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COBALT MOBILITY AND REACTIVITY IN WADI EL-YATIM SOIL IN THE WEST DESERT –EGYPT

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ABSTRACT

This research was aimed to shed light on the cobalt content, its mobility and reactivity in Wadi El-Yatim soil in the Western Desert - Egypt. To achieve this, six soil profiles were taken, with nineteen soil samples representing the top, middle, and bottom of the valley.

The results showed that: - The texture of the soil in the valley soils was sandy in all soil samples that represent the valley soils. The soil reaction ranged from neutral to alkaline, and the electrical conductivity ranged from 5.25 to 50.20 dS/m at 25 ^{O}C. The total content of calcium carbonate ranged from 2.93 to 67.76 gkg^{-1}. The soluble sodium cation was dominant, and the order of the content of the soluble cations was as follows: - sodium > calcium > magnesium > potassium.

The results also showed that the total content of some microelements was as follows: Iron > manganese > lead > zinc > copper > cobalt. It was found from the results that the chemically extracted, available microelements content was: - Iron > manganese > zinc > copper > cobalt > lead.

The results also showed that the chemical forms of the cobalt element were as follows: - the total form > the residual form > the chemically extracted form > the form bound with organic matter > the form bound with iron and manganese > the exchangeable form > the form bound with carbonates > the soluble form.

The results were discussed statistically between the chemical forms of cobalt and some soil variables.

Key Wards: Cobalt forms – Wadi El-Yatim – Mobility of cobalt.

INTRODUCTION

Cobalt (Co) is an important trace element for animals, but not for plants except legumes, where it is required by rhizobia for N fixation in legumes modules (**Howieson and Dilworth, 2016**). Its importance in saving about 25 % of nitrogen fertilizer, on one hand, and hence reducing the environmental pollution with nitrogen, on the other hand, and., at the same time, minimizing the N fertilizer cost (**Gad, 2012**). Cobalt is not critical for all plants but may improve plant growth and yield (**Minz *et al.,* 2018)**. However, relatively lower concentration of cobalt helps in better nodulation and consequently a better growth and yield whereas at a higher level of cobalt, it reduces the bacterial population in the rhizosphere; a lower crop growth and yield **(Minz *et al.,* 2018).** Higher concentration levels of Co in agricultural soils result due to the use of Co-containing compounds to control plant diseases, applied fertilizers, amendments, pesticides, irrigation with waste water, atmospheric deposition, waste materials and industrial activities (**Atafar *et al.*, 2013).**

MATERIALS AND METHODS

Six soil profiles representing the dominant soil land use in Wadi El-Yatim soils in the west desert, Sohage – Egypt, were identified and selected for this study (Figure 1). The main characteristics of the studied soil were determined as follows: -Particle size distribution by dry sieving methods (**Syvitski, 2007**);); pH in soil suspension 1: 2.5 using pH-meter, **3320 Jenway**); electrical conductivity (ECe) in the soil saturation extract using electrical conductivity meter (**YSI model 35**); $CaCO_3$ content volumetrically using the Collin's calcimeter according to **Şenlikçi *et al.*, (2015), Soil Testing Laboratory,(2012)**, soluble cations and anions according to the standard methods outlined **(Haluschak, 2006**). Cation exchange capacity (CEC) of the soils material as a whole was determined using the methods described by **Papanicolaou (1976)**. Total content of elements Co, Fe, Mn, Zn, Cu and Pb content was determined after being digested o.5 g of soil by a mixture of concentrated HNO_3 (4.0 mL) + concentrated H_2SO_4(7.0 mL) + 60 % $HClO_4$(1.0 mL) as recommended by **Thakur *et al.*, (2014)**. Chemically DTPA-extractable Co, Fe, Mn, Zn, Cu and Pb were extracted according to **Tran (2010)** using diethelenetriamine pentaacetic acid and then were measured by Inductively Coupled Plasma (ICP). Sequential extraction of Co was performed following the procedure of **Zimmerman and Weindorf, (2010).**

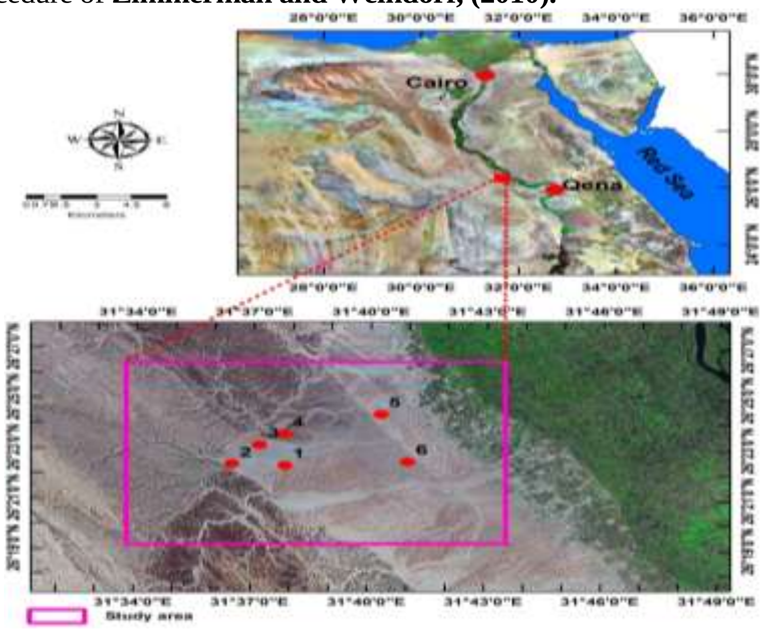


Fig (1) Location map of the soil profiles under study in the Wadi El-Yatim, Egypt

RESULTS AND DISCUSSION

Characterization of the studied soils

Table 1 shows that soil texture of all soil samples of the studied profiles was sand. Data presented in Table 2 reveal that the soil pH values ranged from 6.76 to 8.71, indicating neutral to alkaline soil reaction. Salinity of the different soil layers of the studied profiles varied from non-saline to strongly saline, as ECe values ranged between 0.16 to 50.20 dS/m at 25 ^{O}C. The lowest ECe value characterized the deepest layer of profile No.2 whereas the highest value was associated with the surface layer of profile No. 6. Calcium carbonate $CaCO_3$content in the studied soils ranged between 2.93 and 67.76 gkg^{-1}. The lowest content was found in the deepest layer of profile 1, while the highest content characterized the subsurface layer of profile No.4. Sodium cation (Na^+) was the predominant cation in the soil extract while K^+ was the least in abundance, whereas Ca^{+2} and Mg^{+2} same in between the two extremes. Considering the anionic composition of the soil saturation extract, data reveal the most dominant anion was Cl^- and on the other hand $CO3^{-2}$ anions were entirely absent HCO_3^- was the least abundant anion. The CEC of the soils under study varied within a narrow range from 4.10 to 7.80 $cmol_c kg^{-1}$ soil. The lowest value was recorded in the surface layer of profile No.1, while the highest one was associated with the subsurface layer of profile No.5.The variations encountered in CEC values might be attributed to their different clay contents, different types and percentages of the dominant clay minerals and the content of amorphous inorganic materials in each soil layer of the studied profiles.

Table (1): Particle size distribution and textural classes of the Wadi El –yatim studied soils.

Profile No.	Soil Depth, (Cm.)	Soil particle size (%)			Textural Classes
		Coarse Sand	Fine Sand	Silt+ Clay	
1	0 - 30	42.60	56.98	0.42	Sand
	30 - 50	34.45	64.94	0.61	Sand
	50 - 90	16.10	83.25	0.54	Sand
	90 - 130	3.24	94.22	2.54	Sand
2	0 - 40	19.70	78.78	1.52	Sand
	40 - 100	14.52	83.80	1.68	Sand
	100 - 150	0.48	99.37	0.15	Sand
3	0 - 30	39.68	56.40	3.92	Sand
	30 - 100	55.28	43.18	1.54	Sand
	100 - 150	9.66	89.64	0.70	Sand
4	0 - 40	4.92	83.72	11.36	Sand
	40 - 80	36.57	53.25	10.18	Sand
	80 - 120	25.97	64.57	9.46	Sand
5	0 - 30	0.20	96.90	2.90	Sand
	30 - 60	0.18	97.26	2.56	Sand
	60 - 90	11.20	82.04	6.76	Sand
6	0 - 30	31.35	68.65	0.50	Sand
	30 - 60	72.12	27.32	0.40	Sand
	60 - 90	51.00	2.16	0.30	Sand

Table (2): Chemical properties of the Wadi El –yatim studied soils.

