RESULTS AND DISCUSSION

4-RESULTS AND DISCUSSION

4.1. Depthwise distribution of some cations(Ca^{2+},Mg^{2+},Na^{+} and K^{+}) and trace elements (Fe,Mn,Cu and Zn)within different depths of the leached or/and amended soils:

4.1.1 Depthwise distribution of Ca^{2+},Mg^{2+},Na^{+} and K^{+}

Data presented in Table (2) reveal that percentages of soluble Ca^{2+},Mg^{2+}, Na^{+} and K^{+})remained in the different segments of the investigated soils were reduced markedly due to continuous leaching. The effect of leaching seemed more obvious on both Na^{+} and K^{+} than Ca^{2+} and Mg^{2+}. This finding is probably due to the more solubility of salts of either Na^{+} or K^{+} than those of Ca^{2+} or Mg^{2+}. This means that transport of Na^{+} and K^{+} was much greater than transport of Ca^{2+} and Mg^{2+}.

Application of sludge enhanced transportion of Na^{+} and k^{+} from the surface layers to the layers below. This holds true for all the investigated soils regardless of rate of the applied sludge. On the other hand, percentages of Ca^{2+} and Mg^{2+} remained in the different segments of the investigated soils were, in most cases, higher than the corresponding ones of the control treatment. This is due to the ability of the exchangeable Ca^{2+} and Mg^{2+} to form slightly soluble precipition with carbonate and phosphate ions or to form slightly soluble metal-organic complexes. This finding is confirmed by those of Sample et al., (1979) and Kim et al., (1983) who suggested that the

Table (2) Percentages of total contents of some cations (Na^+, K^+, Ca^{+2} and Mg^{+2}) in the different segements of the leached and amended studied soils.

Soil	Depth cm	Control				Sludge at a rate of 3%				Sludge at a rate of 6%				Gypsum at a rate of 100 % (GR)				Gypsum at a rate of 200 % (GR)			
		Na	K	Ca	Mg	Na	K	Ca	Mg	Na	K	Ca	Mg	Na	K	Ca	Mg	Na	K	Ca	Mg
Abo-Soltan	0-5	0.09	0.16	0.90	1.80	0.01	0.15	1.30	2.10	0.04	0.12	0.60	1.60	0.09	0.12	1.30	2.20	0.04	0.08	1.60	1.60
	5--10	0.21	0.17	0.90	2.30	0.15	0.14	1.50	1.30	0.13	0.14	0.90	2.10	0.13	0.11	1.40	1.70	0.09	0.09	1.90	1.80
	10--16	0.21	0.16	1.10	1.70	0.13	0.14	1.10	1.00	0.12	0.13	1.10	2.30	0.17	0.13	1.50	2.00	0.08	0.12	2.00	1.30
	16--24	0.16	0.16	1.00	1.90	0.01	0.15	1.00	1.70	0.10	0.12	0.80	2.00	0.13	0.11	0.80	1.30	0.08	0.11	2.30	1.80
El-Baalowa	0-5	0.05	0.13	1.20	1.50	0.02	0.11	1.20	1.40	0.05	0.11	1.50	1.40	0.04	0.12	1.70	1.40	0.04	0.07	1.70	1.50
	5--10	0.03	0.14	1.80	1.30	0.03	0.11	1.00	1.40	0.04	0.10	0.50	0.80	0.04	0.12	2.30	1.40	0.30	0.05	1.00	0.70
	10--16	0.05	0.15	2.20	1.60	0.03	0.13	2.00	1.40	0.05	0.14	1.70	2.00	0.04	0.95	1.70	1.00	0.04	0.11	0.70	1.30
	16--24	0.04	0.14	1.60	1.40	0.03	0.12	1.00	1.30	0.05	0.14	1.90	1.70	0.37	0.12	1.40	1.40	0.03	0.12	2.50	1.20
El - Kassasen	0-5	0.03	0.16	1.50	1.30	0.02	0.15	1.50	1.40	0.05	0.15	1.40	2.30	0.04	0.12	1.50	1.60	0.04	0.12	1.50	1.80
	5--10	0.03	0.16	1.00	1.10	0.03	0.12	1.30	1.80	0.06	0.14	1.00	1.80	0.05	0.17	1.60	1.90	0.04	0.12	1.90	1.70
	10--16	0.04	0.18	1.60	1.50	0.03	0.12	1.20	1.30	0.08	0.14	0.80	1.90	0.07	0.11	0.80	1.60	0.03	0.12	1.30	1.60
	16--24	0.04	0.15	1.50	1.50	0.06	0.13	1.10	1.90	0.08	0.17	1.30	2.10	0.08	0.12	0.70	1.50	0.03	0.10	1.00	1.10

(G.R.) gypsum requirement.

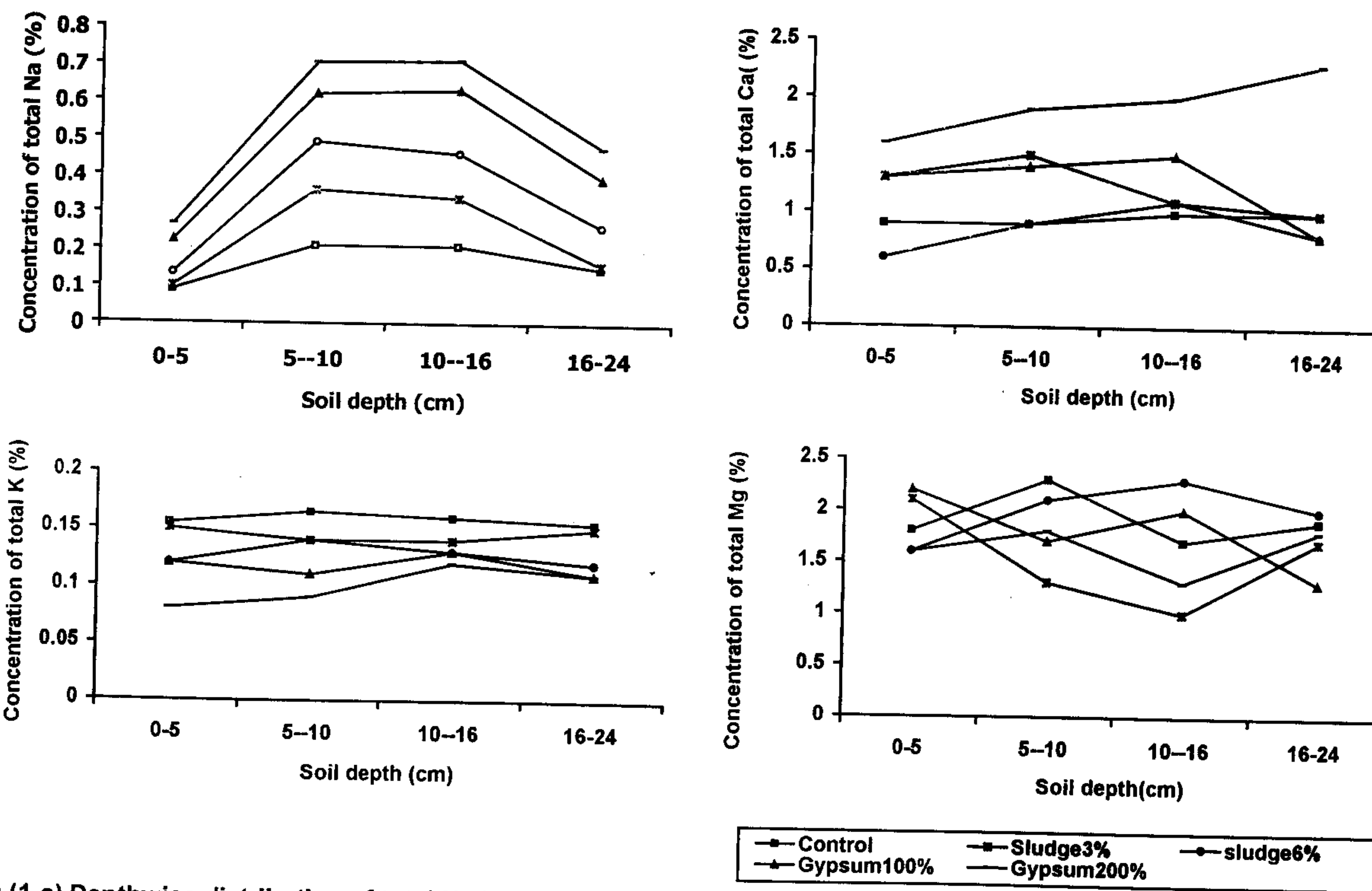

Fig (1-a) Depthwise distribution of total Na,K,Ca and Mg (Abo-Soltan soil)

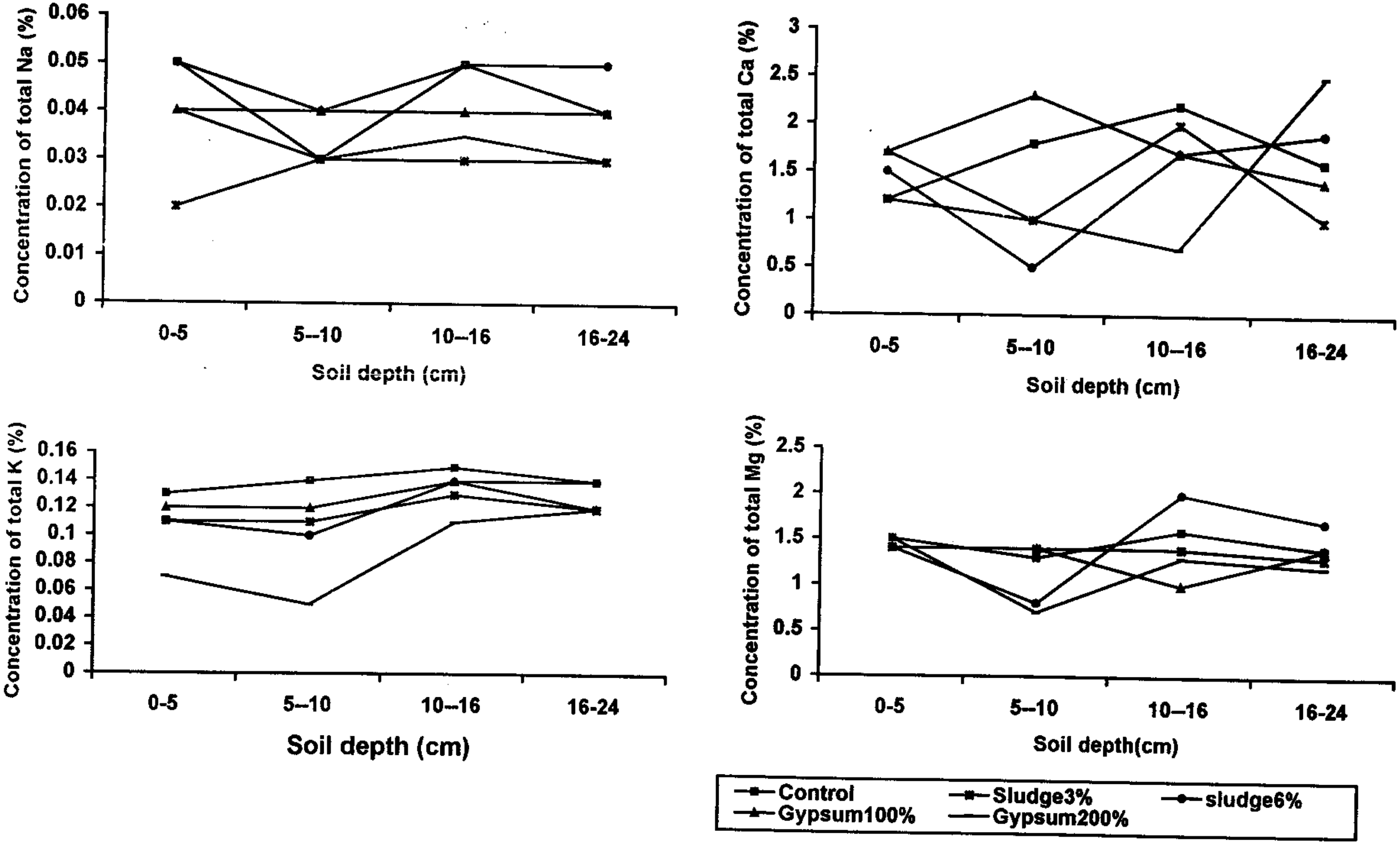

Fig (1-b) Depthwise distribution of total Na,K,Ca and Mg (El-Baalowa)

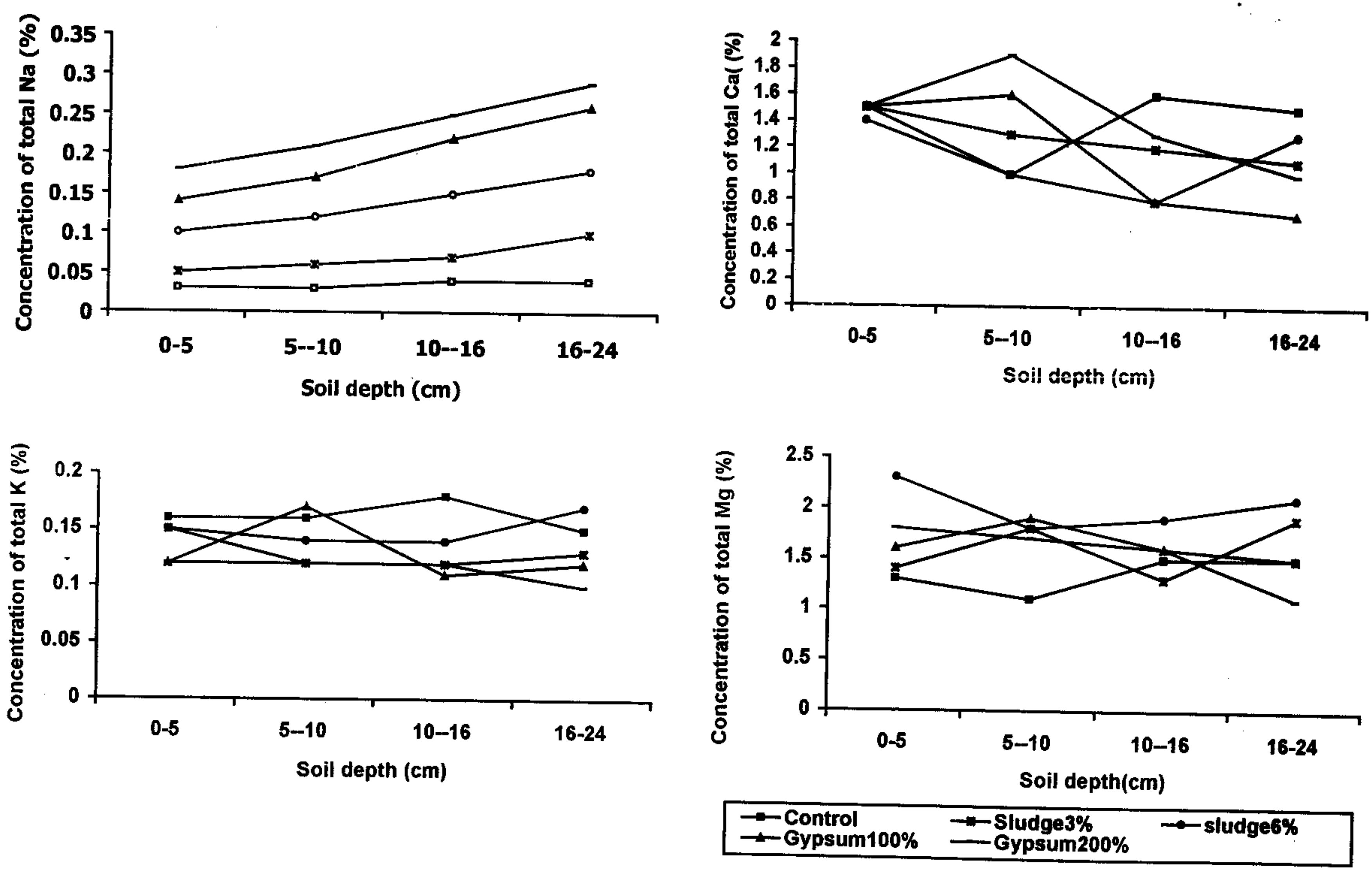

Fig (1-c) Depthwise distribution of total Na,K,Ca and Mg (El-Kassasen soil) exchangeable cations when released into solution by ion exchange reaction, may involve in precipition reactions.

Application of gypsum seemed to enhance transport of Na^+, K^+, Ca^{2+} and Mg^{2+} to the deeper soil segments. The effect seemed more obvious on Na^+ and K^+ than on Ca^{2+} and Mg^{2+}. The application of gypsum resulted in the displacement of cations especially Na^+ from the exchange sites, thus resulting in an increased transport of these cations. The effect of gypsum on increased transport of soil Mg has been reported by **Sumner (1990) Alva and Gascho (1991)** also reported that gypsum –induced transport of Mg. In conclusion, results obtained herein demonstrated that soil amendment with gypsum enhances leaching of exchangeable cations due to cation exchange.

4.1.2. Depthwise distribution of the trace elements (Fe, Mn, Cu, and Zn)

The effect of continuous leaching without or with application of soil amendment on total and AB-DTPA extractable Fe, Mn, Cu, and Zn contents in the different segments of the studied soils is shown by Tables (3 and 4) and illustrated graphically by Figs.(2-a,2-b and 2-c).

It is evident from data presented in this Table that total Fe remained in Abo-Soltan leached soil was highest in the 5-10 cm layer and lowest in the upper most soil layer (0-5 cm) whereas small difference in total Fe content was shown between the deepest successive layers (10-16 and 16-24 cm). A limited transport of Fe occurred within the soil column, being more obvious in the uppermost soil layer (0-5cm).

Table (3) Total contents (mgkg^{-1}) of the trace elements (Fe , Mn, Cu and Zn) in the different segements of the leached and amended studied soils.

