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Total and DTPA-extractable Micronutrients as Correlated to some Soil Properties in Kaluobia Governorate

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THIS WORK aims at studying and evaluating the relation between total and DTPA-extractable Fe, Mn, Zn, Cu and Mo and some soil variables, *i.e.* soil texture, $CaCO_3$ content, O.M and CEC of seventeen soil profiles representing the main soil types of Kaluobia Governorate. Obtained results could be summarized as follows:

- Total iron content ranged from 135 to 66000 mg kg^{-1} whereas DTPA extractable Fe ranged between 4.4 and 18.5 mg kg^{-1} in the studied soils.
- Total manganese content ranged from 87 to 985 mg kg^{-1} while DTPA extractable Mn ranged from 0.4 to 9.5 mg kg^{-1}.
- Total zinc content ranged from 25 to 175 mg kg^{-1} and the DTPA extractable Zn varied between 0.3 to 4.2 mg kg^{-1} depending on soil texture.
- Total copper content in the studied soils ranged between 17.7 and 97.5 mg kg^{-1}, whereas DTPA extractable Cu varied from 1.1 to 9.9 mg kg^{-1} with an increase in the surface layers.
- Total Mo content in the studied soil profiles varied widely from 2.9 to 21.4mg kg^{-1}, DTPA extractable Mo ranged 0.07 to 1.26 mg kg^{-1}. The vertical distribution of DTPA extractable Mo indicates a relative increase of Mo in the top surface layers.
- Highly significant positive correlation was found between total soil content of most of the studied elements and each of $CaCO_3$, silt %, clay % and CEC, whereas highly significant negative correlation was found with sand %.
- In most soil profiles, soil content of available Fe or Mn is considered to be adequate whereas that of available Cu is high and that of Zn is adequate and marginal.

• The trend T indicates that some of the soil profiles are highly symmetric with respect to Fe, Mn, Zn and Cu than with Mo, whereas the specific range (R), shows the homogeneity of some soil profiles with respect to some elements and heterogeneity with respect to others.

Keywords: Total and DTPA-extractable, Micronutrients, Soil properties.

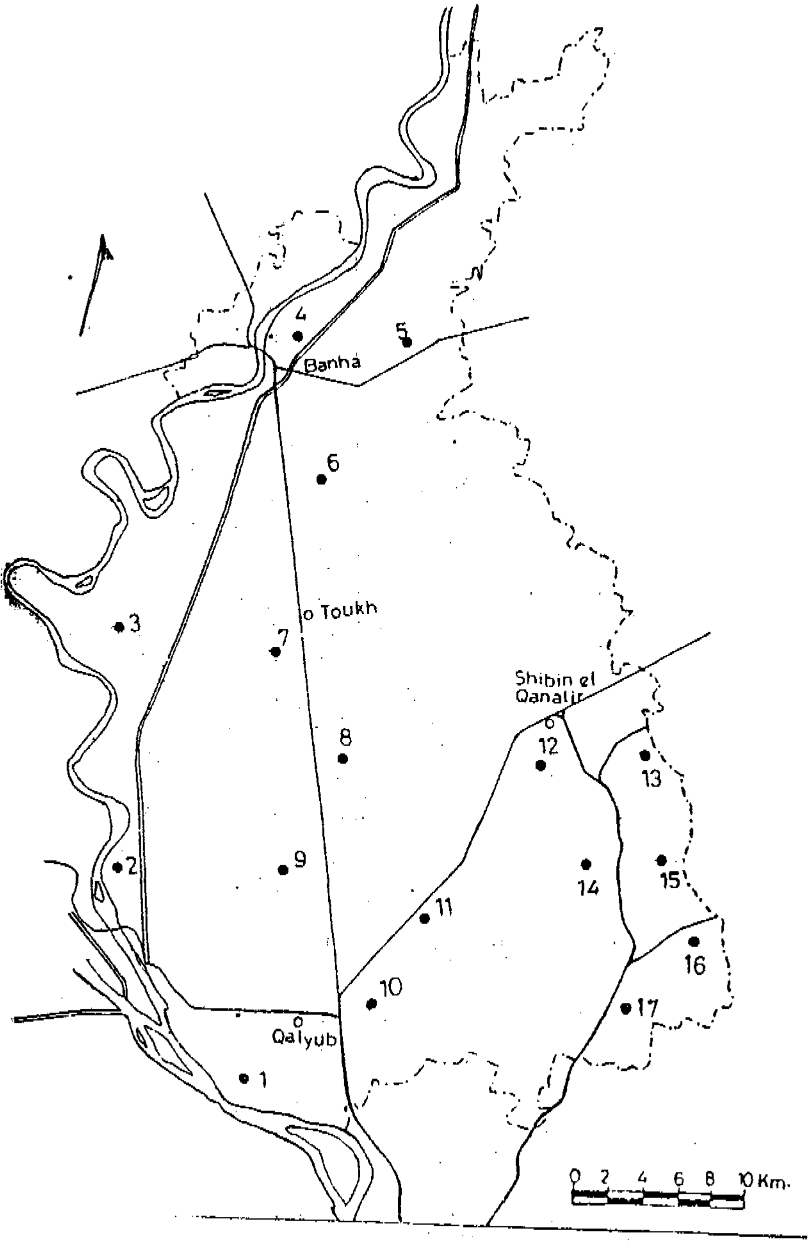
Micronutrients status in soil is dependent almost entirely on the bedrock from which soil parent material was derived. Both geochemical and weathering processes are responsible for formation of soil materials as a final product upon time. Micronutrients are present in all types of soils in the whole. However, their contents and status vary considerably from one soil to another and even in the subsequent layers of the same soil profile. These variations are controlled by several soil environmental factors. Therefore, it is of interest to delineate these factors and to determine their relative contribution to micronutrient forms in soils.

The aim of the present work is to describe the micronutrients status in the agricultural soils of Kaluobia Governorate, which represent different soil types. Moreover, the factors controlling micronutrient status are also considered such as soil texture, $CaCO_3$ and organic matter contents, salinity, soil reaction and cation exchange characteristics.