Profile No.	Soil Depth, (cm.)	pH	EC_e dS/m at 25 ^0C	$CaCO_3$ gkg^{-1}	Cations ($mmol_cL^{-1}$)				Anions ($mmol_cL^{-1}$)				CEC $cmol_cKg^{-1}$ soil
					Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{-2}	HCO_3^-	Cl^-	SO_4^{-2}	
1	0 - 30	8.31	0.57	3.35	1.28	0.56	2.66	1.14	0.0	1.52	1.90	2.22	4.10
	30 - 50	8.07	1.09	9.83	4.78	1.04	2.86	2.20	0.0	1.32	3.30	6.27	5.20
	50 - 90	8.11	1.51	2.93	8.09	1.64	4.27	1.22	0.0	0.92	3.97	10.34	6.30
	90 - 130	8.07	1.20	3.18	7.96	1.48	2.02	0.51	0.0	0.51	2.53	8.94	6.20
2	0 - 40	7.89	0.97	10.46	2.95	1.12	4.24	1.33	0.0	1.86	5.30	2.48	5.30
	40 - 100	7.69	0.91	13.67	3.01	0.83	4.20	1.05	0.0	2.73	3.36	3.00	5.40
	100 -150	8.71	0.16	4.60	0.06	0.00	1.16	0.39	0.0	0.25	0.04	1.32	5.60
3	0 - 30	7.68	1.15	18.41	2.86	0.96	4.94	3.06	0.0	2.35	4.00	5.47	4.60
	30 - 100	7.71	1.15	21.33	3.84	1.20	4.94	1.56	0.0	1.82	3.54	6.18	4.20
	100 -150	8.11	0.25	12.97	1.07	0.23	0.90	0.24	0.0	0.84	0.72	0.88	5.20
4	0 - 40	8.09	14.51	41.83	139.03	16.76	14.84	10.64	0.0	1.96	64.40	114.90	5.60
	40 - 80	8.03	8.85	67.76	54.06	45.00	9.00	1.80	0.0	1.26	81.00	27.60	4.60
	80 - 120	8.17	3.02	11.71	21.40	3.46	3.58	0.83	0.0	0.44	6.33	22.50	5.20
5	0 - 30	7.79	3.17	11.29	24.44	2.45	3.22	1.68	0.0	0.84	2.24	27.59	6.90
	30 - 60	7.28	1.71	16.48	9.83	2.21	2.56	2.24	0.0	1.28	22.50	6.94	7.80
	60 - 90	6.76	5.31	16.56	22.76	4.85	18.40	6.90	0.0	2.76	16.10	34.05	5.80
6	0 - 30	7.75	50.20	15.56	343.16	13.70	209.00	152.00	0.0	171.00	351.50	195.36	5.60
	30 - 60	7.02	45.20	15.06	163.74	39.77	336.00	96.00	0.0	168.00	360.00	107.51	4.20
	60 - 90	7.45	9.13	13.80	67.44	6.39	19.61	17.39	0.0	3.70	66.60	40.52	5.60

Total content of some trace elements

-Total cobalt

Table 3 shows that total cobalt (Co) content ranged from 0.48 to 9.13 $mgkg^{-1}$ with a mean of 3.25 $mgkg^{-1}$. The lowest Co content was found in the deepest layer of profile No.4, whereas the highest one characterized the surface layer of profile No.1.Total iron (Fe) content ranged from 208.0 to 14670.0 $mgkg^{-1}$ with a mean of 5506.0 $mgkg^{-1}$. The lowest Fe content was found in the deepest layer of profile No.6, whereas the highest one characterized the surface layer of profile No. .Total manganese (Mn) content ranged from 3.68 to 194.9 $mgkg^{-1}$ with a mean of 79.96 $mgkg^{-1}$. The lowest Mn content was found in the deepest layer of profile No.6, whereas the highest one characterized the surface layer of profile No.1. Total zinc (Zn) content ranged from 0.79 to 59.61 $mgkg^{-1}$ with a mean of 34.86 $mgkg^{-1}$. The lowest Zn content was found in the deepest layer of profile No.6, whereas the highest one characterized the deepest layer of profile No.4. Total cupper (Cu) content ranged from 0.93 to 41.19 $mgkg^{-1}$ with a mean of 8.64 $mgkg^{-1}$. The lowest Cu content was found in the surface layer of profile No.5, whereas the highest one characterized the deepest layer of profile No.2. Total lead (Pb) content ranged from 1.89 to 70.22 $mgkg^{-1}$ with a mean of 36.40 $mgkg^{-1}$. The lowest Pb content was found in the deepest layer of profile No.5, whereas the highest one characterized the deepest layer of profile No.2.

Table (3): Total content of some trace elements of the Wadi El – yatim studied soils.

Profile No.	Soil Depth, (Cm)	Co	Fe	Mn	Zn	Cu	Pb
		mgKg^{-1}					
1	0 - 30	9.13	14670	194.9	59.46	6.82	27.67
	30 - 50	2.35	7166	92.38	43.95	2.16	10.15
	50 - 90	1.27	3543	42.48	27.63	3.08	5.77
	90 - 130	0.66	2525	32.73	21.24	1.02	29.9
2	0 - 40	2.32	3155	51.02	26.91	11.01	24.99
	40 - 100	5.26	2931	41.94	51.68	21.33	63.41
	100 - 150	8.72	4974	66.57	50.24	41.19	70.22
3	0 - 30	3.22	3573	49.07	34.01	10.26	33.92
	30 - 100	2.90	3147	43.01	16.63	7.95	193.4
	100 - 150	1.25	3976	105.2	24.99	5.44	46.43
4	0 - 40	1.03	2722	51.26	23.88	1.89	47.25
	40 - 80	0.85	3294	54.31	34.35	4.15	45.54
	80 - 120	0.48	12220	168.4	59.61	10.38	13.37
5	0 - 30	5.53	9188	131.9	21.24	0.93	4.25
	30 - 60	3.56	5740	86.52	23.5	7.49	2.99
	60 - 90	1.44	8045	115.4	51.2	13.62	1.89
6	0 - 30	5.60	8150	123.4	59.51	8.93	17.39
	30 - 60	4.15	5391	65.01	31.52	5.00	24.99
	60 - 90	1.99	208	3.68	0.79	1.55	27.67

Chemically DTPA -extractable of some trace elements

Data presented in Table 4 exhibit that chemically (DTPA) extractable Co in the investigated soils varied from 0.12 to 2.36 mgkg^{-1} with a mean of 0.54 mgkg^{-1}. The lowest content occurred in the deepest layer of profile No.1, while the highest one was found in the subsurface layer of profile No.2. Iron (Fe) in the investigated soils varied from 8.61 to 53.28 mgkg^{-1} with a mean of 18.65 mgkg^{-1}. The lowest content occurred in the deepest layer of profile No.1, while the highest one was found in the deepest layer of profile No.5. Manganese (Mn) in the investigated soils varied from 0.84 to 32.86 mgkg^{-1} with a mean of 7.70 mgkg^{-1}. The lowest content occurred in the subsurface layer of profile No.1, while the highest one was found in the deepest layer of profile No.5 .Zinc (Zn) in the investigated soils varied from 1.07 to 12.20 mgkg^{-1} with a mean of 2.13 mgkg^{-1}. The lowest content occurred in the deepest layer of profile No.1, while the highest one was found in the deepest layer of profile No.5. Cupper (Cu) in the investigated soils varied from 0.38 to 8.07 mgkg^{-1} with a mean of 1.23 mgkg^{-1}. The lowest content occurred in the deepest layer of profile No.1, while the highest one was found in the deepest layer of profile No.5. Lead (Pb) in the investigated soils varied from 0.02 to 0.90 mgkg^{-1} with a mean of 0.24 mgkg^{-1}. The lowest content occurred in the deepest layer of profile No.6, while the highest one was found in the deepest layer of profile No.5.

Table (4): Chemically DTPA- extractable of some trace elements of the Wadi El –yatim studied soils.

Profile No.	Soil Depth, (cm.)	Co	Fe	Mn	Zn	Cu	Pb
		mgKg^{-1}					
1	0 - 30	1.49	10.59	2.09	1.78	0.65	0.30
	30 - 50	0.93	9.57	0.84	1.17	0.48	0.44
	50 - 90	0.78	9.51	1.20	1.07	0.43	0.14
	90 - 130	0.56	8.61	1.31	1.43	0.38	0.16
2	0 - 40	1.12	19.27	7.29	1.73	0.68	0.12
	40 - 100	2.36	15.25	3.57	1.72	0.58	0.13
	100 - 150	1. 70	17.57	4.97	1.52	0.75	0.25
3	0 - 30	0.51	22.18	6.00	1.58	0.80	0.38
	30 - 100	0.80	13.38	3.44	1.15	0.47	0.16
	100 - 150	0.20	10.03	6.25	1.32	0.52	0.09
4	0 - 40	0.30	26.78	3.97	1.50	0.95	0.18
	40 - 80	0.55	22.56	1.71	1.45	1.88	0.12
	80 - 120	0.32	19.07	1.53	1.35	2.56	0.29
5	0 - 30	0.23	23.90	13.36	2.11	0.79	0.31
	30 - 60	0.34	34.06	16.25	2.21	1.06	0.27
	60 - 90	0.54	35.28	32.86	12.20	8.07	0.90
6	0 - 30	0.20	24.26	8.85	1.60	0.93	0.07
	30 - 60	0.27	32.52	16.66	1.85	1.30	0.33
	60 - 90	0.23	29.26	14.19	1.74	0.95	0.02

Yatim studied soils

Total cobalt

Table 5 shows that total cobalt (Co) content ranged from 0.48 to 9.13 mgkg^{-1} with a mean of 5.16 mgkg^{-1}. The lowest Co content was found in the sublayer of profile No.4, whereas the highest one characterized the surface layer of profile No.1.

Chemically DTPA extractable cobalt

Data presented in Table 4 exhibit that chemically (DTPA) extractable Co in the investigated soils varied from 0.20 to 2.36 mgkg^{-1} with a mean of 0.74 mgkg^{-1}. The lowest content occurred in the surface layer of profile No.6, while the highest one was found in the subsurface layer of profile No.2. Chemically DTPA extractable cobalt the lowest Co percentage characterized the surface layer of profile No.1, while the highest one was associated with the deepest layer of profile No.4.