Soil	Depth cm	Control				Sludge at a rate of 3%				Sludge at a rate of 6%				Gypsum at a rate of 100 % (GR)				Gypsum at a rate of 200 % (GR)			
		Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn
Abo-Soltan	0-5	30705	520	29.50	63.00	28065	475.0	36.00	215	25170	497	34.50	255	34025	315.5	29.50	96.00	22540	269.50	28.00	45.00
	5--10	36785	540	30.00	70.00	27045	464.5	35.50	205	31885	465	37.00	350	26150	262.5	32.50	75.50	25080	303.00	28.50	45.50
	10--16	33070	487	30.50	70.00	21690	422.5	34.50	230	34885	530	36.00	285	29120	282.5	28.00	58.50	24655	303.50	28.50	52.00
	16--24	32635	455	31.50	95.00	26040	450.0	37.50	255	34245	490	37.50	265	21440	253.5	31.00	65.00	29845	310.00	30.00	56.00
El-Baalowa	0-5	17585	255	28.50	72.50	16390	265	30.00	160	21805	304.5	39.00	235	14010	237.0	29.50	61.00	18770	206.50	27.50	73.60
	5--10	14270	259	27.30	35.50	15875	234	28.30	155	14445	291.5	32.50	295	19200	185.5	31.50	52.50	17775	245.00	26.00	28.50
	10--16	21250	280	30.00	47.50	18415	288	32.50	170	18915	289	37.50	250	12890	200.0	31.50	43.50	15720	233.00	29.00	40.00
	16--24	17570	277	27.00	81.00	15855	252	30.50	130	23180	315	43.00	310	15690	220.0	29.00	41.50	13630	232.50	28.00	50.00
El - Kassasen	0-5	28155	560	29.00	95.00	16380	435	33.50	265	32975	600	44.00	310	22955	365.0	26.50	60.00	28395	360.00	31.00	67.50
	5--10	20035	487.5	28.50	71.50	29210	510	32.50	255	33690	620	44.50	375	27945	480.0	27.50	69.00	31035	341.00	26.50	82.00
	10--16	22850	505	28.50	66.50	24850	480	31.00	180	32650	640	47.00	265	27000	360.0	33.00	67.50	26650	311.00	29.90	63.00
	16--24	22585	445	28.50	68.00	24210	495	29.50	185	33350	675	55.00	410	22935	301.5	28.00	58.00	20820	279.50	28.50	56.50

(G.R.) gypsum requirement.

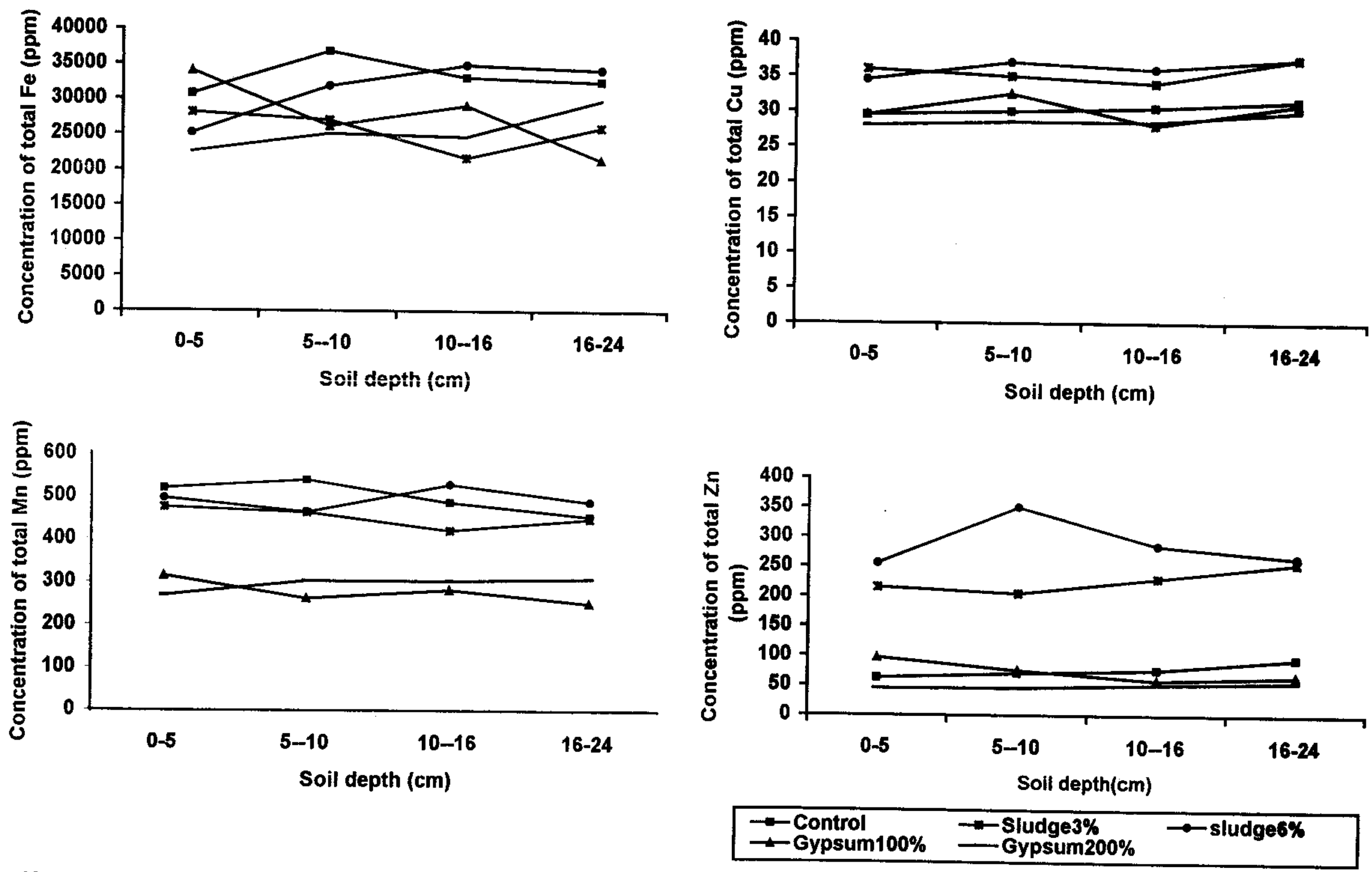

Fig (2-a) Depthwise distribution of total Fe, Mn , Cu and Zn (Abo-Soltan soil)

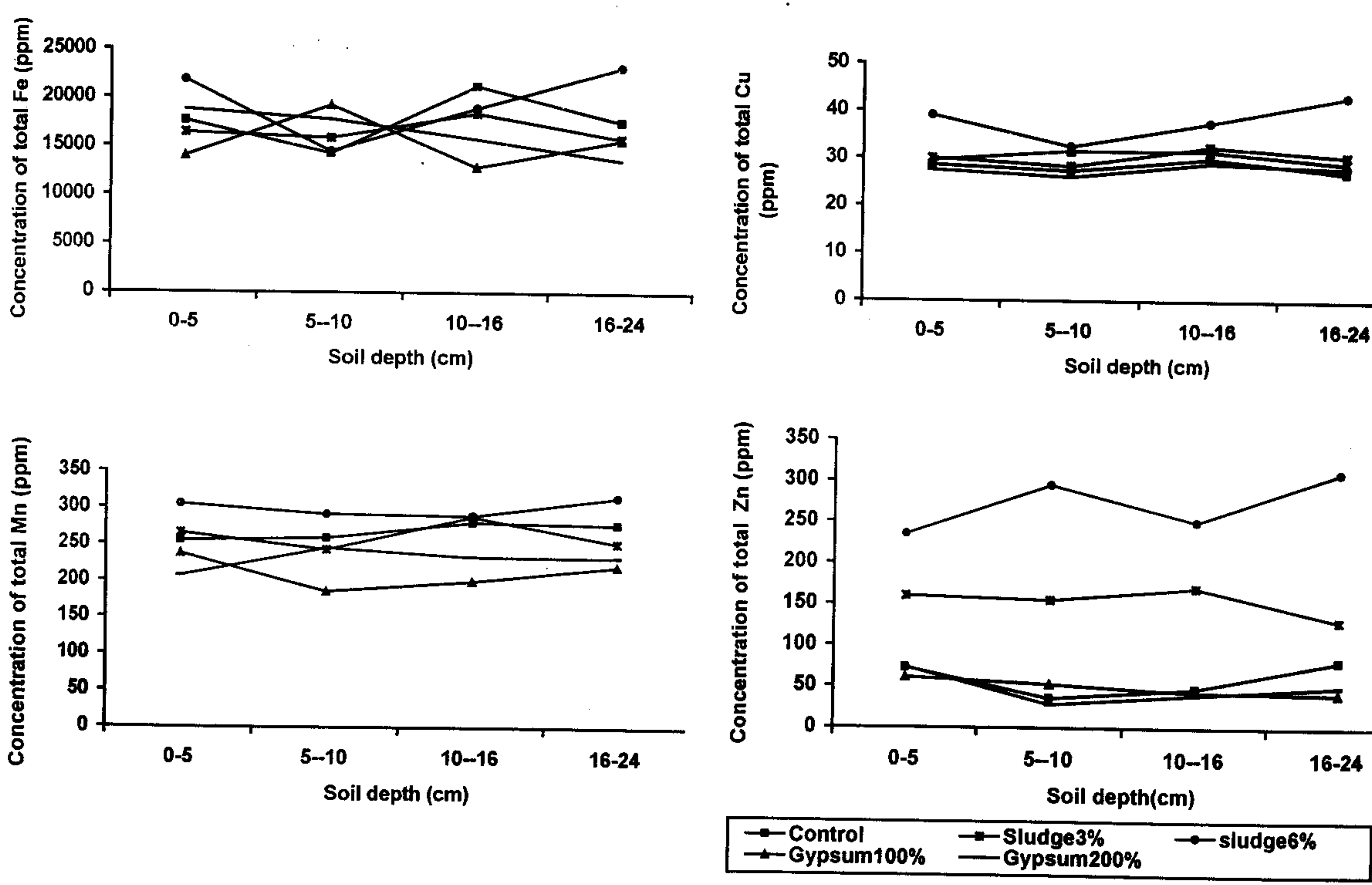

Fig (2-b) Depthwise distribution of total Fe, Mn , Cu and Zn (El-Baalowa soil)

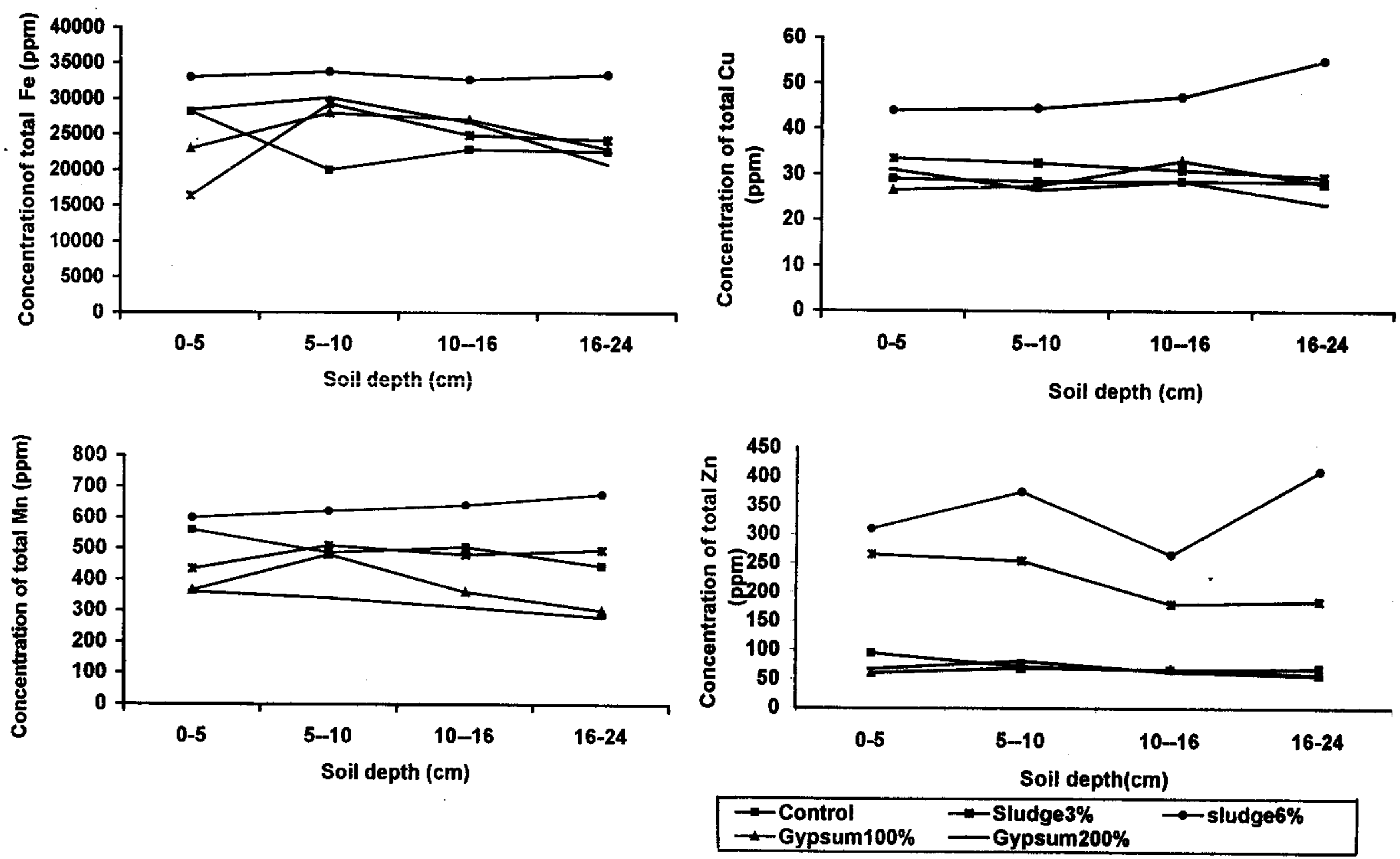

Fig (2-c)Depthwise distribution of total Fe, Mn , Cu and Zn (El-Kassasen soil)

Table (4) AB-DTPA-extractable contents (mgkg^{-1}) of the trace elements (Fe , Mn , Cu,and Zn) in the different segments of the leached and amended studied soils.

Soil	Depth cm	Control				Sludge at a rate of 3%				Sludge at a rate of 6%				Gypsum at a rate of 100 % (GR)				Gypsum at a rate of 200 % (GR)			
		Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn
Abo-Soltan	0-5	7.14	3.14	0.70	0.37	20.53	14.60	1.41	5.10	37.44	14.80	1.56	10.40	5.99	1.77	0.61	0.43	7.06	2.84	0.53	0.38
	5--10	6.44	2.93	0.64	0.34	19.26	23.65	1.27	4.20	31.21	25.85	1.45	16.50	6.33	1.49	0.54	0.35	6.85	1.77	0.60	0.37
	10--16	6.27	2.99	0.64	0.31	20.96	22.10	1.33	4.70	31.52	25.00	1.88	9.90	7.94	1.58	0.63	1.29	7.17	2.50	0.58	0.48
	16--24	6.77	3.00	0.74	0.37	19.03	19.65	1.20	4.80	27.08	24.85	1.70	7.10	5.66	1.28	0.54	0.43	7.15	2.76	0.61	0.46
El-Baalowa	0-5	22.27	3.85	0.73	0.60	35.24	5.03	1.26	4.30	48.25	5.50	1.95	6.50	18.46	1.94	0.58	0.59	21.31	3.00	0.62	0.63
	5--10	21.68	3.98	0.81	0.67	38.19	5.72	1.47	5.00	47.26	6.08	2.04	10.90	17.95	2.27	0.61	0.61	18.98	3.14	0.63	0.71
	10--16	22.34	4.25	0.81	0.67	36.52	5.24	1.34	4.00	46.81	5.58	1.63	11.20	16.15	2.73	0.60	0.64	18.80	3.06	0.63	0.68
	16--24	4.03	3.96	0.78	0.64	39.89	5.75	1.47	4.50	46.23	6.22	1.92	12.60	17.70	2.71	0.62	0.63	17.71	2.67	0.62	0.65
El - Kassasen	0-5	7.96	3.88	0.85	1.90	24.21	7.50	1.47	9.00	26.68	9.73	1.59	9.90	7.14	2.04	0.60	1.42	8.39	2.85	0.68	1.50
	5--10	7.59	3.29	0.87	1.30	22.55	5.14	1.46	8.10	25.04	6.75	1.49	8.40	7.02	2.02	0.66	1.45	6.93	3.25	0.68	1.46
	10--16	8.53	3.01	0.90	0.95	25.29	4.38	1.44	7.20	25.11	5.11	1.53	7.70	5.99	2.03	0.65	1.42	6.74	3.06	0.70	1.39
	16--24	7.62	2.65	0.86	0.98	21.25	4.95	1.06	6.00	25.66	5.72	1.44	6.90	5.70	1.87	0.63	1.41	7.10	2.90	0.67	1.41

(G.R.) gypsum requirement.

In El- Baalowa soil, total Fe content remained in the top soil layer was lower than those of the two successively below layers but was almost equal to that of deepest layer. The distribution of Fe within this soil is somewhat similar to that detected in Abo- Soltan soil.

Transport of Fe within the different depths of El-Kessasen soil seemed very limited . Total Fe was highest in the uppermost soil layer, lowest in the layer below and relatively highe in the deepest successive layers.

Considering AB-DTPA extractable Fe, it is noticed from Table (4) that what could be considered available Fe is highest, generally, in the surface layer and tended to decrease depthwise. This holds true for all the investigated soils and might be attributed to the relatively higher content of total Fe remained in the surface soil layers.

Total Mn in soil of Abo-Soltan followed a depthwise distribution different from that of El-Baalowa or El–Kassaseen soil. In all the investigated soils, Mn did not show a specific pattern. Likewise, AB-DTPA extractable Mn seemed not to portray a certain distribution pattern.

Total Cu contents of the investigated soils as well as the AB-DTPA extractable Cu were almost constant within the different depths of each soil.

Total Zn in Abo-Soltan soil tended to increase with depth whereas AB-.DTPA extractable Zn in the same soil was highest in both the surface and deepest layers and lower in the layers inbetween. In El-Baalowa soil, high accumulation of total Zn characterized the surface soil layer whereas the subsurface soil was characterized by the lowest total Zn content beyond which, it tended to increase with depth to achieve highest value at the deepest soil layer.

In El Kassasen soil, total Zn was highest in the surface few centimeters and decreased with depth. No wide variations could be detected between AB-DTPA extractable Zn contents of the different depths of the investigated soils. Also, no certain pattern characterized available Zn with soil depth.

Data presented in Table (3) and Figs 2 (a,b and c) reveal the effects of sludge on total available contents of the trace element within the different depths of the sludge amended soils. The response due to sludge application and continous leaching seemed dependent on rate of the applied sludge, content of the trace element in the applied sludge, properties of the traces element itself as well as properties of the soil under consideration.

Values of total Fe, Mn, Cu and Zn remainded in 3% sludge amendment soils were generally, lower than the corresponding ones of the continuous water leached soils. Such a result might be attributed to the effect of sludge on forming soluble organometallic complexes easily leachable by water,Also, increasing rate of the applied sludge to 6% resulted in reduction in soils contents of total (Fe, Mn, Cu and Zn), yet the cocentrations of the remained metals were relatively higher than the corresponding ones of the 3% sludge amended soil. This finding might be attributed to the chemical composition of the sludge itself which is considered a source of replenishing soil with these metals.

