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STATUS OF SOME TRACE ELEMENTS AND HEAVY METALS IN THE SOILS OF DAKHLA OASIS, WESTERN DESERT, EGYPT
1. Trace Elements

Abdel-Rahman, M. E.; E. A. Abdel -Hamid and F. A. Hassan
Soil Chemistry and Physics Department, Desert Research Center, El-Matareya, Cairo, Egypt.

The soils of West El-Gedida, Dakhla Oasis (between latitudes 25° 33` and 25° 39` N and longitude 28° 40` and 28° 46` E) represent 43560 feddan. These soils were investigated to assess their contents of Fe, Mn, Zn and Cu. A total of 36 samples representing 9 virgin and cultivated soil profiles were grouped into three soil groups, namely: coarse to moderately coarse-textured soils represented by profiles 1, 2 and 3; moderately fine to fine-textured soils with coarse surface represented by profiles 4, 5 and 6 and moderately fine to fine–textured soils represented by profiles 7, 8 and 9. Soils samples were analyzed for their physical and chemical properties. Total and DTPA-extractable contents of the studied elements were also determined. These soils are of variable texture (coarse sand to clay), having low contents of $CaCO_3$ and organic matter. Most soils were saline having EC of paste extract exceeding 4.0 dSm^{-1}. The mean total content of the studied elements in the different soil groups ranged from 7470.7 to 8476.25, 250.89 to 399.48, 18.49 to 29.88 and 7.73 to 14.42 $mgkg^{-1}$ for Fe, Mn, Zn and Cu, respectively. The lowest means for Fe and Mn and Zn and Cu were recorded in the soils related to the coarse to moderately coarse-textured soils and moderately fine to fine-textured soils, respectively, while the highest means for Fe and Mn and Zn and Cu were related to the moderately fine to fine–textured soils with coarse surface and coarse to moderately coarse-textured soils, respectively. The mean DTPA-extractable content of the studied elements ranged from 3.50 to 4.84, 3.05 to 16.56, 0.42 to 0.48 and 0.31 to 0.40 $mgkg^{-1}$ for Fe, Mn, Zn and Cu, for the three groups, respectively. The lowest means for Mn and Cu; Fe and Zn were recorded in the soil groups: coarse to moderately coarse-textured soils, moderately fine to fine-textured soils with coarse surface and moderately fine to fine –textured soils, respectively, while the highest mean for Fe and Mn, Zn and Cu was related to moderately fine to fine –textured soils, coarse to moderately coarse-textured soils and moderately fine to fine –textured soils with coarse surface, respectively.

Keywords: Dakhla Oasis, trace elements, total content and DTPA-extractable, Fe, Mn, Zn, Cu.

The Western Desert of Egypt is occupied by a series of natural depressions. Among these depressions is Dakhla Oasis, which receives much concern due to its land potentiality, regardless of its low population. Dakhla Oasis, as one of the widest depressions of the Western Desert, encompasses an area of about 2000 Km^2. So it is one of the most promising areas for adding new agricultural lands.

MATERIALS AND METHODS

1. Soil Sampling

Thirty-six samples were collected from nine soil profiles representing the studied area (Fig. 1) which lies between 25° 33\` and 25° 39\`- N and between 28° 40\` and 28° 46\` E. These samples are related to 3 soil groups namely: coarse to moderately coarse-textured soils represented by profiles 1, 2 and 3 ; moderately fine to fine-textured soils with coarse surface represented by profiles 4, 5 and 6 and moderately fine to fine –textured soils represented by profiles 7, 8 and 9. These samples were air dried, crushed, passed through a 2.0 mm sieve and kept for analyses.

2. Soil Laboratory Analysis

The particle size distribution of the soil samples was conducted using the pipette method (Piper 1950) for the heavy- textured soils; where the size distribution comprised the four international system fractions of coarse sand (2.0-0.2mm), fine sand (0.2-0.02mm), silt (0.02-0.002mm) and clay (<0.002mm) and the dry sieving method for the light-textured soils where particle size distribution comprised five coarse fractions (from 2.00-0.063mm), and one fine fraction (<0.063mm). A pH meter and a conductivity salt bridge determined the pH values and electrical conductivity of the soil saturation extract, respectively, as described by Jackson (1958). Calcium carbonate was determined using the Collin's Calcimeter. Organic matter content was determined by rapid titration method (Walkley, 1947). Cation exchange capacity (CEC) and exchangeable cations were determined as described by Richards (1954).

