CHROMIUM IN SOIL, WATER AND VEGETATION OF BAHR EL-BAKAR ENVIRONMENT, EGYPT: AN OVERVIEW

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S urface and subsurface soil samples were collected from ten soil profiles in Bahr EL-Bakar area, out of which two locations were selected to represent soils irrigated with drainage water and the rest was irrigated with Nile water. Samples of different species. Plant were randomly collected from the studied locations to represent natural vegetation and agronomic crops. Data revealed that the studied soils are clay loam to clay-textured, mostly saline-alkali.

The total content of Cr in soils ranges from 11.20 ppm to 43.48 ppm. The statistical analysis reveals that total Cr in soils surface is highly significant positively correlated with total Fe, positive significant with total Co while being significantly negative with total Cu and $SO_4^=$. In the subsurface layer, total Cr is highly significant positively correlated with total Fe, Co, and Ni and significantly positive with total Zn.

DTPA-extractable Cr content is quite low and varies widely from 0.01 to 0.30 ppm, being in the ranges of 0.02 - 0.30 and 0.01-0.14 ppm in soils irrigated with Nile water and those irrigated with drainage water, respectively. Statistically, DTPA- extractable Cr is highly significant positively correlated with extractable Zn, Co and Ni in both soil surface and subsurface layers and with extractable Fe in the subsurface layer while being significant in the top layer. In addition, DTPA-extractable Cr is significant positively correlated with fine sand in both soil layers. Moreover, DTPA- extractable Cr is highly significant positively correlated with EC, Ca^{++} , extractable Cu and Cd and significant positively correlated with Cl in the subsurface layer alone.

Availability index (Av. I.) showed that chemically extractable Cr constitutes 0.1 to 2.7 % in soils irrigated with Nile water while being less pronounced, 0.1 to 0.7 % in soils irrigated with combined drainage water.

The chemical evaluation of water quality showed that most of the studied water samples are marginal for irrigation of some crops. The highest total concentrations are usually in combined drainage water except for Cr, which displayed their highest concentrations in some Nile water samples.

The Cr content of some field crops, vegetables and fodder crops as well as one aquatic plant (Barnyard grass) grown in the studied soils varies considerably from one crop to another and even in the same crop.

Keywords: Chromium, soil, water, vegetation, Bahr El-Bakar, Egypt.

Chromium is the 7th most abundant element in the earth, but 21st in abundance in the crystal rocks. The medical and veterinary factual information indicated that Cr is an essential element for human being and animals (Iyengar,1989 and Anderson, 1989) but there is no doubt that Cr^{6+} compounds are both acutely and chronically tóxic. From the health point of view, Cr plays a role in the so- called glucose - tolerance factor and prevent diabetes as its activity is related to that of insulin, in addition no damages induced by excessive Cr levels have been reported (Pendias and Pendias, 1992).

The soil Cr is mainly inherited from the parent rocks and therefore its higher content is found in soils derived from volcanic rocks (Pendias and Pendias, 1992). Soils contain from as little as 5 ppm to as much as several percent of Cr and supply it in trace to toxic amounts to plants (Pratt, 1966; Baker and Chesnin,1975;Shewry and Peterson,1976). The Cr content of surface soil increases due to pollution from various sources, of which the main ones are industrial wastes, municipal sewage sludge and other anthropogenic sources which are responsible for the elevated Cr content in plants, (Czarnowska,1974 ;Gough *et al.,*1988 and Kitagishi and Yamane, 1981). The behaviour of soil Cr has been extensively studied by Bloomfield and Pruden (1980) who showed that most soil Cr occurs as Cr^{3+} and being within the mineral structures or forms of mixed Cr^{3+} and Fe^{3+} oxides which are relatively unavailable and insoluble while Cr^{6+} is considerably more soluble than Cr^{3+}.

The Cr content of plants has received much attention since the discovery of Schroeder *et al.* (1962) that Cr participates in glucose and cholesterol metabolism, and therefore, it is essential to man and animals. Plant species differ significantly in Cr uptake capacity and distribution within the plant (Grubinger *et al.,* 1994) and dicots might be reasonable target species for Cr hyperaccumulation.

Due to the lack of information about Cr in soil, water, food and feed crops in Egypt, it is realized that this trace metal should be thoroughly

investigated. Therefore, the current work is devoted to study Cr in soils, water and plants in Bahr El- Bakar area.

MATERIALS AND METHODS

Surface and subsurface soil samples (0-20 and 20-40 cm, respectively) were collected from ten soil profiles at Bahr EL-Bakar area (Fig.1). Ten water samples were collected to represent drainage and irrigation waters used for irrigating soils in the studied area. In addition, 15 plant samples were randomly collected to represent natural vegetations and agronomic crops in the area. These concluded watermelon (*Citullus vulgaris*), rice seedlings (*Oryza sativa*), napier grass (*Pinnestum purpurium*), corn (*Zea mays*), barnyard grass (*Panicum cms galli*), vegetable marrow (*Cucurbita pepo*) and eggplant (*Solanum melongena*).

Soil analysis

Determination of some physical and chemical properties of the collected soils were performed as follows:

Mechanical analysis using the pipette method with sodium hexametaphosphate as a dispersing agent (Black,1965). Organic matter content was determined according to the method outlined by Jackson (1973). Soil reaction (pH) was determined with a glass electrode pH-meter in 1 : 2.5 soil water suspension.Total soluble salts were estimated conductimetrically as EC in the water-saturated soil paste extract according to Jackson (1973). Cationic and anionic compositions of the soil saturation extract were determined as described by Richards (1954). Cation exchange capacity and exchangeable sodium were determined according to Jackson (1973).Total heavy metals; Fe, Mn, Cu, Zn, Cd, Pb, Cr, Ni and Co in soil were determined by the Ionic Coupled Plasma (POEMS III Thermo Jarrell Ash) after digestion of the samples with a ternary acids mixture of HNO3, H_2SO_4 and $HClO_4$. Chemically - extractable heavy metals; Fe, Mn, Cu, Zn, Cd, Pb, Cr, Ni and Co were extracted from soils by DTPA reagent (Lindsay and Norvell,1978) and determined by Ionic Coupled Plasma (POEMS III Thermo Jarrell Ash).

Water analysis

EC, pH, soluble cations (Na^+, K^+, Ca^{++}, Mg^{++}), soluble anions ($CO_3^=$, HCO_3^-, Cl^-, $SO_4^=$) in water samples were determined as already mentioned for the soil extract. Heavy metals content of water were examined as outlined by APHA (1992) and determined by Ionic Coupled Plasma (POEMS III Thermo Jarrell Ash) .

Plant analysis

The plant samples (aerial parts and roots) were thoroughly washed with tap water followed by distilled water and oven- dried at 70 °C for 48 hrs., fresh and dry weights were recorded. These samples were wet -digested

by H_2O_2 and H_2SO_4 (Nicholson,1984) and the heavy metals; Fe, Mn, Cu, Zn, Cd, Pb, Cr, Ni and Co were determined by Ionic Coupled Plasma (POEMS III Thermo Jarrell Ash).