Chemically DTPA extractable Co as percentages of total Co constituted 3.57 to 66.67 %.

Soluble cobalt

Table 5 reveals that the values of soluble Co varied from 0.02 to 0.25 $mgkg^{-1}$ with a mean of 0.10 $mgkg^{-1}$. The lowest content was found in the surface layer of profile No.5, while the highest one was associated with the subsurface layer of profile No.2. Soluble Co as percentages of total Co constituted 0.48 to 14.85 %.

Exchangeable cobalt

Values of exchangeable Co varied from 0.01 to 0.41 $mgkg^{-1}$ with a mean of 0.27 $mgkg^{-1}$ (Table 5). The lowest content was recorded in the subsurface layer of profile No.6, whereas the highest one was found in the deepest layer of profile No.2. Exchangeable Co as percentages of total Co constituted 0.24 to 17.56 %.

Carbonate bound cobalt

Table 5 shows that carbonate bound Co values in the studied soil profiles varied from 0.01 to 0.51 $mgkg^{-1}$ with a mean of 0.13 $mgkg^{-1}$. The lowest content occurred in the deepest layer of profile No.3 while the highest one was found in the subsurface layer of profile No.2. Carbonate bound Co represented 0.18 to 12.50 % of total Co.

Fe-Mn bound cobalt

Table 5 shows that the values of Fe-Mn bound Co ranged from 0.01 to 0.65 $mgkg^{-1}$ with a mean value of 0.13 $mgkg^{-1}$. The lowest content existed in the deepest layer of profile No.3, while the highest content was with the subsurface layer of profile No.2. The values of this fraction expressed as a percentage of their corresponding total Co, constituted from 0.54 to 12.36 % .

Organic bound cobalt

Table 5 shows that the organic bound Co in the investigated soil profiles varied from 0.05 to 0.54 $mgkg^{-1}$ with a mean value of 0.20 $mgkg^{-1}$. The lowest content was recorded in the deepest layer of profile No.1 whereas the highest one was associated with the deepest layer of profile No. 2. The values of organic bound, Co as percentage of the total Co form ranged from 0.90 to 18.75 %.

Residual cobalt

Table 5 shows that soluble Co values varied from 0.16 to 7.64 $mgkg^{-1}$ with a mean of 2.46 mg kg^{-1}. The lowest content was found in the deepest layer of profile No.4, while the highest one was associated with the surface layer of profile No.1. In other words; residual Co constitutes 33.33 to 96.43 % of total Co.

Table (5): Chemical forms of cobalt and their corresponding percentages of total Co in soils of the Wadi El –yatim studied soils.

Profile No.	Soil Depth, (Cm)	Total Co	DTPA-Extractable Co		Forms of Co											
					Soluble		Exchangeable		Carbonate bound		Fe-Mn bound		Organic bound		Residual	
		$mgKg^{-1}$	$mgKg^{-1}$	%	$mgKg^{-1}$	%	$mgKg^{-1}$	%	$mgKg^{-1}$	%	$mgKg^{-1}$	%	$mgKg^{-1}$	%	$mgKg^{-1}$	%
1	0 - 30	9.13	1.49	16.32	0.25	2.74	0.21	2.30	0.22	2.41	0.29	3.18	0.52	5.70	7.64	83.68
	30 - 50	2.35	0.93	39.57	0.18	7.66	0.20	8.51	0.15	6.38	0.12	5.11	0.28	11.91	1.42	60.43
	50 - 90	1.27	0.78	61.42	0.06	4.72	0.05	3.94	0.04	3.15	0.08	6.30	0.05	3.94	0.49	38.58
	90 - 130	1.66	0.56	33.73	0.09	5.42	0.02	1.20	0.14	8.43	0.13	7.83	0.18	10.84	1.10	66.27
	W*	3.37	0.92	27.30	0.13	3.86	0.97	28.78	0.13	0.04	0.14	4.15	0.23	6.82	2.43	72.11
2	0 - 40	2.32	1.12	48.28	0.21	9.05	0.33	14.22	0.18	7.76	0.17	7.33	0.23	9.91	1.24	53.45
	40 - 100	5.26	2.36	44.87	0.22	4.18	0.36	6.84	0.51	9.70	0.65	12.36	0.62	11.79	2.90	55.13
	100 - 150	8.72	1. 70	19.50	0.13	1.49	0.41	4.70	0.44	5.05	0.18	2.06	0.54	6.19	7.02	80.50
	W*	16.90	1.80	10.60	0.19	1.12	0.37	2.19	0.40	2.36	0.37	2.19	0.49	2.90	3.83	22.66
3	0 - 30	3.22	0.51	15.84	0.09	2.80	0.14	4.35	0.12	3.73	0.09	2.80	0.07	2.17	2.71	84.16
	30 - 100	2.90	0.80	27.59	0.12	4.14	0.11	3.79	0.10	3.45	0.22	7.59	0.25	8.62	2.10	72.41
	100 - 150	1.25	0.21	16.00	0.04	3.20	0.05	4.00	0.01	0.80	0.01	0.80	0.09	7.20	1.05	84.00
	W*	2.41	0.54	20.75	0.09	3.62	0.09	4.41	0.07	2.90	0.12	5.14	0.16	6.66	1.87	77.59
4	0 - 40	1.03	0.30	29.13	0.05	4.85	0.04	3.88	0.05	4.85	0.07	6.80	0.09	8.74	0.73	70.87
	40 - 100	0.85	0.55	64.71	0.11	12.94	0.15	17.56	0.09	10.59	0.09	10.59	0.11	12.94	0.30	35.29
	100 - 120	0.48	0.32	66.67	0.07	14.85	0.05	10.42	0.06	12.50	0.05	10.42	0.09	18.75	0.16	33.33
	W*	0.85	0.54	58.88	0.08	9.80	0.10	11.76	0.07	8.43	0.08	9.02	0.10	11.76	0.42	49.42
5	0 - 30	5.53	0.23	4.16	0.11	1.99	0.03	0.54	0.02	0.18	0.03	0.54	0.05	0.90	5.30	95.84
	30 - 60	3.56	0.34	9.55	0.09	2.53	0.09	2.53	0.05	1.40	0.04	1.12	0.07	1.97	3.22	90.45
	60 - 90	1.44	0.54	37.50	0.07	4.86	0.08	5.56	0.07	4.86	0.09	6.25	0.23	15.97	2.32	62.50
	W*	3.51	0.40	11.44	0.09	2.53	0.07	1.99	0.04	1.23	0.05	1.52	0.12	3.32	3.61	95.40
6	0 - 30	5.60	0.20	3.57	0.04	0.71	0.03	0.54	0.04	0.71	0.02	0.36	0.07	1.25	5.40	96.43
	30 - 60	4.15	0.27	6.51	0.02	0.48	0.01	0.24	0.06	1.45	0.07	1.69	0.11	2.65	3.88	93.49
	60 - 90	1.99	0.23	11.56	0.06	3.02	0.04	2.01	0.04	2.01	0.03	1.51	0.06	3.02	1.76	88.44
	W*	3.91	0.23	5.88	0.02	0.51	0.03	0.76	0.05	1.19	0.04	1.02	0.08	2.05	3.68	94.12
	W**	5.16	0.74	22.48	0.10	3.57	0.27	8.32	0.13	2.70	0.13	3.84	0.20	5.59	2.64	68.55

W* weighted mean of profile
W weighted mean of all profiles**

Mobility factor of cobalt (Co) in studied soils

The mobility of cobalt (Co) is its capacity to pass into soil compartments where it is less energetically retained, **Alshaebi *et al.* (2009).** It depends on many factors related to the nature of the metal, soil properties, adsorption-desorption reaction, precipitation and dissolution, aqueous complexation, biological immobilization and mobilization, dynamic equilibrium of soil. The mobility of (Co) in soils may be assessed on the basis of their absolute and relative content of forms or fractions weakly bound to soil components.

To assess the potential Co mobility and bioavailability, the mobility factor was calculated and the obtained results show that mobility factor ranges from 2.17 to 41.18 (Table 6). This trend agree, to a great extent, with that of DTPA- extractable trace metal which expresses the available content of these metals. It is also believe that soil properties particularly pH, CEC and texture stimulate the mobility of certain elements regardless of their total content (**Bahnasawy *et al.*, 2019).**

Table (6): Mobility factor of the Wadi El –yatim studied soils.

