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DISTRIBUTION OF SOME NUTRIENTS IN EL-SER AND EL-QAWARIR SOILS OF NORTH SINAI PENINSULA AS CRITERIA OF THEIR GENESIS AND FORMATION

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ABSTRACT: *Thirty-two soil samples collected from fifteen soil profiles representing the gyomorphic units of El-Ser and El-Qawarir area, North Sinai Peninsula were investigated in order to study their total and available nutrients. Moreover, the relation between total and available macro and micronutrients and some soil variables was undertaken.*
The main results could be cited as follows.

1) *Total P, K, Fe, Mn, Zn and Cu ranged from 220 to 960, 300 to 4500, 834 to 3674, 364 to 1284, 44 to 354 and 10 to 112 mg kg^{-1} , respectively. The lowest weighted means of the considered macro and micronutrients were associated with the soils of wind blown Sand (D), while the lowest weighted means of Fe and Zn was detected in the piedmont plain soils (PP3). On the other hand, the highest weighted means of these elements were associated with the soils of piedmont plain (PP2) and alluvial plan (AP).*
2) *The amounts of available P, K, Fe, Mn, Zn and Cu varied from 1.1 to 6.0, 16.0 to 279, 0.69 to 2.07, 0.37 to 1.46, 0.21 to 1.19, and 0.11 to 0.74 mg kg^{-1}, respectively. Generally, available macro and micronutrients were in low amounts.*
3) *Factors affecting total and available macro and micronutrients were predicted through correlation coefficients between some soil variables with total and available elements. Also, the statistical measures, i.e., weighted mean, trend and specific range of these nutrients were computed and interpretend in terms of soil genesis and formation.*

Key words: *Macro and Micronutrients, genesis, formation, Weighted mean, Trend, Specific Range.*

INTRODUCTION

The fast growing population in Egypt, above a very limited area of agricultural land confining to Nile valley and Delta, makes a pressing need to set up expansion programs to face and solve the problems of food, energy, employment and housing plans. to invade the vast areas of desert, to introduce the possible into agriculture have been laid down.

El-Ser and El-Qawarir are among the promising areas for agricultural development in the North Sinai Peninsula, Egypt. The soils of this area were previously investigated where soil survey was carried out to study the soil characteristics and classify such soils from the pedological view point and evaluate their suitability for agriculture production, Al- Sharif *et al.* (2014).

The studied area covers about 660.000 feddans and located in the northeastern part of the Sinai Peninsula between latitude of 30° 31. and 31° 0' N and longitude 33° 30 and 34° 0 E. (Fig.1). The studied area is recommended for a large scale irrigated agricultural development project in Sinai. Water resources will be available mainly through El-Salam canal which will transport a mixture of Nile water and drainage water from the Nile Delta region west of Suez Canal.

The distribution of macro and micronutrient in soil is dependent almost on the bedrock from which soil parent material was derived (Stevenson, 1986). Both geochemical and weathering processes are responsible for formation of soil materials as a final product upon time. However, their contents and status vary considerably from soil to another and even in the subsequent layers of the some soil profiles. The variations are controlled by several soil environmental factors. Therefore, it is of interest to delineate these factors and to determine their relative contribution to macro and micronutrient forms in soils.

Under the Egyptian soil consideration the pedochemistry of such elements was given under consideration with particular emphases on soil genesis and formation (El-Demerdashe *et al;* 1980, Hassona *et al.,* 1996; Abdel-Razik 2002; Garis 2006 and Abd Alla *et al.* 2009).

Therefore, the current investigation is carried out on P, K, Fe, Mn, Zn and Cu nutrient elements to figure their status in soils of El-Ser and El-Qwarir (North Sinai). The total and chemically-extractable contents of these elements were determined in order to assure the sufficiency or deficiency of them to correct the nutrient supply and improve fertility status of the concerned soils. Moreover, the factors controlling elements status such as soil texture, $CaCO_3$ and O.M contents, salinity, Soil reaction and cation exchange characteristics are also considered.

MATERIALS AND METHODS

Fifteen soil profiles representing El-Ser and El-Qwarir area were chosen on basis of the geomorphologic units previously presented by Al-Sharif *et al.,* (2014), Locations of the studied soil profiles are presented in Fig.(1). Tables (1, 2, and 3) show some physical and chemical properties of the studied soils, determined according to Al-Sharif *et al.,* (2014),

Total P, K, Fe, Mn, Zn and Cu in the soils were extracted by digestion in HF-$HClO_4$ acids mixture in a platinum crucible, (Jackson, 1973). Available Fe, Mn, Zn and Cu in soils were extracted using DTPA according to Follet and Lindsay (1971) and Lindsay and Norvell (1978). Available P and K in soil were extracted by 1% potassium sulphate, 0.5M sodium bicarbonate and 1N ammonium acetate, respectively (Soltanpour and Schwab, 1977). In all cases determination of total and available elements in the soil extracts was conducted by nuclean absorption spectrophotometer using the atomic absorption (Perken Elmer-380).

The obtained results of the different soil properties and nutrients status were statistically analyzed using the program outline by SPSS (2003) software to distinguish the possible statistical relationships. The relationships are simple correlations and a stepwise regression between both total and available nutrients contents vs the different studied soil characteristics to defined the significance of these relationships the contribution percentages of soil constituents with either the studied total nutrient contents or the available nutrient fractions.

RESULTS AND DISCUSSION

According to Al-Sharif *et al* (2014), the interpreted geomorphic units of the studied area (El-Ser and El – Qawarir) could be classified into five main geomorphic units namely:

1- Alluvial plain (AP) which are represented by profiles 1, 5, 7, 9 and 10.
2- Piedmont plain (PP1) which are representing by profiles 2, 11, 13, and 15.
3- Piedmont plain Gentelly undulating. (pp2) which are representing by profiles 6 an 14.
4- Piedmont plain (und.) (pp3) which are representing by profiles 3 and 4.
5- Wind blown sand (D) representing by profiles 8.

To assess the relation between geomorphic units and their contents of macro and micro elements, the levels and distribution of total and available P, K, Fe, Mn, Cu and Zn in the representative soil profiles will be discussed. Moreover, on attempt is mode to shed light on their status and factors controlling behavior in the soil of the studied area.

