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THE DISTRIBUTION OF SOME HEAVY METALS IN CULTIVATED SOILS OF EL HAMMAM AREA

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Eight soil profiles representing the soils of the study area were selected, their relevant characteristics were evaluated. Total and DTPA-extractable heavy metals were determined using the recommended methods. Morphological properties of the representative profiles reflects the calcareous nature. Topography is commonly almost flat to slightly undulating and the slope is flat to gently sloping. Soil colour varies from very pale brown to brown. Soil texture is loamy sand to clay loam, the soil structure is dominated with subangular blocky. The identified pedological features are mostly fine nodules, concretions and soft, gypsum spots or nodules and varicolored iron stains. The soils are non- saline.

Total heavy metals in the deep soil profiles ranged from 2.4 to19.2, 16.56 to 53.81, 1324 to 16650, 54.48 to 224.8, 1.5 to 9.93, 0.5 to 27.45, 0.5 to 12.19, 334.4 to985.5 and from15.0 to 96.39 ppm for Cu, Zn, Fe, Mn, Co, Cr, Ni, Sr and V, respectively. On the other hand, the elements in the moderately deep soil profiles ranged from 2.4 to11.23, 16.72 to 32.58, 2593 to 15130, 97.34 to 147.8, 2.45 to 4.66, 1.08 to 13.82, 0.5 to 4.65, 335.7 to 856.0 and from 26.17 to 58.5ppm for these metals, respectively.

The amounts of DTPA-extractable heavy metals in the deep soil profiles ranged from0.382 to 1.427, 0.753 to1.731, 1.465 to 3.788, 0.241 to 3.566, 0.004 to 0.103, 0.01 to 0.065, 0.037 to 0.178, 0.037 to 1.428 and from 1.008 to 3.026 ppm for Cu, Zn, Fe, Mn, Co, Cr, Ni, Sr and V, respectively.

In the moderately deep soil profiles, DTPA-extractable metals ranged from 0.406 to 0.833, 0.871 to1.938, 0.196 to 3.103, 0.381 to 1.484, 0.004 to 0.043, 0.01 to 0.048, 0.057 to 0.152, 0.43 to 2.04 and from 0.975 to 2.426 ppm for Cu, Zn, Fe, Mn, Co, Cr, Ni, Sr and V, respectively.

To shed light on the factors affecting total and DTPA-extractable heavy metals in the studied soils, the correlation coefficients were calculated and discussed. The statistical measures, i.e., weighted mean , trend and specific range of these elements were computed and interpreted in each of the studied soil profiles.

Keywords: heavy metals, calcareous soils, statistical measures, El-Hammam area of Egypt.

There are several studies on heavy metals contents, including Cu , Zn , Fe , Mn , Co , Cr , Ni , Sr and V in the newly cultivated lands (El-Demerdashe *et al*., 1991; El-Kassas, 1992; Abd El-Kariem, 1994; El-Sebaay, 1995; Abd El-Kariem, 1999; Shehata, 1999; Abd El-Kariem, and Abd EL-Hamid, 1999; El-Eweddy, 2000; Ramadan, 2000; Eisa, 2001; Mohammed, 2003; Abd El-Mottaleb, 2003).

The aim of the study is to shed light and evaluate the nature and chemical behaviour of some heavy metals in calcareous soils of El-Hammam area. Moreover, the factors affecting heavy metals status were studied to evaluate the relationship between these elements and soil variables.

MATERIALS AND METHODS

The study area (7500 fed.) is located at the extentsion of El-Hammam canal between Long. 28° 30′ and 28° 41′ E and Lat. 30° 56′ and 31° 02′ N. Eight soil profiles were chosen to represent the soils of the study area. Out of these profiles, five of them (1, 2, 3, 4 and 5) are deep soils, and three profiles (6, 7 and 8) represent moderately deep soils. Twenty eight representative samples were collected following the morphological variations through the entire depth of each profile. Their physical and chemical characteristics are tabulated in tables (1 and 2).

Total and heavy metals contents 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 heavy metals were evaluated after extraction with incomplete NH_4^+ DTPA (pH=7.6) solution (Soltanpour and Workman, 1979).

In all cases, determination of the studied elemental composition was conducted by Plasma Optical Emmission- Mass Spectrometer (POEMS III) Thermo Jerreal Ash (USA).

RESULTS AND DISCUSSION

Soil Characteristics

Before discussing the heavy metals status in the studied area, it is important to throw light on the morphological, physical and chemical properties of the soils under study. Therefore, the following is an account of the soil properties of the investigated soil profiles.

Morphological properties of the representative profiles reflect the calcareous nature of their soils. Topography of the landscape is commonly almost flat to slightly undulating, and the slope is flat to gently sloping. Natural vegetation comprises mostly scattered desert shrubs and most of the arable soils are mostly cultivated with crops or fruits and sometimes with fodder plants. The surface is sometimes covered with few limestone fragments and being void of any other surface features. Soil colour varies from very pale brown to brown. Soil texture is loamy sand to clay loam, and the dominant texture is sandy clay loam. The soil structure is dominantly subangular blocky. Soil wet consistence varies considerably, being slightly sticky to very sticky and slightly plastic to plastic. Pedological features consist of lime nodules, concretions and spots, gypsum spots or nodules and varicolored iron stains.

