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IRON AND MANGANESE STATUS IN SIDI BARRANI SOILS AS A CRITERION FOR SOIL GENESIS AND FORMATION

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ABSTRACT: The current study is performed on 20 soil profiles representing the two major geomorphic units recognized in Sidi Barani area mainly; the coastal plain and the piedmont plain to evaluate Fe and Mn status and distribution and their relation to soil variables initiated by soil origin and pedogenetic processes involved in soil formation.

The obtained results clearly show that total Fe ranged from 2400 to 7020 ppm and 2500 to 7700 ppm in the soils of the coastal and piedmont plains, respectively. Total Mn varies widely from 140 to 300 ppm and from 140 to 342 ppm in those plains, respectively.

Chemically extractable Fe and Mn range from (6.45 to 9.15 ppm and 6.00 to 11.6 ppm for Fe) and (4.65 to 6.70 ppm and 4.70 to 8.15 ppm for Mn) in the coastal and piedmont plains, respectively.

Depthwise distribution of both elements either as total or chemically-extractable forms has been discussed. Moreover, the variations encountered either within or between soil profiles in each geomorphic unit are precisely delineated.

Statistical evaluation of data indicates that total Fe in the soils of coastal plain is significant positively correlated with organic matter, amorphous alumina and exchangeable Ca^{++} while being negatively correlated with soluble Ca^{++}, Mg^{++}, K^+ and SO_4^{--}. Similar correlations were found with Fe in soils of the piedmont plain where total Fe is positively correlated with organic matter and soluble Ca^{++}

while being negatively correlated with Ca CO_3%, pH and exchangeable Ca^{++}. Total Mn in soils of the coastal plain shows a somewhat different correlations where it is positively correlated with silt and organic matter while being negatively correlated with HCO_3^-. Total Mn in soils of the piedmont plain is positively correlated with silt and clay.

On the other hand, chemically extractable Fe in soils of the coastal plain is non correlated with any soil variable while in soils of the piedmont plain it is positively correlated with soluble Ca^{++} but negatively correlated with CEC, exchangeable Ca^{++}, Mg^{++} and Na^+. Likewise chemically extractable Mn is non correlated with any soil variable in soils of the coastal plain while in soils of the piedmont plain extractable Mn is negatively correlated with exchangeable Mg^{++}.

Statistical measures (W, T and R) of total Fe dictate that W of Fe content is more wider in the soils of the piedmont plain, T denotes common negative values in soils of the coastal plain while being almost positive in soils of the piedmont plain, and R values vary either within or between soil profiles of each geomorphic unit.

With regard to total Mn, W indicates that the highest values decrease on possing eastwards and southeastwards, westwards and southwards, along the coastal plain, also there is a tendency of W decrease southwest the piedmont plain. T values indicate an increase of symmetry in soils of the coastal plain rather than those of piedmont plain a R values of total Mn dictates that soils of either plains are heterogenous. The variations in R values of total Fe and Mn are mainly attributed to inherited soil characteristics, modified by pedogenic processes, sedimentation regime as well as local conditions of profiles in each geomorphic unit. Moreover, R values suggest that pedogenic processes had acted in a fairly uniform manner especially in soils of the coastal plain and this implies that an analysis of a surface samples of soils would, to a great extent, give a satisfactory measure of Fe and Mn status of the entire soil profile.

Key words: Soil genesis, soil formation, geomorphic, Sidi Barrani.

INTRODUCTION

The area selected for study is located in Sidi Barani soils, North Western Coast of Egypt between longitudes 25° 30ˉ and 26° 00ˉ East and latitudes 31° 15ˉ and 31° 40ˉ North. Climate is arid to hyperarid and the average annual rainfall is 135 mm. Geomorphologically, the area could be distinguished into two major geomorphic units namely; the coastal plain and the piedmont plain. Both plains are represented by 20 soil profiles. Data in Tables 1,2 show that the soils in former plain are loamey sand to clay loam whereas soils of the latter plain have coarser texture (sand to sandy loam). Soils salinity is non saline to extremely saline and as expected most saline soils occupy the coastal plain. The cationic composition of the soil extract is mostly dominated by Na^+ with some exceptions where Mg^{++} and/or Ca^{++} proceeds. The anionic composition of the soil extract is generally dominated by Cl^- followed by HCO_3^- and/or $SO4^{--}$. Soil reaction is mildly alkaline to alkaline. Organic matter content is considerably low.

$CaCO_3$ content varies widely from 8.03 to 85.77% with an irregular pattern of vertical distribution or a tendency to decrease or increase downward the soil profiles. Likewise, active $CaCO_3$ is widely variable either within or between soil profiles of each geomorphic unit. As a whole, the variations encountered in soil characteristics within or between both geomorphic units are mainly rendered to variation in parent materials, sedimentation regime, depositional point of view, the soils are classified under the order Entisols, suborders Torripsamments and Torriorthents. In brief, all the information concerning soil characteristics are presented elsewhere, Khalil (2007).

The current study is mainly performed to give an insight on the status of both Fe and Mn in such soils. Therefore, total contents and chemically extractable forms of such elements and soil variables contributing to their status are statistically delineated together with the use of the three statistical measures of Oertel and Giles (1963) to find out the role of parent material and pedogenic process that reflected on Fe and Mn status and distribution in the studied soils.

MATERIALS AND METHODS

Twenty soil profiles were selected to represet the main geomorphic units that are recognized in Sidi Barrani area located between longitudes 25° 30ˉ

Table 1. Particale size distribution and exchange characteristics of the studied soils

Geomorphic unit	Profile No.	Depth cm	Sand %	Silt %	Clay %	CEC me/100g soil	Exchangeable cations (me/100g soil) Ca^{++}	Mg^{++}	Na^{+}
	1	0 – 15	77.1	13.7	9.2	14.15	10.36	0.56	2.52
		15 – 55	32.7	44.6	22.7	22.90	15.60	2.70	3.02
		55 – 100	47.4	28.3	24.3	26.48	17.02	1.54	6.66
		100 - 120	32.7	44.6	22.7	24.90	16.60	3.70	3.52
	2	0 – 45	20.1	55.8	24.1	26.23	12.40	3.16	8.96
		45 – 85	41.8	25.4	32.8	5.62	2.77	0.85	1.00
		85 – 115	52.2	18.9	28.9	16.60	13.23	0.72	2.18
	7	0 – 30	82.8	8.9	8.3	11.07	7.96	0.45	1.56
		30 – 75	71.5	16.7	11.8	9.45	6.70	0.36	1.35
		75 – 120	66.2	15.9	17.9	7.30	3.93	0.55	2.02
Coastal plain	8	0 – 30	87.3	5.6	7.1	24.17	10.20	4.20	6.57
		30 – 55	70.8	6.9	22.3	16.75	10.30	1.44	4.40
	11	0 – 15	70.2	17.6	12.2	9.30	5.93	0.50	2.07
		15 – 40	57.4	25.7	16.9	12.20	8.30	0.56	3.60
		40 – 75	63.5	18.6	17.9	13.50	8.50	0.60	3.70
		75 – 120	61.2	21.9	16.9	14.60	8.60	0.65	3.80
		120 -150	54.3	23.2	22.5	16.80	7.50	0.38	5.90
	12	0 – 30	69.6	15.8	14.6	10.70	6.80	0.45	2.20
		30 – 70	60.7	21.4	17.9	11.80	7.15	0.53	2.40
	13	0 – 30	61.3	24.1	14.6	13.35	9.20	0.64	3.15
		30 – 55	58.1	23.5	18.4	12.90	7.60	0.60	2.90
		55 – 85	54.3	23.5	22.2	9.50	5.40	0.35	2.70
		85 – 115	51.7	24.5	23.8	7.60	3.15	0.27	1.40
Piedmont plain	3	0 – 20	100	0	0	7.15	3.93	0.51	2.07
		20 – 60	75.6	11.5	12.9	15.65	8.69	0.83	5.31
		60 – 110	80.0	7.1	12.9	16.75	11.33	0.93	4.72
	4	0 – 35	78.1	11.6	10.3	5.62	2.70	0.90	1.00
	5	0 – 30	100	0	0	4.72	2.45	0.64	0.80
		30 – 60	100	0	0	5.92	2.71	0.55	1.30
		60 – 90	100	0	0	5.82	2.93	0.85	1.35

Table 1. Cont.