Material and Methods

Seventeen soil profilies were chosen at different locations of Kaluobia Governorate to represent the main soil types present in the area (Map 1). Table 1 shows some physical and chemical properties, of the studied soils, determined according to the methods outlined in Jackson (1973) and Loveday (1974).

Total Fe, Mn, Zn, Cu and Mo in the soils were extracted by digestion in HF-$HClO_4$ acids mixture in a platinum crucible, (Jackson, 1973) whereas available Fe, Mn, Zn, Cu and Mo were extracted by DTPA, according to Lindsay and Norvell (1978) Both total and extractable Fe, Mn, Zn, Cu and Mo were determined by Atomic-Absorption Spectrophotometer, Perkin Elmer, model 380. Results were statistically analyzed using an ANOVA F test.



Map 1. Location of the studied soil profiles.

TABLE. 1. Some physical and chemical properties of the studied soil horizons.

Prof No.	Location	Depth (cm)	Particle size distribution %			PH	EC DS m^{-1}	$CaCO_3$ %	O.M %	CEC me/ 100g soil	Soluble cations (meq/L)				Soluble anions (meq/L)			
			Sand	Silt	Clay						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}
1	Abu-El-Ghait	0-20	44.7	365	18.8	7.3	0.97	2.10	1.7	32.0	3.5	3.7	4.7	0.70	-	4.0	4.0	4.6
		25-75	36.4	383	25.3	7.1	0.94	2.80	0.9	38.4	3.5	1.6	3.4	0.20	-	5.0	3.1	0.6
		75-125	25.5	416	32.9	7.3	0.98	3.60	0.9	40.0	3.5	2.7	4.8	0.20	-	3.6	4.0	3.6
2	El-Munira	0-20	36.6	345	28.9	7.5	0.65	1.20	1.7	39.2	4.6	0.5	2.9	0.20	-	4.6	3.2	0.4
		20-50	47.9	322	19.9	7.2	0.84	2.60	0.9	35.2	3.5	2.7	4.5	0.20	-	4.0	4.0	2.9
		50-100	40.1	403	19.6	7.5	0.64	2.30	1.4	33.6	4.6	0.5	3.4	0.10	-	3.2	3.2	2.2
		100-150	41.3	379	20.8	7.5	0.70	2.90	1.2	39.2	3.5	1.6	3.9	0.20	-	3.8	3.2	2.2
3	Kafr El-Ragalat	0-30	69.0	155	15.5	7.4	0.76	0.95	1.7	23.2	3.5	2.7	3.0	1.00	-	5.8	3.1	1.3
		30-70	88.8	32	8.0	7.4	0.61	0.21	0.9	13.0	1.2	2.9	2.4	0.60	-	3.2	2.3	1.6
		70-120	92.9	23	4.8	7.5	0.34	0.32	0.3	8.4	1.2	1.9	2.9	0.40	-	3.0	2.3	1.1
4	Kafr Saad	0-20	65.2	189	15.9	7.4	1.60	2.60	2.3	32.8	4.6	5.6	7.6	0.50	-	5.6	6.0	6.7
		20-50	69.8	149	15.3	7.6	0.98	2.10	0.6	24.8	1.2	2.9	5.6	0.20	-	3.4	6.0	0.5
		50-90	76.0	125	11.5	7.6	0.67	0.43	1.2	18.4	2.3	2.8	4.8	0.20	-	2.8	5.0	2.3
		90-120	90.4	47	4.9	7.6	0.65	2.30	0.6	27.2	1.2	3.0	3.9	0.20	-	3.0	4.0	1.3
5	Shiblamga	0-20	59.1	241	16.8	7.9	1.30	3.30	1.8	47.0	3.5	2.6	10.0	0.20	-	5.2	9.0	2.1
		20-60	58.7	205	20.8	7.8	1.80	2.90	1.7	47.0	2.3	3.8	12.3	0.10	-	3.8	10.0	4.7
		60-110	48.7	196	31.7	7.8	2.20	1.20	1.7	49.0	2.3	3.3	19.5	0.10	-	5.0	18.0	2.2
6	Sandanhor	0-20	64.4	170	18.6	7.6	0.78	3.20	1.9	36.0	2.3	4.3	3.9	0.40	-	5.0	3.3	2.6
		20-50	65.2	164	18.4	7.6	0.91	3.30	1.7	39.2	4.6	2.5	5.0	0.20		7.0	4.1	1.2
		50-100	64.2	160	19.8	7.5	1.10	3.10	1.7	36.2	4.6	2.5	7.2	0.20	-	3.8	8.0	2.7
		100-150	63.7	172	19.1	7.5	1.40	3.10	1.4	52.1	2.3	3.3	9.4	0.20	-	3.8	8.0	3.4
7	Kafr El-Gamal	0-20	71.6	3.7	24.7	7.5	0.66	2.20	1.9	46.3	2.3	4.3	2.0	0.60	-	5.0	2.1	2.1
		20-60	74.7	179	7.4	7.5	0.66	2.50	1.9	28.0	2.3	2.2	2.7	0.30	-	4.0	2.3	1.2
		60-90	85.7	9.6	4.7	7.5	0.62	0.50	1.7	35.2	2.3	2.3	2.8	0.10	-	3.2	2.3	2.0
		90-120	65.8	164	17.8	7.5	1.50	1.60	1.7	38.4	4.6	3.5	10.0	0.40	-	4.2	8.0	6.3
8	Qaha	0-25	68.8	154	15.5	7.6	0.69	6.10	2.2	38.4	2.3	2.8	3.9	0.10	-	3.3	3.3	2.6
		25-60	32.6	151	52.3	7.5	2.10	2.50	1.2	50.2	5.7	5.4	13.8	0.30	-	4.0	11.0	10.2
		60-90	37.4	168	45.8	8.0	1.20	4.50	1.2	50.2	1.2	1.9	12.0	0.10	-	3.0	11.0	1.0
		90-120	38.0	193	42.7	8.3	1.20	2.30	1.2	40.0	1.2	1.9	11.3	0.10	-	4.3	10.0	0.5
9	Sindiyn	0-25	30.7	247	44.6	7.5	0.59	2.40	1.4	50.9	2.9	2.2	2.8	0.20	-	3.0	3.0	2.1
		25-75	30.8	218	47.4	7.6	0.69	2.90	0.9	38.4	2.9	2.7	3.5	0.10	-	2.6	3.0	3.6
		75-110	32.5	229	44.6	7.4	0.96	2.80	1.2	36.0	2.3	3.8	6.8	0.10	-	2.2	6.0	4.8

TABLE 1. Cont.