Profile No.	Soil Depth, (Cm)	Total Co	DTPA-Extractable Co		Forms of Co						M.F%
					Soluble		Exchangeable		Carbonate bound		
		$mgKg^{-1}$	$mgKg^{-1}$	%	$mgKg^{-1}$	%	$mgKg^{-1}$	%	$mgKg^{-1}$	%	
1	0 - 30	9.13	1.49	16.32	0.25	2.74	0.21	2.30	0.22	2.41	7.45
	30 - 50	2.35	0.93	39.57	0.18	7.66	0.20	8.51	0.15	6.38	22.55
	50 - 90	1.27	0.78	61.42	0.06	4.72	0.05	3.94	0.04	3.15	11.81
	90 - 130	1.66	0.56	33.73	0.09	5.42	0.02	1.20	0.14	8.43	15.06
2	0 -40	2.32	1.12	48.28	0.21	9.05	0.33	14.22	0.18	7.76	31.03
	40- 100	5.26	2.36	44.87	0.22	4.18	0.36	6.84	0.51	9.70	20.72
	100 - 150	8.72	1. 70	19.50	0.13	1.49	0.41	4.70	0.44	5.05	11.24
3	0 -30	3.22	0.51	15.84	0.09	2.80	0.14	4.35	0.12	3.73	10.87
	30 - 100	2.90	0.80	27.59	0.12	4.14	0.11	3.79	0.10	3.45	11.38
	100 - 150	1.25	0.20	16.00	0.04	3.20	0.05	4.00	0.01	0.80	8.00
4	0 - 40	1.03	0.30	29.13	0.05	4.85	0.04	3.88	0.05	4.85	13.59
	40 - 100	0.85	0.55	64.71	0.11	12.94	0.15	17.56	0.09	10.59	41.18
	100- 120	0.48	0.32	66.67	0.07	14.85	0.05	10.42	0.06	12.50	37.50
5	0 - 30	5.53	0.23	4.16	0.11	1.99	0.03	0.54	0.01	0.18	2.71
	30 - 60	3.56	0.34	9.55	0.09	2.53	0.09	2.53	0.05	1.40	6.46
	60 - 90	1.44	0.54	37.50	0.07	4.86	0.08	5.56	0.07	4.86	15.28
6	0 - 30	5.60	0.20	3.57	0.04	0.71	0.03	0.54	0.04	0.71	1.96
	30 - 60	4.15	0.27	6.51	0.02	0.48	0.01	0.24	0.06	1.45	2.17
	60 - 90	1.99	0.23	11.56	0.06	3.02	0.04	2.01	0.04	2.01	7.04

Statistically the relationships were made between the extracted Co forms and soil variables this explanted in Figure (2) and Table (7).

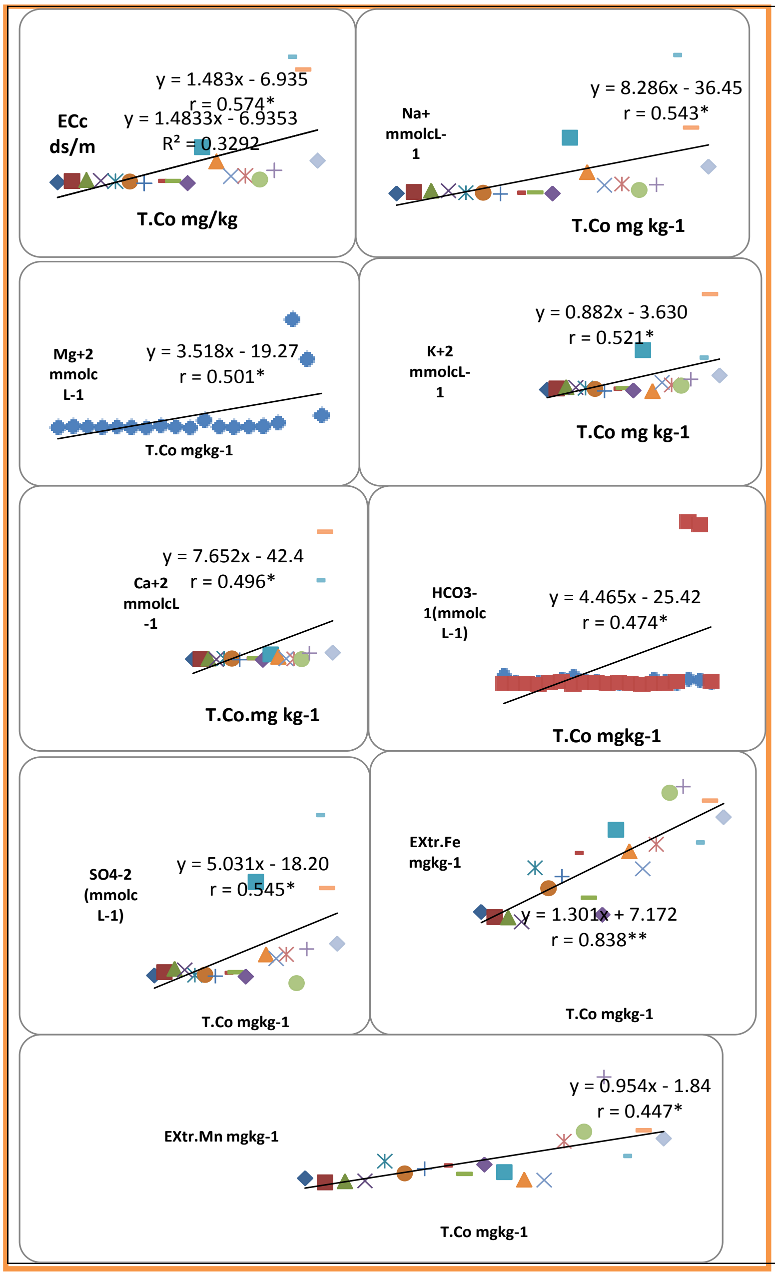
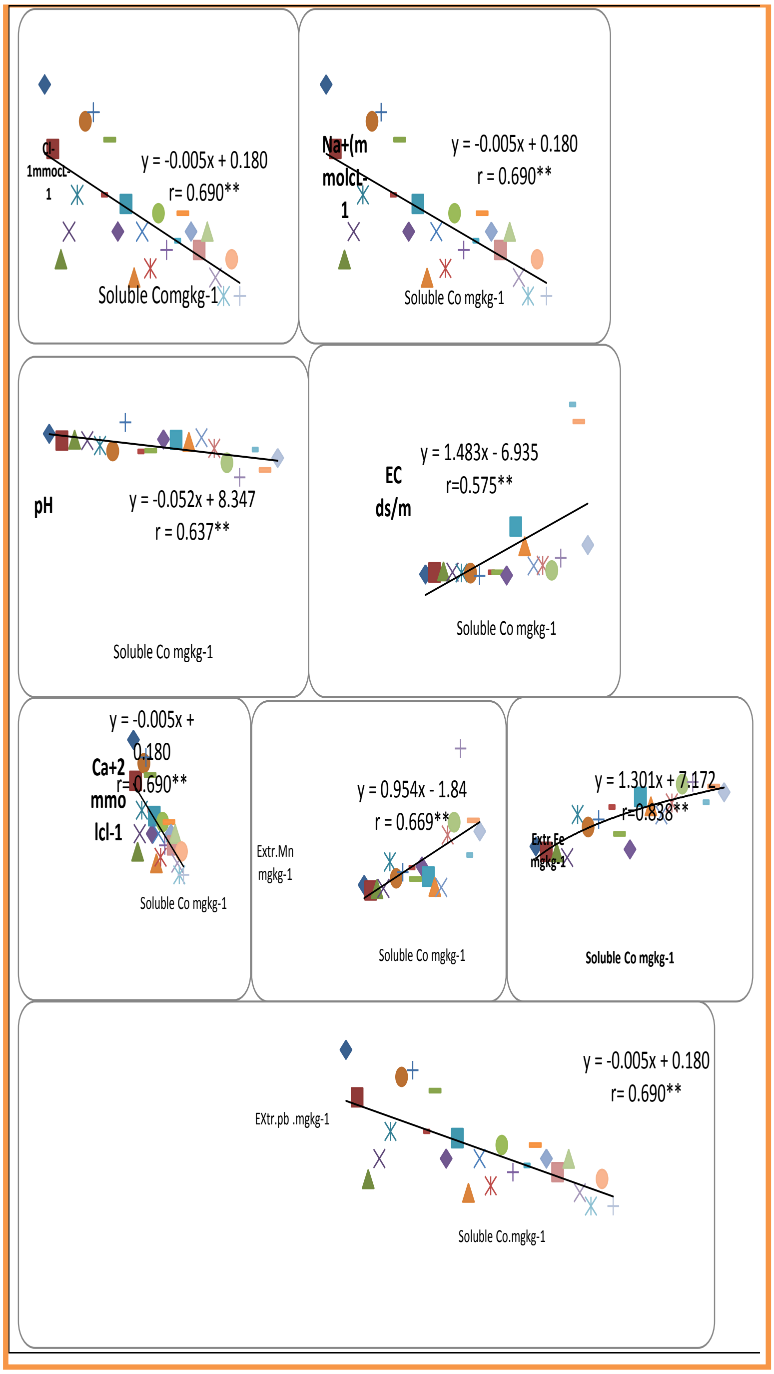


Fig (2). Relationships among some forms of (Co) of some variable of Wadi El – yatim studied soils



y = -0.005x + 0.180
r= 0.690**
Soluble Comgkg-1
y = -0.005x + 0.180
r = 0.690**
Soluble Co mgkg-1
pH
y = -0.052x + 8.347
r = 0.637**
Soluble Co mgkg-1
EC
ds/m
y = 1.483x - 6.935
r=0.575**
Soluble Co mgkg-1
y = -0.005x +
0.180
r=0.690**
Ca+2
mmo
lcl-1
Soluble Co mgkg-1
y = 0.954x - 1.84
r = 0.669**
Extr.Mn
mgkg-1
Soluble Co mgkg-1
y = 1.301x + 7.172
r=0.838**
Soluble Co mgkg-1
y = -0.005x + 0.180
r= 0.690**
EXtr.pb .mgkg-1
Soluble Co.mgkg-1

Fig. (2) Cont.

