4 – RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

4.1. Main soil characteristics:

The morphological properties of soil profiles could be taken as indications of the physio-chemical processes that might have taken place. They could also reveal to the types of parent materials, the mode of deposition and the nature of soil forming factors that dominated during the period of profile developments. Morphological properties could, therefore, be taken not only as criteria for profile differentia, but also as a basis for soil classification. Chemical and physical analyses emphasize field observations and change it to numerical values, which facilitate categorizing each property. The following is the main soil characteristics.

4.1.1. Physical properties:

4.1.1.1. Particle size distribution:

The mechanical composition of the studied soil profiles (Table, 2) shows that sand fraction is the dominant constituent and varies between 87.18 and 95.71%, while clay and silt fractions are trace constituents. Clay content ranges between 1.09 and 5.49% and the silt content ranges between 2.51 and 7.9%, on the other hand, gravel contents differ between 5.03 and 68.38%.

The texture class of the representative soil profiles ranges between slightly gravelly loamy sand and extremely gravelly sand, except the surface layer of profile 4, which is loamy sand.

4.1.1.2. Soil bulk density:

It varies between 1.69 and 1.94 $g.cm^{-3}$, and it tends to increase with depth in soils of profiles 4, 5, 7, 9, 13 and 15 (Table, 2). Data of bulk density appear positive and significant correlation with both sand and gravel contents and other trend, negative and significant correlation with both clay and silt contents (Table, 3).

Table (2): Some soil physical properties of the studied soil samples.

Prof. No	Depth (cm)	Gravel (%)	Particle size distribution % sand	silt	clay	Texture class	Moisture tension (by weight) % Saturation	0.1 bar	0.33 bar	15 bar	A.M	B.D. g.cm^{-3}	H.C. cm.h^{-1}	IR cm.h^{-1}
1	0 - 25	6.24	90.29	6.46	3.25	SI.G.S	18.64	8.81	7.71	3.66	5.15	1.77	10.90	10.70
	25 - 80	5.44	93.41	2.83	3.76	SI.G.S	19.32	8.85	7.49	3.69	5.16	1.76	10.80	
	80 - 150	5.76	89.34	7.90	2.76	SI.G.S	17.78	8.71	7.50	3.62	5.09	1.79	11.50	
2	0 - 20	9.06	89.56	6.78	3.47	SI.G.S	19.32	8.87	7.37	3.69	5.18	1.76	10.30	11.20
	20 - 65	8.00	89.25	7.06	3.69	SI.G.S	19.43	9.66	8.03	3.72	5.94	1.75	9.86	
	65 - 150	5.47	89.66	7.26	3.12	SI.G.S	18.54	8.76	7.14	3.65	5.11	1.78	10.90	
3	0 - 20	5.14	92.60	5.06	2.35	SI.G.S	17.03	7.85	6.92	2.86	4.99	1.82	13.70	18.90
	20 - 110	5.25	89.14	6.78	4.08	SI.G.S	20.23	9.76	8.58	3.76	6.00	1.73	9.18	
	110 - 150	5.08	89.35	6.92	3.73	SI.G.S	19.22	8.92	8.19	3.67	5.25	1.78	8.82	
4	0 - 60	5.33	87.18	7.33	5.49	SI.G.LS	21.30	10.76	9.93	4.62	6.14	1.69	6.84	5.20
	60 - 150	6.05	88.10	6.80	5.10	SI.G.LS	21.18	10.71	9.80	4.59	6.12	1.70	7.47	
5	0 - 30	9.06	90.03	5.84	4.13	SI.G.S	20.23	9.76	8.65	3.76	6.00	1.73	9.30	4.70
	30 - 70	6.41	91.87	6.37	1.77	SI.G.S	16.13	7.68	6.67	2.80	4.88	1.86	14.40	
	70 - 150	7.60	95.65	2.72	1.63	SI.G.S	15.43	6.92	6.08	2.08	4.84	1.88	17.30	
6	0 - 20	8.28	90.47	7.40	2.13	SI.G.S	16.94	7.81	6.54	2.85	4.96	1.83	13.00	19.80
	20 - 40	6.64	94.46	3.33	2.21	SI.G.S	16.85	7.06	6.21	2.82	4.24	1.84	15.00	
	40 - 70	8.52	93.72	3.67	2.66	SI.G.S	17.68	7.90	6.68	2.87	5.03	1.81	13.60	
	70 - 150	16.04	91.79	5.10	3.11	G.S	18.54	8.76	7.23	3.65	5.11	1.78	11.70	
7	0 - 25	5.03	89.08	7.52	3.40	SI.G.S	19.32	8.87	7.24	3.69	5.18	1.76	10.30	9.80
	25 - 75	9.00	90.82	5.88	3.30	SI.G.S	18.64	8.81	7.12	3.67	5.14	1.77	11.00	
	75 - 105	15.10	92.95	4.23	2.82	G.S	17.78	7.94	6.36	2.89	5.05	1.80	12.80	
	105 - 150	16.14	89.17	5.73	5.10	G.LS	22.35	9.95	8.79	4.59	5.36	1.70	7.63	
8	0 - 30	6.79	93.09	4.87	2.04	SI.G.S	16.30	7.77	6.50	2.82	4.95	1.84	14.60	28.40
	30 - 50	8.88	89.92	6.84	3.24	SI.G.S	18.64	8.81	7.49	3.67	5.14	1.77	10.80	
	50 - 80	12.12	89.19	6.97	3.84	SI.G.S	19.54	9.71	8.67	3.73	5.98	1.74	9.59	
	80 - 150	17.88	88.06	7.73	4.21	G.LS	20.23	9.76	8.49	3.76	6.00	1.73	8.75	
9	0 - 10	5.57	89.55	7.02	3.43	SI.G.S	19.32	8.87	7.61	3.69	5.18	1.76	10.40	10.30
	10 - 45	9.12	95.00	3.00	2.00	SI.G.S	16.22	7.03	5.97	2.81	4.22	1.85	15.90	
	45 - 150	42.32	95.63	3.28	1.09	V.G.S	13.92	6.03	5.29	2.02	4.01	1.94	18.30	
10	0-30	8.62	89.84	6.91	3.25	SI.G.S	18.64	8.81	7.64	3.67	5.14	1.77	10.80	12.10
	30-65	52.23	95.71	2.51	1.78	V.G.S	15.51	6.96	5.98	2.78	4.18	1.87	17.00	
	65-150	53.44	93.55	2.62	3.83	V.G.S	19.43	8.92	7.88	3.72	5.20	1.75	10.70	
11	0 - 40	6.61	91.34	7.04	1.62	SI.G.S	15.51	7.64	6.88	2.78	4.86	1.87	14.30	27.80
	40 - 70	12.35	89.77	6.21	4.02	SI.G.S	19.54	9.71	8.44	3.73	6.98	1.74	9.43	
	70 - 150	48.58	91.14	5.54	3.32	V.G.S	18.64	8.81	7.57	3.67	5.14	1.77	11.00	
12	0 - 15	18.55	90.03	7.43	2.54	G.S	17.68	8.62	7.68	2.87	5.75	1.81	12.10	20.90
	15 - 35	20.15	90.32	6.22	3.46	G.S	19.32	8.87	7.76	3.69	5.18	1.77	10.50	
	35 - 150	13.98	90.28	6.04	3.68	SI.G.S	19.43	8.92	8.10	3.72	5.20	1.75	10.10	
13	0 - 20	33.89	92.77	4.14	3.10	G.S	17.34	7.57	6.94	3.09	4.48	1.78	12.10	21.30
	20 - 65	32.09	93.62	3.18	3.20	G.S	18.54	8.04	7.01	3.65	4.39	1.78	12.20	
	65 - 150	24.89	95.66	3.05	1.35	G.S	14.66	6.81	6.06	2.28	4.53	1.91	16.20	
14	0 - 30	5.34	91.48	5.32	3.20	SI.G.S	18.54	8.76	7.96	3.65	5.11	1.78	11.40	18.80
	30 - 60	34.78	93.09	3.80	3.11	G.S	18.54	8.03	7.23	3.65	4.38	1.78	12.20	
	60 - 150	37.13	89.43	6.34	4.23	V.G.S	20.23	9.28	8.35	3.76	5.52	1.73	9.00	
15	0 - 20	54.98	92.57	4.39	3.04	V.G.S	18.54	8.03	6.72	2.93	5.10	1.78	12.10	17.90
	20 - 45	39.86	92.32	6.68	3.00	V.G.S	18.44	8.00	7.05	2.90	5.10	1.79	12.10	
	45 - 150	12.82	95.00	3.34	1.66	SI.G.S	15.43	6.92	6.15	2.77	4.15	1.88	16.70	
16	0 - 20	60.32	95.13	3.37	1.50	Ex.G.S	15.34	6.88	5.85	2.07	4.81	1.89	17.20	26.80
	20 - 45	68.38	92.17	4.99	2.84	Ex.G.S	17.88	8.00	7.05	2.90	5.10	1.79	12.40	

SI = Slightly V = Very Ex = Extremely G = Gravel S = Sand LS= Lomy s

A.M = Available n B.D = Bulk densit H.C. = Hydraulic c = Infiltration

Table (3) :Direct and joint effects of soil variables and some physical properties.

Soil Variables	Coefficient of determination							
	Sat.	0.1 bar	0.33 bar	15 bar	AM %	HC	IR	B.D
Sand	-0.800**	-0.890**	-0.850**	-0.790**	-0.820**	0.891**	0.786**	0.802**
Silt	0.521**	0.657**	0.609**	0.526**	0.674**	-0.660**	-0.480**	-0.530**
Clay	0.970**	0.933**	0.925**	0.920**	0.763**	-0.950**	-0.870**	-0.970**
Gravel	-0.230	-0.330*	-0.280*	-0.320*	-0.280*	0.286*	0.387**	0.280*
O.M	0.060	-0.040	-0.070	-0.070	-0.010	-0.010	0.213	0.044
CaCO3	0.054	-0.060	0.004	-0.020	-0.100	-0.020	0.298*	-0.040
B.D	-0.980*	-0.940*	-0.900*	-0.930*	-0.760*	0.967*	0.910*	
H.C	-0.960*	-0.960*	-0.930*	-0.930*	-0.810*		0.903*	0.967*
I.R	-0.940*	-0.870*	-0.760*	-0.870*	-0.660*	0.903*		0.910*
Sat.		0.937*	0.900*	0.928*	0.761*	-0.960*	-0.940*	-0.980*
0.1 bar	0.937*		0.965*	0.918*	0.895*	-0.960*	-0.870*	-0.940*
0.33 bar	0.900*	0.965*		0.890*	0.859*	-0.930*	-0.760*	-0.900*
15 bar	0.928*	0.918*	0.890*		0.643*	-0.930*	-0.870*	-0.930*
A.M	0.761*	0.895*	0.859*	0.643*		-0.810*	-0.660*	-0.760*

* significant at 5% (r =0.279)
** significant at 1% (r = 0.361)

4.1.1.3. Soil hydraulic conductivity:

It had been carried out in the samples of the studied soil profiles and illustrated in Table (2). These values vary from 6.84 to 18.30 cm.h^{-1}, which reveal a moderately rapid to rapid according to **USDA (1993).** It tends to increase with depth affecting with soil components in profiles 4, 5, 9, 13 and 15, where, sand increase with depth with an decreasing in silt and clay contents in soil profiles 4,5,9 and 15, while gravel increase with depth in soil profile 13, on the other hand, it decreases with depth affecting with soil load in profiles 3, 8 and 12, while the other soil profiles have no specific trend.

Data of the statistical analysis between values of hydraulic conductivity and soil components and properties (Table, 3) show that there are a positive and significant correlation with sand, gravel and bulk density and opposite trend, negative and significant with both silt and clay.

4.1.1.4. Infiltration rate:

Infiltration rate was measured for the surface layers of the profiles under study and its data illustrated in Table (2). The values of infiltration rate changed widely from 4.7 to 28.4 cm.h^{-1}, which indicate a range between moderately and very rapid classes according **USDA (1951)**, which reflect the effect of soil compaction, load or soil texture.

Data of the statistical analysis Table (3) show that the infiltration rate have a positive and significant correlation with each of sand, bulk density and hydraulic conductivity, while a negative and significant correlation is found with each of silt, clay and moisture contents at saturation, field capacity, moisture at .33 bar, wilting point and available moisture range.

4.1.1.5. The moisture contents and its constants:

Data of saturation status, which are recorded in Table (2) vary between 13.92 and 22.35% per weight. These values increase with depth in soil profiles 8, 12, 14 and 16, while an opposite trend is true in soil profiles 4, 5, 9 and 15. The relationship between saturation condition and both silt and clay contents shows a positive and significant correlation, an opposite trend is true with sand and bulk density, Table (3).

Values of soil moisture content at 0.33 bar (in Table, 2) range between 5.29 and 9.93% and increase with depth in profiles 12 and 16, whereas these values appear an opposite trend in profiles 4, 5 and 9. Statistical data (Table, 3) show a positive and significant correlation between moisture contents at 0.33 bar and both silt and clay contents, while a negative and significant correlation with each of sand, gravel and bulk density are occurred.

Data of moisture constants at field capacity (F.C.), wilting point (W.P.) and available moisture (A.M.) for the different studied soil profiles layers are illustrated in Table (2). Values of field capacity at 0.1 bar range between 6.03 and 10.76% and tend to decrease with depth in soil profiles 4, 5, 9, 13 and 15, while an opposite trend is noticed in soil profiles 8 and 12. Data of field capacity show negative and significant correlation with each of sand, gravel and bulk density, and positive and significant correlation with both of clay and silt, Table (3).

Values of wilting point (at 15 bar) vary between 2.02 and 4.62 %, and tend to decrease with depth through different layers of profiles 4, 5, 13 and 15, while soil profiles 8, 12,14 and 16 appear an opposite trend. With regard to the factors which effect on the wilting point values, data show that there are negative and significant correlation with each of sand, gravel and bulk density, the reverse is true for silt and clay (Table, 3).

Data of available moisture, which calculated from the difference between field capacity and wilting point, are very low may be due to the coarse texture of the studied soil profiles. Available moisture contents vary between 4.01 and 6.14% and have negative and significant correlation with each of sand, gravel and bulk density, while an opposite trend is noticed with both silt and clay (Table, 3).

4.1.1.6. Pore size distribution:

Total porosity is the volume of pores and is expressed as a percentage of soil volume. Pore size distribution is classified according to **Deleenheer and De Boodt (1965) and Kohnke (1968)** into the following four main classes: -

1. Quickly drainable (macro-pores) > 28.8 μ.
2. Slowly drainable (meso-pores) 8.62 – 28.8 μ.
3. Water holding (micro-pores) 0.19 – 8.62 μ.
4. Fine capillary (hydration-pores) < 0.19 μ.

Data of pore size distribution of the soils under consideration are found in Table (4). Quickly drainable pores, which are responsible for air voids, vary between 14.7169 and 21.0800%. It appears a decrease with depth in soil profiles 4, 9 and 15 and an opposite trend is noticed in soil profiles 3, 8, 11, 12, 14 and 16, while the other soil profiles have no specific trend. Values of slowly drainable pores change between 1.1214 and 2.9913%. These values tend to decrease with depth in soil profiles 5, 9, 10, 15 and 16, and an opposite trend is found in soil profiles 2, 4, 14 and 16 and there is no trend in the other soil profiles.

Data of water holding pores range from 3.990 to 8.9739 % and do not appear a specific trend. Values of fine capillary or hydration water pores range between 3.9104 and 7.8078 %. These values tend to decrease with depth in soil profiles 4, 5 and 9, and an opposite trend is observed in soil profiles 3, 8, 11, 12, 14 and 16, with no specific trend with the rest.

Finally, data of pore size distribution clear that quickly drainable pores are the predominant ones as a reflection of coarse texture, followed with water holding pores or fine capillary pores, while slowly drainable pores are the lowest.

4.1.2. Chemical properties:

4.1.2.1. Soil pH:

Table (5) shows that the soil pH varies widely along the studied soil profiles, as it ranges from 7.5 (slightly alkaline) to 8.4 (alkaline). These values are considered high if it compare with the ionic balance, which may be due to the effect of silicate contents in siliceous soils.

Table (4):Pore Size Distribution of the studied soil.

Prof. No	Depth (cm)	Pore Size Distribution %			
		Q.D	S.D	W.H	F.C.P
1	0-25	17.3991	1.9470	7.1685	6.4782
	25-80	18.4272	2.3936	6.6880	6.4944
	80-150	16.2353	2.1659	6.9452	6.4798
2	0-20	18.3920	2.6400	6.4768	6.4944
	20-65	17.0975	2.8525	7.5425	6.5100
	65-150	17.4084	2.8836	6.2122	6.4970
3	0-20	16.7076	1.6926	7.3892	5.2052
	20-110	18.1131	2.0414	8.3386	6.5048
	110-150	18.3340	1.2994	8.0456	6.5326
4	0-60	17.8126	1.4027	8.9739	7.8078
	60-150	17.7990	1.5470	8.8570	7.8030
5	0-30	18.1131	1.9203	8.4597	6.5048
	30-70	15.7170	1.8786	7.1982	5.2080
	70-150	15.9988	1.5792	7.5200	3.9104
6	0-20	16.7079	2.3241	6.7527	5.2155
	20-40	18.0136	1.5640	6.2376	5.1888
	40-70	17.7018	2.2082	6.8961	5.1947
	70-150	17.4084	2.7234	6.3724	6.4970
7	0-25	18.3920	2.8688	6.2480	6.4944
	25-75	17.3991	2.9913	6.1065	6.4959
	75-105	17.7120	2.8440	6.2460	5.2020
	105-150	21.0800	1.9720	7.1400	7.8030
8	0-30	15.6952	2.3368	6.7712	5.1888
	30-50	17.3991	2.3364	6.7614	6.4959
	50-80	17.1042	1.8096	8.5956	6.4902
	80-150	18.1131	2.1971	8.1829	6.5048

Q.D = Quikly Drainable (macro pores) > 28.8 μ
S.D = Slowly Drainable (meso pores) 8.62 - 28.8 μ
W.H = Water Holding (micro pores) 0.19 - 8.26 μ
F.C.P=Fine Capillary pores (hydration water pores) < 0.19 μ

Table (4): Cont.

Prof. No	Depth (cm)	Pore Size Distribution %			
		Q.D	S.D	W.H	F.C.P
9	0-10	18.3920	2.2176	5.8460	6.4944
	10-45	17.0015	1.9610	6.3438	5.1985
	45-150	15.3066	1.4356	7.0269	3.9188
10	0-65	17.3991	2.0709	5.9840	6.4959
	65-110	15.9885	1.8326	7.2800	5.1986
	110-150	18.3925	1.8200	7.6670	6.5100
11	0-40	14.7169	1.4212	8.1954	5.1986
	40-70	17.1042	2.2098	6.9030	6.4902
	70-150	17.3991	2.1948	8.7061	6.4959
12	0-15	16.3986	1.7014	7.1632	5.1947
	15-35	18.3920	1.9536	7.6650	6.4944
	35-150	18.3925	1.4350	6.8530	6.6100
13	0-20	17.3906	1.1214	5.9808	5.5002
	20-65	18.6900	1.8334	7.2198	6.4970
	65-150	14.9935	1.4325	7.6718	4.3548
14	0-30	17.4084	1.4240	6.3724	6.4970
	30-60	18.7078	1.4240	7.9407	6.4970
	60-150	18.9435	1.6089	6.7462	6.5048
15	0-20	18.7078	2.3318	7.4285	5.2154
	20-45	18.6876	1.7005	6.3544	5.1910
	45-150	15.9988	1.4476	7.1442	5.2076
16	0-20	15.9894	1.9467	7.4285	3.9123
	20-45	17.6852	1.7005	3.9900	5.1910

Q.D = Quikly Drainable (macro pores) $> 28.8\ \mu$

S.D = Slowly Drainable (meso pores) $8.62 - 28.8\ \mu$

W.H = Water Holding (micro pores) $0.19 - 8.26\ \mu$

F.C.P=Fine Capillary pores (hydration water pores) $< 0.19\ \mu$

Table (5): Some Chemical properties of the studied area.

Prof. No	Depth (cm)	pH	Ec (dSm^{-1})	Soluble Anions $mel.L^{-1}$				Soluble Cations $mei.L^{-1}$				$CaCO_3$ (%)	Gypsum (%)	O.M (%)	ESP
				CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}				
1	0-25	8.0	0.74	0.00	0.50	2.50	5.00	3.40	1.70	2.70	0.20	0.90	1.18	0.07	1.219
	25-80	8.3	0.53	0.00	1.00	2.00	2.75	1.90	1.80	1.80	0.25	1.50	1.19	0.06	0.747
	80-150	8.4	0.68	0.00	1.00	1.50	4.75	2.90	1.70	2.50	0.15	1.70	1.20	0.01	1.16
2	0-20	8.0	0.69	0.00	1.50	1.00	4.75	2.40	1.50	3.00	0.35	1.55	1.00	0.05	1.865
	20-68	8.2	1.40	0.00	2.00	7.00	6.00	5.30	3.20	5.70	0.80	1.85	1.12	0.03	2.744
	65-150	8.3	1.18	0.00	1.50	3.00	8.06	4.90	2.50	4.70	0.46	1.85	1.11	0.02	2.3
3	0-20	8.0	0.47	0.00	1.50	2.50	0.50	1.80	1.10	1.40	0.20	1.30	1.25	0.06	0.095
	20-110	8.0	0.54	0.00	2.00	3.00	0.10	1.90	1.60	1.50	0.10	1.80	1.19	0.03	0.414
	110-150	8.2	1.20	0.00	2.00	5.50	4.20	4.30	2.50	4.50	0.40	1.70	1.22	0.04	2.314
4	0-60	8.3	0.59	0.00	1.00	3.00	2.25	2.90	1.70	1.50	0.15	1.10	1.34	0.04	0.195
	60-150	8.4	1.20	0.00	1.00	5.00	6.75	3.40	1.70	7.40	0.25	0.90	1.16	0.02	5.267
5	0-30	8.2	0.90	0.00	1.50	3.30	4.40	2.90	2.00	4.00	0.30	2.80	1.17	0.03	2.449
	30-70	8.3	0.80	0.00	3.00	4.00	1.60	1.70	2.40	4.20	0.30	2.20	1.22	0.01	3.739
	70-150	8.3	1.30	0.00	3.00	7.00	3.23	3.90	2.80	6.13	0.40	2.20	1.13	0.02	3.526
6	0-20	7.7	0.90	0.00	1.50	3.00	4.70	3.60	2.30	3.00	0.30	2.00	1.15	0.05	1.299
	20-40	7.9	0.70	0.00	1.00	3.00	3.51	2.20	0.71	4.40	0.20	2.60	1.12	0.02	3.968
	40-70	7.7	3.10	0.00	1.50	13.00	17.60	6.90	3.30	21.50	0.40	1.70	1.12	0.02	11.334
	70-150	8.0	6.00	0.00	3.00	35.00	23.00	30.50	4.10	26.00	0.40	6.40	1.10	0.04	7.371
7	0-25	8.4	0.73	0.00	0.80	3.00	4.10	2.80	2.40	2.50	0.20	1.30	1.22	0.06	1.017
	25-75	8.3	1.20	0.00	1.40	5.00	5.80	2.50	2.40	7.10	0.20	3.10	1.27	0.03	5.153
	75-105	7.7	5.10	0.00	2.20	30.00	23.80	37.10	10.90	7.50	0.50	9.00	1.10	0.04	0.988
	105-150	7.7	5.30	0.00	2.30	34.00	17.70	32.00	9.70	12.00	0.30	6.20	1.08	0.03	2.628
8	0-30	8.2	1.20	0.00	1.00	5.50	5.20	4.30	2.50	4.50	0.40	1.70	1.34	0.04	2.287
	30-50	8.4	0.50	0.00	0.40	3.00	1.90	1.00	0.70	3.40	0.20	3.10	1.23	0.02	4.011
	50-80	8.4	2.70	0.00	2.50	15.00	10.30	9.60	2.00	16.00	0.20	4.40	1.26	0.03	7.872
	80-150	8.1	1.17	0.00	1.00	6.50	4.80	2.90	2.00	6.90	0.50	7.90	1.14	0.01	4.984

Table (5): Cont.