Piedmont plain		90 – 120	100	0	0	4.92	2.52	0.55	1.06
		120 - 150	100	0	0	6.80	3.70	0.70	1.25
	6	0 – 30	100	0	0	10.40	7.15	0.38	2.34
		30 – 60	75.9	12.2	11.9	9.30	6.44	0.54	1.77
	9	0 – 25	83.5	9.7	6.8	7.00	3.93	0.50	1.93
		25 – 45	67.4	19.5	13.1	16.75	9.90	1.50	5.50
	10	0 – 35	88.9	6.6	4.5	5.80	2.70	0.68	1.25
	15	0 – 20	100	0	0	5.50	2.80	0.20	1.15
		20 – 50	100	0	0	5.70	2.85	0.20	1.05
		50 – 80	100	0	0	7.14	3.05	0.20	1.15
		80 – 120	100	0	0	8.05	4.15	0.25	1.30
	16	0 – 30	100	0	0	5.50	2.70	0.22	1.20
		30 – 60	100	0	0	6.15	2.95	0.30	1.35
		60 – 90	100	0	0	4.40	1.15	0.03	0.75
	17	0 – 20	100	0	0	5.60	2.75	0.23	1.18
	20	0 – 25	100	0	0	7.15	3.05	0.20	0.95
		25 – 60	100	0	0	6.15	2.90	0.30	1.27
		60 – 95	100	0	0	4.50	1.17	0.03	0.80
		95 – 120	100	0	0	4.40	1.10	0.03	0.70
	21	0 – 20	100	0	0	4.70	1.27	0.02	0.75
		22 – 50	100	0	0	6.15	2.85	0.30	1.20
		50 – 85	63.1	20.1	16.8	7.05	3.05	0.03	0.70
		85 -115	60.4	21.8	17.8	6.15	2.75	0.30	1.80
	22	0 – 25	100	0	0	4.40	1.05	0.03	0.80
		25 – 60	76.8	13.8	9.4	4.00	0.95	0.02	0.95
		60 – 80	65.6	17.5	16.9	4.20	1.05	0.02	0.95
	23	0 – 30	100	0	0	3.70	0.75	0.04	0.60
		30 – 65	100	0	0	5.15	1.15	0.02	0.75
		65 – 85	100	0	0	5.05	1.10	0.02	0.80
		85 –110	100	0	0	6.00	1.27	0.03	0.90
		110 -150	100	0	0	5.20	0.90	0.02	0.70

Table 2. Some chemical characteristics of the studied soils

Geomorphic unit	Profile No.	Depth cm	O.M. %	$CaCO_3$ %	Al_2O_3 * %	pH	Chemical composition of the soil saturation extract							
							EC	Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3	Cl^-	SO^{--}
							dS/m		me/l				me/l	
Coastal plain	1	0 – 15	0.7	41.6	0.08	8.4	3.31	5.6	9.1	16.95	1.49	8.5	21.7	2.94
		15 – 55	0.9	28.1	0.06	8.3	4.11	6.3	6.3	27.68	0.86	6.0	19.6	15.54
		55 – 100	0.5	27.7	0.05	8.3	13.12	27.30	30.10	90.93	7.85	6.0	110.5	30.68
		100 - 120	0.4	45.6	0.02	8.2	19.96	29.4	28.0	134.83	8.35	4.5	115.5	80.58
	2	0 – 45	0.9	23.9	0.16	8.3	2.15	5.25	5.95	11.28	0.12	9.0	4.9	8.7
		45 – 85	0.5	26.4	0.02	8.3	2.18	3.5	5.6	10.09	2.61	8.0	4.9	8.9
		85 – 115	0.4	28.1	0.19	8.3	4.92	5.6	14.0	28.09	1.54	6.5	9.45	33.28
	7	0 – 30	0.5	65.5	0.06	8.3	6.38	14.0	18.9	57.11	17.70	10.0	85.4	12.31
		30 – 75	0.3	36.6	0.02	8.7	13.01	24.0	14.5	79.6	12.63	9.5	91.0	30.23
		75 – 120	0.2	43.5	0.06	8.6	27.20	27.5	28.5	218.6	15.16	7.5	239.5	42.76
	8	0 – 30	0.6	59.2	0.03	7.9	5.22	17.5	17.5	17.37	3.79	7.0	38.5	10.66
		30 – 55	0.5	43.3	0.16	8.1	6.84	9.1	14.7	68.05	8.58	8.0	51.1	41.33
	11	0 – 15	1.15	20.5	0.05	8.8	122.80	44.1	48.9	1098.91	59.47	6.0	1010.5	234.88
		15 – 40	0.7	27.5	0.06	8.5	57.70	50.4	62.9	415.2	54.4	6.5	350.2	226.2
		40 – 75	0.5	46.3	0.08	8.6	33.50	26.1	29.4	258.24	24.03	6.5	211.5	119.77
		75 – 120	0.3	58.5	0.06	8.7	19.60	47.5	49.8	89.9	11.2	7.0	123.4	68.00
		120 - 150	0.3	68.2	0.05	8.6	36.98	42.2	47.4	264.8	20.2	6.0	227.6	141.0
	12	0 – 30	0.4	61.5	0.05	8.0	4.92	10.5	8.6	22.68	9.5	7.0	23.8	20.48
		30 – 70	0.3	44.1	0.05	8.4	5.68	6.3	9.1	33.6	8.79	7.5	23.1	27.19
	13	0 – 30	0.8	26.0	0.08	8.7	161.48	68.5	87.8	1489.2	45.49	5.5	115.5	57.99
		30 – 55	0.4	19.7	0.02	8.8	100.65	47.6	58.4	814.6	131.6	6.5	637.5	408.4
		55 – 85	0.3	29.8	0.02	8.7	63.40	46.6	54.9	445.4	106.2	7.5	387.0	258.6
		85 – 115	0.2	17.5	0.02	8.7	61.40	47.6	48.9	426.6	98.6	8.5	342.3	270.9
Piedmont plain	3	0 – 20	0.1	66.8	0.04	8.2	3.48	7.0	11.2	12.80	3.79	6.5	21.7	6.59
		20 – 60	0.2	50.7	0.02	8.4	2.48	4.2	7.7	14.39	2.13	8.0	7.7	12.72
		60 – 110	0.2	59.8	0.03	8.7	3.25	3.5	7.0	19.40	2.87	9.5	21.7	1.57
	4	0 – 35	0.5	55.4	0.08	8.1	2.57	4.2	9.8	10.52	1.16	8.5	15.4	1.78
	5	0 – 30	0.2	44.8	0.02	8.1	1.62	4.55	4.55	6.38	0.73	8.0	6.3	1.91
		30 – 60	0.2	36.8	0.03	8.3	1.46	6.3	4.2	3.84	0.35	8.0	5.6	1.09

Table 2. Cont.