Prof No.	Location	Depth (cm)	Particle size distribution%			PH	EC Dsm^{-1}	$CaCO_3$ %	O.M %	CECme/ 100g soil	Soluble cations (meq/L)				Soluble anions (meq/L)			
			Sand	Silt	Clay						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}
10	Qalyub	0-25	45.8	290	25.2	7.4	1.1	3.10	2.2	37.6	5.2	4.5	4.7	0.50	-	4.8	4.0	6.1
		25-50	40.0	213	38.7	7.5	0.65	3.30	1.2	45.0	3.5	1.6	2.9	0.30	-	2.4	3.0	1.9
		50-90	43.6	204	36.0	7.4	0.84	2.30	1.2	36.0	4.0	2.1	3.8	0.30	-	2.8	3.0	4.4
		90-120	38.4	172	44.4	7.4	0.70	2.20	0.9	37.6	3.5	2.7	3.6	0.20	-	2.9	3.0	4.2
11	Nawa	0-30	34.9	215	43.6	7.6	1.20	3.70	1.9	39.2	2.3	2.8	9.2	0.30	-	4.4	.80	2.2
		30-60	30.3	199	51.8	7.9	1.50	3.50	1.7	35.2	1.7	1.8	14.0	0.20	-	5.0	12.0	0.7
		60-90	36.3	167	47.0	8.1	1.60	3.20	1.4	37.6	1.2	0.9	17.3	0.20	-	3.0	16.0	0.6
		90-120	35.3	247	40.0	7.8	1.90	3.30	1.4	27.2	1.2	1.9	19.0	0.20	-	3.4	18.0	0.9
12	Kafr Shibin	0-20	39.2	327	28.1	7.7	1.40	4.30	2.3	24.0	3.5	3.7	9.4	0.60	-	5.0	8.0	4.2
		20-60	41.4	287	29.9	7.8	1.10	2.90	0.9	24.4	2.3	1.8	7.4	0.30	-	4.0	7.0	0.8
		60-90	46.0	264	27.6	7.7	1.10	2.80	0.9	24.8	2.3	1.8	8.8	0.20	-	2.8	8.0	2.3
		90-120	43.5	252	31.6	7.7	1.30	2.30	1.1	32.4	2.9	2.7	9.0	0.20	-	3.8	9.0	2.0
13	Abu Zaabal	0-25	86.3	47	9.0	7.2	1.20	1.10	0.9	17.2	3.5	5.7	4.8	0.40	-	3.0	4.0	7.4
		25-50	87.7	62	6.1	7.3	0.90	2.20	0.6	9.2	3.5	4.7	2.8	0.30	-	3.0	3.0	5.3
		50-75	93.5	24	4.1	7.4	0.70	1.10	0.6	4.8	2.3	2.8	2.5	0.30	-	2.2	2.0	3.7
14	Abu-Zaabal 11	0-25	47.7	233	29.0	7.4	1.10	2.60	1.7	25.6	3.5	3.7	6.0	0.30	-	4.4	6.0	3.1
		25-60	41.7	234	34.9	7.4	1.90	3.60	1.4	34.0	3.5	8.8	11.3	0.20	-	3.2	10.4	0.2
		60-90	31.8	266	41.6	7.5	1.80	3.40	1.2	23.4	2.3	3.8	15.6	0.10	-	3.0	14.0	4.8
		90-120	35.3	258	38.9	7.5	1.80	3.70	1.4	16.8	1.2	3.9	16.4	0.10	-	3.6	16.0	2.0
15	El-Khanka	0-20	90.3	43	5.4	7.4	5.80	4.30	1.7	37.0	6.9	16.5	43.5	1.10	-	6.4	43.0	.18.6
		20-75	84.6	68	8.6	7.6	3.40	1.40	0.9	15.6	6.9	4.3	27.5	1.00	-	3.4	25.0	11.3
		75-120	96.8	13	1.9	7.8	2.00	0.30	0.9	1.2	2.9	3.3	12.3	0.50	-	2.0	12.0	5.0
16	El-Gabal El-Asfar	0-20	87.2	86	4.2	7.1	0.93	0.40	1.9	23.4	3.5	2.2	4.8	0.75	-	4.0	4.0	3.3
		20-60	92.6	24	5.0	7.3	0.71	0.30	1.2	8.6	2.3	2.3	3.9	0.50	-	2.2	3.0	3.8
		60-100	95.5	02	4.3	7.3	0.75	0.20	0.9	3.2	2.3	2.8	3.9	0.50	-	2.4	3.0	4.1
17	El-Qalag	0-20	79.0	57	15.3	7.1	0.96	1.60	1.7	20.0	3.5	3.7	3.7	0.73	-	6.0	3.0	2.6
		25-60	90.5	03	9.2	7.1	0.51	0.30	1.2	12.8	2.3	1.8	2.6	0.22	-	2.0	3.0	0.9
		60-90	93.3	14	5.3	7.3	0.96	0.10	0.6	8.4	4.6	2.0	4.6	0.22	-	2.8	3.0	5.6

Results and Discussion

Data in Table 2 show the total and available Fe, Mn, Zn, Cu and Mo contents in the studied soil profiles.

I. Iron

**Total iron*

The data show that total Fe content of the studied soil horizons ranges between 135 and 66000 mg kg^{-1}. The lowest values characterize the deepest layers of profiles 3 and 5, respectively due to their high content of sands which are very poor in iron . On the other hand, the highest content of total Fe was found in the surface layer of profile 12 (Kafr-Shibin).