The obtained data were subjected to the statistical analysis according to Snedecor and Cochran (1982). Using "Costat program" simple correlation and regression analysis were also computed.
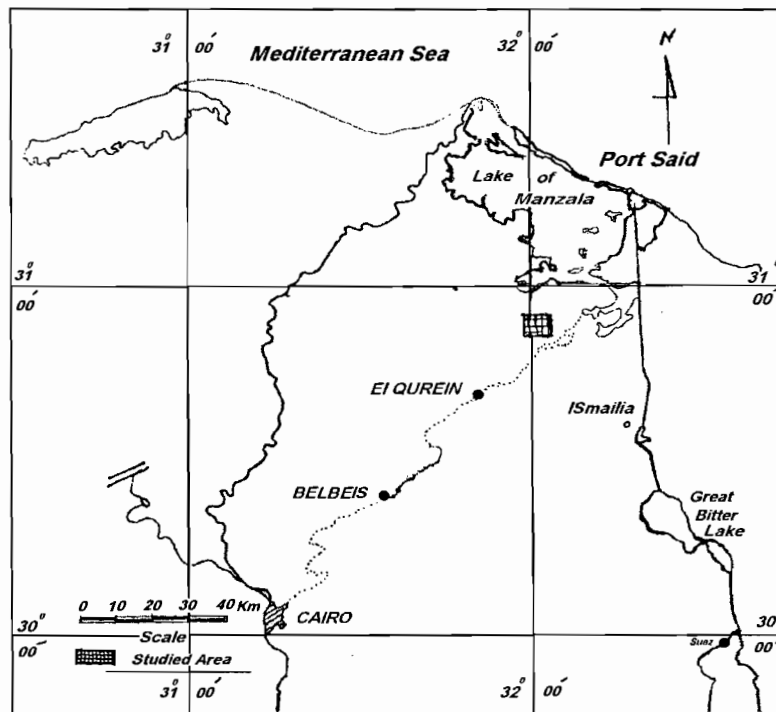

Fig. (1).Location map of the studied area

RESULTS AND DISCUSSION

Soil Characteristics

Analytical data (Tables, 1a and 1b) showed that most of the soil samples are clay-textured, except the subsurface layers of profiles 2, 4, and 5 and the surface layer of profile 6, as well as profiles 8 and 9 which are clay loam. Saturation percentage (SP) ranged from 70 to 110 % and cation exchange capacity (CEC) varied from 26.63 to 47.82 me / 100 g soil. The high values of SP and CEC reflect the medium to heavy texture of the studied soils.

Organic matter contents are generally low (0.6 to 2.5 %). Salinity of the saturation extract, as evidenced by the EC values, is commonly highly saline (CE ~ 5 to 32.6 dS/m) except for layers of profile 1 that are slightly saline (EC = 2.79 - 3.00 dS/m). Values of soil pH ranged from 7.8 to 8.8,

indicating that the soils are slightly alkaline to alkaline. ESP values varied widely from as low as 18.88 up to 67.14 %. When ESP is combined with the other soil parameters (pH and EC), it indicates that these soils are mostly saline - alkaline. The cationic composition of soluble salts is mostly dominated by Na $^+$ followed by Ca $^{2+}$ and/or Mg $^{2+}$, then K $^+$ is the least cation. Soluble anions are mostly dominated by Cl $^-$ followed by SO_4^{2-}/ HCO_3^- and CO_3^{2-}. The total contents of Co, Pb and Cd ranged from 16.35 to 45.73 ppm, from 36.00 to 138.20 ppm and from 3.11 to 5.05 ppm, respectively. Their DTPA-extractable contents varied from 0.07 to 0.55 ppm, 1.50 to 4.20 ppm and from 0.001 to 0.04 ppm, respectively.

Micronutrients (Fe, Mn, Zn, Cu and Ni) contents in soils varied widely either with regard to their total or DTP A- extractable contents, but it seems that the soils are well-supplied with these essential elements.

1-Total chromium

Data presented in table (2) showed that the total content of Cr in the studied soils varies from 11.2 to 43.48 ppm, being in the ranges of 11.2 - 25.52 and 14.32 - 43.48 ppm in soils irrigated with Nile water and those irrigated with combined drainage water, respectively. The lowest and highest Cr contents are found in the subsurface layers (20 - 40 cm) of clay loam texture. The weighted mean of total Cr ranges from 14.11 to 24.61 ppm in soils irrigated with Nile water while being relatively higher (16.80 - 29.05 ppm) in soils irrigated with combined drainage water (profiles 7 and 9). This is expected since the combined drainage water is usually enriched with numerous heavy metals. It is also clear that Cr is either accumulated in the top soil surface layer or in the subsoil layer depending on soil characteristics. Several studies showed that Cr may accumulate in the top soil layer or in subsoil layer depending on soil origin, soil management practices, cultivated crops and irrigation water type, (Groove and Ellis, 1980; Pier *et al.,* 1992 and Pendias and Pendias, 1992).

Accordingly, the Nile alluvial soils of the studied locations are inherited from non - serpentine parent material impoverished in Cr and this is reflected on its content in soils. Moreover, additional sources of Cr (i.e., electroplating sludge, Cr pigment, tannery wastes, leather manufacturing wastes) are negligible; therefore most Cr determined in soils is mainly rendered to soil parent material rather than pollution source (Palmer and Wittbrodt, 1991; Schwarz *et al.,* 1999). Nevertheless, a very minor part of the total Cr is soluble, thus strongly restricting plant availability of Cr and its uptake.

To figure out the relationship between total Cr and soil variables (Tables 1 and 2) the data are evaluated statistically according to Snedecor and Cochran (1982) using "Costat program" where simple correlation and regression analysis are computed.

TABLE (1a). The percentages of particle size distribution of the studied soils.

| Depth (cm) | Particle size distribution (%) | | | | |
	CS	FS	Si	C	Texture Class
0- 20	0.32	6.88	20.63	72.17	Clay
20-40	0.62	17.14	31.25	50.99	Clay
0- 20	0.63	11.30	24.08	64 .00	Clay
20-40	1.27	27.79	35.04	35.90	Clay Loam
0- 20	0.60	11.32	20.99	67.09	Clay
20-40	1.36	21.12	32.12	45.40	Clay
0- 20	5.56	31.03	18.29	45.12	Clay
20-40	0.95	38.05	21.58	39.42	Clay Loam
0- 20	1.40	19.35	25.08	54.17	Clay
20-40	2.51	32.55	34.90	30.04	Clay Loam
0- 20	2.11	39.47	23.50	34.92	Clay loam
20-40	2.80	29.26	25.45	42.49	Clay
0- 20	14.55	24.56	12.85 22.43	48.04	Clay
20-40	1.22	10.56		65.79	Clay
0- 20	2.26	31.76	28.24	37.74	Clay loam
20-40	4.21	37.62	24.16	34.01	Clay loam
0- 20	2.03	41.61	24.52	31.84	Clay loam
20-40	2.09	42.43	17.34	38.14	Clay loam
0- 20	1.75	11.60	22.80	63.85	Clay
20-40	1.04	5.25	61.66	32.05	Silty clay loam

CS= coarse sand (2 - 0.2 mm)   FS= fine sand (0.2 - 0.02 mm)
Si= silt (0 02 - 0.002 mm)   C= clay (< 0.002 mm)

The statistical analysis reveals that total Cr in both soil surface (0-20 cm) and subsurface (20-40 cm) layers are significant to highly significant positively correlated with total Co (r=0.643 and 0.886 respectively, significant positively correlated with total Fe (r= 0.794 and 0.769 respectively), while being significant negatively correlated with total Cu (r = -0.629) and $SO_4^=$ (r = -0.691) in the top layer and significant positively correlated with total Zn (r = 0.671) and total Ni (r = 0.704) in the subsurface layer. Other relations of total Cr with soil variables are non significant. The obtained regression equations for the significant relations are presented on figs. (2-9).