Piedmont plain		60 – 90	0.1	38.7	0.03	8.4	1.34	3.5	3.5	6.22	0.45	7.0	4.2	2.47
		90 – 120	0.1	41.4	0.04	8.5	1.43	4.2	7.7	2.22	0.18	7.5	4.2	2.6
		120 -150	0.1	42.7	0.03	8.6	1.48	2.8	9.1	2.63	0.28	9.0	4.9	0.91
	6	0 – 30	0.3	8.9	0.08	8.2	1.63	4.9	5.6	4.56	1.24	7.0	7.7	1.6
		30 – 60	0.2	16.2	0.06	8.2	2.54	4.9	9.8	9.48	1.27	8.0	8.4	9.05
	9	0 – 25	0.4	52.4	0.02	8.1	2.83	7.2	4.7	11.35	5.03	6.5	15.3	6.48
		25 – 45	0.3	50.9	0.02	8.2	3.36	5.95	11.55	14.05	2.02	6.5	23.1	3.97
	10	0 – 35	0.2	8.0	0.02	8.2	2.68	7.0	3.5	14.73	2.02	6.0	18.9	2.35
	15	0 – 20	0.2	85.8	0.02	8.4	4.35	8.4	10.1	21.4	5.3	7.0	25.2	13.0
		20 – 50	0.3	63.4	0.02	8.4	7.53	10.5	11.9	48.93	8.11	8.0	31.9	39.54
		50 – 80	0.2	73.5	0.02	8.4	1.92	5.5	5.6	7.1	2.1	8.0	6.4	5.9
		80 – 120	0.1	62.9	0.02	8.7	2.48	8.4	9.45	5.54	1.39	9.5	10.5	4.78
	16	0 – 30	0.4	18.6	0.03	7.9	2.77	9.1	11.2	5.54	1.87	8.5	7.0	12.21
		30 – 60	0.3	21.7	0.04	7.9	2.28	8.4	6.65	6.78	0.99	8.0	8.75	6.07
		60 – 90	0.2	21.7	0.07	7.9	3.98	14.35	9.45	9.71	6.73	8.0	27.3	4.94
	17	0 – 20	0.4	11.8	0.02	7.9	4.58	15.9	14.4	16.2	2.18	7.0	24.5	17.18
	20	0 – 25	0.6	17.8	0.03	8.0	4.08	10.5	8.5	18.54	3.29	8.5	18.4	13.93
		25 – 60	0.4	18.4	0.02	8.0	2.51	7.0	8.0	10.1	2.03	6.5	13.1	7.53
		60 – 95	0.4	29.2	0.02	8.1	1.87	6.3	2.8	8.33	0.63	9.0	7.7	1.36
		95 – 120	0.2	38.7	0.07	8.2	1.97	7.3	4.7	7.8	0.81	8.0	8.1	4.51
	21	0 – 20	0.4	41.2	0.02	8.1	1.92	8.75	5.25	3.46	1.77	8.5	5.6	5.13
		22 – 50	0.3	44.7	0.20	8.4	1.43	6.1	3.55	3.23	1.22	6.3	4.6	3.2
		50 – 85	0.2	44.1	0.02	8.1	1.94	7.7	6.3	4.42	0.99	7.5	10.5	1.41
		85 – 115	0.3	52.6	0.03	8.1	2.33	15.75	4.55	2.01	1.04	7.5	12.6	3.25
	22	0 – 25	0.8	33.3	0.02	8.0	1.99	10.5	5.25	2.22	1.98	9.0	10.5	0.45
		25 – 60	0.4	43.5	0.02	8.1	2.22	5.6	6.3	8.70	1.62	10.0	11.9	0.32
		60 – 80	0.4	37.7	0.03	8.2	2.26	14.0	2.1	5.74	0.71	7.5	14.7	0.35
	23	0 – 30	0.3	64.8	0.02	8.1	2.35	7.7	10.5	3.46	1.62	8.5	8.4	6.38
		30 – 65	0.1	68.7	0.05	8.4	1.78	10.5	1.05	5.74	0.48	7.0	7.0	3.77
		65 – 85	0.2	74.5	0.02	8.4	2.58	10.85	4.55	9.88	0.48	7.0	14.7	4.06
		85 – 110	0.1	45.2	0.06	8.4	2.95	8.05	7.35	13.63	0.51	5.5	21.7	2.34
		110 - 150	0.2	41.4	0.08	8.5	3.71	7.35	10.85	18.40	0.53	6.0	27.3	3.83

and 26° 00¯ East and latitudes 31° 15¯ and 31° 40¯ North.

Laboratory analyses

1- Particle size distribution using the pipette method (Piper, 1950).

2- pH of soil paste using pH meter, total salinity was expressed as(EC_e), the soluble ions in soil paste extract, total $CaCO_3$ content using calcimeter, Organic mater content, CEC and exchangeable Cations were determined according to Page *et al.* (1982).

3- Amorphous inorganic Al_2O_3 were determined by the ICP.MS. TSA (POE. MS.111).

4- Total Fe and Mn contents were extracted from soil samples, by digestion in a mixture of conc. HNO_3 + conc. H_2SO_4 + 62% perchloric acid as recommended by Hesse (1971), and determined using ICP. MS. TSA (POE. MS.111).

5- Chemically- extractable Fe and Mn contents were extracted by DTPA-TEA according to Lindsay and Norvell (1978) and determined by using ICP.MS. TSA (POE.MS.111).

RESULTS AND DISCUSSION

Iron

Iron is the fourth most abundant metal in rocks forming the earth's crust, where it forms 0.1 to 7.0%, Bear (1976). In soils, total Fe content is variable from as low as 0.02 to more than 50% depending on soil parent material and processes of soils formation while sedimentary rocks contain 17000, 29000 and 48000 ppm Fe in limestone, sandstone and shale, respectively, Dixon *et al.* (1977).

Total Fe in the studied soils

Data presented in Table 3 show that total Fe in the soils of the coastal plain ranged widely from 2400 to 7020 ppm. The highest content characterizes the uppermost surface layer of profile 2 whereas the lowest one is associated with the deepest layer of profile 13. Total Fe in soils of the piedmont plain ranges from 2500 to 7700 ppm. The highest Fe content is obtained for the surface layer of profile 22 while the least Fe content is associated with the surface layer of profile 15.