The depthwise distribution of the abovementioned heavy elements indicates, generally, that non of investigated elements portrayed a certain

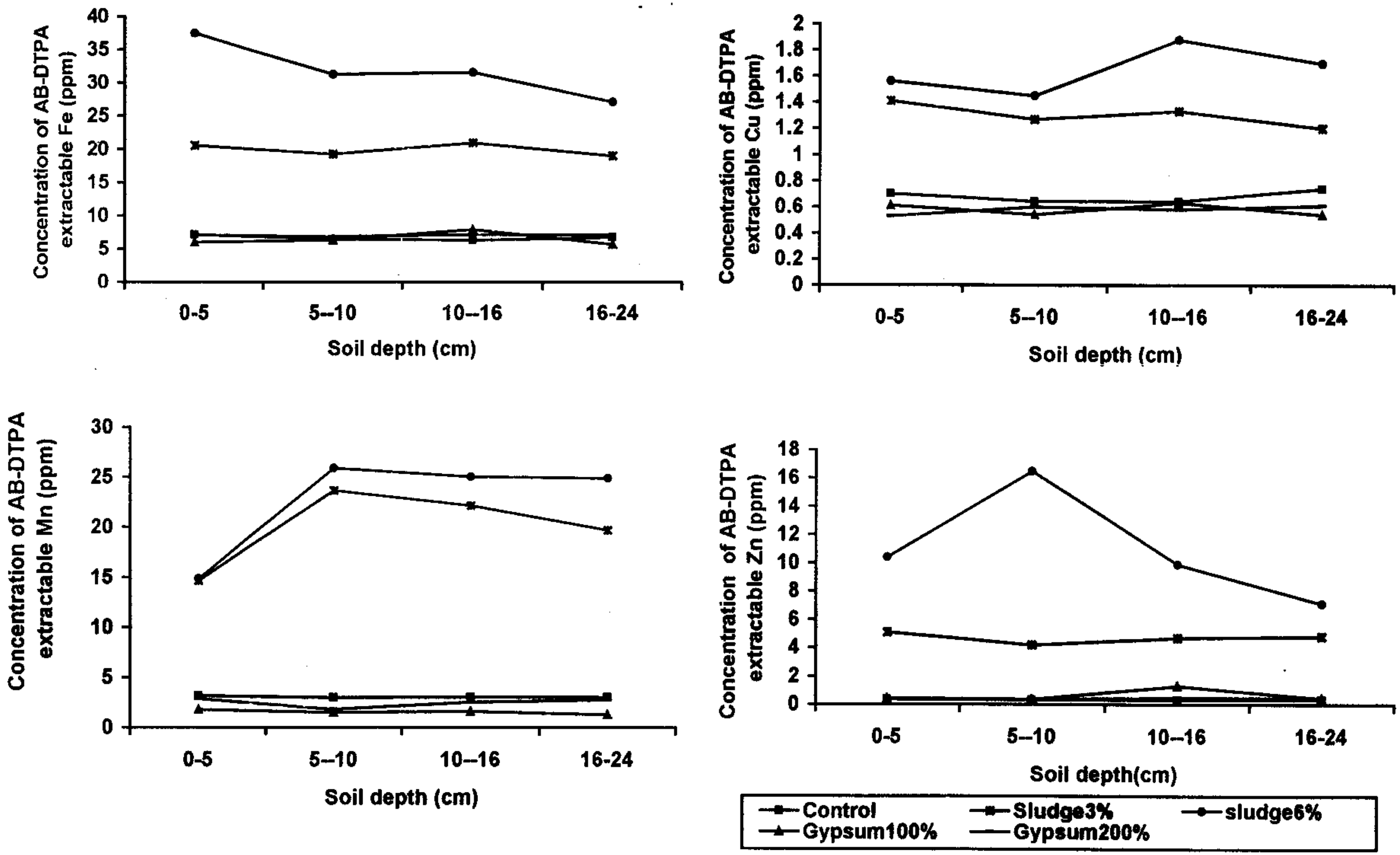

Fig (3-a) Depthwise distribution of AB-DTPA -extractable Fe, Mn , Cu and Zn (Abo-Soltan soil)

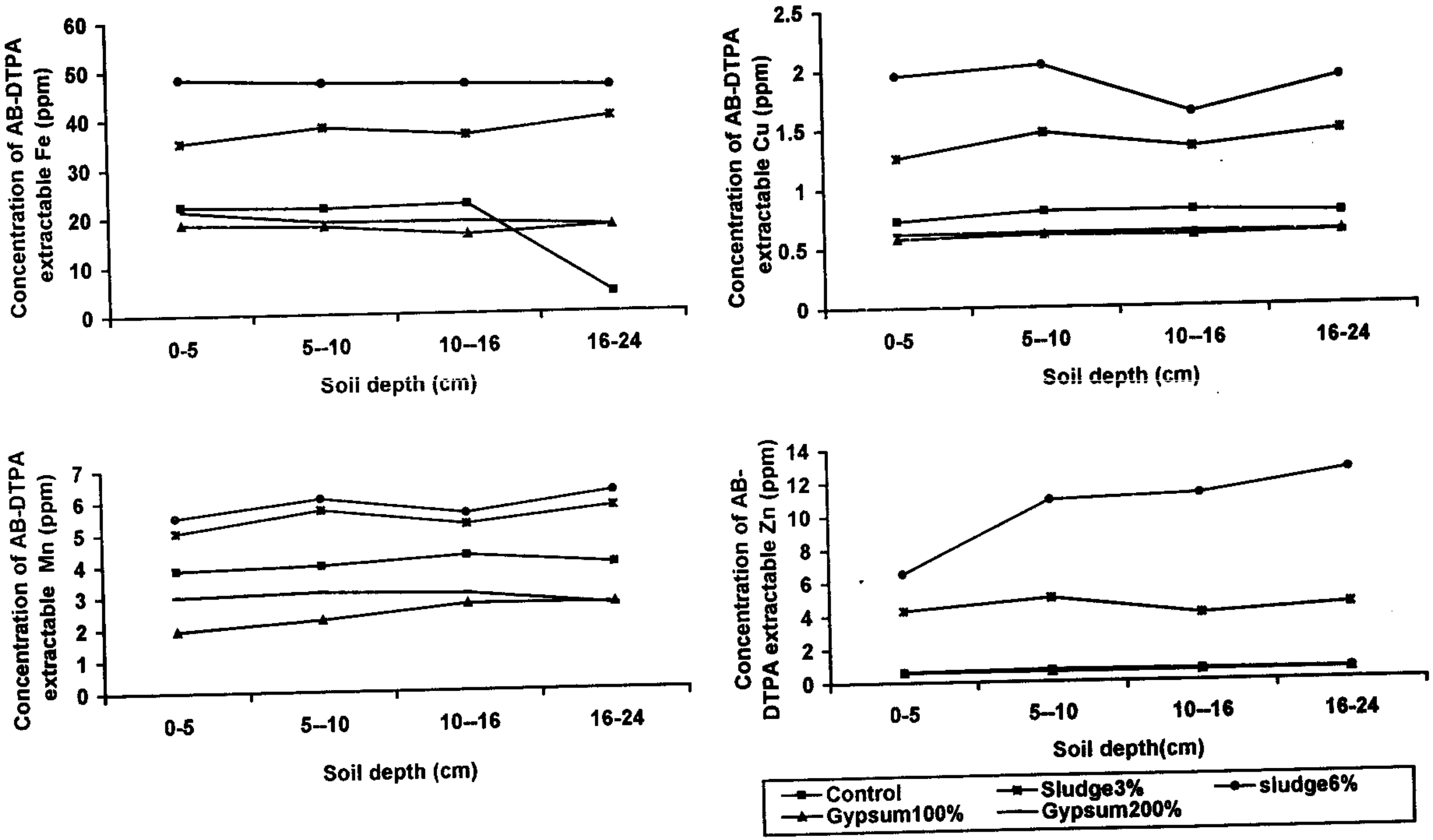

Fig (3-b)Depthwise distribution of AB-DTPA -extractable Fe, Mn , Cu and Zn (El-Baalowa soil)

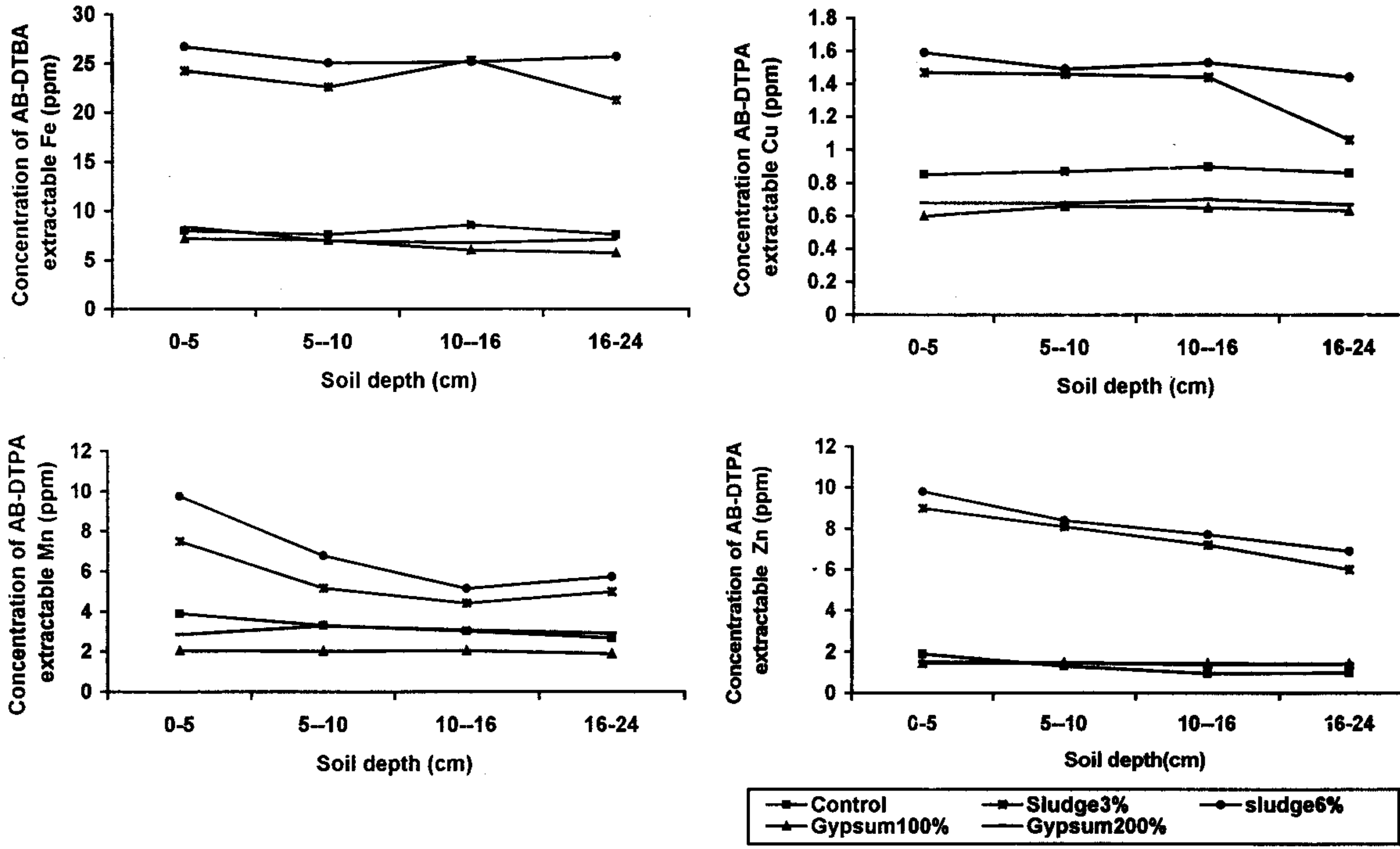

Fig (3-C) Depthwise distribution of AB-DTPA -extractable Fe, Mn , Cu and Zn (El-Kassasen soil) pattern of ditribution with depth. Likewise, depthwise distribution of the AB-DTPA extractable Fe, Mn, Cu and Zn was of no certain pattern . Rate of the applied sludge seemed to be of an obvious effect on increasing availability of the tested trace elements.

Pattern of both total and AB-DTPA extractable trace elements could be taken as an indication to the direction of transport of these elements. The water extractable elements' in the sequential leachate fractions may give an evidence to the transport of the trace elements downwards within soil columns and then out with the leachate.

Application of gypsum seemed to be of a marked effect on reducing the remained soils contents of total as well as AB-DTPA extractable trace elements. Application of gypsum might enhance leaching of trace elements , probably due to reducing soil pH through the effect of SO_4^{2-} ions which are added as accompanying anions of Ca^{2+}. Also, application of gypsum might decrease dispersion and consequently increased transport of water soluble trace elements out of the soil column . The application of the high rate of gypsum resulted in the displacement of Fe, Mn, Cu, and Zn from the exchange sites, thus resulted in an increased transport of these trace elements. This finding is evident by the more reduced values of both total and available Fe,Mn,Cu and Zn upon application of the higher rate of gypsum. Therefore, it was expected that transport of trace elements is much greater in the soils amended with the higher rate of the applied gypsum. In conclusion, application of gypsum improves soil physical and chemical properties, thus maximized the effect of gypsum on the transport of trace metals in the studied soils.

4.2. Leachability and transport of some cations and anions and trace elements

4.2.1 Within the unamended soils:

The leaching process takes place mainly by the displacement of soil solution by leaching water. Two processes occur namely, salt dissolution of slightly soluble salts which result in increase in some ions. This process supplies the soil solution with an additional amount of Ca^{2+} ions. The second process is the exchange of released Ca^{2+} with Na^{+} on the exchange complex. The solutes transport through soils is strongly affected by their reaction with soil constituents. Thus, in order to evaluate the relative effectiveness of soil amendments for improving and reclaiming the sodic soils, it was necessary to follow up the ions transport, within the different depths of the amended soils (as mentioned before) as well as the soluble ions especially the sodium one removed during the leaching process(**Abbas, 1985 and Balba, 1995**).

Data presented in Tables (5,6,7,8,9and 10) reveal that continuous leaching of the investigated soils resulted in removal of appreciable quantities of most of the soluble ions. This could be detected through the values of EC determined for each leachate fraction Transport of considerable amounts of soluble salts due to leaching and it was indicated by the recovery of these salts in leachate fractions.

The EC values of the first leachate of the unamended soils were 77, 24 and 75 dSm^{-1} in Abo-Soltan, ElBaalowa and El-Kassasen, respectively. These values decreased in the second leachate to 30,8 and 9.5dSm-1,

Table (5) Cations , anions, EC and pH of sequential extracts of soils treated with different materials (Abo-Soltan)

Soil	Tretment	Ext. No.	Macronutrients(meq/L) Cations Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Anions $CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	EC dSm^{-1}	pH	Extr. Tim. (min)
Abo-Soltan	Control	1	18.50	106.50	1304.20	2.18	-	2.60	1150	278.78	77.00	6.75	65
	Sludge 3%		22.50	59.00	1717.40	2.56	-	5.40	1100	696.06	90.00	5.90	57
	Sludge 6%		31.50	45.00	2173.90	4.46	-	5.80	1875	374.06	103.00	5.94	95
	Gyp.100%		17.50	112.50	1413.00	2.18	-	4.60	1275	265.58	75.00	6.79	42
	Gyp.200%		22.00	191.00	2043.50	4.38	-	11.00	2025	224.88	103.00	6.47	101
	Control	2	11.00	33.50	456.50	1.19	-	2.00	327	173.19	30.00	6.83	63
	Sludge 3%		10.00	15.00	230.40	0.79	-	4.40	79.00	172.79	16.50	6.82	57
	Sludge 6%		17.00	7.50	171.70	0.85	-	5.00	13.00	179.05	10.90	6.46	105
	Gyp.100%		10.00	40.00	510.80	1.22	-	4.00	320	238.02	33.00	6.79	51
	Gyp.200%		12.50	11.50	156.50	0.73	-	3.80	8.00	169.43	11.10	7.03	103
	Control	3	10.50	8.50	106.50	0.47	-	1.00	23.00	101.97	7.90	6.87	55
	Sludge 3%		9.00	3.50	65.50	0.37	-	1.40	4.00	72.97	6.00	6.69	55
	Sludge 6%		19.00	4.50	89.10	0.65	-	3.60	3.00	106.65	7.20	6.48	78
	Gyp.100%		8.00	5.50	72.20	0.36	-	1.40	8.00	76.66	6.40	6.87	54
	Gyp.200%		17.50	7.00	85.80	0.61	-	2.20	2.00	106.71	7.30	6.92	104
	Control	4	10.00	4.50	52.20	0.33	-	0.60	4.00	62.43	4.80	6.80	51
	Sludge 3%		9.50	3.50	48.70	0.35	-	1.20	2.00	58.85	4.60	6.90	58
	Sludge 6%		17.00	3.50	67.40	0.51	-	2.80	1.00	84.61	5.60	6.46	81
	Gyp.100%		7.50	4.00	46.90	0.31	-	1.00	3.00	54.71	4.40	6.85	50
	Gyp.200%		18.50	6.50	65.20	0.56	-	1.80	1.00	87.96	5.80	6.95	108
	Control	5	9.50	4.00	39.10	0.29	-	0.60	2.00	50.29	3.80	6.90	43
	Sludge 3%		10.00	3.00	41.30	0.33	-	1.20	1.00	52.43	4.10	6.76	55
	Sludge 6%		17.00	3.00	42.20	0.45	-	2.60	1.00	59.05	4.60	6.60	79
	Gyp.100%		8.50	5.00	43.30	0.29	-	1.00	2.00	54.09	3.90	6.90	56
	Gyp.200%		19.50	5.50	50.00	0.48	-	1.40	1.00	73.08	4.70	6.91	99
	Control	6	9.00	4.00	29.30	0.24	-	0.40	1.00	41.14	3.20	6.83	39
	Sludge 3%		10.50	2.00	32.80	0.31	-	1.20	1.00	43.41	3.60	6.80	53
	Sludge 6%		17.00	3.00	32.60	0.41	-	2.60	1.00	49.61	3.70	7.10	80
	Gyp.100%		9.50	4.50	33.50	0.29	-	1.00	1.00	45.79	3.60	6.95	57
	Gyp.200%		19.00	5.00	38.60	0.43	-	1.40	1.00	60.63	4.10	6.90	94