From the regression equations, one can conclude that each increase of 1 ppm of total Fe and Co is associated with (0.003 and 0.006 ppm), (0.6727 and 0.9753 ppm) increase in total Cr of the soil surface and subsurface layers, respectively. Moreover, each increase of 1 ppm total Cu and soluble $SO_4^=$ corresponds to a decrease of total Cr in the surface layer by 0.0967 ppm and 0.1093 ppm. In contrast, the increase of 1 ppm total Zn and Ni in the subsurface soil is met with 0.4574 and 0.3888 ppm of total Cr. These associations are expected to be mainly rendered to soil parent material with slight modifications due to soil formation processes since the studied soils are young from the pedological view point. It is also evident that total Cr either in the surface or subsurface is strongly associated with total Co followed by Zn and Ni in the subsurface layer while the association of total

Cr and total Fe whether in the top soil surface or in the layer beneath is of less pronounced magnitude.

TABLE (1b). Chemical composition of the saturation extract of the studied soils.

Profile No.	Depth (cm)	O.M	SP	pH in paste	EC dS/m	Na⁺	K⁺	Ca⁺⁺	Mg⁺⁺	CO⁺⁺₃	HCO⁻₃	Cl⁻	SO₄⁼	CEC me/100 g. soil	ESP
1	0-20	2.5	110.0	8.3	3.0	16.6	1.4	13.0	4.5	0.4	1.9	17.5	15.7	47.3	18.9
	20-40	2.4	85.0	8.4	2.8	10.0	0.9	12.0	3.5	0.6	1.6	17.5	6.7	47.8	20.7
2	0-20	1.3	87.0	8.4	11.9	67.9	2.8	50.5	9.5	0.2	0.5	56.0	74.0	46.7	47.4
	20-40	1.7	89.5	8.5	9.1	62.6	2.3	30.0	14.0	0.2	1.1	66.0	41.6	38.0	60.7
3	0-20	0.6	91.5	8.8	5.2	23.9	0.8	31.0	2.0	0.2	1.2	28.0	28.3	38.0	59.4
	20-40	1.1	90.0	8.8	6.1	27.2	1.1	31.5	3.5	0.6	1.2	44.5	16.3	41.3	57.2
4	0-20	2.2	77.4	7.9	15.9	70.0	1.6	67.0	14.0	0.8	2.1	85.0	17.0	39.1	52.1
	20-40	1.8	75.0	8.3	32.1	150.0	2.1	152.5	35.0	0.6	1.1	200.0	137.9	36.4	47.0
5	0-20	1.8	72.5	8.5	10.8	43.5	1.7	64.0	8.5	0.5	1.7	67.0	48.5	36.4	56.7
	20-40	1.5	70.0	8.7	5.9	30.0	2.0	21.0	3.5	0.6	2.2	30.0	23.7	32.1	60.6
6	0-20	1.9	70.0	8.3	11.2	81.3	1.7	26.0	10.0	0.2	1.8	80.0	37.0	35.9	54.1
	20-40	1.9	85.0	8.5	6.3	38.3	1.7	22.5	4.5	1.0	1.9	31.5	32.5	32.6	31.0
7	0-20	1.2	75.0	8.7	5.2	28.7	1.6	25.0	7.0	0.4	0.7	29.0	32.2	35.9	37.0
	20-40	1.6	85.0	8.5	11.5	73.5	3.0	61.5	15.5	0.2	0.9	59.0	93.3	26.6	67.1
8	0-20	1.5	85.0	8.4	5.5	32.2	0.0	21.0	6.0	0.6	1.1	41.0	16.5	39.7	25.0
	20-40	2.2	75.0	8.0	6.0	27.0	3.3	23.0	6.0	0.6	2.0	43.0	13.7	36.4	31.1
9	0-20	1.6	78.0	8.0	32.6	205.0	11.3	122.5	23.5	0.2	1.2	267.0	93.9	34.2	35.2
	20-40	1.6	70.0	8.2	26.0	158.7	6.0	87.0	28.0	0.8	1.6	214.0	57.9	32.6	38.9
10	0-20	1.7	75.0	7.8	7.5	40.4	1.9	26.5	13.5	0.6	2.2	59.5	20.0	32.1	34.2
	20-40	1.3	72.5	8.5	18.2	107.0	0.4	55.0	22.5	0.2	0.6	99.0	85.1	31.0	51.8

O.M = Organic matter   SP = Saturation %   CES = Cation-exchange-capacity

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TABLE (2). Total heavy metals content (ppm) in the soils of the studied area.

Profile No.	Depth (cm)	Fe	Mn	Zn	Cu	Co	Ni	Pb	Cd	Cr
1	0-20	31690	126.41	95.70	22.52	24.95	31.94	40.08	4.02	24.95
	20-40	51700	125.28	90.77	24.82	28.51	48.56	36.00	5.05	21.04
2	0-20	15440	272.50	71.44	38.98	20.35	33.69	39.22	4.42	13.75
	20-40	29860	160.26	91.84	25.60	30.74	48.04	38.92	4.81	23.65
3	0-20	22650	222.34	74.42	23.82	19.83	17.72	138.21	4.77	17.80
	20-40	31140	121.72	69.58	25.82	21.76	20.83	36.42	4.65	27.71
4	0-20	28470	116.26	69.50	29.88	22.57	14.11	39.18	4.42	22.02
	20-40	15090	251.09	49.97	57.94	16.35	9.36	39.37	4.69	11.20
5	0-20	21720	128.52	83.89	61.08	21.78	25.72	39.92	4.31	15.44
	20-40	24320	130.11	74.57	24.14	23.22	27.28	45.27	4.00	18.22
6	0-20	29780	219.08	71.39	29.18	26.02	20.95	40.18	4.85	23.38
	20-40	25970	130.81	68.86	29.93	22.21	26.69	38.07	5.01	18.67
7	0-20	26230	284.56	82.49	72.30	23.70	33.88	36.02	4.09	19.28
	20-40	16760	230.62	73.28	96.25	21.17	34.58	107.49	3.82	14.32
8	0-20	51200	126.62	84.48	30.83	33.98	53.75	36.17	3.85	23.70
	20-40	32570	256.47	85.84	32.60	34.08	51.12	51.81	3.78	25.52
9	0-20	20460	256.47	85.50	76.94	22.15	27.67	57.14	3.71	14.63
	20-40	49540	261.88	95.58	28.22	45.73	67.22	59.12	3.11	43.48
10	0-20	17700	268.76	86.49	101.47	23.76	38.00	71.06	3.75	15.39
	20-40	15630	240.67	74.32	129.31	21.66	35.94	84.12	4.05	12.82

2- DTPA - extractable chromium

The amount of DTPA - extractable amounts of Cr from the studied soils are shown in table (3). These data reveal that the DTPA- extractable Cr varies widely from 0.01 to 0.30 ppm, being in the ranges of 0.01 - 0.30 and 0.01 - 0.12 ppm in soils irrigated with Nile water and those irrigated with drainage water, respectively.

