984	-9.8557	9.1183
		40 - 55	15.7688	419.5350	-49.2069	11.4916
		55 - 100	14.1545	492.5477	-57.4158	6.3052

III) Hydro-dynamic conditions:

The C-M pattern of Passega (1957 and 1964) are used as a tool for indicating the hydro-dynamic conditions of sedimentation.

Data of these conditions is constructed in Fig. (2) by plotting C, which is the grain size associated with one percent value of cumulative curve against M, which is the median diameter, using log-log paper.

Soils of river terraces were related by rolling (N-O) probable mechanism of transportation except the surface layer of profile 1 and 40-60 cm layer of profile 4 were appeared rolling and suspension (O-P) hydro-dynamic conditions (Table, 5).

Soils of Wadi El-Natrun:

They have a predominant area of transition soils which are affected by soils of river terraces. The sedimentological characteristics of these soils as follows:

I) The statistical size parameters according Folk and Ward (1957)

1- Measures of average size:

A-Median (Md):

Data in Table (2) show that soils of Wadi El-Natrun have median values of coarse and very coarse sand except the 0-45 cm layer of profile 6 and 12-35 cm layer of profile 9 which have median sand, while, the deepest layer of profile 13 has median value as fine sand.

B-Mean Size (M_Z):

Values of mean size in Table (3) show that coarse sand is found in soils of profiles 6, 8 & 12, the deepest layers of profile 9 and the surface layer of profile 13. Very coarse sand is observed in soils of profile 11. Mean size of medium sand is located in soils of profile 7, subsurface layer of profile 13and the top layer of profile 10. Fine sand is in the upper two layers of profile 9, while very fine sand is found in deepest layer of profile 13.

2- Standard Deviation as a measure of sorting:

Data in Table (3) clear that soils of transition soils except two deepest layers of profile 9, gullies soils and isolated plateau have sorting values between poorly and very poorly sorted, which reveal that, these soils are transported by water or weathered in situ according to Inman (1952). On the other hand, soils of windblown sand, deepest two layers of profile 9 and the surface layer of isolated plateau (profile 13) has sorting value, between moderately well sorted and moderately sorted, which indicate that water and wind agents have contributed together in transportation and deposition of these sediments.

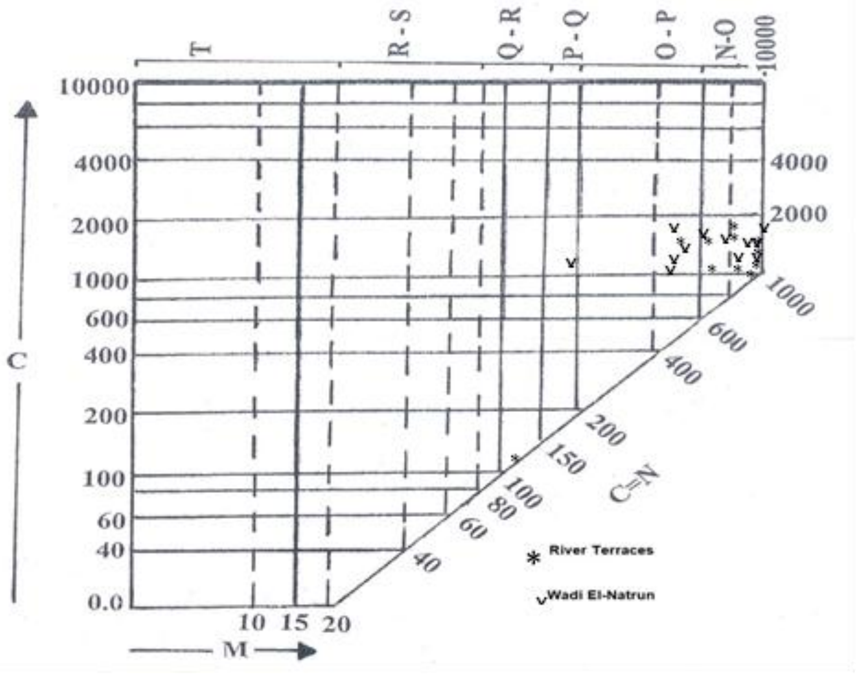

Fig (2): C-M Pattern diagram for hydrodynamic conditions of the studied soils.

Table (5): One percentile, median size and hydrodynamic conditions of the studied area.