Prof. No	Depth (cm)	pH	Ec (dSm^{-1})	Soluble Anions mel.L^{-1} CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Soluble Cations mei.L^{-1} Ca^{++}	Mg^{++}	Na^+	K^+	$CaCO_3$ (%)	Gypsum (%)	O.M (%)	ESP
9	0-10	8.3	0.88	0.00	0.50	3.50	5.15	4.04	1.09	3.62	0.40	1.10	1.23	0.05	2.428
	10 - 45	8.4	1.16	0.00	0.50	6.00	5.86	4.09	2.02	5.85	0.40	2.85	1.12	0.02	3.213
	45-150	8.0	1.80	0.00	2.10	5.50	11.63	4.00	1.03	13.75	0.45	7.70	1.10	0.03	10.33
10	0 - 30	8.1	1.10	0.00	0.10	2.90	8.20	5.80	2.50	2.55	0.35	0.88	1.16	0.04	0.583
	30 - 65	8.2	1.70	0.00	1.50	11.00	5.65	3.90	1.80	12.20	0.25	0.22	1.15	0.01	9.312
	65 - 150	7.9	0.74	0.00	0.40	2.60	5.01	3.40	1.70	2.71	0.20	9.55	1.10	0.02	1.228
11	0 - 40	8.2	0.80	0.00	0.50	2.50	5.30	2.90	1.70	3.40	0.30	2.80	1.24	0.06	2.006
	40 - 70	8.3	1.00	0.00	0.50	6.00	3.90	2.70	1.80	5.5	0.40	3.10	1.15	0.02	3.985
	70 - 150	7.8	6.19	0.00	0.50	37.00	30.10	33.90	7.80	24.80	1.10	9.20	1.17	0.04	6.322
12	0 - 15	8.0	1.50	0.00	1.00	10.50	4.54	4.80	2.90	8.10	0.24	9.92	1.31	0.05	4.579
	15 - 35	7.5	0.90	0.00	0.50	6.00	3.18	3.40	1.80	4.30	0.18	14.33	1.22	0.04	2.604
	35 - 150	8.0	2.70	0.00	1.50	22.00	4.02	8.80	4.30	14.20	0.22	26.46	1.15	0.01	6.478
13	0 - 20	8.2	1.20	0.00	0.30	4.50	7.10	3.00	1.70	6.40	0.80	5.90	1.12	0.06	4.669
	20 - 65	8.0	6.50	0.00	2.50	25.00	41.50	20.90	2.10	44.50	1.50	5.20	1.17	0.03	13.326
	65 - 150	7.6	10.10	0.00	1.50	90.00	14.40	57.40	3.60	43.20	1.70	10.00	1.16	0.05	9.317
14	0 - 30	8.1	0.86	0.00	0.50	4.50	3.95	3.50	1.10	3.90	0.45	1.97	1.12	0.04	2.47
	30 - 660	8.2	0.81	0.00	0.50	5.50	2.53	2.20	1.50	4.18	0.65	13.07	1.19	0.02	3.169
	60 - 150	7.6	4.45	0.00	2.90	16.00	26.81	12.10	3.11	29.50	1.00	11.10	1.15	0.02	12.629
15	0 - 20	8.0	1.00	0.00	0.70	4.30	5.57	1.90	1.80	6.42	0.45	9.46	1.23	0.05	5.395
	20 - 45	8.1	0.99	0.00	0.20	4.80	5.15	4.00	1.60	4.25	0.30	7.26	1.21	0.01	2.426
	45 - 150	8.1	2.20	0.00	1.50	13.00	8.86	7.70	3.40	11.86	0.40	9.90	1.18	0.02	5.805
16	0 - 20	8.0	0.90	0.00	1.00	3.00	5.22	4.40	2.20	2.00	0.62	12.65	1.30	0.05	0.362
	20 - 45	7.8	3.70	0.00	1.50	19.00	19.44	26.10	6.10	7.10	0.64	18.05	1.28	0.03	1.332

4.1.2.2. Soil salinity:

Data presented in Table (5) indicate that the studied soil profiles vary, considerably with respect to their salinity levels. The relatively high salinity value ($10.1 dSm^{-1}$) is detected in the deepest layer of profile 13, while the lowest one ($0.47 dSm^{-1}$) is found in the surface layer of profile 3. Soil salinity values tend to increase throughout the sequent layers of soil profiles 3,4,6,7,9,11,13,14 and 16. Most of the representative profiles appear non-saline level.

4.1.2.3. Soluble cations and anions:

Table (5) presents the soluble cations and anions composition of the studied soils. It is obvious that Na^+ is the dominant soluble cation in most soil profile layers followed by Ca^{+2} and Mg^{+2}, while K^+ constituents the lowest one. The highest contents of Na^+, Ca^{+2}, Mg^{+2} and K^+ are detected in layers 20-65 cm of profile 13 ($44.5 me.l^{-1}$), 65 – 150 cm of profile 13 ($57.4 me.l^{-1}$), 75-105 cm of profile 7 ($10.9 me.l^{-1}$) and 65-150 cm of profile 13 ($1.7 me.l^{-1}$), respectively, whereas the lowest ones are in layers 0-20 cm of profile 3 ($1.4 me.l^{-1}$), 30-50 cm of profile 8 ($1.0 me.l^{-1}$), 30-50 cm of profile 8 ($0.7 me.l^{-1}$) and 20-110 cm of profile 3 ($0.1 me.l^{-1}$), respectively.

Data of Table (5) show that the distribution of soluble anions is found in the descending order of chloride > sulphate > bicarbonate, where the soluble carbonate is not observed. The higher contents of these anions are recorded in layers 65-150 cm of profile 13 ($90 me.l^{-1}$), 20-65 cm of profile 13 ($41.5 me.l^{-1}$) and deepest layers of profiles 5 and 6 ($3.0 me.l^{-1}$), respectively, while the lowest ones are found in layers 0-20 cm of profile 2 ($1.0 me.l^{-1}$), 20-110 cm of profile 3 ($0.1 me.l^{-1}$) and 0-30 cm of profile 10 ($0.1 me.l^{-1}$), respectively.

4.1.2.4. Total carbonate:

Table (5) includes the values of the total carbonate contents of the studied soil profiles, which vary between 0.22 % in the subsurface layer of profile 10 and 26.46 % in the deepest layer of profile 12. It is clear that soils of profile 12 have the highest content of $CaCO_3$ followed by soils of profile 14, while soils of profile 1 have the lowest one. It is obvious that there is no trend pertaining to either lateral or vertical distribution. These distribution patterns indicate that the studied soil profiles may represent varies degrees of discontinuity.

4.1.2.5. Gypsum content:

Data of gypsum content in the studied soils is illustrated in Table (5), and represents low constituent. Its values range from 1.00 to 1.34%. Soils of profile 8 appear the highest content, while soils of profile 2 have the lowest one.

4.1.2.6. Organic matter:

Table (5) shows that the organic matter content of the different studied soils profiles is very low. It ranges between 0.01 and 0.07 %, may be due to the coarse texture, barren soil conditions, arid condition and high temperature all year. Surface layers of all the representative profiles have the relatively high contents of organic matter and, in general, decrease with depth.

4.1.2.7. Exchangeable sodium percentage:

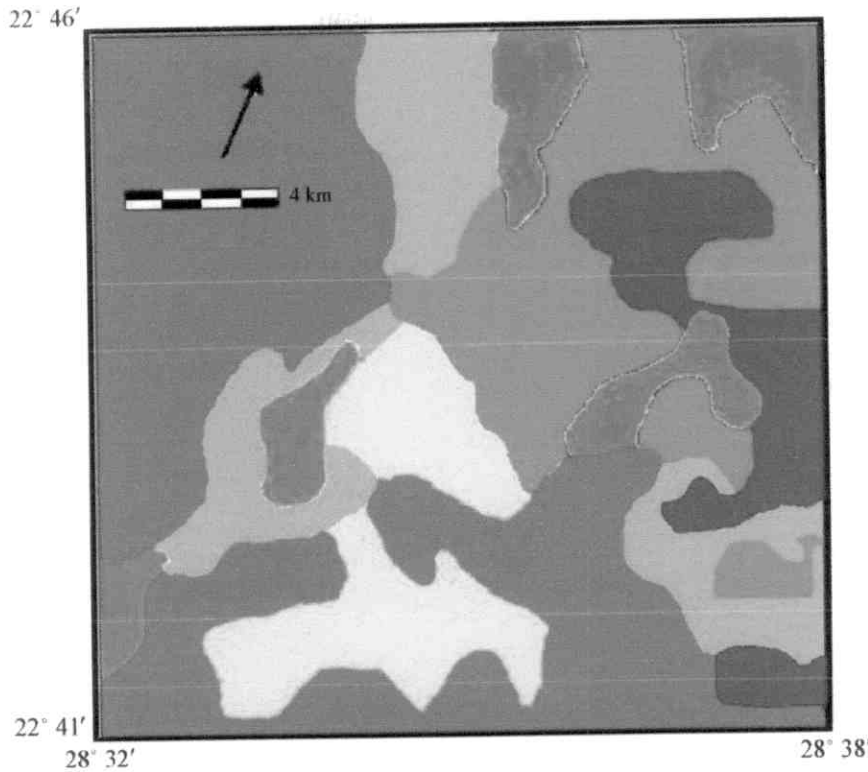
Data of Table (5) show that the values of exchangeable sodium percentage vary widely according to soluble cations distribution and its balance. ESP varies from 0.095 to 13.326%, which indicate that the soils under consideration do not appear alkali effect.

4.2. Taxonomic units:

Field studies observations, physical and chemical properties of the studied area indicate that the soils under investigation can be classified into six taxonomic units (family level), Fig. (7) as follows:

➢ **The first unit:**

It is represented by profiles 1, 2, 3, 4 and 5. Field observations show that topography is almost flat, soil profiles depth is very deep, and the surface layers have yellow colour, while the subsurface ones appear pale brown as predominance. Soil texture is slightly gravelly sand in all representative profiles, except profile 4 that has slightly gravelly loamy sand, single grain structure in their surface layers and massive in the subsurface ones. Soil consistence through the studied profiles is non-sticky, non-plastic (wet), loose (moist), and very friable



Typic Torripsamments, very deep, siliceous, hyperthermic.

Typic Torriorthents, sandy, very deep, mixed, hyperthermic.

Typic Torriorthents, sandy skeletal, very deep, mixed, calcareous, hyperthermic.

Typic Haplocalcids, sandy, very deep, mixed, calcareous, hyperthermic.

Typic Haplocalcids, sandy skeletal, very deep, mixed, hyperthermic.

Typic Haplocalcids, sandy skeletal, shallow, mixed, calcareous, hyperthermic.

Fig. (7): Taxonomic units of the studied area

(dry), except few layers show soft. Gravel contents are common and vary from 5.08 to 9.06 %. Effervescence show slightly calcareous, where total carbonate ranges between 0.9 and 2.8 %. Gypsum contents in this unit range between 1.0 and 1.34%. Organic matter contents range between 0.01 and 0.07%. Soil salinity is non-saline, where EC_e ranges between 0.53 and 1.40 dSm^{-1} Values of pH in this unit ranges between 8 and 8.4. Exchangeable sodium percentage is very low and ranges between 0.095 and 5.267%, so, the soil under consideration is non-sodic.

The following is the field description of the representative soil profiles.

Profile Number: 1

Location : East El-Oweinat

(Longitude 28° 32' 09", latitude 22° 43' 45")

Topography : Almost flat

Slope : Less than 2.0 %.

Elevation : 264.6 m a.s.l.

Parent material: Sandstone

Surface stones : Not stony

Vegetation : Barren

Water table : Not observed

Depth (cm)	Description
0 – 25	Yellow (10 YR 7/6) dry, pale brown (10 YR 6/3) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; gradual smooth boundary.
25 – 80	Pale brown (10 YR 7/5) dry, pale brown (10 YR 6/3) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; clear smooth boundary.
80 – 150	Very pale brown (10 YR 7/4) dry, light yellowish brown (10 YR 6/4) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common fine gravels; slightly calcareous.

Profile Number: 2

Location	: East El-Oweinat (Longitude $28^{O}32^{\backslash}45^{\backslash\backslash}$, latitude $22^{O}45^{\backslash}15^{\backslash\backslash}$)
Topography	: Almost flat
Slope	: Less than 2.0 %.
Elevation	: 262.9 m a.s.l
Parent material	: Sandstone
Surface stones	: Not stony
Vegetation	: Barren
Water table	: Not observed

Depth (cm)	Description
0 – 20	Yellow (10 YR 7/6) dry, light yellowish brown (10 YR 6/4) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; clear smooth boundary.
20 – 65	Brownish yellow (10 YR 6/6) dry, yellowish brown (10 YR 5/6) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common fine gravels; slightly calcareous; clear smooth boundary.
65 – 150	Very pale brown (10 YR 7/4) dry, light yellowish brown (10 YR 6/4) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common fine gravels; slightly calcareous.

Profile Number: 3

Location	: East El-Oweinat (Longitude 28° 33' 03", latitude 22° 42' 15")
Topography	: Almost flat
Slope	: Less than 2.0 %.
Elevation	: 266.9 m a.s.l.
Parent material	: Sandstone
Surface stones	: Not stony
Vegetation	: Barren
Water table	: Not observed

Depth (cm)	Description
0 – 20	Yellow (10 YR 7/6) dry, yellowish brown (10 YR 5/4) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); few fine gravels; slightly calcareous; clear smooth boundary
20 – 110	Yellow (10 YR 7/6) dry, yellowish brown (10 YR 5/4) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common fine gravels; slightly calcareous; abrupt wavy boundary.
110 – 150	Light gray (10 YR 7/2) dry, light yellowish brown (10 YR 6/4) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common medium angular gravels; very few fine soft lime; slightly calcareous.

Profile Number: 4

Location	: East El-Oweinat
	(Longitude 28^{O} 33$^{\backslash}$ 39$^{\backslash\backslash}$, latitude 22^{O} 44$^{\backslash}$ 45$^{\backslash\backslash}$)
Topography	: Almost flat
Slope	: Less than 2.0 %.
Elevation	: 262.9 m a.s.l.
Parent material	: Sandstone
Surface stones	: Not stony
Vegetation	: Barren
Water table	: Not observed

Depth (cm)	Description
0 – 60	Yellow (10 YR 7/6) dry, yellowish brown (10 YR 5/6) moist; slightly gravelly loamy sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; clear smooth boundary.
60 – 150	Brownish yellow (10 YR 6/6) dry, yellowish brown (10 YR 5/8) moist; slightly gravelly loamy sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common fine gravels; slightly calcareous.

Profile Number: 5

Location : East El-Oweinat

(Longitude 28^{O} 35$^{\backslash}$ 45$^{\backslash\backslash}$, latitude 22^{O} 42$^{\backslash}$ 15$^{\backslash\backslash}$)

Topography : Almost flat

Slope : Less than 2.0 %.

Elevation : 264.3 m a.s.l.

Parent material : Sandstone

Surface stones : Not stony

Vegetation : Barren

Water table : Not observed

Depth (cm)	Description
0 – 30	Yellow (10 YR 8/8) dry, brownish yellow (10 YR 6/6) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; clear wavy boundary.
30 – 70	Brownish yellow (10 YR 6/6) dry, yellowish brown (10 YR 5/8) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), friable (moist), soft (dry); common very fine gravels; slightly calcareous; clear wavy boundary.
70 – 150	Very pale brown (10 YR 7/4) dry, pale brown (10 YR 6/3) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous.

The investigated soil profiles of this unit have no evidence of profile development, i.e., gravel contents were less than 35%, and have no diagnostic horizons within the control section or lithic or paralithic contact within 50 cm of the surface. Therefore, these soils fit to the order "Entisols" according to the **USDA (1999)**, and sub order "Psamments". The climatic data (Table 1) show that the soil moisture regime is usually dry most of years in all parts of soil layers, so, these soils fit to great group "Torripsamments". Since these soils did not have any lithic or paralithic contact within 50 cm of the surface, they would fit to subgroup "Typic Torripsamments". In sequence, this unit is classified up to the family level " Typic Torripsamments, very deep, siliceous, hyperthermic".

- **The second unit:**

It is represented by profiles 6, 7 and 8, and almost characterized as the previous one, but the texture is gravelly sand in the deepest layer of profile 6 and gravelly loamy sand in deepest layer of profiles 7 and 8. The gravel content ranges between 5.03 and 17.88%. Effervescence tends to be slightlly calcareous, while the deepest layers of soils vary between calcareous and strongly calcareous, where total carbonate ranges from 1.3 to 9.0% without appearing either calcic or petrocalcic horizons. Gypsum content in these soils range between 1.08 and 1.34%. On the other hand, organic matter content appears as very low constituents (0.01- 0.06%). Soil salinity of the studied soils of this unit varies from 0.5 to 6.0 dSm^{-1}. Values of pH in the soils of this unit range between 7.7 and 8.4. Exchangeable sodium percentage varies from 0.988 to 11.334 %, so, the soils of this unit tend to be non- alkaline soils.

The field description of the representative soil profiles are given hereafter:

Profile Number: 6

Location : East El-Oweinat

(Longitude 28° 33' 03'', latitude 22° 41' 15'')

Topography : Almost flat

Slope : Less than 2.0 %.

Elevation : 268.8 m a.s.l.

Parent material : Sandstone

Surface stones : Not stony

Vegetation : Barren

Water table : Not observed

Depth (cm)	Description
0 – 20	Yellow (10 YR 7/6) dry, brownish yellow (10 YR 6/6) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common very fine gravels; slightly calcareous; clear wavy boundary.
20 – 40	Yellow (10 YR 7/6) dry, brownish yellow (10 YR 6/6) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), loose (moist), loose (dry); common very fine gravels; slightly calcareous; clear smooth boundary.
40 – 70	Brownish yellow (10 YR 6/6) dry, yellowish brown (10 YR 5/6) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common few very fine gravels; slightly calcareous; clear smooth boundary.
70 – 150	Light gray (10 YR 7/2) dry, light yellowish brown (10 YR 6/4) moist; gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); many gravels; few lime segregation; calcareous.

Profile Number: 7

Location	: East El-Oweinat (Longitude $28^{O} 34' 33''$, latitude $22^{O} 43' 15''$)
Topography	: Almost flat
Slope	: Less than 2.0 %.
Elevation	: 264.1 m a.s.l.
Parent material	: Sandstone
Surface stones	: Not stony
Vegetation	: Barren
Water table	: Not observed

Depth (cm)	Description
0 – 25	Yellow (10 YR 7/6) dry, light yellowish brown (10 YR 6/4) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; clear wavy boundary.
25 – 75	Brownish yellow (10 YR 6/6) dry, yellowish brown (10 YR 5/6) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common very fine gravels; very few soft lime; slightly calcareous; clear smooth boundary.
75 – 105	Light gray (10 YR 7/2) dry, light yellowish brown (10 YR 6/4) moist; gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); many gravels; few lime segregation; strongly calcareous; clear smooth boundary.
105 – 150	Light gray (10 YR 7/2) dry, light yellowish brown (10 YR 6/4) moist; gravelly loamy sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); many fine rock fragments, many gravels; few lime segregation; strongly calcareous.

Profile Number: 8

Location	: East El-Oweinat (Longitude $28^{O} 34' 51''$, latitude $22^{O} 41' 45''$)
Topography	: Almost flat
Slope	: Less than 2.0 %.
Elevation	: 266.0 m a.s.l.
Parent material	: Sandstone
Surface stones	: Not stony
Vegetation	: Barren
Water table	: Not observed

Depth (cm)	Description
0 – 30	Yellow (10 YR 7/6) dry, light yellowish brown (10 YR 6/4) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; clear wavy boundary.
30 – 50	Brownish yellow (10 YR 6/6) dry, yellowish brown (10 YR 5/6) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common fine gravels; few lime segregation and concretions; slightly calcareous; clear wavy boundary.
50 – 80	Light gray (10 YR 7/2) dry, light yellowish brown (10 YR 6/4) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common fine gravels; moderate lime segregation and concretions; calcareous; gradual smooth boundary.
80 – 150	Light gray (10 YR 7/2) dry, light yellowish brown (10 YR 6/4) moist; gravelly loamy sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); many fine rock fragments, many gravels; few lime segregation and concretions; strongly calcareous.

The previous information reveal that the soils of this unit is classified as: "Typic Torriorthents, sandy, very deep, mixed, hypothermic" according to Soil Taxonomy of the **USDA (1999).**

➢ **The third unit:**

It is represented by soil profiles 9, 10 and 11, which have the same features of the two previous units, except the texture is very gravelly sand in the deepest layers. Gravel content ranges between 5.57 and 53.44 %, and effervescence is few in the most profile layers of this unit. Total carbonate content varies from 0.22 to 9.55 % and tends to increase with depth in profiles 9 and 11. Secondary carbonate is few. Gypsum contents are low and range from 1.10 to 1.24 %, with decreasing trend with depth in profiles 9 and 10. Organic matter contents is very low and ranges 0.01- 0.06 %, with no trend with depth. Soil salinity varies from 0.74 to 6.19 dSm^{-1}, with increasing trend with depth in profiles 9 and 11. Values of pH range between 7.8 and 8.4. Exchangeable sodium percentage varies from 0.583 to 10.33 %, thus the soils of this unit tend to be non- alkaline.

The field description of the representative soil profiles are given hereafter:

Profile Number: 9

Location	: East El-Oweinat (Longitude $28^{O} 33' 03''$, latitude $22^{O} 42' 45''$)
Topography	: Almost flat
Slope	: Less than 2.0 %.
Elevation	: 264.3 m a.s.l.
Parent material	: Sandstone
Surface stones	: Not stony
Vegetation	: Barren
Water table	: Not observed

Depth (cm)	Description
0 – 10	Yellow (10 YR 7/6) dry, brownish yellow (10 YR 6/6) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common very fine gravels; slightly calcareous; clear smooth boundary.
10 – 45	Brownish yellow (10 YR 6/6) dry, yellowish brown (10 YR 5/8) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), friable (moist), soft (dry); few very fine gravels; slightly calcareous; clear smooth boundary.
45 – 150	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; very gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); abundant fine to medium rock fragments; few lime segregation and concretions; calcareous.

Profile Number: 10

Location : East El-Oweinat
(Longitude $28^{O} 34^{\backslash} 33^{\backslash\backslash}$, latitude $22^{O} 44^{\backslash} 45^{\backslash\backslash}$)

Topography : Almost flat

Slope : Less than 2.0 %.

Elevation : 262.1 m a.s.l.

Parent material: Sandstone

Surface stones : Not stony

Vegetation : Barren

Water table : Not observed

Depth (cm)	Description
0 – 30	Yellow (10 YR 7/6) dry, brownish yellow (10 YR 6/6) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; clear smooth boundary.
30 – 65	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; very gravelly sand; massive; non sticky, non plastic (wet), firm (moist), hard (dry); abundant fine to medium rock fragments; many soft lime concretions; strongly calcareous; gradual wavy boundary.
65 – 150	Very pale brown (10 YR 7/3) dry, pale brown (10 YR 6/3) moist; very gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); abundant fine to medium rock fragments; few lime segregation and concretions; calcareous.

Profile Number: 11,

Location : East El-Oweinat

(Longitude 28° 36' 57", latitude 22° 41' 45")

Topography : Almost flat

Slope : Less than 2.0 %.

Elevation : 263.5 m a.s.l.

Parent material: Sandstone

Surface stones : Not stony

Vegetation : Barren

Water table : Not observed

Depth (cm)	Description
0 – 40	Yellow (10 YR 7/6) dry, brownish yellow (10 YR 6/6) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels; slightly calcareous; clear smooth boundary.
40 – 70	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); common fine gravels; very few lime segregation and concretions; slightly calcareous; gradual wavy boundary.
70 – 150	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; very gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); abundant fine to medium gravels and rock fragments; few lime segregation and concretions; strongly calcareous.

According to Soil Taxonomy of the **USDA (1999),** soils of this unit could be classified as: "Typic Torriorthents, sandy skeletal, very deep, mixed, calcareous, hyperthermic".

➤ **The fourth unit:**

It is represented by profiles 12 and 13. Soil colour of the surface layers is around reddish yellow and brownish yellow, while it is light gray in the subsurface ones. Soil texture is slightly gravelly sand to gravelly sand. Gravels are many in the representative profiles, except the deepest layer of profile 12. its values range between 13.98 and 33.89 %, with an increasing trend with depth in soils of profile 13. Soil profile layers of this unit are strongly calcareous except the surface layer of profile 13. which is calcareous. Content of total carbonate varies from 5.20 to 26.46 %, with an increasing trend with depth in profile 12. The field description reveal that $CaCO_3$ content and features are enough for forming of calcic horizon within the control section. Gypsum content ranges between 1.12 and 1.31 %: with decreasing trend with depth in profile 12. Organic matter content is very low and ranges between 0.01- 0.06 %. It tends to decrease with depth in profile 12. Soil salinity varies from 0.9 to 10.1 dSm^{-1} with an increasing trend with depth in profile 13. Values of pH range between 7.5 and 8.2. Exchangeable sodium percentage varies from 2.604 to 13.326 %, and has no specific trend with depth.

The field description of the representative soil profiles are given hereafter:

Profile Number: 12

Location : East El-Oweinat

(Longitude 28° 37' 15'', latitude 22° 43' 45'')

Topography : Almost flat

Slope : Less than 2.0 %.

Elevation : 260.5 m a.s.l.

Parent material: Sandstone

Surface stones : Not stony

Vegetation : Barren

Water table : Not observed

Depth (cm)	Description
0 – 15	Reddish yellow (10 YR 7/6) dry, brownish yellow (10 YR 6/6) moist; gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); many fine gravels; few lime segregation and concretions, strongly calcareous; clear smooth boundary.
15 – 35	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); many fine gravel and rock fragments; moderate lime segregation; strongly calcareous; clear wavy boundary.
35 – 150	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), firm (moist), hard (dry); common fine gravels; many lime segregation and concretions; strongly calcareous.

Profile Number: 13

Location : East El-Oweinat
(Longitude $28^{O} 37^{\backslash} 15^{\backslash\backslash}$, latitude $22^{O} 42^{\backslash} 15^{\backslash\backslash}$)

Topography : Almost flat

Slope : Less than 2.0 %.

Elevation : 264.0 m a.s.l.

Parent material: Sandstone

Surface stones : Not stony

Vegetation : Barren

Water table : Not observed

Depth (cm)	Description
0 – 20	Brownish yellow (10 YR 6/6) dry, brownish yellow (10 YR 6/6) moist; gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); many different sizes of rock fragments; few lime segregation, calcareous; clear wavy boundary.
20 – 65	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); many fine to coarse rock fragments; moderate lime segregation and concretions; strongly calcareous; clear wavy boundary.
65 – 150	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; gravelly sand; massive; non sticky, non plastic (wet), friable (moist), hard (dry); many fine to coarse rock fragments; moderate lime segregation and concretions; strongly calcareous.

The representative soil profiles show that soils of this unit are classified as " Typic Haplocalcids, sandy, very deep, *mixed*, calcareous, hyperthermic", according to Soil Taxonomy of the **USDA (1999).**

➢ **The fifth unit:**

It is represented by profiles 14 and 15. Soil colour of the surface layer is brownish yellow and in the subsurface ones is pale brown while it is light gray in the deepest layers. The soil texture in this unit is slightly gravelly sand underlain gravelly sand and very gravelly sand in profile 14, while profile 15 appears the opposite sequence i.e. very gravelly underlain slightly gravelly sand. Gravel content in the soils of this unit ranges between 5.34 and 54.98 %, with an increasing trend with depth in profile 14, the opposite trend is true for profile 15. Effervescence is strongly calcareous except the surface layer of profile 14 is slightly calcareous. Total carbonate content varies from 1.97 to 13.07 %, with no trend with depth. Data show that the presence of calcic horizon is more related with the secondary carbonate accumulations. Gypsum content ranges between 1.12 and 1.23 %, with decreasing trend with depth in profile 15. Organic matter content ranges between 0.01 and 0.05 %. Soil salinity varies from 0.81 to 4.45 dS m^{-1}. Values of pH range between 7.6 and 8.2, and the exchangeable sodium percentage varies from 2.426 to 12.629 %.