The highest content is associated with soils of the subsurface layer (20 - 40cm) of profile 4, while the lowest content is that of the subsurface layer of profile 7. The weighted mean of extractable Cr ranges from 0.025 to 0.145 and 0.015 to 0.110 ppm in soils irrigated with Nile water and those irrigated with combined drainage water, respectively. This means that DTPA - extractable Cr is seemingly higher in soils irrigated with Nile water, or soils under Nile water irrigation provides more available Cr to the grown plants. Thus, Nile water coincided with soil properties stimulate more available Cr than combined drainage water does. It is also apparent that the amount of DTPA- extractable Cr from the top soil surface (0 - 20 cm depth) exceeds that of the subsurface layer, at least in 70 % of the studied soils. This is expected on light of the soil variables controlling Cr availability in the top layer, particularly oxidation of Cr^{3+} to Cr^{6+} which is known by its

higher solubility and the possible occurrence of organically -bound form of Cr which is expected to be superior in the top soil layer. On the contrary, the heavy texture of the subsurface layer decreases aeration and consequently minimizes oxidation of Cr^{3+} to Cr^{6+}. Also, organic matter content is considerably low, thus organically - bound Cr form is of lower magnitude. This finding stands in agreement with Mohamed (1998) who found that the vertical distribution of extractable Cr in El- Gabal EL- Asfar farm showed a relative increase of Cr in the top surface layers and indicated statistically that extractable Cr displayed a significant negative correlation with soil depth.

To substantiate the relationship between DTPA- extractable Cr and some soil variables, correlation coefficients and regression analysis were computed. The obtained coefficients indicate that DTPA- extractable Cr from both surface and subsurface soil layers is significant positively correlated with fine sand (r =0.601 and 0.648, respectively) and highly significant positively correlated with extractable Zn (r = 0.719 and 0.757, respectively), Co (r = 0.756 and 0.868, respectively) and Ni (r = 0.805 and 0.924, respectively) from the soil surface and subsurface layers, respectively. Extractable Cr is also significant positively correlated with extractable Fe (r = 0.696) of the soil top layers while being highly significant positively correlated with extractable Fe (r = 0.951) of the subsurface layers. Moreover, extractable Cr of the subsurface layers is significant positively correlated with EC (r = 0.679), soluble Cl⁻ (r = 0.661), extractable Cd (r = 0.702) and highly significant positively correlated with soluble Ca (r = 0.767) and extractable Cu (r = 0.734). In other words, the extractable Cr from the top layers displayed only 5 significant correlations (with fine sand, Fe, Zn, Co and Ni) that are unique in both soil layers while Cr in the subsurface layers displayed further correlations with soil salinity and some of its major components (Ca^{++} and Cl⁻) beside extractable Cu and Cd. Other relations of extractable Cr with soil variables are statistically insignificant. For convenience, the obtained regression equations for the significant relations are recorded on figs.(10 – 24).

Based on the abovementioned statistical evaluation, one can conclude that fine sand is highly significant positively correlated with extractable Cr from both soil layers and each increase in fine sand will increase extractable Cr by 0.003 - 0.005 ppm. This confirms that Cr oxidation enhanced by fine sand stimulates the transfer of Cr^{3+} having minor solubility to Cr^{6+} which is readily soluble. Align with this, Fe which is positive highly significant or significant with extractable Cr, plays a pronounced role in Cr^{3+} oxidation and 1 ppm of Fe will increase extractable Cr from the surface and subsurface layers by 0.002 and 0.006 ppm, respectively. Moreover, the role of soil salinity, soluble Ca^{++} and Cl⁻ in increasing extractable Cr through increasing its solubility could not be ignored. Furthermore, the contribution of other
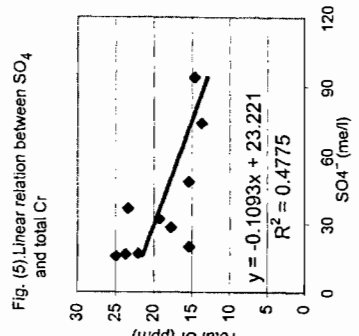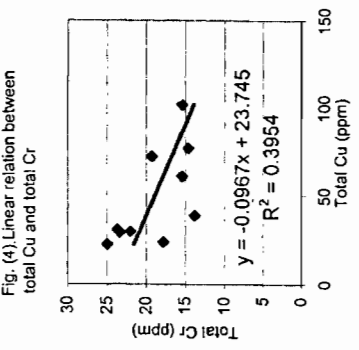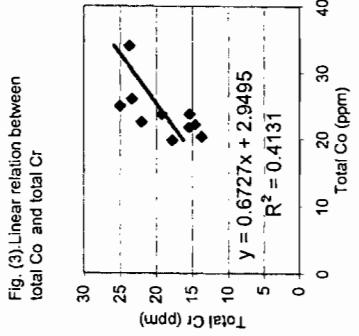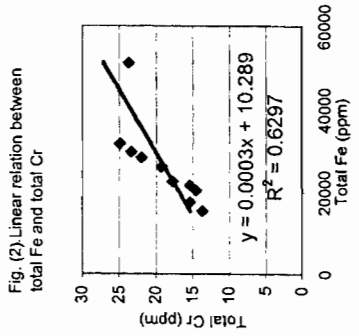
extractable heavy metals to the increase of DTPA - extractable Cr could be arranged in the descending order: Cd, Co, Ni, Cu, Zn. Noteworthy to mention that the prominent role of the associations (Co and Ni) and (Cu and Zn) in stimulating Cr extractability clarifies that those associations in soils have, to a certain extent, unique behaviour. The very low content of soil organic matter and the narrow range of pH did not clarify their significance in increasing Cr extractability in case of organic matter and hindering its extractability in case of pH. Nevertheless, their role in controlling Cr availability and extractability could not entirely precluded. Likewise, the exchange of Cr^{3+} and Cr^{6+} as cation or anion on the negative and positive charges of clay surface, though of very small magnitude, yet it can not be excluded completely as a factor contributing to extractable Cr.