Physical and Chemical Properties

Tables (1 and 2) show that soil texture varies from loamy sand to clay loam. The soils are non-saline as indicated by EC_e values which range from 0.12 to 2.7 dSm^{-1} except for the subsurface layer of profile 3 whose salinity is 4.25 dSm^{-1}. The highest EC_e value was found in the deepest layer (60-90cm) of profile 5 whereas the least value was in the surface layer (0-15cm) of the same profile. The anionic and cationic compositions indicate the possible dominance of $Na_2\ SO_4$. Soil reaction is neutral to alkaline, as indicated by pH values which ranged from 7.14 to 8.85.

Total Content of Heavy Metals

Table (3) reveals that total heavy metals content in the studied soils ranged widely. To visualize the distribution of total heavy metals to soil units in the studied area, the data in table (3) show that total heavy metals in deep soil profiles ranged from 2.4 to19.2, 16.56 to 53.81, 1324 to 16650, 54.48 to 224.8, 1.5 to 9.93, 0.5 to 27.45, 0.5 to 12.19, 334.4 to985.5 and from15.0 to 96.39 ppm for Cu, Zn, Fe, Mn, Co, Cr, Ni, Sr and V, respectively. On the other hand, the elements in moderately deep soil profiles ranged from 2.4 to11.23, 16.72 to 32.58, 2593 to 15130, 97.34 to 147.8, 2.45 to 4.66, 1.08 to 13.82, 0.5 to 4.65, 335.7 to 856.0 and from 26.17 to 58.5ppm for these metals, respectively.

To differentiate the studied soils on basis of the relationship between heavy metals content and soil units, the statistical measures suggested by Oertel and Giles(1963) were applied. The data in table (4) show that the weighted mean of total Cu, Zn, Fe, Mn, Co, Cr, Ni, Sr, and V in deep soil profiles ranged from 4.794 to 13.486, 26.226 to 34.541, 6699.600 to 11429.273, 105.787 to 155.645, 3.697 to 5.316, 5.317 to 12.713, 1.311 to 5.725, 503.170 to 814.227, and from 39.031 to 56.551 ppm, respectively. In moderately deep soil profiles the weighted mean of these metals is somewhat lower, where it ranged from 3.930 to 7.609, 22.640 to 29.939, 5793.630 to 6384.118, 104.272 to 127065, 2.970 to 5.099, 4.410 to 11.615, 4.816 to 0.500, 462.571 to716.967 and from 35.970 to 54.914 ppm, respectively. Accordingly, the deep soil profiles are somewhat enriched with the studied elements if compared to the moderately deep ones. The minute variations within profiles of each soil mapping unit may be attributed to local conditions prevailing in each site or to soil formation processes and sedimentation regimes prevailed during soil formation.

The other statistical measures of Oertel and Giles (1963), i.e., trend (T) and specific range (R) in table (4) reveal highly symmetrical distribution for most of the studied soils in both soil units, as indicated by the smallest value of T and R. This suggests that pedogenic processes had acted in a fairly uniform manner throughout the solum. On the other hand, exceptional cases are recorded for Fe, Co, Cr, and Ni in some profiles having relatively high values of T and R. Their measures give an evidence of certain soil formation and development processes for local prevailing conditions in such soils.

Factors Affecting Total Heavy Metals in the Studied Soils

The present data show that some factors are involved in controlling the behaviour of the studied elements. Therefore, the relationships between total elements contents and factors that may affect them were assessed through correlation coefficients that were computed. The correlation coefficients indicated that total Cu is positive and highly correlated with soluble K^+ (r=0.88**) and with soluble Cl^- (r=0.45*) while being insignificant positively correlated with pH(r=0.1), EC (r=0.16), $CaCO_3$ % (r=0.05), soluble Na^+ (r=0.23), soluble Mg^{++} (r=0.01), soluble HCO_3^- (r=0.17), soluble SO_4^{--} (r=0.02), silt (r=0.2) and clay (r=0.03). Also, Cu is insignificant negatively correlated with soluble Ca^{++} (r=-0.07), coarse sand (r=-00.4) and fine sand (r=-0.07).

Total Zn is insignificant positively correlated with pH(r=0.27), $CaCO_3$% (r=0.19), soluble Ca^{++} (r=-0.05), while it is insignificant negatively correlated with EC (r=-0.04), silt (r=-0.06),clay (r=0.14), soluble Na^+ (r=0.05), soluble K^+ (r=-0.13), soluble Mg^{++} (r=-0.07), soluble HCO_3^- (r=-0.11), soluble Cl^- (r=-0.08), soluble SO_4^{--} (r=-0.03), coarse sand (r=-0.27) and fine sand (r=-0.1).

