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VARIABILITY OF HEAVY AND TRACE METAL CONTENTS IN THE SOILS ADJACENT TO EL-SALAM CANAL, EGYPT

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This work was undertaken on 10 profiles representing cultivated and virgin soils adjacent to EL-Salam canal. The results reveal that these soils are clay textured, highly saline to extremely saline, with Na^+ and Cl^- being the most predominant among soluble ions. The soil reaction class was neutral to mildy alkaline and the soils were non- calcareous.

The total and chemically extractable Cu, Zn, Fe, Mn, Cd and Co varied widely within and between soil profiles. Computation of the weighted means of the trace and heavy metals showed different levels of abundance of such metals. This showed that Bahr El-Bakar and Bahr Hadous soils were enriched in total and chemically extractable Cu, Zn, Mn, and Cd together with chemically extractable Fe and Co, while being impoverished in total Fe and Co, respectively. In contrast, Romana soils had low contents of total and chemically extractable Mn and Cd and low extractable amounts of Cu, Fe and Co. The El- Tina mud flats and Baloza soils had very low contents of total and chemically – extractable Zn.

Variability in trace and heavy metals amounts within and between the profiles representing each location could be ascribed to variation in parent materials and / or the sedimentation regime. Other factors include site-specific conditions and the possible contamination with some elements such as Cd or Co either from native sources or from polluting sources of the metropolitan area.

Keywords: trace elements, heavy metals, El-Salam canal, Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza, Romana.

Small amounts of the trace elements Cu, Zn, Fe, and Mn in soils are considered necessary for plant growth. However, excessive amounts of these elements are detrimental for plant life. On the other hand, some trace elements are toxic for higher plants even at low concentration levels.

In Egypt, many studies concerning trace elements and heavy metals content and distribution have been carried out (Abdel-Hamid *et al.*, 1991; El-Demerdashe *et al.*, 1991; Abdel-Karim and Abdel-Hamid, 1999; El-Eweddy, 2000; Eissa, 2001; Mohammed, 2003;Nashida *et al.*, 2003; Abbas, *et al.*, 2003; Abdel-Motaleb, 2003; and Mourid, 2005).

Since soils around El-Salam Canal constitute the back bone of a great project for land reclamation and agricultural development of North Sinai region, it is hoped that the current study will contribute to a better understanding of the nature and chemical behaviour of some trace and heavy metals in such soils.

MATERIALS AND METHODS

Ten soil profiles representing the cultivated and virgin soils along Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana localities were chosen for the study (Fig. 1).The representative soil samples were collected following the morphological variations throughout the entire depth of soil profiles. The physical and chemical characteristics of these soils were determined according to Richards (1954).

Total trace elements and heavy metals were extracted by digestion in a mixture of conc. HNO_3+conc. H_2SO_4+62% perchloric acid as recommended by Hesse (1971).

Chemically extractable contents of trace and heavy metals were extracted with NH_4 HCO_3 DTPA Solution (pH=7.6), (Soltanpour and Workman, 1979). Weighted means were calculated as described by Oertel and Gilkes (1963).

In all cases, determination of the studied elemental composition was conducted by plasma optical emission (Mass Spectrometer, POEMS 111, Thermo Jevreal Ash, USA).

RESULTS AND DISCUSSION

Soil Characteristics

Seven soils studied had clay texture (Table 1) with three other soils having either sandy loam or sandy clay textures. The soils are highly to extremely saline as indicated by EC_e values which ranged widely between 16.4 and 190.0 dS/m.