TABLE (3). The amounts of DTPA- extractable heavy metals from the soils of the studied area (ppm).
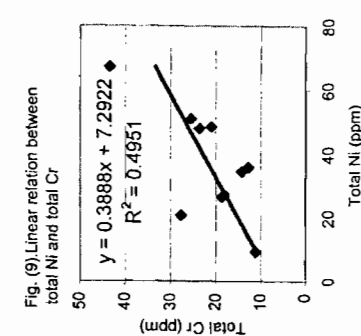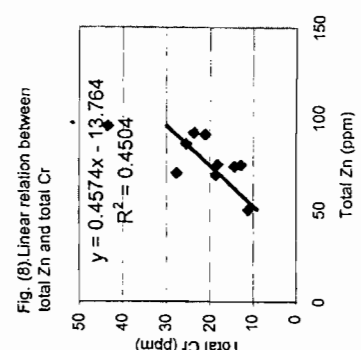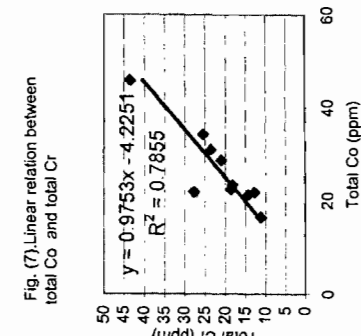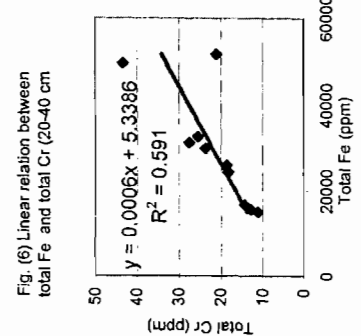
Profile No.	Depth (cm)	Fe	Mn	Zn	Cu	Co	Ni	Pb	Cd	Cr
1	0-20	33.80	18.46	8.03	2.15	0.20	0.62	3.80	0.02	0.05
	20-40	28.94	14.92	6.31	1.77	0.12	0.42	3.10	0.02	0.04
2	0-20	19.74	18.76	4.63	1.27	0.10	0.26	2.30	0.01	0.02
	20-40	21.16	17.46	5.47	1.35	0.12	0.27	2.30	0.02	0.03
3	0-20	22.42	15.92	5.25	0.89	0.20	0.39	2.20	0.01	0.06
	20-40	25.56	13.80	4.40	0.86	0.11	0.32	2.00	0.01	0.06
4	0-20	70.22	29.92	9.60	2.53	0.55	1.28	3.60	0.02	0.20
	20-40	69.78	21.80	7.96	2.52	0.51	1.34	2.70	0.04	0.30
5	0-20	25.76	18.40	5.78	2.69	0.23	0.44	4.20	0.01	0.06
	20-40	26.30	16.24	5.94	1.45	0.24	0.39	3.10	0.01	0.03
6	0-20	40.24	13.84	5.07	1.29	0.15	0.53	2.20	0.02	0.09
	20-40	33.90	11.72	5.31	0.80	0.09	0.33	2.20	0.01	0.07
7	0-20	23.34	8.94	3.60	0.63	0.08	0.17	1.60	0.01	0.02
	20-40	20.36	8.34	3.47	0.57	0.07	0.17	1.50	0.01	0.01
8	0-20	58.64	19.82	8.19	1.19	0.22	0.58	2.40	0.00	0.15
	20-40	47.62	20.64	6.93	1.25	0.20	0.51	2.70	0.00	0.14
9	0-20	33.56	14.38	5.23	1.50	0.12	0.33	2.50	0.02	0.10
	20-40	30.00	6.30	5.10	1.47	0.13	0.32	2.40	0.02	0.12
10	0-20	65.22	22.92	7.00	1.02	0.25	0.54	2.90	0.01	0.04
	20-40	28.72	19.26	3.98	0.76	0.09	0.25	1.80	0.02	0.02

The relationship between DTPA-extractable Cr / total Cr (availability index) is worked out (table 4), and it was found that DTPA- extractable Cr constitutes 0.1 to 2.7 % of total Cr in soils irrigated with Nile water while being less pronounced (0.1 to 0.7 % of total Cr) in soils irrigated with combined drainage water. The highest percent (2.7 %) among the studied soils is strictly confined to the subsurface layer of profile 4 whereas the lowest one (0.1 %) is associated with the subsurface layer of profile 2 and the surface and subsurface layers of profile 7.

Linear relations of total Cr in the surface layers (0-20 cm soil depth).

Fig. (2). Linear relation between total Fe and total Cr

Fig. (3). Linear relation between total Co and total Cr

Fig. (4). Linear relation between total Cu and total Cr

Fig. (5). Linear relation between SO_4 and total Cr

$y = 0.0003x + 10.289$
$R^2 = 0.6297$

$y = 0.6727x + 2.9495$
$R^2 = 0.4131$

$y = -0.0967x + 23.745$
$R^2 = 0.3954$

$y = -0.1093x + 23.221$
$R^2 = 0.4775$

Linear relations of total Cr in the sub-surface layers (20-40 cm soil depth).

Fig. (6). Linear relation between total Fe and total Cr (20-40 cm

Fig. (7). Linear relation between total Co and total Cr

Fig. (8). Linear relation between total Zn and total Cr

Fig. (9). Linear relation between total Ni and total Cr

$y = 0.0006x + 5.3386$
$R^2 = 0.591$

$y = 0.9753x - 4.2251$
$R^2 = 0.7855$

$y = 0.4574x - 13.764$
$R^2 = 0.4504$

$y = 0.3888x + 7.2922$
$R^2 = 0.4951$

Linear relations of extractable Cr in the surface layers (0-20 cm soil depth).

Fig. (10).Linear relation between fine sand (%) and extractable Cr (ppm) at depth 0-20 cm with r = 0.623*

$y = 0.0028x + 0.0158$
$R^2 = 0.3614$

Fine sand (%)
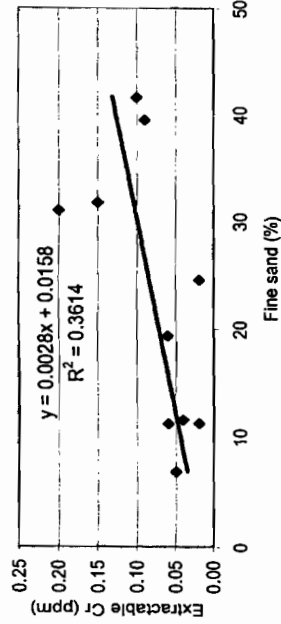
Extractable Cr (ppm)

Fig. (11).Linear relation between extractable Fe (ppm) and extractable Cr (ppm) at depth 0-20 cm with r =0.698*

$y = 0.0022x - 0.0056$
$R^2 = 0.4851$

Extractable Fe (ppm)

Extractable Cr (ppm)

Fig. (12).Linear relation between extractable Zn and extractable Cr

$y = 0.0221x - 0.0589$
$R^2 = 0.5173$
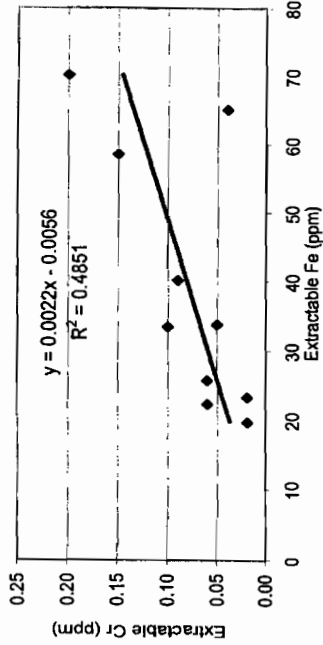
Extractable Zn (ppm)

Extractable Cr (ppm)

Fig. (13).Linear relation between extractable Co and extractable Cr
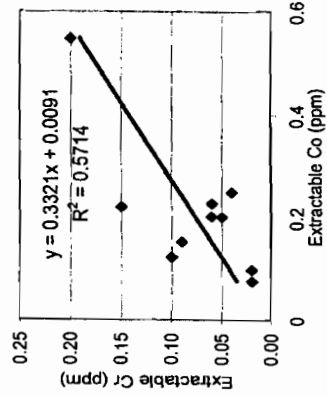
$y = 0.3321x + 0.0091$
$R^2 = 0.5714$

Extractable Co (ppm)

Extractable Cr (ppm)

Fig. (14).Linear relation between extractable Ni and extractable Cr

$y = 0.1532x + 0.0003$
$R^2 = 0.6474$

Extractable Ni (ppm)

Extractable Cr (ppm)

Linear relations of extractable Cr in the sub-surface layers (20-40 cm soil depth).