The field description of the representative soil profiles are given hereafter:

Profile Number: 14

Location	: East El-Oweinat (Longitude $28^{O} 36^{\backslash} 03^{\backslash\backslash}$, latitude $22^{O} 44^{\backslash} 15^{\backslash\backslash}$)
Topography	: Almost flat
Slope	: Less than 2.0 %.
Elevation	: 264.0 m a.s.l.
Parent material	: Sandstone
Surface stones	: Not stony
Vegetation	: Barren
Water table	: Not observed

Depth (cm)	Description
0 – 30	Brownish yellow (10 YR 6/6) dry, brownish yellow (10 YR 6/6) moist; slightly gravelly sand; single grain; non sticky, non plastic (wet), loose (moist), loose (dry); common fine gravels slightly calcareous; clear smooth boundary.
30 – 60	Very pale brown (10 YR 7/3) dry, pale brown (10 YR 6/3) moist; gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), slightly hard (dry); many fine to course rock fragments; many lime segregation and concretions; strongly calcareous; gradual wavy boundary.
60 – 150	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; very gravelly sand; massive; non sticky, non plastic (wet), firm (moist), hard (dry); abundant fine to coarse rock fragments and gravels; many lime segregation and concretions; strongly calcareous.

Profile Number: 15

Location	: East El-Oweinat (Longitude $28^{o}37^{\prime}33^{\prime\prime}$, latitude $22^{o}44^{\prime}15^{\prime\prime}$)
Topography	: Almost flat
Slope	: Less than 2.0 %.
Elevation	: 259.0 m a.s.l.
Parent material	: Sandstone
Surface stones	: Not stony
Vegetation	: Barren
Water table	: Not observed

Depth (cm)	Description
0 – 20	Brownish yellow (10 YR 6/6) dry, brownish yellow (10 YR 6/6) moist; very gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); abundant fine to coarse rock fragments; few lime segregation; strongly calcareous; clear wavy boundary.
20 – 45	Very pale brown (10 YR 7/3) dry, pale brown (10 YR 6/3) moist; very gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); abundant fine to coarse rock fragments; moderate lime segregations; strongly calcareous; clear wavy boundary.
45 – 150	Light gray (10 YR 7/2) dry, pale brown (10 YR 6/3) moist; slightly gravelly sand; massive; non sticky, non plastic (wet), friable (moist), hard (dry); common fine gravels; moderate lime segregation; strongly calcareous.

Soil classification of this unit according to **USDA (1999)** is " Typic Haplocalcids, sandy skeletal, very deep, mixed, calcareous, hyperthermic"

➤ **The six unit:**

Soil colour of the representative profile 16 is pale brown in the surface layer and yellow in its subsurface one. Soil texture is extremely gravelly sand, where gravel content is 60.30 % in the surface layer and 68.38 % in the subsurface one. Effervescence is calcareous in the surface layer, while the subsurface one appears strongly calcareous, where total carbonate in the surface and subsurface layers are 12.65 and 18.05 %, respectively mostly found in moderate segregation and concretion features and closely related the presence of calcic horizon. Total carbonate content increases with depth. Gypsum content is 1.30 and 1.28 % in the surface and subsurface layers, respectively, with decreasing trend with depth. Organic matter contents are 0.05 and 0.03 % in the surface and subsurface layers, respectively, with decreasing trend with depth. Soil salinity values are 0.90 and 3.70 dSm^{-1}, in surface and subsurface layers, respectively, with increasing trend with depth. Values of pH are 8.0 in the surface layer and 7.8 in the subsurface one. Exchangeable sodium percentage is 0.362 and 1.332. in the surface and subsurface layers, respectively.

The field description of the representative soil profile is given hereafter:

Profile Number: 16

Location : East El-Oweinat

(Longitude 28° 35' 27'', latitude 22° 45' 15'')

Topography : Almost flat

Slope : Less than 2.0 %.

Elevation : 261.1 m a.s.l

Parent material : Sandstone

Surface stones : Not stony

Vegetation : Barren

Water table : Not observed

Depth (cm)	Description
0 – 20	Pale brown (10 YR 6/3) dry, pale brown (10 YR 6/3) moist; extremely gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), soft (dry); dominant fine to coarse rock fragments; moderate soft lime; calcareous; abrupt smooth boundary.
20 – 45	Yellow (10 YR 8/8) dry, pale brown (10 YR 6/3) moist; extremely gravelly sand; massive; non sticky, non plastic (wet), very friable (moist), hard (dry); dominant fine to coarse rock fragments; moderate lime segregation and concretions; strongly calcareous; clear wavy boundary.
45 -	Rocky.

The soils of this unit are classified according to **USDA (1999)** as " Lithic Haplocalcids, sandy skeletal, shallow, mixed, calcareous, hyperthermic"

4.3. Micronutrients:

Contents of total and available micronutrients depend on the parent materials, weathering processes and degree of leaching. Iron, manganese, zinc and copper are more abundant micronutrients in soils, so, they are discussed as follows:

4.3.1. Total contents of the micronutrients:

➢ **Iron (Fe):**

Data in Table (6) show that the total iron content in soils of the first unit vary between 5185.7 mg kg^{-1} in the subsurface layer (25-80 cm) of profile 1 and 14804.4 mg kg^{-1} in the surface layer (0-60 cm) of profile 4. The vertical distribution pattern of total iron contents tends to decrease with depth in soil of profiles 4 and 5. The statistical weighted mean (W), trend (T) and specific range (R) of iron are illustrated in Table (7). Values of (W) range between 6345.9 and 13695.5 mg kg^{-1} in profiles 1and 4, respectively. Values of trend parameter (T) in soil profiles 1 and 4 indicate more symmetry and are probably determined as such by pedogenic processes as by the original concentration in the parent material (-0.071 and -0.075, respectively) than in profiles 2, 3 and 5, which have trend values 0.282, 0.204 and -0.244, respectively. Values of specific range parameter (R) in this unit vary between 0.142 and 0.451, which indicate that the soil parent material in these profiles is formed of homogeneous materials.

Total iron contents in soils of the second unit vary between 8063.4 mg kg^{-1} in a layer 75-105 cm of profile 7 and 12869.5 mg kg^{-1} in the deepest layer 105-150 cm of the same profile. The total iron contents tend to increase with depth in profile 8, whereas there are no trend in the other soil profiles 6 and 7. Values of weighted mean (W), which illustrated in Table (7) ranges between 10118.5 mg kg^{-1} in profile 7 and 11331.6 mg kg^{-1} in profile 8. Values of trend parameter (T) in soil profiles of this unit are -0.144, -0.061 and 0.061 for profiles 6,7 and 8 , respectively, which indicate that more symmetry. Values of specific range parameter (R) in this unit range from 0.089 to 0.475, which indicate that the soil parent material tends to be homogeneous.

Table (6): Total contents of some micronutrients in the studied soils.

Tax. Unit	Prof. No.	Depth (cm.)	Fe (mg.kg^{-1})	Mn (mg.kg-1)	Zn (mg.kg-1)	Cu (mg.kg-1)
I	1	0-25	6831.9	74.4	62.9	14.2
		25-80	5185.7	70.1	52.2	7.9
		80-150	7083.9	88.5	67.7	10.2
	2	0-20	7156.5	81.1	75.2	14.9
		20-65	11240.4	86.5	83.5	17.2
		65-150	9952.7	83.4	78.3	15.6
	3	0-20	7825.8	69.3	68.1	7.5
		20-110	11121.3	83.4	114.2	17.4
		110-150	7948.5	77.5	103.1	10.4
	4	0-60	14804.4	160.5	119.4	24.6
		60-150	12956.2	152.9	117.5	23.3
	5	0-30	12756.2	175.5	89.3	16.9
		30-70	9792.9	93.8	87.8	14.9
		70-150	8402.3	75.3	84.3	12.9
II	6	0-20	12840.4	68.3	102.2	12.6
		20-40	9567.8	60.9	90.2	16.3
		40-70	9714.5	61.3	96.5	18.8
		70-150	11358.7	63.5	98.5	11.8
	7	0-25	10773.9	64.9	92.4	19.8
		25-75	8547.9	58.2	85.2	12.8
		75-105	8063.4	53.3	84.8	9.9
		105-150	12869.5	60.2	89.5	17.9
	8	0-30	10638.8	81.3	76.2	12.3
		30-50	10962.7	82.2	79.4	16.9
		50-80	11605.9	89.8	82.6	18.6
		80-150	11616.3	100.2	94.7	24.1
III	9	0-10	11207.6	77.3	72.4	17.7
		10-45	9665.2	70.3	68.2	14.7
		45-150	8843.1	68.2	56.3	8.7
	10	0-30	11052.9	119.6	89.8	23.1
		30-65	9211.7	63.3	66.3	11.8
		65-150	8820.8	86.8	86.2	15.9
	11	0-40	9359.4	80.3	84.1	17.6
		40-70	11488.5	132.6	98.6	20.7
		70-150	9860.8	92.9	92.6	20.0
IV	12	0-15	8792.5	84.7	113.4	25.4
		15-35	8442.2	60.2	52.1	14.4
		35-150	8593.9	72.1	93.7	15.8
	13	0-20	8809.9	59.2	96.8	27.5
		20-65	7743.4	53.9	89.0	22.3
		65-150	5283.6	38.3	81.1	16.3
V	14	0-30	10886.2	88.3	95.3	14.3
		30-60	7735.9	75.4	86.8	12.3
		60-150	11954.5	159.3	98.8	16.9
	15	0-20	11146.3	46.3	82.6	12.8
		20-45	11447.2	48.9	88.7	14.3
		45-150	9689.2	43.2	71.2	8.7
VI	16	0-20	9754.9	83.3	58.2	12.9
		20-45	16488.7	92.3	72.3	15.7

Table (7): Weighted mean (W), Trend (T) and Specific range (R) of total micronutrientsin the studied soils.

Tax. Unit	Prof. No.	Iron			Manganese			Zinc			Copper		
		W	T	R	W	T	R	W	T	R	W	T	R
I	1	6345.9	0.071	0.299	79.4	0.063	0.189	61.2	-0.027	0.253	14.7	0.034	0.837
	2	9966.2	0.282	0.410	84.0	0.035	0.064	79.4	0.053	0.104	15.9	0.068	0.144
	3	9835.8	0.204	0.335	79.9	0.133	0.176	105.1	0.352	0.439	14.2	0.472	0.718
	4	13695.5	-0.075	0.142	155.9	-0.028	0.049	118.3	-0.010	0.016	23.8	-0.032	0.055
	5	9643.9	-0.244	0.451	100.3	-0.441	0.999	86.2	-0.034	0.058	14.2	-0.158	0.281
II	6	10988.6	-0.144	0.298	63.4	-0.085	0.132	97.5	-0.046	0.151	13.9	0.097	0.504
	7	10118.5	-0.061	0.475	58.9	-0.092	0.197	87.6	-0.052	0.087	14.9	0.375	0.664
	8	11331.6	0.061	0.089	91.9	0.116	0.206	86.5	0.119	0.214	19.7	-0.247	0.600
III	9	9192.6	-0.180	0.257	74.4	-0.037	0.122	60.2	-0.169	0.268	10.7	-0.394	0.838
	10	9358.4	-0.153	0.239	93.9	-0.214	0.599	81.8	-0.089	0.287	17.8	0.264	0.635
	11	9946.0	0.059	0.214	97.5	0.176	0.537	91.5	0.081	0.158	19.5	0.097	0.159
IV	12	8593.5	-0.023	0.041	71.8	-0.153	0.341	86.5	-0.237	0.708	16.6	-0.348	0.664
	13	6491.7	-0.263	0.543	45.8	-0.360	0.552	85.6	-0.116	0.183	19.6	-0.288	0.701
V	14	10897.1	0.001	0.387	128.3	0.312	0.654	95.7	0.004	0.125	15.4	0.075	0.298
	15	10176.5	-0.087	0.173	44.6	-0.038	0.128	75.6	-0.084	0.231	10.2	-0.205	0.550
VI	16	13495.9	0.277	0.499	88.3	0.057	0.102	66.0	0.119	0.214	14.5	0.108	0.194

As for the third unit, the total iron contents change from 8820.8 mg kg^{-1} in the deepest layer (65-150 cm) of profile 10 to 11488.5 mg kg^{-1} in the subsurface layer (40-70 cm) of profile 11. The total iron contents tend to decrease with depth in soils of profiles 9 and 10, whereas there is no trend in the different layers of profile 11. Values of weighted mean (W) (Table 7) range between 9192.6 mg kg^{-1} in profile 9 and 9946.0 mg kg^{-1} in profile 11. Values of trend parameter (T) indicate that the soil under consideration have values between -0.180 and 0.059, which appear symmetrical distribution. Values of specific range parameter (R) in this unit are between 0.214 and 0.257, which indicate that these profiles were formed of a uniform parent material or to the mild effect of the pedogenic processes.

With regard to the fourth unit, the total iron contents range between 5283.6 mg kg^{-1} in the deepest layer (65-150 cm) of profile 13 and 8809.9 mg kg^{-1} in the surface layer (0-20 cm) of the same profile. The total iron contents tend to decrease with depth in soils of profile 13, whereas there was no trend in profile 12. Values of weighted mean (W) as illustrated in Table (7) are 8593.5 mg kg-1 in profile 12 and 6491.7 mg kg-1 in profile 13. Values of trend parameter (T) in soil profile 12 and 13 are -0.023 and -0.263, respectively, which indicated that soil of profile 12 is more symmetrical than in profile 13. Values of specific range parameter (R) in this unit are 0.041 in profile 12 and 0.543 in profile 13, which indicate that soils of this unit is composed of heterogeneous materials.

For the fifth unit, the total iron contents range between 7735.9 mg kg^{-1} in the subsurface layer (30-60 cm) of profile 14 and 11954.5 mg kg^{-1} in the deepest layer (60-150 cm) of the same profile. The total iron contents of this unit have no trend with depth in the representative profile. Values of weighted mean (W) which illustrate in Table (7) are 10897.1 mg kg^{-1} in profile 14 and 10176.5 mg kg^{-1} in profile 15. Values of trend parameter (T) in soil profiles 14 and 15 are 0.001 and -0.087, respectively, which indicated that the soil of profile 14 was more symmetrical than profile 15. Values of specific range parameter (R) in this unit are 0.387 in profile 14 and 0.173 in profile 15, which indicate that the soil under consideration of this unit derives from uniform parent material.

Soils of the sixth unit appear that the total iron contents are 9754.9 mg kg^{-1} in the surface layer (0-20 cm) of the representative profile 16 and 16488.7 mg kg^{-1} in the subsurface layer (20-45 cm) of the same profile. Concentration of total iron contents tends to increase with depth in this unit. Value of weighted mean (W) as illustrated in Table (7) is 13495.9 mg kg^{-1}, trend parameter (T) is 0.227 and specific range (R) is 0.499, which reveals to weak symmetry and tend to be homogenous.

Further information about the relationship between total iron content and some soil variables such as soil mechanical fractions and lime contents is elucidated by using the correlation coefficients in Table (8), which is conducted to substantiate the role of these constituents on controlling total iron contents. The obtained coefficients show positive significant correlation between total iron contents and each of silt, clay and silt+clay, i.e., 0.372^{**}, 0.399^{**} and 0.440^{**}, respectively. In contrast, there is a significant and negative correlation between total iron content and sand contents (-0.428^{**}). These findings are in close agreement with those of **El-Gundy et al. (1990)**.

- **Manganese (Mn):**

Soils of the first unit appear that the total Mn contents range widely from 69.3 mg kg^{-1} in the surface layer (0-20 cm) of profile 3 to 175.5 mg kg^{-1} in the surface layer (0-30 cm) of profile 5. The vertical distribution pattern of the total manganese contents tends to decrease with depth in soil layers of profiles 4 and 5, while the total manganese contents do not portray any specific pattern with depth in profiles 1, 2 and 3. Values of weighted mean (W), which illustrated in Table (7), range between 79.4 mg kg-1 in profile 1 and 155.9 mg kg^{-1} in profile 4, with particular distribution pattern for the soil profiles of this unit, except in profiles 4 and 5. Values of trend parameter (T) in soils range between –0.441 and 0.133, which indicated more symmetry in profile 1,2 and 4. Values of specific range parameter (R) in profiles 1, 2, 3 and 4 in this unit range

Table (8): Direct and joint effects of some soil variables on some total micronutrients of the studied soil profiles.

Variables	Coefficient of determination			
	Fe	Mn	Zn	Cu
Sand	-0.428**	-0.542**	-0.478**	-0.503**
Silt	0.372**	0.403**	0.383**	0.422**
Clay	0.399**	0.538**	0.477**	0.445**
Silt + Clay	0.440**	0.522**	0.482**	0.496**
$CaCO_3$ %	-0.105	-0.198	0.011	-0.039

* significant at 5% (r =0.279)

** significant at 1% (r = 0.361)

profile 11. Values of trend parameter (T) are 0.081 and -0.089 in the soil profiles 11 and 10, respectively. These values indicated more symmetry than in profile 9, which has trend value equal to -0.169. Values of specific range parameter (R) in this unit range between 0.158 and 0.287, which indicate homogeneity of the parent materials in the soil of this unit for zinc contents.

For the fourth unit, the total zinc contents range between 52.1 mg kg^{-1} in the subsurface layer (15-35 cm) of profile 12 and 113.4 mg kg^{-1} in the surface layer (0-15 cm) of the same profile. The total zinc content tends to decrease with depth in soils of profile 13, whereas there is no specific trend in the soil profile 12. Values of weighted mean (W), as illustrated in Table (7), are 85.6 mg kg^{-1} in profile 13 and 86.5 mg kg^{-1} in profile 12. The trend parameter values (T) in soil profiles of this unit are -0.116 in profile 13 and -0.237 in profile 12, which indicate that profile 13 was more symmetrical than profile 12. Values of specific range parameter (R) in this unit are 0.183 in profile 13 and 0.708 in profile 12, which indicate that the parent materials of this soils are homogeneous and heterogeneous, respectively for their contents of its total zinc.

Data of the total zinc contents in the fifth unit range between 71.2 mg kg^{-1} in the layer (45-150 cm) of profile 15 and 98.8 mg kg^{-1} in the deepest layer (60-150 cm) of profile 14. The total zinc contents in soils of this unit have no specific trend with depth. Values of weighted mean (W), as illustrated in Table (7), are 75.6 mg kg^{-1} in profile 15 and 95.7 mg kg^{-1} in profile 14. Values of trend parameter (T) in soil profiles of this unit are –0.084 in profile 15 and 0.004 in profile 14, which indicate that these profiles have a highly symmetrical phase. Values of specific range parameter (R) in this unit are 0.125 and 0.231 in soil profiles 14 and 15, respectively, which indicate that these soil profiles are composed of homogeneous soil materials.

For the sixth unit, the total zinc contents are 58.2 mg kg^{-1} in the surface layer (0-20 cm) and 72.3 mg kg^{-1} in the subsurface layer (20-45 cm) of the representative profile. The content of the total zinc content tends to increase with depth.

(1971), **Ahmed (1979), El Nennah et. al. (1982)** and **Awadalla et. al.(1982).**

➢ **Zinc (Zn):**

Soils of the first unit appear that the total zinc contents range widely from 52.2 mg kg^{-1} in the subsurface layer (25-80 cm) of profile 1 to 119.4 mg kg^{-1}in the surface layer (0-60 cm) of profile 4. The vertical distribution pattern of the total zinc contents tends to decrease with depth in soil layers of profiles 4 and 5, while the total zinc contents do not portray any specific pattern with depth in profiles 1,2 and 3. Values of weighted mean (W), which illustrated in Table (7), range between 61.2 mg kg^{-1} in profile 1 and 118.3 mg kg`1in profile 4. Values of trend parameter (T) in the soil profiles of this unit range between -0.010 and 0.053 which indicate more symmetry with exception of profile 3 which has trend value 0.352. Values of specific range parameter (R) in this unit range between 0.016 and 0.439, which indicate that the soil parent materials in this unit form from homogeneous materials.

For the second unit, the total zinc contents vary from 76.2 mg kg^{-1} in the surface layer (0-30 cm) of profile 8 to 102.2 mg kg^{-1} in the surface layer (0-20 cm) of profile 6. The total zinc contents tend to increase with depth in soils of profile 8, while other profiles have no specific trend. Values of weighted mean (W), as illustrated in Table (7), range between 86.5 mg kg^{-1} in profile 8 and 97.500 mg kg^{-1} in profile 6. Values of trend parameter (T) in soil profiles of this unit are between -0.046 and 0.119, which indicate symmetry distribution. Values of specific range parameter (R) in this unit range from 0.087 in profile 7 to 0.214 in profile8,which indicate the soil parent material tend to be homogeneous.

The total zinc contents in the third unit vary from 56.3 mg kg^{-1} in the deepest layer (45-150 cm) of profile 9 to 98.6 mg kg^{-1} in the subsurface layer (40-70 cm) of profile 11. The total zinc contents tend to decrease with depth in soils of profile 9, whereas there are no specific trend in the other soil profiles 10 and 11. Values of weighted mean (W), as illustrated in Table (7), range.between 60.2 mg kg^{-1} in profile 9 and 91.5 mg kg^{-1} in profiles 12 and 13 are -0.153 and -0.360, respectively, which indicated that the soil of profile 12 is more symmetrical than in soil profile 13. Values of specific range parameter (R) in this unit are 0.341 in profile 12 and 0.552 in profile 13, which indicate that these soils are formed from homogeneous materials.

The fifth unit appears that the total manganese contents range between 43.2 mg kg^{-1} in the layer (45-150 cm) of profile 15 and 159.3 mg kg^{-1} in the deepest layer (60-150 cm) of profile 14. The total manganese contents of this unit have no specific trend with depth. Values of weighted mean (W), as illustrated in Table (7), are 44.6 mg kg^{-1} in profile 15 and 128.3 mg kg^{-1} in profile 14. Values of trend parameter (T) in soil profile 14 are 0.312, while it is -0.038 in profile 15. The trend of mean values in soil layers of profile 15 show a highly symmetrical than in profile 14. Values of specific range parameter (R) in this unit are 0.654 in profile 14, which indicate that the parent materials were heterogeneous and 0.128 in profile 15,which indicate that the soil found to be homogeneous, where the value of (R) is less than 0.5.

The total manganese contents in the sixth unit are 83.3 and 92.3 mg kg^{-1} in the surface and subsurface layer of representative profile 16, respectively. Concentration of total Mn content, it tends to increase with depth in the soils of this unit. Value of weighted mean (W), as illustrated in Table (7), is 88.3 mg kg^{-1}. Value of trend parameter (T) in the studied soil profile is 0.057, which indicated high symmetry. Value of specific range parameter (R) in this unit is 0.102, which indicate that these soils have uniform parent material.

The relationships between total manganese content and some soil variables are illustrated in Table (8). These data show a highly significant and positively correlation between total manganese contents and each of silt, clay and silt+clay (0.403^{**}, 0.538^{**} and 0.522^{**}, respectively). In contrast, a significant and negatively correlation is observed between total manganese contents and sand contents (-0.543^{**}). These results are in agreement with **Ghonem et. al. (1971)**, **Metwally et. al.**

between 0.049 and 0.189, which indicate that the soil parent materials in these soils are formed of homogeneous materials, while in profile 5 the value of (R) is 0.999, which indicates the soil parent material is formed of heterogeneous materials.

For the second unit, the total manganese contents vary from 53.3 mg kg^{-1} in the layer (75-105 cm) of profile 7 to 100.2 mg kg^{-1} in the deepest layer (80-150 cm) of profile 8. The total manganese content tends to increase with depth in soils of profile 8. Values of weighted mean (W), as illustrated in Table (7), range between 58.9 mg kg^{-1} in profile 7 and 91.9 mg kg^{-1} in profile 8. Values of trend parameter (T) in soil profiles of this unit are -0.085, -0.092 and 0.116 for profiles 6,7 and 8, respectively, which indicated more symmetry. Values of specific range parameter (R) in this unit range from 0.132 to 0.206, which indicates that the soil parent material is composed of homogeneous materials.

For the soils of third unit, total manganese contents vary from 63.3 mg kg^{-1} in the subsurface layer (30-65 cm) of profile 10 to 132.6 mg kg^{-1} in the subsurface layer (40-70 cm) of profile 11. The total manganese content tends to decrease with depth in soils of profile 9, whereas there is no specific trend in the other soil profiles. Values of weighted mean (W), as illustrated in Table (7), range between 74.4 to 97.5 mg kg^{-1}. Values of trend parameter (T) in soil profiles of this unit range between -0.214 to 0.176, which indicate the soil profile 9 was highly symmetrical than the other soils. Values of specific range parameter (R) in this unit are 0.122, 0.599 and 0.537 in profiles 9,10 and 11, respectively, indicate that the soil of profile 9 is composed of homogeneous soil material, while soils of the rest profiles of the unit composed of heterogeneous materials in manganese.

For the fourth unit, the total manganese contents range between 38.3 mg kg^{-1} in the deepest layer (65-150 cm) of profile 13 and 84.7 mg kg^{-1} in the surface layer (0-15 cm) of profile 12. The total manganese content tends to decrease with depth in soil profile 13. Values of weighted mean (W), as illustrated in Table (7), are 45.8 mg kg^{-1} in profile 13 and 71.8 mg kg^{-1} in profile 12. Values of trend parameter (T) in soil

The weighted mean (W) value is 66.0 mg kg^{-1}, as illustrated in Table (7). Value of trend parameter (T) in the studied soil profile is 0.119, which indicated a symmetrical distribution through the representative profile. The corresponding value of specific range parameter (R) in this unit is 0.214, which indicate homogeneous sediments for the distribution of zinc content.