Table 3. Total and chemically extractable Fe and Mn and their Statistical measures in the studied soils

Geomorphic unit	Profile No.	Depth cm	Fe mg/kg		Mn mg/kg		Statistical measures					
							Total Fe			Total Mn		
			Total	Extr*.	Total	Extr.	W**	T***	R****	W	T	R
Coastal plain	1	0 – 15	6070	8.80	240.20	6.70	6060.4	-0.002	0.002	234.7	-0.023	0.043
		15 – 55	6060	8.00	240.15	6.50						
		55 – 100	6060	8.00	230.00	6.50						
		100 - 120	6055	7.70	230.15	5.15						
	2	0 – 45	7020	7.60	230.00	5.05	7011.3	-0.001	0.003	223.9	-0.026	0.045
		45 – 85	7010	7.60	220.00	5.00						
		85 – 115	7000	7.00	220.07	6.60						
	7	0 – 30	5350	8.00	163.20	6.00	5065.0	-0.053	0.124	162.8	-0.003	0.030
		30 – 75	5220	7.75	165.07	5.80						
		75 – 120	4720	7.60	160.20	5.70						
	8	0 – 30	4700	7.60	150.15	5.60	4745.5	0.01	0.021	145.6	-0.03	0.068
		30 – 55	4800	7.50	140.20	6.70						
	11	0 – 15	6000	8.00	300.00	6.15	5761.8	-0.04	0.09	239.0	-0.203	0.355
		15 – 40	6020	7.70	297.00	6.05						
		40 – 75	6015	7.70	215.05	6.00						
		75 – 120	5500	7.60	220.40	5.50						
		120 -150	5525	7.50	216.16	5.50						
	12	0 – 30	4800	7.40	210.00	5.00	4777.1	-0.005	0.008	210.0	0.000	0.000
		30 – 70	4760	7.00	210.00	4.80						
	13	0 – 30	4770	6.60	207.00	4.70	3698.7	-0.225	0.641	194.0	-0.063	0.139
		30 – 55	3850	6.60	206.00	4.70						
		55 – 85	3800	6.45	185.00	4.65						
		85 – 115	2400	9.15	180.00	7.05						
Piedmont plain	3	0 – 20	5050	6.15	210.27	5.40	5045.5	-0.001	0.002	204.2	-0.029	0.064
		20 – 60	5050	6.10	210.05	5.35						
		60 – 110	5040	6.00	197.15	5.30						
	4	0 – 35	4000	7.50	197.05	4.80	4000.0	0.000	0.000	197.1	0.000	0.000
	5	0 – 30	4012	7.40	185.20	4.70	4016.4	0.001	0.007	181.1	-0.022	0.044
		30 – 60	4010	7.40	183.00	4.70						

Table 3. Cont.

Piedmont plain		60 – 90	4000	7.20	180.00	5.15						
		90 – 120	4040	7.20	180.00	5.00						
		120 - 150	4020	7.00	177.3	5.00						
	6	0 – 30	5370	8.15	177.00	6.20	5365.0	-0.001	0.002	165.6	-0.065	0.014
		30 – 60	5360	8.05	154.15	6.20						
	9	0 – 25	4600	8.05	140.00	6.50	4566.7	-0.007	0.016	229.8	0.391	0.879
		25 – 45	4525	8.00	342.00	6.50						
	10	0 – 35	4500	8.15	340.00	6.40	4500.0	0.000	0.000	340.0	0.000	0.000
	15	0 – 20	2500	9.00	220.00	7.00	2550.8	0.02	0.027	174.7	-0.206	0.383
		20 – 50	2550	9.00	177.70	6.60						
		50 – 80	2560	10.70	170.05	8.15						
		80 – 120	2570	10.60	153.15	8.00						
	16	0 – 30	7000	10.50	150.50	7.70	7015.0	0.002	0.004	143.5	-0.047	0.073
		30 – 60	7020	10.40	140.00	7.40						
		60 – 90	7025	7.80	140.00	5.05						
	17	0 – 20	7030	7.80	182.00	5.00	7030.0	0.000	0.000	182.0	0.000	0.000
	20	0 – 25	5550	7.70	180.05	4.80	5008.1	-0.098	0.154	171.2	-0.049	0.117
		25 – 60	5000	9.75	177.50	6.16						
		60 – 95	4792	9.00	166.60	6.00						
		95 – 120	4780	10.05	166.05	8.05						
	21	0 – 20	4770	10.00	240.00	8.00	4897.7	0.026	0.853	278.7	0.139	0.269
		22 – 50	3600	10.15	270.00	7.70						
		50 – 85	3615	10.15	277.00	6.20						
		85 -115	7777	9.75	315.00	6.00						
	22	0 – 25	7700	9.70	317.00	6.00	7139.3	-0.073	0.143	298.4	-0.059	0.369
		25 – 60	7000	8.05	330.00	5.80						
		60 – 80	6682	8.00	220.00	5.70						
	23	0 – 30	6670	11.60	216.00	7.15	6533.3	-0.02	0.041	214.0	-0.009	0.14
		30 – 65	6660	11.00	208.05	7.00						
		65 – 85	6500	10.90	207.15	6.60						
		85 –110	6400	10.00	200.00	6.50						
		110 -150	6420	9.90	230.00	6.40						

* Extr= Cemically extractable ** W= Weighted mean

*** T= Trend **** R= Specific range

Depthwise distribution of Fe in the coastal plain indicates an apparent uniformity of Fe content downward most of the studied soil profiles or at least between pairs or more of layers such as those of profiles 11 and 12 where the variations in total Fe content of profile layers lie within the some range of magnitude. Exceptional case is found in profile 13 where total Fe tends to decrease progressively with depth.

With regard to the soils of the piedmont plain, total Fe displayed nearly the same pattern observed for soils of the coastal plain where total Fe has homogenous distribution throughout the entire depth of profiles 3, 5, 6, 9, 15, 16 and 23 while tends to decrease progressively with depth in profiles 20, 21 and 22.

It is interesting to note that in profile 21 total Fe tends to decrease down to 85cm depth then increases abruptly to reach a maximum while in profile 22 the pair of deepest layers has nearly the same Fe content, therefore the tendency of Fe decrease is from the surface layer to the subsurface is abrupt, followed by another abrupt decrease from the subsurface layer to the two layers beneath. In brief, the obtained date are in hormony with Ibrahim *et al.* (1979), Khalil *et al.* (1981) and El-Demerdashe *et al.* (1991).

The relationship between total Fe and soil variables in the study area statistical analysis, according to data in Tables 1, 2 and Figs 1 to12. This leads to the belief that some soil factors are involved in controlling Fe distribution in soils beside the geogenetic origin of soils as well as weathering action and its bearing on soil constituents. Accordingly, the correlation coefficients between total Fe and determined soil variables have been computed.

From the statistical evaluation, it is clear that total Fe in the soils of the coastal plain is significant positively correlated with organic matter ($r = 0.505$), amorphous alumina ($r = 0.442$) and exchangeable Ca^{++} ($r = 0.510$) while being significant negatively correlated with soluble Ca^{++} ($r = -0.459$), Mg^{++} ($r = -0.410$), K^{+} ($r = -0.662$) and SO_4^{--} ($r = -0.511$). Similar correlations were obtained for total Fe in soils of the piedmont plain where total Fe is positively correlated significantly with organic matter ($r = 0.340$) and soluble Ca^{++} ($r = 0.531$) while being negatively correlated significantly with $CaCO_3$% ($r = -0.350$), pH ($r = -0.504$) and exchangeable Ca^{++} ($r = -0.343$).