Fig. (15).Linear relation between fine sand and extractable Cr .

$y = -0.0046x - 0.0383$
$R^2 = 0.4205$
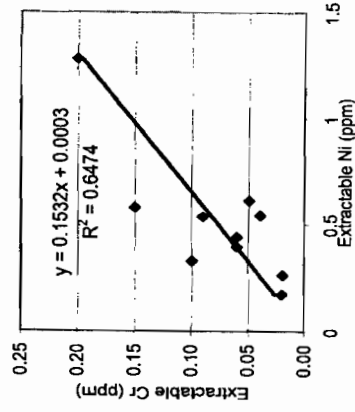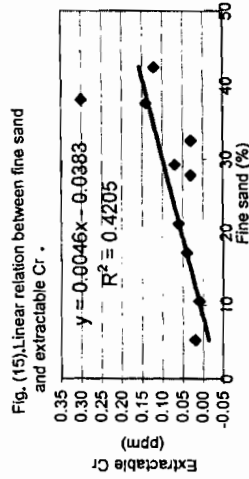
Fig. (16).Linear relation between EC and extractable Cr .

$y = 0.0061x + 0.007$
$R^2 = 0.4615$
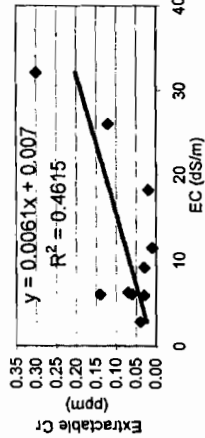
Fig. (17).Linear relation between Ca++ and extractable Cr .

$y = 0.0016x + 0.0043$
$R^2 = 0.5876$
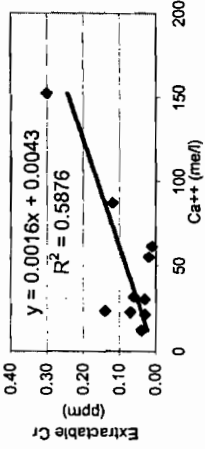
Fig. (18).Linear relation between Cl⁻ and extractable Cr .

$y = 0.0008x + 0.0159$
$R^2 = 0.4366$
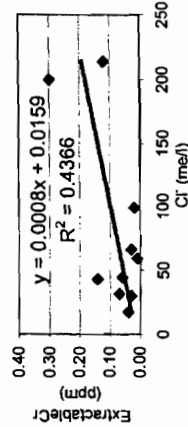
Fig. (19).Linear relation between extractable Fe and extractable Cr .

$y = 0.0056x - 0.1034$
$R^2 = 0.9044$
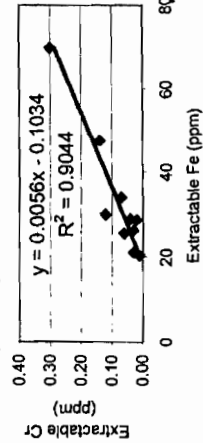
Fig. (20).Linear relation between extractable Zn and extractable Cr .

$y = 0.0486x - 0.1846$
$R^2 = 0.5737$
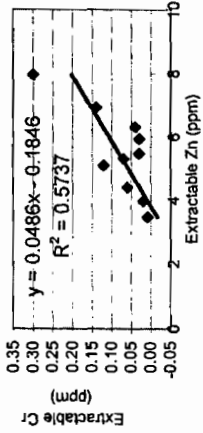
Fig. (21).Linear relation between extractable Cu and extractable Cr .

$y = 0.1124x - 0.0622$
$R^2 = 0.5526$
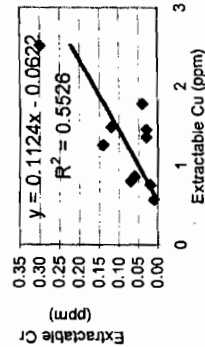
Fig. (22).Linear relation between extractable Co and extractable Cr .

$y = 0.5894x - 0.017$
$R^2 = 0.7537$
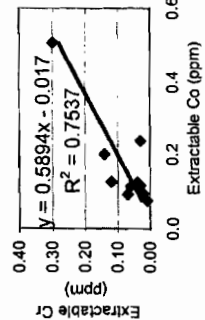
Fig. (23).Linear relation between extractable Ni and extractable Cr .

$y = 0.2435x - 0.023$
$R^2 = 0.8537$
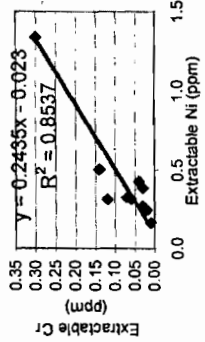
Fig. (24).Linear relation between extractable Cd and extractable Cr .

$y = 5.6598x + 0.0092$
$R^2 = 0.4931$
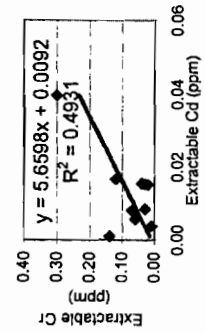
TABLE (4). Availability index of Cr (extractable as percent of total in the studied Soils).

Profile No.	Depth (cm)	Chemical Extr.*Cr (ppm)	Total Cr (ppm)	Av. I**
1	0-20	0.05	24.95	0.2
	20-40	0.04	21.04	0.2
2	0-20	0.02	13.75	0.1
	20-40	0.03	23.65	0.1
3	0-20	0.06	17.80	0.3
	20-40	0.06	27.71	0.2
4	0-20	0.20	22.02	0.9
	20-40	0.30	11.20	2.7
5	0-20	0.06	15.44	0.4
	20-40	0.03	18.22	0.2
6	0-20	0.09	23.38	0.4
	20-40	0.07	18.67	0.4
7	0-20	0.02	19.28	0.1
	20-40	0.01	14.32	0.1
8	0-20	0.15	23.70	0.6
	20-40	0.14	25.52	0.5
9	0-20	0.10	14.63	0.7
	20-40	0.12	43.48	0.3
10	0-20	0.04	15.39	0.3
	20-40	0.02	12.82	0.2

*Chemically extractable by DTPA
** Availability index

Water Quality and Suitability for Irrigation

From table (5), the following hydrochemical characteristics could be outlined:

1- The salinity varies widely from 1.28 dSm^{-1} in water sample No. (1) to 11.73 dSm^{-1} in water sample No. (10) with a mean value of 2.9 dSm^{-1}. Generally, water salinity increases from west to east. This may be attributed to the subsequent addition of sewage water to the Nile water. The pH values ranged between 8.1 and 8.6, indicating that the water samples are slightly alkaline to alkaline.