The wide range of Fe content is apparently associated with soil texture and is probably dependent on type of parent materials from which the soil was formed. It is worthy to note that soils of El-Monira, Qaha, Qalyub, Kafr-Shibin and Abu-Zabal contained amounts of total Fe exceeding 50000 mg kg^{-1}. These soils are characterized by their low content of $CaCO_3$ and fairly high content of clay. The lowest values to total iron (< 20000 mg kg^{-1}) are found in coarse textured soils represented by profiles 5, 6, 7, 13 and 17, while the medium textured soils represented by profiles 1, 3, 4, 9, 11. 16 and 17 have moderate amounts of total Fe (Mohamed, 1982).

Statistical analysis shows that total Fe is positively and high significantly correlated with $CaCO_3$% (r = 0.499^{**}) , silt % (r=0.599^{**}) and clay % (0.652^{**}) but negatively and significantly correlated with sand %, this is in accordance with results of El-Falaky (1981) and Hassona , *et al.* (1996)

**DTPA-extractable iron*

Data presented in Table 2 show that the values of chemically available (DTPA-extractable) Fe ranges between 4.4 and 18.5 mg kg^{-1}. The highest value of DTPA-extractable Fe is found in the surface layer of profile 16 that represents the soil of El-Gabal El-Asfar, while the lowest one belongs to the coarse-textured soils of Kafr El- Ragalat, profile (3).

Considering the critical level of DTPA-extractable Fe, which has been proposed by Soltanpour and Schwab (1977), the index values of DTPA-extractable

Fe are as follows:

Low, 0-2 mg kg^{-1}, marginal, 2.1-4.0 mg kg^{-1} adequate , >4 mg kg^{-1}.

The values of the studied soil profiles indicate that the studied soils belong to the adequate level.

The vertical distribution of DTPA-extractable Fe reveals a tendency for accumulation of available Fe in the surface layers, this behavior may be due to continuous addition of fertilizers and manures, which is in a good agreement with El-Saadani *et al*, (1987).

The statistical analysis shows that DTPA- extractable Fe is significantly, positively correlated with $CaCO_3$% (r = 0.331*), OM%(r = 0.422*) and CEC (r=0.322*) and positively highly significantly correlated with silt % (r=0.340**) and clay % (r=0.319**). In contrast, available Fe is negatively, highly significantly correlated with sand % (r =-0.373**). Similar results were obtained by Kishk *et al* (1980) and Hafez *et al.* (1992).

**Depth wise distribution of total iron*

Data in Table 3 show that the weighted mean (W) for total Fe in the studied profiles varies widely between 12936 and 60716.

The lowest values of (W) for total Fe are associated with the light textured soil, which are the soils of Kafr El-Ragal at, Shiblanga, Sandanhor, Abo-Zabaal and El-Khanka. The highest values of (W) range between 41916and 60716 and characterize the soils derived from fine textured Nile sediments. The soils of profile 1, 4, 7, 16, 17 have moderate values of (W) ranging between 23625 to 35968 Fe.

The wide variations of weighted mean in the studied soil profiles 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.

Considering the trend (T), data indicate that the soils represented by profiles 6, 8, 11 ,and 14 displays the highest symmetric values of total Fe among the studied profiles. The results also show that Fe content in most of the studied profiles is usually higher in the surface layers than in the deeper ones as indicated by the negative value for the trend.

TABLE. 2. Total and DTPA-extractable (mg/Kg^{-1}) Fe, Mn, Zn, Cu, and Mo of the studied soil horizons.

Prof No.	Location	Depth (cm)	Iron		Manganese		Copper		Zinc		Molybdenum	
			Total	DTPA Extract.	Total	DTPA Extract.	Total	DTPA Extract.	Total	DTPA Extract.	Total	DTPA Extract.
1	Abu-El-Ghait	0-20	21120	11.2	720	5.4	68.6	8.2	105	3.6	16.5	0.84
		25-75	38210	10.0	890	3.5	81.5	7.3	124	1.8	11.0	0.30
		75-125	41150	10.7	790	6.8	85.4	5.4	130	3.6	20.5	1.04
2	El-Munira	0-20	55600	13.4	820	4.5	59.9	6.9	80	2.5	16.0	0.80
		20-50	51200	8.9	650	3.4	67.7	4.8	71	2.2	9.5	0.83
		50-100	54200	11.2	540	3.9	70.2	4.5	55	2.9	11.5	0.38
		100-150	41300	15.6	619	2.9	68.5	5.2	60	1.4	7.5	0.54
3	Kafr El-Ragalat	0-30	43200	12.5	650	9.5	49.6	9.2	100	1.9	20.5	0.78
		30-70	12300	11.1	190	7.2	29.8	5.8	60	1.9	6.5	0.34
		70-120	10200	4.4	146	1.5	30.9	2.8	25	0.4	3.5	0.36
4	Kafr Saad	0-20	44500	12.5	550	4.3	52.3	9.3	155	2.3	8.5	0.62
		20-50	41300	8.9	559	7.5	58.5	4.4	105	2.2	5.5	0.16
		50-90	12200	5.6	220	2.4	29.4	5.5	40	0.5	20.5	0.30
		90-120	11500	8.9	180	1.5	29.5	6.2	59	1.4	17.0	0.80
5	Shiblamga	0-20	12500	13.5	820	2.3	33.6	8.9	140	2.6	8.0	0.66
		20-60	10200	10.2	710	1.6	24.5	8.8	158	2.3	21.0	0.16
		60-110	15300	12.3	720	2.4	24.6	7.5	150	2.3	20.0	0.76
6	Sandanhor	0-20	21500	9.2	560	3.7	32.4	7.9	102	3.0	9.8	0.22
		20-50	19000	8.9	650	2.5	35.9	8.6	92	2.6	18.0	0.91
		50-100	19500	10.2	520	8.4	38.9	7.5	97	1.3	4.0	0.36
		100-150	19500	10.2	770	4.9	24.8	8.9	94	1.2	14.0	0.26
7	Kafr El-Gamal	0-20	54300	12.3	775	5.2	53.3	9.1	175	3.2	15.0	0.9
		20-60	16500	9.5	251	6.2	22.4	8.3	81	1.5	5.0	1.26
		60-90	15100	4.5	190	4.6	21.5	7.9	45	0.5	5.0	0.42
		90-120	21200	8.2	790	8.2	53.9	8.7	59	1.4	6.0	0.14
8	Qaha	0-25	55600	10.8	755	3.7	54.7	8.1	91	4.0	15.5	0.32
		25-60	51200	11.2	890	4.0	89.6	7.5	25	3.6	13.5	0.32
		60-90	54500	13.4	870	0.5	82.7	9.0	115	3.8	14.4	0.32
		90-120	54300	9.4	820	0.4	91.5	8.9	98	2.9	17.0	0.32
9	Sindiyun	0-25	20500	11.7	790	5.4	23.9	8.8	102	3.8	7.0	0.54
		25-75	55000	8.5	725	8.1	85.4	8.6	98	2.5	12.0	0.30
		75-110	41500	8.9	720	6.3	74.1	7.2	86	1.9	11.2	0.34

TABLE. 2. Cont.