TABLE(1). Particle size distribution

Profile No.	Depth, cm	Coarse sand%	Fine sand%	Silt%	Clay%	Soil texture Texture
1	0-30	25.30	56.68	7.87	9.97	L.S
	30-60	8.13	63.09	13.15	16.63	S.L
	60-110	10.95	51.03	22.59	15.43	S.L
2	0-30	7.39	54.31	19.70	18.40	S.L
	30-60	5.93	46.37	36.67	11.03	S.L
	60-100	6.68	50.69	31.67	10.95	S.L
3	0-20	14.10	40.01	24.08	21.81	S.C.L
	20-55	6.30	17.78	18.99	29.11	S.C.L
	55-80	6.05	15.76	13.62	19.17	S.L
	80-100	12.5	49.7	19.25	18.13	S.L
4	0-20	5.95	52.72	31.68	22.28	S.C.L
	20-50	4.18	43.47	19.05	28.70	S.C.L
	50-80	4.94	43.08	23.65	28.38	S.C.L
	80-110	6.06	48.11	23.60	24.66	S.C.L
5	0-15	20.11	51.66	21.17	22.65	S.C.L
	15-30	7.01	52.24	5.38	31.05	S.C.L
	30-60	5.53	53.35	9.70	21.83	S.C.L
	60-90	8.10	50.20	19.30	24.30	S.C.L
	90-150	13.66	45.21	17.20	34.63	S.C.L
6	0-30	14.19	46.07	6.44	20.54	S.C.L
	30-60	6.41	42.44	18.80	22.75	S.C.L
	60-95	9.68	44.07	28.35	21.35	S.C.L
7	0-30	19.80	24.50	25.00	37.50	S.C.L
	30-60	22.00	42.00	28.20	21.50	S.C.L
	60-90	13.80	70.50	13.30	8.20	S.C.L
8	0-25	11.00	54.90	7.50	15.60	L.S
	25-50	9.50	61.10	10.90	18.50	S.L
	50-80	9.50	61.10	10.90	18.50	S.L

L.S: loamy sand,
S.L: sandy loam,
S.C.L: sandy clay loam,
S.L: sandy loam

TABLE (2). Chemical characteristics of the studied soils.

Profile No.	Depth, cm	pH	EC, dS/m	$CaCO_3$ %	Soluble cations and anions(me/l)							
					Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4
1	0-30	7.96	0.23	34.39	0.98	0.25	0.53	1.40	-	0.63	0.95	1.58
	30-60	8.25	0.23	44.11	1.66	0.20	0.53	1.40	-	0.63	0.48	2.70
	60-110	8.22	0.19	45.88	0.93	0.22	1.40	1.40	-	1.30	0.95	1.70
2	0-30	7.74	0.21	35.88	0.80	0.25	0.35	0.35	-	0.70	0.95	0.10
	30-60	7.57	0.40	42.94	1.70	0.25	0.35	2.10	-	1.20	1.43	1.80
	60-100	7.93	0.60	41.76	4.10	0.25	0.35	0.53	-	0.88	1.90	2.40
3	0-20	8.43	0.70	41.17	8.00	0.28	0.35	0.53	-	1.23	2.90	5.00
	20-55	7.95	4.25	42.35	22.40	0.46	0.30	3.15	-	0.70	5.23	23.00
	55-80	8.47	1.47	30.30	8.52	0.25	0.53	0.70	-	0.70	7.13	8.50
	80-100	8.51	1.11	40.58	8.93	0.20	0.53	2.00	-	1.30	9.50	0.90
4	0-20	8.10	0.28	33.52	1.10	0.33	0.35	0.70	-	0.80	0.95	0.23
	20-50	8.20	0.33	36.47	2.43	0.25	0.53	0.18	-	0.84	1.43	1.12
	50-80	8.06	0.43	48.82	2.43	0.27	0.35	0.53	-	1.05	1.90	0.63
	80-110	7.94	0.19	47.05	0.84	0.23	0.88	0.70	-	0.70	0.48	1.47
5	0-15	8.18	0.12	31.17	7.78	0.24	0.70	2.80	-	1.50	2.85	7.17
	15-30	8.07	0.44	49.41	1.75	0.26	0.70	0.53	-	0.88	0.95	1.41
	30-60	7.75	2.03	32.35	12.30	0.37	0.70	0.53	-	1.10	0.95	11.85
	60-90	7.68	2.70	34.11	12.80	0.37	10.00	3.15	-	1.10	3.33	11.89
	90-150	7.82	1.55	58.23	11.80	0.32	3.70	1.05	-	1.30	1.43	14.14
6	0-30	8.49	0.19	38.23	1.03	0.26	0.35	0.75	-	0.45	0.48	1.46
	30-60	7.84	0.68	36.47	0.85	0.40	1.75	0.70	-	0.81	0.98	1.91
	60-95	8.27	0.20	35.29	0.87	0.25	0.53	0.18	-	0.80	0.48	1.70
7	0-30	7.99	1.67	41.17	11.80	1.00	0.70	1.20	-	1.23	8.08	5.40
	30-60	7.75	1.03	44.11	6.44	0.36	3.30	1.20	-	0.49	0.95	9.86
	60-90	7.88	1.31	45.29	8.40	0.35	4.70	1.05	-	1.40	0.48	12.62
8	0-25	7.14	0.31	35.29	0.91	0.29	0.53	0.53	-	0.81	0.95	0.50
	25-50	7.81	0.66	31.76	2.60	0.33	1.75	1.05	-	0.81	2.38	2.54
	50-80	8.85	0.59	42.94	2.60	0.37	0.70	1.05	-	1.50	2.38	0.84