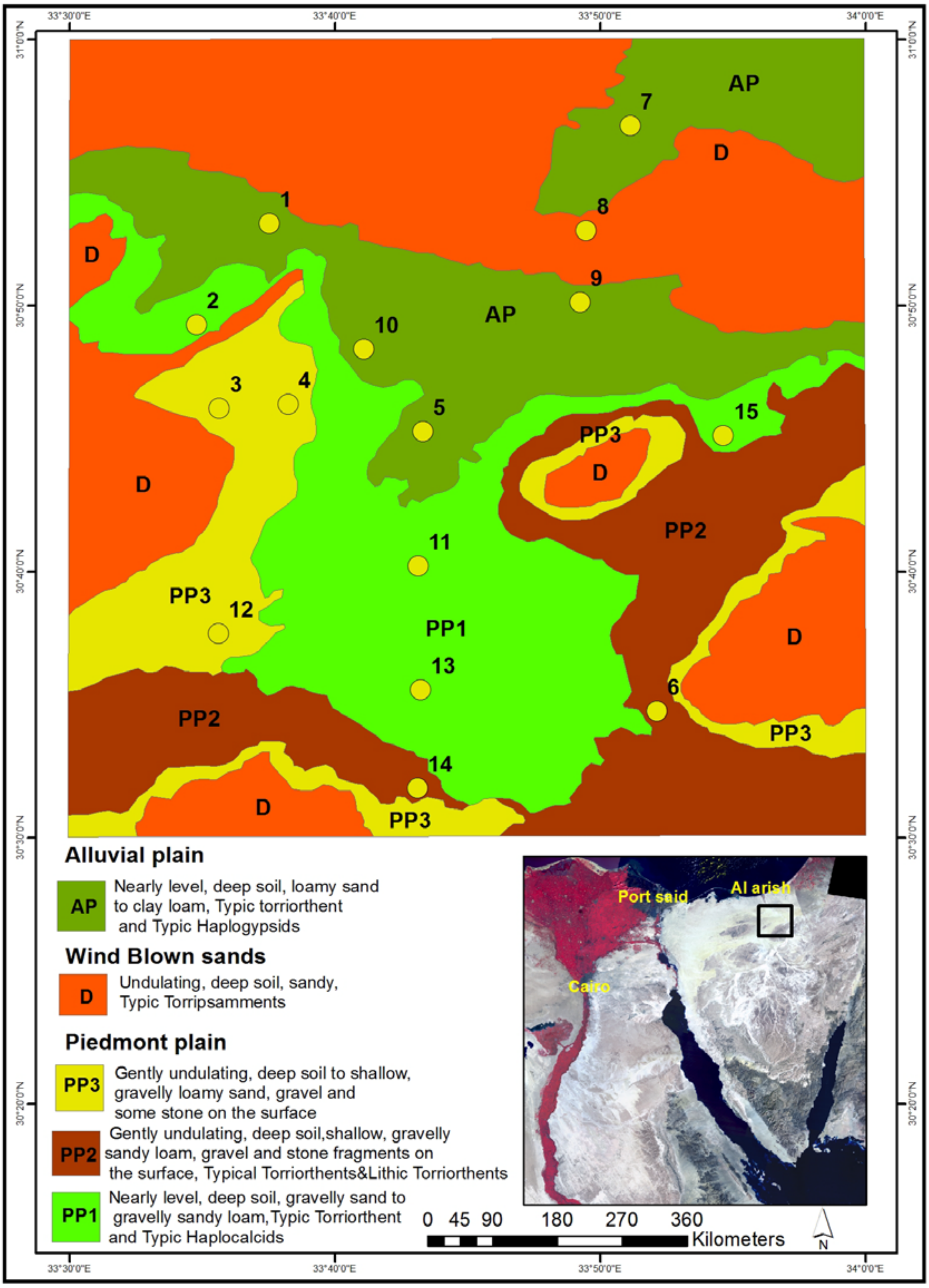

Fig. (1): Physiographic units and profiles location of studied area

Table (1): Particle size distribution, texture class, organic matter and $CaCO_3$% of the studied soil profiles

Horizon	Profil No.	Depth Cm	Gravel %	Particle size distribution %				Text. Class	$CaCO_3$ %	O.M %
				C.S	F.S	Slit	Clay			
Alluvial plain										
A	1	0-20	-	39.48	24.92	13.52	12.08	SL	24.12	0.47
C		20-50	2	60.01	17.48	10.45	12.06	SL	11.26	0.32
C_1		50-100	4	76.06	13.44	6.43	4.07	S	11.26	0.23
A	5	0-15	-	76.05	3.96	11.62	16.37	SL	20.10	0.38
C		15-35	2	65.80	8.31	25.13	0.76	LS	17.28	0.31
C_1		35-100	8	59.91	8.52	17.50	14.07	SL	18.89	0.24
A	7	0-25		45.50	3.81	27.54	23.15	SCL	46.23	0.27
C		25-100	-	82.40	6.56	4.53	6.51	LS	2.81	0.24
A	9	0-10	-	73.02	7.58	11.35	8.05	LS	20.50	0.32
C		10-60	-	72.77	7.02	11.43	8.78	LS	13.27	0.21
A	10	0-25	-	79.74	5.38	7.89	6.99	LS	8.44	0.41
C		25-45	-	51.94	6.65	19.33	22.08	SCL	23.72	0.32
C_y		45-100	-	40.51	5.49	20.21	24.79	SCL	19.69	0.18
Piedmont plain (PP1)										
A	2	0-10	5	80.46	6.49	3.65	9.37	LS	20.10	0.27
C		10-30	20	87.64	5.23	3.81	3.32	GS	14.07	0.21
C_1		30-100	40	81.82	12.08	3.72	2.38	GS	13.27	0.17
A	11	0-35	55	81.88	3.25	8.82	6.05	GLS	13.27	0.21
C		35-60	20	71.31	2.92	22.72	3.05	GLS	10.05	0.19
C_1		60-100	13	80.15	1.12	16.38	2.35	LS	8.44	0.12
A	13	0-25	3	83.25	2.29	8.71	5.75	LS	5.27	0.32
C		25-100	9	84.51	1.37	8.30	5.82	SL	26.58	0.17
A	15	0-20	3	73.16	12.51	8.24	6.09	LS	9.25	0.27
C_k		20-100	20	54.48	6.22	26.72	12.58	GSL	16.85	0.20
Piedmont plain (PP2)										
A	6	0-35	13	48.47	8.18	26.16	17.19	SL	20.91	0.25
C		35-100	65	44.06	6.01	26.84	23.09	GSCL	27.60	0.24
A	14	0-25	50	60.85	20.90	16.11	12.14	GSL	27.58	0.26
Piedmont plain (PP3)										
A	3	0-30	45	71.76	13.51	5.13	9.60	GLS	25.60	0.22
A_y	4	0-40	40	72.64	11.08	10.04	6.24	GLS	27.60	0.27
A	12	0-45	35	76.57	5.15	11.71	6.57	GLS	10.05	0.25
C		45-100	20	82.79	5.80	7.69	3.72	GS	8.44	0.21
Wind Blown Sand										
A	8	0-30	-	82.22	5.79	7.46	4.53	S	2.01	0.16
C		30-100	-	85.86	3.84	6.17	4.13	S	1.61	0.11

Table (2): Chemical Analysis of the Saturation extract Soils and gypsum contents of the studied soil profiles.