Prof. No.	Location	Depth (cm)	Iron		Manganese		Copper		Zinc		Molybdenum	
			Total	DTPA Extract	Total	DTPA Extract.	Total	DTPA Extract	Total	DTPA Extract.	Total	DTPA Extract.
10	Qalyub	0-25	59200	9.8	980	7.2	91.1	6.5	140	4.2	15.4	0.59
		25-50	54000	11.2	890	6.5	69.8	6.3	125	1.9	15.4	0.66
		50-90	55000	10.7	810	3.7	74.9	5.5	120	2.2	14.4	0.88
		90-120	52000	11.2	850	5.6	65.1	5.1	98	2.8	9.0	0.75
11	Nawa	0-30	54200	13.4	940	7.1	97.5	7.2	147	3.8	17.5	0.91
		30-60	50500	13.3	824	5.6	66.4	5.4	65	2.9	15.4	0.56
		60-90	50200	11.9	820	5.4	60.1	5.1	80	1.4	8.0	0.30
		90-120	44500	10.3	790	5.6	66.4	4.4	89	2.2	4.0	0.36
12	Kafr Shibin	0-20	66000	15.6	960	4.9	78.3	7.5	115	4.1	15.0	0.08
		20-60	58200	12.3	750	2.0	63.7	4.3	102	3.3	5.0	0.12
		60-90	55000	11.2	780	2.8	72.6	4.1	102	3.9	14.0	0.09
		90-120	55000	7.9	770	9.4	71.6	3.4	100	1.2	17.0	0.08
13	Abu-Zaabal 1	0-25	19500	8.5	250	6.2	46.1	1.2	75	3.5	11.0	0.12
		25-50	12200	10.1	175	3.7	23.7	1.5	54	1.5	9.0	0.31
		50-75	11500	4.5	87	1.2	27.4	1.4	30	0.5	5.0	0.76
14	Abu-Zaabal 11	0-25	63500	11.2	985	6.2	79.4	5.8	159	3.9	17.0	0.24
		25-60	62500	12.2	840	3.0	58.4	5.8	135	3.2	15.0	0.38
		60-90	58200	15.5	840	3.3	56.9	4.1	130	2.7	14.2	0.24
		90-120	59100	7.9	870	3.5	63.1	4.1	140	2.4	16.0	0.16
15	El-Khanka	0-20	21500	11.2	189	6.0	24.3	4.9	55	1.5	7.7	0.08
		20-75	19200	10.3	146	1.9	22.3	1.2	42	0.9	4.3	0.07
		75-120	12300	5.5	105	2.6	17.7	1.1	32	0.3	5.5	0.26
16	El-Gabal El-Asfar	0-20	42300	18.5	440	7.3	51.5	9.9	52	1.6	21.4	0.72
		20-60	28900	10.2	395	5.3	28.4	4.1	45	0.7	16.0	0.18
		60-100	17500	12.5	385	5.2	20.4	2.7	49	0.7	12.0	0.34
17	El-Qalag	0-20	512	10.2	750	9.3	58.3	2.9	152	3.7	9.0	0.56
		25-60	210	10.2	179	4.8	22.6	1.2	56	0.4	7.3	0.47
		60-90	135	7.6	176	5.5	24.1	1.9	52	0.4	2.9	0.47

TABLE 3. Weighted mean (W), trend (T) and specific range (R) of total Fe, Mn, Cu, Zn and Mo in the studied soil profiles.

Prof. .No.	Location	Iron			Manganese			Copper			Zinc			Molybdenum		
		W	T	R	W	T	R	W	T	R	W	T	R	W	T	R
1	AbuEl-Ghait	35968	0.41	0.56	813	0.12	0.21	67.0	-0.02	0.25	122.6	0.14	0.20	15.9	-0.04	0.60
2	El-Munira	49486	-0.11	0.29	625.8	-0.24	0.45	43.5	-0.27	0.23	63.2	-0.21	0.40	10.4	-0.35	0.82
3	Kafr El-Ragalat	19150	-0.56	1.72	286.6	-0.56	1.76	25.3	-0.48	0.043	55.4	-0.45	1.4	8.8	-0.57	1.93
4	Kafr Saad	24683	-0.45	1.34	315.8	-0.43	1.20	16.1	-0.69	1.80	76.7	-0.51	1.5	13.9	0.39	1.08
5	Shiblanga	12936	0.034	0.39	734.5	-0.10	0.15	17.3	-0.48	0.52	151.1	0.14	0.12	18.2	0.56	0.71
6	Sandanhor	19666	-0.09	0.13	634.8	0.12	0.41	12.6	-0.61	1.11	96.3	-0.10	0.11	10.9	0.10	1.28
7	Kafr El-Gemal	23625	-0.56	1.66	457.8	-0.41	1.31	13.6	-0.74	2.38	82.0	-0.53	1.94	6.9	-0.54	1.45
8	Qaha	53716	-0.04	0.08	634.5	-0.19	0.21	34.3	-.037	1.07	114.3	0.20	0.5	15.0	-0.03	0.14
9	Sindiyn	42863	0.52	0.80	738.2	-0.76	0.14	29.0	0.17	2.12	95.7	-0.11	0.17	10.5	0.033	0.48
10	Qalyub	41916	-0.29	0.17	872.1	-0.11	0.19	35.3	-0.61	0.74	119.7	-0.15	0.42	13.5	-0.12	0.48
11	Nawa	49850	-0.08	0.19	843.5	-0.10	0.18	40.9	-0.58	0.91	95.2	-0.35	0.86	11.2	-0.36	1.21
12	Kafr Shibin	57900	-0.12	0.19	797.5	-0.17	0.33	31.0	-0.60	0.47	103.7	-0.18	0.11	11.9	-0.21	1.01
13	Abu-Zaabal I	14400	-0.26	0.56	170.8	-0.32	0.95	24.5	-0.46	0.91	53.0	-0.33	0.85	8.3	-0.25	0.72
14	Abu-Zaabal II	60716	-0.04	0.09	877.4	-0.11	0.25	33.5	-0.57	0.67	140	-0.12	0.21	15.5	-0.09	0.18
15	El-Khanka	16056	-0.25	0.57	126.2	-0.33	0.67	12.1	-.50	0.54	38.7	-0.36	0.59	5.4	-0.30	0.62
16	El-Gabal-ElAsfar	27020	-0.36	0.92	400	-0.10	0.14	18.5	-0.64	1.68	48.8	-0.13	0.11	15.5	-0.28	0.61
17	El-Qalng	26888	-0.47	14	336.7	-0.55	1.71	24.2	-0.58	1.47	81.1	-0.57	1.2	6.3	-0.30	0.97