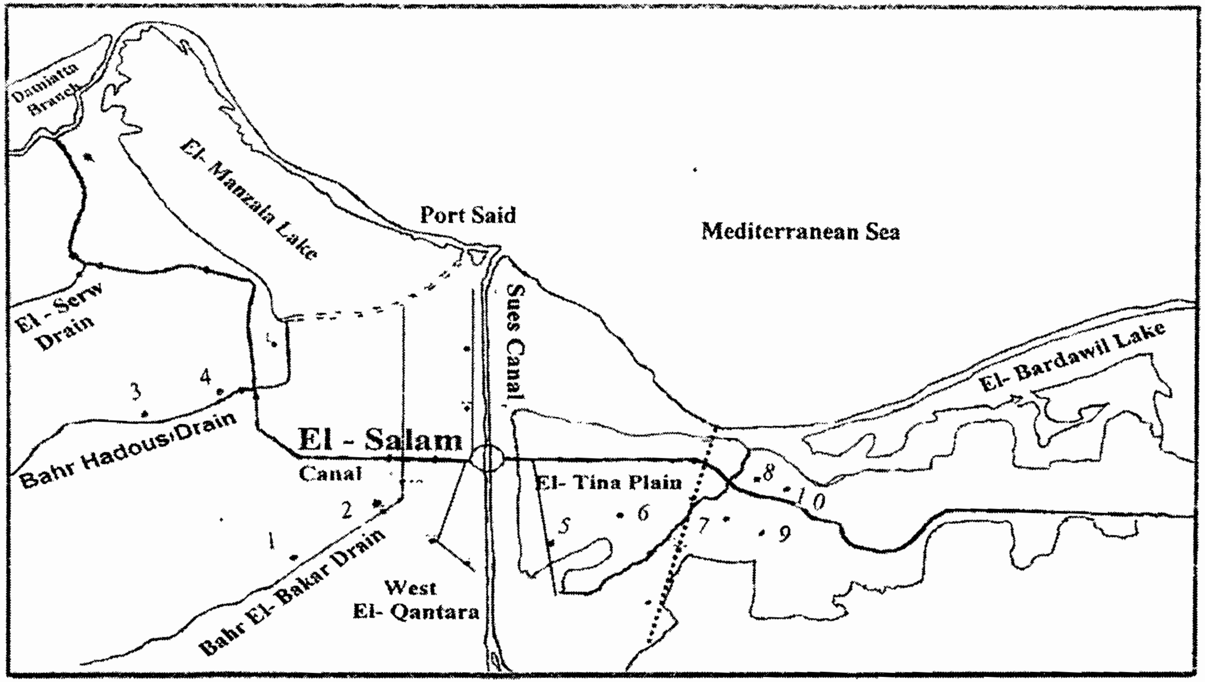

Fig. (1) Location map of the studied profiles

The highest EC_e value characterized the surface layer (0-15) of profile (7) in El-Tina plain, whereas the least values are associated with the deepest layer (60-110cm) of profile (3) in Bahr Hadous soils. Soluble Na dominated the exchange complex followed by Mg^{++} and / or Ca^{++}. Soluble Cl^- dominates the soluble anions, followed by SO_4^{--} and HCO_3^-. Soluble CO_3^{--} was not detected. Soil reaction is neutral to mildly alkaline, as indicated by pH values which ranged from 7.1 to 7.9. Calcium carbonate content ranges from 0.13 to 2.1%, indicating that the soils are non-calcareous.

Total and DTPA - Extractable Heavy Metals

The amounts of total and chemically extractable trace and heavy metals Cu, Zn, Fe, Mn Cd and Co in the studied soil are given in table (2).

1-Copper

Total copper

The data (table 2) shows that total Cu content of the studied soil profiles ranges between 10.47 and 60.45 mg kg^{-1} soil. The lowest content was detected in the surface layer (0-5cm) of profile 6 (Tina mud flat) whereas the highest content of total Cu was in the deepest layer (70-130cm) of profile 2 (Bahr El-Bakar).

Total Cu ranges from 38.33 to 60.45, 37.88 to 49.96, 10.47 to 41.16, 17.05 to 43.16 and from 20.08 to 34.85 mg/kg^{-1} soil in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza, and Romana, respectively.

The weighted mean for total Cu in the studied soils varies widely, being in the ranges of 11.78 to 51.08 mg kg^{-1} soil with the lowest value (11.78 mg kg^{-1} soil) in Tina mud flat (profile 6), while the highest mean (51.08ppm) is recorded in Bahr El-Bakar (Profile 2).

For convenience the weighted means of total Cu are 45.25 ,51.08, 42.85 , 47.88, 11.78 , 39.40, 17.72 ,37.87 ,23.17 and 31.79 mg kg^{-1} soil in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza, and Romana, respectively. In short, the total Cu weighted mean for the studied area follows the order; Bahr El-Bakar ≥Bahr Hadous> Baloza >Romana>Tina mud flat .