2- Concerning the major dominante ions and the chemical water type, they are generally defined on basis of cation and anion proportions. Referring to the hydrochemical formula shown in table (5), the investigated water samples are dominated by three different sequences as follows:

Table (5). Chemical analyses data of water samples in the studied area

Sample NO.	pH	EC dsm-1	TDS ppm		Ca++	Mg++	Na+	K+	HCO3-	CO3=	Cl-	SO4=	Hydrochemical formula	Na Cl	Na2 SO4	Na HCO3	Mg Cl2	Mg SO4	Mg(HCO3)2	Ca Cl2	Ca SO4	Ca (HCO3)2	SAR	RSC
1	8.19	1.28	816	ppm	84.296	39.06	395.83	16.00	324.93	39.336	375	330.24	$Cl_{44} SO_{4,29} HCO_{3,22} / Na_{71} Mg_{14} Ca_{13}$	44	29	0	0	0	14	0	0	13	9.58	0.18
				meq/l	3.21	3.25	17.21	0.41	5.33	1.31	10.58	6.88												
				%	13.30	13.50	71.50	1.70	22.00	5.00	44.00	29.00												
2	8.38	1.37	873	ppm	53.58	47.74	388.63	18.00	274.94	44.25	375.00	354.24	$Cl_{44} SO_{4,31} HCO_{3,25} / Na_{71} Mg_{17} Ca_{11}$	44	28	0	0	3	14	0	0	11	9.21	-0.67
				meq/l	2.68	3.98	16.81	0.46	4.51	1.48	10.56	7.38												
				%	11.20	16.60	70.10	1.90	18.80	6.20	44.10	30.80												
3	8.48	1.50	958	ppm	78.584	32.55	350.75	19.00	384.92	49.17	345.00	226.08	$Cl_{43} HCO_{3,36} SO_{4,21} / Na_{68} Ca_{18} Mg_{12}$	43	21	6	0	0	12	0	0	18	8.37	1.31
				meq/l	3.93	2.710	15.25	0.49	6.31	1.64	9.72	4.71												
				%	17.60	12.10	68.10	2.20	28.20	7.30	43.40	21.00												
4	8.42	1.46	936	ppm	53.58	32.55	359.72	19.00	249.95	29.502	390.00	261.60	$Cl_{51} HCO_{3,24} SO_{4,25} / Na_{75} Mg_{13} Ca_{12}$	51	24	0	0	1	12	0	0	12	9.53	-0.31
				meq/l	2.68	2.71	15.64	0.49	4.10	0.98	10.99	5.45												
				%	12.50	12.60	72.20	2.30	19.10	4.60	51.50	25.30												
5	8.48	1.57	1001	ppm	78.584	39.06	388.63	14.00	489.9	39.336	405.00	172.80	$Cl_{47} HCO_{3,33} SO_{4,15} / Na_{69} Ca_{16} Mg_{13}$	47	15	9	0	0	13	0	0	16	8.87	2.16
				meq/l	3.93	3.25	16.81	0.36	8.03	1.31	11.41	3.60												
				%	16.10	13.30	69.00	1.50	33.00	5.40	46.40	14.80												
6	8.45	1.62	1036	ppm	84.296	39.06	388.63	19.00	349.93	29.502	390.00	290.40	$Cl_{46} HCO_{3,25} SO_{4,25} / Na_{72} Mg_{14} Ca_{13}$	46	26	1	0	0	14	0	0	13	9.35	0.26
				meq/l	3.21	3.25	16.81	0.49	5.74	0.98	10.99	6.05												
				%	13.50	13.70	70.70	2.10	24.20	4.10	46.30	25.50												
7	8.60	3.07	1964	ppm	89.30	67.27	690.00	29.00	259.14	39.336	945	414.72	$Cl_{65} SO_{4,21} HCO_{3,10} / Na_{73} Mg_{14} Ca_{11}$	65	10	0	0	11	3	0	0	11	13.36	-4.52
				meq/l	4.47	5.61	30.00	0.74	4.25	1.31	26.62	8.64												
				%	11.00	13.70	73.50	1.80	10.40	3.20	65.20	21.20												
8	8.45	2.80	1792	ppm	78.584	71.607	611.57	25.00	287.94	25.568	900	298.08	$Cl_{68} SO_{4,17} HCO_{3,13} / Na_{72} Mg_{16} Ca_{11}$	68	5	0	0	12	4	0	0	11	11.95	-4.33
				meq/l	3.93	5.97	26.59	0.64	4.72	0.85	25.35	6.21												
				%	10.60	16.10	71.60	1.70	12.70	2.30	68.30	16.80												
9	8.52	11.73	7507	ppm	196.46	368.90	57.50	39.00	399.92	73.755	600.00	600.00	$Cl_{41} SO_{4,28} HCO_{3,20} / Mg_{70} Ca_{22} Na_{8}$	8	0	43	0	27	0	0	1	21	0.56	-31.54
				meq/l	9.82	30.74	2.50	1.00	6.56	2.46	22.54	12.50												
				%	22.30	69.70	5.60	2.30	14.90	5.60	51.20	28.40												
10	8.61	2.88	1843	ppm	85.728	78.12	638.48	29.00	374.92	44.253	930.00	261.60	$Cl_{67} HCO_{3,36} SO_{4,13} / Na_{72} Mg_{16} Ca_{11}$	67	6	0	0	7	9	0	0	11	11.95	-3.17
				meq/l	4.29	6.51	27.76	0.72	6.15	1.48	26.20	5.45												
				%	10.90	16.60	70.70	1.80	15.70	3.60	66.70	13.90												

$Cl^- > SO_4^= > HCO_3^- > Na^+ > Mg^{+2} > Ca^{+2}$ (about 40 %)

$Cl^- > HCO_3^- > SO_4^= / Na^+ > Mg^{+2} > Ca^{+2}$ (about 30 %)

$Cl^- > HCO_3^- > SO_4^= / Na^+ > Ca^{+2} > Mg^{+2}$ (about 20 %) .

These sequences clearly demonstrate that Cl⁻ dominates the anions while Na⁺ dominates the cations except in one case (water sample No. 9) where Mg^{++} is considerably higher than Na⁺. Consequently, the dominant chemical water types are HCO_3 - Ca, HCO_3 - Mg, Cl -Na and SO_4 -Na. Locally, the latter type may be related to the leaching of sediments rich in sulphate minerals or drainage water from industrial or agricultural activities.

The relationships between cations and anions percentages result in four main groups of hypothetical salt assemblages (Collin, 1923) as follows:
- NaCl, Na_2SO_4, Na HCO_3, Mg $(HCO_3)_2$, Ca $(HCO_3)_2$ (30 %)
- NaCl, Na_2SO_4, $MgSO_4$, Mg $(HCO_3)_2$, Ca $(HCO_3)_2$ (50 %)
- NaCl, Na_2SO_4, Mg $(HCO_3)_2$, Ca $(HCO_3)_2$ (10 %)
- NaCl, $MgCl_2$, Mg SO_4, Ca SO_4, Ca $(HCO_3)_2$ (10 %)

Considering the quality of water and its suitability for irrigation purpose, a number of classifications have been proposed. In this regard, FAO (1985) developed a set of guidelines for the interpretation of water quality. Applying this classification to the investigated water samples, it reveals that;

1- 70 % of the studied water samples, Nos. 1,2,4,6,7,8 and 10, have severe restrictions on use due to SAR and Cl⁻.

2- 50 % of the studied water samples, Nos. 1, 2, 6, 8 and 10, have slight to moderate restrictions on use due to salinity and HCO_3⁻.