TABLE (3). Total content of the studied heavy metals in the investigated soils (ppm).

Profile No.	Depth, cm	Cu	Zn	Fe	Mn	Co	Cr	Ni	Sr	V
1	0-30	8.67	23.63	8198	184.30	3.27	1.40	0.50	922.5	42.64
	30-60	8.78	53.81	15030	218.90	9.93	27.45	12.19	420.5	96.39
	60-110	19.20	23.36	2107	99.93	2.67	1.16	0.93	985.5	33.26
2	0-30	6.44	20.51	4148	98.49	2.29	0.59	0.50	740.8	34.21
	30-60	6.34	26.29	1513	118.50	2.61	1.72	2.44	912.3	33.60
	60-100	2.40	42.56	15210	224.50	7.09	11.56	7.55	731.9	46.72
3	0-20	4.85	33.12	3473	176.60	5.43	15.11	4.70	334.4	47.49
	20-55	8.35	28.00	1324	71.47	1.50	0.50	1.02	663.5	17.69
	55-80	9.74	32.80	15640	127.10	7.51	17.28	8.38	364.6	65.81
	80-100	2.51	19.03	4579	54.48	3.27	2.77	0.50	639.3	33.58
4	0-20	2.40	16.56	2429	65.85	1.37	0.50	0.50	434.3	15.00
	20-50	16.86	41.96	16650	224.80	8.01	23.00	10.13	490.4	77.90
	50-80	9.31	47.78	16250	163.00	7.54	18.65	10.03	405.7	69.39
	80-110	7.94	25.87	7388	139.00	3.03	4.63	0.50	788.2	28.62
5	0-15	5.48	26.20	8407	131.50	3.69	6.16	0.50	677.1	52.85
	15-30	10.91	30.20	15540	131.40	6.60	12.61	8.61	569.1	76.28
	30-60	10.80	21.05	7499	97.45	2.32	1.72	0.50	892.5	36.48
	60-90	5.16	35.94	9456	147.80	4.06	10.51	0.50	767.7	68.33
	90-150	4.10	22.97	8048	135.30	3.48	7.77	0.50	698.5	56.69
6	0-30	11.23	32.58	2593	139.20	4.58	10.51	4.65	454.9	56.65
	30-60	6.02	26.14	2887	100.40	4.66	12.29	3.13	388.3	54.43
	60-95	5.17	31.33	15130	144.50	6.25	12.13	7.04	560.9	53.41
7	0-30	178.80	27.70	5404	105.90	2.45	1.24	0.50	590.9	31.93
	30-60	3.57	22.29	6106	98.13	4.22	5.83	0.50	813.2	58.50
	60-90	10.06	32.58	7164	108.80	3.56	6.16	0.50	746.8	52.96
8	0-25	2.40	16.72	4358	97.34	2.45	1.08	0.50	779.1	26.17
	25-50	3.86	24.42	5442	128.60	2.56	1.40	0.50	856.0	34.62
	50-80	5.27	26.08	7283	147.80	3.74	13.82	0.50	335.7	45.26

TABLE (4). Statistical measures of the studied soil profiles.