Chemically extractable copper

Data presented in table (2) show that DTPA- extractable Cu in the studied soils ranged from 0.07 to 23.03 mg kg^{-1} soil. The highest content was found in the subsurface layer (30-70cm) of profile (2, Bahr El-Bakar), while the lowest one is associated with the surface layer (0-15cm) of profile(5), of Tina mud flat and the surface layer (0-15) of profile (7) of Baloza.

TABLE (1). Some Chemical and Physical Properties of the Studied Soils

Location	Profile	Depth (cm)	pH	EC	Cations me/l				Anions me/l				$CaCO_3$ %	Sand %	Silt %	Clay%	Texture Class
				dS/m	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}					
Bahr El-Bakar	1	0-30	7.8	54.1	50.5	43.9	490	35.5	—	22.7	490.3	106.3	1.17	5.1	23.4	71.5	Clay
		30-60	7.9	75.1	33.6	63	797	39.0	—	3	810.1	110.1	1.56	7.5	17.3	75.2	Clay
		60-120	7.9	91.4	46.3	202	730	22.8	—	6.04	963.3	183.4	1.24	12.7	8.2	79.1	Clay
	2	0-30	7.1	143	60.6	84	1690	52.7	—	15.3	1701	171	0.18	15.0	14.1	70.9	Clay
		30-70	7.2	168	23.4	26.8	170	22.4	—	18.6	1383	380	0.20	6.5	17.7	75.8	Clay
		70-130	7.4	91.5	45.5	201	698	21.2	—	9.9	718	240	0.13	6.9	1311	79.7	Clay
Hadous	3	0-30	7.5	154.5	49.3	73	560	20.5	—	9.7	1580	114.8	0.24	8.4	19.4	72.2	Clay
		30-60	7.6	19.7	23.13	15	171	12.0	—	17.3	166	37.7	1.34	9.9	18.3	71.8	Clay
		60-110	7.5	16.4	26	51.5	98	9.3	—	20.4	107	56.8	2.35	9.3	20.1	70.6	Clay
	4	0-30	7.3	130.3	116.4	235	1254	28.3	—	11	1256	340	1.70	14.3	18.2	67.5	Clay
		30-65	7.7	89.6	123.1	29.8	921	29.4	—	15.2	940	147.5	1.90	22.5	14.3	63.2	Clay
		65-110	7.4	54.5	46	28.2	986	37.8	—	13.8	518	66.8	0.95	12.7	17.5	69.8	Clay
Tina mud flat	5	0-15	7.3	176.7	26.6	136	2092	27.7	—	9.9	2190	240.1	—	—	—	—	S.Crust
		15-45	7.1	143.9	35.6	188	1459	36.1	—	11.8	1513	196	0.30	11.8	22.8	65.4	Clay
	6	0-5	7.3	163.3	47.5	97.5	1590	30.1	—	15	1500	250	—	—	—	—	S.Crust
		5-25	7.2	130	56.9	50.8	1493	21.0	—	5	1401	215	0.18	10.9	21.7	67.4	Clay
Baloza	7	0-15	7.4	173.7	49.4	14.2	2025	10.9	—	6	2050	46	1.47	49.2	28.3	22.3	S.L
		15-45	7.4	67.3	45.5	16.5	639	10.6	—	4.6	6667	41.3	2.10	55.2	22.8	25.2	S.L
		45-70	7.3	118.7	62.5	22.9	1234	10.3	—	6.3	1270	53.8	0.50	53.3	9.7	37.0	S.Clay
	8	0-15	7.5	198	16.88	130	2013	32.1	—	16.4	1991	167	—	—	—	—	S.Crust
		15-35	7.3	110.3	14.3	114	1243	40.2	—	12.5	1150	69	0.42	12.2	9.7	78.1	Clay
		35-70	7.2	15	53.1	234	1587	44.9	—	13.4	1800	105.7	0.41	10.3	20.1	69.6	Clay
Romana	9	0-15	7.4	149.9	62.3	120	1654	57.5	—	6.3	1797	90.8	0.33	46.5	28.3	25.2	S.L
		15-45	7.6	95.9	90.5	95.3	1996	53.4	—	6.4	1115	88	0.46	53.6	23.6	22.8	S.L
		45-70	7.5	76	56.3	150	713	39.4	—	5.7	842.5	110	0.34	51.4	11	37.6	S.Clay
	10	0-16	7.2	181.5	93.3	115	1942	49.8	—	5	1939	256.8	0.18	50.6	25.6	23.8	S.L
		16-35	7.3	157 5	73.2	140	1689	44.5	—	5.1	1500	441.2	0.35	51.1	23.7	25.2	S.L
		35-80	7.3	144.3	136.8	140	1432	48.3	—	5.8	1417	264	0.29	52.5	22.8	24.7	S.L