Horizon	Profil No.	Depth cm	pH	ECe (dS/m)	Anions (meq/L)				Cations (meq/L)				Gyp. %
					$CO^{=}_3$	HCO^-_3	$CO^{=}_3$	HCO^-_3	$CO^{=}_3$	HCO^-_3	$CO^{=}_3$	HCO^-_3	
Alluvial plain													
A	1	0-20	7.64	5.22	-	0.95	43.0	22.68	18.58	9.92	37.43	0.70	0.52
C		20-50	7.73	10.14	-	1.22	75.0	47.06	44.87	5.75	72.31	0.35	0.97
C_1		50-100	7.81	8.52	-	1.90	70.0	41.43	33.33	14.2	65.50	0.30	0.51
A	5	0-15	7.49	9.08	-	2.04	63.0	49.04	51.28	22.79	39.13	0.88	1.3
C		15-35	7.55	19.20	-	0.95	190.0	35.74	61.54	26.11	137.8	1.23	1.0
C_1		35-100	7.53	15.0	-	1.09	164.0	8.81	65.40	33.36	74.86	0.28	0.7
A	7	0-25	7.66	6.86	-	1.15	42.0	25.21	41.05	19.45	6.81	0.60	3.5
C		25-100	7.92	3.70	-	0.81	15.0	53.35	33.33	12.34	23.14	0.35	1.0
A	9	0-10	7.33	29.4	-	0.81	168.0	158.8	76.92	21.48	227.9	1.35	0.5
C		10-60	7.43	28.0	-	0.81	556.0	32.13	261.5	108.8	217.8	0.77	1.0
A	10	0-25	7.78	6.91	-	1.22	55.0	62.19	44.87	4.51	68.05	0.98	1.1
C		25-45	7.52	15.20	-	1.76	150.0	153.5	87.74	107.7	107.1	0.58	0.8
C_y		45-100	7.50	9.75	-	0.95	84.0	47.61	71.79	8.46	51.89	0.42	7.1
Piedmont plain (PP1)													
A	2	0-10	8.17	1.74	-	2.04	7.0	14.0	8.97	2.14	8.17	3.76	0.36
C		10-30	7.82	3.73	-	1.09	20.0	29.82	24.36	5.27	20.42	0.86	0.41
C_1		30-100	7.91	2.52	-	1.22	15.0	14.8	14.74	4.40	11.23	0.65	0.40
A	11	0-35	7.73	5.23	-	1.36	33.0	35.1	26.28	8.28	34.59	0.31	4.0
C		35-60	7.70	11.65	-	1.49	98.0	75.84	62.82	23.6	88.47	0.44	1.0
C_1		60-100	7.77	8.55	-	1.08	65.0	88.18	46.15	19.25	88.46	0.40	1.0
A	13	0-25	7.82	9.55	-	1.36	93.0	117.6	39.7	15.8	62.09	0.90	0.6
C		25-100	7.83	18.20	-	1.49	180.0	51.1	51.30	32.65	148.0	0.63	1.5
A	15	0-20	7.93	1.84	-	2.04	3.00	18.36	11.54	1.42	9.53	0.91	3.0
C_k		20-100	7.80	15.0	-	1.36	128.0	67.79	41.03	35.51	119.1	1.51	9.3
Piedmont plain (PP2)													
A	6	0-35	7.43	20.5	-	0.95	214.0	28.86	89.74	63.34	90.17	0.56	0.4
C		35-100	7.66	17.68	-	0.68	184.0	40.48	51.30	32.65	141.2	0.62	1.0
A	14	0-25	6.95	64.3	-	0.68	950.0	370.7	660.3	203.9	455.9	1.26	1.8
Piedmont plain (PP3)													
A	3	0-30	7.96	2.42	-	1.22	17.0	12.66	10.26	7.02	12.76	0.84	0.5
A_y	4	0-40	7.28	56.50	-	0.95	700.0	337.2	333.3	160.5	544.4	1.11	6.4
A	12	0-45	8.02	8.07	-	1.49	75.0	90.48	12.82	6.93	69.75	0.97	3.5
C		45-100	7.99	10.70	trace	1.49	100.0	12.45	18.59	11.04	83.36	0.95	5.0
Wind Blown Sand													
A	8	0-30	8.5	0.6	-	1.63	4.0	2.89	3.85	1.09	3.30	0.28	0.7
C		30-100	8.65	0.51	-	2.04	4.0	1.76	2.56	1.14	3.81	0.29	0.7

Table (3): Cation exchange capacity and exchangeable cations of investigated soil samples.

Horizon	Profil No.	Depth cm	CEC ($cmol_c$/kg soil)	Exchangeable cations (me/L)			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}
Alluvial plain							
A	1	0-20	15.4	9.22	1.46	1.09	0.66
C		20-50	9.8	5.06	2.40	0.92	0.51
C_1		50-100	12.6	6.22	3.12	1.72	0.57
A	5	0-15	14.2	6.82	3.16	1.66	0.72
C		15-35	13.5	7.65	2.1	2.11	0.39
C_1		35-100	13.8	8.11	2.24	1.92	0.44
A	7	0-25	19.7	11.22	2.65	1.81	0.84
C		25-100	13.3	6.28	3.06	2.07	0.68
A	9	0-10	12.8	6.37	2.78	1.83	0.59
C		10-60	11.6	7.12	1.56	1.12	0.39
A	10	0-25	13.2	7.54	2.11	2.41	0.88
C		25-45	11.0	7.08	1.69	1.52	0.44
C_y		45-100	8.7	4.32	2.04	1.22	0.42
Piedmont plain (PP1)							
A	2	0-10	12.7	6.41	2.84	1.89	0.65
C		10-30	8.5	5.42	1.56	0.91	0.39
C_1		30-100	8.8	5.22	1.49	0.78	0.42
A	11	0-35	8.8	5.31	1.61	0.69	0.40
C		35-60	8.2	5.41	1.48	0.74	0.28
C_1		60-100	7.4	4.11	2.02	0.81	0.22
A	13	0-25	10.2	6.10	2.12	1.15	0.38
C		25-100	9.6	5.17	1.97	1.72	0.41
A	15	0-20	8.8	4.61	2.84	1.89	0.65
C_k		20-100	10.9	5.21	2.48	1.28	0.58
Piedmont plain (PP2)							
A	6	0-35	17.6	10.82	2.42	1.51	0.94
C		35-100	16.5	10.15	2.12	2.14	1.16
A	14	0-25	14.8	9.42	1.72	1.56	1.08
Piedmont plain (PP3)							
A	3	0-30	11.4	7.11	1.58	1.44	0.62
A_y	4	0-40	10.5	6.44	1.52	1.38	0.54
A	12	0-45	8.5	3.82	2.95	0.84	0.46
C		45-100	7.5	3.34	2.51	0.81	0.31
Wind Blown Sand							
A	8	0-30	7.3	3.12	2.54	0.79	0.33
C		30-100	7.0	3.22	2.40	0.68	0.24

Total and available nutrient content in the studied area

Total and available macronutrient contents.

Many investigators concluded that, soil system is a function of soil potentiality for the essential plant nutrients, which usually related to the nature soil parent material. This may result from a combination of compositional difference between the physical and chemical properties of soils, (Officer *et al,* 2006).