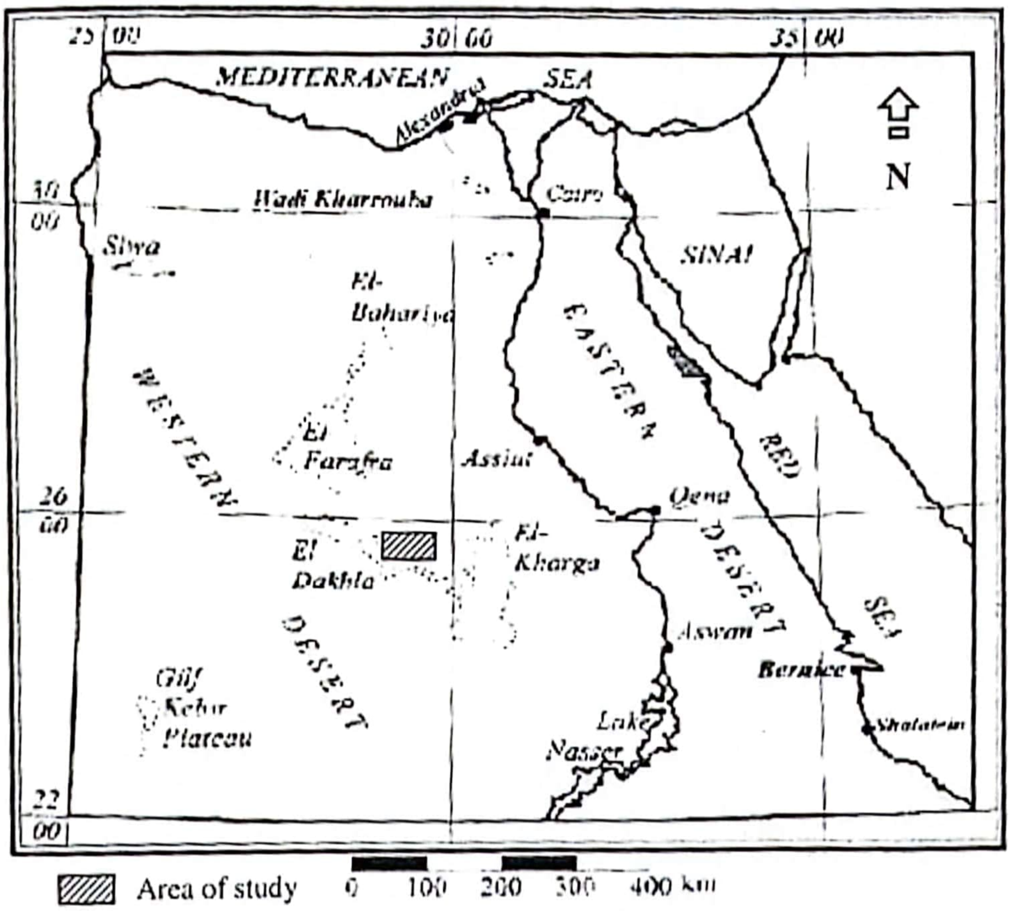

Fig. 1: The map of Egypt showing the location of the study area.

The soil samples were also analyzed for total content of the studied elements in the filtered extracts obtained from samples digested by concentrated acids of HNO_3 + H_2SO_4 + 60 % $HClO_4$ as outlined by Hesse (1971), while the DTPA-extractable contents of the studied elements were extracted using $5x10^{-3}$ N DTPA in 10^{-2} N $CaCl_2$ and 10^{-1}M triethanolamine (TEA) at pH 7.3 according to Lindsay and Norvell (1978). In all cases, the elements were determined using Unicam 929 atomic absorption spectrometer.

3. Statistical Parameters for Element Contents of Soils

Parameters of weighted mean (W), trend (T), and specific range (R) were calculated according to Oertel and Giles (1963).

RESULTS AND DISCUSSION

1. Soil Properties

Table (1) shows the results of some selected physical and chemical properties of the studied soil samples. Data show that the soils vary widely in their textural class between sand and clay. The total carbonate content ranged from 0.40 to 7.0 % with the average of 2.79 %. The lowest content was recorded in the deepest layer of profile 4, while the highest content was found in the surface layer of profile 8. Data in table (1) indicate that soils ranged from neutral to very strongly alkaline, where pH values ranged between 6.77 and 9.43. The lowest value was recorded in the subsurface layer of profile3. In general, soil salinity ranged from non-saline to very strongly saline where EC values ranged from 0.20 to 63.40 dSm^{-1}. The lowest value was found in the subsurface layer of profile 3, while the highest value was recorded in the deepest layer of profile 7.

The CEC of the studied soils reflects the soil textural class. It ranged from 1.15 to 69.24 $me100g^{-1}$ soil. The lowest value was related to the medium sand of the subsurface layer of profile 3 (of the coarse to moderately coarse–textured soils), while the highest value was recorded the clay-textured layer (70-110 cm) of profile 4 (of the moderately fine to fine-textured soils with coarse surface). On the other hand, data in table (1) show that the exchangeable cations followed three different orders: the first order: Ca > Mg > K > Na was related to the first soil group (coarse to moderately coarse –textured soils); the second order: Ca > Na > Mg > K was recorded in the second soil group (moderately fine to fine-textured soils with coarse surface) and the third order: Ca > Mg > Na > K which found in the third soil group (moderately fine to fine-textured soils).