Specific range (R) for total Fe is generally larger than 0.08 and less than 1.72, which may suggest that these profiles are derived from a uniform parent material or can indicate pedogenic processes. In other words, the specific range of total Fe indicates that the soil materials of profiles 6, 8, 10, 11, 12,and 14 are homogeneous in depth, whereas the other profiles are probably formed from heterogeneous soil materials.

II. Manganese

**Total manganese*

The data presented in Table 2 show that total manganese content of horizons range from 87 to 985 mg kg^{-1}. The highest total Mn value is that recorded for the surface layer of profile 14 (Abu-Zabal II), while the lowest is that of the 50-75cm layer of profile 13 (Abu-Zabal I).

Generally, the wide range of total Mn in the studied soils can be attributed to the difference in the type and nature of soil materials. The sandy soils (profiles 3, 4, 13, 15, 16 and 17) are characterized by the lowest contents of Mn, while the heavy textured ones (1,2, 5, 6, 7, 8, 9, 10, 11, 12 and 14 have a fairly high content of Mn. These results could be ascribed to the parent materials of these soils.

Statistical analysis shows that Mn is positively and highly significantly correlated with $CaCO_3$% (r =0.620**) ,OM%(r = 0.411**),CEC(r=0.661**), silt% (r=0.687**) and clay % (r =0.802**) . Similar results were reported by Ghanem *et al.* (1971) for OM and clay % and Abdel-Razik (1994) for clay, clay+silt and organic matter. On the other hand, total Mn is negatively and highly significantly correlated with sand (r=0.857**) content and negatively correlated with pH (r =-0.262*).

**DTPA-extractable manganese*

Data presented in Table 2 show that the values of chemically available (DTPA-extractable) Mn range between 0.4 and 9.5 mg kg^{-1}. The highest value of DTPA-extractable Mn is found in the surface layer of profile 3 (Kafr El-Ragalat), while the lowest one belongs to the deepest layer of profile 8 (Qaha)

Regarding the influence of depth on the available Mn, higher values are found in the surface layers than the subsurface ones in the most of the studied soil profiles, this is ascribed to surface applications of both fertilizers and manures.

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 indicate that the studied soil samples belong to either the low or the adequate level groups (9.9 and 90.1%, respectively).

The statistical analysis shows that DTPA-extractable Mn is highly significantly but negatively correlated with soil pH (r=-0.379**). No significant correlation could be detected with all the other tested factors.

**Depth wise distnbution of total manganese*

Data in Table 3 show that the weighted mean (W) of total Mn in the studied profiles ranges between 126.2 and 877.4. It show also, the similarity of values of weighted mean (W) for total Mn within some of the studied profiles, for instance, the weighted means of Sandanhor and Qaha soils (profiles 6 and 8) Qalyub and Abu-Zabal soils (profiles 10 and 14) and Shiblanga and Sindiyun soils (profiles 5 and 9). On the other hand , the rest of studied soil profiles show a wide range of the considered weighted mean within the studied area.

The values of trend (T) show that the soils of Abu El-Ghait, Shiblanga, Sandanhor, Qalyub, Nawa, Abu-Zabal and El-Gabal El-Asfar (profiles, 1, 5, 6, 10, 11, 14 and 16) are highly symmetrical. Mn values as the T-values range between -0.10 and -0.12. In addition, the values of specific range (R) for the studied profiles show that soil materials of profiles 1, 5, 8. 9. 10, 11, and 15 are homogeneous whereas those of the other profiles have heterogeneous soil materials (Table 3).

III. Copper

**Total copper*

The data presented in Table 2 show that total copper content in the soil horizons varies from 17.7 to 97.5 mg kg^{-1}. The highest value is found in the surface layer of profile 11 (Nawa), while the lowest is detected in the deepest layer of profile 15 (El-Khanka). The alluvial soils (fine textured) have more Cu compared to the sandy soils (coarse textured). The vertical distribution of total Cu content indicates no specific pattern that could be used to distinguish one soil type from another except for profiles 15 and 16 in which Cu decreased with depth. In other words, total Cu distribution with depth does not follow any specific pattern pertaining to soil type.

Statistical analysis reveals positive and highly significant correlation between total Cu soil content and each of $CaCO_3$% (r 0.486**), CEC(r 0.394**), silt % (r = 0.641**) and clay % (r = 0.709**). The data on the other hand, reveal a highly significant but negative correlation between soil total Cu and sand content% (r= -0.775**).

**DTPA-extractable copper*

Data presented in Table 2 show that the value of chemically available (DTPA-extractable) Cu content varies from 1.1 to 9.9 mg kg^{-1}. These data indicate that the highest value of DTPA-extractable Cu is associated with the soils of El-Gabal El-Asfar (profile, 16) which are irrigated with sewage water, while the lowest DTPA-extractable Cu content characterized the soils of El-Khanka (profile, 15).