Total phosphorus

The total phosphorus expressed as mg kg^{-1} in the different geomorphic units was in general relatively high in the surface layers of the studied soil profiles where the organic materials are relatively abundant. This denotes to its role as a P-source. This was true, since P content tended to lesser with increasing the soil depth. This phenomenon was contemporary associated with a decrease in soil organic matter content. The highest content of total P (960 mg kg^{-1}) was detected in the deepest layer of profile 15 (piedmont plain pp1), while the lowest p value (220 mg kg^{-1}) was recorded in the surface layers of profile 1 (alluvial plain Ap). Total phosphorus content tends to increase with depth in profiles 1, 5, 6, 8, 12, 13 and 15 and tends to decrease with depth in profiles 7 and 9, while in profiles 2, 10 and 11 the distribution of total phosphorus content does not portray any specific pattern with depth. The total values of phosphorus differed widely between the studied soils depending on the type of deposits and their constituents as shown in Table (4). The wide variations of weighted mean in the studied soil profile may be attributed to geogenic factors rather than pedogenic ones.This may be ascribed to the intern changes in the nature of parent material rather than to soil. Moreover, the studied soils can be categorized according to the weighted mean of total P of each locality in the following order:

wind blown sand > piedmont plain (pp1)> piedmont plain (pp3)> piedmont plain (pp2) > alluvial plain (Ap).

Data in Table (4) show that the available amounts of P in the different studied soil sediments did not exceed 1.3% of the total content. This is presumably due to either adsorption on the surface of $CaCO_3$ particles and /or precipitation due to the reaction with soluble Ca^{++}. The relatively high values of available P were (6 mg kg^{-1}) detected in the surface layer of profile 5 (Alluvial plain), while the lowest available P amounts (1.1 mg kg^{-1}) was recorded in the deepest layer of profile 10.

Considering the critical level of DTPA-extractable P, which has been proposed by Soltanpour and Schwab (1977), the index value of DTPA-extractable P are as follows:

V. low < 10 mg kg^{-1}, moderate 10 – 15 mg kg^{-1} and high > 15 mg kg^{-1}. The P values of the studied soil profile indicate they have low level of available phosphorus.

Potassium

Concerning the data of total K in the different geomorphic units of the studied area (Table 4), total K content ranged from 300 to 4500 mg kg^{-1} in the subsurface, and surface, layer of profiles 8 and 6, respectively. In general, the highest value of total K was found in the soils of piedmont plain (pp2), while the lowest ones were recorded in the wind blown sand soils (D). The recorded highest total K – values in the piedmont sediments are mainly due to the occurrence of a relatively high content of the K-bearing minerals in the mechanical fractions such as feldspars and hydrous mica. Moreover, total K in the studied soils can be arranged in the order.

Piedmont plain (pp2) > alluvial plain (Ap) > piedmont plain (pp1) > piedmont plain (pp3) > wind blown sand (D).

The depthwise distribution of total K in the studied soils follows three patterns. The first pattern is observed in profiles 1, 6, 7, 8, 9, 12 and 15 where total K tends to decrease with depth. The second converse pattern was recorded in profiles 2, 5, 10 and 11, where total K does not portray any specific pattern with depth. The third pattern was found in profile 13 where total K increased with depth.

Table 4

Table (4) reveals that, the available K in the studied geomorphic units did not exceed 30.2% of the total K contents. Also, their values are generally affected by the total contents, where the highest value was detected in the piedmont plain (pp2). Available K values varied between 16 mg kg^{-1} in the deepest layer of profile 7, representing the soils of alluvial plain (Ap) and 279 mg kg^{-1} in the surface layers of profile 6, representing the soils of piedmont plain (pp2). Pal *et al.* (1999) explained that the high levels of potassium might be as a result of climate, geology, dominating clay minerals and mineralogical structure. However, despite these high levels of K its availability to plants is limited as K tends to be lost by leaching and adsorption.

According to Soltanpour and Schwab (1977) the index values used for DTPA-extractable K are as follows:

V. low 0-85 mg kg^{-1} , low 85 – 200 mg kg^{-1} , moderate 200-300 mg kg^{-1} , high 300 – 500 mg kg^{-1} .

Very high > 500 mg kg^{-1}

The obtained result indicate that the studied soils are belonging to very low, low and moderate groups representing 75%, 18.75% and 6.25% of tested soil samples, respectively.

Micronutrient elements:

The most important factors' affecting it's potentially for micronutrient supplies are mineral and organic constituents of soil besides a suitable air-moisture region. Data obtained for total and DTPA-extractable contents of the studied micronutrient are given in Table (4).

1- Iron.

Table (4) shows the total content of Fe. The total content ranges widely from 834 to 367 mg kg^{-1}. The lowest values characterized the surface layer of profile 15, while the highest content was found in the subsurface layer of profile 2 (piedmont plain pp1). These results are in agreement with those of Hafez *et al* (1992) and Abdel-Rahman & El-Demerdashe (2003). As reported by Schwartzman and Taylor (1989), Fe may be a structure constituent of clay minerals, or may be bound to clay surface as an exchangeable cation. Nevertheless, the sandy nature of the studied soils dictates that the total content of Fe is mostly related to amorphous iron present as coatings on sand grains, as agglomerates with other amorphous materials or precipitated by $CaCO_3$ if present in appreciable amounts.

With respect to the depthwise distribution of total Fe, data in Table (4) show that total Fe, content is mostly higher in the top surface layer then tends to decrease with depth in profiles 1, 6, 7, 8, 12 and 13. Some exceptional cases was found in profiles 9, 11 and 15, which their total Fe content tended to increase with depth, The distribution of total Fe content does not portray any specific pattern with depth in profiles 2, 5 and 10.

The DTPA-extractable Fe in the studied soils varies widely from 0.69 to 2.07 mg kg^{-1}. The lowest and highest content is detected in the surface and subsurface layer of profile 8 representing the wind blown sand. Viets and Lindsay (1973) and El-Gala et al (1986) reported that the critical level as determined by the DTPA method is 4.0 mg kg^{-1}. Soils, below this level most growing plants are not able to provide their nutritional requirements. Accordingly, most of the studied soil profiles representing El-Ser and El-Qawarir area are low in the content of available Fe.

Depthwise distribution of DTPA-extractable Fe shows that it tends to decrease steadily or irregularly with depth in most of soil profiles with two exceptional cases where extractable Fe tends to increase with depth in profiles 10 and 15.

Manganese

The data presented in Table (4) show that total amounts of Mn content of the studied soil ranged from 364 mg kg^{-1} in the deepest layer of profile 7 and 1284 mg kg^{-1} is the subsurface layer of profile 5, representing the alluvial plain soils (Ap). The higher recorded Mn-values throughout soil profile layer or among the studied soil sites are mainly attributed to the occurrence of relatively high content of Mn-bearing minerals, i.e, clay minerals and magnenesferrite (Schwartzman and Taylor, 1989). Moreover, total Mn content in the studied soil could arrange in the following order.

Piedmont plain (pp2) > Piedmont plain (pp3) > alluvial plain (Ap) > piedmont plain (pp1) > wind blown sand (D).

With respect to the depthwise distribution of total Mn, data in Table (4) show that Mn follows three different paterns dominated by continuous increase downward in soil profiles (1, 9, 13, 6 and 12). The second one is decrease with depth (profiles 7, 15, and 8), while irregular distribution pattern with depth was found in profile 5, 10, 2 and 11.