Weight									
Profile No.	**Co**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Sr**	**V**	**Zn**
1	4.814	8.395	13.486	7292.636	155.386	3.884	814.227	53.035	31.738
2	4.306	5.317	4.794	7782.300	154.897	3.902	788.690	39.031	31.064
3	4.443	8.910	6.899	6699.600	105.787	3.860	503.170	41.264	28.670
4	5.316	12.713	9.739	11429.273	155.645	5.725	538.318	50.703	34.541
5	3.697	7.431	6.471	9004.900	129.460	1.311	736.060	56.551	26.226
6	5.099	11.615	7.609	6384.118	127.065	4.816	462.571	54.914	29.939
7	3.410	4.410	64.143	6224.667	104.277	0.500	716.967	47.797	27.523
8	2.968	5.958	3.933	5793.625	126.031	0.500	636.856	35.969	22.636
Trend									
1	0.472	4.997	0.556	-0.110	-0.157	6.767	-0.117	0.244	0.343
2	0.880	8.012	-0.256	0.876	0.573	6.804	0.065	0.141	0.515
3	-0.222	-0.696	0.297	0.482	-0.669	-0.218	0.335	-0.151	-0.155
4	2.881	24.425	3.058	3.705	1.364	10.451	0.240	2.380	1.086
5	0.002	0.206	0.181	0.071	-0.016	1.622	0.087	0.070	0.001
6	0.113	0.105	-0.322	1.462	-0.087	0.036	0.017	-0.031	-0.081
7	0.392	2.556	-0.641	0.152	-0.015	0.000	0.213	0.497	-0.006
8	0.211	4.516	0.639	0.329	0.295	0.000	-0.183	0.374	0.354
Range									
1	1.509	3.130	0.781	1.772	0.766	3.010	0.694	1.190	0.959
2	1.114	2.062	0.843	1.760	0.814	1.807	0.229	0.336	0.710
3	1.354	1.883	1.048	2.137	1.154	2.041	0.654	1.166	0.491
4	1.248	1.770	1.485	1.244	1.021	1.682	0.711	1.241	0.904
5	0.157	1.466	1.052	0.893	0.389	6.186	0.439	0.704	0.568
6	0.327	0.153	0.796	1.964	0.347	0.812	0.373	0.059	0.215
7	0.519	1.116	2.732	0.283	0.102	0.000	0.310	0.556	0.374
8	0.434	2.138	0.730	0.505	0.400	0.000	0.817	0.531	0.413

Total Fe is shown to be insignificant positively correlated with pH(r=0.21), $CaCO_3$ % (r=0.06) and clay (r=0.11). Also, it is insignificant but negatively correlated with EC(r=-0.17), soluble Na^+ (r=-0.14), soluble K^+ (r=-0.23), soluble Ca^{++}(r=-0.01), soluble Mg^{++} (r=-0.32), soluble HCO_3^- (r=-

0.12), soluble Cl^- (r=-0.06), soluble SO_4^{--} (r=-0.13), fine sand (r=-0.03) and silt(r=-0.18).

Total Mn displays a pattern quite similar to that displayed by Fe where it is insignificant positively correlated with pH(r=0.21), $CaCO_3$ % (r=0.09), while being insignificant negatively correlated with EC(r=-0.33), soluble Na^+ (r=0.29), soluble K^+ (r=-0.26), soluble Ca^{++}(r=-0.04), soluble Mg^{++} (r=-0.24), soluble HCO_3^- (r=-0.12), soluble Cl^- (r=-0.30), soluble SO_4^{--} (r=-0.24), coarse sand(r=0.09), fine sand (r=-0.03), silt (r=-0.18) and clay (r=-0.1).

The obtained coefficients indicated that total Co is insignificant positively correlated with $CaCO_3$% (r=0.13) and clay (r=0.16) while it is significant negatively correlated with pH(r=0.36). Also, total Cl is insignificant negatively correlated with EC(r=-0.27), soluble Na^+ (r=-0.25), soluble K^+ (r=-0.32), soluble Ca^{++}(r=-0.01), soluble Mg^{++} (r=0.32), soluble HCO_3^- (r=-0.21), soluble Cl^- (r=-0.09), soluble SO_4^{--} (r=-0.22), coarse sand (r=0.21), fine sand (r=-0.01) and silt(r=-0.15) .

Statistical evaluation of total Cr content in relation to soil variables indicated that total Cr is significant positively correlated with pH(r=0.45), but insignificant positively correlated with $CaCO_3$%(r=0.14) and clay (r=0.24) while being insignificant negatively correlated with EC (r= -0.2), soluble Na (r=-0.14), soluble K^+ r= 0.26, soluble Ca^{++} (r=-0.01), soluble Mg (r=-0.27), soluble HCO_3^- (r=-0.11), soluble Cl^- (r=-0.11), soluble SO_4^{--} (r=-0.16), coarse sand (r=0.25), fine sand (r=-0.07) and silt (r=-0.19).

Data also show that Ni is insignificant positively correlated with pH(r=0.32), $CaCO_3$% (r=0.11) while being insignificant negatively correlated with EC, soluble Na^+, K^+, Ca^{++}, HCO_3^-, Cl^- and SO_4^{--} (the respective coefficients are -0.26, -0.28, -0.30,-0.29, -0.3, -0.11 and -0.27, respectively). In contrast, Ni is significant negatively correlated with Mg^{++} (r=-0.38) and coarse sand (r=-0.38).

Total Sr is highly significant negatively correlated with pH (r=-0.62),while being insignificant negatively correlated with soluble K^+ (r=-0.05), soluble Cl^- (r=-0.18) and clay (r=-0.32). Moreover, total Sr is insignificant positively correlated with EC, soluble Na^+, soluble Ca^{++}, soluble Mg^{++}, soluble HCO_3^-, solubleSO_4^{--},coarse sand, fine sand and silt (the respective correlation coefficients are 0.09, 0.07, 0.25, 0.29, 0.05, 0.18, 0.21, 0.19 and 0.12, respectively).