2. Trace Elements

Iron

Tables (2) and (3) give the total and DTPA-extractable of Fe. The total content ranged between 899 and 10593 $mgkg^{-1}$ with the average of 7930 $mgkg^{-1}$. The lowest content was recorded in the surface layer of profile 1 (coarse to moderately coarse –textured soils), while the highest value was found in the deepest layer of profile 4 (moderately fine to fine-textured soils with coarse surface). Data in table (2) reveal that the distribution of total Fe content between the different soil groups follows the order: moderately fine to fine-textured soils with coarse surface > moderately fine to fine-textured soils > coarse to moderately coarse–textured soils. These results are in agreement with those of El-Demerdashe *et.al.*(1991) and Hafez *et.al.* (1992) and Abdel-Rahman and El-Demerdashe (2003). According to Schwertmann and Taylor (1989), Fe exists in the structural constituents of many clay minerals, may exist as an amorphous iron oxide coating clay external surface, or may be bound to clay surface as an exchangeable cation.

The DTPA-extractable Fe in the studied soils ranged from 2.09 to 13.74 $mgkg^{-1}$ with the average of 3.95 $mgkg^{-1}$. The lowest content was observed in the (40-75 cm) layer of profile 7 (moderately fine to fine-textured soils), while the highest value was recorded in the (30-70 cm) layer of profile 9 in the same soil group. Based on the data tabulated in table (3), the distribution of DTPA-extractable Fe in the different soil groups follows the order: moderately fine to fine-textured soils > moderately fine to fine-textured soils with coarse surface > coarse to moderately coarse– textured soils. Viets and Lindsay (1973) and El-Gala *et.al.* (1986), reported that the critical level, as determined by the DTPA method, is 4.0 mgkg-1. Soils below this level are not able to provide most growing plants with their nutritional requirements.

Manganese

Table (2) presents the amounts of total Mn in the studied soils. Examination of these data reveals that total Mn content varies widely between 80.70 and 662.70 $mgkg^{-1}$ with an average of 308.96 $mgkg^{-1}$. It should be pointed out that these values are much lower than the comparable values for Fe. The least content characterizes the surface layer of profile 7 (moderately fine to fine-textured soils), while the highest content is that recorded for the surface layer of profile 8 in the same soil group containing moderate amount of $CaCO_3$. These results are in agreement with those of El-Demerdashe *et.al.* (1991).

With regard to the distribution of total Mn content between the different soil groups, data in table (3) show that the distribution follows the order: moderately fine to fine-textured soils with coarse surface > moderately fine to fine-textured soils > coarse to moderately coarse–textured soils.

The values of the DTPA-extractable Mn are given in table (3). They ranged between 0.80 and 53.84 $mgkg^{-1}$ with an average of 7.57 $mgkg^{-1}$. The lowest content was recorded in the (40-70 cm) layer of profile 1 (coarse to moderately coarse–textured soils), while the highest content was related to the (10-30 cm) layer of profile 9 (moderately fine to fine-textured soils). As reported by Viets and Lindsay (1973) and El-Gala *et.al.* (1986), the critical level of Mn as determined by the DTPA method is 1.0 $mgkg^{-1}$. It is clearly apparent that the studied soils contain an average, which is far higher than the critical level. It was reported by Miller (1955) that the optimum concentration ratio of Fe to Mn in the nutrient medium of plant growth is about 2.0 (i.e. Fe content being about twice Mn content). The Fe to Mn ratios of the current study were 1.15, 1.13 and 0.26 for the coarse to moderately coarse–textured soils, moderately fine to fine-textured soils with coarse surface and moderately fine to fine-textured soils, respectively. Therefore, such rates indicate excessive Mn over Fe, which might aversely affect Fe uptake by plants growing in these soils.

Zinc

The total Zn content for the studied soils is given in table (2). The data indicate that the content varies from 2.17 to 61.80 $mgkg^{-1}$ with the average of 25.84 $mgkg^{-1}$. The lowest content is found in the (30-70 cm) layer of profile 9 (moderately fine to fine-textured soils), while the highest content was related to the subsurface layer of profile 4 (moderately fine to fine-textured soils with coarse surface) which have higher organic matter content, and organic matter is usually rich in Zn. The data of this work indicate the presence of a positive correlation between total Zn and organic matter content of the soils (Table 4).