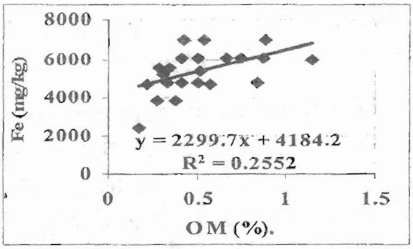

Fig. 1. Linear relation between total Fe (mg/kg) and OM (%) in soils of the coastal plain

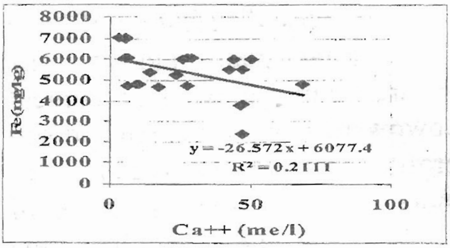

Fig.2. Linear relation between total Fe (mg/kg) and Ca++ (me/l) in soils of the coastal plain

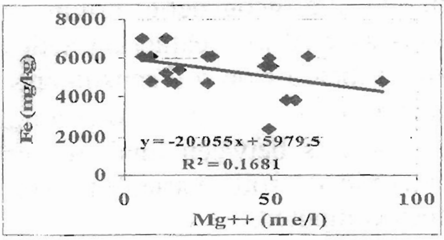

Fig. 3. Linear relation between total Fe (mg/kg) and Mg++ (me/l) in soils of the coastal plain

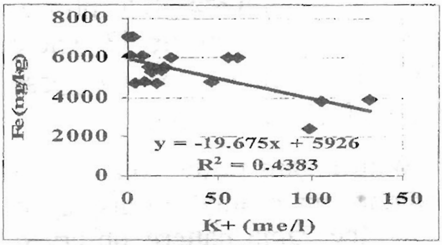

Fig. 4. Linear relation between total Fe (mg/kg) and K+ (me/l) in soils of the coastal plain

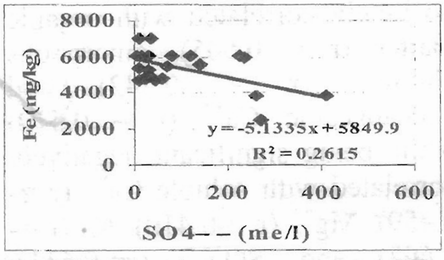

Fig. 5. Linear relation between total Fe (mg/kg) and SO4– – (me/l) in soils of the coastal plain

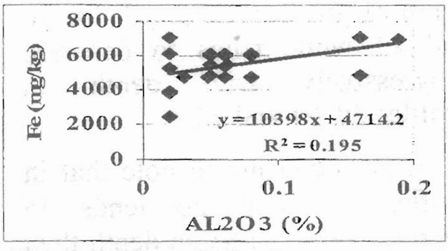

Fig. 6. Linear relation between total Fe (mg/kg) and AL2O3 (%) in soils of the coastal plain

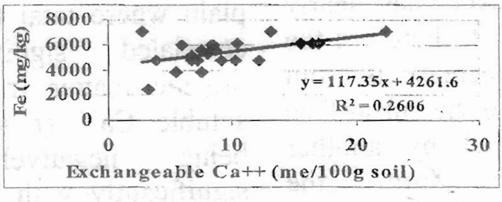

Fig. 7. Linear relation between total Fe (mg/kg) and exchangeable Ca++ (me/100g soil) in soils of the coastal plain

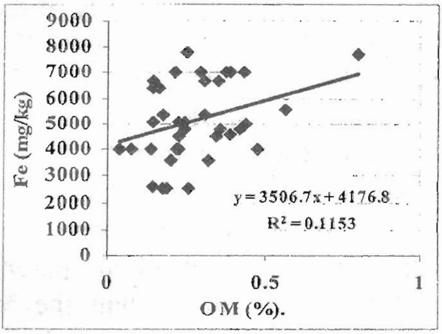

Fig.8. Linear relation between total Fe (mg/kg) and OM (%) in soils of the piedmont plain

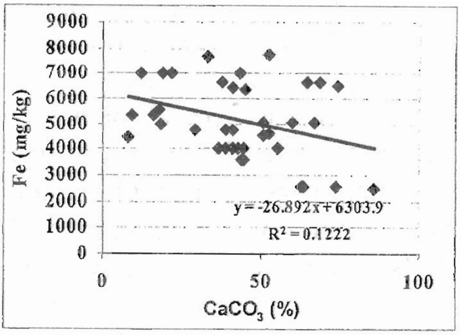

Fig.9. Linear relation between total Fe (mg/kg) and CaCO3 (%) in soils of the piedmont plain

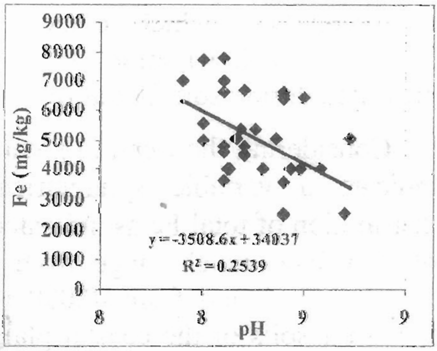

Fig.10. Linear relation between total Fe (mg/kg) and pH in soils of the piedmont plain

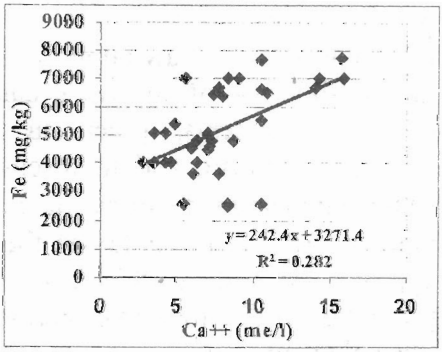

Fig.11. Linear relation between total Fe (mg/kg) and Ca++ (me/l) in soils of the piedmont plain

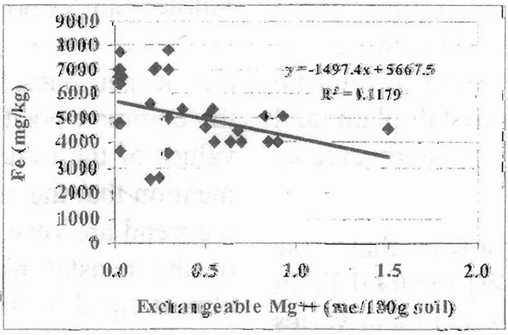

Fig.12. Linear relation between total Fe (mg/kg) and exchangeable Mg++ (me/100g soil) in soils of the piedmont plain

To work out the relationship between the distribution of total Fe and locality of the studied soil profiles in the coastal plain and piedmont plain, the three statistical measures suggested by Oertel and Giles (1963) have been employed. These measures namely, the weighted mean, trend and specific range, were derived for each complete profile from the analytical results of trace metals in the subsequent layers. In other words, the object of this presentation is to draw attention to the possible use of analytical data of trace elements, given in a summarized form, and to discuss some interesting features of the obtained results in so far as they appear, to reflect the general properties of distribution of certain trace element in soils.

To accomplish a reliable comparison within and between the studied soils on basis of these measures, it is convenient to present the distribution of total Fe in soils of the coastal plain and piedmont plain in the study area as follows.

Table 3 shows that the weighted mean (W) for total Fe in the soils of the coastal plain varies from 3698.7 to 7011.3 ppm and is somewhat more wider in the soils of the piedmont plain, being in the range of 2550.8-7139.3 ppm. The variations encountered in the groups of profiles within and between each geomorphic units (coastal and piedmont plain) may be ascribed to the chance of variation in the calcareous parent material itself rather than the to soil formation processes or local conditions prevailing in each geomorphic unit. These variations may also be associated with geomorphology which coincides with the sedimentation regime prevailed during soil formation.