The data shows that DTPA- extractable Cu ranges from 2.59 to 23.03, 4.02 to 17.58, 0.07 to 2.64, 0.07 to 2.41 and from 1.4 to3.48 mg/kg soil in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana, respectively. From these data, one can conclude that extractable Cu in the studied soils follows the order; Bahr El-Bakar > Bahr Hadous ≥ Tina mud flat ≥ Baloza > Romana.

From these data it is clear that Bahr El-Bakar and/or Bahr Hadous soils are relatively enriched in DTPA- extractable Cu compared to other locations.

Soltanpour and Schwab (1977) proposed that the index value used for DTPA-extractable Cu be as follows: low- (0.05mg kg^{-1} soil) and high-Cu (>0.5 mg kg^{-1} soil).Therefore, the data for extractable Cu in the soil profiles indicate that the studied soils are high in their content of extractable Cu except for the surface layer (0-15cm) of profile (5) of Tina mud flat and the same layer (0-15 cm) of profile (7) of Baloza area which are low in their content of extractable Cu. This may be attributed to the extremely saline condition of those layers where EC_e values are 176.7 and 173.7 dS/m in those layers, respectively.

2- Zinc

Total zinc

The obtained data (Table 2) show that total Zn content of the studied soils reveals that it ranged from 24.04 to 90.35 mg/kg soil. The lowest content was found in the subsurface layer (5-25cm) of profile (6, Tina mud flat). while, the highest one was in the deepest layer (70-130cm) of profile(2 ,Bahr EL-Bakar area).

Total Zn varies widely from 53.03 to 90.35, 60.25 to 88.05, 24.04 to 50.15, 34.33 to 50.15 and from 37.74 to 54.30 mg/kg soil in the soils of Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana, respectively.

Computation of the weighted mean for total Zn in the studied soils ranges from 24.72 to 80.58 mg kg soil with the highest value (80.58 mg kg^{-1} soil) in profile 4 (Bahr-Hadous), and the lowest (24.72 mg kg^{-1} soil) in profile 6 (Tina mud flat soils). To suffice, the weight means of Zn are 67.05, 75.71, 69.04, 80.58, 24.72, 46.17, 36.37, 46.73 and from 39.91 to 48.16 mg kg^{-1} in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana, respectively. In short, the total Zn weighted mean for the studied soils follows the order; Bahr Hadous>Bahr El-Bakar>Romana>Baloza>Tina mud flat.

According to Chapman (1965) the levels of total Zn content below 50 mg kg^{-1} could be considered low and those above 100 mg kg^{-1} soil could be considered high. On basis of those levels, the soils of Bahr El-Bakar and Bahr Hadous belong to the medium level, whereas Tina mud flat, Baloza and Romana soils belong to low level.

Chemically extractable zinc

Data presented in table (2) show that the values of chemically-extractable Zn in the investigated soils vary widely between 1.56 and 16.88 mg/kg soil. The highest value (16.88 mg kg^{-1} soil) is associated with the deepest layer (70-130cm) of profile (2) of Bahr El-Bakar soils, while the lowest value (1.56 mg kg^{-1} soil) is associated with the subsurface layer (15-35cm) of profile(8) of Baloza soils.

TABLE (2). Trace Elements Content of the Studied Profiles (mg/kg).