The values of DTPA-extractable Zn are reported in table (3), where they range from 0.04 to 1.03 mgkg-1. The lowest content was recorded in the deepest (70-120cm) layer of profile 1 (coarse to moderately coarse-textured soils), while the highest value was found in the subsurface (12-40 cm) layer of profile 7 (moderately fine to fine-textured soils). Kamh (1981) reported values ranging from 1.0 to 5.8 $mgkg^{-1}$ with the upper range in heavy soils. Statistical calculation indicates that within all measured soil properties of the current study work, DTPA-extractable Zn is correlated positively significantly only with organic matter content (Table 4). Ibrahim *et.al.* (1994) developed a mathematical model to assess Zn availability as a function of some soil factors. They reported that DTPA-extractable Zn was significantly affected by organic matter, $CaCO_3$, soil pH and clay content of soils. However, it should be mentioned that the work of Ibrahim *et.al.* (1994) dealt with "artificial" soils, which were constituted of washed sand mixed with variable amounts of calcite and clay separates. Based on the indexes of Viets and Lindsay (1973) and El-Gala *et al.* (1986), soils of the present study are deficient in available Zn.

Copper

Table (2) shows that the total Cu content of the studied soils varies from 1.20 to 41.10 $mgkg^{-1}$ with the average of 12.03 $mgkg^{-1}$. The lowest content was found in the (0-18 cm)as well as the (90-120 cm) layer of profile 8 (moderately fine to fine-textured soils), while the highest value was recorded in the deepest layer of profile 2 (coarse to moderately coarse-textured soils). As was the case with Zn there is a positive correlation between total Cu and organic matter content. This result is in agreement with that of Tahoun *et al.* (1999).

The DTPA-extractable Cu of soils, as given in table (3), ranges from 0.04 to 0.82 $mgkg^{-1}$ with an average of 0.35 $mgkg^{-1}$. The least amount was found in the deepest layer of profile 1 (coarse to moderately coarse–textured soils), while the highest value was recorded in the (35-70 cm) layer of profile 5 (moderately fine to fine-textured soils with coarse surface). Based on the conclusion by Kabata Pendias and Pendias (1992) who reported that Cu levels less than 2 mg Cu / kg soil are likely to be inadequate for growth of most plants, all of the soils of current study are deficient in available Cu. The reason for this phenomenon may be related to some intrinsic genetic soil factors, which are related to the quantity and thermodynamic stability of the native Cu phases.

TABLE (1). Physical and chemical properties of the studied soil samples.