Depth wise distribution of available Cu indicates that, in most cases, extractable Cu increases in the surface layers and tends to decrease with depth.

According to Soltanpour and Schwab (1977), the index values used for DTPA-extractable Cu are as follows: low, 0-0.05mg kg^{-1}, high > 0.5 mg kg^{-1} Cu. The data of the soil profiles indicate that the studied soils are high in their content of available copper.

The statistical evaluation of available Cu in relation to soil variables indicates that the extractable Cu is positively and highly significantly correlated with each of $CaCO_3$% (r=362**), OM% (r=0.629**) and CEC (r=0.736**) and positively significantly correlated with silt % (r = 0.334*) and clay %(r = 0.279*). On the other hand, available Cu correlated negatively and highly significantly with sand content % (r =-0.356*).

**Depth wise distribution of total copper*

Table 3 shows that the weighted mean (W) of total Cu in the studied profiles varies widely between 12.09 and 66.96. The lowest values of (W) are associated with the low percent of silt and clay fractions. The highest values of (W) characterized the soils derived from fine textured Nile sediments. The wide variations encountered within or between profiles may reflect the variations in parent materials as affected by both geogenic or pedogenic processes.

Considering the trend (T) and specific range (R), data reveal that the computed trend indicates more symmetrical Cu distribution in profiles 1, 2 and 9 as indicated by the smallest values of (T) . The specific range (R) indicates that the soil profiles 1, 2, 3, 5, 6, 8, 11, 13 and 15 are formed of homogeneous materials , while the other profiles are constituted from heterogeneous soil materials

IV. Zinc

**Total zinc*

Table 2 shows that Zinc content of horizons ranges from 25 to 175 mg kg^{-1}. The highest value characterizes the surface layer of profile 7 (Kafr El-Gemal), while the lowest value characterizes the deepest layer of profile 3 (Kafr El-Ragalat)

From these data, it seems that the wide range of total Zn is correlated with some soil constituents particularly soil texture, for instance, the highest total Zn is found in the heavy textured soils while the lowest values are detected in the sandy textured soils.

According to Chapman (1965) the levels of total Zn content below 50 mg kg^{-1} could be considered low and those above 100mg kg^{-1} could be considered high.

The results indicated that the soils belonging to medium and high Zn levels groups represented 43.3% and 43.4%, respectively, whereas 13.3% only belongs to the low level one.

Distribution of total Zn through the studied soils may be influenced but some factors; relationships between total Zn and some of these factors were computed. The obtained correlation coefficients indicate that total Zn positively and highly significantly correlated with $CaCO_3$% (r=0.505**), OM% (r = 0.452**), CEC (r=0.565**), silt % (r=0.428**) and clay % (r=0.544**), while it is showing a highly significant but negative correlation with sand content% (r=-0.536**). These findings are in agreement with those of Metwally *et al.* (1977) and Kamh (1981).

**DTPA-extractable zinc*

Data presented in Table 2 show that the values of chemically available (DTPA-extractable) Zn in the soils under consideration vary between 0.3 to 4.2

mg kg^{-1}. The highest value is presented in the surface layer of profile 10 (Qalyub), while the lowest one is that of the deepest layer of profile 15 (El-Khanka).

Regarding the influence of depth on soil content of available Zn, it could be noticed that the highest values are found in the surface soil layers while the lowest ones are generally detected in the deepest layers, this is true in all the studied profiles except in the 75-125 cm and 50-100 cm layers of profiles 1 and 2, respectively.

The tendency of Zn to accumulate in the surface layers may be due to the presence of the organic matter in these layers in relatively higher amounts besides of the added fertilizers and manures.

According to Soltanpour and Schwab (1977) the index values used for DTPA–extractable Cu are as follows: low 0-0.9 mg kg^{-1}, abstained marginal 1-1.5 mg kg^{-1}, adequate > 1.5 mg kg^{-1}. The obtained results indicate that the studied soils are belonging to adequate and marginal groups represent 66.7% and 16.6% of tested samples respectively, whereas 16.7% of the studied soils belonging to the low level.

The statistical evaluation of available Zn in relation to soil variables indicates that the DTPA-extractable Zn is correlated positively and highly significantly with the percentages of $CaCO_3$ ($r=0.614^{**}$), OM ($r=0.398^{**}$), silt ($r=0.521^{**}$), clay ($r=0.574^{**}$) and CEC($r=0.497^{**}$) and negatively highly significantly correlated with sand content % ($r=-0.627^{**}$).

**Depth wise distribution of total zinc*

Data in Table 3 reveal that the majority of the studied profiles have an irregular vertical distribution of soil total Zn with depth, which is probably associated with the changes in soil texture.

The value of weighted mean (W) of total Zn in the studied profiles varies between 36.7 and 151.1. The lowest values of (W) characterize the sandy and light textured soils, while the rest of the studied soil profiles are characterized by high weighted mean values of total Zn.

Considering the trend (T), the values presented in Table 3 show that the computed trend of the soils of profiles 1, 2. 5. 6, 8, 9.10, 12, 14 and 16 are of more symmetrical Zn distribution than other profiles . The specific range (R) of Zn shows that the soil materials of profiles 2, 3. 6, 12, 13 and 16 are homogeneous, whereas the other soil materials of the other profiles are heterogeneous regarding Zn content. Also, the relative values of trend (T) show that in most of the studied profiles, total Zn is usually higher in the surface layers than in the deeper ones.

V. Molybdenum

**Total molybdenum*

The distribution and levels of total Mo content in the studied soil horizons are shown in Table 2. Total soil Mo ranges from 2.9 to 21.4 mg kg^{-1}. The highest value characterizes the surface layer of profile 16 representing the soils of El-Gabal El-Asfar, while the lowest value characterizes the deepest layer of profile 17 representing the soil of El-Qalag . High Mo content in the soil profiles of Abu-El Ghait, Kafr El-Ragalat, Shiblanga, Qaha, Abu-Zaabal and El-Gabal El-Asfar were probably due to the presence of either colloidal particles in the clay fraction of the soil or high content of organic matter.