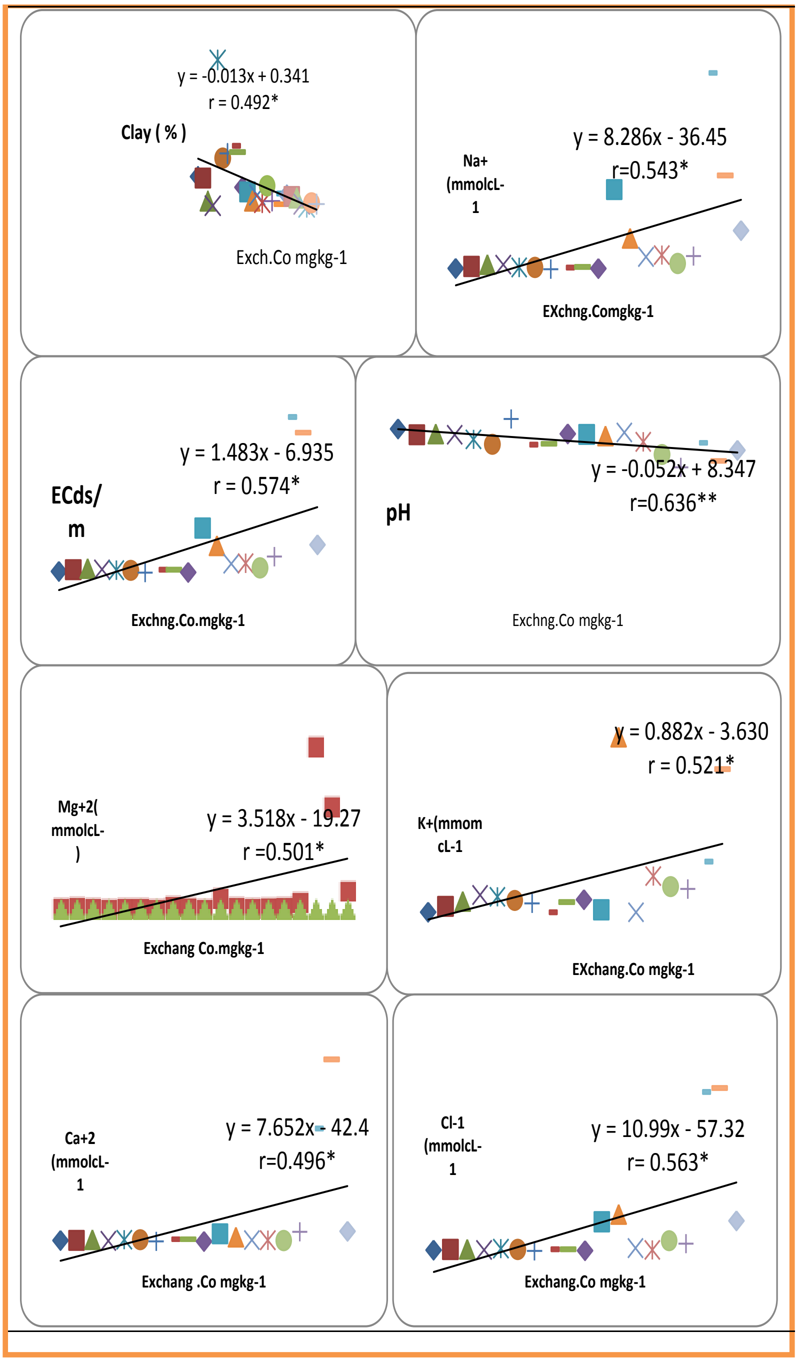

y = -0.013x + 0.341
r = 0.492*
Clay (%)
Exch.Co mgkg-1
y = 8.286x - 36.45
r=0.543*
Na+ (mmolcL-1
EXchng.Comgkg-1
y = 1.483x - 6.935
r = 0.574*
ECds/m
Exchng.Co.mgkg-1
y = -0.052x + 8.347
r=0.636**
pH
Exchng.Co mgkg-1
Mg+2(mmolcL-)
y = 3.518x - 19.27
r =0.501*
Exchang Co.mgkg-1
y = 0.882x - 3.630
r = 0.521*
K+(mmom cL-1
EXchang.Co mgkg-1
Ca+2 (mmolcL-1
y = 7.652x - 42.4
r=0.496*
Exchang .Co mgkg-1
Cl-1 (mmolcL-1
y = 10.99x - 57.32
r= 0.563*
Exchang.Co mgkg-1

Fig. (2) Cont.

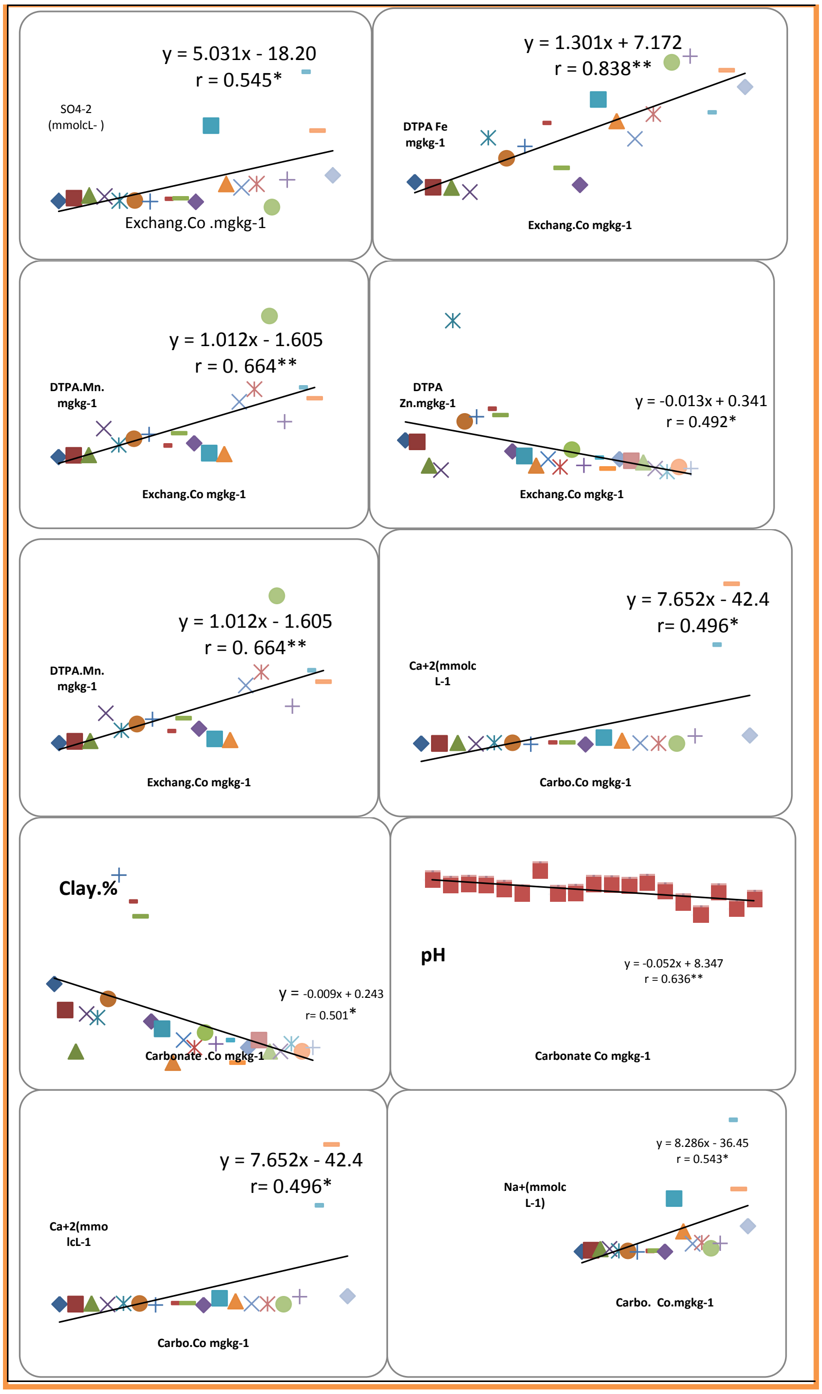
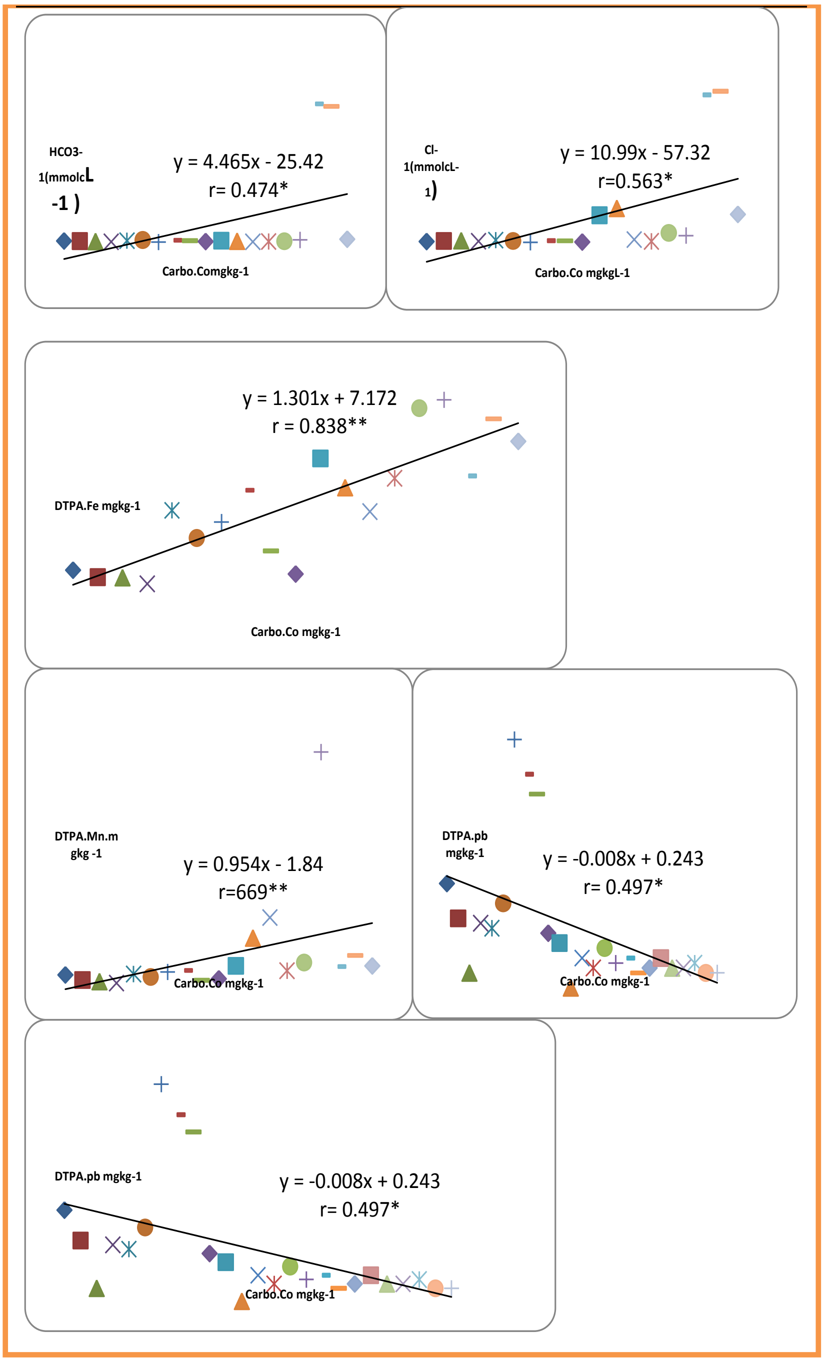