Profile No.	Depth Cm	pH (1:1)	EC dS m⁻¹	CaCO₃ %	O.M %	Particle size distribution (%): coarse fraction 2.0-1.0	1.0-0.5	0.5-0.25	0.25-0.125	0.125-0.063	Fine fraction < 0.063	Silt	clay	Texture class	CEC me 100g⁻¹ soil	Exchangeable Cations me 100g⁻¹ soil: Na	K	Ca	Mg
coarse to moderately coarse textured soils																			
1	0-15	7.76	17.18	1.90	0.27			10.17*	25.16**			26.18	18.49	SL	17.06	0.53	0.83	0.37	5.07
	15-40	8.90	6.52	1.30	0.13	13.28	29.55	46.08	8.96	1.91	1.65			MS	2.00	0.79	0.06	0.45	0.60
	40-70	7.88	10.25	1.30	0.08	19.42	31.08	37.05	6.69	3.63	2.93			CS	2.49	0.12	0.15	0.78	0.08
	70-150	8.07	8.14	1.50	0.13	17.56	31.43	40.22	3.82	5.53	1.40			CS	3.11	0.61	0.73	0.64	0.91
2	0-10	8.41	7.74	2.40	0.17	1.74	10.06	50.74	18.75	10.74	8.69			MS	4.87	0.09	0.78	2.12	0.92
	10-45	8.47	21.70	1.70	0.10	13.15	22.34	38.09	11.80	7.19	7.11			MS	9.82	0.72	0.69	1.52	1.17
	45-75	8.77	49.70	1.70	0.07	19.81	24.75	34.64	11.12	6.77	8.14			CS	3.75	2.66	0.83	0.11	0.58
	75-130	7.75	57.10	0.80	0.67	21.21	25.06	34.26	9.12	5.50	4.67			CS	7.23	0.54	0.08	0.76	0.57
3	0-30	8.40	0.47	8.80	0.17	0.18	1.70	22.69	58.06	14.65	2.81			MS	1.22	0.6	0.09	0.47	0.77
	30-60	8.45	0.75	8.80	0.05	0.29	1.66	18.23	61.45	16.87	1.77			MS	1.15	0.06	0.06	0.52	0.56
	60-95	8.76	0.60	8.30	0.05			28.47*	40.47**			17.95	5.87	LS	4.00	0.12	0.03	2.06	1.40
	95-140	9.06	0.58	5.50	0.56			28.01*	33.25**			16.28	21.46	SCL	13.84	0.06	0.03	6.78	3.61
moderately fine to fine textured soils with coarse surface																			
4	0-30	8.67	0.49	5.90	0.19			67.24*	20.49**			12.24	4.08	LS	7.15	0.07	0.07	0.49	0.73
	30-70	8.77	8.74	0.00	0.01			2.80*	58.11**			39.43	48.45	C	34.00	15.75	7.10	6.12	2.69
	70-110	8.81	7.36	0.50	0.84			0.00*	7.04**			19.34	73.62	C	49.24	29.91	7.64	15.71	11.66
	110-150	8.77	9.61	0.80	0.94			0.29*	6.85**			20.92	72.34	C	47.05	34.62	7.08	8.45	11.76
5	0-10	7.60	45.72	2.00	0.17			11.86*	47.87**			12.65	7.85	LS	6.77	0.56	2.09	1.45	0.60
	10-35	6.94	47.90	2.40	0.44			17.26*	20.63**			31.00	30.48	CL	38.11	8.76	2.90	7.18	4.76
	35-70	7.51	58.90	1.50	0.19			26.36*	20.90**			21.97	27.56	CL	21.01	9.62	2.08	3.09	2.43
	70-120	7.76	96.40	1.50	0.74			34.78*	17.59			16.77	30.44	CL	23.06	7.56	1.37	6.32	4.51
6	0-20	7.77	2.07	5.40	0.17	3.01	4.82	16.41	54.55	16.07	5.96			MS	5.83	0.17	1.10	1.66	2.08
	20-65	7.95	7.56	5.00	0.29			10.09*	19.61**			28.01	39.47	CL	34.09	0.08	1.57	16.75	13.01
	65-90	7.51	5.40	1.50	0.13			10.12*	17.17**			22.97	49.19	C	42.07	9.75	2.56	22.65	15.65
	90-150	7.56	6.60	1.50	0.10			14.56*	17.57**			16.50	51.38	C	42.07	0.47	4.13	18.91	14.22
moderately fine or fine textured soils																			
7	0-17	7.36	55.00	1.15	0.11			18.06*	25.30**			28.16	30.00	CL	28.94	5.80	2.30	10.56	7.75
	17-40	7.48	57.60	0.60	0.57			28.75*	29.42**			18.47	19.80	SCL	24.18	7.02	3.58	5.53	3.93
	40-75	7.08	46.70	1.60	0.03			20.56*	10.98**			28.03	30.43	SCL	23.09	14.56	6.37	1.78	1.76
	75-150	8.67	65.40	1.70	0.76			22.28*	15.30**			25.75	36.58	CL	36.18	4.68	2.75	11.80	14.54
8	0-18	7.65	7.86	7.00	0.70			42.00*	20.10**			16.75	21.19	SCL	17.18	0.52	0.67	8.41	5.07
	18-40	7.95	7.60	1.50	0.03			10.47*	24.57**			30.66	44.77	C	42.10	11.50	11.49	9.00	6.87
	40-90	8.06	6.29	1.80	0.03			8.11*	15.48**			30.68	45.16	C	47.84	8.80	7.32	7.56	2.78
	90-130	8.17	8.40	1.10	0.03			1.07*	14.30**			28.54	56.47	C	52.19	17.22	10.00	11.27	7.84
9	0-10	7.65	1.70	5.40	0.03			2.19*	17.56**			67.16	23.18	SiL	16.50	0.08	0.67	8.89	4.71
	10-50	8.57	0.50	4.30	0.27			8.12*	21.47**			23.63	40.95	C	42.09	0.75	6.32	20.64	10.56
	50-90	8.07	0.76	5.10	0.03			42.70*	18.84**			12.78	27.00	SCL	18.65	0.20	0.29	8.76	5.87
	90-110	8.08	1.00	5.90	0.44			22.11*	30.56**			12.78	23.95	SCL	16.82	0.32	0.74	7.08	5.71

* course sand 2.0 - 0.2mm **: fine sand 0.2 – 0.02mm

SL: sandy loam MS: medium sand CS: course sand LS: loamy sand SCL: sandy clay loam C: clay SiL: silty loam

TABLE (2). Total content of trace elements in the studied soils of Dakhla Oasis, Egypt.