The relationship between total zinc content and some soil variables are presented in Table (8). It is obvious that total zinc contents appear positive and significant correlation with each of silt, clay and (silt + clay) contents, with r values of 0.384^{**}, 0.477^{**} and 0.482^{**}, respectively. In contrast, there is a significant negative correlation between total zinc contents and sand fraction contents ($r = -0.479^{**}$). These results are agreement with the findings of **Hassan (1979), Orabie et. al. (1981), El-Sayed (1983)** and **Naeem (1996)**. Whereas, there was no correlation between the concentrations between total zinc and total carbonate contents.

- **Copper (Cu):**

Soils of the first unit appear that the total copper contents vary widely from 7.5 mg kg^{-1} in the surface layer (0-20 cm) of profile 3 to 24.6 mg kg^{-1} in the surface layer too (0-60 cm) of profile 4. The vertical distribution pattern of the total copper contents tends to decrease with depth in soil layers of profiles 4 and 5, while other profiles have no any specific pattern with depth. Values of weighted mean (W), which illustrated in Table (7), range from 14.2 mg kg^{-1} in profiles 3 and 5 to 23.8 mg kg^{-1} in profile 4. Values of trend parameter (T) range between -0.158 and 0.068 in soil profiles 1, 2, 4 and 5, which indicate more symmetry than in profile 3 which has trend value equal to 0.472. Values of specific range parameter (R) in this unit vary from 0.055 in soils of profile 4 to 0.281 in profiles 1, 4 and 5, which indicate that the soil parent material in this profile tends to be homogeneous materials. On the other hand, the values of specific range are 0.837 and 0.718 in profiles 1 and 3, respectively, indicate that the soil parent material in these profiles is formed from heterogeneous materials.

As for the second unit, the total copper contents vary from 9.9 mg kg^{-1} in the layer 75-105 cm of profile 7 to 24.1 mg kg^{-1} in the deepest layer (80-150 cm) of profile 8. The total copper contents tend to increase with depth in the soils of profile 8. Values of weighted mean (W), as illustrated in Table (7), range between 13.9 mg kg^{-1} in profile 6 and 19.7 mg kg^{-1} in profile 8. Values of trend parameter (T) in soil profiles of this unit range from -0.247 to 0.375, which indicate that the soil profile 6 is more symmetrical than other profiles. Values of specific range parameter (R) in soils of this unit range from 0.504 to 0.664, which indicate that the soil parent materials are heterogeneous.

As for the third unit, total copper contents vary from 8.7 mg kg^{-1} in the layer (45-150 cm) of profile 9 to 23.1 mg kg^{-1} in the surface layer (0-30 cm) of profile 10. The total copper contents tend to decrease with depth in soils of profile 9, whereas there are no specific trend in the other soil profiles. Values of weighted mean (W), as illustrated in Table (7), range between 10.7 mg kg^{-1} in profile 9 and 19.5 mg kg^{-1} in profile 11. Values of trend parameter (T) in soil profile 11, indicate more symmetry than in profiles 9 and 10, i.e., -0.392 and 0.292, respectively. On the other hand, parameter of specific range of soil profile 11 is 0.160, and indicated a composed of homogeneous soil materials in total copper contents, while in soil profiles 9 and 10, the corresponding values are 0.830, 0.690, respectively and show a composed of heterogeneous soil materials.

With regard to the soils of the fourth unit, total copper contents range between 14.4 mg kg^{-1} in the subsurface layer (15-35 cm) of profile 12 and 27.5 mg kg^{-1} in the surface layer (0-20 cm) of profile 13. The total copper contents tend to decrease with depth in soils of profile 13, whereas, there is no specific trend in soil profile 12. Values of weighted mean (W), which is illustrated in Table (7), are 16.6 mg kg^{-1} in profile 12 and 19.6 mg kg^{-1} in profile 13. Values of trend parameter (T) in soil profile 12 and 13 are -0.347 and -0.287, respectively, and show more symmetrical distribution in soil profile 13 than in profile 12. Values of specific range parameter (R) in this unit are 0.664 and 0.701 in profiles 12 and 13, respectively, which indicate that the soils of this unit are composed of heterogeneous materials.

Concerning the soils of the fifth unit, total copper contents range between 8.7 mg kg^{-1} in the deepest layer (45-150 cm) of profile 15 and 16.9 mg kg^{-1} in the deepest layer (60-150 cm) of profile 14. The total copper contents of this unit have no specific trend with depth. Values of weighted mean (W), as illustrated in Table (7), are 15.4 and 10.2 mg kg^{-1} in profiles 14 and 15, respectively. Values of trend parameter (T) of the representative profiles are 0.075 and -0.205, respectively, which indicate that the total copper content is highly symmetrical in profile 14 than profile 15. Values of specific range parameter (R) in this unit are 0.298 in profile 14 and 0.550 in profile 15, which indicate that soil profile 14 has homogeneous materials in cupper, while soil profile 15 has heterogeneous materials.

The representative profile of the sixth unit appears copper contents of 12.9 mg kg^{-1} in the surface layer (0-20 cm) of profile 16 and 15.7 mg kg^{-1} in the subsurface layer (20-45 cm) of the same profile. Total copper contents tend to increase with depth in this unit. Value of weighted mean (W) is 14.5. Value of trend parameter (T) in the studied soil profile is 0.108, which indicate symmetric distribution. Value of specific range parameter (R) in this unit is 0.194, which indicate homogeneous soil materials in its total copper contents.

The relationship between total copper contents and some soil variables are presented in Table (8). The obtained coefficients show a positive and significant correlation between total copper contents and each of silt, clay and silt + clay, i.e., 0.422^{**}, 0.445^{**} and 0.496^{**}, respectively. In contrast, there is a significant and negative correlation between total copper contents and sand content ($r = -0.503^{**}$). These results were in agreement with **Roszuk (1968), El-Demerdash (1970), El-Sayed (1971), Abdel-Hamid (1981)** and **Barakat (1998).**

4.3.2. Available micronutrients:

Available amounts of four trace elements (Fe, Mn, Zn and Cu) have been estimated for the different studied soil profiles (Table 9).

- **Iron (Fe):**

Soils of the first unit appear that the available iron contents range between 0.12 mg kg-1 in the deepest layer (70–150 cm) of profile 5 and 3.86 mg kg-1 in the surface layer (0–60 cm) of profile 4. The vertical distribution pattern of the available iron contents tends to decrease with depth in soil layers of profiles 4 and 5.

As for the second unit, the available iron contents range between 1.02 mg kg^{-1} in the surface layer (0–20 cm) of profile 6 and 3.32 mg kg^{-1} in the deepest layer (80 – 150 cm) of profile 8. The content of available iron tends to decrease with depth in profile 7, the reverse is true for profile 8.

The soils of third unit have available iron contents range between 0.36 mg kg^{-1} in the deepest layer (45-150 cm) of profile 9 and 2.98 mg kg^{-1} in the subsurface layer (40–70 cm) of profile 11. The content of available iron in this unit tends to decrease with depth in profile 9, while profile 10 shows an opposite trend.

With regard to the fourth unit, the available iron contents range between 0.46 mg kg^{-1} in the subsurface layer (15-35 cm) of profile 12 and 1.68 mg kg^{-1} in the subsurface layer (20-65 cm) of profile 13. Iron contents have, in general, no specific trend with depth.

As for the fifth unit, the available iron content ranges between 0.46 mg kg^{-1} in the subsurface layer (30-60 cm) of profile 14 and 3.74 mg kg^{-1} in the deepest layer (60-150 cm) of the same profile.

Soils of the six unit, which represented by profile 16, appear that the available iron contents range between 0.88 mg kg^{-1} in the surface later (0-20 cm) and 1.44 mg kg^{-1} in its subsurface one (20-45 cm), with increasing trend with depth.

Table (9):Chemically extractable micronutrients in the studied area.

Taxonomic unit	Prof. No.	Depth (cm)	Fe (mg.kg-1)	Mn (mg.kg-1)	Zn (mg.kg-1)	Cu (mg.kg-1)
I	1	0-25	2.44	0.32	0.22	0.10
		25-80	2.52	0.22	0.25	0.18
		80-150	2.38	0.04	0.19	0.06
	2	0-20	1.38	0.22	0.48	0.10
		20-65	1.92	0.10	0.54	0.14
		65-150	1.22	0.08	0.39	0.09
	3	0-20	2.07	0.28	0.12	0.01
		20-110	2.42	0.18	0.66	0.19
		110-150	1.16	0.22	0.52	0.06
	4	0-60	3.86	1.42	1.32	0.41
		60-150	3.65	1.28	1.12	0.38
	5	0-30	2.71	0.20	0.85	0.16
		30-70	0.14	0.03	0.14	0.04
		70-150	0.12	0.01	0.12	0.04
II	6	0-20	1.02	0.08	0.28	0.04
		20-40	2.44	0.36	0.29	0.06
		40-70	1.38	0.44	0.30	0.07
		70-150	1.97	0.32	0.32	0.09
	7	0-25	2.22	1.22	0.40	0.02
		25-75	1.24	1.08	0.24	0.02
		75-105	1.12	1.02	0.28	0.01
		105-150	3.01	1.98	1.08	0.24
	8	0-30	1.68	0.44	0.14	0.04
		30-50	1.94	0.32	0.32	0.10
		50-80	2.74	0.56	0.59	0.16
		80-150	3.32	0.60	0.88	0.20
III	9	0-10	1.98	0.34	0.98	0.13
		10-45	1.48	0.28	0.36	0.08
		45-150	0.36	0.26	0.27	0.02
	10	0-30	0.44	0.48	0.44	0.11
		30-65	2.28	0.08	0.24	0.06
		65-150	2.62	0.26	0.62	0.16
	11	0-40	1.10	0.32	0.24	0.19
		40-70	2.98	0.30	0.80	0.21
		70-150	1.40	0.15	0.73	0.17
IV	12	0-15	0.62	0.32	0.62	0.16
		15-35	0.46	0.26	0.46	0.08
		35-150	0.78	0.46	0.78	0.22
	13	0-20	1.50	0.60	0.50	0.21
		20-65	1.68	0.34	0.68	0.28
		65-150	1.40	0.32	0.21	0.16
V	14	0-30	0.68	0.40	0.68	0.12
		30-60	0.46	0.48	0.46	0.11
		60-150	3.74	0.32	0.92	0.27
	15	0-20	3.52	0.36	0.98	0.16
		20-45	3.32	0.42	0.52	0.13
		45-150	2.98	0.46	0.32	0.07
VI	16	0-20	0.88	0.28	0.29	0.06
		20-45	1.44	0.16	0.33	0.12

A further information about the relationship between the available iron contents and some soil variables i.e., mechanical fractions and total contents, could be elucidated from the correlation coefficients presented in Table (10). The obtained data show a negative significant correlation with sand contents ($r = -0.336^{**}$) and positive significant correlation with clay and total iron content, i.e., $r = 0.567^{**}$ and 0.368^{**}, respectively. These findings were in agreement with **Holah (1977), Abd El Aal (1983), El-Toukhy (1987), Mohamed (1990), El-Shazly et. al. (1991)** and **Naeem (1996).**

According to **Lindsay and Norvell (1978)**, data of available iron appear a deficient level in all layers of studied profiles, except of some profile layers at soil sites 4, 5 and 15, which show a marginal level.

➢ **Manganese (Mn):**

Soils of the first unit appear that the available manganese contents vary from 0.01 mg kg^{-1} in the deepest layer (70-150 cm) of profile 5 to 1.42 mg kg^{-1} in the surface layer (0-60) of profile 4. The vertical distribution pattern of the available manganese contents tends to decrease with depth in profiles 1, 2, 4 and 5.

As for the second unit, the available Mn contents vary from 0.08 mg kg^{-1} in the surface layer (0-20 cm) of profile 6 and 1.98 mg kg^{-1} in the deepest layer (105-150 cm) of profile 7. The Mn contents tend to increase with depth in profile 6, except its deepest layer (70-150 cm), and profile 8, except the surface one (0-30 cm), while it tends to decrease with depth in profile 7, with exception of the deepest layer (105-150 cm).

Concerning the third unit, the available Mn contents range between 0.08 mg kg^{-1} in the subsurface layer (30-65 cm) of profile 10 and 0.48 mg kg^{-1} in the surface layer (0-30 cm) of the same profile. The available Mn contents tend to decrease in profiles 9 and 11.

The soils of fourth unit show available Mn contents range between 0.26 mg kg^{-1} in the subsurface layer (15-35 cm) of profile 12 and 0.60 mg kg^{-1} in the surface layer (0-20 cm) of profile 13. Its content tends to decrease in profile 13.

Table (10): Direct and joint effects of some soil variables on some available micronutrients of the studied soil profiles.

Variables	Coefficient of determination			
(%)	Fe	Mn	Zn	Cu
Sand	-0.336*	-0.331*	-0.576**	-0.436**
Silt	0.164	0.153	0.331*	0.178
Clay	0.567**	0.514**	0.787**	0.718**
Total element	0.368**	0.280*	-0.154	0.006
$CaCO_3$ %	-0.121	0.040	0.199	0.180

* Significant at 0.05 = 0.278

** Significant at 0.01 = 0.361

With respect to the fifth unit, the available Mn contents range between 0.32 mg kg^{-1} in the deepest layer (60-150 cm) of profile 14 and 0.48 mg kg^{-1} in the subsurface layer (30-60 cm) of the same profile. Available Mn tends to increase with depth in profile 15.

As for the six unit, the available Mn content range between 0.16 mg kg^{-1} in the subsurface layer (20-45 cm) of the representative profile 16 and 0.28 mg kg^{-1} in its surface layer with a decreasing trend with depth.

Further information about the relationship between available Mn content and some soil variables illustrated in Table (10) and show that there are a negative significant correlation between available Mn contents and sand contents (-0.331^{*}), a positive significant correlation with clay and total manganese (0.514^{**} and 0.280^{*}). These findings were in agreement with **Ismail (1968), El Damaty et al. (1971), El Laboudi et al. (1971), Ghonem et al. (1971) and Mohamed (1990).**

Available manganese, according to **Lindsay and Norvell (1978)** show a dêficient level in the surface layer of the studied profiles, except surface layer of profiles 4 and 7 which appear adequate level.

- **Zinc (Zn):**

Soils of the first unit appear that the available Zn contents range between 0.12 mg kg^{-1} in both surface layer (0-20 cm) of profile 3 and the deepest one (70-150 cm) of profile 5 and 1.32 mg kg^{-1} in the surface layer (0-60 cm) of profile 4. The vertical distribution pattern of the available Zn contents tends to decrease in profiles 4 and 5.

As for the second unit, the available Zn contents range between 0.14 mg kg^{-1} in the surface layer (0-30 cm) of profile 8 and 1.08 mg kg^{-1} in the deepest layer (105-150 cm) of profile 7. The available zinc contents tend to increase with depth in profiles 6 and 8.

The available Zn contents in the third unit range between 0.24 mg kg^{-1} in both subsurface layer (30-56 cm) of profile 10 and the surface layer (0-40 cm) of profile 11 and 0.98 mg kg^{-1} in the surface layer (0-10 cm) of profile 9. The available Zn contents tend to decrease with depth in profile 9.

The soils of the fourth unit have available Zn contents range between 0.21mg kg^{-1} in the deepest layer (65-150 cm) of the profile 13 and 0.78 mg kg^{-1} in the deepest layer (35-150 cm)of profile 12. The available Zn content has no trend distribution with depth.

Data of the available Zn contents in the fifth unit range between 0.32 mg kg^{-1} in the deepest layer (45-150 cm) of profile 15 and 0.98 mg kg^{-1} in the surface layer (0-20 cm) of the same profile. The available Zn contents in this unit have a decreasing trend in profile 15.

The soils of sixth unit have available Zn contents 0.29 mg kg^{-1} in the surface layer of the representative profile and 0.33 mg kg^{-1} in its subsurface layer with an increasing trend with depth.

The relationships between available Zn contents and some soil variables, i.e., soil mechanical fractions and lime content are presented in Table (10), and appear a negative significant correlation with sand (-0.576^{**}), positive significant correlation with both of clay and silt (0.787^{**}, 0.331^{*}, respectively). These findings were in agreement with **Mohamed (1990).**

Contents of available Zinc of the studied area show a deficient level in the studied profile layers, except of profiles 5,9.12,13,14 and 15 that appear a marginal level, while, surface layer of profile 4 appears adequate level according to **Lindsay and Norvell (1978).**

➢ **Copper (Cu):**

Soils of the first unit appear that the available Cu contents range between 0.01 mg kg^{-1} in the surface layer (0-20 cm) of profile 3 and 0.41 mg kg^{-1} in the surface layer (0-60 cm) of profile 4. The vertical distribution pattern of the available Zn contents tends to decrease in both profiles 4 and 5.

The available Cu contents in the second unit range between 0.01 mg kg^{-1} in the layer 75-105 cm of profile 7 and

0.24 mg kg^{-1} in the deepest layer (105–150 cm) of the same profile.

As for the third unit, the available Cu contents range between 0.02 mg kg^{-1} in the deepest layer (45–150 cm) of profile 9 and 0.21 mg kg^{-1} in the subsurface layer (40-70 cm) of profile 11, with no specific trend with depth.

Soils of the fourth unit show an available Cu content ranges between 0.08 mg. kg^{-1} in the subsurface layer (15-35 cm) of profile 12 and 0.28 mg kg^{-1} in the subsurface layer (20-65 cm) of profile 13, with no specific trend with depth.

Concerning the soils of the fifth unit, the available Cu contents range between 0.07 mg kg^{-1} in the deepest layer (45–150 cm) of profile 15 and 0.27 mg kg^{-1} in the deepest layer (60–150 cm) of profile 14 with decreasing trend in profile 15.

The representative profile of the sixth unit appears that available Cu content is 0.06 mg kg^{-1} in the surface layer and 0.12 mg kg^{-1} in the subsurface one, with increasing trend with depth.

The relationship between available Cu contents and some soil variables are presented in Table (10). The obtained coefficients show a negative and significant correlation with sand (-0.436^{**}), a positive significant correlation with clay (0.718^{**}). These findings are in agreement with **Mitchell (1964), Salama (1981), El Sayed (1983), El-Toukhy (1987) and Naeem (1996).**

According to **Lindsay and Norvell (1978)**, data of available copper appear a deficient level in all profile layers of the studied area, except of some layers of profiles 4 and 13, which show adequate level.

4.3.3 Extractable heavy metals:

Heavy metals are considered an important limiting factor for agriculture utilization, so it must be estimate and evaluate, especially for the soils under study in a virgin nature.

Data in Table (11) show the contents of chemically extractable lead (Pb), nickel (Ni) and cobalt (Co) in the different studied soil profile layers.

Table (11): Chemically extractable of some heavy metals (mg kg^{-1}).

Tax. unit	Prof. No.	Depth (cm)	Pb	Ni	Co
I	1	0-25	0.01	0.22	0.24
		25-80	0.01	0.32	0.22
		80-150	0.02	0.22	0.10
	2	0-20	0.88	0.01	0.01
		20-65	0.72	0.02	0.01
		65-150	0.82	0.08	0.02
	3	0-20	0.10	0.01	0.02
		20-110	0.02	0.04	0.01
		110-150	0.04	0.02	0.01
	4	0-60	0.20	0.08	0.12
		60-150	0.60	0.10	0.16
	5	0-30	0.40	0.54	0.01
		30-70	0.22	0.32	0.02
		70-150	0.12	0.01	0.01
II	6	0-20	0.22	0.02	0.02
		20-40	0.40	0.20	0.10
		40-70	0.01	0.48	0.02
		70-150	0.02	0.32	0.01
	7	0-25	0.30	0.06	0.10
		25-75	0.44	0.10	0.12
		75-105	0.32	0.18	0.16
		105-150	0.23	0.14	0.12
	8	0-30	0.14	0.78	0.11
		30-50	0.22	0.20	0.08
		50-80	0.08	0.78	0.02
		80-150	0.04	0.64	0.08
III	9	0-10	0.01	0.54	0.00
		10-45	0.42	0.69	0.00
		45-150	0.46	0.68	0.01
	10	0-30	0.04	0.18	0.01
		30-65	0.42	0.77	0.12
		65-150	0.12	0.01	0.03
	11	0-40	0.18	0.36	0.08
		40-70	0.16	0.76	0.01
		70-150	0.09	0.28	0.12
IV	12	0-15	0.12	0.02	0.04
		15-35	0.52	0.01	0.01
		35-150	0.60	0.14	0.06
	13	0-20	0.48	0.12	0.30
		20-65	0.54	0.04	0.02
		65-150	0.56	0.08	0.06
V	14	0-30	0.52	0.60	0.30
		30-60	0.48	0.44	0.28
		60-150	0.50	0.48	0.31
	15	0-20	0.18	0.20	0.22
		20-45	0.44	0.10	0.30
		45-150	0.34	0.10	0.31
VI	16	0-20	0.02	0.62	0.01
		20-45	0.12	0.24	0.08

DTPA-extractable lead varies between 0.01 and 0.88 $mg.kg^{-1}$, the relatively high contents are associated with the layers of profile. These amounts are considered relatively low levels, as compared with those obtained by **El-Gala et. al. (1990)** who mentioned that the available Pb content ranged between 0.2 and 2.2 mg kg^{-1} in sandy soils of Ismailia Governorate, as well as, 7.44 mg kg^{-1} in El-Saff surface soils irrigated with wastewater **(Abdel Hady, 2001)**.

DTPA-extractable nickel ranges from 0.01 to 0.78 mg kg^{-1}. Soils of profiles 8,9 and 10 recorded relatively high contents. Also, these contents are relatively low as compared to those obtained by **Metwally and Rabie (1989)** who showed that DTPA extractable nickel ranged from 0.28 to 0.88 mg kg^{-1} in sandy soils.

Data of extractable cobalt range between nil in the upper two layers of profile 9 and 0.31 mg kg^{-1} in deepest layer of profiles 14 and 15, these amounts of extractable cobalt are less than the toxic level according to **Lindsay (1979)**.

4.4. Grain size parameters:

Data of statistical size parameters of different representative soil profiles according to **Folk&Ward (1957)**, deposition environment of **Sahu (1964)** and transportation mechanism of **Passiga (1957&1964)** are discussed for each unit as follows:

- **Soils of the first unit:**

According to the data of Tables (12 and 13) and figures (8 to 12), the value of mean size (M_Z) varies between 1.47 and 2.07 Ø, which is corresponded with medium sand, except the surface layer profile 5 (fine sand, 2.07 Ø). The sorting value ranges from 1.47 to 2.42 Ø, indicate to poorly and very poorly sorted. Skewness measure (S_{KI}) is geometrically independent of sorting, perfectly symmetrical curves have $S_{KI} = 0.00$ and the absolute mathematical limits are from −1 to +1. Data of S_{KI} show two clustering, the first one represents profiles 1 and 2 and the deepest layer of profile 5, which have nearly symmetrical (-0.07 to 0.03 Ø) and indicate the homogeneous distribution. The rest profile layers appear fine or positive skewed (0.11 to 0.24 Ø), indicate that the samples have a tail of fine grains, which

Table (12) : Statistical size parameters of the studied soil profiles according to Folk & Ward (1957) and Sahu (1964)

Tax. Unit	Prof. No	Depth . cm	ø 5	ø 16	ø 25	ø 50	ø 75	ø 84	ø 95	Md	Folk and Ward (1957)				Sahu (1964)			
											Mz	σ_1	Ski	KG	Y1	Y2	Y3	Y4
I	1	0 - 25	-0.70	-0.15	0.40	2.10	2.90	3.50	6.50	2.10	1.82	2.00	-0.01	1.18	12.06	313.91	-34.56	5.90
		25 - 80	-0.85	-0.30	0.00	1.95	2.75	3.30	6.20	1.09	1.65	1.97	-0.02	1.05	11.77	299.41	-33.31	5.04
		80 - 150	-0.50	0.00	1.15	2.20	2.95	3.65	6.50	2.15	1.95	1.97	0.01	1.59	12.39	316.04	-33.53	8.35
	2	0 - 20	-0.60	-0.15	0.20	2.15	3.10	3.85	6.45	2.20	1.95	2.07	0.03	1.00	11.90	330.66	-37.04	5.19
		20 - 65	-0.70	-0.30	-0.05	2.25	3.15	3.85	6.75	2.20	1.93	2.17	-0.01	0.95	13.46	356.09	-40.46	4.48
		65 - 150	-0.85	-0.35	-0.10	2.25	3.15	3.80	6.20	2.30	1.90	2.11	-0.07	0.89	12.54	336.34	-37.93	3.84
	3	0 - 20	-0.25	0.35	0.70	1.75	2.75	3.35	5.80	1.70	1.82	1.67	0.20	1.21	7.14	237.01	-24.75	7.96
		20 - 110	-0.60	-0.05	0.60	1.95	2.70	3.45	8.00	1.90	1.78	2.18	0.13	1.68	16.15	373.08	-41.61	9.15
		110 - 150	-0.60	-0.20	0.20	1.40	2.50	3.15	6.40	1.40	1.47	1.89	0.24	1.25	11.30	284.00	-32.00	7.87
	4	0 - 60	-0.50	-0.05	0.95	2.20	3.15	3.70	9.30	2.20	1.95	2.42	0.12	1.83	20.19	452.13	-51.37	9.54
		60 - 150	-0.70	-0.25	0.15	1.90	2.70	3.20	9.10	1.90	1.62	2.35	0.11	1.58	19.30	418.53	-48.28	8.03
	5	0 - 30	-0.35	0.25	0.65	2.20	3.10	3.75	8.30	2.20	2.07	2.19	0.15	1.45	14.50	375.69	-41.91	8.22
		30 - 70	-0.75	-0.15	0.35	1.65	2.70	3.40	5.80	1.70	1.63	1.88	0.13	1.14	10.55	281.22	-31.06	6.65
		70 - 150	-0.55	0.10	0.60	1.80	2.80	3.15	4.15	1.85	1.68	1.47	-0.06	0.88	4.89	184.40	-18.25	4.59
II	6	0 - 20	-0.65	0.10	0.80	2.10	2.85	3.55	6.50	2.10	1.92	1.95	0.04	1.43	11.55	305.89	-32.73	7.66
		20 - 40	-0.55	0.30	0.75	1.70	2.50	2.95	4.60	1.70	1.65	1.44	0.03	1.21	5.50	185.56	-17.88	6.97
		400 - 70	-0.80	-0.20	0.30	1.60	2.45	3.00	5.35	1.65	1.47	1.73	0.05	1.17	9.42	242.58	-26.03	6.37
		70 - 150	-1.00	-0.40	-0.01	1.35	2.25	3.05	7.10	1.35	1.33	2.09	0.20	1.47	15.56	338.69	-38.80	8.34
	7	0 - 25	-0.50	0.10	0.60	1.80	2.80	3.60	7.30	1.80	1.83	2.06	0.22	1.45	13.19	337.54	-37.54	8.79
		25 - 75	-0.15	0.25	0.30	1.45	2.60	3.35	7.15	1.45	1.52	2.01	0.31	1.30	12.89	317.83	-36.27	8.43
		75 - 105	-1.05	-0.55	-0.20	1.20	2.25	2.75	6.30	1.20	1.13	1.94	0.16	1.23	13.36	290.41	-33.34	6.91
		105- 150	-1.10	-0.65	-0.30	0.90	2.00	2.65	9.10	0.90	0.97	2.37	0.33	1.82	22.31	424.04	-50.50	10.30
	8	0 - 30	-0.60	-0.15	0.45	1.85	2.60	3.00	5.50	1.90	1.57	1.71	-0.04	1.16	8.95	237.91	-24.99	5.86
		30 - 50	-0.50	-0.05	0.65	1.90	2.80	3.60	7.40	1.90	1.82	2.11	0.16	1.51	14.34	351.63	-39.18	8.58
		50 - 80	-0.55	-0.10	0.55	1.90	2.70	3.50	7.60	1.90	1.77	2.13	0.14	1.55	15.10	358.48	-40.05	8.63
		80 - 150	-0.40	0.40	1.05	1.95	2.80	3.65	8.10	2.00	2.00	2.10	0.25	1.99	14.88	362.49	-39.19	11.86

Table (12) : Con.