y = 5.031x - 18.20
r = 0.545*
SO4-2 (mmolcL-)
Exchang.Co .mgkg-1
y = 1.301x + 7.172
r = 0.838**
DTPA Fe mgkg-1
Exchang.Co mgkg-1
y = 1.012x - 1.605
r = 0. 664**
DTPA.Mn. mgkg-1
Exchang.Co mgkg-1
DTPA Zn.mgkg-1
y = -0.013x + 0.341
r = 0.492*
Exchang.Co mgkg-1
y = 1.012x - 1.605
r = 0. 664**
DTPA.Mn. mgkg-1
Exchang.Co mgkg-1
y = 7.652x - 42.4
r= 0.496*
Ca+2(mmolc L-1
Carbo.Co mgkg-1
Clay.%
y = -0.009x + 0.243
r= 0.501*
Carbonate .Co mgkg-1
pH
y = -0.052x + 8.347
r = 0.636**
Carbonate Co mgkg-1
y = 7.652x - 42.4
r= 0.496*
Ca+2(mmo lcL-1
Carbo.Co mgkg-1
y = 8.286x - 36.45
r = 0.543*
Na+(mmolc L-1)
Carbo. Co.mgkg-1

Fig. (2) Cont.



HCO3-
1(mmolcL
-1)
y = 4.465x - 25.42
r= 0.474*
Carbo.Comgkg-1
Cl-
1(mmolcL-
1)
y = 10.99x - 57.32
r=0.563*
Carbo.Co mgkgL-1
y = 1.301x + 7.172
r = 0.838**
DTPA.Fe mgkg-1
Carbo.Co mgkg-1
DTPA.Mn.m
gkg -1
y = 0.954x - 1.84
r=669**
Carbo.Co mgkg-1
DTPA.pb
mgkg-1
y = -0.008x + 0.243
r= 0.497*
Carbo.Co mgkg-1
DTPA.pb mgkg-1
y = -0.008x + 0.243
r= 0.497*
Carbo.Co mgkg-1

Fig. (2) Cont.

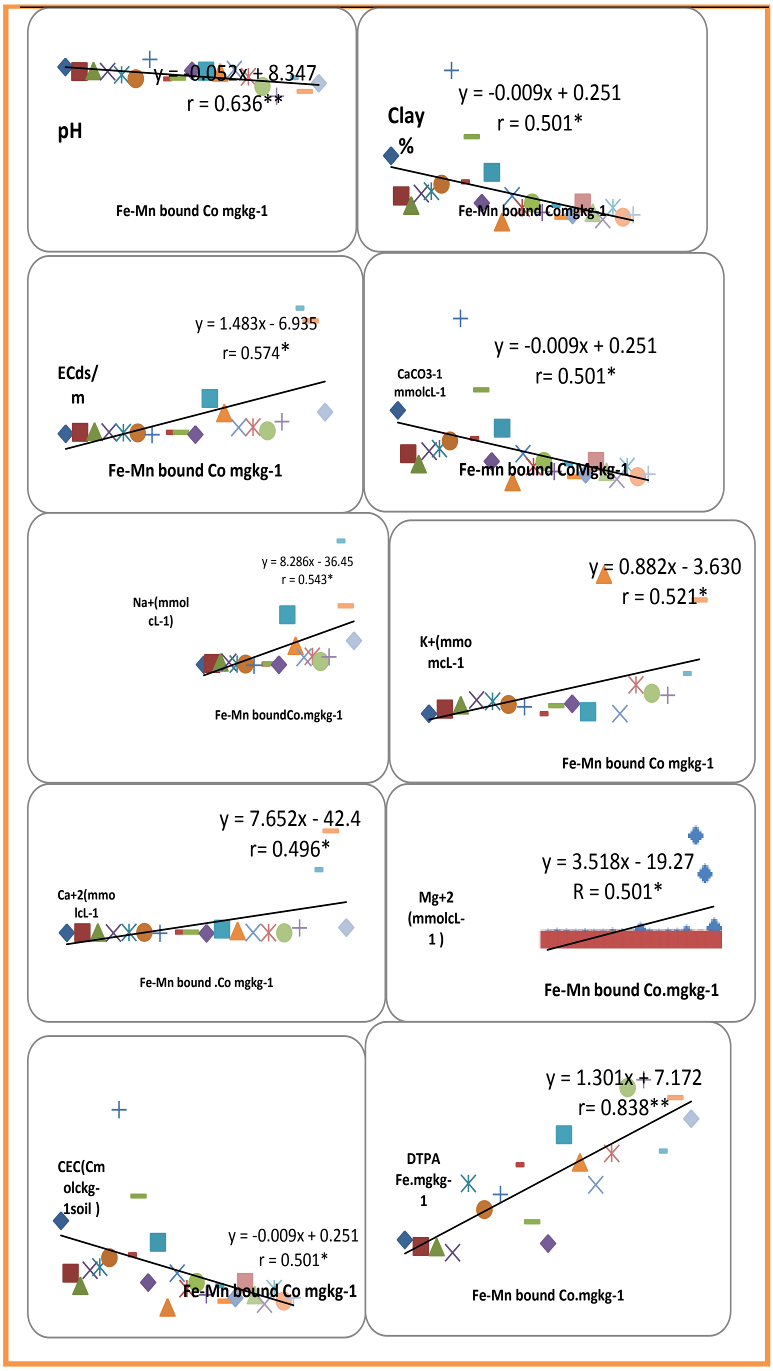
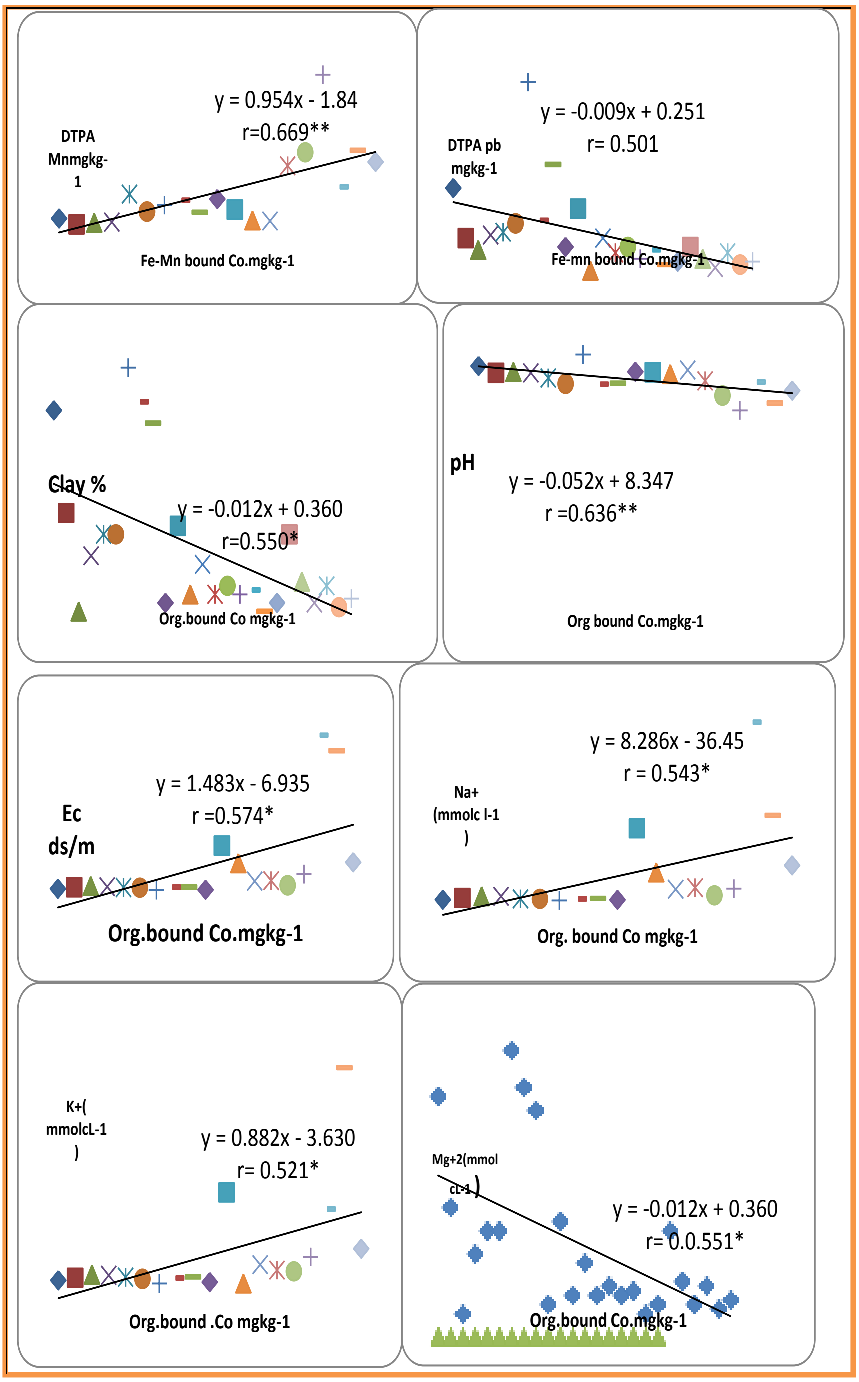