Table (5)Cont

Soil	Tretment	Ext. No.	Macronutrients(meq/L)								EC dSm^{-1}	pH	Extr. Tim. (min)
			Cations				Anions						
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$			
Abo-Soltan	Control	7	9.50	4.00	27.20	0.23	-	4.00	1.00	39.93	2.90	6.78	40
	Sludge 3%		10.50	2.50	29.50	0.29	-	1.20	1.00	40.59	3.25	6.73	51
	Sludge 6%		17.50	2.50	26.10	0.38	-	2.60	1.00	42.88	3.30	6.95	81
	Gyp.100%		10.00	4.00	32.20	0.28	-	0.80	1.00	44.68	3.40	6.85	57
	Gyp.200%		18.50	4.50	32.70	0.41	-	1.20	1.00	53.91	3.70	7.00	90
	Control	8	9.50	4.00	25.00	0.23	-	0.20	-	38.53	2.85	6.44	40
	Sludge 3%		10.00	3.00	26.50	0.28	-	1.20	-	38.58	3.00	6.75	48
	Sludge 6%		17.50	2.50	23.50	0.37	-	2.40	-	41.47	3.10	6.86	82
	Gyp.100%		10.50	4.50	27.60	0.27	-	0.80	-	42.32	3.10	6.85	60
	Gyp.200%		18.50	5.00	27.20	0.37	-	1.00	-	50.07	3.30	6.91	89
	Control	9	9.50	4.00	25.00	0.23	-	0.20	-	38.53	2.80	6.40	40
	Sludge 3%		10.50	3.50	24.10	0.27	-	1.20	-	37.17	2.90	6.94	49
	Sludge 6%		17.50	2.50	20.40	0.36	-	2.40	-	38.38	2.80	7.00	84
	Gyp.100%		10.00	4.00	27.00	0.27	-	0.80	-	40.47	3.00	6.80	66
	Gyp.200%		19.00	4.50	24.50	0.36	-	1.00	-	47.35	3.10	6.87	89
	Control	10	9.50	4.00	25.00	0.23	-	0.20	-	38.53	2.75	6.50	45
	Sludge 3%		11.00	3.50	23.00	0.27	-	1.20	-	36.57	2.70	6.90	51
	Sludge 6%		16.50	2.50	20.10	0.35	-	2.40	-	37.05	2.70	7.43	87
	Gyp.100%		10.00	4.00	27.00	0.27	-	0.80	-	40.47	3.00	6.50	71
	Gyp.200%		18.50	5.00	21.20	0.35	-	1.00	-	44.05	2.80	6.84	89
	Control	11	9.50	4.00	25.00	0.23	-	0.20	-	38.53	2.70	6.20	47
	Sludge 3%		11.00	3.50	23.00	0.27		1.20	-	36.57	2.60	6.82	53
	Sludge 6%		16.50	2.50	20.00	0.35	-	2.40	-	36.95	2.60	7.40	74
	Gyp.100%		10.00	4.00	27.00	0.27	-	0.80	-	40.47	3.00	6.50	72
	Gyp.200%		18.00	5.50	19.50	0.35	-	1.00	-	42.35	2.70	6.80	92

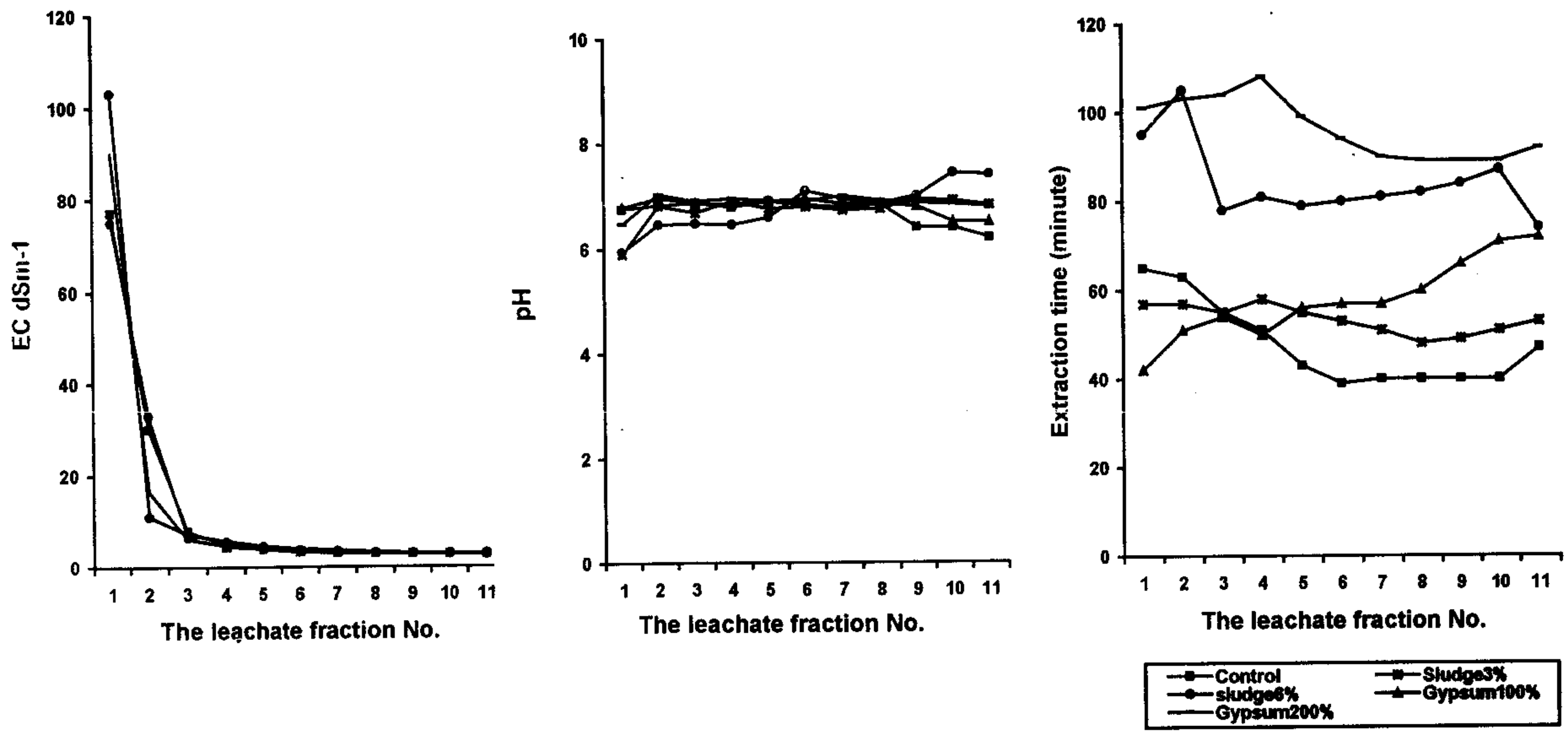

Fig (1) EC,pH and extraction time of the leachate fractions of Abo-Soltan

Table (6) Trace elements contents ($mgkg^{-1}$) of sequential extracts of soil treated with different materials (Abo-Soltan)

Soil	Tretment	Extract No.	Micronutrient ($mgkg^{-1}$)			
			Fe	Mn	Cu	Zn
Abo-Soltan	Control	1	0.194	0.066	0.060	0.078
	Sludge 3%		0.064	0.082	0.078	0.230
	Sludge 6%		0.230	0.128	0.124	0.198
	Gyp.100%		0.100	0.050	0.030	0.064
	Gyp.200%		0.560	0.022	0.110	0.066
	Control	2	0.100	0.010	0.028	0.154
	Sludge 3%		0.314	0.030	0.126	0.308
	Sludge 6%		0.720	0.052	0.162	0.224
	Gyp.100%		0.072	0.036	0.060	0.074
	Gyp.200%		0.170	0.076	0.040	0.242
	Control	3	0.152	0.010	0.044	0.094
	Sludge 3%		0.364	0.014	0.064	0.032
	Sludge 6%		0.150	0.014	0.056	0.092
	Gyp.100%		0.094	0.070	0.030	0.130
	Gyp.200%		0.250	0.072	0.010	0.276
	Control	4	0.092	0.002	0.036	0.046
	Sludge 3%		0.244	0.004	0.026	0.178
	Sludge 6%		0.094	0.004	0.200	0.054
	Gyp.100%		0.042	0.032	0.022	0.134
	Gyp.200%		0.780	0.032	0.034	0.172
	Control	5	0.042	0.002	0.010	0.022
	Sludge 3%		0.142	0.004	0.014	0.102
	Sludge 6%		0.042	0.002	0.008	0.002
	Gyp.100%		0.022	0.020	0.006	0.042
	Gyp.200%		0.003	0.016	0.018	0.880

Table (7) Cations , anions, EC and pH of sequential extracts of soils treated with different materials (El-Baalowa)

Soil	Tretment	Ext. No.	Macronutrients(meq/L)								EC dSm^{-1}	pH	Extr. Tim. (min)
			Cations				Anions						
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$			
El Baalowa	Control	1	19.00	59.00	308.70	1.59	-	6.60	125	256.69	24.00	7.29	60
	Sludge 3%		21.50	46.50	269.50	1.63	-	6.20	150	182.93	20.50	6.37	42
	Sludge 6%		23.00	53.00	315.20	1.79	-	9.00	175	208.99	24.00	6.52	49
	Gyp.100%		18.50	59.00	282.60	1.54	-	12.20	150	199.44	22.00	7.04	36
	Gyp.200%		18.50	56.50	244.50	1.46	-	14.60	125	181.36	20.00	7.14	47
	Control	2	14.50	17.50	106.50	0.82	-	2.40	9.00	127.92	8.00	6.95	57
	Sludge 3%		14.50	13.00	100.00	0.59	-	4.00	11.00	113.09	9.50	6.95	37
	Sludge 6%		16.50	17.50	102.20	0.64	-	7.40	13.00	116.09	9.50	7.46	46
	Gyp.100%		17.00	24.00	99.40	0.95	-	5.60	15.00	120.75	9.00	7.20	33
	Gyp.200%		13.00	25.00	89.10	0.87	-	3.80	9.00	115.07	8.00	7.16	49
	Control	3	13.50	12.00	56.20	0.69	-	1.80	3.00	77.59	6.00	7.08	58
	Sludge 3%		13.50	10.00	52.20	0.48	-	3.40	4.00	68.78	6.00	7.25	38
	Sludge 6%		16.00	10.50	61.90	0.58	-	4.20	4.00	80.78	7.00	6.80	45
	Gyp.100%		16.50	17.00	65.20	0.77	-	2.80	4.00	92.67	6.50	6.61	32
	Gyp.200%		16.00	19.00	65.20	0.77	-	3.40	4.00	93.57	7.00	6.91	48
	Control	4	13.00	9.50	35.30	0.64	-	1.60	1.00	55.84	4.10	7.19	57
	Sludge 3%		13.00	9.50	39.80	0.47	-	3.40	3.00	56.37	5.00	7.09	36
	Sludge 6%		17.00	12.00	39.30	0.82	-	3.60	2.00	63.52	5.00	7.12	45
	Gyp.100%		17.00	11.50	39.70	0.72	-	2.00	1.00	65.92	5.00	6.58	31
	Gyp.200%		15.00	12.00	45.60	0.72	-	2.20	3.00	68.12	5.50	7.08	49
	Control	5	12.00	8.50	26.10	0.57	-	1.40	1.00	44.77	3.10	6.81	59
	Sludge 3%		10.00	4.00	20.00	0.31	-	1.60	1.00	31.71	4.00	6.97	36
	Sludge 6%		16.00	8.50	26.10	0.73	-	3.20	2.00	46.13	2.50	6.66	43
	Gyp.100%		17.00	11.50	27.80	0.64	-	1.80	1.00	44.14	4.10	6.90	35
	Gyp.200%		19.00	10.50	30.00	0.66	-	2.20	1.00	56.96	4.10	6.83	48
	Control	6	10.00	8.00	21.90	0.48	-	1.40	1.00	37.98	2.40	7.18	59
	Sludge 3%		11.00	8.00	18.30	0.57	-	2.20	1.00	34.67	3.10	6.52	37
	Sludge 6%		16.00	8.50	17.70	0.69	-	3.00	2.00	37.89	2.90	6.64	44
	Gyp.100%		18.00	10.00	22.20	0.61	-	1.80	1.00	48.01	3.60	6.55	33
	Gyp.200%		19.50	10.50	23.50	0.63	-	2.00	1.00	51.13	3.50	6.52	49

Table (7) Cont

Soil	Tretment	Ext. No.	Macronutrients(meq/L)								EC dSm^{-1}	pH	Extr. Tim. (min)
			Cations				Anions						
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$			
El-Baalowa	Control	7	10.00	6.00	10.10	0.45	-	1.40	1.00	24.15	1.80	6.90	61
	Sludge 3%		11.00	6.50	13.30	0.51	-	2.00	1.00	28.31	2.20	6.55	33
	Sludge 6%		15.50	8.00	12.00	0.64	-	3.00	2.00	31.14	2.40	7.39	41
	Gyp.100%		18.50	10.00	15.70	0.59	-	1.40	1.00	42.39	2.80	6.55	34
	Gyp.200%		20.00	9.50	18.30	0.61	-	1.80	1.00	45.61	3.20	6.55	47
	Control	8	9.00	6.00	4.70	0.41	-	1.40	1.00	17.71	1.30	7.22	70
	Sludge 3%		10.00	5.00	8.90	0.47	-	2.00	1.00	21.37	1.80	6.45	35
	Sludge 6%		16.50	7.50	7.80	0.58	-	3.00	1.00	28.38	2.00	7.04	40
	Gyp.100%		19.00	10.00	11.50	0.56	-	1.40	1.00	38.66	2.40	6.74	36
	Gyp.200%		20.00	9.00	13.70	0.57	-	1.60	1.00	40.67	2.80	6.53	45
	Control	9	7.50	6.00	2.40	0.36	-	1.20	-	15.06	1.00	7.31	74
	Sludge 3%		9.50	5.00	5.80	0.45	-	1.80	-	18.95	1.50	6.71	33
	Sludge 6%		13.50	6.50	4.90	0.56	-	2.60	-	22.86	1.60	6.93	40
	Gyp.100%		20.00	8.50	7.50	0.54	-	1.20	-	35.34	2.30	6.89	37
	Gyp.200%		20.00	8.00	10.20	0.56	-	1.40	-	37.36	2.50	6.58	47
	Control	10	7.00	5.50	1.00	0.33	-	1.20	-	12.63	0.80	7.30	76
	Sludge 3%		9.00	4.50	4.60	0.42	-	1.80	-	16.72	1.30	6.65	34
	Sludge 6%		12.50	5.50	3.40	0.51	-	2.00	-	19.91	1.40	6.97	42
	Gyp.100%		19.50	8.50	4.70	0.51	-	1.20	-	32.01	1.90	6.62	40
	Gyp.200%		20.50	8.00	6.50	0.54	-	1.40	-	34.14	2.20	6.77	45
	Control	11	6.00	4.00	0.80	0.31	-	1.20	-	9.91	0.60	6.23	83
	Sludge 3%		8.00	4.50	3.50	0.35	-	1.80	-	14.61	1.10	6.70	33
	Sludge 6%		10.00	2.50	3.65	0.48	-	1.40	-	15.23	1.20	7.17	74
	Gyp.100%		20.00	8.50	3.30	0.48	-	1.20	-	31.08	1.80	6.54	36
	Gyp.200%		20.50	8.00	4.20	0.48	-	1.20	-	31.93	1.90	7.04	45
	Control	12	5.00	4.00	0.80	0.31	-	1.20	-	8.91	0.60	6.20	75
	Sludge 3%		7.50	5.00	2.60	0.32	-	1.80	-	13.62	1.00	6.61	51
	Sludge 6%		10.00	2.50	3.20	0.48	-	1.40	-	14.78	1.20	6.90	40
	Gyp.100%		19.00	8.50	3.10	0.48	-	1.20	-	29.88	1.80	6.50	36
	Gyp.200%		20.00	7.50	2.40	0.46	-	1.20	-	29.16	1.80	6.82	46

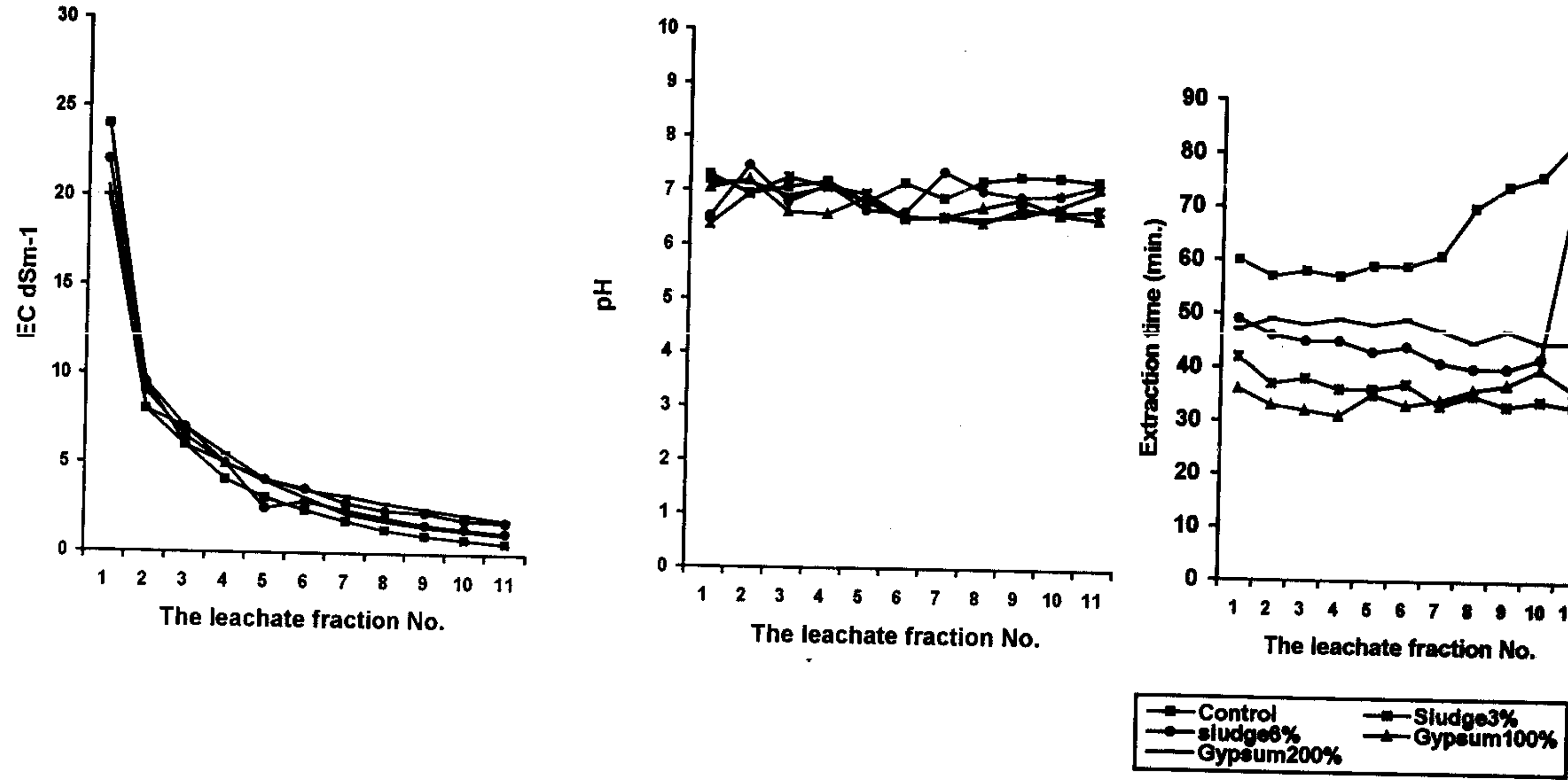

Fig (2) EC,pH and extraction time of the leachate fractions of El-Baalowa

Table (8) Trace elements contents (mgkg^{-1}) of sequential extracts of soil treated with different materials (El-Baalowa)