Total V is insignificant positively correlated with pH(r=0.25), total $CaCO_3$% (r=0.18), soluble Ca^{++} (r=0.24) and clay (r=0.31),while it is insignificant negatively correlated with EC (r=-0.17) soluble Na (r=-0.14), soluble K^+ (r=-0.25), soluble Mg^{++} (r=-0.13), soluble HCO_3^- (r=-0.11), soluble Cl^- (r=-0.18), soluble SO_4^{--} (r=-0.04), coarse sand (r=-0.05), fine sand(r=-0.03)and silt(r=-0.28).

Based on the aforementioned data, it is concluded that total Co and Sr are significant negatively correlated while Cr is positively correlated with pH.

Chemically Extractable Content of Heavy Metals

Table (5) reveals that chemically extractable heavy metals content in the study varies considerably from one soil unit to another area. To shed light on the distribution of chemically extractable heavy metals in the soil mapping units of the studied area, data in table (5) show that DTPA-extractable heavy metals in deep soil profiles ranged from 0.382 to 1.427, 0.753 to1.731, 1.465 to 3.788, 0.241 to 3.566, 0.004 to 0.103, 0.01 to 0.065, 0.037 to 0.178, 0.037 to 1.428 and from 1.008 to 3.026 ppm for Cu, Zn, Fe, Mn, Co, Cr, Ni, Sr and V, respectively.

In moderately deep soil profiles, DTPA-extractable metals ranged from 0.406 to 0.833, 0.871 to1.938, 0.196 to 3.103, 0.381 to 1.484, 0.004 to 0.043, 0.01 to 0.048, 0.057 to 0.152, 0.43 to 2.04 and from 0.975 to 2.426 ppm for Cu, Zn, Fe, Mn, Co, Cr, Ni, Sr and V, respectively.

Factors Affecting Chemically Extractable Heavy Metals

To search for evidence indicating the relationship between extractable heavy metals and soil variables, correlation coefficients are computed. The obtained coefficients indicated that DTPA-extractable Cu is significant positively correlated with pH (r=0.38), but it is insignificant positively correlated with $CaCO_3$% (r=0.02), soluble Mg^{++} (r=0.04), soluble HCO_3^- .On the other hand, Cu is insignificant negatively correlated with EC(r=-0.32), soluble Na^+ (r=-0.32), soluble K^+ (r=-0.11), soluble Ca^{++} (r=-0.25), soluble Cl^- (r=-0.34), silt (r=-0.07) and clay (r=-0.25). Data also show that DTPA-extractable Zn is insignificantly correlated positively with pH (r=0.07), EC (r=0.12), soluble Na^+ (r=0.10), soluble Ca^{++}(r=0.09), soluble Mg^{++}(r=0.22), soluble SO_4^{--} (r=0.12) and coarse sand (r=0.19). On the other hand, it is insignificant negatively correlated with $CaCO_3$% (r=-0.06), soluble K^+ (r=-0.09), soluble HCO_3^- (r=-0.06), soluble Cl^- (r=-0.01), fine sand (r=-0.01), silt (r=-0.08) and clay (r=-0.06). Therefore, none of the soil variables is significant in extractable Zn.

It is shown that DTPA-extractable Fe is insignificant positively correlated with pH(r=0.09), EC (r=0.19), soluble Na^+ (r=0.22), soluble K^+ (r=0.05), soluble Mg^{++} (r=0.06), soluble HCO_3^- (r=0.13), soluble Cl^- (r=0.24), soluble SO_4^{--} (r=0.11), coarse sand (r=0.03) and fine sand (r=0.01), while it is significant negatively correlated with clay(r=-0.42).Also, it is negatively correlated but insignificant with $CaCO_3$% (r=-0.15), soluble Ca^{++} (r=-0.34) and silt (r=-0.24). Therefore, clay is shown to be the main soil factor adversely affect extractable Fe.

DTPA-extractable Mn is insignificant positively correlated with pH (r=0.2), soluble K^+ (r=0.02), soluble Mg^{++} (r=0.05), coarse sand (r=0.25) and fine sand(r=0.01), while it is insignificant negatively correlated with EC (r=0.07), $CaCO_3$% (r=-0.13), soluble Na (r=-0.06), soluble Ca^{++} (r=-0.33), soluble HCO_3^- (r=-0.27), soluble SO_4^{--} (r=0.13), silt(r=-0.13) and clay (r=0.3).

The obtained coefficients indicated that DTPA extractable Co is insignificant positively correlated with pH (r=0.07), EC (r=0.07), soluble Na^+ (r=0.10), soluble K^+ (r=0.12), soluble Mg^{++} (r=0.01), coarse sand (r=0.01) and silt (r=0.04). Also, it is insignificantly correlated but negative with $CaCO_3$% (r=-0.13), soluble Ca^{++} (r=-0.23), soluble HCO_3^- (r=-0.13), soluble SO_4^{--} (r=-0.08) and clay(r=-0.06).