y = -0.052x + 8.347
r = 0.636**
pH
Fe-Mn bound Co mgkg-1
y = -0.009x + 0.251
r = 0.501*
Clay %
Fe-Mn bound Comgkg-1
y = 1.483x - 6.935
r= 0.574*
ECds/m
Fe-Mn bound Co mgkg-1
y = -0.009x + 0.251
r= 0.501*
CaCO3-1 mmolcL-1
Fe-mn bound CoMgkg-1
y = 8.286x - 36.45
r = 0.543*
Na+(mmol cL-1)
Fe-Mn boundCo.mgkg-1
y = 0.882x - 3.630
r = 0.521*
K+(mmo mcL-1
Fe-Mn bound Co mgkg-1
y = 7.652x - 42.4
r= 0.496*
Ca+2(mmo lcL-1
Fe-Mn bound .Co mgkg-1
y = 3.518x - 19.27
R = 0.501*
Mg+2 (mmolcL-1)
Fe-Mn bound Co.mgkg-1
CEC(Cm olckg-1soil)
y = -0.009x + 0.251
r = 0.501*
Fe-Mn bound Co mgkg-1
y = 1.301x + 7.172
r= 0.838**
DTPA Fe.mgkg-1
Fe-Mn bound Co.mgkg-1

Fig. (2) Cont.



y = 0.954x - 1.84
r=0.669**
DTPA Mnmgkg-1
Fe-Mn bound Co.mgkg-1
y = -0.009x + 0.251
r= 0.501
DTPA pb mgkg-1
Fe-mn bound Co.mgkg-1
Clay %
y = -0.012x + 0.360
r=0.550*
Org.bound Co mgkg-1
pH
y = -0.052x + 8.347
r =0.636**
Org bound Co.mgkg-1
Ec ds/m
y = 1.483x - 6.935
r =0.574*
Org.bound Co.mgkg-1
Na+ (mmolc l-1)
y = 8.286x - 36.45
r = 0.543*
Org. bound Co mgkg-1
K+(mmolcL-1)
y = 0.882x - 3.630
r= 0.521*
Org.bound .Co mgkg-1
Mg+2(mmol cL-1)
y = -0.012x + 0.360
r= 0.0.551*
Org.bound Co.mgkg-1

Fig. (2) Cont.

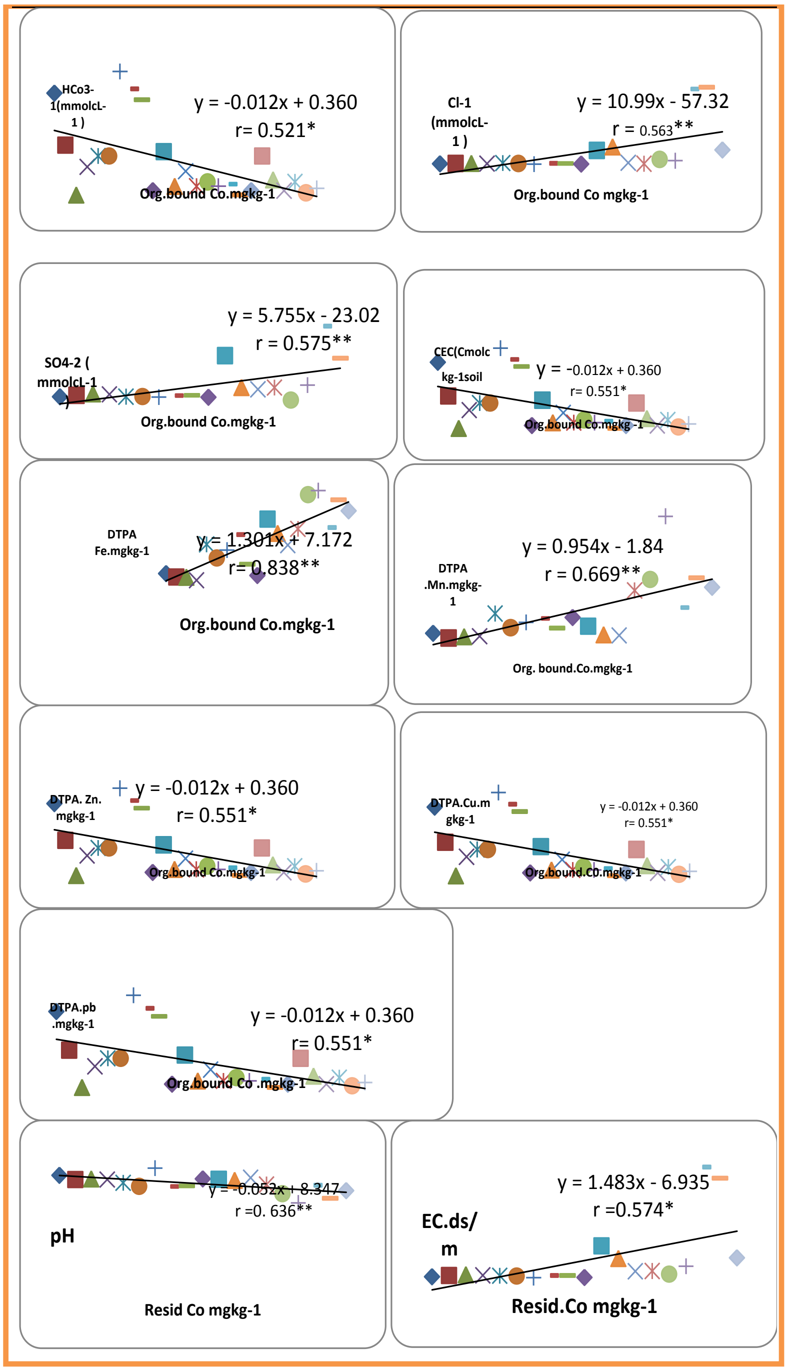

HCo3-1(mmolcL-1)
y = -0.012x + 0.360
r= 0.521*
Org.bound Co.mgkg-1
Cl-1 (mmolcL-1)
y = 10.99x - 57.32
r = 0.563**
Org.bound Co mgkg-1
y = 5.755x - 23.02
r = 0.575**
SO4-2 (mmolcL-1)
Org.bound Co.mgkg-1
CEC(Cmolc kg-1soil
y = -0.012x + 0.360
r= 0.551*
Org.bound Co.mgkg-1
DTPA Fe.mgkg-1
y = 1.301x + 7.172
r= 0.838**
Org.bound Co.mgkg-1
y = 0.954x - 1.84
r = 0.669**
DTPA .Mn.mgkg-1
Org. bound.Co.mgkg-1
DTPA. Zn. mgkg-1
y = -0.012x + 0.360
r= 0.551*
Org.bound Co.mgkg-1
DTPA.Cu.m gkg-1
y = -0.012x + 0.360
r= 0.551*
Org.bound.CO.mgkg-1
DTPA.pb .mgkg-1
y = -0.012x + 0.360
r= 0.551*
Org.bound Co .mgkg-1
y = -0.052x + 8.347
r =0. 636**
pH
Resid Co mgkg-1
y = 1.483x - 6.935
r =0.574*
EC.ds/ m
Resid.Co mgkg-1

Fig. (2) Cont.