Regarding the available amount of Mn in the studied soil profiles, data in Table (4) reveal that its values did not exceed than 0.26% of the total Mn content. This means the values of available Mn were not affected by the total contents. The lowest value (0.37 mg kg^{-1}) and the highest one (1.46 mg kg^{-1}) are recorded for the surface layer of profile 10 and the subsurface, layer of profile 1 representing the alluvial plain soils (Ap). Nonetheless, the lower amount of available Mn in the soils may be attributed to the relatively higher content of $CaCO_3$, which inversely affect Mn availability.

According to Soltanpour and Schwab (1977), the critical values of DTPA-extractable Mn are as follows: low 0 – 1.8 mg kg^{-1} , adequate > 1.8 mg kg^{-1}. The results of the studied soil profiles show that the studied soil samples belong to low level group (100%).

Zinc

Total Zn contents in the studied soils are presented in Table (6). Its total amounts ranged between 44.0 and 354 mg kg^{-1} in the surface layer of profile 13 and the deepest layer of profile 15, respectively. In general, the highest values of total Zn in the studied geomorphic units were obtained from the piedmont plain (pp2), while the lowest ones are recorded for the wind blown sand (D). The highest Zn-Values could be mainly due to the occurrence of relatively high content of Zn – bearing minerals especially amorphous and crystalline Fe complexes (El-Bassiouny, 2006).

Depthwise distribution of total Zn reveals that it tends to increase with depth in most soil profiles (1, 2, 11, 12, 13 and 15). It decreased with depth in profile 6, 7, 8, 9 and 10 and decreased down to the subsurface layer then increased abruptly in the case of profile 5.

Concerning the available amount of Zn is the studied soils, data in table (4) reveal that it did not exceed 0.91% of the total Zn contents. Its values varied widely from 0.21 to 1.19 mg Kg^{-1}. The lowest content is found in the 10 - 60 cm layer of profile 9, representing the alluvial plain soils (Ap), while the highest content is observed in the surface layer of profile 6 representing piedmont plain soils (pp2). The lowest amount of available Zn in studied soils may be attributed to the relatively high content of $CaCO_3$ which inversely affected Zn availability.

According to Soltanpour and Schwab (1977), the index values used for DTPA-extractable Zn are as follows: low 0 – 0.9 mg kg^{-1}, marginal 1 – 1.5 mg kg^{-1}, adequate > 1.5 mg kg^{-1}. The obtained results indicate that the studied soils are belonging to low and marginal groups representing 96.9% and 3.1% of the tested sample, respectively.

Copper

The data presented in Table (4) show that total Cu content in the studied soil profiles ranged between 10.0 and 112 mg kg^{-1}. The lowest content was recorded in the surface layer of profile 12 representing the piedmont plain soils (pp3), while the highest content was found in the deepest layer of profile 1 (Alluvial plain soils Ap). The recorded highest Cu – Values may be due to the occurrence of relatively high content of Cu – bearing minerals.

With regard to the geomorphic units, data indicate that the geomorphic units could be arranged to their total Cu contents of the following orders:

Piedmont plain (pp3) > alluvial plain (Ap) > piedmont plain (pp1) > piedmont plain (pp2) > wind blown sand (D).

Depthwise distribution of total Cu content reveal that, it tends to increase of soil depth in profiles (1, 6, 8, 12 and 15) and tends to decrease downward the profile depth in profiles 5, 7 and 9. On the other hand, total Cu content does not portray any specific pattern with depth in profiles 2, 10, 11 and 13.

The available amounts of Cu in the studied soils showed a range from 0.11 to 0.74 mg kg^{-1} in the deepest layer of profiles 5 and the subsurface layer of profile 1, respectively. There values did not exceed 2.12 % of the total Cu contents. The relatively low amounts of available Cu content in the studied soils may be attributed to the relatively coarse of skeletal texture grade being of a very poor ability for Cu retention.

According to Soltanpour and Schawab (1977), the index values used for DTPA-extractable Cu are as follows: low 0 – 0.5 mg kg^{-1}, high > 0.5 mg kg^{-1} Cu.The data of the studied soils indicate that the studied soils are belong to either low and the high levels groups (84.4% and 15.6%, respectively).

Macro and Micronutrients and soil components

The relationship between total and DTPA-extractable macro and micronutrients and some soil components such as clay %, fine sand %, coarse sand and %, silt %, ECe, pH, CEC, gypsum and $CaCO_3$%, are computed using statistical analysis.

Table (5) shows that total P is positively significant correlated with gypsum and silt% (r = 0.357 * and r = 0.377 *, respectively). Also, negatively significant correlation was found total P and fine sand (r = - 0. 416 *). On the other hand, available P in the studied soil is insignificantly correlated with the other investigated factors. These results are in agreement with those of Abdel Aal and Ewees (2010).

The multiple regression analysis was carried out to determine the relationship between total and available p and some soil variables, the multiple regression equations are.

Total P = 812 + 24 Gypsum – 0.139 Fe Total + 0.326 Mn Total - 27 Zn Available -520 Cu Available

Available P = 1.55 – 0.086 F.S + 0.137 CEC – 0.101 Gypsum

Total K is highly positively significant correlated with CEC (r = 0.624^{**}), silt% (r=0.532^{**}) and $CaCO_3$% (r = 0.552^{**}). and positively significant correlated with each of ECe and clay% (r = 0.372^{*} and r = 0.418^{*} respectively), It is highly significant negatively correlated with pH (r= - 0.608^{**}) and coarse sand percent (r = - 0.554^{**}). Similar results were obtained by Khalil *et al* (2004) and Abd el Aal and Ewess (2010).

Available K is significantly correlated with CEC (r = 0.395^{*}), and very highly significant correlated with total K (r = 0.615^{**}). No significant correlation could be detected with all the other tested factors.

The multiple regression equations are:

Total K = 8478 – 1123 pH – 1.31 EC + 6.1 $CaCO_3$ +5.1 C.S + 29.3 Slit – 3.7 Clay – 10.0 CEC + 6.52 K available + 964 Zn available

Available K = 10.1 + 0.38 CEC + 0.0460 K Total

Data in Table (5) show that total Fe is highly negatively correlated with total phosphorus (r = - 0.508^{**}) , In contrast, DTPA-extractable Fe is insignificantly correlated with the investigated factors.

The multiple regression equations are:

Total Fe = 3033 – 1.78 P Total

Available Fe = 0.966 + 0.0747 P available + 0.00089 K Total + 0.00082 K available

With regard to total Mn, data in Table (5) reveal that total Mn is significant positively correlated with total p (r = 0.354^{*}), while DTPA-extractable Mn is insignificantly correlated with the investigated soil factors.

The multiple regression equations of total and DTPA-Mn in the studied soils are:

Total Mn=428 + 0.457 P Total

DTPA Mn=0.618 + 0.179 Fe available – 0.0528 P available + 0.00759 F.S

Total Zn is significant positively correlated with silt% and CEC (r = 0.412^{*} and r = 0.400^{*}, respectively), while total Zn is significant negatively correlated with total Fe (r = - 0.352*).

Table 5

DTPA-extractable Zn is highly positively correlated with each of CEC, Total Fe and total Zn ($r = 0.601^{**}$, $r = 0.506^{**}$ and $r = 0.565^{**}$, respectively) and positively correlated with silt % ($r = 0.408^{*}$), and clay% ($r = 0.367^{*}$), while available Zn is highly negatively significant correlated with coarse sand % ($r = - 501^{**}$) and negatively significant correlated with total P ($r = -0.353^{*}$).