DTPA-extractable Cr is highly significant negatively correlated with clay (r=-0.55). Also, it is negatively correlated but insignificant with pH (r=-0.12), EC (r=-0.18), $CaCO_3$% (r=-0.24), soluble Na^+ (r=-0.23), soluble K^+ (r=-0.19), soluble Ca^{++} (r=-0.31), soluble HCO_3^- (r=-0.20), soluble Cl^- (r=-0.18), soluble SO_4^{--}(r=-0.20) and silt (r=-0.19), while being insignificant positively correlated with soluble Mg^{++} (r=0.10), coarse sand (r=0.23) and fine sand(r=0.31).

DTPA-extractable Ni is insignificant positively correlated with pH (r=0.23), soluble K^+ (r=0.26), fine sand (r=0.01) and silt (r=0.08), while it is significant negatively correlated with soluble Ca^{++} (r=-0.44), $CaCO_3$%(r=-0.21), soluble Na^+(r =-0.19), soluble Mg^{++}(r=-0.15), soluble HCO_3^-(r=-0.18), soluble Cl^-(r=-0.04), soluble SO^{--}_4(r=-0.27), coarse sand(r=-0.02) and clay(r=-0.09).

DTPA-extractable Sr is insignificant positively correlated with pH (r=0.14), soluble HCO_3^- (r=0.03), soluble Cl^- (r=0.11), soluble SO_4^{--} (r=0.01), coarse sand (r=0.02) and clay (r=0.01), while it is insignificant negatively correlated with EC (r=-0.14), $CaCO_3$% (r=-0.12), soluble Na^+(r=0.02), soluble K^+ (r=-0.18), soluble Ca^{++} (r=-0.08), soluble Mg^{++}(r=-0.06), fine sand (r=-0.22) and silt (r=-0.1). Therefore, none of the studied soil variables has individually affect extractable Sr.

DTPA-extractable V is highly significant positively correlated with clay (r=-0.50), and significant positively correlated with soluble Na^+ (r=0.37). Data also reveal that DTPA-extractable V is insignificant positively correlated with pH (r=0.22), EC (r=0.27), soluble K^+ (r=0.06), soluble Ca^{++} (r=0.01), soluble Mg^{++} (r=0.17), soluble HCO_3^- (r=0.06), soluble Cl^- (r=0.33), soluble SO_4^{--} (r=0.34) and coarse sand (r=0.15), while it is significant negatively correlated with fine sand (r=-0.45), and negatively correlated but insignificant with $CaCO_3$% (r=-0.08), and silt (r=-0.18). Therefore, clay and soluble Na stimulate V extractability while fine sand displayed depressive effect.

From the foregoing correlations, one can conclude that chemically extractable Mn and Cr are significant negativilely correlated with clay content while the reverse is true for V which is significant positively correlated with clay content.

TABLE (5). Chemically extractable elements in the studied soils (ppm).

Profile No.	Depth, cm	Cu	Zn	Fe	Mn	Co	Cr	Ni	Sr	V
1	0-30	0.916	1.215	3.788	3.566	0.027	0.075	0.130	0.180	1.326
	30-60	1.080	1.582	3.164	2.576	0.015	0.039	0.112	0.650	1.505
	60-110	1.427	0.935	2.016	0.880	0.004	0.036	0.085	0.671	1.069
2	0-30	0.416	0.966	2.058	1.795	0.103	0.063	0.167	0.601	1.065
	30-60	0.778	1.349	2.588	1.338	0.015	0.023	0.127	0.521	1.008
	60-100	0.456	1.731	2.584	0.645	0.004	0.036	0.078	0.528	1.173
3	0-20	0.945	1.513	3.552	3.082	0.032	0.013	0.178	0.370	1.210
	20-55	0.580	1.453	3.240	1.817	0.030	0.034	0.123	0.177	2.164
	55-80	0.563	0.861	2.954	1.493	0.031	0.023	0.072	1.369	2.588
	80-100	0.580	1.419	2.700	0.877	0.060	0.018	0.053	0.921	2.614
4	0-20	0.692	0.808	1.916	0.674	0.004	0.030	0.134	0.107	1.453
	20-50	0.742	0.841	2.352	0.729	0.004	0.018	0.081	0.037	1.503
	50-80	0.524	0.845	1.585	0.541	0.015	0.018	0.080	0.508	1.905
	80-110	0.652	1.091	2.610	1.436	0.008	0.020	0.093	0.432	1.152
5	0-15	0.625	1.096	2.206	0.490	0.006	0.026	0.074	1.428	2.848
	15-30	0.653	1.236	2.674	0.508	0.007	0.010	0.082	1.054	3.026
	30-60	0.580	1.301	3.782	0.461	0.008	0.028	0.082	0.755	2.386
	60-90	0.537	1.294	1.503	0.579	0.005	0.010	0.057	0.349	1.524
	90-150	0.382	0.753	1.465	0.241	0.004	0.013	0.037	0.675	1.287
6	0-30	0.833	1.046	0.196	1.489	0.016	0.010	0.133	0.430	1.605
	30-60	0.652	0.983	2.108	0.891	0.016	0.025	0.120	0.546	1.897
	60-95	0.630	1.234	1.815	0.533	0.010	0.010	0.110	2.040	2.134
7	0-30	0.735	0.871	2.574	1.707	0.043	0.013	0.152	0.522	1.788
	30-60	0.406	1.938	1.684	0.435	0.017	0.015	0.057	0.961	2.426
	60-90	0.514	1.257	2.076	0.381	0.004	0.015	0.062	0.451	2.26
8	0-25	0.593	0.957	2.270	1.022	0.004	0.036	0.058	0.470	0.984
	25-50	0.612	1.935	2.324	0.821	0.004	0.018	0.102	0.468	0.975
	50-80	0.820	1.716	3.102	1.216	0.004	0.038	0.124	0.177	1.139