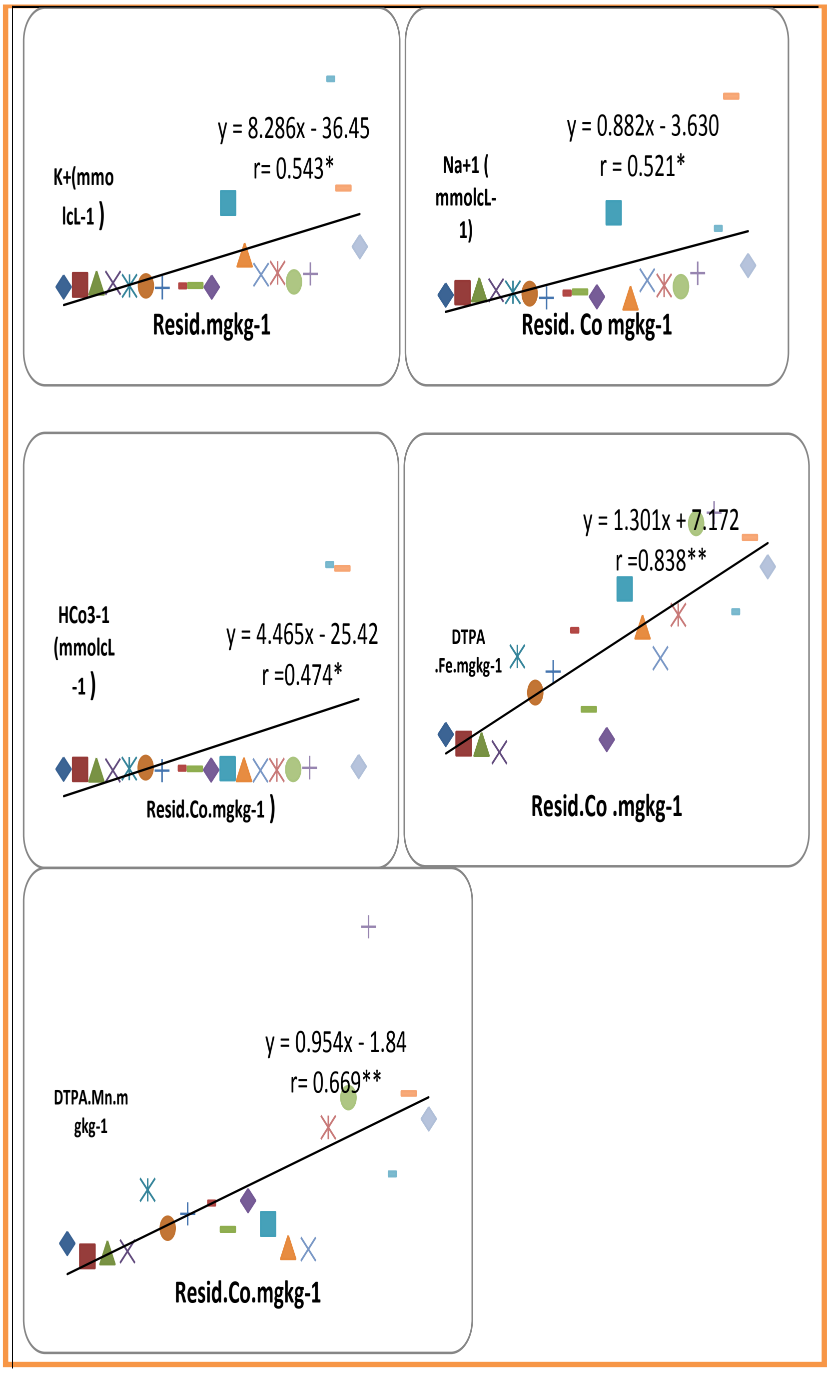

K+(mmo
lcL-1)
y = 8.286x - 36.45
r= 0.543*
Resid.mgkg-1
Na+1 (
mmolcL-
1)
y = 0.882x - 3.630
r = 0.521*
Resid. Co mgkg-1
HCo3-1
(mmolcL
-1)
y = 4.465x - 25.42
r =0.474*
Resid.Co.mgkg-1)
DTPA
.Fe.mgkg-1
y = 1.301x + 7.172
r =0.838**
Resid.Co .mgkg-1
DTPA.Mn.m
gkg-1
y = 0.954x - 1.84
r= 0.669**
Resid.Co.mgkg-1

Fig. (2) Cont.

Table (7): Correlation coefficients (r) among the studied Co forms and some corresponding variable of the Wadi El –yatim studied soils.

Variables	Variable (Co) $mgKg^{-1}$							
	Total	DTPA-extractable	Soluble	Exchangeable	Carbonate	Fe-Mn Bound	Organic Bound	Residual
Silt + Clay (%)				0.492*	0.501*	0.501*	0.550*	
pH		0.636**	0.842**	0.636**	0.636**	0.636**	0.636**	0.636**
EC(dS/m)	0.574*	0.575*	0.574*	0.574*		0.574*	0.574*	0.574*
CaCO3 (gKg-1)						0.501*		
Soluble Na+ (mmolcL-1)	0.543*	0.543*	0.690**	0.543*	0.543*	0.543*	0.543*	0.521*
Soluble K+ (mmolcL-1)	0.521*	0.519*		0.521*		0.521*	0.521*	0.543*
Soluble Ca+2 (mmolcL-1)	0.496*	0.496*			0.496*	0.496*		
Soluble Mg+2 (mmolcL-1)	0.501*	0.501*				0.501*		
Soluble HCO3- (mmolcL-1)	0.475*	0.474*	0.690**		0.474*		0.551*	0.474*
Soluble Cl- (mmolcL-1)		0.563*			0.563*		0.563*	
Soluble SO4-2 (mmolcL-1)	0.545*			0.545*			0.575*	
CEC (Cmolc Kg-1 soil)						0.501*	0.551*	
Fe DTPA extractable (mgKg-1)	0.838**	0.838**	0.838**	0.838**	0.838**	0.838**	838**	0.838**
Mn DTPA extractable (mgKg-1)	0.669**	0.669**	0.669**		0.669**	0.669**	0.669**	0.669**
Zn DTPA extractable (mgKg-1)				0.492*				
Cu DTPA extractable (mgKg-1)							0.551*	
pb DTPA extractable (mgKg-1)			0.690**		0.497*	0.501*		

(1) Significant correlation only are shown in the Table
(2) Levels of significance 5% (*) and 1% (**)

CONCLUSION

Statistical relationships were made between the extracted Co forms and soil variables: Data indicated that there were high significant between the total form of Co, the Fe-DTPA, and the Mn-DTPA. As for the chemically extracted form of cobalt using DTPA, there were high significant between Co-DTPA and the pH, the Fe-DTPA, and Mn-DTPA.

While the soluble form of Co, had high positive significant relationships with the pH, Na^{+}, HCO_3^{-}, Fe-DTPA, the Mn-DTPA, and the Pb-DTPA. While the exchangeable form of Co, had high positive significant among of the pH and the Fe-DTPA. As for the Co form bound with CO_3^{-2}, there were high positive significant among each of the pH and the Fe-DTPA and the Mn-DTPA.

The results showed that the form of Co Fe-Mn bound, had high, positive significant among each of pH and the Fe-DTPA and the Mn-

DTPA. The results also showed that the form of Co OM bound, had high positive significant among each of the pH, Cl^-, SO_4^{-2}, and Mn-DTPA. At least, the residual form of Co, had high positive significant among each of the pH and the Fe-DTPA and the Mn-DTPA.

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حركة وفاعلية الكوبلت بأراضى وادى اليتيم بالصحراء الغربيه- مصر

عبدالسلام علوة

مركز بحوث الصحراء- القاهرة- مصر

يهدف هذا البحث إلى إلقاء الضوء على محتوى الكوبلت وحركته وفاعليته وتوزيعه بأراضى وادى اليتيم بالصحراء الغربيه – مصر. ولتحقيق ذلك تم أخذ عدد من القطاعات ألارضيه بواقع 19 عينه تربه تمثل قمة ووسط وقاع الوادى.

وقد أوضحت النتائج أن:– قوام التربه بأراضى الوادى قوام رملى فى كل عينات التربه الممثله لأراضى الوادى. وكان تفاعل التربه يتراوح ما بين متعادل إلى قلوى كما أن التوصيل الكهربائى يتراوح ما بين 5,25 إلى 50,20 ديسمينز لكل سم وكانت كمية كربونات الكالسيوم الكليه تتراوح ما بين 2,93 إلى 67,76 جرام لكل كيلوجرام.

كان كاتيون الصوديوم الذائب هو السائد وترتيب محتوى الكاتيونات الذائبه كالتالى :– الصوديوم > الكالسيوم> الماغنسيوم> البوتاسيوم وكان أنيون الكلوريد هو السائد فى الأراضى المدروسه وترتيب محتوى الأنيونات كالاتى:– الكلوريد> الكبريتات> البيكربونات أما أنيون الكربونات فكان غائباً.

وقد تبين من النتائج أن محتوى العناصر الصغرى والمستخلصه كيميائياً أن:– :– الحديد> المنجنيز> الزنك> النحاس > الكوبلت> الرصاص.

كما أوضحت النتائج أن الصور الكيميائيه لعنصر الكوبلت كالاتى :– الصوره الكليه > الصوره المتبقيه > الصوره المستخلصه كيميائياً > الصوره المرتبطه بالماده العضويه> الصوره المرتبطه بالحديدوالمنجنيز> الصوره المتبادله> الصوره المرتبطه بالكربونات>