The multiple regression equations of total and DTPA-Zn are:

Total Zn = 31.5 + 2.59 Slit + 1.79 CEC + 158 Zn available

DTPA-Zn =0.080 + 0.00192 C.S + 0.00834 Slit + 0.0094 CEC – 0.000418 P Total + 0.00038 K Total + 0.000748 Zn Total + 0.353 Cu available

Total Cu is positively significant correlated with fine sand % ($r = 0.407^{*}$).

DTPA-extractable Cu is highly positively significant correlated with CEC ($r = 0.469^{**}$) and available Zn ($r = 0.684^{**}$). On the other hand, DTPA – extractable Cu is significant negatively correlated with coarse sand % ($r = - 0.385^{*}$) and total P ($r = -$ o.442*).

The multiple regression equations of total and DTPA-extractable Cu are:

Total Cu = 43.8 + 2.19 F.S

DTPA – Cu = 0.266 – 0.00060 C.S + 0.00633 CEC – 0.000213 P Total + 0.394 Zn available

Depthwise distributions of total contents of each micronutrient:

To explain the relationship between the distribution of total micronutrients and geomorphic units of the studied soil profiles, the three statistical measures suggested by Oertal and Giles (1963) have been calculated, Table (6), these measures could be written as follows:

1) $W = [\sum (c \times d)/p]$

Where,

c = concentration of elements in the layer.
d = thickness of layer.
p = depth of profile.
W = weighted mean.

2) T = (w – s)/w when w > s
T = (w – s)/w when s > w

Where , W = weighted mean.
S = the concentration in the surface layer.
T = Trend.

All values for (T) lie in the range of –1 to +1 and are in a sense, symmetrical when (T) is small but distorted when (T) is large because a value of +1 is possible whereas a value of –1 is impossible.

3) R = (H – L)/ W

Where, R = Specific range.
L = the lowest observed concentration in the solum.
H = the highest observed concentration in the solum, and,
W = weighted mean.

Value for (R) can not be negative but where there is no definite upper limit; a value greater than 1 are common and a value of up to 0.99 has been noted.

According to Oertel (1961), the "weighted mean" concentration for a trace element in a soil profile is probably an outcome of pedogenic processes as it also indicates the original concentration in the parent material (Oertel 1961). The trend (T) and specific range (R) on the other hand, are an outcome of the pedogenic processes alone (except where the parent material is markedly hetero- generous in trace element contents).

Table (6) presents the above – mentioned statistical measures, i. e weighted mean (W), trend (T) and specific range (R) for total contents of Fe, Mn, Cu and Zn in the studied soil profiles representing the soils of El-Ser and El-Qawarir area.

Iron (Fe)

Data listed in Table (6) reveal that the weighted means (W) of total Fe in the studied area varies widely between 946 and 2856 mg kg^{-1}. The lowest value is recorded in profile 15 (piedmont plain pp1), while the highest value characterized the soils of profile 2. The studied soils can be categorized according to the weighted mean of total Fe in the following order.

Alluvial plain (Ap) > piedmont plain (pp2) > piedmont plain (pp1) > wind blown sand (D) > piedmont plain (pp3).

Table 6

Values of the trend (T) indicate symmetrical distribution of profiles 1 and 7 (alluvial plain), 13 (piedmont pp1), 6 (piedmont pp2), 12 (piedmont pp3) and 8 (windblown sand D), while in the other profiles they are distorted. The specific range (R) of total Fe shows that profiles 9, 11, 13, 15, 6, 12 and 8 are of homogeneous materials, while the other profile are of heterogeneous materials.

Manganese (Mn)

Table (6) reveals that the weighted means (W) of total Mn ranged from 406 to 1039 mg kg^{-1} , the highest and lowest values are detected in profiles 4 and 12 (piedmont pp3), with a tendency of increase towards the fine texture.

According to the weighted mean of total Mn, the studied soils cau be categorized in the following order:

Piedmont (pp3) > alluvial plans (Ap) > piedmont (pp1) > wind blown snad D > piedmont (pp2).

The values of trend (T) indicates more symmetrical Mn distribution in profiles 5, 7, 10, 13, 15, 12 and 8 as indicated by their small (T) values, while the other profiles are less symmetrical. The specific range (R) of Mn shows that the soils of profiles 1, 9, 11, 13, 15, 6, 12 and 8 are homogeneous materials, whereas, profiles 5, 7, 10, and 2 are heterogeneous soil materials.

Copper (Cu)

The weighted mean (W) of total Cu in the studied soil profiles (Table 6) varied between 18 and 112 mg kg^{-1}, the lowest value is found in profile 13 (piedmont pp1), while the lowest value in detected in profile 4 (piedmont pp3). The values of trend (T) indicate that total Cu distribution in profiles 5, 7, 9, 10, 11, 13, 15, and 6 are more symmetrical than the other soil profiles. Specific range (R) of total Cu shows that their soil materials in profiles 5,7,9,13 and 15 are homogeneity, while the other soil profiles are found of heterogeneous soil materials.

Zinc (Zn)

The weighted mean (W) of total Zn in the studied soil profiles ranges from 59 to 350 mg/kg^{-1}. The lowest value is associated with the piedmont plain (pp3) (profile 12), while the highest values characterized the soils of profiles 15 (piedmont plain pp1).

Considering the trend (T) and specific range (R) of total Zn in the studied soil profiles, data in table (6) reveal that alluvial plain (profiles 1, 5, 7, 9 and 10), piedmont plain (profiles 11, 15, 6, and 12) and wind blown sand (profile 8) are highly symmetrical as indicated by the small values of (T) and (R).

In conclusion, the wide variation of weighted means in the studied area may be attributed to geogenic factors rather than pedogenic ones, i. e. may be ascribed to the intern changes in the nature of parent material rather than to soil. Moreover, the levels of such elements could be used as guide for subtending the nature of parent materials together with the pedogenic factors acted on them. Thus lead to the prediction of soil geneses and formation.

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توزيع بعض العناصر الغذائية في أراضي السر والقوارير شمال سيناء كدليل على نشأة وتكوين هذه الأراضي

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الملخص العربى

يهدف هذا البحث إلى دراسة حالة بعض العناصر الغذائية الكبرى والصغرى في أراضي منطقة السر والقوارير شمال سيناء وكذلك العلاقة بين هذه العناصر وبعض متغيرات التربة الهامة حيث تم جمع عدد 32 عينة تربة من 15 قطاع أراض ممثلة الوحدات الجيومورفولجية السائدة في منطقة السر والقوارير.

ويمكن تلخيص النتائج الهامة فيما يلي:

1- يتراوح تركيز عناصر الفوسفور، البوتاسيوم، الحديد، المنجنيز، الزنك والنحاس الكلي ما بين 220 إلى 960، 300 إلى 4500، 834 إلى 3674، 364 إلى 1284، 44 إلى 354، 10 إلى 112 ملليجرام/ كجم على الترتيب. وقد كان أقل تركيز لهذه العناصر مرتبط بالأراضي المتكونة بالرياح Wind blown sand وكذلك وجد أقل تركيز لعنصر الحديد والزنك في أراض السهل البيدمونت (pp3) ومن ناحية أخرى فقد كان أعلى تركيز لهذه العناصر مرتبط بأراضي سهل البيدمونت (pp2) والسهل الرسوبي (Ap).