Tax. Unit	Prof. No	Depth cm	ø 5	ø 16	ø 25	ø 50	ø 75	ø 84	ø 95	Md	Folk and Ward (1957)				Sahu (1964)			
											Mz	σ_1	Ski	KG	Y1	Y2	Y3	Y4
III	9	0 - 10	-0.55	0.00	1.15	2.50	3.50	3.95	7.10	2.50	2.15	2.15	-0.03	1.33	13.60	360.55	-39.53	6.54
		10-45	-0.45	-0.20	-0.15	2.10	3.15	3.50	4.25	2.10	1.80	1.64	-0.16	0.58	5.66	212.12	-22.13	2.20
		45 - 150	-0.65	-0.20	0.00	1.45	2.40	2.95	4.15	1.45	1.40	1.51	0.04	0.82	5.97	188.55	-19.85	4.68
	10	0 - 65	-0.50	0.10	1.15	2.35	3.25	3.85	7.30	2.35	2.10	2.12	0.03	1.52	13.80	356.80	-38.84	7.99
		65 - 110	-0.40	0.20	0.50	1.65	2.70	3.15	4.00	1.65	1.67	1.40	0.04	0.82	3.81	171.58	-16.97	5.03
		110 - 150	-0.55	-0.05	0.50	1.70	2.75	3.25	5.00	1.70	1.63	1.67	0.06	1.01	7.46	227.80	-24.11	5.84
	11	0 - 40	-0.50	-0.05	0.30	1.35	2.90	3.50	6.05	1.35	1.60	1.88	0.32	1.03	9.92	282.23	-32.04	7.37
		40 - 70	-0.60	-0.12	0.20	1.70	2.85	3.70	8.20	1.70	1.76	2.29	0.26	1.36	16.80	401.57	-48.59	8.13
		70 - 150	-0.55	-0.10	0.25	1.55	2.60	3.30	7.10	1.55	1.58	2.01	0.24	1.33	12.95	319.05	-36.02	8.19
IV	12	0 - 15	-0.30	0.40	0.80	1.75	2.80	3.25	7.10	1.75	1.80	1.83	0.25	1.52	10.23	281.70	-30.09	9.65
		15 - 35	-0.60	-0.05	0.35	1.30	2.35	2.85	8.10	1.30	1.37	2.04	0.32	1.78	15.47	334.41	-37.64	10.87
		35 - 150	-0.70	-0.25	0.15	1.10	2.10	2.65	8.00	1.10	1.17	2.04	0.33	1.83	16.30	332.34	-37.75	11.04
	13	0 - 20	-0.85	-0.30	0.20	1.45	2.55	2.90	7.00	1.45	1.35	1.99	0.16	1.37	13.76	309.42	-35.00	7.70
		20 - 65	-0.80	-0.15	0.25	1.30	2.35	2.80	5.80	1.30	1.32	1.74	0.19	1.29	10.09	246.26	-26.94	7.83
		65 - 150	-0.90	-0.35	0.00	1.05	2.10	2.40	3.95	1.05	1.03	1.42	0.09	0.95	6.56	168.23	-17.82	5.54
V	14	0 - 30	-0.25	0.50	0.95	1.85	2.85	3.35	7.30	1.85	1.90	1.86	0.25	1.63	10.53	290.83	-30.79	10.27
		30 - 60	-0.60	0.00	0.40	1.30	2.20	2.65	6.70	1.30	1.32	1.77	0.25	1.66	11.54	261.40	-28.16	10.16
		60 - 150	-0.50	0.10	0.60	1.50	2.40	2.95	8.30	1.50	1.52	2.05	0.28	2.00	15.73	340.94	-37.51	11.91
	15	0 - 20	-0.40	0.20	0.60	1.70	2.75	3.30	5.80	1.70	1.73	1.71	0.18	1.18	8.00	245.34	-26.06	7.52
		20 - 45	-0.70	-0.10	0.25	1.25	2.50	3.05	5.60	1.25	1.40	1.74	0.26	1.15	9.27	247.30	-27.41	7.62
		45 - 150	-0.85	-0.30	-0.05	1.00	2.20	2.70	4.20	1.00	1.13	1.52	0.20	0.92	6.90	189.24	-20.72	6.11
VI	16	0 - 20	-0.65	-0.15	0.25	1.30	2.40	2.85	4.20	1.30	1.33	1.48	0.11	0.92	6.04	184.93	-19.45	5.74
		20 - 45	-0.85	-0.35	-0.10	1.10	2.15	2.70	6.00	1.10	1.15	1.80	0.24	1.25	11.28	258.42	-29.18	7.74

Table (13) : The values of mean size, sorting,skeweness and kurtosis of the studied aria

Tax. unit	Prof. No	Depth (cm)	Mean Size (M_z)		Sorting (σ_1)	Skeweness (S_k)	Kurtosis (K_G)
I	1	0-25	1.82	ms	Very poorly sorted	Nearly symmetrical	Lepto kurtic
		25-80	1.65	ms	poorly sorted	Nearly symmetrical	Meso kurtic
		80-150	1.95	ms	Poorly sorted	Nearly symmetrical	Very lepto kurtic
	2	0-20	1.95	ms	Very poorly sorted	Nearly symmetrical	Meso kurtic
		20-65	1.93	ms	Very poorly sorted	Nearly symmetrical	Meso kurtic
		65-150	1.90	ms	Very poorly sorted	Nearly symmetrical	Platy kurtic
	3	0-20	1.82	ms	poorly sorted	Fine skewed	Lepto kurtic
		20-110	1.78	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
		110-150	1.47	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
	4	0-60	1.95	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
		60-150	1.62	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
	5	0-30	2.07	fs	Very poorly sorted	Fine skewed	Lepto kurtic
		30-70	1.63	ms	poorly sorted	Fine skewed	Lepto kurtic
		70-150	1.68	ms	poorly sorted	Nearly symmetrical	Platy kurtic
II	6	0-20	1.92	ms	poorly sorted	Nearly symmetrical	Lepto kurtic
		20-40	1.65	ms	poorly sorted	Nearly symmetrical	Lepto kurtic
		40-70	1.47	ms	poorly sorted	Nearly symmetrical	Lepto kurtic
		70-150	1.33	ms	Very poorly sorted	Fine skewed	Lepto kurtic
	7	0-25	1.83	ms	Very poorly sorted	Fine skewed	Lepto kurtic
		25-75	1.52	ms	Very poorly sorted	Strongly fine skewed	Lepto kurtic
		75-105	1.13	ms	poorly sorted	Fine skewed	Lepto kurtic
		105-150	0.97	cs	Very poorly sorted	Strongly fine skewed	Very lepto kurtic
	8	0-30	1.57	ms	poorly sorted	Nearly symmetrical	Lepto kurtic
		30-50	1.82	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
		50-80	1.77	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
		80-150	2.00	ms	Very poorly sorted	Fine skewed	Very lepto kurtic

fs : fine sand ms : medium sand cs : coarse sand

Table (13) : Cont.

Tax. unit	Prof. No	Depth (cm)	Mean Size (M_z)		Sorting (σ_1)	Skeweness (S_k)	Kurtosis (K_G)
III	9	0-10	2.15	fs	Very poorly sorted	Nearly symmetrical	Lepto kurtic
		10-45	1.80	ms	Very poorly sorted	Coarse skewed	Very play kurtic
		45-150	1.40	ms	Very poorly sorted	Nearly symmetrical	Very play kurtic
	10	0-30	2.10	fs	Very poorly sorted	Nearly symmetrical	Very lepto kurtic
		30-65	1.67	ms	Very poorly sorted	Nearly symmetrical	Platy kurtic
		65-150	1.63	ms	Very poorly sorted	Nearly symmetrical	Meso kurtic
	II	0-40	1.60	ms	Very poorly sorted	Strongly fine skewed	Meso kurtic
		40-70	1.76	ms	Very poorly sorted	Fine skewed	Lepto kurtic
		70-150	1.58	ms	Very poorly sorted	Fine skewed	Lepto kurtic
IV	12	0-15	1.80	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
		15-35	1.37	ms	Very poorly sorted	Strongly fine skewed	Very lepto kurtic
		35-150	1.17	ms	Very poorly sorted	Strongly fine skewed	Very lepto kurtic
	13	0-20	1.35	ms	Very poorly sorted	Fine skewed	Lepto kurtic
		20-65	1.32	ms	Very poorly sorted	Fine skewed	Lepto kurtic
		65-150	1.03	ms	Very poorly sorted	Nearly symmetrical	Meso kurtic
V	14	0-30	1.90	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
		30-60	1.32	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
		60-150	1.52	ms	Very poorly sorted	Fine skewed	Very lepto kurtic
	15	0-20	1.73	ms	Very poorly sorted	Fine skewed	Lepto kurtic
		20-45	1.40	ms	poorly sorted	Fine skewed	Lepto kurtic
		45-150	1.13	ms	Very poorly sorted	Fine skewed	Meso kurtic
VI	16	0-20	1.33	ms	Very poorly sorted	Fine skewed	Meso kurtic
		20-45	1.15	ms	Very poorly sorted	Fine skewed	Lepto kurtic

fs : fine sand ms : medium sand cs : coarse sand

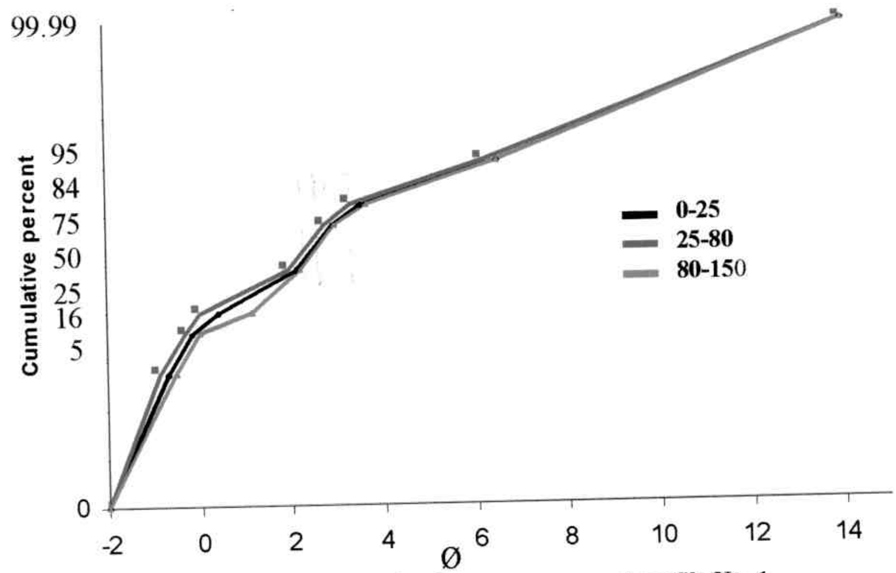


Fig. (8): Cumulative frequency curve of profile No. 1

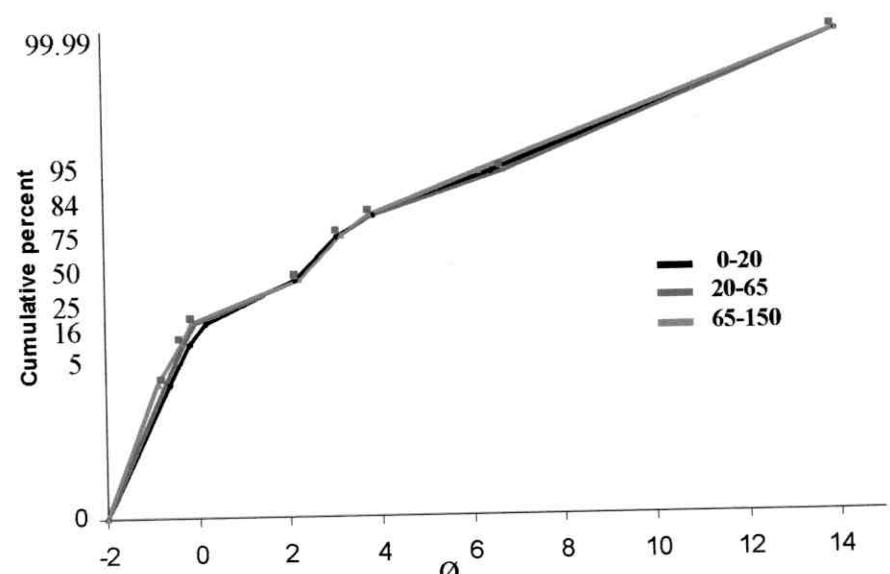


Fig. (9): Cumulative frequency curve of profile No. 2

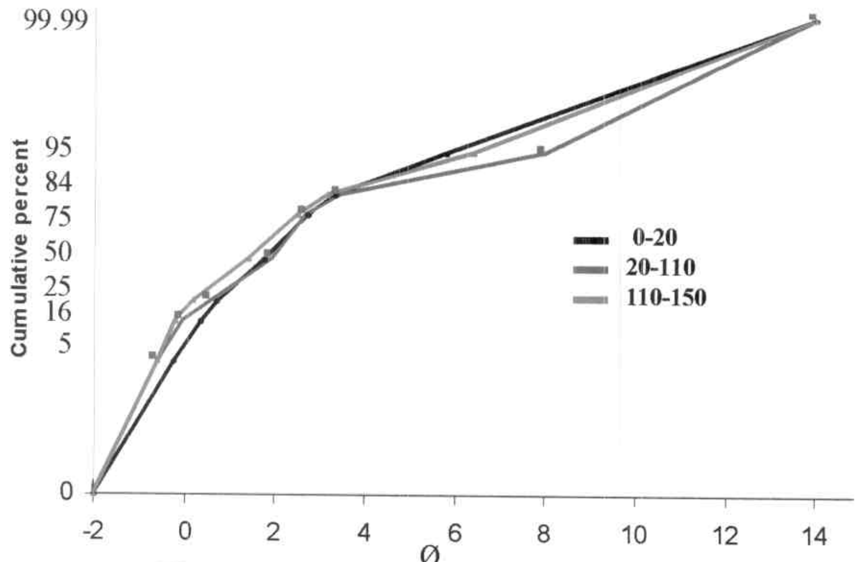


Fig. (10): Cumulative frequency curve of profile No. 3

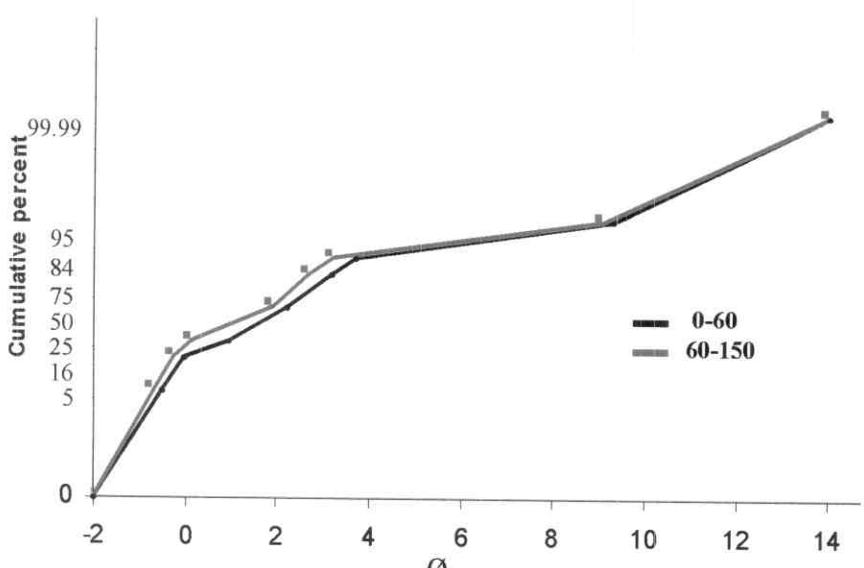


Fig. (11): Cumulative frequency curve of profile No. 4

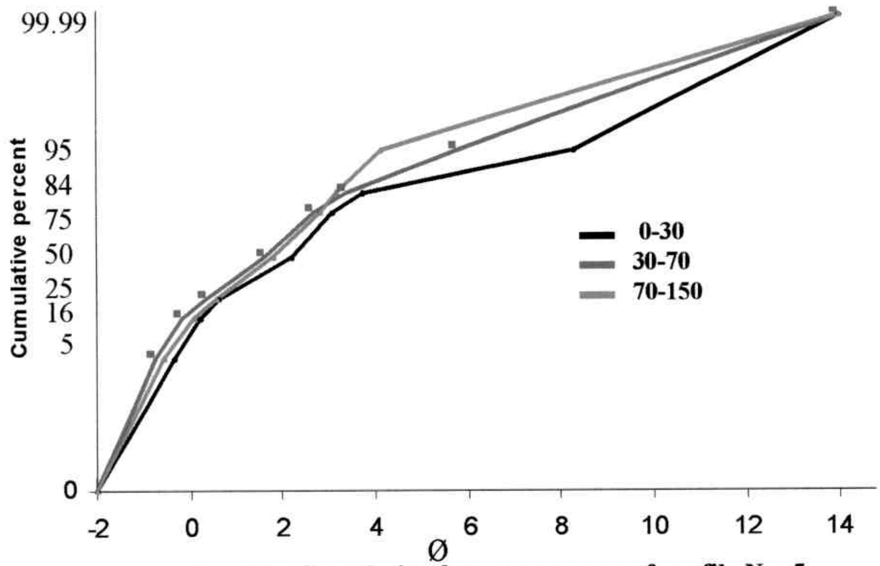


Fig. (12): Cumulative frequency curve of profile No. 5

represent the second cluster. Kurtosis measure, the ratio of sorting in the extremes of the distribution compared with the sorting in the central part, is a sensitive and valuable test of the normality of a distribution. Values of Kurtosis show three different models, i.e., a) normal curve or mesokurtic limit (0.95 to 1.05) in subsurface layer of profiles 1 and 2 (except the deepest layer). B) platykurtic (0.89 and 0.88) in the deepest layers of profiles 2 and 5, and c) lepto and very leptokurtic (1.14 to 1.83) in profiles 1 (except layer 25-80 cm), 3,4 and 5 (except the deepest layer). The normal and platy values of kurtosis are corresponding to energy environment and high modification of grain size, while the lepto and very leptokurtic show the opposite trends.

According to **Sahu (1964)**, every environment of deposition has its characteristic energy conditions and energy fluctuations through space and time. The preservation of these fluctuations is subjected to the availability of sufficient amounts of source materials of all sizes, therefore, size distribution indicates that the properties of the deposition environment. The following discriminate function can be used for the classification purpose using the previously calculated statistical measurements according to the method of **Folk&Ward (1957)**. To distinguish between the aeolian and littoral (beach) environments, the following equation is used:

$$\mathbf{Y_1 = -3.5688\,M_Z + 3.7016\,6_I^2 - 2.0766\,S_{KI} + 3.1135\,K_G}$$

Y_1 of less than –2.7411 represents the aeolian deposits, whereas, those of greater than –2.7411 represents beach environments.

To distinguish between beach environments and shallow agitated marine environments, the following equation is used:

$$\mathbf{Y_2 = 15.6534\,M_Z + 65.7091\,6_I^2 + 18.1071\,S_{KI} + 18.5043\,K_G}$$

Y_2 of less than 65.3650 indicates to a beach deposits, whereas those of greater than 65.3650 represents shallow agitated water deposits.

To distinguish between shallow agitated marine environments and fluvial processes, the following equation is used:

$$\mathbf{Y_3 = 0.2852\,M_Z - 8.7604\,6_I^2 - 4.8932\,S_{KI} + 0.0482\,K_G}$$

Y_3 of less than –7.4190 indicates to fluvial (deltaic) deposits, whereas those of greater than –7.4190 represents shallow marine water deposits.

To distinguish between fluvial (deltaic) processes and turbidity current depositions, the following equation is used:

$$\mathbf{Y_4 = 0.7215\ M_Z - 0.4030\ 6_I^2 + 6.7322\ S_{KI} + 5.2927\ K_G}$$

Y_4 of less than 9.8433 indicates to a turbidity current deposits, whereas those of greater than 9.8433 represents fluvial (deltaic) deposits.

The standard deviation of the discriminate function are progressively increased in the sequence:

aeolian < beach < shallow agitated marine < fluvial (deltaic) < turbidity current deposits.

According to the limits of **Sahu (1964)**, data of Table (12) show that all profiles of this unit represent fluvial (deltaic) deposits, whereas, Y_3 values are between –51.37 and –18.25 and less than –7.4190.

According to the method of **Passiga (1957&1964)**, which indicate the transportation mechanism (C-M diagram) of the precipitated deposits by using the values of Ø 1 and Ø 50 (Table, 14). The C-M diagram shows that the transportation mechanism of the soils under consideration are belong to O–P segments representing rolling and suspension mechanism, except the deepest layer of profile 1 (80–150 cm) and the subsurface layer of profile 5 (30–70 cm), which are transported as suspension and rolling mechanism P–Q segments.

- **Soils of the second unit:**

From the values of Tables (12 and 13) and Figures (13 to 15), the mean size value laies between 0.97 and 2.00 Ø, which corresponding to coarse and medium sand. All the soil profile layers of this unit have medium sand fraction, except the deepest layer of profile 7 which has coarse sand fraction. The values of M_Z decrease with depth, except in profile 8 that has an opposite trend. The sorting values of the studied soils of this unit range between 1.44 and 2.37 Ø, indicate poorly sorted to very poorly sorted. Skewness values (S_{KI}) through of different

Table (14) : Grain size image of the studied area.

Tax. unit	Prof. No	Depth (cm)	Diameter (f) 1%	Diameter (f) 50%	Diameter (?) 1%	Diameter (?) 50%	Transportation Mechanism
I	1	0-25	-1.10	2.10	2.1434	0.2333	O - P
		25-80	-1.30	1.95	2.4621	0.2589	O - P
		80-150	-1.00	2.20	1.9999	0.2177	P - Q
	2	0-20	-1.00	2.15	1.9999	0.2253	O - P
		20-65	-1.20	2.25	2.2972	0.2103	O - P
		65-150	-1.25	2.25	2.3782	0.2103	O - P
	3	0-20	-0.90	1.75	1.8660	0.2973	O - P
		20-110	-1.10	1.95	2.1434	0.2589	O - P
		110-150	-1.10	1.40	2.3599	0.2103	O - P
	4	0-60	-1.00	2.20	1.9999	0.2177	O - P
		60-150	-1.05	1.90	2.0704	0.2680	O - P
	5	0-30	-0.90	2.20	1.8660	0.2177	O - P
		30-70	-1.20	1.65	2.2972	0.1593	P - Q
		70-150	-1.05	1.80	2.0704	0.2872	O - P
II	6	0-20	-1.15	2.10	2.2190	0.2333	O - P
		20-40	-0.95	1.70	1.9317	0.3078	O - P
		40-70	-1.25	1.60	2.3782	0.3299	O - P
		70-150	-1.40	1.35	2.6388	0.3923	O - P
	7	0-25	-1.00	1.80	1.9999	0.2872	O - P
		25-75	-1.20	1.45	2.2972	0.3661	O - P
		75-105	-1.35	1.20	2.5489	0.4353	O - P
		105-150	-1.50	0.90	2.8281	0.5359	O - P
	8	0-30	-1.10	1.85	2.1838	0.2774	O - P
		30-50	-1.00	1.90	1.9999	0.2680	O - P
		50-80	-1.05	1.90	2.0704	0.2680	O - P
		80-150	-0.90	1.95	1.8660	0.2589	O - P

O-P = Rolling and suspension. P-Q = Suspension and rolling.