Soil	Tretment	Extract No.	Micronutrient (mgkg^{-1})			
			Fe	Mn	Cu	Zn
El-Baalowa	Control	1	0.204	0.066	0.096	0.106
	Sludge 3%		0.140	0.128	0.124	0.326
	Sludge 6%		0.910	0.312	0.230	0.242
	Gyp.100%		0.088	0.066	0.094	0.310
	Gyp.200%		0.078	0.104	0.084	0.128
	Control	2	0.202	0.010	0.038	0.248
	Sludge 3%		0.270	0.086	0.072	0.224
	Sludge 6%		0.280	0.044	0.106	0.102
	Gyp.100%		0.058	0.030	0.048	0.144
	Gyp.200%		0.092	0.144	0.070	0.176
	Control	3	0.190	0.044	0.048	0.134
	Sludge 3%		0.364	0.056	0.040	0.190
	Sludge 6%		0.242	0.086	0.084	0.168
	Gyp.100%		0.076	0.056	0.036	0.158
	Gyp.200%		0.088	0.100	0.030	0.146
	Control	4	0.180	0.020	0.030	0.084
	Sludge 3%		0.222	0.024	0.018	0.112
	Sludge 6%		0.194	0.026	0.042	0.082
	Gyp.100%		0.020	0.026	0.020	0.082
	Gyp.200%		0.024	0.042	0.020	0.066
	Control	5	0.060	0.006	0.018	0.026
	Sludge 3%		0.062	0.012	0.006	0.042
	Sludge 6%		0.086	0.018	0.024	0.052
	Gyp.100%		0.016	0.012	0.008	0.026
	Gyp.200%		0.016	0.020	0.004	0.024

Table (9) Cations , anions, EC and pH of sequential extracts of soils treated with different materials (El-Kassasen)

Soil	Tretment	Ext No	Macronutrients(meq/L)								EC dSm^{-1}	pH	Extr. Tim. (min)
			Cations				Anions						
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$			
El-Kassasen	Control	1	187	190.00	1021.70	1.77	-	3.60	1275	121.87	75.00	5.44	341
	Sludge 3%		190	60.00	1076.10	1.87	-	7.00	1225	95.97	74.00	5.65	228
	Sludge 6%		176	24.00	1432.24	1.77	-	7.60	1375	251.41	68.00	5.82	167
	Gyp.100%		166	129.00	1063.03	1.68	-	3.60	1275	81.11	66.00	6.05	188
	Gyp.200%		172	193.00	913.00	1.77	-	4.80	1200	74.97	70.00	5.82	287
	Control	2	17.50	13.00	147.80	0.57	-	2.60	3.00	173.27	9.50	7.61	314
	Sludge 3%		18.00	12.00	132.60	0.61	-	6.40	7.00	149.81	9.20	6.81	190
	Sludge 6%		19.00	10.00	117.40	0.84	-	7.00	17.00	123.24	9.00	7.66	153
	Gyp.100%		16.00	11.00	117.40	0.54	-	2.60	5.00	137.34	9.00	7.23	204
	Gyp.200%		16.50	12.50	102.20	0.58	-	3.80	4.00	123.98	10.00	7.16	281
	Control	3	15.50	11.00	115.20	0.46	-	2.20	1.00	138.96	8.00	7.29	259
	Sludge 3%		16.50	9.00	88.30	0.54	-	4.60	1.00	108.74	6.50	6.91	173
	Sludge 6%		24.00	10.00	85.80	0.61	-	6.40	8.00	106.01	6.50	6.62	141
	Gyp.100%		15.00	9.00	80.30	0.46	-	2.20	1.00	101.56	6.00	7.15	196
	Gyp.200%		15.00	8.50	92.40	0.47	-	2.80	1.00	111.57	7.50	7.34	234
	Control	4	16.00	8.00	73.90	0.43	-	1.80	1.00	95.53	6.10	7.40	259
	Sludge 3%		17.00	7.00	54.30	0.46	-	3.60	1.00	74.16	5.30	7.30	157
	Sludge 6%		19.50	8.00	59.30	0.54	-	5.60	2.00	79.74	5.00	6.81	148
	Gyp.100%		13.50	7.00	54.00	0.38	-	1.80	1.00	72.03	4.90	7.35	144
	Gyp.200%		17.50	8.50	70.60	0.45	-	2.20	1.00	93.85	6.60	7.21	227
	Control	5	15.50	8.00	47.80	0.41	-	1.60	1.00	69.11	5.00	7.17	239
	Sludge 3%		18.50	6.00	41.80	0.45	-	3.20	1.00	62.55	4.04	7.05	157
	Sludge 6%		19.00	7.00	46.90	0.46	-	4.60	1.00	67.76	4.40	6.82	136
	Gyp.100%		13.50	7.00	32.80	0.33	-	1.40	1.00	51.23	3.70	7.12	122
	Gyp.200%		18.50	8.00	47.80	0.43	-	1.80	1.00	71.93	4.50	7.18	216
	Control	6	18.00	6.50	30.00	0.38	-	1.40	-	53.48	3.70	7.16	228
	Sludge 3%		18.50	6.00	32.80	0.43	-	3.00	-	54.73	3.70	7.00	147
	Sludge 6%		19.00	7.00	33.50	0.45	-	4.00	-	55.95	3.90	6.94	133
	Gyp.100%		15.50	5.00	28.70	0.33	-	1.40	-	48.13	3.40	7.07	129
	Gyp.200%		20.00	7.50	30.80	0.41	-	1.80	-	56.91	4.00	7.07	211

Table (9) Cont.

Soil	Tretment	Ext No	Macronutrients(meq/L)								EC dSm^{-1}	pH	Extr. Tim. (min)
			Cations				Anions						
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$			
El-Kassasen	Control	7	19.00	7.00	22.20	0.37	-	1.40	-	47.17	2.80	7.17	218
	Sludge 3%		8.00	5.50	26.10	0.41	-	2.60	-	47.41	3.20	7.21	140
	Sludge 6%		18.50	7.00	27.80	0.43	-	3.80	-	49.93	3.50	6.98	126
	Gyp.100%		17.00	5.50	27..8	0.33	-	1.40	-	49.23	3.40	7.26	140
	Gyp.200%		21.00	8.50	22.20	0.41	-	1.60	-	50.51	2.30	7.15	205
	Control	8	19.50	5.50	13.00	0.36	-	1.20	-	37.16	2.30	7.05	222
	Sludge 3%		18.00	5.50	21.40	0.38	-	2.60	-	42.68	2.70	7.22	135
	Sludge 6%		18.50	6.00	23.60	0.42	-	3.40	-	45.12	3.00	6.90	120
	Gyp.100%		17.00	5.00	20.50	0.31	-	1.40	-	41.41	2.80	7.03	150
	Gyp.200%		22.00	8.00	15.90	0.41	-	1.60	-	44.71	2.70	7.12	196
	Control	9	19.00	6.00	6.40	0.33	-	1.20	-	30.53	1.90	7.13	230
	Sludge 3%		17.50	5.00	16.90	0.37	-	2.40	-	37.37	2.50	6.91	132
	Sludge 6%		17.50	5.50	18.80	0.42	-	3.20	-	39.02	2.60	6.97	118
	Gyp.100%		17.00	5.00	15.30	0.29	-	1.40	-	36.19	2.20	7.03	170
	Gyp.200%		22.50	9.00	9.90	0.37	-	1.60	-	40.17	2.30	7.02	213
	Control	10	19.00	6.00	4.00	0.33	-	1.20	-	28.13	1.70	7.05	241
	Sludge 3%		18.00	4.50	13.50	0.36	-	2.40	-	33.95	2.20	6.97	131
	Sludge 6%		18.00	4.00	15.90	0.37	-	3.00	-	35.27	2.30	6.94	116
	Gyp.100%		17.50	5.00	11.20	0.29	-	1.20	-	32.79	2.20	7.00	186
	Gyp.200%		22.50	9.50	6.50	0.33	-	1.40	-	37.46	2.10	7.05	220
	Control	11	19.00	5.00	3.00	0.30	-	1.20	-	26.10	1.70	7.05	245
	Sludge 3%		18.00	3.50	2.80	0.35	-	2.20	-	22.45	2.10	7.07	138
	Sludge 6%		17.00	4.00	12.10	0.36	-	2.80	-	30.66	2.15	6.95	111
	Gyp.100%		17.00	4.50	9.10	0.27	-	1.20	-	29.67	2.10	7.00	198
	Gyp.200%		23.50	8.50	3.90	0.35	-	1.40	-	34.85	2.00	7.07	239

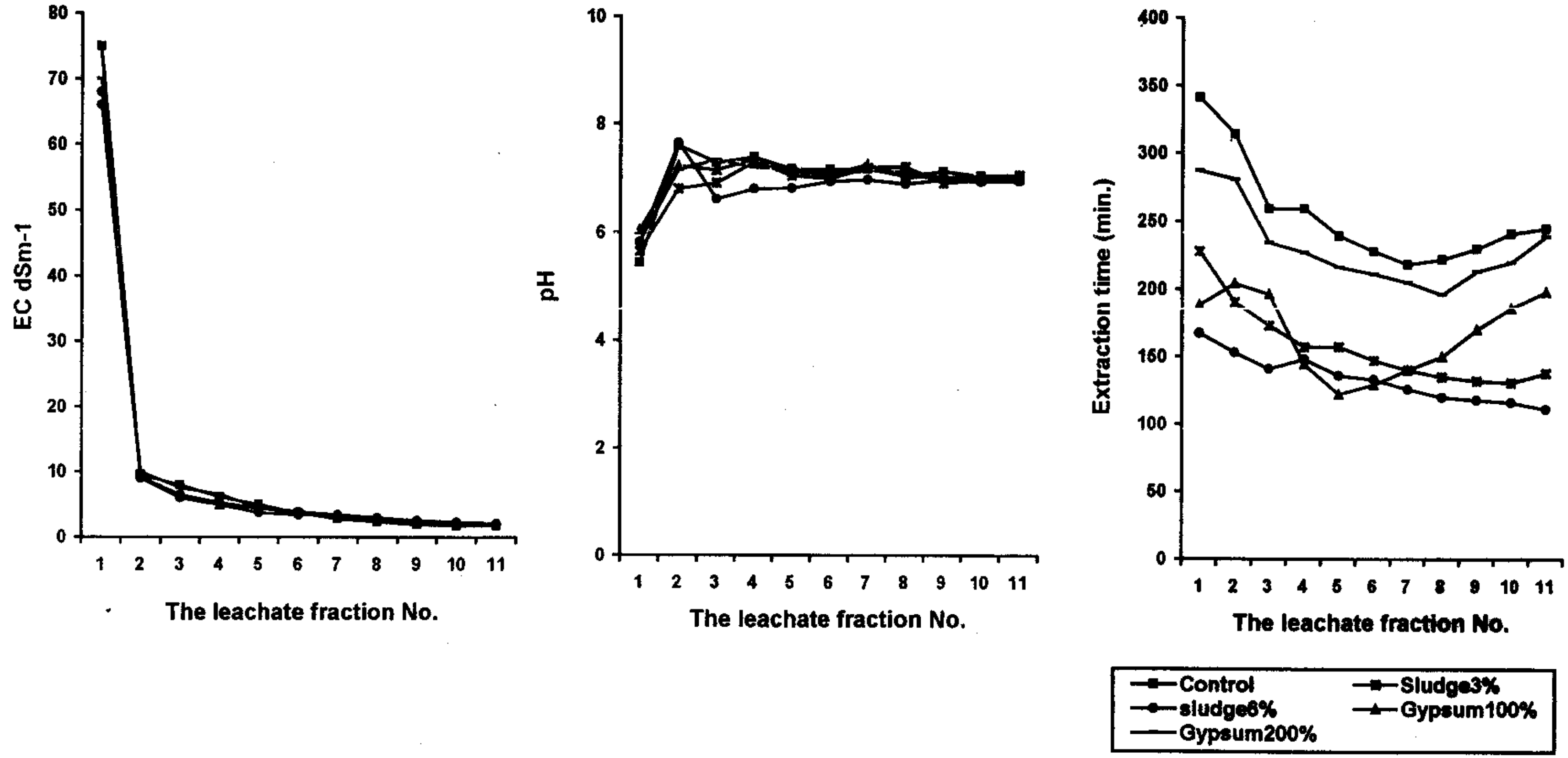

Fig (3) EC,pH and extraction time of the leachate fractions of El-Kassasen

Table (10) Trace elements contents (mgkg^{-1}) of sequential extracts of soil treated with different materials (El-Kassasen)

Soil	Tretment	Extract No.	Micronutrient (mgkg^{-1})			
			Fe	Mn	Cu	Zn
El-Kassasen	Control	1	0.218	0.354	0.116	0.118
	Sludge 3%		0.230	0.558	0.170	0.312
	Sludge 6%		0.244	0.412	0.176	0.210
	Gyp.100%		0.068	0.418	0.074	0.116
	Gyp.200%		0.132	0.560	0.074	0.074
	Control	2	0.204	0.010	0.044	0.076
	Sludge 3%		0.204	0.074	0.168	0.222
	Sludge 6%		0.310	0.038	0.100	0.096
	Gyp.100%		0.058	0.276	0.060	0.212
	Gyp.200%		0.058	0.044	0.052	0.074
	Control	3	0.092	0.012	0.042	0.028
	Sludge 3%		0.194	0.028	0.092	0.184
	Sludge 6%		0.136	0.084	0.058	0.100
	Gyp.100%		0.062	0.020	0.028	0.134
	Gyp.200%		0.062	0.022	0.022	0.076
	Control	4	0.076	0.004	0.024	0.012
	Sludge 3%		0.100	0.016	0.052	0.102
	Sludge 6%		0.112	0.034	0.028	0.058
	Gyp.100%		0.026	0.014	0.018	0.082
	Gyp.200%		0.044	0.018	0.010	0.026
	Control	5	0.054	0.002	0.010	0.004
	Sludge 3%		0.024	0.006	0.020	0.024
	Sludge 6%		0.062	0.014	0.016	0.034
	Gyp.100%		0.008	0.006	0.004	0.038
	Gyp.200%		0.016	0.010	0.002	0.018

respectively. Such results illustrate a sharp decrease in the EC values of the second leachate fraction of all the unamended soils.

Also, the time required to receive this leachate fraction seemed to be obviously decreased. Continuous leaching of the unamended soils decreased the EC values to 6.2 , 0.5 and 1.70 dSm-1 in eleventh, twelveth and eleventh leachate fractions of Abo-Soltan, El-Baalowa and El-Kassasen soils, respectively. This means that although leaching was enough to reduce salinity of El-Baalowa and El-Kassasen soils, yet it was not so in Abo-Soltan one. This indicates to the necessety of presence of soil amendment to facilitate the leaching of salts out of Abo-Soltan soil columns. The chromatography theory is used to demonstrate the salt movement in the soil when water is applied. The water fills the soil pores, forming a thin layer on the soil particles surfaces. Increasing the water rather than the volume of pores, the water moves downward carrying the dissolved salts from the upper layer to a lower one. A gain the pores of this layer are filled and water moves to a lower layer, and so on , until the end of the soil column where it infiltrates with its load of salts **(Gardner and Broks, 1957).**

Data in Tables (5,7 and 9) reveal that the pH values of the different leachate fractions of the unamended soils fluctuated slightly about neutrality in most cases. The number of extractions seemed to be of no effect on pH values whereas a very slight effect could be detected due to differentiations in soil characteristics. The lower values of the different leachate fractions is probably due to presence of the soluble cations in the SO_4^{2-} form rather than the HCO_3^- one, The presence of Cl^- in the highest concentration among the soluble anions accounts also for the neutral pH values.

Regarding values of the leached Ca^{2+}, data in the same above mentioned Tables reveal that Ca^{2+} concentration was highest in the first leachate fraction of all the studied soils and tended to decrease to almost constant values in the fifth leachate fraction regardless of the soil type. Magnesium followed a trend similar, to a great extant, to that of Ca^{2+},i.e its concentration decreased, generally, by increasing number of the leachate fraction. Values of Mg^{2+} tended , however, to be constant in the fourth, fifth and sixth leachate fractions of Abo-Soltan, El-Baalowa and El-Kassasen soils, respectively.

Likewise, Na^+ and K^+ concentrations were highest in the first leachate fraction then tended to decrease with number of extractions to achieve almost constant values in the seventh or eleventh leachate fraction, respectively.

The hydrolysis of Na-clay in water results in replacement of adsorbed Na^+ by another cation in the solution, especially divalent cations. If divalent cations were not present, mostly hydrogen ions would be retained in place of Na^+ **(Wiklander,1965)**

Several investigators **(Oster and Halverson, 1978)** consider that excessive exchangeable Na^+, as the case herein, in saline sodic soils is sufficiently reduced during leaching and that no special reclamation procedures are required.