2- تراوح تركيز عناصر الفوسفور، بوتاسيوم، حديد، منجنيز، زنك، نحاس الميسرة فيما بين 1.1 إلى 6.0، 16 إلى 279، 0.69 إلى 2.07، 0.37 إلى 1.46، 0.21 إلى 1.19، 0.11 إلى 0.74 ملليجرام/ كجم على الترتيب وبصفة عامة فإن هذه العناصر وجدت بكميات قليلة.

3- أجري التحليل الإحصائي ما بين هذه العناصر الغذائية الكلية والمسبرة وبعض متغيرات التربة لتحديد مدى الارتباط بين المحتوى الكلي والميسر وكذلك أجريت المقاييس الإحصائية وهي المتوسط الوزني (W) والاتجاه (T) والنطاق النوعي (R) للمحتوى الكلي لعناصر الحديد والمنجنيز والزنك والنحاس وقد نوقشت النتائج لتحديد أصل ومنشأ ومدى تجانس وتكوين أراضي الدراسة.

Table (4). Total and available contents (mg/kg) of some nutrients of the investigated soil samples.

Horizon	Profil No.	Depth cm	P (mg/kg)			K (mg/kg)			Fe (mg/kg)			Mn (mg/kg)			Zn (mg/kg)			Cu (mg/kg)		
			To.	Av.	Av/To	To.	Av.	Av/To	To.	Av.	Av/To	To.	Av.	Av/To	To.	Av.	Av/To	To.	Av.	Av/To
Alluvial plain																				
A	1	0-20	220.0	1.10	0.50	2300.0	184.0	8.0	2938.0	1.53	0.05	470.0	0.93	0.19	94.0	0.62	0.65	72.0	0.48	0.67
C		20-50	420.0	1.20	0.29	850.0	23.0	2.7	1938.0	1.58	0.08	514.0	1.46	0.28	122.0	0.38	0.31	78.0	0.74	0.95
C_1		50-100	440.0	1.40	0.32	750.0	19.0	2.5	1636.0	1.21	0.07	920.0	1.13	0.12	144.0	0.81	0.56	112.0	0.54	0.48
A	5	0-15	620.0	6.0	0.97	1100.0	43.5	3.9	1502.0	1.71	0.11	534.0	0.66	0.12	188.0	0.45	0.24	92.0	0.44	0.48
C		15-35	820.0	2.40	0.29	2000.0	53.5	2.7	1436.0	0.99	0.07	1284.0	0.79	0.06	118.0	0.49	0.41	92.0	0.55	0.60
C_1		35-100	820.0	1.90	0.23	1500.0	43.5	2.9	2238.0	1.71	0.08	428.0	0.93	0.22	244.0	0.55	0.22	72.0	0.11	0.15
A	7	0-25	800.0	3.20	0.40	2700.0	83.0	3.1	1704.0	1.28	0.07	1112.0	0.79	0.07	224.0	0.77	0.34	72.0	0.62	0.86
C		25-100	560.0	3.50	0.62	750.0	16.0	2.1	1168.0	0.99	0.08	364.0	0.96	0.26	166.0	0.56	0.34	54.0	0.42	0.78
A	9	0-10	820.0	2.50	0.30	2700.0	175.0	6.5	1938.0	1.86	0.09	684.0	0.39	0.06	124.0	0.23	0.18	98.0	0.20	0.20
C		10-60	540.0	1.10	0.20	1750.0	85.0	4.8	2272.0	1.07	0.05	984.0	0.66	0.07	104.0	0.21	0.20	92.0	0.19	0.21
A	10	0-25	860.0	2.20	0.26	1000.0	64.0	6.4	1636.0	0.99	0.06	856.0	0.37	0.04	82.0	0.26	0.32	72.0	0.13	0.18
C		25-45	870.0	1.70	0.19	1900.0	64.0	3.4	3240.0	1.07	0.03	1092.0	1.06	0.10	68.0	0.22	0.32	30.0	0.20	0.67
C_y		45-100	480.0	1.10	0.23	1600.0	33.0	2.1	3040.0	1.36	0.04	406.0	0.63	0.15	66.0	0.55	0.83	58.0	0.30	0.52
Piedmont plain (PP1)																				
A	2	0-10	360.0	4.70	1.30	850.0	257.0	30.2	2272.0	1.36	0.06	428.0	0.79	0.18	86.0	0.34	0.39	20.0	0.19	0.95
C		10-30	340.0	1.90	0.56	1250.0	81.0	6.5	3674.0	1.36	0.04	984.0	0.93	0.09	166.0	0.53	0.32	98.0	0.49	0.50
C_1		30-100	360.0	2.20	0.61	1100.0	87.0	7.9	2706.0	0.85	0.03	450.0	0.39	0.09	180.0	0.40	0.22	92.0	0.25	0.27
A	11	0-35	860.0	1.80	0.21	1250.0	104.0	8.3	1068.0	0.93	0.09	470.0	0.84	0.18	108.0	0.22	0.20	26.0	0.19	0.73
C		35-60	860.0	1.40	0.16	1350.0	28.5	2.1	1102.0	0.86	0.08	814.0	0.66	0.08	130.0	0.40	0.31	44.0	0.26	0.59
C_1		60-100	740.0	1.90	0.26	850.0	21.5	2.5	1570.0	1.86	0.12	770.0	1.22	0.16	130.0	0.26	0.20	20.0	0.13	0.65
A	13	0-25	540.0	2.40	0.44	750.0	45.0	6.0	1436.0	0.99	0.07	620.0	0.83	0.13	44.0	0.40	0.91	22.0	0.34	1.54
C		25-100	780.0	3.70	0.47	1500.0	60.0	4.0	1270.0	1.86	0.15	856.0	0.61	0.07	218.0	0.32	0.15	16.0	0.34	2.12
A	15	0-20	740.0	1.70	0.23	900.0	68.0	7.5	834.0	0.78	0.09	664.0	0.58	0.09	332.0	0.49	0.15	64.0	0.35	0.55
C_k		20-100	960.0	1.70	0.18	750.0	83.0	11.1	974.0	1.20	0.12	578.0	0.85	0.15	354.0	0.51	0.14	72.0	0.27	0.37
Piedmont plain (PP2)																				
A	6	0-35	500.0	2.50	0.50	4500.0	279.0	6.2	1604.0	1.99	0.12	620.0	0.79	0.13	316.0	1.19	0.38	46.0	0.62	1.34
C		35-100	620.0	2.40	0.39	1100.0	66.0	6.0	1134.0	0.93	0.08	898.0	0.79	0.09	280.0	0.59	0.21	48.0	0.49	1.02
A	14	0-25	820.0	2.10	0.26	2400.0	77.0	3.2	2104.0	0.93	0.04	962.0	0.81	0.08	316.0	0.40	0.13	50.0	0.26	0.52
Piedmont plain (PP3)																				
A	3	0-30	500.0	2.70	0.54	1000.0	75.5	7.5	2538.0	1.49	0.06	578.0	0.79	0.14	98.0	0.46	0.47	86.0	0.35	0.41
A_y	4	0-40	620.0	1.50	0.24	1000.0	33.0	3.3	2070.0	1.36	0.07	406.0	0.93	0.23	126.0	0.36	0.29	112.0	0.35	0.31
A	12	0-45	740.0	1.90	0.26	1250.0	106.0	8.5	1904.0	1.93	0.10	1028.0	1.30	0.13	48.0	0.27	0.56	10.0	0.19	1.90
C		45-100	900.0	1.80	0.20	1000.0	87.0	8.7	1736.0	1.49	0.09	1048.0	0.54	0.05	68.0	0.23	0.34	50.0	0.14	0.28
Wind Blown Sand																				
A	8	0-30	500.0	2.40	0.48	500.0	36.0	7.2	1970.0	2.07	0.10	856.0	0.53	0.06	130.0	0.43	0.33	32.0	0.30	0.94
C		30-100	800.0	1.70	0.21	300.0	24.0	8.0	1370.0	0.69	0.05	514.0	0.53	0.10	102.0	0.29	0.28	54.0	0.19	0.35