		Depth (cm)	Cu		Zn		Fe		Mn		Cd		Co	
			Total	EXTR	Total	EXTR	Total	EXTR	Total	EXTR	Total	EXTR	Total	EXTR
Bahr El-Bakar	1	0-30	52	13.27	80.56	6.94	16850	79.13	733.9	148	1.27	0.05	24.33	0.76
		30-60	49	16.19	81.59	13.26	16463	146.4	947.1	107	1.32	0.07	27.93	1.18
		60-120	40	2.59	53.03	12.06	19125	206.8	662	147	0.53	0.06	18	1.46
		W	45.25		67.05		17890.75		751.25		0.913		22.665	
	2	0-30	38.33	15.71	71.83	13.12	19499	76.59	713.1	115.8	0.64	0.06	22.89	1.72
		30-70	46.6	23.03	56.63	11.12	19500	81.21	1167	101.3	0.71	0.06	20.06	3.42
		70-130	60.45	22.49	90.35	16.88	14900	63.43	915.1	79.2	1.24	0.05	30.73	3.43
		W	51.08		75.71		17376.69		945.99		0.939		25.64	
Hadous	3	0-30	49.96	11.61	74.6	10.24	12305	147.38	720.8	81.4	0.16	0.06	26.13	3.58
		30-60	44.01	12.29	63.71	6.22	5309	84.18	585.3	80.3	0.52	0.05	22.25	2.5
		60-110	37.88	9.12	68.91	6.14	7660	101.14	711.5	80.12	0.67	0.07	20.84	3.16
		W	42.85		640.4		8285.64		674.45		0.49		22.69	
	4	0-30	42.46	4.02	60.25	5.38	11626	181.8	633.4	71.5	0.94	0.08	25.34	3.88
		35-65	48.63	17.58	78.43	6.5	12775	142.54	762.3	98	1.05	0.07	27 55	2.88
		60-110	46.44	14.44	8805	7.56	15125	168.44	321.5	101.6	1.21	0.07	27.48	3.18
		W	47.88		80.58		14058 27		555.57		1.135		26.25	
Tina mud flat	5	0-15	41.16	0.07	55.15	3.92	19875	136.2	625.8	41.8	1.19	0.04	18.33	1.52
		15-45	38.52	2.41	41.68	3.82	12950	171.4	671.3	37.6	1.05	0.01	14.56	0.58
		W	39.4		46.17		15258.34		656.13		1.097		19.15	
	6	0-5	10.47	0 58	27.44	2.82	19125	29.2	224	15.2	0.5	ND	7.38	ND
		5-25	12.11	264	24.04	2.61	19625	33.4	231.5	15.8	1.04	0.01	7.27	ND
		W	11.78		24.72		19525		230		0.932		7.29	
Baloza	7	0-15	43.16	0.07	50.15	3.42	18875	146	656.8	80.8	1.1	0.04	16.13	1.52
		15-45	38.52	2.41	46.68	2.82	12950	171	641.3	81	1.06	0.01	19.56	0.58
		95-70	34	2.09	44.73	3.56	9784	175	521	95	1.01	0.03	17.56	0.34
		W	37.87		46.73		13088.93		601.66		1.051		15.97	
	8	0-15	18.61	1.13	36.14	2.54	10837	41.2	331.1	14.6	1.04	0.01	11.02	0.01
		15-35	18.24	0.82	38.35	1.56	16899	35.2	452.7	34.4	1.14	0.02	19.08	0.22
		35-70	17.05	0.44	34.33	1.6	14375	35.2	687	16	1.3	0.02	18.29	0.06
		W	17.72		36.37		16838		343.5		1.198		16.95	
Romana	9	0-15	22.12	2.28	38.55	3.32	10587	22.4	315.6	12	1.4	0 01	12.5	0.06
		15-45	20.08	1.81	37.74	4.81	10062	25.8	278 1	11.8	1.28	0.02	10.61	0.08
		45-70	27 5	3.48	43.34	3.86	11602	25.2	389.2	15.4	1.64	0.04	18.8	0.2
		W	23 17		39.91		10724 5		325.81		1.434		13.94	
	10	0-16	34.62	2.18	51.14	4.38	18761	27.6	325.6	10.1	1.04	0.01	11.07	0.24
		16-35	34.85	2.14	54.3	6.8	14125	24.2	331.5	15.2	1.3	0.02	14.39	0.34
		35-80	29.5	1.4	44.5	4 4	14628	33.4	334 6	15.8	1.4	0.03	15.27	0.4
		W	31.79		48.16		19335.14		323.06		1.304		14.22	