Profile No.	Depth, cm	$mg\,kg^{-1}$			
		Fe	Mn	Zn	Cu
Coarse to moderately coarse-textared soils					
1	0-15	899	471.8	49.3	18.7
	15-40	8484	149.5	37.8	14.8
	40-70	8628	397.6	30.1	13.3
	70-120	8220	323.8	51.5	18.1
2	0-10	7539	179.3	31.8	15.2
	10-45	7272	221.5	18.3	12.8
	45-75	7113	303.7	32.4	25.2
	75-130	9816	314.7	61.0	41.1
3	0-30	7323	173.9	10.3	3.2
	30-60	7515	278.2	11.6	3.3
	60-95	9321	97.6	11.3	3.2
	95-140	7518	99.1	13.2	4.1
Moderately fine to fine-textured soils with coarse surface					
4	0-30	8289	233.0	23.3	21.2
	30-70	9282	273.5	61.8	27.5
	70-110	8808	206.8	41.8	23.4
	110-150	10593	501.4	55.8	16.7
5	0-10	8028	401.6	19.7	17.4
	10-35	8016	894.1	54.8	16.4
	35-70	8190	894.1	21.5	15.9
	70-110	8256	591.7	13.3	9.5
6	0-20	7794	215.6	12.7	4.4
	20-65	7584	245.7	15.3	5.1
	65-90	8271	167.0	16.4	4.4
	90-150	8604	169.3	13.3	5.4
Moderately fine to fine-textured soils					
7	0-12	7947	80.7	37.3	11.4
	12-40	7761	81.4	54.3	18.1
	40-75	8298	126.2	37.1	21.8
	75-150	8826	323.9	44.0	12.7
8	0-18	7509	662.7	8.3	1.2
	18-40	7878	397.8	8.5	3.3
	40-90	7866	335.9	9.3	3.2
	90-120	7830	219.5	9.1	1.2
9	0-10	7473	261.2	3.5	6.9
	10-30	7581	283.0	4.0	3.8
	30-70	7497	241.9	2.2	5.1
	70-110	7686	304.0	4.3	4.0

Factors Affecting Fe, Mn, Zn and Cu Status in the Studied Soils.

The presented data show that some factors are involved in controlling the studied elements. To substantiate the relationship between total and DTPA-extractable forms and some soil properties, correlation coefficients were computed and presented in table (4).

TABLE (3). DTPA- extractable contents of trace elements in the studied soils of Dakhla Oasis, Egypt.

Profile No.	Depth, cm	$mg\,kg^{-1}$			
		Fe	Mn	Zn	Cu
Course to moderately coarse-textured soils					
1	0-15	2.97	2.01	0.51	0.16
	15-40	3.26	1.07	0.91	0.19
	40-70	2.86	0.80	0.27	0.10
	70-120	2.86	1.00	0.04	0.04
2	0-10	2.87	1.84	0.50	0.41
	10-45	2.54	1.24	0.56	0.21
	45-75	2.71	1.50	0.67	0.31
	75-130	3.11	0.88	0.95	0.60
3	0-30	6.05	4.94	0.46	0.34
	30-60	4.47	3.14	0.24	0.43
	60-95	4.11	5.58	0.26	0.37
	95-140	4.32	12.57	0.33	0.61
Moderately fine to fine-textured soils with coarse surface					
4	0-30	3.61	1.07	0.72	0.31
	30-70	3.92	2.50	0.57	0.19
	70-110	3.07	2.19	0.30	0.11
	110-150	3.24	2.19	0.40	0.16
5	0-10	2.80	1.23	0.38	0.79
	10-35	2.18	2.07	0.50	0.57
	35-70	3.79	2.41	0.43	0.82
	70-110	3.99	2.19	0.92	0.77
6	0-20	4.73	6.45	0.46	0.32
	20-65	4.24	6.25	0.32	0.27
	65-90	3.58	4.84	0.35	0.24
	90-150	2.79	3.92	0.22	0.22
Moderately fine to fine-textured soils					
7	0-12	2.31	1.56	0.21	0.16
	12-40	2.14	1.42	1.03	0.45
	40-75	2.09	1.16	0.21	0.35
	75-150	2.38	1.52	0.53	0.33
8	0-18	3.31	3.08	0.53	0.45
	18-40	3.46	4.27	0.38	0.34
	40-90	3.99	6.33	0.23	0.30
	90-120	3.20	2.37	0.21	0.38
9	0-10	6.87	50.52	0.47	0.39
	10-30	7.22	53.84	0.88	0.44
	30-70	13.74	51.30	0.48	0.34
	70-110	7.34	21.38	0.39	0.25

TABLE (4). Values of correlation coefficients between some soil properties and total and DTPA-extractable elements in soils of Dakhla Oasis, Egypt.

soil variable	Fe		Mn		Zn		Cu	
	Total	DTPA-extractable	Total	DTPA-extractable	Total	DTPA-extractable	Total	DTPA-extractable
pH	0.10	0.19	- 0.32	0.09	- 0.28	- 0.19	- 0.28	- 0.16
EC	0.08	- 0.47*	0.20	- 0.382*	0.54**	0.29	0.56**	0.36*
$CaCO_3$	- 0.161	0.500**	- 0.11	0.50**	- 0.63**	- 0.11	- 0.57**	0.16
O.M	0.18	- 0.19	0.05	- 0.17	0.63**	0.35*	0.52**	- 0.04
CEC	0.13	- 0.08	0.08	0.04	0.07	- 0.19	- 0.13	- 0.19

* and ** denote the significance of correlation at 0.05 and 0.01 levels, respectively.