Table (5): Coefficient correlation between macro and micronutrients and some selected chemical and physical properties in the soils under investigation.

Soil properties	pH	EC	Gyp.	$CaCO_3$	O.M	C.S	F.S	Slit	Clay	CEC	P. total.	P. avail.	K. total	K. Avail.	Fe. total.	Fe. Avail.	Mn. Total	Mn. Avail.	Zn. total.	Zn. Avail.	Cu. total
EC	-0.747**																			
Gyp.	-0.129	0.208																		
$CaCO_3$	-0.553**	0.402*	0.156																	
O.M	-0.393*	0.100	-0.171	0.256																
C.S	0.487**	-0.208	-0.240	0.611**	-0.322															
F.S	-0.299	0.290	-0.122	0.205	0.430*	-0.377*														
Slit	-0.458*	0.262	0.287	0.480**	0.060	-0.770**	-0.094													
Clay	-0.392*	0.113	0.209	0.632**	0.254	-0.815**	0.066	0.578**												
CEC	-0.498**	0.256	-0.178	0.667**	0.535**	-0.592**	0.275	0.483**	0.575**											
P.tot.	-0.126	0.243	0.357*	0.034	-0.139	0.046	-0.416*	0.377*	-0.015	-0.073										
P.ava.	0.084	-0.142	-0.234	0.219	0.170	0.240	-0.306	-0.137	0.115	0.336	-0.042									
K.tot.	-0.608**	0.372*	-0.115	0.552**	0.282	-0.554**	0.196	0.532**	0.418*	0.624**	0.022	-0.007								
K.ava.	-0.112	0.020	-0.134	0.287	0.279	-0.218	0.177	0.079	0.168	0.395*	-0.243	0.203	0.615**							
Fe.tot.	-0.159	0.024	-0.157	0.226	0.132	-0.188	0.322	-0.190	0.212	-0.041	-0.508**	-0.195	0.176	0.172						
Fe.ava.	-0.016	-0.009	-0.045	0.121	0.020	-0.042	-0.060	0.012	0.087	0.031	-0.166	0.224	0.266	0.285	0.185					
Mn.tot	-0.101	0.141	-0.117	0.147	0.001	-0.013	-0.165	0.299	-0.060	0.095	0.354*	-0.106	0.209	-0.106	0.010	-0.021				
Mn.ava	-0.122	0.031	0.006	0.034	0.080	-0.197	0.211	0.123	0.101	0.032	-0.177	-0.204	-0.064	-0.135	0.106	0.219	0.030			
Zn.tot.	-0.268	0.266	0.156	0.316	-0.125	-0.311	0.161	0.412*	0.257	0.400*	0.183	0.128	0.285	0.109	-0.352	-0.051	-0.033	-0.082		
Zn.ava.	-0.152	0.065	-0.063	0.301	0.083	-0.501**	0.227	0.408*	0.367	0.601**	-0.353*	0.063	0.500**	0.282	-0.036	0.145	-0.073	0.129	0.506**	
Cu.tot.	-0.322	0.211	0.021	0.187	0.243	-0.094	0.407*	-0.067	-0.042	0.243	-0.230	-0.124	0.060	-0.138	0.234	-0.135	-0.057	-0.126	0.117	0.219	
Cu.ava.	-0.154	-0.037	-0.137	0.313	0.282	-0.385*	0.325	0.250	0.255	0.469**	-0.442*	0.096	0.291	0.034	-0.032	0.073	0.072	0.338	0.267	0.684**	0.342

*Significant at $p < 0.05$ (r=0.349)
**Significant at $p < 0.01$ (r=0.449)

Table (6): Weighted mean, trend and specific range of total trace elements in the studied soils.

Geomorphic units	Profile No	Fe			Mn			Cu			Zn		
		Weighted mean	Trend	Specific Range	Weighted mean	Trend	Specific Range	Weighted mean	Trend	Specific Range	Weighted mean	Trend	Specific Range
Alluvial plain (Ap)	1	1987	-0.324	0.655	708	0.336	0.636	94	0.226	0.430	127	0.260	0.394
	5	1967	0.236	0.408	815	0.132	1.392	79	-0.141	0.253	224	0.148	0.230
	7	1302	-0.236	0.412	551	-0.504	1.358	59	-0.181	0.305	181	-0.192	0.320
	9	2216	0.125	0.151	934	0.268	0.321	93	-0.051	0.065	107	-0.157	0.187
	10	2729	0.401	0.588	656	-0.234	1.046	56	-0.222	0.750	70	-0.146	0.229
Piedmont plain(PP1)	2	2856	0.204	0.491	555	0.229	1.002	86	0.767	0.907	168	0.491	0.560
	11	1277	0.164	0.393	676	0.305	0.509	28	0.071	0.857	122	0.083	0.180
	13	1312	-0.086	0.127	797	-0.069	0.296	18	-0.182	0.333	175	0.749	0.994
	15	946	0.118	0.148	595	-0.104	0.145	70	0.086	0.114	350	0.051	0.063
Piedmont plain (PP2)	6	1299	0.190	0.362	801	0.023	0.472	47	0.021	0.430	293	-0.073	0.123
	14	2104	-	-	962	-	-	50	-	-	316	-	-
Piedmont plain (PP3)	3	2538	-	-	578	-	-	86	-	-	98	-	-
	4	2070	-	-	406	-	-	112	-	-	126	-	-
	12	1812	-0.048	0.093	1039	0.11	0.019	32	0.688	1.250	59	0.186	0.339
Wind blown sand	8	1550	-0.213	0.387	617	-0.279	0.554	47	0.319	0.468	110	-0.154	0.255

SCL = Sandy Clay Loam GLS = Gravely Loamy Sand S = Sandy SL = Sandy Loam GSL = Gravely Sandy Loam LS = Loamy Sand
GSCL = Gravely Sandy Clay Loam GS = Gravely Sand