The soluble anions seemed, generally, highest in the first leachate fraction and tended to decrease with increasing number of leachate fractions. This was true for $HCO3^-$, Cl^- and SO_4^{2-}. However, the extent to which the anion concentrations in the leachate fractions was reduced differed

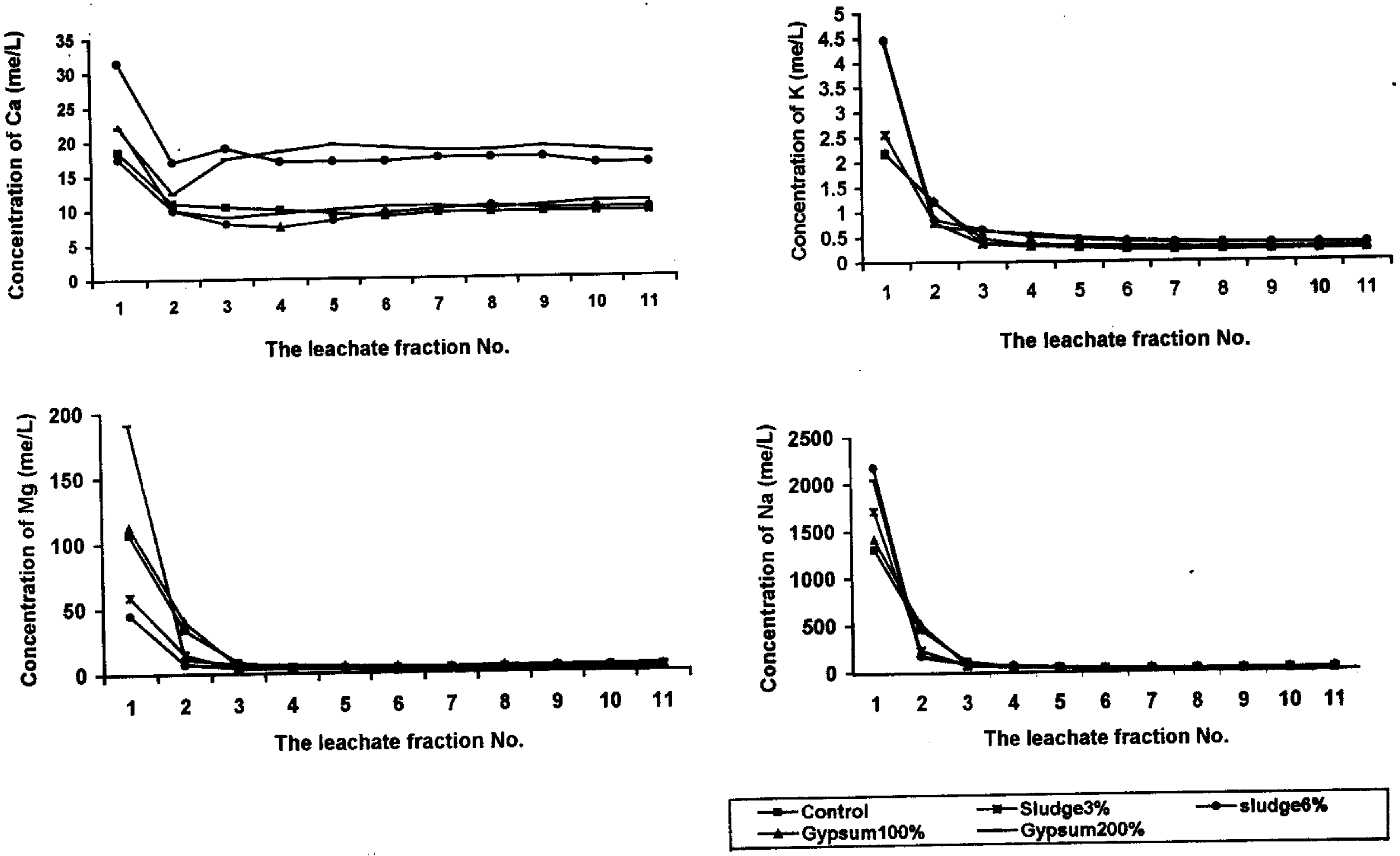

Fig (4) Concentrations of Ca, Mg, Na and K in the leachate fractions of Abo-Soltan

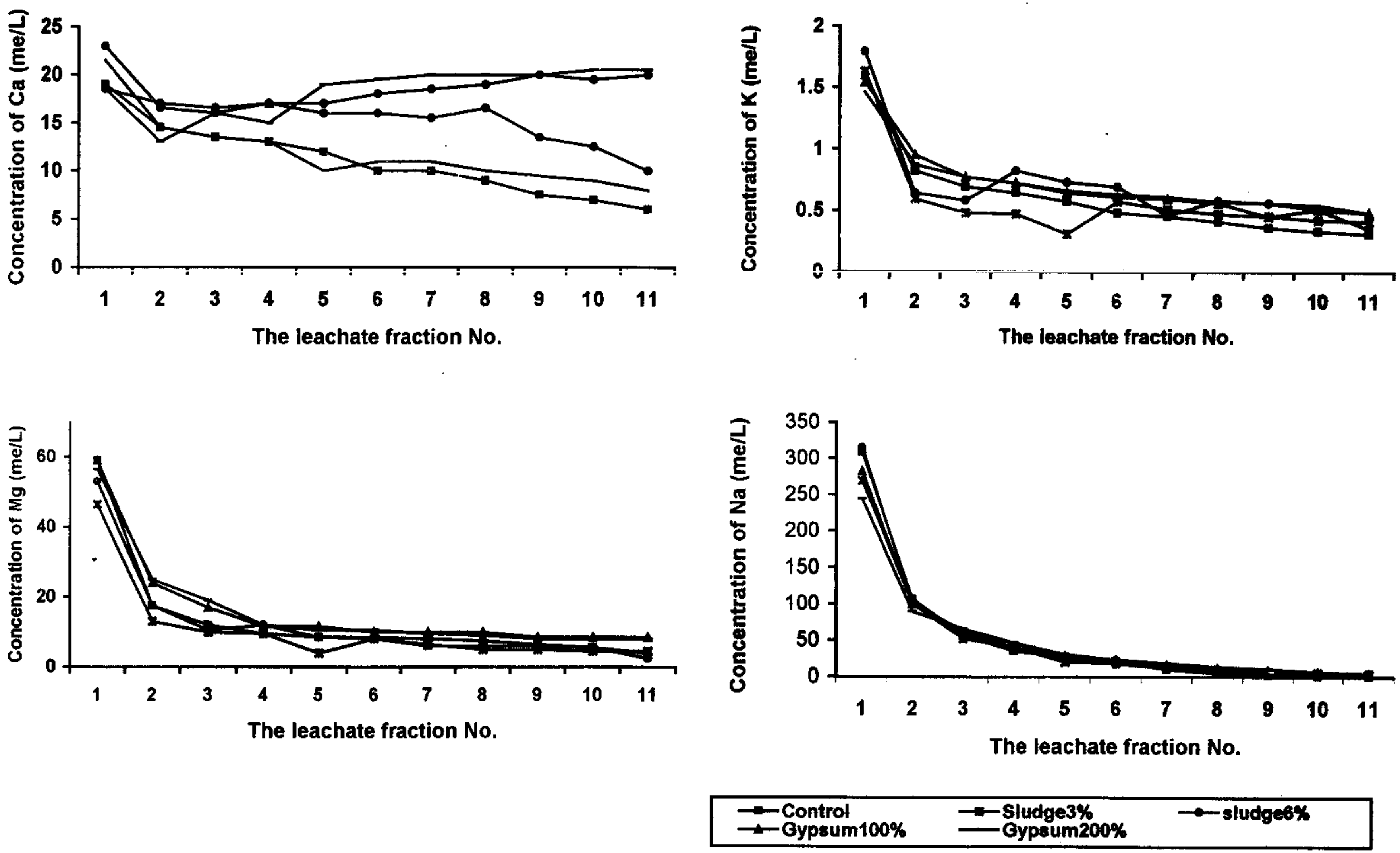

Fig (5) Concentrations of Ca, Mg, Na and K in the leachate fractions of El-Baalowa

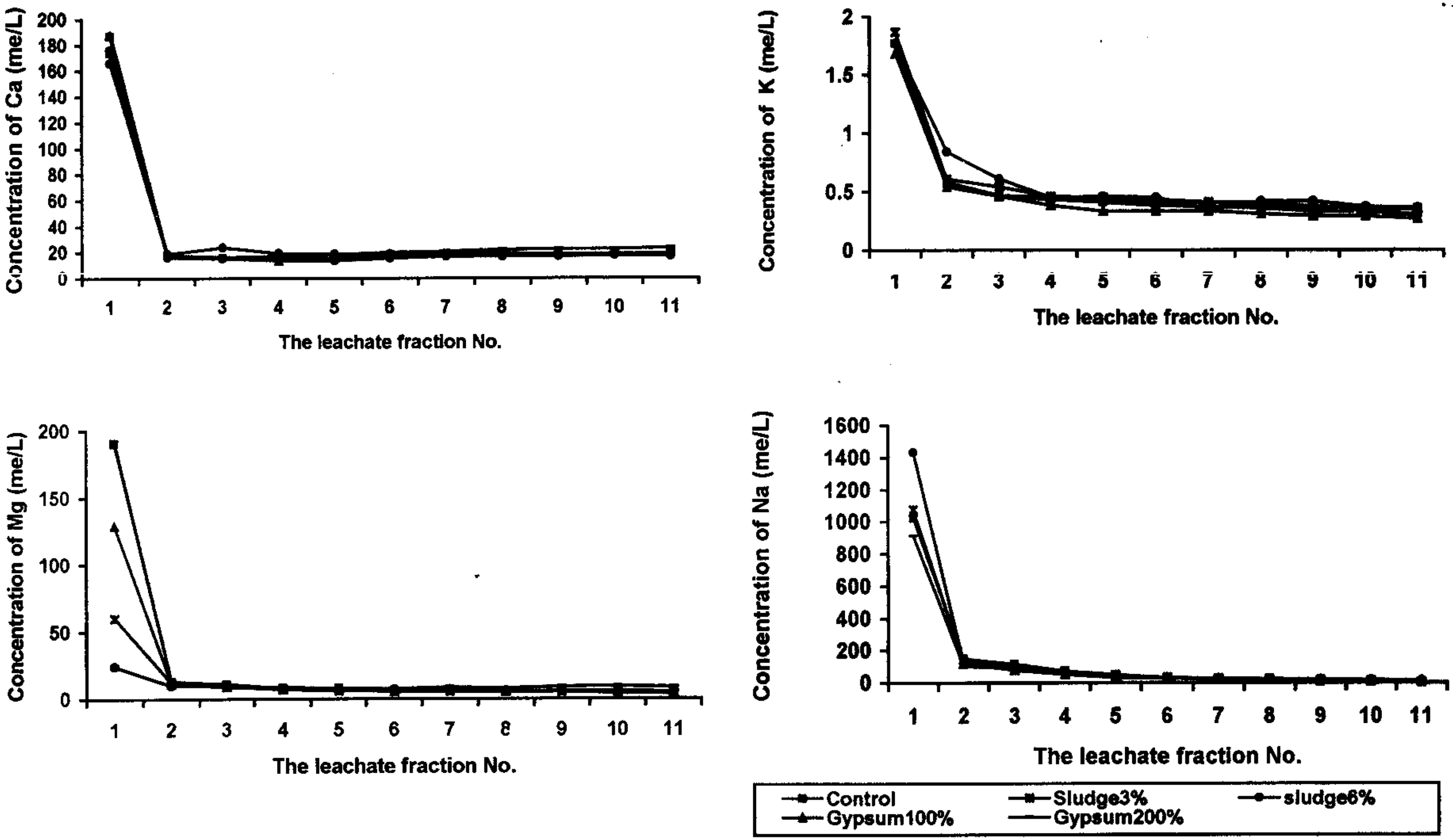

Fig (6) Concentrations of Ca, Mg, Na and K in the leachate fractions of El-Kassasen according to type of the anion itself where the effect of leaching seemed more abovious on the Cl^- anions which are more readily leachable.

Data presented in Tables (6,8 and 10) reveal that non of the trace elements, except for Fe in the first leachate fraction, was detected in an appreciable concentration. This is mainly due to the low concentrations of the soluble fractions of Fe, Mn, Cu, and Zn in soils, especially under the high alkaline pH prevailing in such saline sodic soils. Continuous application of water may enhance hydrolysis of soil bases and hence increased soil pH and decreased solubility of trace elements.

4.2.2. Within the amended soils:

As the leaching proceeds, the amount of leachable salts would differ from one treatment to another, depending on amendments reaction with soil constituents, and the resulting amounts of soluble calcium made available for the exchange reaction which in turn, supply the soil solution with additional leachable salts.

4.2.2.1. Within the sludge amended soils:

Considering EC values of the leachate fractions of suldge-amended soils, data presented in Tables (5,7 and 9) indicate that the higher rate of the applied sludge (6%) was associated with higher EC values in the first leachate fraction than the other subsequent leachate ones of the different investigated soils. However, no obvious variations could be detected in EC values among these sequent leachate fractions due to difference in rate of the applied sludge. The effect of applied sludge on removal of soluble salts out the soil column seemed, generally, to be more pronounced in case of the higher rate of the applied sludge.

Slightly acidic or alkaline pH values characterized the leachate fractions of the sludge amended soils of Abo-Soltan and El-Baalowa. Relatively higher values of pH were, generally, recorded for the leachates of EL-Kassasen soil then those of Abo-Soltan and El-Baalowa. Rate of applied sludge seemed of no effect on values of pH of the different leachate fractions of the different studied soils. The role of the organic amendments in reducing EC,pH and ESP was reported by **Singh et al., (1981), Ahmed et al., (1988), Singh and Singh (1989), Avinelech et al.,(1990) and Anand (1992).**

Data presented in Tables (5,7 and 9) reveal concentrations of the different cations and anions in the leachate fractions of the sludge amended soils. It is obvious from these data that all the cations(i.e.Ca^{2+},Mg^{2+},Na^{+} and K^{+}) and anions i.e. (HCO_3^-, CO_3^2 and Cl^-) were found in highest concenterations in the first leachate fractions, beyond which concentrations of most of these ions tended to decrease yet it is worthly to mentioned that $CO_3^{2-}$and HCO_3^- were not affected too much by leaching as Cl^- . However, rate of the sludge applied to the investigated soils seemed to exert a more pronounced effect on concentrations of ions in the successive leachate fractions. The higher rate of the applied sludge resulted in,in most cases, higher concentrations of the different cations and anions in the leachates.

A few exceptions occurred, such as the case in the SO_4^{2-} concentration in the first leachate fraction of Abo-Soltan soil, Mg^{2-} and Na^+ in the second leachate fraction of the same soil.

Progressive leaching resulted in lower concentrations of the studied ions in the leachate and the effect seemed more on the more easily leachable ions such as Na^+ and Cl^-

Data in Tables (6,8and 10)illustrate effect of the applied sludge on leachability of Fe, Mn , Cu, and Zn. Results show a positive effect on concentrations of Fe , Mn and Cu due to application of sludge and also increasing its rate of application to 6% especially in the leachate fractions No.1,2 and 3. This holds true for Abo-Soltan and El-Baalowa soils. These results are in accordance with those of **Lindsay and Norvell (1978),** who reported that increasing level of the applied organic substances increases solubility and availability of most trace elements. The increases in trace elements concentrations in the leachate of the sludge amended soils compared to the control or gypsum amended soils. This is attributed to the high concentrations of these elements in the sludge. In El-Kassasen soil no certain effect could be detected on concentrations of soluble Fe,Mn,Cu,and Zn due to rising rate of the applied sludge, however, concentrations of the trace elements gradually decreased by due to continuous leaching process.

4.2.2.2. Within the gypsum amended soils

The effect of the applied gypsum on the ionic composition of the leachate fractions is somewhat different from that of the applied sludge. The applied gypsum resulted in EC values highest in the first leachate fraction, decreased sharply in the second leachate one and tended to decrease gradually thereafter until almost constant values after eleven leachate fractions.

In Abo-Soltan soil, the higher rate of the applied gypsum showed higher effect, in this concern, than the lower one did. Such an effect is probably due to the ability of the higher rate of gypsum to provide more favorable physical conditions for leaching. Moreover, the higher rate of the applied gypsum allows, more Ca^{2+} ions to replace the exchangeable Na^{+} ones on the soil complex, thus leading to more concentration of the leached Na^{+} ions in the soil leachate.

In El-Baalowa and El-Kassasen soils, the effect of rate of the applied gypsum was quite different from that observed in Abo-Soltan soil, i.e. the lower rate of the applied gypsum was more effective in leaching Na^{+} ions out the soils as it was indicated by the concentration of Na^{+} in the first leachate fraction.

Concentration of Mg^{2+} in the first leachate of the investigated soils which were amended with the lower rate of the applied gypsum was higher than its corresponding concentrations in the soils amended with the higher rate of the applied gypsum. In the subsequent leachate fractions no certain trend could be detected. Also, K^{+} did not portary a particular trend due to rate of the applied gypsum.

Carbonate ions were not shown in any leachate fraction. This occurred in all the gypsum amended soils regardless of rate of the applied gypsum. On the other hand, bicarbonate HCO_3^- ions were detected in highest concentrations in the first leachate fractions then decreased gradually. Also, rate of the applied gypsum seemed to be of no pronounced effect on concentration of HCO3^{-} ions in the leachate.

Chloride ions were detected in highest concentrations in the first leachate fractions then tended to decrease in the other subsequent leachate ones until they were completely dsiappeared in the 5th to 7th leachat fractions. Rate of the applied gypsum gave contradictory results on concentration of Cl^{-} ions in the leachate of the different soils e.g. the higher rate of the applied gypsum resulted in higher concentration of Cl^{-} in the first leachate fraction of Abo-Soltan soil whereas the opposite was true in the leachates of El-Baalowa and El-Kassasen soils.

The higher leachability of Cl^{-} could be attributed to the the high solubility of the chloride salts and the high diffusion rate of chloride out of the soil columns.

Sulfate ions were found to be highest in the first leachate fraction of the different investigated soils then were decreased in the subsequent leachate fractions. The lower rate of the applied gypsum showed lower effect on leaching SO_4^{2-} out of the soil columns of the investigated soils than the higher rate did. The higher rate of the applied gypsum might provided soluble Ca^{2+} and SO_4^{2-} in concentrations high enough to excced the solubility product of $CaSO_4$,thus led to reprecipitiation of SO4^{2-} in the from of $CaSO_4$.