The vertical distribution of total Mo content in the soils under consideration indicates no specific pattern that could be used to distinguish one soil type from another, except for soils of Kafr El-Ragalat, Nawa, Abu-Zaabal, El-Gabal El-Asfar and El-Qalag in which total Mo tended to decrease with depth.

Computed correlation coefficients between total Mo content and soil variables, indicate that total Mo is positively significantly correlated with OM% ($r=0.311^*$), CEC ($r=0.305^*$), silt %($r=0.279^*$) and clay % ($r=0.277^*$) On the other hand, sand content is negatively significantly correlated with total Mo ($r=-0.316^*$).

**DTPA-extractable molybdenum*

Data presnted in Table 2 show that the amount of DTPA-extractable Mo in the soils under consideration ranges from 0.07 to 1.26 mg kg^{-1}. The lowest value is found in the deepest layer of profile 15 representing the soil of El-Khanka, while the highest value is detected in the subsurface layer of profile 7 representing the soils of Kafr El-Gemal.

The vertical distribution of extractable Mo indicates a relative increase of Mo in the top surface layers or the subsurface ones with a tendency to decrease downwards in the soil profiles. This could be explained by the presence of favorable soil variables governing extractable Mo in the uppermost surface layers of each soil profile.

The statistical evaluation of available Mo in relation to soil variables indicates that the DTPA-extractable Mo is correlated negatively and significantly with EC(r=-0.327*). In contrast, DTPA-extractable Mo is insignificantly correlated with the other investigated factors.

******Depth wise distribution of total molybdenum*

Considering the weighted mean (W) of total Mo, data in Table 3 show that it varies widely between 4.5 and 18.2. The lowest values (5.4 and 8.8) characterize the soils of Kafr El-Ragalat, Kafr El-Gemal , Abu-Zaabal, El-Khanka and El-Qalag which have coarse texture, while the highest values (10.4 to 18.2) are those of the alluvial soils. The wide variation in the values of (W) within each of these profiles is either attributed to the depositional regime or to the variation within the parent materials from which the soils were derived.

The values of the trend (T) in Table 3 show that the soils of Abu-El-Ghait, Sandanhor, Qaha, Qalyub, Kafr Shibin and Abu-Zaabal are highly symmetrical as the T-values range from-0.03 and 0.01. The rest of soils are less symmetric as T-values range from-0.25 to 0.57. The values of the specific range (R) of total Mo in the studied soil profiles range between 0.14 and 1.93. The low values are associated with the soils of Qaha (profile, 8) having highly symmetrical distribution of Mo, while those of high R-values belong to the soils of Kafr El-Ragalat.

The statistical measures could be taken as indicators of the possible variation in parent sediments, depositional regime as well as the pedogenic processes prevailing during soil formation

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المحتوى الكلي والميسر للمغذيات الصغرى وعلاقتها لبعض خواص التربة فى أراضى محافظة القليوبية

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يهدف هذا البحث الى دراسة كل من المحتوى الكلي والميسر لبعض المغذيات الصغرى (الحديد، المنجنيز، الزنك، النحاس، الموليبدنم) وعلاقتها بخواص الأرض فى محافظة القليوبية.

و لتحقيق الهدف من البحث اختير سبعة عشرة قطاعا ارضيا لتمثل أنواع الأراضي المختلفة بالمحافظة وقدر بهابعض الخواص الطبيعية والكيميائية وكذلك تركيز العناصر المشار اليها سابقا ويمكن تلخيص النتائج المتحصل عليها فيما يلى:

- تراوح تركيز الحديد الكلي فى الأراضي تحت الدراسة ما بين ١٣٥، . . .٦٦ ملليجرام/كجم بينما تراوح تركيز الحديد المستخلص بال DTPA بين ٤ ٤، ٥ . ١٨ ملليجرام/كجم.
- تراوح تركيز المنجنيز الكلي في الأراضي تحت الدراسة ما بين ٥ . . ، ٩٨٥ ملليجرام/كجم، بينما تراوح تركيز المنجنيز المستخلص بال DTPA بين ٤ . . ، ٥ . ٩ ملليجرام/كجم.
- تراوح تركيز الزنك الكلي في الأراضي تحت الدراسة ما بين ٢٥، ١٧٥ ملليجرام/كجم، بينما تراوح تركيز الزنك المستخلص بال DTPA بين ٣ . . ، ٢ . ٤ ملليجرام/كجم متوقفا على قوام التربة.
- تراوح تركيز النحاس الكلي في الأراضي تحت الدراسة ما بين ٧ . ١٧، ٥ . ٩٧ ملليجرام/كجم، بينما تراوح تركيز النحاس المستخلص بال DTPA بين ١ . ١، ٩ . ٩ ملليجرام/كجم مع زيادة تركيزة في الطبقات السطحية.
- تراوح تركيز الموليبدنم الكلي في الأراضي تحت الدراسة ما بين ٩ . ٢، ٤ . ٢١ ملليجرام/كجم، بينما اختلف تركيز الموليبدنم المستخلص بال DTPA بين ٠٧ . . ، ٢٦ . ١ ملليجرام/كجم وقد أظهر التوزيع الرأسي للموليبدنم المستخلص بال DTPA زيادة تركيزة نسبيا فى الطبقات السطحية.

- أظهر التحليل الاحصائى وجود ارتباط موجب عالى المعنوية بين محتوى التربة من معظم العناصر تحت الدراسة ومحتوى التربة من كل من كربونات الكالسيوم، ٪للسلت، ٪للطين والسعة التبادلية الكاتيونية بينما وجدت علاقة سالبة عالية المعنوية مع ٪ للرمل.
- وجد أن معظم القطاعات تحت الدراسة ذات محتوى كافى من الحديد والمنجنيز الميسر وذات محتوى عالى من النحاس الميسر بينما كانت ذات محتوى كافي ومحدود من الزنك.
- يشير الإتجاه (T) الى أن معظم قطاعات التربة كانت عالية التناسق بالنسبة لكل من الحديد والمنجنيز والزنك والنحاس بينما أظهر النطاق النوعي (R) تجانس بعض قطاعات التربة بالنسبة لبعض العناصر وعدم التجانس بالنسبة للبعض الآخر.