Table (14) :Cont.

Tax. unit	Prof. No	Depth (cm)	Diameter (f)		Diameter (?)		Transportation Mechanism
			1%	50%	1%	50%	
III	9	0-10	-1.10	2.50	2.1434	0.1768	P - Q
		10-45	-1.00	2.10	1.9999	0.2333	O - P
		45-150	-1.15	1.45	2.2190	0.3661	O - P
	10	0-30	-1.00	2.35	1.9999	0.3923	O - P
		30-65	-0.95	1.65	1.9317	0.1593	P - Q
		65-150	-1.10	1.70	2.1434	0.3078	O - P
	11	0-40	-1.00	1.35	1.9999	0.3923	O - P
		40-70	-1.10	1.70	2.1434	0.3078	O - P
		70-150	-1.10	1.55	2.1434	0.3415	O - P
IV	12	0-15	-0.85	1.75	1.8024	0.2973	O - P
		15-35	-1.10	1.30	2.1434	0.4062	O - P
		35-150	-1.25	1.10	2.1434	0.4666	O - P
	13	0-20	-1.25	1.45	2.3782	0.3661	O - P
		20-65	-1.20	1.30	2.2972	0.4062	O - P
		65-150	-1.30	1.05	2.4621	0.4830	O - P
V	14	0-30	0.85	1.85	0.5548	0.2774	O - P
		30-60	-1.10	1.30	2.1434	0.4062	O - P
		60-150	-1.00	1.50	1.9999	0.3536	O - P
	15	0-20	-1.00	1.70	1.9999	0.3078	O - P
		20-45	-1.20	1.25	2.2972	0.4205	O - P
		45-150	-1.30	1.00	2.4621	0.5000	O - P
VI	16	0-20	-1.10	1.30	2.1434	0.4062	O - P
		20-45	-1.25	1.10	2.3782	0.4666	O - P

O-P = Rolling and suspension. P-Q = Suspension and rolling.

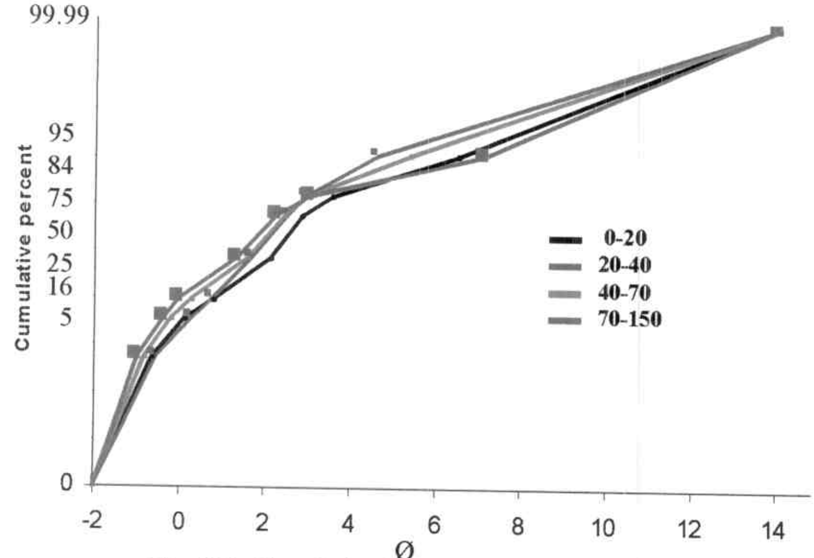


Fig. (13): Cumulative frequency curve of profile No. 6

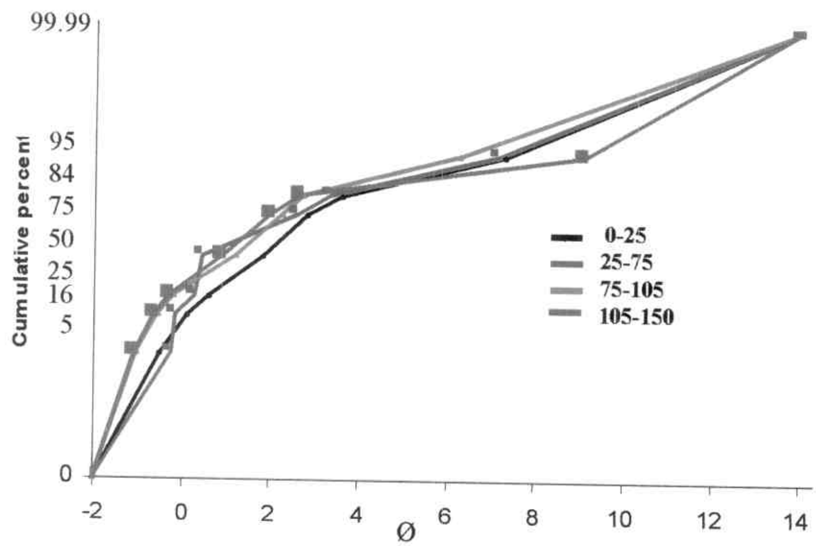


Fig. (14): Cumulative frequency curve of profile No. 7

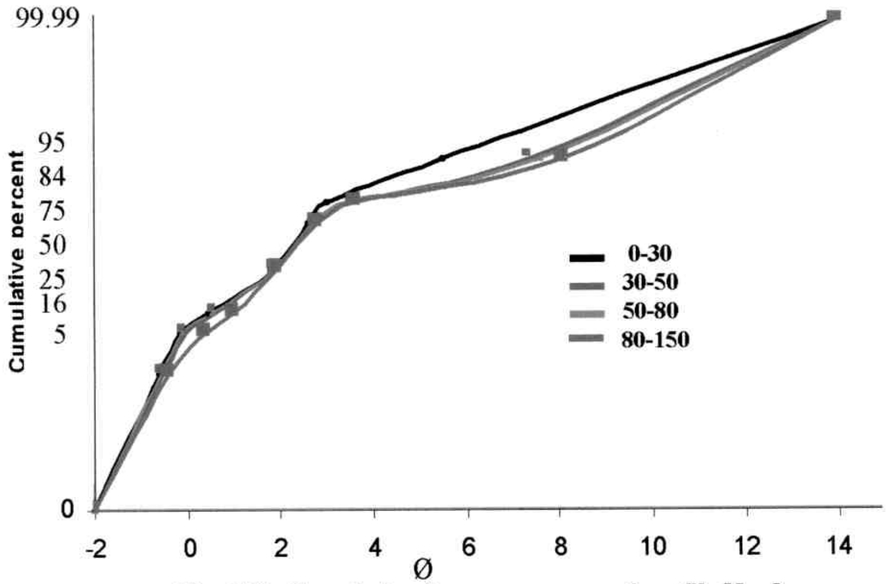


Fig. (15): Cumulative frequency curve of profile No. 8

soil profile layers are between –0.04 and 0.33, which show a nearly symmetrical, positively skewed and very positively skewed. Soil profile layers of 6 and 8, except the deepest layer and surface layer, are nearly symmetrical indicate a homogeneous distribution, other different profiles and layers lay between positively skewed and very positively skewed, indicate that the soil samples have a "tail" of fine grains. Values of Kurtosis (K_G) of the studied area range between 1. 6 and 1.99 and represent two clusters, i.e., soil profile layers of 6, profile 7 (except the deepest layer) and surface layer of profile 8 have leptokurtic cluster, while other profiles appear very leptokurtic one. Data of kurtosis clear very high-energy environment and very low modification of grain size.

Parameters of **Sahu (1964)** in this unit show that values within Y_3 range between –50.5 and –17.88, indicating the fluvial (deltaic) deposition (Table, 12).

According to **Passiga (1957&1964),** data of Table (14) indicate that the transportation mechanism by using C-M diagram belong to O–P segments representing rolling and suspension for all their profile layers.

- **Soils of the third unit:**

Data of **Folk &Ward (1957)**, which illustrated in Tables (12 and 13) and Figures (16 to 18), show that values of mean size (M_Z) ranges between 1.4 and 2.15 Ø, indicates that the diameters of soils belonging to this unit are within medium and fine sand . Medium sand fraction is the predominant size in this unit, while fine sand is in surface layers of profiles 9, 10. The values of "M_Z" decrease with depth with, exception in soil profile 11. Sorting values range between 1.4 and 2.29, indicate poorly and very poorly sorted. Skewness values (S_{KI}) of different soil profile layers vary between –0.16 and 0.32, indicate negatively skewed, nearly skewed, positively skewed and very positively skewed. The obtained data show that all samples of profile 11 have a "tail" of fine grains, on the other hand, layers of profiles 9 and 10 appear homogenous distribution, except the subsurface layer (10 – 45 cm) of profile 9 has a "tail" of coarse grains. Values of Kurtosis (K_G) of the

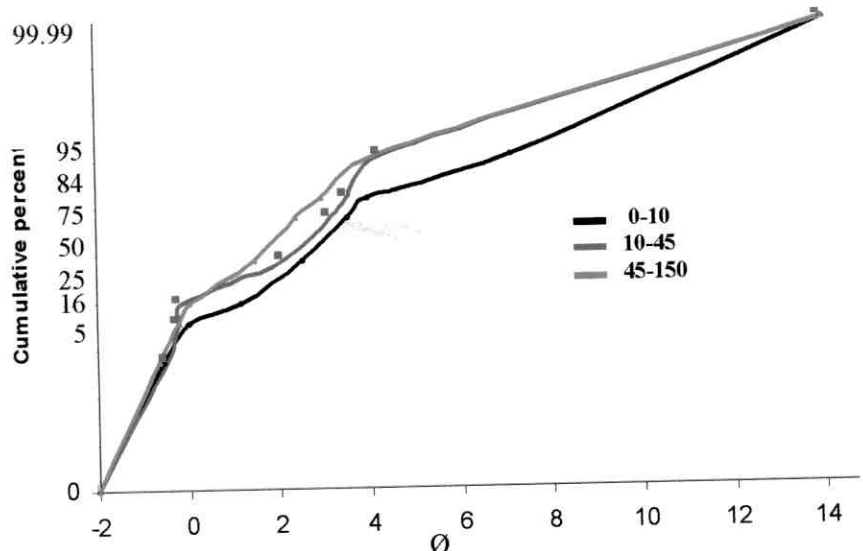


Fig. (16): Cumulative frequency curve of profile No. 9

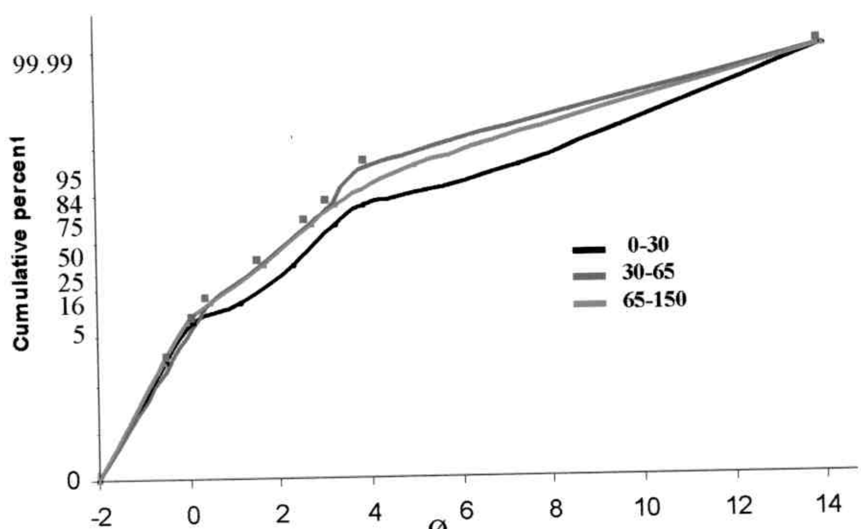


Fig. (17): Cumulative frequency curve of profile No. 10

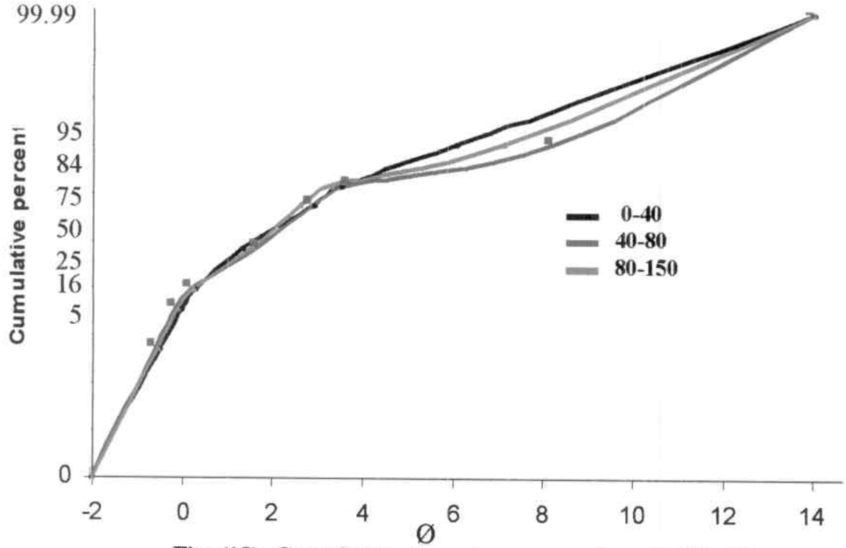


Fig. (18): Cumulative frequency curve of profile No. 11

studied unit vary between 0.58 and 1.52, which correspond range between very platykurtic and very leptokurtic. Leptokurtic and very leptokurtic limits are found in the surface layer of profiles 9, 10 and profile 11, except the surface layer. These limits show very high-energy environment and very low modification of grain size. Mesokurtic is found in the deepest layer of profile 10 (65–150 cm) and the surface one of profile 11, while platy and very platykurtic are found in profile 9, except surface layer and subsurface layer of profile 10, which related to low energy environment and high modification of grain size.

Parameters of **Sahu (1964)** in the soil under consideration unit show that values of Y_3 are less than –7.4190, which indicate fluvial (deltaic) deposition (Table, 12).

According to **Passiga (1957&1964)**, data of Table (14) indicate that the transportation mechanism by using C-M diagram belong to O–P segments representing rolling and suspension, except the surface layer of profile 9 and the subsurface layer of profile 10 that are related to P-Q segments, which indicate suspension and rolling mechanism.

- **Soils of the fourth unit:**

According to the data of Tables (12 and 13) and figures (19 and 20), values of mean size (M_Z) range between 1.03 and 1.80 Ø, which corresponded with medium sand. These values tend to decrease with depth in the all representative profiles. The sorting values vary from 1.42 to 2.04 Ø, indicating poorly and very poorly sorted. Skewness measure (S_{KI}) ranges between 0.09 and 0.33, indicate that a nearly symmetrical to strongly fine skewed value. All layers of the representative soil profiles are positively and very positively skewed, except the deepest layer of profile 13 that show a nearly symmetrical skewed, indicate that the most layers of the representative profiles have a "tail" of fine grains. Kurtosis values of this unit change from 0.95 to1.83 Ø corresponding to mesokurtic and very platykurtic, respectively. All layers of profile 12 appear very leptokurtic. The two upper layers of profile 13 represent leptokurtic, while the deepest layer shows mesokurtic. Values of kurtosis point to

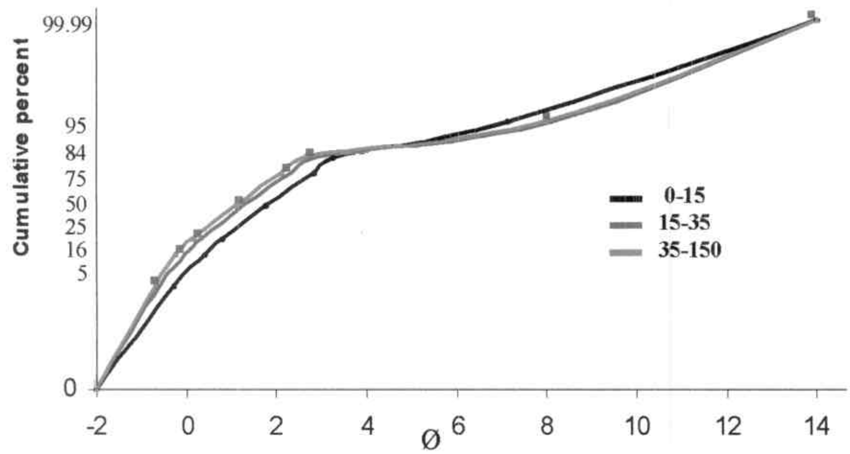


Fig. (19): Cumulative frequency curve of profile No. 12

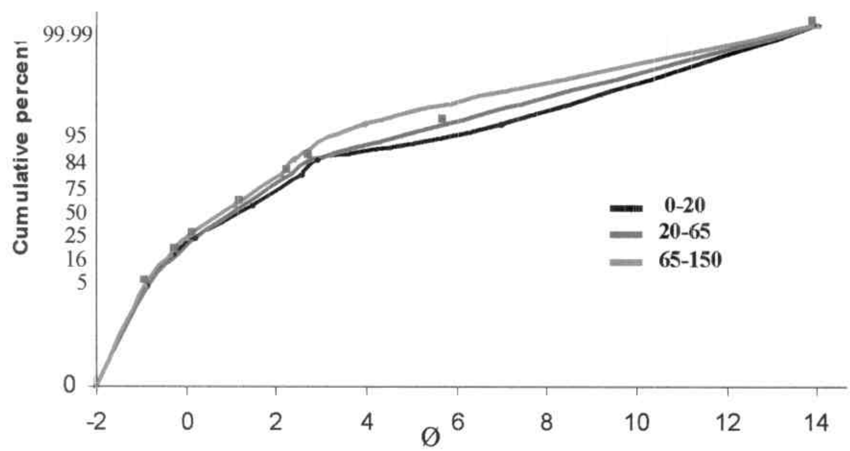


Fig. (20): Cumulative frequency curve of profile No. 13

very high-energy environment and very low modification of grain size, except deepest layer of profile 13, which correspond to low energy environment and high modification of grain size.

According to **Sahu (1964)**, the soils of this unit reveal to fluvial (deltaic) deposition (Table, 12).

According to the method of **Passiga (1957&1964)** the transportation mechanism of the studied soil is represented by rolling and suspension, which belong to O-P segments (Table, 14).

- **Soils of the fifth unit:**

The sedimentological data, which illustrated in Tables (12 and 13) and Figures (21 and 22), show that values of mean size (M_Z) range between 1.13 and 1.9 Ø which points to medium sand. Generally, values of "M_Z" decrease with depth. The sorting values range between 1.52 and 2.05 Ø, which show that the studied sediments fall in poorly and very poorly sorted. Skewness values (S_{KI}) range between 0.18 and 0.28, which point to positively skewed and indicate that these soils have a "tail" of fine grains. Values of Kurtosis (K_G) of the studied unit vary between 0.92 and 2.00, which corresponding mesokurtic and very leptokurtic. Soils of the representative profiles point to lepto and very leptokurtic, except the deepest layer of profile 15 which is mesokurtic. The soils under consideration are affected by very high-energy environment and very low modification of grain size, while the exception layer show the opposite effect.

Parameters of **Sahu (1964)** in this unit reveal that the soil environment of deposition is fluvial (deltaic), Table (12).

According to C-M diagram of **Passiga (1957&1964)**, data of Table (14) are belong to O–P segments and representing the rolling and suspension media.

- **Soils of the sixth unit:**

Measurements of **Folk&Ward (1957)**, illustrate in Tables (12 and 13) and Figure (23).The mean size (M_Z) is medium sand. The sorting values reveal to very poorly sorted. Skewness values (S_{KI}) are positively skewed which indicate that these soils have a "tail" of fine grains. Values of Kurtosis (K_G)

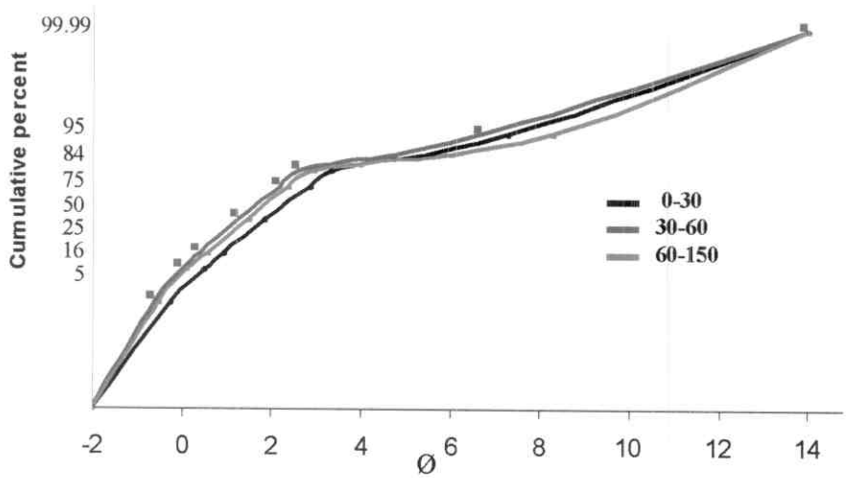


Fig. (21): Cumulative frequency curve of profile No. 14

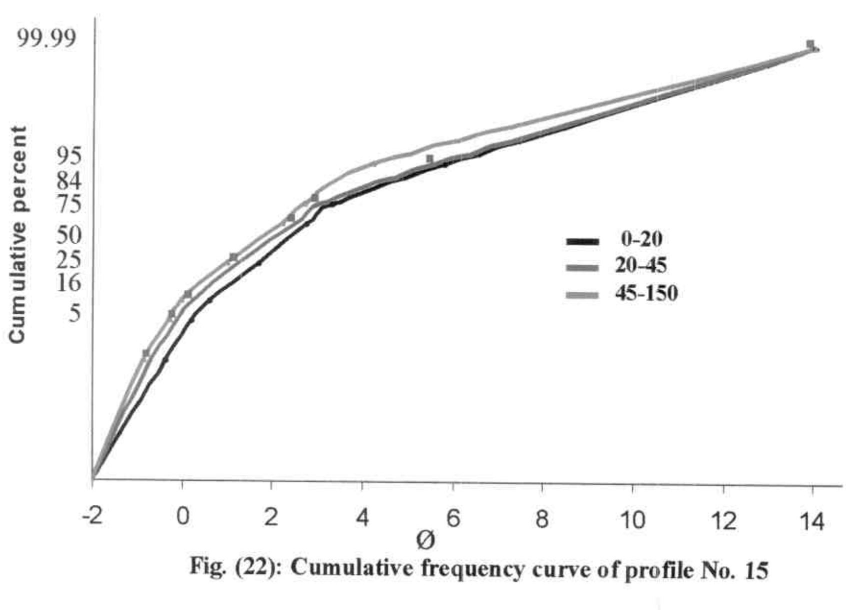


Fig. (22): Cumulative frequency curve of profile No. 15

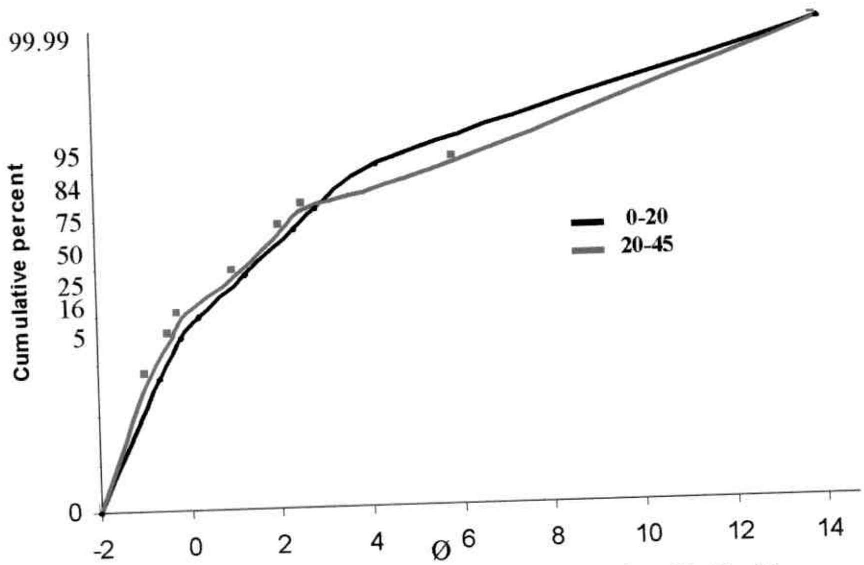


Fig. (23): Cumulative frequency curve of profile No. 16

of the studied unit are mesokurtic and leptokurtic in surface and subsurface layers, respectively. Such values indicate to very low energy environment and very high modification of grain size in the surface and opposite effect in the subsurface layer. Parameters of **Sahu (1964)** in this unit reveal that the soils are deposited under aqueous environment by fluvial (deltaic) condition (Table, 12).

According to C-M diagram of **Passiga (1957&1964)**, data of Table (14) show that the studied soils belong to O–P segments, which points to rolling and suspension (Table, 14).

4.5. Mineralogy of sand fraction:

4.5.1. Mineralogy of heavy minerals:

The heavy minerals suit has proved as a useful guide to the type of source rock, which the sand has derived **(Boswell, 1933).** Mineral of sand fraction could be used as a tool to evaluate soil profile uniformity and its development, as well as, soil genesis in terms of the degree of mineral weathering, **Bear (1964) and Brewer (1964)**. According to **Mitchell (1975) and Bayoumi <u>et</u> <u>al</u>. (1992)**, they emphasized the importance of the dominant heavy minerals for identifying the soil genesis. Their occurrence in rocks may be essential are accessory, they are usually primary, but occasionally they are secondary, **Mitchell (1975).**

The obtained data of identified heavy minerals in the sand fraction of size ranges between 125 and 63 μ, are illustrated in Table (15) after separation of both light and heavy mineral grains by using bromoform with specific gravity 2.85 ± 0.02 g/cm^3. Heavy minerals have specific gravity more than 2.85 g/cm^3.