Considering the trend (T), data indicate a variable symmetrical distribution of total Fe as indicated by T values which range from -0.225 to 0.01 and from -0.098 to 0.026 for soils of the coastal plain and piedmont plain, respectively. In general, total Fe is somewhat lower in the soil surface layer or follows an opposite trend when increased in the surface layer than the deeper ones, as indicated by the common positive and negative values of the trend. Noteworthy to mention that the negative values of the trend are very common in soils of the coastal plain while being almost equal to the positive values in soils of the piedmont plain. Thus the trend indicates that Fe has a tendency to accumulate entirely in the soil surface of the coastal plain while has unequal ability to accumulate in the top surface or deeper in soils of the piedmont plain.

As to the specific range (R) of total Fe, Table 3 shows that its values vary either within or between soil profiles, being in the range of 0.002 to 0.124 in almost all profiles of the coastal plain except for profile 13 where the specific range rises up to 0.641. Likewise, the specific range of Fe in soils of the piedmont plain commonly varies from 0.002 to 0.154 except for profile 21 whose specific range of Fe rises up to 0.853. In brief, the common specific range of total Fe in both soils of the coastal plain and piedmont plain suggests that pedogenic processes had acted in a fairly uniform manner through the solum and it implies that an analysis of the surface layer of soil profile, to a large extent, gives a satisfactory measure of Fe status in the entire profile. These data are in agreement with the finding of El-Demerdashe *et al.* (1980).

Chemically-extractable Fe in the studied soils

Data in Table 3 show that DTPA-extractable Fe in all the studied soils ranges from 6.00 to 11.60 ppm. Under the conditions of the coastal plain soils, extracted Fe ranges from 6.45 and 9.15 ppm The highest and lowest contents are found in two subsequent layers of profile 13 where the highest content characterizes the deepest layer (85-115 cm depth) whereas the lowest content is associated with the layer overlying such depth (55-85 cm depth) in the same profile.

Under the conditions of soils of the piedmont plain, DTPA-extractable Fe is somewhat more wider, between 6.00 and 11.60 ppm. The highest content is obtained in the surface layer of profile 23 which seemingly attains the highest average of extractable Fe. In contrast, the lowest extractable amounts of Fe characterizes profile 3 where the least extractable Fe is associated with the deepest layer of such profile.

Depthwise distribution of DTPA-extractable Fe shows a common feature where many pairs of layers within profile depth attain nearly the same content of extractable Fe. For instance, in the soil profiles representing the coastal plain the (15-55 and 55-100 cm), (0-45 and 45-85 cm), (15-40 and 40-75 cm) and (0-30 and 30-55 cm) of profiles 1, 2, 11 and 13, respectively attain the same content of extractable Fe. Likewise, in the soils of the piedmont plain, pairs of similar extractable Fe contents appear in many of subsequent layers constituting profile 3, 5, 6, 9, 15, 16, 21, 22 and 23. The apparent similarities in the amounts of extractable Fe denotes that the factors controlling such component are, more or less, similar. Despite this similarity, it is obvious that extractable Fe tends to show a slight decrease in almost all soil profiles of the coastal plain except for profile 13 where the decrease continues to 55-85 cm layer then followed by an abrupt increase of extractable Fe in the deepest layer of such profile. Align with the former tendency of extractable Fe decrease downward the soil profiles, the representative profiles of the piedmont plain show similar pattern except for profiles 15 and 20 which displayed an inverse pattern where extractable Fe tends to increase downward the soil profile.

To figure out the role of soil variables in controlling Fe extractability, statistical analysis is performed and the correlation coefficients indicate no correlation between extractable Fe from the soils of the coastal plain with any soil variable. In contrast, Fe extracted from the soils of the piedmont plain is significantly correlated positively with soluble Ca^{++} while being negatively correlated significantly with CEC (r= -0.427), exchangeable Ca^{++}, Mg^{++} and Na^{+}. These correlations may indicate that the Fe status in soils of the coastal plain is somewhat different from that prevailed in the piedmont plain or the factors controlling Fe extractability from the soils of the coastal plain are combination of insignificant soil variables rather than profound significant ones whereas in soils of the piedmont plain, significant factors such as soil texture, CEC and some exchangeable cations (Ca, Mg and Na) beside soluble Ca^{++} are the prime movers in controlling Fe extractability.

Manganese

Manganese is among the most abundant trace elements in the lithosphere, its common range in rocks in 350-2000 ppm with its highest content in the mafic rocks. The total content of Mn in soils depends exclusively on the type of rock from which soil is derived and processes of weathering both

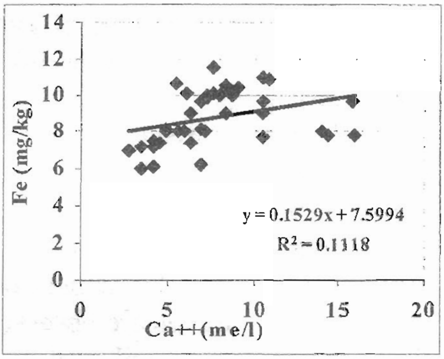

Fig.13. Linear relation between extractable Fe (mg/kg) and Ca++ (me/l) in soils of the piedmont plain

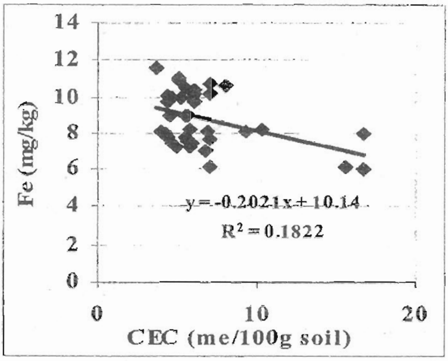

Fig.14. Linear relation between extractable Fe (mg/kg) and CEC (me/100g soil) in soils of the piedmont plain

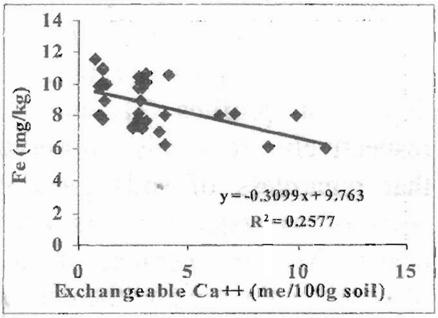

Fig.15. Linear relation between extractable Fe (mg/kg) and exchangeable Ca++ (me/100g soil) in soils of the piedmont plain

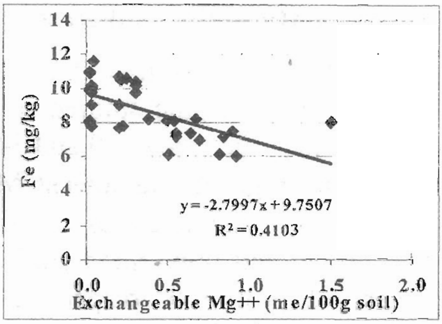

Fig.16. Linear relation between extractable Fe (mg/kg) and exchangeable Mg++ (me/100g soil) in soils of the piedmont plain

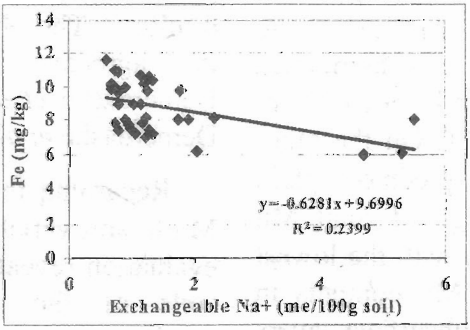

Fig.17. Linear relation between extractable Fe (mg/kg) and exchangeable Na+ (me/100g soil) in soils of the piedmont plain

geochemical and pedochemical, Mitchell and Mackenzie (1969). Mckenzie (1967-1977 and 1980) and Bartlett (1986) stated that Mn in likely to occur in soils as oxides and hydroxides in the form of coatings on soil particles and as nodules of different diameters. Manganese may be present in soils in non-exchangeable, exchangeable and soluble forms, but the main part is present as insoluble oxides, Wiklander (1964).