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توزيع بعض العناصر الثقيلة فى الأراضى المنزرعة بمنطقة الحمام

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لإجراء هذه الدراسه تم اختيار ثمانية قطاعات أرضية تمثل منطقة الدراسه وتم تقييم صفاتها الكيمائية والطبيعيه وكذلك الكميه الكليه للعناصر الثقيله والكميه المستخلصه كيمائيا بواسطةDTPA. مستخدما فى ذلك الطرق العلمية السليمه.

تظهر النتائج أن أهم الصفات المورفولوجيه بمنطقة الدراسه أن هذه الأراضى الجيريه تتميز بطبوغرافيا شبه مستويه ومستويه مع وجود تموج بسيط فى بعض مساحات منه ويتراوح لون التربه بين البنى الباهت الى البنى ويسودها القوام الطمى الرملى الى الطمى الطينى ويسود البناء الكتلى شبه الزاوى البناء الأرضى وتظهر بها بعض الصخور والتجمعات الجيريه والجبسيه وهى أراضى غير ملحيه.

تتراوح الكميه الكليه فى الأراضى العميقة القطاع بين٢,٤-١٩,٢ ، ١٦,٥٦-٥٣,٨٦ ، ١٣٢٤-١٦٦٥ ، ٥٤,٤٨-٢٢٤,٨ ، ١,٥-٢٩,٩٣ ، ,٥-٢٧,٤٥ ، ,٥-١٢,١٩، ٣٣٤,٤-٩٨٥,٥، ١٥-٩٦,٣٩ جزء فى المليون لكل من النحاس، الزنك، الحديد، المنجنيز، الكوبالت، الكروم، النيكل، السنترشيوم والفانديوم على الترتيب.

بينما كانت االكميه فى الأراضى متوسطة العمق تتراوح بين ٢,٤-١١,٢٣ ، ١٦,٧٢-٣٢,٥٨، ٢٥٩٣-١٥١٣٠ ، ٩٧,٣٤-١٤٧,٨ ، ٢,٤٥-٤,٦٦ لهذه العناصر على الترتيب

هذا وتظهر النتائج أن الكميه المستخلصه فى الأراضى عميقة القطاع بواسطةDTPA بين ,٣٨٢-١,٤٢٧ ، ,٧٥٣-١,٧٣١ ، ١,٤٦٥-٣,٧٨٨ ، ,٢٤١-٣,٥٦٦ ، ,٠٠٤-,١٠٣ ، ,٠١-,٠٦٥ ، ,٠٣٧-,١٧٨ ، ,٠٣٧-١,٤٢٨ ، ١,٠٠٨-٣,٠٢٦ لكل من النحاس، الزنك، الحديد، المنجنيز، الكوبالت، الكروم، النيكل، السنترشيوم والفانديوم على الترتيب، بينما كانت هذه الكميه فى الأراضى المتوسطة العمق تتراوح بين,٤٠٦-,٨٣٣ ، ,٨٧١- ١,٩٣٨، ,١٩٦-٣,١٠٣ ، ,٣٨١- ١,٤٨٤، ,٠٠٤-,٠٤٣، ,٠١-,٠٤٨ ، ,٠٥٧-,١٥٢، ,٤٣-٢,٠٤، ,٩٧٥-٢,٤٢٦ لهذه العناصر على الترتيب.

هذا وقد درست العوامل الأرضيه التى تؤثر على الكميه الكليه والمستخلصه كيمائيا واحصائيا بحساب معامل الارتباط وقد نوقشت النتائج مناقشه علميه وأيضا تم حساب ومناقشة المقاييس الاحصائيه مثل المتوسط الموزون والاتجاه والمدى النوعى ونوقشت علمياً ويظهر مما سبق أن هناك عدة عوامل تؤثر على تكوين وتطور هذه الأراضى مما ينعكس على سلوك بعض العناصر تحت الدراسه.