Physiographic units	Profile No.	Depth (cm)	One percentile (micron)	Median diameter (micron)	Mechanism of transportation	
					Segment	Indication
River Terraces						
Oldest river terraces	1	0 - 25	1744	552	O - P	Rolling & Suspension
		25 - 60	1808	736	N - O	Rolling
		60 - 100	1872	872	N - O	Rolling
	2	0 - 50	1744	904	N - O	Rolling
		50 - 110	1808	1000	N - O	Rolling
	3	0 - 50	1744	1038	N - O	Rolling
		50 - 100	1626	686	N - O	Rolling
River terraces of deltaic stage	4	0 - 20	1872	814	N - O	Rolling
		20 - 40	1872	1000	N - O	Rolling
		40 - 60	936	234	O - P	Rolling & Suspension
		60 - 100	1936	1254	N - O	Rolling
	5	0 - 20	1744	1000	N - O	Rolling
		20 - 55	1744	904	N - O	Rolling
		55 - 120	1744	936	N - O	Rolling
Wadi EL-Natrun						
Transition soils	6	0 - 45	1808	468	O - P	Rolling & Suspension
		45 - 100	1872	1038	N - O	Rolling
	7	0 - 20	1744	662	N - O	Rolling
		20 - 70	1744	590	O - P	Rolling & Suspension
		70 - 120	1808	710	N - O	Rolling
	8	0 - 20	1872	872	N - O	Rolling
		20 - 100	1872	1000	N - O	Rolling
	9	0 - 12	1518	552	O - P	Rolling & Suspension
		12 - 35	1464	436	O - P	Rolling & Suspension
		35 - 95	1680	968	N - O	Rolling
		95 - 150	1572	788	N - O	Rolling
Gullies soils	10	0 - 30	1872	788	N - O	Rolling
		30 - 100	1872	1114	N - O	Rolling
Windblown Soils	11	0 - 40	1872	1278	N - O	Rolling
		40 - 120	1872	1410	N - O	Rolling
	12	0 - 50	1808	1152	N - O	Rolling
		50 - 120	1808	1114	N - O	Rolling
Isolated plateau	13	0 - 40	1872	1000	N - O	Rolling
		40 - 55	1410	519	O - P	Rolling & Suspension
		55 - 100	1278	196.8	P - Q	Suspension & Rolling

3-Skewness:

Soils of Wadi El-Natrun have skewness values of strongly fine – skewed which indicate that the studied samples have tails of fine grains, except the surface layer of profile 6which have skewness value 0.062 φ reveals to near symmetrical class (Table 3).

4-Kurtosis:

Data of kurtosis (Table 3), which measures the ratio of sorting in the extreme of the distribution compared with the sorting in the central part, showed that soils of Wadi El-Natrun have three clusters of kurtosis: the first is lepto-, very lepto- and extremely leptokurtic in soils of profiles 6, 8, 11 & 12 and the deepest layer of profile 7, the deepest layers of profile 9, deepest layer of profile 10 and upper most surface layers of profile 13 which reveal to a very high energy environment and very low modification of grain size. The second cluster is mesokurtic in upper two surface layers of profiles 7 and 9 and the surface layer of profile 10. The third cluster is platykurtic in the deepest layer of profile 13.

Mesokurtic and platykurtic classes both indicate that the sediments have very low energy environment and very high modification of grain size.

II-Depositional Environments:

Applying the discriminate function of Sahu (1964), Table (4) reveals that the parent materials of soils of Wadi El-Natrun unit are mainly deposited by fluvial deltaic deposition for the 35 – 95 cm layer of profile 9 and the deepest layer of profile 11 which are formed shallows agitated marine deposition.

III-Hydro-dynamic conditions:

The C-M pattern data illustrated in Fig. (2) and Table (5), show that the mechanism of transportation of soils of Wadi El-Natrun were three characteristic types of transportation. The first and the main type exists in most layers of profiles 8, 10, 11 and 12, deepest layer of profile 6, surface and deepest layer of profile 7, two deepest layers of profile 9 and surface layer of profile 13which belongs to (N-O) segments indicating transportation by rolling. The second cluster is rolling and suspension mechanism (O-P) the surface layer of profile 6, subsurface layer of profiles 7 & 13 and uppermost surface layers of profile 9, while the third cluster is observed in thedeepest layer of profile 13, which is related to suspension and rolling mechanism (P-Q).

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دراسات على نمط ترسيب التربة فى بعض أراضي غرب دلتا النيل- مصر

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الملخص العربي

تهدف الدراسة الحالية إلى التمييز بين مختلف بيئات الترسيب وطبيعتها وميكانيكياتها وكدلك مختلف الظروف الهيدر وديناميكية، في بعض أراضي غرب دلتا النيل بمصر، التي تتميز بوجود وحدتين فيزيوجرافيتين رئيسيتين هما الشرفات النهرية مختلفة الأعمار، والوحدة المعقدة لوادي النطرون.

وقد أوضحت الدراسة أن أراضي غرب دلتا النيلعلى وجه العموم ذات قيم وسيط median (M_d) بين رمل خشن ورمل خشن جدا. بينما كان المتوسط البياني average size (M_z) يتبع الترتيب : الرمل الخشن > الرمل المتوسط> الرمل الناعم، كما سادت قيم معامل الفرز sorting ما بين الرديئة والرديئة جداً عدا أراضي الرمال الريحية فقد أظهرت أنها ذات قيم معامل فرز متوسطة الجودة إلى متوسطة moderately sorted و moderately well sorted، بينما كانت قيم مقياس التناسق skewness تميل إلى أن تتراوح بين positive و very positive والذي يشير إلى توزيع ذو ذيل من الحبيبات الناعمة ، بينما دل مقياس التفرطح (الانبعاج) Kurtosis على سيادة قيم lepto (مدبب) و very leptokurtic (مدببجدا).

وقد أكدت دراسة بيئة الترسيب Dposition environment على سيادة البيئة الدلتاوية Fluvial (deltaic) بينما أشارت دراسة الظروف الهيدروديناميكية hydrodynamic إلى أن ميكانيكية الترسيب كانت الدحرجة rolling بالإضافة إلى الدحرجة مع المعلق rolling & suspension.