Total Mn in the studied soils

Table 3 reveals that the total content of Mn in the studied soils varies widely between 140 and 342 ppm. The highest and lowest Mn contents characterizes the subsurface and upperment surface layers of profile 9, respectively. Within the soils of the coastal plain, total Mn ranges from 140.2 to 300.0 ppm. The lowest content is found in the subsurface layer (30-55 cm depth) of profile 8 while the highest content is associated with the top surface layer (0-15 cm depth) of profile 11. On the other hand, soils of the piedmont plain have a wider range of total Mn (140.0-342.0 ppm) with the lowest and highest total Mn contents in the surface and subsurface layers of profile 9.

Depthwise distribution of total Mn in the soils of the coastal plain shows nearly constant total Mn or slight decrease downward the soil profiles except for profile 11 which displays an abrupt decrease in the total Mn of the lowermost layers relative to the uppermost ones. Similar patterns are observed for total Mn in soils of the piedmont plain besides a pronounced accumulation in some deeper layers such as the subsurface layer (28-45 cm depth) of profile 9 and the deepest layers (85-115cm depth) (110-150cm depth) of profiles 21 and 23, respectively. It is also observed that regardless of soils location, pairs of subsequent layers attain nearly the same content of total Mn such as the top and the deepest layers of profiles 1, 5, 11, 13 and 20, the deepest layers of profiles 2, 16 and 21, the top layers of profiles 3 and 12 and all layer of profile 7. The obtained results are in agreement with El – Demerdashe *et al.* (1980) and El-Demerdashe *et al.* (1991).

Regarding the relation of total Mn to soil variables, the statistical evaluation reveals that total Mn in soils of the coastal plain is significant positively correlated with silt and organic matter while being negatively correlated significantly with soluble HCO_3, Figs. 18 to 20. On the other hand, total Mn in soils of the piedmont plain is significant positively correlated with silt and clay, Figs. 21 and 22.

Table 3 includes the statistical measures; weighted means trend and specific range of total Mn. The computed weighted mean of the soils of the coastal plain shows a remarkable decrease of total Mn on passing from profile 11 (the highest W) to profiles 6 and 7 (the lowest W), i.e., eastwards and south-eastwards and also from profiles 1 and 2 westwards and southwards. Also, the area represented by profiles 21 and 22 in the soils of the piedmont plain attains the highest W of total Mn that depressed sharply south-west the study area to reach its minimum in profile 16. The computed trend ranges from – 0.003 to – 0.063 and from -0.009 to 0.391 in the soils of the coastal and piedmont plains, respectively, indicating an increase of symmetry in soils of the coastal plain rather than those of the piedmont plain which display less symmetrical distribution of Mn.

These values of trends denote that the symmetry of the concentration change with depth, tends to display a slight decrease on passing westwards the study area. In brief, the values of trend indicate that some profiles in both coastal and piedmont plain display nearly the same symmetry of Mn distribution such as profiles (1, 2, 3, 5 and 8), (6, 13 and 22), (16 and 20) and (11 and 15). Generally, the results show that total Mn is usually higher in the surface layer than the deeper ones, as indicated by the common negative values for the trend. The obtained data for T in the studied soils are in harmony with El-Demerdashe *et al.* (1980).

Specific range (R) of total Mn indicates that the soils of the study area either located along the coastal plain or piedmont plain are heterogenous in respect to their soil materials. This is clearly evidenced by R values which differ from on soil type to another and even within the soils occupying each geomorphic unit from one profile to another. These variations in R values of total Mn are mainly attributed to inherited soil characteristics modified by pedogenicprocesses, sedimentation regime as well as local condition of each soil profile. In general, the specific range of total Mn ranges from 0.043 to 0.355 in soils of the

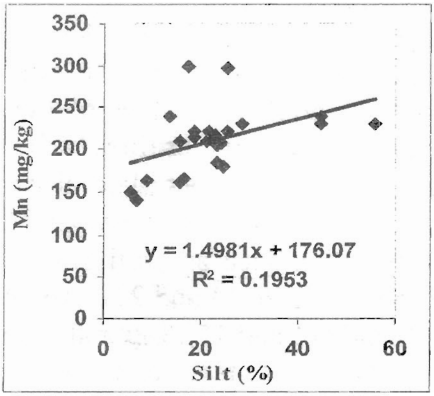

Fig.18.Linear relation between total Mn (mg/kg) and silt (%) in soils of the coastal plain

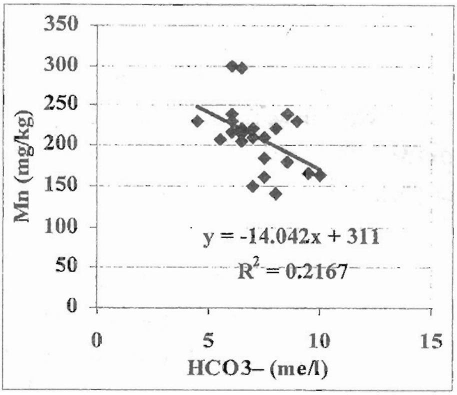

Fig.19. Linear relation between total Mn (mg/kg) and HCO3– (me/l) in soils of the coastal plain

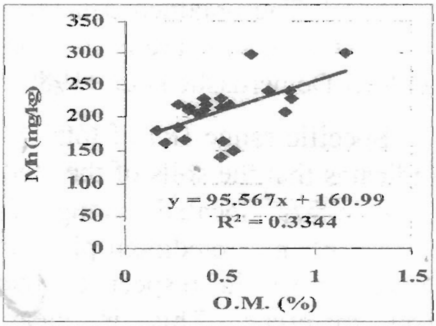

Fig.20. Linear relation between total Mn (mg/kg) and O.M. (%) in soils of the coastal plain

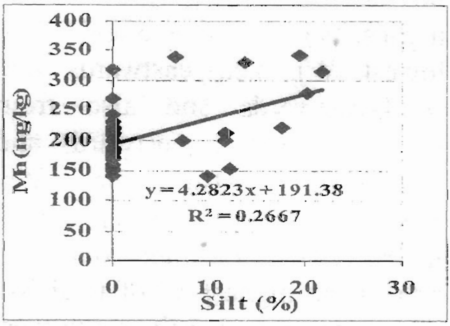

Fig.21. Linear relation between total Mn (mg/kg) and silt (%)in soils of the piedmont plain

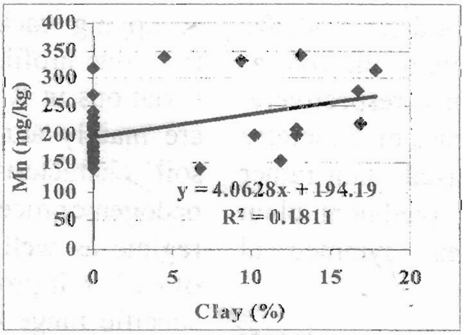

Fig.22. Linear relation between total Mn (mg/kg) and clay (%) in soils of the piedmont plain

coastal plain while being much wider (0.014 to 0.879) in soils of the piedmont plain. These values suggest that pedogenic process had acted in a fairly uniform manner especially in soils of the coastal plain and this implies that an analysis of a surface sample of soils would, to a large extent, give a satisfactory measure of Mn status of the entire soil profile.