- **Opaque minerals:**

The opaque minerals occurs sub-rounded or rounded grains, with elongate, spherical or irregular shapes. These minerals are counted as opaques because they are not possible to identify their individuals, i.e., almost entirely iron ores of magnetite, ileminite…etc.

15): Frequency distribution of heavy minerals (%) of sand fraction (0.063-0.125 mm) in the representative soil

Tax. Unit	Profile No.	Depth (cm)	Opaques	Amphiboles	Pyroxenes	Epidote	Biotite	Zircon	Rutile	Tourmaline	Garnet	Kyanite	Staurolite	Silimonite	Andalusite	Monazite	Others
I	1	0-25	41.45	4.66	2.59	4.15	4.15	23.32	6.74	7.25	1.04	0.52	1.04	0.52	0.52	1.04	1.04
		25-80	37.38	6.54	2.34	3.27	3.27	23.36	6.54	9.35	1.40	0.93	1.87	0.93	0.93	0.93	0.93
		80-150	40.61	5.58	2.03	2.54	2.03	25.38	7.11	8.63	1.52	0.51	1.52	0.51	0.51	0.51	1.20
	5	0-30	34.09	6.82	4.55	5.45	4.55	20.45	6.82	3.64	4.55	0.91	4.09	1.36	1.36	0.45	0.91
		30-70	35.90	7.69	4.10	5.13	4.10	20.51	7.18	4.10	3.59	1.03	2.56	1.54	1.03	0.51	1.03
		70-150	38.46	4.98	3.62	8.60	4.52	22.62	3.62	1.36	3.62	0.90	3.17	1.36	1.36	0.90	0.90
II	6	0-20	36.87	6.91	4.61	3.69	2.30	23.04	8.76	3.23	3.23	0.92	2.30	0.92	0.92	1.38	0.92
		20-40	42.21	5.19	2.60	5.19	2.60	25.97	5.84	1.95	1.95	0.65	1.95	1.30	1.30	0.00	1.30
		40-70	35.27	8.48	3.13	4.02	2.23	24.55	8.48	4.02	3.57	0.89	2.23	0.89	0.89	0.45	0.89
		70-150	33.98	7.28	4.37	2.91	4.85	24.27	9.22	4.37	2.43	0.97	1.94	0.97	0.49	0.97	0.97
	8	0-30	37.36	2.30	1.72	4.60	0.00	28.74	11.51	7.47	1.72	0.57	1.15	0.57	0.57	1.15	0.57
		30-50	37.74	6.29	2.52	1.89	1.26	22.01	8.18	5.66	3.14	1.26	3.14	2.52	1.89	1.26	1.26
		50-80	40.19	4.78	2.39	3.83	3.35	21.53	9.09	9.09	1.91	0.48	0.96	0.48	0.48	0.48	0.96
		80-150	39.02	4.88	1.95	4.39	1.95	24.39	9.27	8.29	1.46	0.49	1.46	0.49	0.49	0.49	0.98
III	11	0-40	35.55	3.79	4.74	4.74	6.16	21.33	7.11	4.74	3.32	0.95	3.32	1.42	1.42	0.47	0.95
		40-80	38.81	3.65	3.20	4.57	3.65	22.83	5.94	5.94	3.65	0.91	2.28	1.37	1.37	0.91	0.91
		80-150	39.53	4.65	2.33	3.26	3.72	23.26	7.91	4.19	3.72	0.93	4.19	0.47	0.47	0.47	0.93
IV	12	0-10	41.67	4.69	2.08	3.65	2.08	26.04	7.81	5.21	1.56	0.52	1.56	0.52	1.04	0.52	1.04
		11232	38.99	4.59	2.29	6.88	3.67	22.94	6.88	4.59	2.29	0.92	2.29	0.92	0.92	0.92	0.92
		30-150	37.57	5.78	5.78	5.78	4.62	20.23	8.67	4.62	1.73	0.58	1.73	1.16	1.16	0.58	0.00
V	15	0-20	39.44	3.76	3.29	2.35	3.29	25.82	7.04	4.69	2.35	0.94	1.88	1.41	1.41	0.47	1.88
		20-45	40.80	3.48	3.98	3.98	1.99	26.37	6.97	4.48	1.99	0.50	1.49	1.49	1.00	0.50	1.00
		45-150	45.45	3.74	3.74	2.67	2.14	26.74	6.42	3.74	1.60	0.53	1.07	0.53	0.53	0.53	0.53
VI	16	0-20	39.72	4.21	3.27	4.67	1.40	24.77	7.01	3.74	4.21	0.93	2.34	1.40	0.93	0.47	0.93
		20-45	41.47	6.91	4.15	3.69	1.38	25.35	4.61	1.84	3.69	0.46	2.30	1.38	1.38	0.46	0.92

The microscopical examination shows that opaque minerals in the soils under consideration vary between 33.98 % in the deepest layer of profile 6 and 45.45 % in the deepest layer of profile 15. Opaque minerals are represented by the highest content of heavy minerals or predominant constituents in the studied soils.

Contents of opaque minerals in soils of the first unit vary between 34.09 % in the surface layer of profile 5 and 41.45 % in the same layer of profile 1 and tend to increase with depth without regarding to the surface layer of profile 1.

Soils of the second unit vary in their contents of opaque minerals from 33.98 to 42.21 % of the total heavy minerals and tend to increase with depth in profile 8, except deepest layer, while soil profile 6 appears a decrease trend except surface layer.

Concerning the soils of the third unit, opaque minerals contents vary from 35.55 to 39.53 % of the total heavy minerals, with an increase with depth.

With regard to the soils of unit 4, opaque minerals contents change from 37.57 to 41.67 %, and they decrease with depth.

Soils of the fifth unit, has a relatively high average content of opaque minerals, which vary between 39.44 and 45.45 % of total heavy minerals, and it tends to increase with depth.

Concerning the soils of unit 6, opaque minerals record 39.72 % in the surface layer and 41.47 % in the subsurface one, which show an increase with depth in the representative profile.

Generally, the distribution of opaque minerals, increasing with depth, may be reflecting the effect of pedogenic processes.

- **Amphiboles group:**

The common minerals of this group consideration are hornblend, actinolite and tremolite. The microscopical examination reveals that the amphiboles minerals range from 2.3 to 8.48 % of total heavy minerals.

Amphiboles content in the soils of the first unit ranges between 4.66 and 7.69 % of total heavy minerals. They tend to increase with depth, except the deepest layer of both representative profiles 1 and 5. Amphiboles constitute in the second unit, which represented with profiles 6 and 8, and range between 2.3 and 8.48 % of total heavy minerals, with no specific trend. Concerning the unit 3, which has the lower contents of amphiboles (3.65–4.65 % of total heavy minerals) and has no trend with depth. The soils of unit 4, which represented by profile 12, contain amphiboles range between 4.59 and 5.78 %. This unit does not appear distribution trend through soil profile. Amphiboles content in the fifth unit ranges between 3.48 and 3.74 % of total heavy minerals, with trend of homogeneity distribution through the representative profile. Data of amphiboles content in the unit 6 are 4.21 % in the surface layer and 6.91 % in the deepest one of total heavy minerals, with an increase trend with depth.

- **Pyroxenes group:**

Augite, hypersthene, enstatite and dioposide represent minerals of this group. Data of Table (15) reveal that total pyroxenes contents change from 1.72 to 5.78 % of total heavy minerals. In soils of unit 1, they vary between 2.03 and 4.55 % of total heavy minerals contents which tend to decrease with depth. Concerning the soils of second unit, which they range between 1.72 and 4.61 %. The distribution of pyroxenes minerals does not appear any trend through the representative profiles. Pyroxenes contents in the soils of the third unit range between 2.33 and 4.74 % of total heavy minerals and tend to decrease with depth. In the soils of the fourth unit, pyroxenes vary from 2.08 to 5.78 % of total heavy minerals. The vertical distribution indicate an increase with depth trend. With regard to the fifth unit, pyroxene contents are 3.29 and 3.98 % of total heavy minerals, and appear a homogenous distribution with depth. The six unit contains pyroxene minerals 3.27 % in the surface layer and 4.15 % in the subsurface one of total heavy minerals, which indicate an increase with depth.

➢ Epidots:

Epidots content varies between 1.89 and 8.60 % of total heavy minerals. Soils of the first unit have a relatively high content of Epidots and appears a content ranges between 2.54 and 8.60 % and tends to decrease with depth, except in deepest layer of profile 2. Epidots in soils of the second unit range from 1.89 to 5.19 %, and tend to decrease with depth in soil profile 6, an opposite trend is noticed in soil of profile 8, with exception of surface layers of both profiles. Soil profile 11 in the third unit shows that epidots content varies between 3.26 and 4.74 % and decreasing with depth. Epidots in the fourth unit range between 3.65 and 6.88 % of total heavy minerals, while they vary between 2.35 and 3.98 % of total heavy minerals in the fifth unit. The last unit appears epidots content 4.67 % in the surface layer and 3.69 % of deepest one.

➢ Biotite:

Biotite contents vary between nil and 6.16 % of total heavy minerals. The first unit contains biotite between 2.03 and 4.52 % of total heavy minerals, it tends to decrease with depth in soil of profile 1 and to be homogeneous in soil of profile 2. The second unit appears biotite contents of nil to 4.85 % of total heavy minerals, without a specific trend. Soils of the third unit have higher biotite contents, which vary between 3.65 and 6.16 % of total· heavy minerals. Biotite contents in the unit 4 range from 2.08 to 4.62 % of total heavy minerals, with an increase with depth trend. Soils of unit 5 contain biotite content of 1.99 - 3.29 %. Contents of biotite in the surface layer of profile 16 is 1.4 %, while in the subsurface one records 1.38 % of total heavy minerals in last unit.

➢ Zircon:

Zircon contents represent the second abundant minerals after opaques, which vary between 20.23 and 28.74 % of total heavy minerals. The first unit attains zircon contents range from 20.45 to 25.38 % of total heavy minerals, with an increase with depth. Zircon content in second unit is 21.53 and 28.74 % of total heavy minerals. It tends to increase with depth and varies between 21.33 and 23.26 % of total heavy minerals in soils of unit 3. Zircon content appears an opposite trend in the fourth unit, with regards to the previous unit and varies between 20.23 and 26.04 % of total heavy minerals. Soils of fifth unit have zircon contents between 25.82 and 26.74 % of total heavy minerals, with an increase with depth trend. Contents of zircon in unit 6 are 24.77 % in the surface layer and 25.35 % in the subsurface one.

➢ **Rutile:**

Rutile mineral content follows zircon pattern and range between 3.62 and 11.51 % of total heavy minerals. In the first unit, it varies between 3.62 and 7.18 %. Rutile content in the second unit ranges from 5.84 and 11.5 % of total heavy minerals, with a relatively high rutile content. Soils of the third unit have rutile content of 5.94 - 7.91 % of total heavy minerals. Rutile content in the unit 4 varies from 6.88 to 8.67 % of total heavy minerals. The fifth unit has rutile contents of 6.42 - 7.04 % of total heavy minerals. Content of rutile in the unit 6 is 7.01 % in the surface layer and 4.61 % of total heavy minerals. The contents of rutile tend to decrease with depth in both two last units of 5 and 6.

➢ **Tourmaline:**

Tourmaline mineral follows rutile in its contents, where it varies between 1.36 and 9.35 % of total heavy minerals. Tourmaline content in the first unit ranges from 1.36 to 9.35 % of total heavy minerals. The second unit appears tourmaline content of 1.95 - 9.09 % of total heavy minerals. Contents of tourmaline in the third unit are 4.19 and 5.94 % of total heavy minerals. The fourth unit contains tourmaline content of 4.59 - 5.21 % of total heavy minerals. Tourmaline contents in unit 5 are 3.74 and 4.69 % of total heavy minerals. In unit 6, tourmaline content in the surface layer is 3.74 %, while in the deep layer is 1.84 % of total heavy minerals. Tourmaline contents tend to decrease with depth in both units 5 and 6.

➢ **Garnet:**

Garnet content in the studied soils varies between 1.04 and 4.55 % of total heavy minerals. Garnet in the first unit ranges from 1.04 to 4.55 % of total heavy minerals. Profile 1 has the lower contents, which tend to increase with depth. On the other hand, soil of profile 5 has higher garnet contents. The second unit appears garnet content between 1.46 and 3.57 % of total heavy minerals. Garnet content in unit 3 ranges between 3.32 and 3.72 % of total heavy minerals and it tends to increase with depth. The contents of garnet in unit 4 are 1.56 and 2.29 % of total heavy minerals. The unit 5 contains garnet from 1.60 to 2.35 % of total heavy minerals, which decrease gradually with depth. Garnet content is 4.21 % in the surface layer and 3.69 % in the subsurface layer in unit 6, with decreasing contents with depth.

➢ **Other heavy minerals:**

Other heavy minerals represent a trace constituent. Kyanite mineral ranges from 0.46 to 1.26 % of total heavy minerals in the studied soil. Staurolite mineral varies from 0.96 and 4.19 % of total heavy minerals, which tends to decrease with depth in units 5 and 6. Silimonite mineral content is between 0.48 and 2.52 % of total heavy minerals, with decreasing trend with depth in units 3 and 6, while an opposite trend is noticed in unit 4. Contents of andalusite mineral vary between 0.47 and 1.89 % of total heavy minerals and tend to decrease with depth in units 3 and 5, while unit 6 appears an opposite trend. Monazite mineral in the studied soils ranges from nil to 1.38 % of total heavy minerals, which tends to decrease with depth in profiles 1 and 16, while profiles 2 and 15 show an opposite trend. Other minerals cannot be identified in the studied slights between nil and 1.88 %.

4.5.2. Mineralogy of light minerals:

Light minerals have a specific gravity less than 2.85 g/cm^3. The light minerals are almost entirely composed of quartz and feldspars. The frequency distribution of light minerals presented in Table (16).

Table (16): Frequency distribution of light minerals of sand fraction. (0.063-0.125 mm) in the representative soil profiles.

Tax. Unit	Profile No.	Depth (cm)	Quartz (%)	Feldspars (%)			
				Orthoclase	Plagioclase	Microcline	Total
I	1	0-25	95.5	1.5	1.5	1.5	4.5
		25-80	97.0	1.0	1.0	1.0	3.0
		80-150	96.0	1.0	1.5	1.5	4.0
	5	0-30	96.5	1.0	1.0	1.5	3.5
		30-70	96.0	1.0	1.5	1.5	4.0
		70-150	97.0	1.0	1.0	1.0	3.0
II	6	0-20	96.0	1.0	1.5	1.5	4.0
		20-40	95.0	1.5	2.0	1.5	5.0
		40-70	96.0	1.0	1.5	1.5	4.0
		70-150	96.5	1.0	1.5	1.0	4.0
	8	0-30	97.5	1.5	0.5	0.5	2.5
		30-50	96.5	1.0	0.5	2.0	3.5
		50-80	96.5	1.0	1.0	1.5	3.5
		80-150	97.0	1.0	1.0	1.0	3.0
III	11	0-40	95.5	1.0	2.0	1.5	4.5
		40-80	95.5	1.5	1.5	1.5	4.5
		80-150	96.0	1.5	1.5	1.0	4.0
IV	12	0-10	96.5	1.0	1.5	1.0	3.5
		10-30	97.0	1.0	1.0	1.0	3.0
		30-150	97.5	1.0	0.5	1.0	2.5
V	15	0-20	96.5	1.0	1.5	1.0	3.5
		20-45	96.0	1.0	2.0	1.0	4.0
		45-150	96.0	1.5	1.0	1.5	4.0
VI	16	0-20	96.0	1.5	1.0	1.5	4.0
		20-45	96.0	1.5	1.5	1.0	4.0

- **Quartz:**

According to **Pettijohn (1984)**, quartz is the most prolitic constituent of detrital sediments. Its detailed study in the light portion of the sediment is of great consequence by their nature and abundance frequently valuable indices of provenance.

Data of quartz contents in soils of the first unit vary between 95.5 and 97.0 % of the total light minerals. Content of quartz, in the second unit, ranges between 95.0 and 97.5 % of the total light minerals. In the third unit, percentages of quartz range between 95.5 and 96.0 % of the total light minerals. As for the fourth unit, quartz content varies between 96.5 and 97.5 % of the total light minerals. Quartz content in the soil profile layers of the fifth unit differs from 96.0 to 96.5 % of the total light minerals. In the six unit, quantity of quartz is 96.0 % of the total light minerals in both layers. These data pointed to a tend of homogeneity distribution of quartz through soils of the studied area.

- **Feldspars:**

Feldspar minerals, which find in the soil under consideration, are orthoclase, plagioclase and microcline. The distribution of these minerals is found in Table (16), and its contents were 1.0–1.5, 0.5–2.0 and 0.5–2.0 % of total light minerals, respectively. Data of feldspars minerals content appear as a trace constituent of the total light minerals, according to **Hassona (1989)**, the presence of feldspars could be taken as indication of weathering prevailing during soil formation and evolution, which is not so drastic to cause a complete decay of these minerals susceptible to weathering.

4.5.3. Uniformity, maturity and origin of soil materials:

According to **Pettijohn (1984)** the mineral's stability is resistance to alteration, solution and chemical decomposition. All minerals are not equally immune to solute and decay. **Haseman and Marshall (1945)**, **Brewer (1955)** and **Barshad (1964)** found that the minerals assemblages as well as the distribution of the resistant and susceptible minerals to weathering and their ratios are used to evaluate the origin and uniformity of soil profiles. In this respect, the ratios recommended by **Haseman and Marshall (1945)** Zircon / Tourmaline, Zircon / Rutile, Zircon / Rutile + Tourmaline are taken as criteria for investigating profiles uniformity, while Amphibole + Pyroxene / Zircon + Tourmaline and Biotite / Zircon + Tourmaline are taken as criteria for investigating soil development.

Regardless of the contents of opaque minerals, data in Table (17) reveal to the resistant minerals (zircon, rutile and tourmaline) are the abundant minerals at different units of the studied area, while pyroboles (pyroxenes + amphiboles), epidotes and other heavy minerals are found in less pronounced amounts. On the other hand, opaque minerals were less abundance comparatively with different soils of Egypt equally desert or alluvial soils (generally more than 50 %). These findings could lead to conclude that the dominance of resistant minerals is due to the effect of weathering processes and supposition decay of amphiboles, pyroxenes and epidotes. As well as, the nearly similar values of ultra stable minerals reveal to uniformity of parent material throughout the studied soil profiles. **Folk (1961)** mentioned that ultra – stable group are zircon, tourmaline and rutile; because the first two are very hard and inert (even more than quartz). They can survive many reworking. When old sediments are reworked to form younger ones, zircon and tourmaline are about the only ones that can survive. An abundance of tourmaline and zircon in heavy suite then means either: 1) prolonged abrasion and / or chemical attack has occurred or 2) the minerals are being reworked from older sediments.

Marshall and Haseman (1943) and Barshad (1964) cleared that the constancy of a trend of index minerals throughout the profile layers or horizons, indicated by their percentage of the ratios between two index minerals, suggested uniformity of parent material. Moreover, amphiboles and pyroxenes are readily susceptible to weathering and decay, thus, their frequencies give indication of the presence or absence of recent deposition and / or degree of soil development.

Table (17): Uniformity and weathering ratios of the studied soil profiles.

Tax. Unit	Profile No.	Depth (cm)	Z/R	Z/T	Z/(R+T)	Wr_1	Wr_2
I	1	0-25	3.46	3.22	1.67	0.24	0.14
		25-80	3.57	2.50	1.47	0.27	0.10
		80-150	3.57	2.94	1.61	0.22	0.06
	5	0-30	3.00	5.62	1.96	0.47	0.19
		30-70	2.86	5.00	1.82	0.48	0.17
		70-150	6.25	16.63	4.54	0.36	0.19
II	6	0-20	2.63	7.13	1.92	0.44	0.09
		20-40	4.45	13.32	3.33	0.28	0.09
		40-70	2.90	6.11	1.96	0.41	0.08
		70-150	2.63	5.55	1.79	0.41	0.17
	8	0-30	2.50	3.85	1.51	0.11	0.00
		30-50	2.69	3.89	1.59	0.32	0.05
		50-80	2.37	2.37	1.18	0.23	0.11
		80-150	2.63	2.94	1.39	0.21	0.06
III	11	0-40	3.00	4.50	1.80	0.33	0.24
		40-80	3.84	3.84	1.92	0.24	0.13
		80-150	2.94	5.55	1.92	0.25	0.14
IV	12	0-10	3.33	5.00	2.00	0.22	0.07
		10-30	3.33	5.00	2.00	0.25	0.13
		30-150	2.33	4.38	1.52	0.47	0.19
V	15	0-20	3.67	5.51	2.20	0.23	0.11
		20-45	3.78	5.89	2.30	0.24	0.06
		45-150	4.17	7.15	2.63	0.25	0.07
VI	16	0-20	3.53	6.62	2.30	0.26	0.05
		20-45	5.50	17.13	4.16	0.41	0.05

Wr1 = (A+P)/(Z+T)
Wr2 = B/(Z+T)

P = Pyroxines
A = Amphiboles

R = Rutile
Z = Zircon

T = Tourmalin
B = Biotite

Generally, data in Table (17) and figure (24) , which clear the ratios of zircon / rutile, zircon / tourmaline and zircon / rutile + tourmaline, show homogeneity and uniformity of parent material through the studied profiles in the studied area, with regardless of some scattering values. The weathering values of amphiboles + pyroxenes / zircon + tourmaline and biotite / zircon + tourmaline, in Table (17), and figure (25) indicate that the studied soils have degree of soil development or could be taken as indication of old pedological history, due to the poorly contents of pyroboles (pyroxenes and amphiboles) or biotite rather than the most resistant minerals at different layers of the studied soil profiles under consideration.

Examination of heavy and light minerals by using polarizing microscope reveals a very high relief and many well-rounded grains of zircon and tourmaline, as well as other heavy minerals, and so, quartz grains tend to be rounded.

According to **Pettijohn (1984)**, if heavy minerals are newly derived from crystalline rocks, they are little worn. Cleaved fragments and more or less enhedral crystals characterize the assemblage. If, however, the heavies are derived from earlier sediments, the less stable species tend to be absent and the more stable survivors show notable rounded. They also, added that time or duration is determined largely by relief. Rapidity of erosion is a function of relief. High relief promotes high rate of erosion, whereas low relief is associated with a retarded rate of erosion. On the basis of these statements, the soil under consideration show that, a high rate of erosion due to the studied minerals have high and very high relief.

Ingerson and Ramisch (1942) observed that quartz grains of igneous and metamorphic rocks, even those of granites, tended to be elongated and that such elongation was commonly parallel to the C– axes, an expression of the prismatic habit of quartz, therefore is an expression of its initial shape.

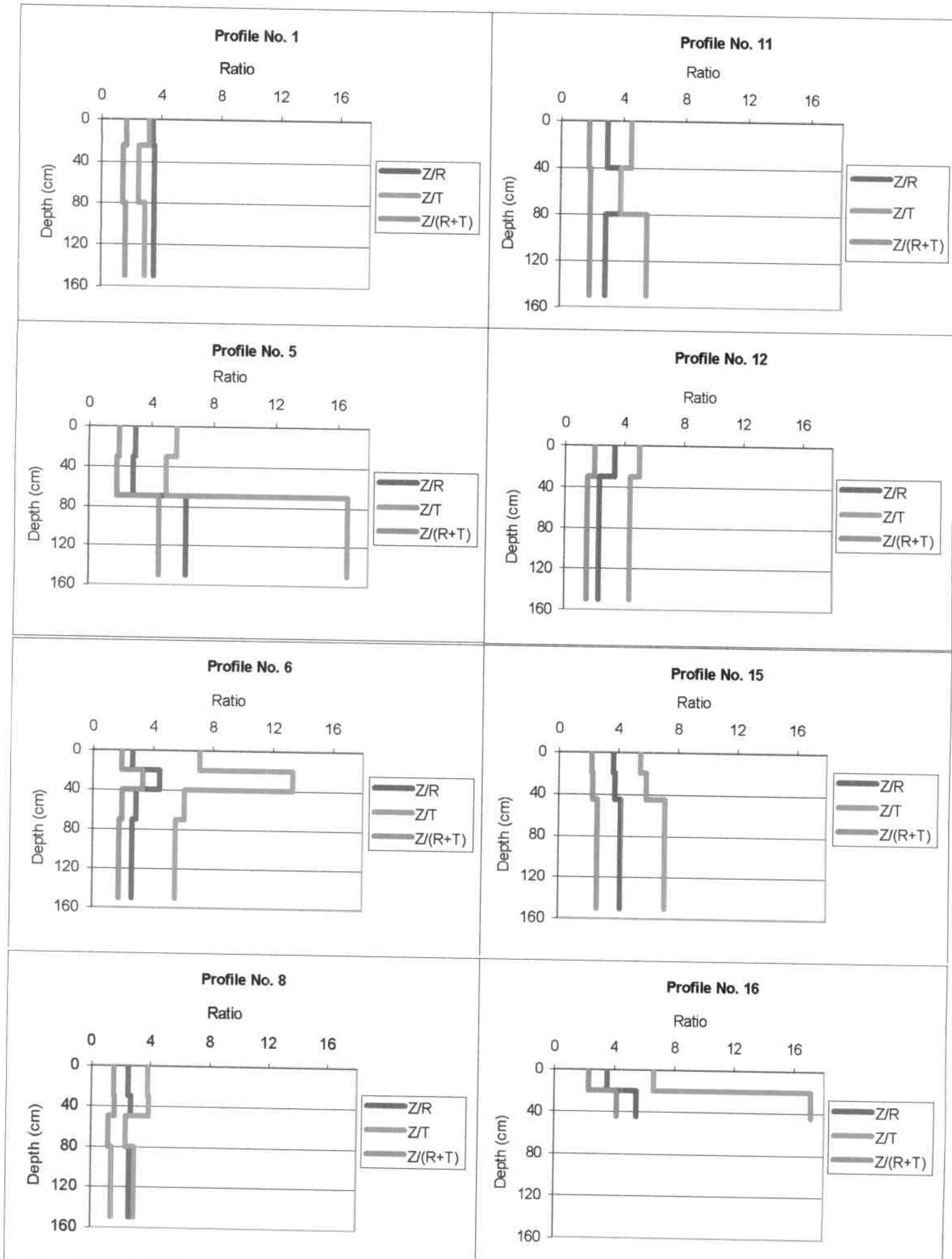


Fig. (24): Depthwise distribution of resistant mineral ratio in the studied area.