TABLE(5). Weighted mean (W), trend (T) and specific range (R) of total content of trace elements in soils of Dakhla Oasis, Egypt.

Profile No.	Fe			Mn			Zn			Cu		
	W $mgkg^{-1}$	T	R	W $mgkg^{-1}$	T	R	W $mgkg^{-1}$	T	R	W $mgkg^{-1}$	T	R
Coarse to moderately coarse-textured soils												
1	7461.93	0.88	1.04	324.44	- 0.45	0.99	43.02	- 0.15	0.50	16.29	-0.15	0.33
2	8332.15	0.10	0.32	264.97	0.32	0.51	40.66	0.22	1.05	27.82	0.45	1.02
3	7926.32	0.08	0.25	153.13	- 0.14	1.18	11.76	0.12	0.25	3.51	0.09	0.26
Moderately fine to fine-textured soils with coarse surface												
4	9306.60	0.11	0.25	308.39	0.24	0.96	47.17	0.51	0.82	22.27	0.05	0.48
5	8159.73	0.02	0.03	739.36	0.46	0.67	25.92	0.24	1.60	13.82	- 0.26	0.57
6	8134.50	0.04	0.13	198.01	- 0.09	0.40	14.34	0.11	0.26	5.01	0.12	0.20
Moderately fine to fine-textured soils												
7	8433.68	0.06	0.13	213.05	0.62	1.14	46.31	0.19	0.37	15.73	0.28	0.66
8	9766.15	0.23	0.04	367.17	- 0.80	1.21	8.95	0.07	0.11	2.42	0.50	0.87
9	7578.82	0.01	0.03	273.71	0.05	0.23	3.39	- 0.03	0.63	4.63	-0.49	0.67

The obtained coefficients show that no statistically significant correlation was detected between total content of Fe, Mn and any of the soil properties, which were determined in this work. This result was in agreement with those of El-Falah (1995) and Abdel-Rahman and El-Demerdashe (2003). On the other hand, data in table (4) indicate that total Zn and Cu are positively and highly significantly correlated with EC and organic matter, but negatively and highly significantly correlated with $CaCO_3$ content. This result is in agreement with that of Ibrahim *et al.* (1994).

DTPA-extractable Fe shows a significant negative correlation with EC and a highly significant positive correlation with $CaCO_3$; with no significant correlation with organic matter. DTPA-extractable Mn shows a significant negative correlation with EC and a significant positive correlation with $CaCO_3$ with no significant correlation with organic matter. Data also show that DTPA- Zn and DPTA-Cu are positively and significantly correlated with O.M and EC, respectively.

To work out the relationship between the distribution of elements (Fe, Mn, Zn and Cu) and locality of the studied soil profiles, the three statistical measures suggested by Ortel and Giles (1963) namely, weighted mean , trend and specific range were applied.

Table (5) show that the weighted mean for total Fe, Mn, Zn and Cu in the studied soils varies from 7461.93 to 9766.15; 153.15 to 739.36; 3.39 to 47.17 and 2.42 to 27.82 $mgkg^{-1}$, respectively. The variation observed within the studied profiles may be due to the variation of soil formation processes or local conditions prevailing in each site.

With respect to the trend, data in table (5) indicate symmetrical distribution of total Fe, Mn, Zn and Cu as indicated by the T values which ranged from 0.01 to 0.88; - 0.80 to 0.62; - 0.15 to 0.51 and – 0.49 to 0.50, for each of those elements, respectively. These results show that the studied elements are either somewhat lower in the surface are being higher in the surface layer than in the deepest ones as indicated by the positive or negative values for the trend.

Data in table (5) show that specific range for total content of Fe, Mn, Zn and Cu was widely variable where ranged from 0.03 to 1.04; 0.23 to 1.21; 0.11 to 1.60 and 0.20 to 1.02, respectively. This show that the pedogenic processes had acted in a fairly uniform manner through the solum.

Computation of the weighted mean, trend and specific range of the DTPA- extractable trace elements were carried out in table (6). It is clear that the weighted mean for DTPA-extractable Mn varied very widely where it ranged from 1.09 to 40.81 $mgkg^{-1}$. It also, varied widely for Fe, Zn and Cu where the ranges were 2.26 to 9.60 for Fe; 0.30 to 0.75 for Mn and 0.10 to 0.74 for Cu.