To interpret the obtained data in an attempt to search for evidence relating the distribution of extractable Zn to locality. Data in table (2) show that DTPA- extractable Zn ranged from 6.94 to 16.88, 5.38 to 10.24, 2.61 to 3.92, 1.56 to 3.42 and from 3.32 to 6.8 mg kg^{-1} soil in Bahr El-Bakar, Bahr

Hadous, Tina mud flat, Baloza and Romana soils, respectively. The DTPA - extractable Zn follows the order; Bahr El-Bakar ≥ Bahr Hadous > Romana > Tina mud Flat ≥ Baloza

According to Soltanpour and Schwab (1977), the index values used for DTPA-extractable Zn are as follows; low (0.0-0.9 mg kg^{-1} soil), marginal (1.0-1.5 mg kg^{-1} soil) and adequate (>1.5 mg kg^{-1} soil). In light of these index values, the obtained results indicate that the studied soils have adequate Zn level.

3- Iron

Total iron

Data in table (2) show that total iron content in the studied soils ranges between 5309 and 19875 mg kg^{-1} soil with the highest level in the surface layer(0-15 cm) of profile 5 of Tina mud flat, while the lowest content is that of the sub surface layer (30-60cm) of profile 3 of Hadous soils.

Total Fe content ranges from 14900 to 19500, 5309 to 15125, 12950 to 19876, 9784 to 18875 and from 10062 to 19626 mg kg^{-1} soil in Bahr El-Bakar,Bahr Hadous, Tina mud flat, Baloza and Romana soils, respectively. From these data, one can state that El-Tina mud flat is relatively enriched in total Fe compared with Bahr El-Bakar soils, while Bahr Hadous soil attains the lowest Fe content. The total Fe contents in the studied soil profiles illustrate the following order; Tina mud flat > Bahr El-Bakar > Baloza > Romana > Bahr Hadous.

Table (2) also shows the weighted mean for total Fe in the studied soils which varies widely between 8285.64, 19525 mg kg^{-1} soil. The lowest value of W for total Fe is associated with profile 3 of Bahr Hadous soil, while the highest is associated with Tina mud flat soils.

The weighted means for total Fe are 17890.75 and 17376.69, 8285.64 and 14058.27, 15258.34 and 19525, 13088.93 and 16838 and 10724.5 and 19335.19 mg kg^{-1} soil in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana soils, respectively. In short, the weighted mean of total Fe in the studied soils follows the order; Tina mud flat > Bahr El-Bakar > Baloza > Romana > Bahr Hadous. The variations encountered within or between both profiles in each location could be ascribed to the chance of variation in parent material and/or sedimentation regime prevailed during soils formation and development.

Chemically extractable iron

Data presented in table (2) show that DTPA-extractable Fe ranged from 22.4 to 206.8 $mgkg^{-1}$ soil. The highest DTPA- Fe value was found in the deepest layer (60-120cm) of profile(1) of Bahr EL-Bakar area, while the lowest was in the surface layer (0-15cm) of profile (10) of Romana soils.

In short, these data show that DTPA- extractable Fe ranges from 63.42 to 206.8, 84.18 to 181.8, 29.2 to 171.4, 35.2 to 175.0 and from 22.4 to 33.4 mg kg^{-1} soil in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza, and

Romana soils, respectively. From the data one can conclude that DTPA-Fe in the studied soils follows the order; Bahr El-Bakar > Bahr Hadous > Baloza > Tina mud flat > Romana.

Considering the critical level of soil Fe, Soltanpour and Schwab (1977) reported that the index of DTPA-extractable iron was as follows: low (0.2 mg kg^{-1} soil), marginal (2.1-4.0 $mgkg^{-1}$ soil) and adequate (>4 $mgkg^{-1}$ soil). In light of this index, the soils have an adequate level of Fe.

4- Manganese

Total manganese

The distribution and level of total Mn in the studied soils are presented in table (2). Values show that the amount of total Mn ranges from 224.0 to 1167.0 mg kg^{-1} soil. The highest Mn content is associated with the subsurface layer (30-70cm) of profile (2) in Bahr El-Bakar, while the least content is found in the top layer (0-5cm) of profile (6) of Tina mud flat.