Considering concentrations of the trace elements i.e. Fe,Mn,Cu and Zn in the leachate fractions of the gypsum amended soils, data in Tables (6,8 and 10) reveal that the studied trace elements were found in variable

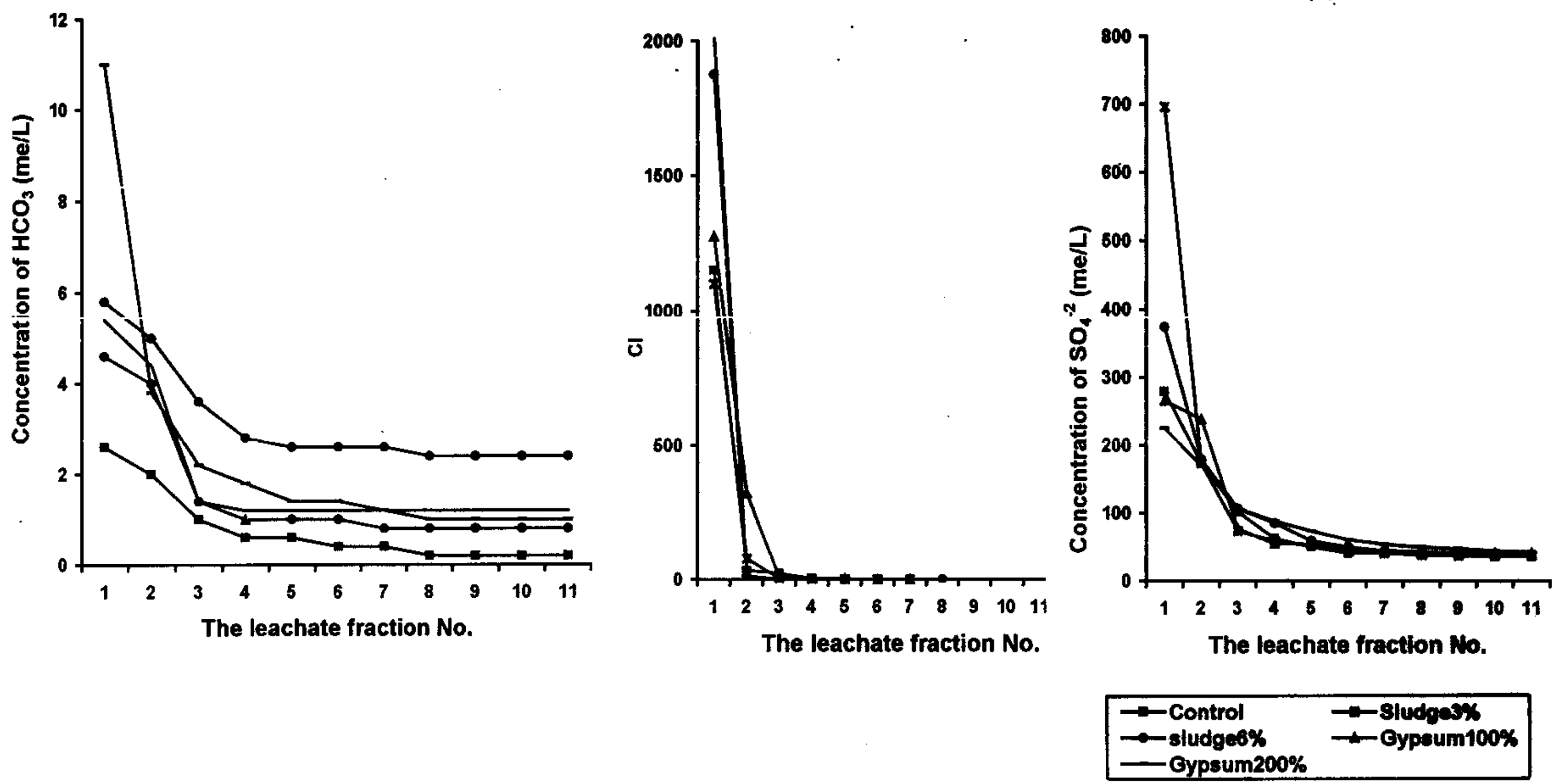

Fig (7) Concentrations of HCO_3^-, Cl^- and SO_4^{2-} of the leachate fractions of Abo-Soltan

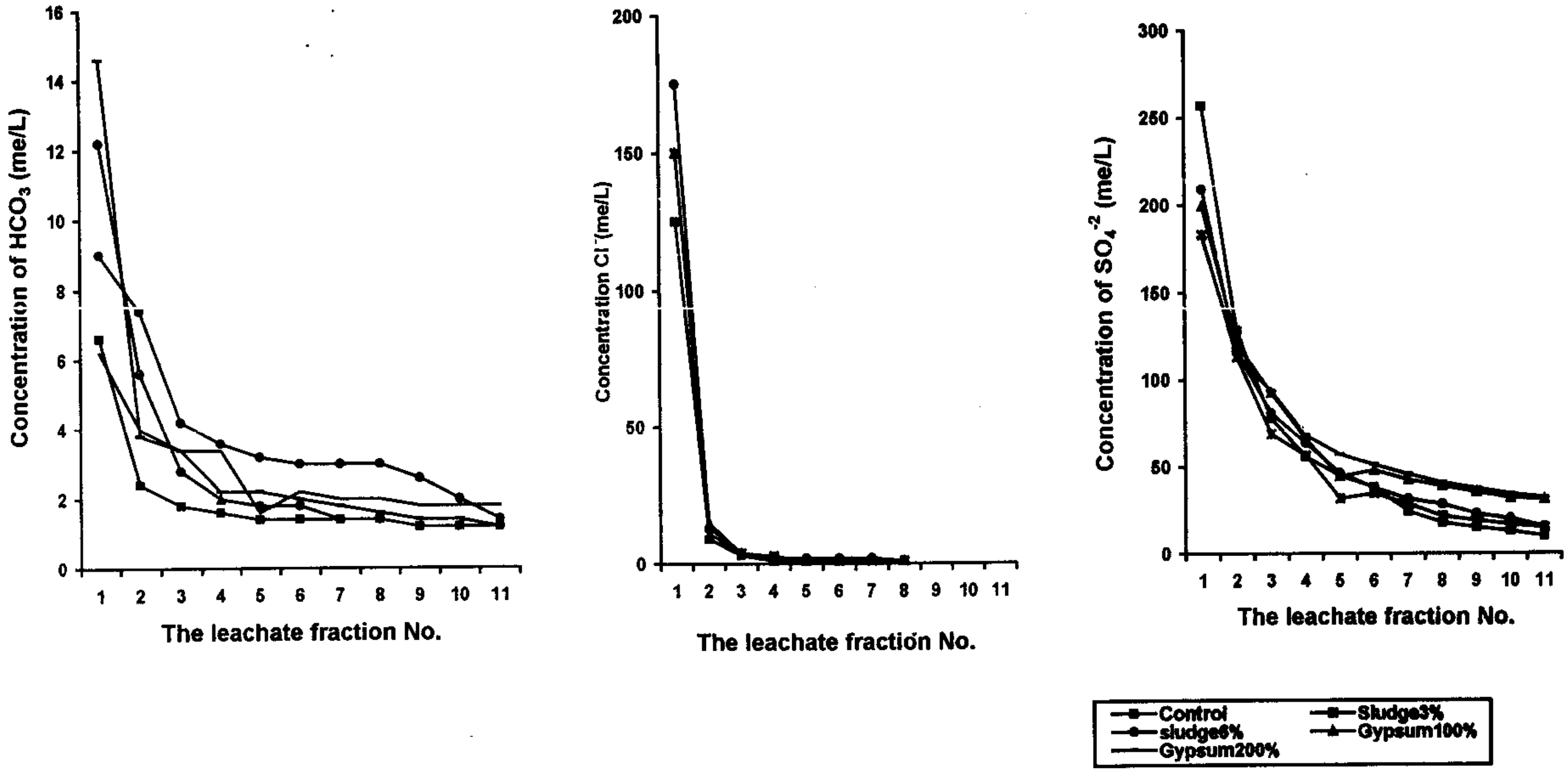

Fig (8) Concentrations of HCO_3^- ,Cl^- and SO_4^{2-} of the leachate fractions of El-Baalowa

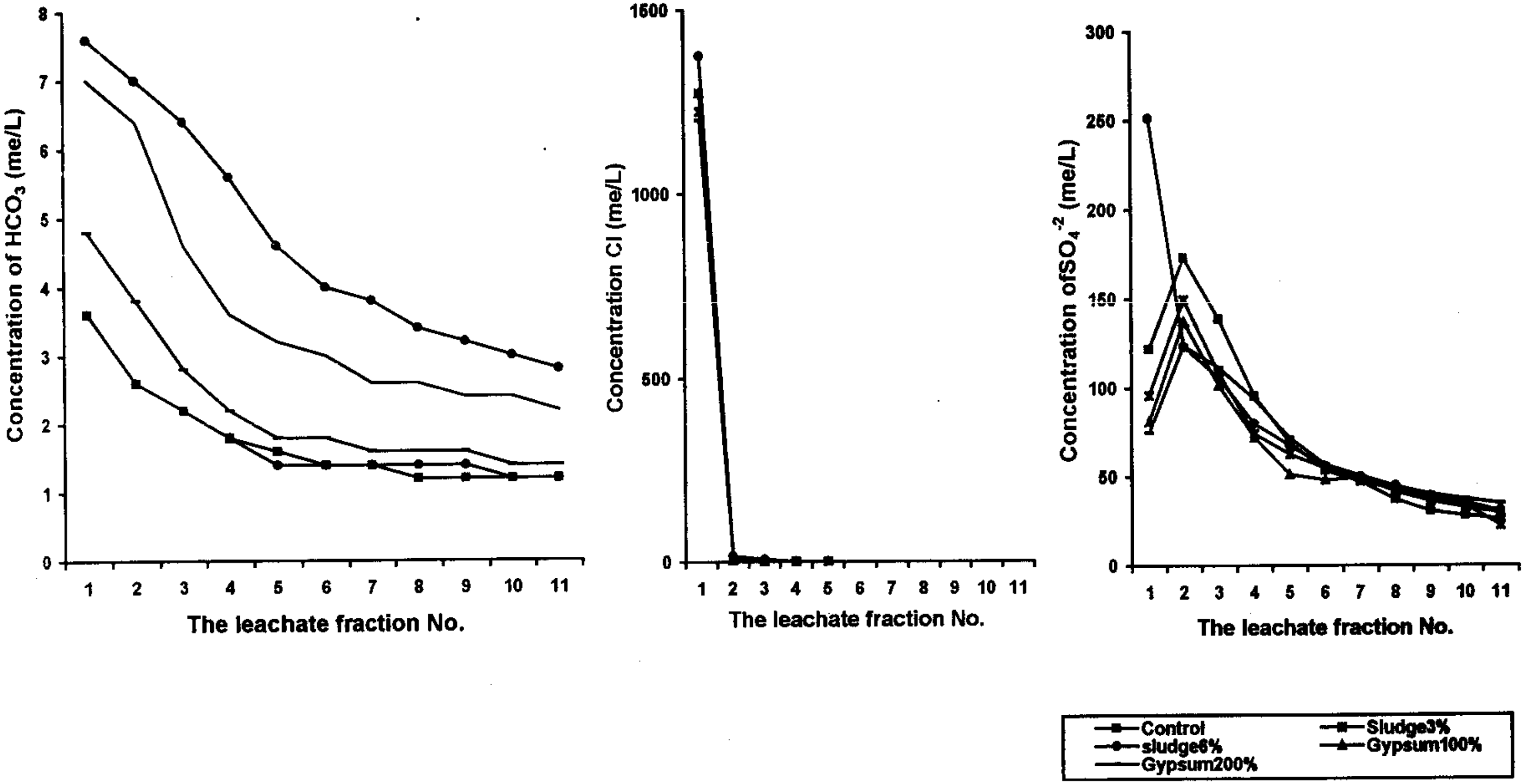

Fig (9) Concentrations of HCO_3^-, Cl^- and SO_4^{2-} of the leachate fractions of El-Kassasen amounts in the successive leachate fractions. It is worthy to indicate that the rate of the applied gypsum could not show a detected effect on concentration of the investigated trace elėments. Responses of the different soil leachate fractions to the applied gypsum varied depending on type of the trace element itself, the concerned soil, the physico-chemical features of soil as well as its textural class.In the fifth leachate fraction concentrations of most the investigated trace elements were quite low and hence no appreciible concentrations of these elements were expected to be found in the subsequent leachate fractions.

Thus, the pervious graphs may represent satisfactory, the general tend of salt removal, although they are not suitable for numerical characterization of leaching efficiency.

4.3. Trace elements fractions in the continuously leached and amended soils.

Fractionation of the trace elements remained in soils after leaching whether in absence of a soil amendment or in presence of the organic amendment (sewage sludge)or inorganic one (gypsum) was conducted according to **McLaren and Crawford (1973)**. The studied elements were fractionated into I-water soluble(free plus complexed) and exchangeable, II- bound by inoganic sites (especially adsorbed), III- bound by organic sites and IV- occluded (bound by Al and Fe oxides)

4.3.1.Iron fractions in the tested soils:

I-Soluble and exchangeable iron:

Data presented in Tables (11,12,13) reveal that values of soluble and exchangeable Fe ranged from 0.2 to 0.7 $mgkg^{-1}$ in the water leached soils. The corresponding values of those amended with sludge at a rate of 3% ranged from 0.0-0.4 $mg\ kg^{-1}$, whereas those of the soils amended with sludge at rate of 6% ranged from 0.1-0.5 $mgkg^{-1}$.

Values of soluble and exchangeable Fe of the soils amended with gypsum at a rate of 100 % of the gypsum requirements (GR) ranged from 0.2 to 0.9 $mgkg^{-1}$.The corresponding values when gypsum was applied at a rate of 200% of GR ranged from 0.2-0.9 $mgkg^{-1}$ soil. No certain trend could be detected for soluble and exchangeable Fe with depth, however, it is obvious from the above mentioned results that values of soluble and exchangeable Fe of the different segements of the amended soils are lower, to a great extent, than the corresponding values of the saline sodic ones(before leaching and /or amendment application) . This finding is expected since the soluble and exchangeable fractions of Fe are more readily to be leached out of the soil columns.

II-Iron bound by inorganic sites(especially adsorbed iron).

Data presented in Tables (11,12 and 13) show that values of Fe bound by inorganic sites of the leached soils ranged from 0.9-19 $mgkg^{-1}$ soil, the corresponding values ranged from 13.3 to 82.9 $mgkg^{-1}$ soil in the soils amended with sludge at a rate of 3 % and from 57.4 to 116.7 $mgkg^{-1}$ soil in the soils amended with sludge at a rate of 6% .

In the gypsum amended soils, the range 16 to 33 $mgkg^{-1}$ soil was detected upon application of gypsum at a rate of 100% of GR while the range 28 to 39 $mgkg^{-1}$ soil was obtained in the soils amended with gypsum at a rate of 200% of GR.

These results reveal that values of Fe bound by inorganic sites were generally higher in the sludge amended soils than in the gypsum amended ones. Sludge content of Fe might account for such a finding.

III-Iron bound by organic sites:

Values of organically bound Fe presented in Tables (11,12 and 13) reveal the range 55 to 162 $mgkg^{-1}$ in the water leached soils, the range 118.5 to 266.6 mg kg^{-1}soil in the soils amended with sludge at a rate of 3% and the range 37.0-335.5 $mgkg^{-1}$ soil in the soils received sludge at a rate of 6% . The corresponding values in the soils amended with gypsum at rate of 100% of GR ranged from 41.0 to 139.0 $mgkg^{-1}$ soil while these of soils received gypsum at a rate of 200 % of GR ranged from 29 to 122 $mgkg^{-1}$ soil

Again , the sludge treated soils showed higher values of organically bound Fe than the gypsum treated ones.

IV- Occluded iron

Occluded Fe ranged from 877 to 1580 $mgkg^{-1}$ in the continously leached soils, 1041 to 1861.6 $mgkg^{-1}$ soil in the soils reseived sludge at a rate of 3 %, 1176 to 1850 in the soils received sludge at a rate of 6% , 905 to 1472 $mgkg^{-1}$ soil in the soils amended with gypsum at a rate of 100% of the GR and 948 to 1621.5 $mgkg^{-1}$ soil in the soils treated with sludge at a rate of 6%.

V- The residual iron:

The residual Fe fraction although was the dominant Fe form which was detected in far higher values than the other forms of Fe, yet it did exhibit any consistent pattern of distribution with depth. Similar findings were reported by **Sinai et al (1995) and Tadros (1997)**.

Values of the residual fraction of Fe seemed to be dependent on values of total Fe and seemed to folow its same pattern of distribution irrespective of the different treatments.

4.3.2·Manganese Fractions in the tested soils:

Data presented in Tables (11,12 and 13) illustrate the Mn fractions in the different segments of the leached and amended soils

I-Soluble and exchangeable Manganes:

Values of soluble and exchangeable Mn in the leached soils were very small and ranged from0.1 to 0.4 2 mg kg^{-1} soil. The corresponding values in the sludge amended soils were obviously higher than those of the leached ones, being ranging from 0.7 to 5.2 mg kg^{-1} soil when sludge was added at a rate of 3% and from 2.2 to 9.5 2 mg kg^{-1} soil when sludge rate was raised to 6%.

Gypsum added at any of its rates resulted in extremely low values of soluble and exchangeable Mn as compared with those obtained due to sludge application where these values ranged from 0.2 to 0.72 mg kg^{-1} soil upon applying gypsum at a rate .of 100% of the GR and ranged from 0.3 to 1.42 mg kg^{-1} soil when rate of the applied gypsum was 200% of the GR.

Noteworthy to indicate that this fraction of Mn did not portray a specific patteren with soil depth. Also, the concentrations of this fraction remained in the sludge amended soils seemed higher than the corresponding ones of the gypsum amended soils. This is due to sludge higher content of Mn.

II-Manganese bound by inorganic sites:

Values of this fraction of Mn remained in the soils seemed relatively higher than the corresponding ones of the soluble + exchangeable Mn fraction as well as these of the Mn fraction bound by the organic sites.

Inorganically bound Mn in the water leached soils ranged from 34.0 2 mg kg^{-1} soil to 103 2 mg kg^{-1} . The sludge-amended soils showed the range 101.5 to 155.0 2 mg kg^{-1} when sludge was applied at a rate of 3% while the range 98.5 to 164.5 was shown by the soils amended at the rate of 6 %. No obvious differences could be detected between values of this fraction of Mn due to rate of the applied sludge. On the other hand, values of inorganicall bound Mn in the sludge amended soils are markedly higher than the corresponding ones of soils reclaimed with leaching only or the gypsum amended soils at any of its rates of application. Inorganically bound Mn ranged from 36.6 to 98.5 2 mg kg^{-1} soil upon application of gypsum to the saline-sodic soils at a rate of 100% of the GR while it ranged from 33.6 to 105.5 2 mg kg^{-1} soil when gypsum was applied at a rate of 200 % of the GR.

III-Manganes bound by organic sites :

This fraction of Mn ranged from 16 to 40.5 2 mg kg^{-1} soil in the soils reclaimed by leaching only, from 22 to 46.5 mg kg^{-1} in the soils amended with sludge at a rate of 3% and from 22.5 to 48.5 2 mg kg^{-1} soil when rate of the applied sludge was 6 %.

Values of organically bound Mn in the gypsum amended soils were the lowest compared with the corresponding ones of the leached or sludge amended soils. These values ranged from 10.5 to 26.5 2 mg kg^{-1} soil when gypsum was applied to soils at a rate of 100% of the GR while they ranged from 6.0 to 28 mg kg^{-1} soil when rate of the applied gypsum was 200 % of the GR.

IV-Occluded manganese:

The occluded Mn fraction is the highest among the Mn fractions (other than the residual fraction).

Values of this fraction ranged from 67.5 to 148 mg kg^{-1} soil in leached soils, from 64.0 to 170.0 mg kg^{-1} in the soils amended with the lower rate of sludge 3% from 60.0 to 168.5 mg kg^{-1} in the soil received sludge at a rate of 6%.