Chemically extractable Mn in the studied soils

Data in Table 3 show that DTPA-extractable Mn ranged from 4.65 to 6.70 ppm in soils of the coastal plain while being somewhat higher (4.70-8.15ppm) in soils of the piedmont plain. The lowest value is associated with the 55-85cm layer of profile 13 of the soils of coastal plain while being in the top surface layers (down to 60cm) of profile 5 of the piedmont plain. On the other hand, the highest extractable Mn content is found in the surface layer of profile 1 (coastal plain soils) and the subsurface layer (50-80cm depth) of profile 15 (piedmont plain soils).

Depthwise distribution of DTPA-extractable Mn shows some similarity between some layers within the investigated soil profiles with nearly no distinct pattern pertaining to any soils in each landform.

To search for evidence indicating the relationship between extractable Mn and soil variables, correlation coefficients are computed Fig. 23. These coefficients indicate that chemically extractable Mn of soils of the piedmont plain is negatively correlated significantly with exchangeable Mg^{++}. On the contrary, extractable Mn from soils of the coastal plain does not have any significant correlation with soil variables. These data also dictate that many soil variables such as $CaCO_3$, organic matter, pH, silt, clay, soluble Ca^{++}, Mg^{++} and EC_e may individualy or jointly affect chemically extractable Mn, yet their individual effects may not quite significant since their role in controlling Mn in soils could not entirely be ignored.

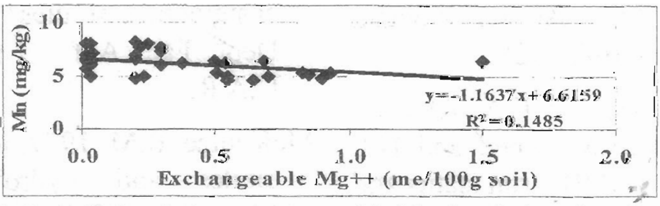

Fig.23. **Linear relation between extractable Mn (mg/kg) and exchangeable Mg++ (me/100g soil) in soils of the piedmont plain**

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صور الحديد والمنجنيز كدالة لأصل وتكوين أراضي سيدي براني "الساحل الشمالي الغربي"

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أجريت هذه الدراسة ٢٠ قطاع أرضي ممثلة لوحدتين من الوحدات الجيومورفولوجية في منطقة سيدي براني هي السهل الساحلي والسهل البيدمونتي لتقييم صور وتوزيع الحديد والمنجنيز وعلاقتهما بمتغيرات التربة المورثة من مادة الأصل والعمليات البيدوجينية في تكوين الأراضي.

أظهرت النتائج بوضوح أن الحديد الكلى يتراوح بين (٢٤٠٠ـ ٧٠٢٠ جزء في المليون) و(٢٥٠٠ـ ٧٥٠٠ جزء في المليون) في أراضي السهل الساحلي والبيدمونتي على التوالي. كما يتراوح المنجنيز الكلى بين (١٤٠ـ ٣٠٠ جزء في المليون) و(١٤٠ـ ٣٤٢ جزء في المليون) في أراضي هذه السهول على التوالي.

وقد توقف التوزيع الرأسي لكلا العنصرين سواء المحتوى الكلى او المستخلص بعمق القطاعات الأرضية. كذلك فان التغيرات الملحوظة سواء بين القطاعات أو في داخلها في كل وحدة جيومورفولوجية تم تحديدها.

وقد أظهر التحليل الإحصائي للنتائج أن هناك ارتباط معنوي موجب بين الحديد والمادة العضوية والالومينا الامورفية والكالسيوم المتبادل بينما كان الارتباط سالبا مع الكالسيوم والمغنيسيوم والبوتاسيوم والكبريتات الذائبة في أراضي السهل الساحلي. كذلك كان الارتباط بين الحديد في أراضي السهل البيدمونتي موجبا مع المادة العضوية والكالسيوم الذائب بينما كان الارتباط سالبا مع محتوى كربونات الكالسيوم ورقم الحموضة والكالسيوم المتبادل.

أما عن المنجنيز فقد كان المحتوى الكلى له في أراضي السهل الساحلي ذو ارتباط موجب مع السلت والمادة العضوية بينما كان الارتباط سالبا مع البيكربونات الذائبة. أما المنجنيز الكلى في أراضي السهل البيدمونتي فقد كان له ارتباط موجب مع السلت والطين.

ومن جهة أخرى كان الحديد والمنجنيز المستخلصين كيماويا من أراضي السهل الساحلي لا يرتبطان بأي من متغيرات التربة. بينما الحديد في أراضي السهل البيدمونتي كان ارتباطه موجبا مع الكالسيوم الذائب. وكان ارتباطه سالبا مع السعة التبادلية الكاتيونية والكاتيونات المتبادلة من الكالسيوم والمغنيسيوم والصوديوم.

بينما في أراضي السهل البيدمونتي كان المنجنيز المستخلص ذو ارتباط سالب مع المغنيسيوم المتبادل.

وقد أظهرت المقاييس الإحصائية وهي المتوسط الوزني والاتجاه والمدى النوعي أن الحديد الكلى في أراضي السهل البيدمونتي ذو متوسط وزني أوسع، أما الاتجاه فكان ذو قيم سالبة في أراضي السهل الساحلي بينما كان ذو قيم موجبة في أراضي السهل البيدمونتي، واختلف المدى النوعي سواء في داخل الوحدات الجيومورفولوجية أو فيما بينها.

وبالنظر إلى المحتوى الكلى للمنجنيز فان المتوسط الوزني اعطى قيم مرتفعة تقل بالاتجاه شرقا وجنوب شرقي وغربا وجنوبا عبر السهل الساحلي. بينما كان اتجاه النقص في المتوسط الوزني للمنجنيز هو جنوب غرب السهل البيدمونتي.

وقد أظهر الاتجاه أن هناك زيادة في التماثل في أراضي السهل الساحلي عنها في أراضي السهل البيدمونتي. أما المدى النوعي فقد اظهر أن أراضي كلا السهلين غير متجانسة. كما كان اختلاف قيم المدى النوعي لكلا من الحديد والمنجنيز الكلى راجعا إلى الصفات الموروثة للتربة معدلة بالعمليات البيدوجينية ونظام الترسيب وموقع القطاعات في كل وحدة جيومورفولوجية. وفضلا عن ذلك فقد أظهرت قيم المدى النوعي أن العمليات البيدوجينية قد تمت بطريقة متجانسة نوعا وخصوصا في أراضي السهل الساحلي. وهذا يعنى أن تحليل هذين العنصرين في الطبقة السطحية يمكن إلى حد ما أن يعطى مقياسا مرضى لهذين العنصرين في داخل القطاع.