The results of T values indicate that Fe, Mn, Zn and Cu are often higher in the surface layer than the deepest ones as indicated by the common negative values for the trend.

The specific range for the studied elements varied widely and ranged from 0.13 to 0.72; 0.30 to 0.75 and from 0.34 to 1.50 for Fe, Mn, Zn and Cu, respectively. This indicates that the pedogenic processes had acted throughout the solum in each soil profile.

TABLE (6). Weighted mean (W), trend (T) and specific range (R) of DTPA-extractable content of trace elements in soils of Dakhla Oasis, Egypt.

Profile No.	Fe			Mn			Zn			Cu		
	W mgkg-1	T	R	W mgkg-1	T	R	W mgkg-1	T	R	W mgkg-1	T	R
Coarse to moderately coarse-textured soils												
1	2.96	- 0.01	0.14	1.09	-0.84	1.11	0.34	-0.50	2.56	0.10	-0.60	1.50
2	2.85	- 0.01	0.20	1.19	-0.55	0.81	0.75	0.33	0.60	0.41	0.00	0.95
3	4.67	- 0.30	0.42	7.17	0.31	1.32	0.32	- 0.44	0.69	0.45	0.24	0.60
Moderately fine to fine-textured soils with coarse surface												
4	3.45	- 0.05	0.25	2.05	0.48	0.70	0.48	-0.50	0.88	0.18	-0.72	1.11
5	3.41	0.18	0.53	2.15	0.43	0.55	0.62	0.39	0.87	0.74	-0.07	0.34
6	3.62	- 0.3	0.54	5.11	- 0.26	0.50	0.30	-0.53	0.80	0.25	-0.28	0.40
Moderately fine to fine-textured soils												
7	2.26	-0.02	0.13	1.42	- 0.10	0.28	0.52	0.60	1.58	0.34	0.53	0.85
8	3.59	0.08	0.22	4.48	0.31	0.89	0.30	- 0.77	1.07	0.35	- 0.29	0.43
9	9.60	0.28	0.72	40.81	- 0.24	0.80	0.52	0.10	0.94	0.33	- 0.18	0.58

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حالة بعض العناصر الصغرى والفلزات الثقيلة في أراضي الواحات الداخلة - الصحراء الغربية - مصر

١- العناصر الصغرى

محمد عيسى عبد الرحمن - إدريس عبد الواحد عبد الحميد - فتحي أحمد حسن
قسم كيمياء وطبيعة الأراضي- مركز بحوث الصحراء- المطرية - القاهرة - مصر.

أجريت الدراسة علي ستة وثلاثون عينة أرضية جمعت من تسعة قطاعات مابين أرض لم يسبق زراعتها إلي أرض منزرعة وهي:
coarse to moderately coarse-textured soils ، moderately fine to fine-textured
soils with coarse surface ، moderately fine to fine-textured soils وذلك لدراسة
حالة كل من الحديد ؛ المنجنيز ؛ الزنك ؛ النحاس. وقد أوضحت النتائج أن المحتوى الكلي من
العناصر تحت الدراسة في الأراضي السابقة تراوح مابين ٧٤٧٠.٧ - ٨٤٧٦.٢٥ ، ٢٥٠.٨٩ -
٣٩٩.٤٨ ، ١٨.٤٩ - ٢٩.٨٨ ، ٧.٧٣ - ١٤.٤٢ ملليجرام / كجم لكل من الحديد ، المنجنيز ،
الزنك ، النحاس علي التوالي ، وكان أقل محتوى لكل من الحديد ، المنجنيز ؛ الزنك ، النحاس
في أراضي coarse to moderately coarse-textured soils ، moderately fine to
fine-textured soils علي التوالي ، بينما كان أعلي محتوي لها في أراضي moderately
fine to fine-textured soils with coarse surface ، coarse to moderately coarse-
textured soils علي التوالي . كما أوضحت النتائج أن المحتوى الميسر تراوح مابين ٣.٥ -
٤.٨٤ ؛ ٣.٠٥ - ١٦.٥٦ ؛ ٠.٤٢ - ٠.٤٨ ؛ ٠.٣١ - ٠.٤٠ ملليجرام / كجم لكل الحديد ،
المنجنيز ، الزنك ، النحاس علي التوالي ، وكان أقل محتوي لكل من المنجنيز ، النحاس ؛ الحديد
، الزنك في أراضي coarse to moderately coarse-textured soils ، moderately
fine to fine-textured soils with coarse surface ، moderately fine to fine-
textured soils علي التوالي ، بينما أعلي محتوى لكل من الحديد ، المنجنيز ؛ الزنك ، النحاس
في أراضي moderately fine to fine-textured soils ، coarse to moderately
coarse-textured soils ، moderately fine to fine-textured soils with coarse
surface علي التوالي.