Table (2) also shows that soils of Bahr El-Bakar are relatively enriched in total Mn compared with soils of Bahr Hadous soils, while other soils have moderate total Mn content that varies remarkably with location. This discrepancy is mainly contingent on the inherited characteristics exerted by the parent material and depositional regime of these soils together with environmental impact with contributes to less pronounced extent.

Data recorded in table (2) reveal that the weighted means of total Mn in Bahr El-Bakar, Bahr Hadous, Tina mud Flat, Baloza and Romana soils are 751.25 and 945.79, 555.57 and 674.45, 230 and 656.13, 343.5 and 601.66, and 325.81 and 332.06 mg kg^{-1} soil, respectively. In short, the weighted mean of the studied soils follows the order; Bahr El-Bakar > Bahr Hadous > Tina mud flat ≥ Baloza ≥ Romana. Similar results was reported by Mahmoud (2003).

Chemically extractable manganese

Table (2) shows that the values of chemically extractable (DTPA-extractable) Mn ranged widely from 10.1 to 148.0 mg kg^{-1} soil. The highest value of DTPA-extractable Mn was found in the surface layer (0-30cm) of profile (1, Bahr El-Bakar), while the lowest was in the top layer (0-16cm) of profile (10, Romana).

The results show that the DTPA-extractable Mn ranges from 79.2 to 148.0, 71.5 to 101.6, 15.2 to 41.8, 14.6 to 95.0 and, from 10.1 to15.8 mg kg^{-1} soil in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana soils, respectively, In short, the studied soils follow the order; Bahr El-Bakar > Bahr Hadous > Baloza > Tina mud flat ≥ Romana.

According to Soltanpour and Schwab (1977), the critical levels of DTPA - extractable Mn are as follows: low (0-1.8 mg kg^{-1} soil) and adequate (>1.8 mg kg^{-1} soil). This indicates that the soil profiles studied have adequate levels of Mn.

5- Cadmium

Total cadmium

The total Cd contents (Table 2) range from 0.16 to 1.32 mg kg^{-1} soil. The highest value was found in the subsurface layer (30-60cm) of profile (1) of Bahr El-Bakar soils, whereas the lowest value was recorded in the top surface layer (0-5cm) of profile (6) in Tina mud flat soils. The total Cd ranged from 0.53 to 1.32, 0.16 to 1.21, 0.5 to 1.19, 1.01 to 1.3 and, from 1.01 to 1.64 mg kg^{-1} soil in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana soils, respectively.

The weighted mean suggested by Oertel and Giles (1963) was computed and tabulated (Table 2).which shows that the weighted means (W) of total Cd range from 0.49 to 1.434 mg kg^{-1} soil with the highest mean in profile (15) of Romana soils, and the lowest mean in profile (3) of Bahr Hadous soils. For convenience, the weighted means of total Cd are 0.913 to 0.938, 0.49 to 1.135, 0.932 to1.097, 1.051 to 1.198 and from 1.304 to 1.434 mg kg^{-1} soil in Bahr El- Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana soils, respectively. Comparing total Cd in the studied soils, one can notice that the studied soils follow the order; Baloza > Romana > Tina mud flat > Bahr Hadous > Bahr El-Bakar.

The minute variations encountered within or between both profiles representing each location could be due to the variations in parent material and/or sedimentation regime that prevailed during soils formation and development.

Chemically extractable cadmium.

Levels of chemically extractable Cd content in the studied soils are presented in table (2). The data show that DTPA- extractable Cd varies within a very narrow limit from ND to 0.08 mg kg^{-1} soil. The lowest value of DTPA extractable Cd is found in Tina mud flat profiles, while the highest one characterizes to the surface layer (0-35cm) of profile (4) in Bahr Hadous soils.

The DTPA - extractable Cd ranged from 0.0 5 to 0.07, 0.05 to 0.08, ND to 0.04, 0.01 to 0.04 and from 0.01 to 0.04 mg kg^{-1} soil, in Bahr El-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana soils, respectively. The variations are mostly attributed to contamination with Cd either from native sources or from polluting sources of the metropolitan area together with the local conditions in each soil. It is worth while exploring similar explanations for the distribution of other elements studied rather than attribute them solely to differences in p.m. or provenance.