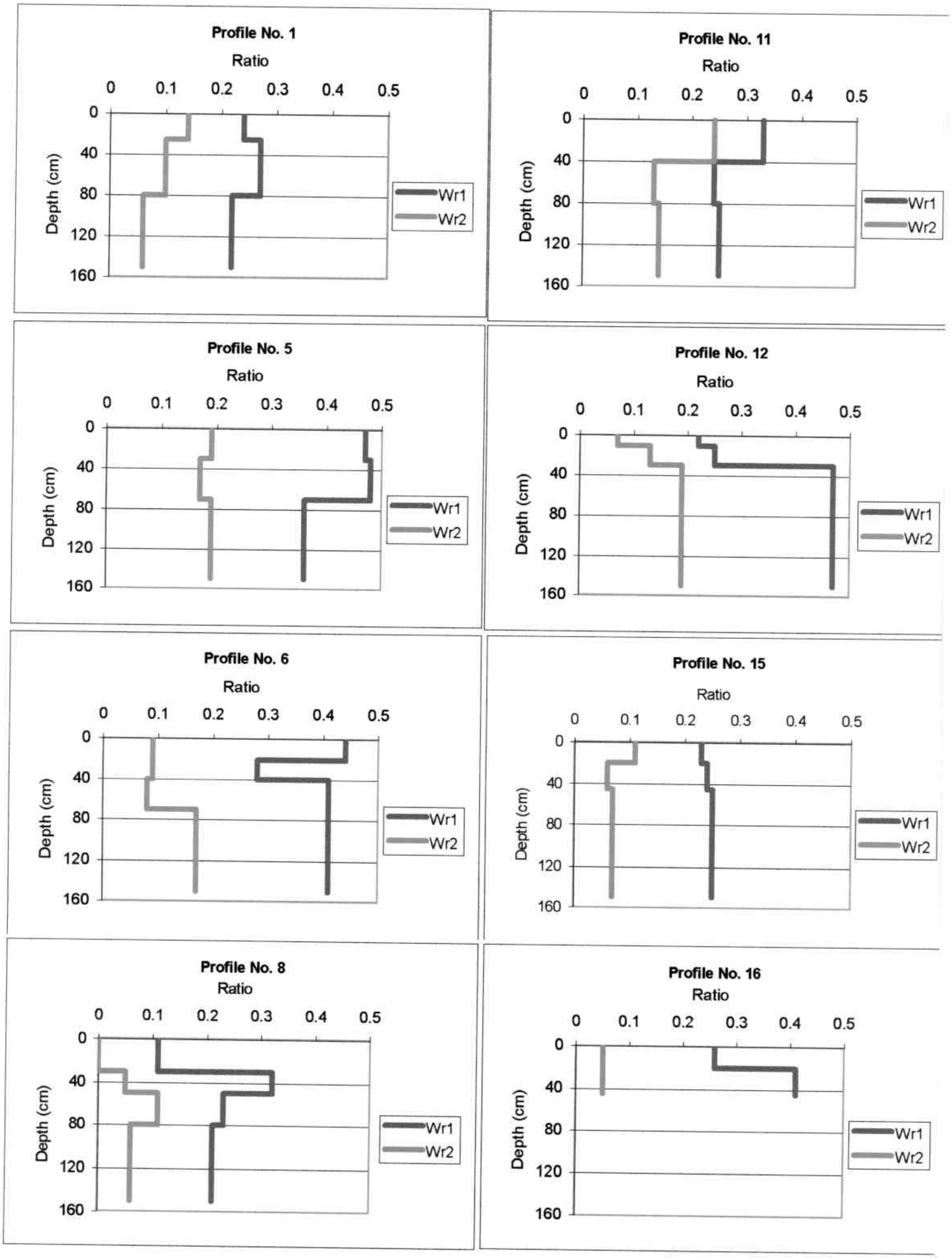


Fig. (25): Depthwise distribution of weathering ratio in the studied area.

According to **Pettijohn (1984)**, it is obviously important to know if sediment is a first – cycle sediment derived from a crystalline rock or whether it is second – cycle and derived from earlier sediments. The distinction between a first – cycle sediment and a second – cycle sediment is fundamental but is a distinction difficult to make in very mature sediments such as arkosic sands are apt to be first – cycle sediment. The quartz of first – cycle sands is apt to be angular, although some may be rounded because of resorption in the magma or to corrosion in the weathering profile. Rounded overgrowth on the quartz is proof of a second – cycle origin.

Crook (1968) and Cleary and Conolly (1971) stated that quartz is not wholly insoluble and under certain conditions, as in some soils, shows marked corrosion and rounding. **Sloss and Feray (1948)** mentioned that within sandstone, however, it is not only stable but tends to grow, as secondary outgrowth proves. It is notably more stable than chert, which is commonly subject to the intrastratal solution.

According to **Pettijohn (1984)**, the heavy mineral suite has , then, proved a useful guide to the type of source rock from which the sand was derived. Quartz, especially with worn overgrowths, rutile, rounded tourmaline and rounded zircon reveal to reworked sediments.

From the previous observations, constituents of heavy and light minerals and reviews that the parent material or source rock of the studied area is reworked sediments.

4.6 Land Evaluation

Different properties of soils under consideration are prosed for **Sys and Verheye system (1978)** and the results of soil evaluation data are illustrated in Table (18). Soil texture is considered the main limiting factor for the different taxonomic units of the studied area, in addition to shallow depth in soils of the sixth unit. The soils of the studied area are belonging the S3 category (marginally suitable), which falls within a rating (Ci) of 50-25, except some representative profiles, i.e., 10 and 13 which their current suitability is N1 (not suitable) and have severe or very severe limitation that can be corrected. Whereas,

Table (18): Rating of suitability index after Sys and Verheye system for the studied soil profiles.

Tax. unit	Profile No.	Topography	Wettness	Texture	Depth	$CaCO_3$	Gypsum	Salinity & Alkalinity	Suitability		
									Ci	Order	Class
I	1	100	100	30.0	100	95	100	100	28.50	S	S3
	2	100	100	30.0	100	95	100	100	28.50	S	S3
	3	100	100	30.0	100	95	100	100	28.50	S	S3
	4	100	100	30.0	100	95	100	100	28.50	S	S3
	5	100	100	30.0	100	96	100	100	28.50	S	S3
II	6	100	100	30.0	100	96	100	100	28.50	S	S3
	7	100	100	30.0	100	97	100	100	29.10	S	S3
	8	100	100	30.0	100	97	100	100	29.10	S	S3
III	9	100	100	29.6	100	97	100	100	28.71	S	S3
	10	100	100	25.0	100	96	100	100	24.00	N	N1
	11	100	100	28.0	100	97	100	100	27.16	S	S3
IV	12	100	100	30.0	100	100	100	100	30.00	S	S3
	13	100	100	25.0	100	98	100	95	23.28	N	N1
V	14	100	100	27.4	100	98	100	100	26.85	S	S3
	15	100	100	28.2	100	99	100	100	27.92	S	S3
VI	16	100	100	25.0	55	98	100	100	13.48	N	N2

soils of the sixth unit (profile 16) are evaluated as N2, which have severe or very severe limitations that can not be corrected, i.e., coarse texture and shallow soil depth.

4.7 Land suitability for certain crops

Crops requirements were studied according to **Sys et. al., 1993** for different studied taxonomic units, which involved climate, landscape and soil conditions. Data of Table (19) show the rating values, suitability indices and classes of the representative soil profiles as follow:

- Soils of the first unit appear a current suitable for crops can be arranged according their descending suitability into fruits of: olive, citrus, guava, tomato and mango from fruits ; field crops of sesame, cotton, castor beans, millets, cowpea, maize, sunflower, pea, sorghum, safflower, groundnut, alfalfa and soya; vegetables of watermelon, green pepper, onion, carrots, cabbage and sweet potato
- The current suitable crops for the soils of the second unit are as follow: fruits of olives, citrus, guava, mango and tomato from fruits; field crops of sesame, safflower, castor beans, cotton, millets, maize, cowpea, sunflower, sorghum, alfalfa, pea and soya; vegetables of: watermelon, green pepper, carrots, cabbage, sweet potato and onion.
- Soils of the third taxonomic unit show that olive also is the best fruit crop followed by citrus, tomato, mango and guava. Safflower is more suitable field crop and followed by cotton, sorghum, sesame, castor beans, millets, maize, sunflower, cowpea, pea, alfalfa and groundnut. While watermelon too is the more suitable vegetable crop followed by green pepper, carrots, cabbage, onion and sweet potato.
- The highly suitable crops for soils of the fourth taxonomic unit are: fruits of olives, citrus, guava, tomato and mango; field crops of safflower, sesame, sorghum, cotton, castor beans, millets, groundnut, maize, sunflower, cowpea and alfalfa; vegetables of watermelon, cabbage, green pepper, onion and carrots.

Table (19) : The suitable crops for the studied soils units after Sys et al. (1993).

Unit I			Unit II			Unit III			Unit IV			Unit V		
Crop	Ci	Order	Crop	Ci	Order	Crop	Ci	Order	Crop	Ci	Order	Crop	Ci	Order
Olive	80.7	S1	Olive	77.5	S1	Olive	72.9	S2	Water melon	66.7	S2	Olive	66.6	S2
Water melon	74.7	S2	Water melon	64.6	S2	Water melon	57.1	S2	Olive	66.6	S2	Water melon	53.2	S2
Citrus	67.7	S2	Citrus	53.7	S2	Green pepper	49.1	S3	Safflower	49.6	S3	Safflower	39.9	S3
Green pepper	66.8	S2	Green pepper	52.6	S2	Citrus	45.7	S3	Sesame	47.5	S3	Sesame	38.1	S3
Onion	65.8	S2	Sesame	52.2	S2	Safflower	42.2	S3	Sorghum	46.3	S3	Sorghum	37.1	S3
Carrots	65.1	S2	Safflower	51.4	S2	Cotton	40.3	S3	Cotton	46.1	S3	Cotton	37.0	S3
Sesame	53.7	S2	Castor beans	50.0	S2	Sorghum	40.1	S3	Castor beans	45.6	S3	Castor beans	36.5	S3
Cotton	52.6	S2	Cotton	49.1	S3	Sesame	40.0	S3	Millets	43.6	S3	Citrus	35.6	S3
Castor beans	52.3	S2	Millets	48.8	S3	Carrots	39.2	S3	Ground nuts	43.2	S3	Green pepper	35.6	S3
Millets	51.2	S2	Guava	48.0	S3	Castor beans	39.0	S3	Cabbage	42.5	S3	Millets	34.7	S3
Cabbage	50.6	S2	Maize	47.5	S3	Cabbage	37.8	S3	Citrus	42.4	S3	Cabbage	34.0	S3
Guava	50.5	S2	Cow pea	47.5	S3	Millets	37.8	S3	Green pepper	42.4	S3	Maize	33.3	S3
Cow pea	50.1	S2	Sunflower	47.5	S3	Onion	37.5	S3	Maize	41.5	S3	Sunflower	33.3	S3
Maize	50.1	S2	Sorghum	47.3	S3	Maize	36.7	S3	Sunflower	41.5	S3	Cow pea	32.8	S3
Sunflower	50.1	S2	Carrots	46.7	S3	Sunflower	36.7	S3	Cow pea	41.0	S3	Sweet potato	31.5	S3
Pea	49.6	S3	Cabbage	45.3	S3	Cow pea	36.7	S3	Sweet potato	39.3	S3	Pea	31.0	S3
Sorghum	48.8	S3	Mango	44.7	S3	Sweet potato	34.7	S3	Guava	39.1	S3	Carrots	30.6	S3
Sweet potato	48.7	S3	Tomato	42.9	S3	Tomato	34.2	S3	Pea	38.8	S3	Guava	30.3	S3
Tomato	48.2	S3	Sweet potato	40.7	S3	Pea	33.8	S3	Onion	36.7	S3	Onion	30.3	S3
Mango	47.8	S3	Onion	38.6	S3	Mango	33.1	S3	Carrots	36.4	S3	Alfalfa	28.5	S3
Safflower	46.0	S3	Alfalfa	38.0	S3	Alfalfa	31.5	S3	Alfalfa	35.4	S3	Tomato	26.2	S3
Ground nuts	42.5	S3	Pea	34.0	S3	Guava	31.0	S3	Tomato	31.0	S3	Mango	25.5	S3
Alfalfa	42.2	S3	Soya	27.0	S3	Ground nuts	25.6	S3	Mango	30.3	S3			
Soya	30.5	S3							Soya	25.5	S3			
Chick beans	29.5	S3												

➢ Soils of the fifth unit show suitable fruits of: olives, citrus, guava, tomato and mango; field crops of safflower, sesame, sorghum, cotton, castor beans, millets, maize, sunflower, cowpea, pea and alfalfa; vegetables of watermelon, green pepper, cabbage, sweet potato, carrots and onion.

According to Fathy et. al. (1979, Arabic reference), soil characteristics of sandy texture, loose structure, very deep depth and climatic conditions of Egypt are more suitable for the palm date trees than other crops.

4.8 Consumptive use

Irrigation water is one of the most limiting factors, which face the horizontal agricultural expansion in Egypt. So, the optimum use for irrigation water and delineation of water requirements for each crop separately is very important in this field. Water consumptive use is considered an effective tool in the crop water requirement equation, irrigation planning and water management decisions. The climatological data which concerning the monthly air temperature, precipitation, relative humidity, evaporation and sunshine hours are presented and illustrated in Tables (1 and 20) and, these data used to calculate the reference crop evapotranspiration (ET_o). The seasonal reference evapotranspiration values according to **Doorenbos and Pruitt (1977)** equation are summarized in Table (20) and Fig. (26), which indicate a gradually increase from January to July and opposite trend is observed till the end of year. Inspection of this curve shows that the maximum amount of water required is 8.9 mm/day in June and July, this is corresponded to the period of maximum air temperature, while the minimum one is 3.7 mm/day, which records in January and December, which is corresponded with the period of minimum air temperature.

The consumptive use (mm/season & m^3/fed.season) for selected best crops are calculated and reported in Tables (21 to 23). The data of fruit crops are 8527.3, 8527.3, 5015.6, 6859.4, 5439.1 and 2039.5 m^3/fed./season for guava, mango, olive, citrus, palm and tomato, respectively. The consumptive use of field crops is 5942.6, 3103.8, 3203.8, 1754.3 and 4505.8 m^3/fed./season for

Table (20): Reference evapotranspiration (ETo) of the studied area by using radiation method.

DATA	Jan.	Fep.	Mar.	Apr.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Adjustment factor (C)	0.85	0.85	0.85	0.92	0.92	0.92	0.92	0.92	0.92	0.85	0.85	0.85
Weight Factor for radiation effect (w)	0.95	0.61	0.68	0.73	0.77	0.78	0.78	0.78	0.76	0.74	0.66	0.61
Extraterrestrial radiation(Ra) mm/day.	9.80	11.50	13.70	15.30	16.40	16.70	16.60	15.70	14.30	12.30	10.30	9.30
Maximum possible sunshine (N) h/day.	10.70	11.30	12.00	12.70	13.30	13.70	13.50	13.00	12.30	11.60	10.90	10.60
Mean actual sunshine (n) h/day.	10.60	11.40	12.00	12.70	13.20	13.50	13.40	12.90	12.30	11.60	11.10	10.80
Mean incoming shortwave radiation (Rs) mm/day.	7.30	8.70	10.30	11.50	12.20	12.40	12.40	11.70	10.70	9.20	7.80	7.10
ETo mm/day	3.70	4.50	6.00	7.70	8.60	8.90	8.90	8.40	7.50	5.80	4.40	3.70

ETo= c (w * Rs)

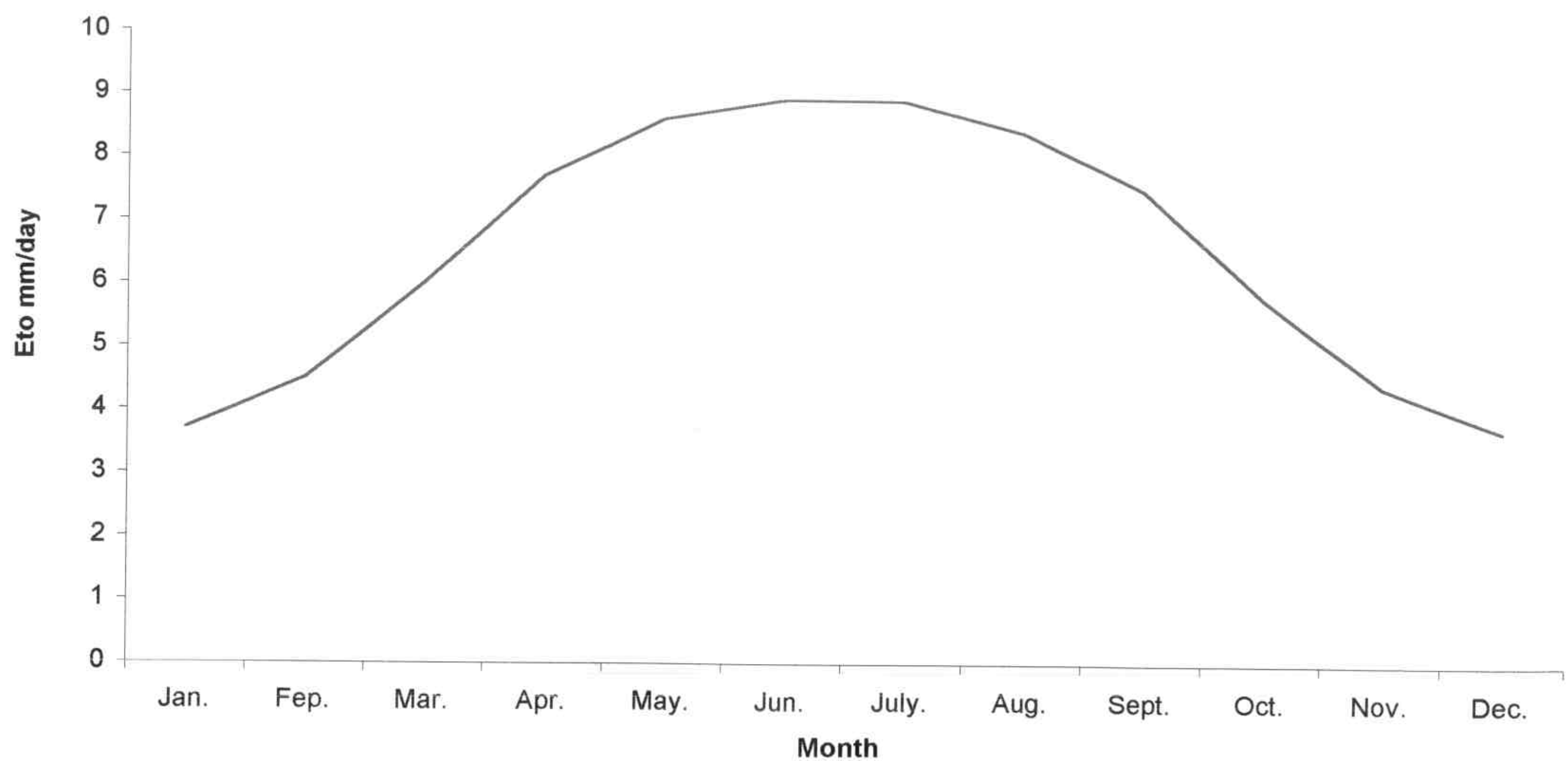


Fig. (26): Seasonal consumptive use (Eto) for the studied area.

Table(21): Calculated consumptive use for some selected fruits crops .

Month	Guava		Mango		Olive		Cetrus		Palm		Tomato	
	All year		All year		All year		All year		All year		1/9 - 3/1	
	K_C	ET_C	K_C	ET_C	K_C	ET_C	K_C	ET_C	K_C	ET_C	K_C	ET_C
Jan.	0.85	97.60	0.85	97.60	0.50	57.40	0.75	86.10	0.43	57.30	0.50	5.60
Feb.	0.85	114.80	0.85	114.80	0.50	67.50	0.75	101.30	0.43	67.30		
Mar.	0.85	158.10	0.85	158.10	0.50	93.00	0.70	130.20	0.43	97.30		
Apr.	0.85	196.40	0.85	196.40	0.50	115.50	0.70	161.70	0.43	126.40		
May	0.85	226.60	0.85	226.60	0.50	133.30	0.70	186.60	0.43	148.00		
June	0.85	227.00	0.85	227.00	0.50	133.50	0.65	173.60	0.43	156.10		
July	0.85	234.60	0.85	234.60	0.50	138.00	0.65	179.40	0.43	148.00		
Aug,	0.85	221.30	0.85	221.30	0.50	130.20	0.65	169.30	0.43	138.60	0.45	101.30
Sep.	0.85	191.30	0.85	191.30	0.50	112.50	0.65	146.30	0.43	129.00	0.75	134.90
Oct.	0.85	152.80	0.85	152.80	0.50	89.90	0.70	125.90	0.43	102.60	1.15	151.80
Nov.	0.85	112.20	0.85	118.20	0.50	66.00	0.70	92.40	0.43	68.40	0.85	97.60
Dec.	0.85	97.60	0.85	97.60	0.50	57.40	0.70	80.40	0.43	56.00		
Seasonal ET_0 (mm)		2030.30		2030.30		1194.20		1633.20		1295.00		485.60
(m^3/fed)		8527.30		8527.30		5015.60		6859.40		5439.10		2039.50

ET_c = Crop evapotranspiration = Kc * ET_o

ET_o = Referance evapotranspiration.

Kc = Crop Coefficient.

Table(22): Calculated consumptive use for some selected field crops .

Month	Cotton		Sunflower		Ground nut		Sesame		Maize	
	1/2-13/8		15/4-15/8		15/4-15/8		1/5-31/7		5/4-13/8	
	KC	ETC	KC	ETC	KC	ETC	KC	ETC	KC	ETC
Jan.										
Feb.	0.50	67.50								
Mar.	0.80	148.80								
Apr.	0.80	184.80	0.30	34.70	0.40	46.20			0.50	96.30
May	1.25	333.30	0.70	186.60	0.70	186.60	0.40	106.60	0.85	226.60
June	1.25	333.80	1.05	280.40	0.95	253.70	0.70	186.90	1.20	320.40
July	0.90	248.40	0.70	193.20	0.75	207.00	0.45	124.20	1.20	331.20
Aug,	0.90	98.30	0.35	44.10	0.55	69.30			0.90	98.30
Sep.										
Oct.										
Nov.										
Dec.										
Seasonal ET_0 (mm)		1414.9		739		762.8		417.7		1072.8
(m^3/fed)		5942.6		3103.8		3203.8		1754.3		4505.8

ET_c = Crop evapotranspiration = Kc* Eto

ET_o = Referance evapotranspiration.

Kc = Crop Coefficient.

Table(23): Calculated consumptive use for some selected vegetables crops .

Month	Water melon		Green pepper		Carrot		Cabbage		Onion	
	15/1-3/5		1/2-5/6		10/7-19/10		1/7-24/10		15/8-5/12	
	K_C	ET_C	K_C	ET_C	K_C	ET_C	K_C	ET_C	K_C	ET_C
Jan.	0.50	27.80								
Feb.	0.80	108.00	0.40	54.00						
Mar.	1.05	195.30	0.95	176.70						
Apr.	1.05	242.60	1.10	254.10						
May	0.50	12.90	0.95	253.30						
June			0.95	42.30						
July					0.75	140.20	0.45	124.20		
Aug,					0.90	234.40	0.75	195.30	0.40	50.40
Sep.					1.10	247.50	1.03	231.80	0.70	157.50
Oct.					0.80	88.20	0.95	132.20	0.95	170.80
Nov.									0.85	112.20
Dec.									0.75	13.90
Seasonal ET_0 (mm)		586.6		780.4		710.3		683.5		504.8
(m^3/fed)		2463.7		3277.7		2983.3		2870.7		2120.2

ETc = Crop evapotranspiration = Kc * Eto

ET_o = Referance evapotranspiration.

Kc = Crop Coefficient.

cotton, sunflower, groundnut, sesame and maize, respectively. With regard to vegetable crops, data of consumptive use are 2463.7, 3277.7, 2983.3, 2870.7 and 2120.2 m^3/fed./season for watermelon, green pepper, carrots, cabbage and onion, respectively.

Data of physical properties of soil under consideration indicate that the soils have coarse texture with low moisture values of wilting point, field capacity and available moisture vs high values of mean temperature, bulk density, hydraulic conductivity and infiltration rate, need to a good soil-water management. The center pivot, sprinkler and trickle irrigation systems are more suitable, whereas, they have attainable efficiencies between 70 – 90% and 75 – 90 %, respectively according to **Solomon (1988)** for its ability to save water for cultivation these newly reclaimed areas and continuity of projects for longer periods.

Studies of ground water according to the **Technical Report 4 (1981)**, which deduces that total volume of good quality ground water stored is $50*10^{12}$ m^3 for total surface area of the western desert occupied by this aquifer system is about 500.000 km^2 with a thickness of about 1000 m, which consider the singular source of irrigation water and by using the previous data of consumptive use the area can be cultivated for a long period of more than hundred years.