Relatively similar values were obtained for occluded Mn in the gypsum amended soils where these values ranged from 69.5 to 136.5

Table (11) Trace elements fractions in different segments of the amended soil (Abo-Soltan)

Treatment	depth	Fe					Mn					Cu					Zn				
	cm	Sol	Bou	Org.	Occ	Res.	Sol	Bou	Org.	Occ	Res.	Sol	Bou.	Org.	Occ	Res.	Sol	Bou	Org.	Occ	Res.
Control	0-5	0.6	1.4	55.0	976.0	29672.0	0.2	34.0	16.0	139.5	330.3	0.1	0.3	2.0	26.0	1.1	0.1	0.6	6.6	14.0	41.8
	5--10	0.2	1.2	65.5	894.5	35832.6	0.2	39.5	16.5	146.5	337.3	.0.1	0.3	2.5	25.5	1.6	0.0	0.4	7.0	12.0	50.6
	10--16	0.4	16.0	56.5	919.5	32092.0	0.2	37.7	16.0	134.5	298.6	0.1	0.3	2.5	23.0	4.6	0.0	0.6	7.0	13.5	56.9
	16--24	0.4	12.0	56.5	891.5	31585.4	0.1	35.0	16.5	148.0	255.4	0.1	0.3	3.0	24.0	4.1	0.1	0.3	6.0	11.5	77.1
Sludge 3%	0-5	0.4	26.9	118.5	1080.5	26838.7	1.3	106.5	22.0	113.5	231.7	0.2	0.7	3.0	27.0	5.1	0.0	26.5	24.0	29.0	135.5
	5--10	0.0	54.2	118.5	1063.0	26819.3	2.8	105.5	28.5	117.5	210.2	0.2	0.7	3.5	25.5	5.6	0.1	15.9	22.5	27.5	139.0
	10--16	0.1	82.9	127.5	1041.0	20438.5	4.2	101.5	30.5	130.0	156.3	0.2	0.8	2.5	25.5	5.5	0.1	32.5	24.5	30.5	142.4
	16--24	0.2	70.2	128.0	1204.0	24637.6	3.2	110.5	27.0	115.0	194.3	0.2	0.8	4.0	26.0	6.5	0.0	33.0	28.5	35.5	158.0
Sludge 6%	0-5	0.4	87.6	199.0	1390.0	23493.1	3.6	107.6	26.5	104.5	254.9	0.2	1.0	3.0	26.5	3.8	0.0	54.0	44.0	69.0	88.0
	5--10	0.1	116.4	2[illegible]4.5	1536.5	30007.5	6.1	106.0	22.5	98.5	327.4	0.2	1.1	4.0	27.5	4.2	0.0	57.0	48.0	75.5	69.5
	10--16	0.4	87.0	167.5	1176.0	33455.1	4.4	98.5	22.5	168.5	236.1	0.3	0.9	3.5	25.5	5.8	0.0	42.0	37.0	49.0	157.0
	16--24	0.2	116.7	158.0	1213.6	32766.6	8.4	106.5	27.5	112.5	235.1	0.2	0.8	3.0	25.0	8.5	0.0	43.0	36.0	45.0	142.0
Gypsum 100%	0-5	0.8	2.8	44.0	970.5	33006.9	0.5	38.6	10.5	136.0	129.9	0.2	0.3	2.0	23.0	4.0	0.0	0.7	5.5	14.0	75.8
	5--10	0.5	2.5	42.6	921.0	16894.5	0.3	36.6	11.5	136.5	77.8	0.2	0.3	2.0	23.0	7.0	0.0	0.5	6.0	13.5	55.5
	10--16	0.3	3.0	43.0	905.0	28168.7	0.3	36.6	11.0	127.0	107.6	0.2	0.3	2.0	23.5	2.0	0.0	0.4	5.5	13.5	39.1
	16--24	0.4	1.8	41.0	912.0	2048.8	0.2	36.4	10.5	136.0	71.4	0.2	0.3	1.5	22.5	6.6	0.0	0.4	5.5	12.0	47.1
Gypsum 200%	0-5	0.4	3.2	32.0	1016.0	21488.4	0.6	39.2	7.5	118.5	103.7	0.2	0.3	1.5	24.5	1.5	0.0	0.5	5.0	20.0	19.5
	5--10	0.5	3.6	29.0	948.0	24098.9	1.0	34.9	6.0	129.0	132.1	0.2	0.3	1.5	24.0	2.5	0.1	0.8	3.6	13.0	27.6
	10--16	0.6	3.1	32.0	982.5	23636.8	0.8	35.0	6.5	117.5	143.2	0.2	0.3	2.0	22.5	3.6	0.0	0.4	5.0	12.0	34.6
	16--24	0.8	3.9	29.0	978.5	28832.8	0.7	33.6	6.0	114.0	155.8	0.2	0.3	1.5	23.5	4.5	0.0	0.5	4.0	13.5	38.0

Sol =soluble + exchangable Bou =Bound by inorganic sites org= Bound by organic site occ = occluded Res= Residual

Table (12) Trace elements fractions in different segments of the amended soil (El-Baalowa)

Treatment	depth	Fe					Mn					Cu					Zn				
	cm	Sol	Bou	Org.	Occ	Res.	Sol	Bou	Org.	Occ	Res.	Sol	Bou.	Org.	Occ	Res.	Sol	Bou.	Org.	Occ	Res.
Control	0-5	0.4	1.5	146.0	1174.0	16263.1	0.1	85.0	38.5	67.5	63.9	0.0	0.3	3.0	24.0	1.2	0.1	0.6	8.5	17.0	46.3
	5--10	0.5	1.7	162.0	1580.0	12625.8	0.1	87.0	36.5	88.5	46.9	0.1	0.3	2.5	24.0	0.4	0.2	0.7	9.0	13.0	12.6
	10--16	0.5	1.9	162.0	1337.0	19748.6	0.1	80.0	38.5	81.0	80.4	0.2	0.4	2.5	23.5	3.4	0.2	0.6	9.0	13.0	24.7
	16--24	0.3	1.8	158.0	1388.0	16023.9	0.1	103.0	41.5	71.0	61.4	0.1	0.5	2.0	23.6	0.9	0.0	0.8	9.0	11.5	59.7
Sludge 3%	0-5	0.1	48.1	238.5	1587.6	14515.8	1.6	126.5	38.5	86.0	12.4	0.2	0.7	2.0	26.0	1.1	0.0	27.5	30.5	27.0	75.0
	5--10	0.2	42.7	252.5	1861.6	13728.1	3.0	132.0	41.0	79.5	12.5	0.2	0.7	3.0	23.0	1.4	0.0	28.0	33.0	32.5	61.5
	10--16	0.3	24.0	226.0	1521.5	16643.2	0.7	134.0	41.6	71.5	40.3	0.2	0.7	3.0	23.5	5.1	0.0	15.6	27.5	20.5	106.4
	16--24	0.3	29.3	241.5	1222.5	14361.4	1.7	124.5	46.5	64.0	15.3	0.2	0.6	3.0	23.0	3.7	0.0	15.3	32.5	28.0	54.2
Sludge 6%	0-5	0.5	75.2	301.0	1685.5	19742.8	4.8	126.0	42.5	72.0	59.2	0.2	0.8	3.6	23.5	11.0	0.4	41.5	47.0	41.0	105.1
	5--10	0.5	101.5	324.5	1749.5	12269.0	8.9	118.0	42.0	78.5	55.9	0.2	0.7	3.5	23.0	5.1	0.1	44.5	64.0	47.6	148.9
	10--16	0.6	72.1	321.0	1804.6	16716.8	2.2	125.5	47.6	60.0	53.8	0.2	0.8	3.0	26.5	7.0	0.1	39.0	52.0	62.5	106.4
	16--24	0.2	96.7	286.5	1766.6	21030.1	6.0	135.5	45.5	67.6	60.5	0.2	0.7	3.5	23.5	15.0	0.2	51.5	46.0	44.0	168.3
Gypsum 100%	0-5	0.3	3.1	139.0	1343.0	12624.6	0.6	98.5	26.5	81.0	30.5	0.3	0.4	-2.5	25.5	0.9	0.0	0.8	10.0	14.5	36.7
	5--10	0.2	2.3	123.0	1244.0	17830.5	0.6	93.0	19.0	82.5	90.4	0.2	0.4	2.0	24.0	4.9	0.0	0.8	5.0	13.0	11.3
	10--16	0.9	2.6	119.5	1472.0	11295.0	0.6	85.5	18.0	83.6	12.8	0.3	0.3	2.0	24.0	4.5	0.4	0.8	10.0	13.5	18.8
	16--24	0.6	2.5	116.0	1274.0	14296.9	0.7	84.5	19.5	79.5	35.8	0.2	0.3	2.0	22.0	2.0	0.2	0.7	10.0	14.0	16.6
Gypsum 200%	0-5	0.3	3.9	122.0	1530.0	17113.8	0.6	105.5	15.0	96.5	88.9	0.2	0.3	1.5	23.5	0.5	0.0	0.9	8.6	15.0	49.1
	5--10	0.4	3.4	91.6	1621.5	16058.2	0.3	64.8	9.0	120.0	50.9	0.2	0.3	1.5	23.6	2.0	0.0	0.8	9.5	17.6	0.7
	10--16	0.4	3.9	84.5	1450.5	14180.7	0.5	93.0	8.0	110.0	21.5	0.2	0.3	1.5	26.0	3.0	0.1	0.9	8.5	15.0	15.5
	16--24	0.9	3.3	88.5	1480.0	12057.3	0.7	64.6	7.5	108.0	51.7	0.2	0.3	1.5	23.0		0.1	0.8	7.0	17.6	24.6

Sol =soluble + exchangable   Bou =Bound by inorganic sites   org= Bound by organic sites   occ = occluded   Res= Residual

Table (13)Trace elements fractions in different segments of the amended soil (El-Kassasen)

Treatment	depth	Fe					Mn					Cu					Zn				
	cm	Sol	Bou.	Org.	Occ	Res.	Sol	Bou.	Org.	Occ	Res.	Sol	Bou.	Org.	Occ	Res.	Sol	Bou.	Org.	Occ	Res.
Control	0-5	0.3	1.5	72.5	877.0	27203.7	0.4	52.1	24.0	110.5	373.0	0.1	0.4	3.0	24.5	1.0	0.0	1.9	11.5	17.5	64.1
	5--10	0.6	0.9	85.0	985.0	18963.5	0.3	49.8	21.0	144.5	271.9	0.2	0.4	2.5	24.0	1.4	0.0	1.9	10.5	14.0	45.1
	10--16	0.7	0.9	83.6	1062.5	21712.4	0.4	50.9	23.5	120.0	310.2	0.1	0.4	2.0	23.0	3.0	0.2	1.9	9.5	13.5	41.4
	16--24	0.5	1.0	57.6	1156.5	21369.5	0.1	49.3	40.5	127.5	227.6	0.1	0.3	2.0	23.5	2.6	0.1	2.3	9.0	11.0	667.6
Sludge 3%	0-5	0.3	17.9	202.5	1409.0	14750.3	4.5	138.5	31.5	141.0	119.5	0.2	0.8	2.0	29.0	1.5	0.0	32.5	32.0	28.0	172.5
	5--10	0.4	13.3	266.6	1655.5	27284.3	3.3	153.0	34.5	143.0	176.2	0.2	0.7	3.0	22.5	6.1	0.2	26.5	33.5	31.0	164.8
	10--16	0.2	24.0	230.5	1452.5	23142.8	4.0	151.0	35.5	170.0	110.5	0.2	0.8	3.6	23.5	3.0	0.1	29.0	24.0	21.5	105.4
	16--24	0.3	33.4	246.0	1108.0	22822.3	5.2	155.0	41.0	165.5	128.3	0.2	0.7	3.5	22.5	2.6	0.0	24.5	36.6	30.5	94.5
Sludge 6%	0-5	0.1	72.4	305.5	1558.5	31038.6	7.9	163.0	45.5	144.5	249.1	0.2	1.0	4.0	24.0	14.8	0.1	56.5	34.5	42.5	167.4
	5--10	0.4	57.4	335.5	1698.5	31698.2	6.2	164.5	43.0	157.5	258.8	0.3	1.0	4.0	22.5	16.7	0.1	50.0	48.5	49.0	227.4
	10--16	0.3	86.7	331.5	1850.5	30381.0	9.3	148.4	48.5	146.0	287.8	0.3	0.9	3.0	24.5	18.3	0.1	49.0	53.0	55.5	107.4
	16--24	0.4	76.9	291.0	1706.6	31276.2	9.5	145.0	28.5	159.0	315.5	0.3	0.9	4.0	25.5	24.3	0.3	44.0	47.5	48.5	272.7
Gypsum 100%	0-5	0.3	1.6	104.0	1209.0	21640.1	0.6	50.6	20.5	81.0	204.3	0.2	0.3	2.0	20.5	3.5	0.0	22.0	9.0	15.0	33.8
	5--10	0.3	2.3	120.6	1153.5	26668.4	0.6	51.4	18.5	78.0	329.6	0.2	0.4	2.0	21.5	3.4	0.0	22.0	6.5	13.5	46.8
	10--16	0.4	2.8	107.0	1363.5	25526.3	0.2	49.7	20.5	73.5	218.1	0.2	0.4	2.0	21.5	8.9	0.0	24.0	10.5	11.5	43.1
	16--24	0.3	3.3	106.0	1207.0	21618.4	0.7	49.9	16.0	69.5	160.9	0.2	0.3	2.5	21.5	3.5	0.0	21.0	11.5	11.0	33.4
Gypsum 200%	0-5	0.2	2.8	97.5	1485.5	26809.0	0.7	46.1	11.0	90.0	207.2	0.2	0.3	2.0	21.5	7.0	0.0	18.0	7.5	15.5	42.7
	5--10	0.4	2.9	91.5	1552.5	28487.7	0.6	52.2	6.5	147.0	130.2	0.2	0.4	2.0	20.0	3.9	0.0	2.5	11.0	16.5	52.0
	10--16	0.4	3.2	83.5	1350.5	25212.4	0.5	49.6	5.5	105.5	148.9	0.2	0.4	1.5	26.5	1.3	0.0	2.6	8.0	15.0	37.4
	16--24	0.4	2.9	72.5	1466.0	19288.2	1.4	51.8	28.0	104.0	116.8	0.2	0.4	2.0	24.5	1.4	0.0	2.3	6.5	17.5	30.2

Sol =soluble + exchangable Bou =Bound by inorganic sites org= Bound by organic sites occ = occluded Res= Residual mgkg^{-1} in the soils received gypsum at a rate 100% of the GR and from 90.0to 147.0 mg kg^{-1} in the soils received the higher rate of gypsum.

Residual Mn fraction seemed to be the prevailing fraction compared with the other fractions. This holds true for all the investigated soils and under all the studied treatments. The feature was more obvious in the soils reclaimed with leaching only and the gypsum amended ones where the propertions by which residual Mn fraction contributed to the total Mn content in these soils were higher than the corresponding ones in the sludge amended soils.

4.3.3.Copper fractions in the tested soils :

The different Cu fractions remained in the leachate and amended soils are shown in Tables (11,12 and 13)

I- Soluble and exchangeable copper fraction:

It could be noticed that , in most cases, soluble and exchangeable Cu fraction was detected in very minute conentrations do not exceed 0.3 mg kg^{-1} soil whether in the soils reclaimed by leaching only or those received sludge or gypsum at the different used rates.

II- Copper bound by inorganic sites:

Copper was found in this fraction in slightly higher concentrations than the corresponding ones detected in the soluble and exchangeable fraction where its concentrations, generally, did not exceed 1.1 mg kg^{-1} soil.

III- Copper bound by organic sites :

Organically bound Cu fraction represented a considerable portion of total Cu. **Sposito et al., (1982b)** reported that organically bound form of Cu increased with an increase total Cu content in soils as a results of application of sewage sludge. The results obtained herein confirm this finding where values of this Cu fraction ranged from 2.0 to 3.0 mg kg^{-1} soil, in soils reclaimed with sludge at its lower rate of application and from 3.0 to 4.0 mg kg^{-1} soil in the soils received the highest rate of the applied sludge.

In the soils amended wih the lower rate of gypsum, the organically bound Cu ranged from 1.5 to 2.5 mg kg^{-1} soil whereas the corresponding values of the soils amended with gypsum at its highes rate of application ranged from 1.5 to 2 mg kg^{-1} , soil.

Iv- Occlude copper:

Values of occluded Cu seemed independent on soil type or soil treatment where very slight variations could be detected in values of this fraction among the three studied soils and also among the 5 reclamation treatments.

Generally occluded Cu ranged from 20.0 to 21.0 mg kg^{-1} soil only

V- The residual Copper:

Values of residual Cu fraction did not represent a large portion of the total Cu content . This finding coincides with that of **Asami et al (1995)** who concluded that between 40 and 50% of the total Cu was present in the residual fraction.

4.3.4. Zinc fractions in the tested soils

Data presented in Tables (11,12 and 13) reveal the concentrations of the different Zn fractions in the studied soils under the different soil treatments.

I- Soluble and exchangeable Zn fraction:

Likewise the Cu soluble and exchangeable fraction, soluble and exchangeable Zn fraction seems very low, independent on soil type or treatment and of no detected values up to a few decimals do not exceed 0.4 mg kg^{-1} soil. Such low values may be due to precipitation of Zn^{2+} as hydroxides and carbonates or framatrion of organic ligands.

II- Zn bound by inorganic sites:

This fraction of Zn was very low in the soils reclaimed by leaching only and those amended with gypsum at any of its used rates, however in the soil received sludge at a rate of 3% , values of Zn in this fraction ranged from 15.6 to 33.0 mg kg^{-1} soil. The corresponding values of the soils received sludge at a rate of 6 % ranged from 39.0 to 57.0 mg kg^{-1} soil.

III - Zinc bound to the organic sites:

This Zn fraction ranged from 6.0 to 11.5 mg kg^{-1} soils in the leached soils which did not receive any amendment, whereas in the soils amended with sludge at a rate of 3% , its values ranged from 22.5 to 35.6 mg kg^{-1} soil and in the soils received slude at a rate of 6% the corresponding values ranged from 34.5 to 64.0 mg kg^{-1}soil.

The organically bound Zn fraction showed values in the gypsum amended soils extermely lower than the corresponding ones of sludge amended soils where its concentrations ranged from 5.0 to 11.5 mg $kg^{-1}$when gypsum was applied at a rate of 100 % of the GR and ranged from 3.6 to 11.0 mg $kg^{-1}$when the soils received gypsum at a rate of 200 % of the GR.

IV - Occluded Zinc:

Occluded Zn fraction is the second highest fraction among all Zn fractions. Values of this fraction ranged from 11.0 to 17.5 mg kg^{-1}in the soils reclaimed by leaching only , whereas in the soils amended with sludge at a rate of 3% values of the occluded Zn ranged from 20.5 to 35.5 mg kg^{-1}soil. Increasing rate of the applied sludge was associated with increase in values of occluded Zn fraction which ranged from 41.0 to 75.5 mg kg^{-1}.

Values of occluded Zn fraction in the soils amended with gypsum at a rate of 100 % of the GR ranged from 11.0 to 15 0 mg kg^{-1}soils whereas those of the soils amended with gypsum at a rate of 200 % of the GR ranged from 12.0 to 20.0 mg kg^{-1}soil.

V- The residual zinc:

Noteworthy to indicate that most of the total Zn is present in residual form. This finding stands in well a greement with that of **Liang et al (1990).**

Transformations from the soluble, exchangeable and weakly bound Zn to the reaidual fractions are likely to account for the low value of soluble, exchangeable and inorganically bound Zn as compred to the residual form.