6- Cobalt

Total cobalt

Total Co ranges from 7.27 to 30.73 mg kg^{-1} soil. The highest Co content is associated with the deepest layer (70-130cm) of profile (2) in Bahr El-Bakar, while the lowest value characterizes profile (6) in Tina mud flat.

Weighted mean values for total Co in the studied soils varied widely from 7.29 to 26.25 mg kg^{-1} soil. The highest level was found in profile (4) representing Bahr Hadous soils, while the lowest was found in profile (6, Tina mud flat soils).

The weighted mean of total Co are 22.065 and 25.64, 22.69 and 26.25, 7.29 and 19.15, 15.97 and 16.96, and 13.94 and 14.22 mg kg^{-1} soil in Bahr El- Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana soils, respectively. The total Co content in the studied soils illustrates the following order; Bahr Hadous ≥ Bahr EL-Bakar > Baloza > Tina mud flat > Romana. The variations encountered within and/or between both soil profiles representing each locality may be attributed to local conditions prevailing in each site such as irrigation, drainage and managements. It may also be associated with sedimentation regime prevailing during soil formation and profile development.

Chemically extractable cobalt

Table (2) shows that DTPA-extractable Co in the studied soils ranges from N.D to 3.88 mg kg^{-1} soil. The highest value was recorded in the surface layer (0-35cm) of profile (4) in Bahr Hadous soils, while the lowest value was found in profile (6) of Tina mud flat soils.

The DTPA - extractable Co ranges from 0.76 to 3.45, 2.5 to 3.88, ND to 1.52, 0.01 to 1.02 and from 0.06 to 0.4 mg kg^{-1} soil in Bahr EL-Bakar, Bahr Hadous, Tina mud flat, Baloza and Romana soils, respectively. It can be concluded that the distribution of Cd in the soils studied follows the order; Bahr Hadous > Bahr EL-Bakar > Romana > Baloza > Tina mud flat.

The minute variations encountered within or between the groups of soil profiles may be attributed to local conditions prevailing in each site. It may also be associated with sedimentation regime prevailing during soil formation.

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السلوك الكيميائي لبعض العناصر الشحيحة والثقيلة فى الأراضي المجاورة لترعة السلام – مصر

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أجريت هذه الدراسة على عشر قطاعات تمثل الأراضي المنزرعة والبور المجاورة لترعة السلام. وقد أوضحت النتائج أن الأراضي يسودها القوام الطينى، عالية الى شديدة الملوحة وتتميز الايونات الذائبة بسيادة الصوديوم والكلوريد وتفاعل التربة متعادل إلى مائل القلوية والأراضي غير جيرية .

ويختلف المحتوى الكلى والمستخلص كيميائيا اختلافا بينيا سواء فى قطاع التربة أو بين القطاعات. وبحساب المتوسط الوزنى للعناصر النادرة والثقيلة فى التربة تبين أن هناك اتجاهات لسيادة هذه العناصر، وتبين هذه الاتجاهات أن أراضى بحر حدوث وبحر البقر تعتبر غنية نسبيا فى المحتوى الكلى والميسر كيميائيا لعناصر النحاس والزنك والمنجنيز والكادميوم بالإضافة إلى الحديد والكوبلت الميسرين كيميائيا بينما تفتقر فى المحتوى الكلى للحديد والكوبلت على التوالى. وعلى العكس تحتوى أراضى رومانة على اقل مستوى من المنجنيز والكادميوم الكلى والميسر كيميائيا وكذلك اقل مستوى من النحاس والحديد والكوبلت المستخلصة كيميائيا، بجانب ذلك تحتوى أراضى سهل الطينة وبالوظة على اقل محتوى من الزنك الكلى والمستخلص كيميائيا.

وباختصار فان الاختلافات الواضحة فى مستوى العناصر الدقيقة والثقيلة خلال وبين القطاعات الممثلة لكل موقع من مواقع الدراسة يمكن إرجاعها إلى احتمالات الاختلاف فى مواد الأصل المكونة لتربة هذه القطاعات بالإضافة إلى نظام ترسيب التربة السائد خلال تكوينها وتطورها. وهذا لا ينفى الظروف المحلية لكل موقع من مواقع الدراسة واحتمال التلوث البيئي ببعض العناصر مثل الكادميوم والكوبلت من مصادرها الأصلية أو مصادر تلوث المناطق الحضرية.