3- 10 % of the studied water samples, No. 5, have slight to moderate restrictions due to salinity, SAR, and HCO_3⁻.

4- 10 % of the water samples, represented by the water sample No. 3, are considered suitable for irrigation as they have slight to moderate restrictions due to salinity, SAR, pH, Cl⁻ and HCO_3⁻.

5- 20 % of the water samples, Nos. 4 and 9, have none to slight restrictions due to salinity, SAR and HCO_3⁻.

6- 30% of the water samples, Nos. 5, 7 and 9, have none to moderate restrictions due to salinity, SAR, Cl⁻ and HCO_3⁻.

Richards (1954) provided a classification of water quality for irrigation based on sodium adsorption ratio (SAR) and the specific conductance (micromhos/cm). Applying this classification, to the studied water samples, reveals that two major water classes could be distinguished: C3-S2: most of the studied water samples, about 90 %, belong to this class. While only one water samples (No. 9) belongs to C3-S1. Both water classes can't be used on soils even with adequate drainage due to high salinity. Special management for salinity control may be required and plants with good salt tolerance should be selected. The water samples may cause an appreciable sodium hazard in fine-textured soils (such as the soils under study) having high cation exchange capacity, especially under low leaching conditions.

Eaton (1950) introduced the residual sodium carbonate (RSC) in water evaluation for irrigation purpose. It is defined as follows:

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+}) \text{ in me/l}$$

Considering the investigated water samples, the calculated RSC values are mostly negative, where the concentration of $(CO_3^= + HCO_3^-)$ is very low and never exceeds the concentration of $(Ca^{++} + Mg^{++})$. So such type of water belongs to the safe class for irrigation (RSC < 1.5 me/l).

In conclusion, the evaluation of water samples shows that most of the studied water samples are marginal for irrigation of some crops in the soils under investigation. However, it must be taken into account that a further irrigation with waste water, especially with increased utilization of contaminated sludge, could lead to a greater accumulation of pollutants, salinity and alkalinity in the soil and create health hazards.

Chromium Content in Irrigation Water

Table (6) presents the concentrations of Cr- in irrigation water from Nile canals and combined drainage source. These data reveal that Cr concentration ranged from 0.002 to 0.018 ppm. The highest concentration is in some Nile water samples (i. e., samples No. 3, 1 and 6 respectively). The variations encountered in Cr concentrations in the irrigation canals are mainly rendered to the contamination sources, which vary from one locality to another.

Comparing the total load of Cr added to soil from one liter irrigation water with the maximum permissible level of Cr in irrigation water (National Academy of Science and National Academy of Engineering, U. S. A., 1972), it is clear that all water samples has no restriction to be used for irrigation. However, the possible accumulation of Cr effect due to length of irrigation period may lead to hazardous effect unless availability of this trace metal in soils is controlled.

Chromium Content in Grown Plants

According to Page (1981), only a part of the total amount of heavy metals in soils is available to plants. In this regard, numerous investigations have showed that crop species differ significantly in heavy metals uptake, distribution within plants and transport to edible parts, and this is nearly dependent on several soil and plant factors. Nevertheless, in most cases and under optimum soil and plant conditions, available contents and, to some extent, total content of elements are expectedly reflected on their respective contents in grown plants but this is again disturbed depending on whether the element is essential to plant or not. Moreover, this rule is less valid in case of restricted plant growth (enrichment factor) or in case of vigorous growth (dilution factor).

TABLE (6). Total chromium content (mg/1) of water samples of the studied area.

Sample No.	Water type	Cr
1	Nile water	0.003
2	Nile water	0.006
3	Nile water	0.006
4	Nile water	0.008
5	Nile water	0.006
6	Nile water	0.018
7	Combined drainage	0.002
8	Nile water	0.009
9	Combined drainage	0.017
10	Nile water	0.004
Max. permissible Conc. in irrigation water (mg/1)*		0.100

* National Academy of Science and National Academy of Engineering water quality criteria, Washington, D. C. , U S A (1972).

Since food crops represent an important pathway for the movement of heavy metals from soils to humans (Harmsen, 1977), it is of interest to throw light on Cr content in plants grown in the studied soils in order to evaluate the potential risk, if any, from food crops.

Data set out in table (7) present the contents of Cr in some field crops, vegetables and fodder crops as well as one aquatic plant (Barnyard grass) grown in the studied soils. These data show that Cr content varies considerably from one crop to another and even in the same crop depending on the soil and plant factors as well as irrigation water type, fertilization scheme and management practices. In field crops, the highest Cr content (25.98 mg kg^{-1}) is that of rice seedlings grown in location 9 which is irrigated with combined drainage water while rice seedlings grown in locations 1 and 4 have comparatively of low Cr content (11.16 and 7.94 mg kg^{-1}, respectively). This indicates that rice grown in soils irrigated with combined drainage water (location 9) accumulated about 2-3 folds of Cr compared to those grown in the other two locations (1 and 4). Chromium content of corn plants varies widely even in soils irrigated with Nile water, being 6.95 and 2.71 mg kg^{-1} in plants grown in locations 3 and 8, respectively. This may be rendered to plant growth stage and soil characteristics enhancing Cr accumulation in the former location rather than the latter one.

Regarding vegetables, data show that Cr content in watermelon is quite low (1.46 and 1.82 mg kg^{-1}) in plants grown in both locations 1 and 5

irrigated with Nile water while being considerably high (7.70 and 6.27 mg kg^{-1}) in plants grown in location 3 irrigated with Nile water and in location 9 irrigated with combined drainage water. The increase of Cr content in watermelon grown in the latter locations may be explained on basis of the relative increase of DTPA- extractable or available Cr in soils of those locations as shown before. Other vegetables, i.e., vegetable marrow and eggplants grown in locations 5 and 8, respectively (irrigated with Nile water) accumulate Cr within the same range of magnitude where Cr content in vegetable marrow reached 5.88 mg kg^{-1} while being 4.52 and 6.56 mg kg^{-1} in eggplants.

As to grown fodder crops (Napier grass) they are grown in locations 2 and 6 irrigated with Nile water, however the accumulated Cr content varies considerably, being 5.94 and 9.12 mg kg^{-1} in plants grown in those locations, respectively. Again, this is rendered to soil extractable or available Cr, which is seemingly, lower in the former location (2) relative to the latter one (6).

With regard to the aquatic plant (Barnyard grass), which is grown jointly with rice in location 4, it also accumulates 5.53 mg kg^{-1} of Cr.

Based on the foregoing presentation, and in light of the data presented in table (7) it can be concluded that the grown plants which are irrigated by Nile water can be arranged according to their average Cr contents in the following order:

Rice > fodder (Napier grass) > vegetable marrow > eggplant (plant and eggapple) =Barnyard grass (aquatic plant) > Corn > watermelon.

TABLE (7). Chromium content in plants grown in the studied area.

Location	Irrigation Source	Grown plant		Cr (ppm)
1	Nile water	Watermelon Rice seedlings	(Citullus vulgaris) (Oryza sativa)	1.46 11.16
2	Nile water	Fodder (Napier grass)	(Pinnestum purpurium)	5.94
3	Nile water	Watermelon Corn	(Citullus vulgaris) (Zea mays)	0.77 6.95
4	Nile water	Rice seedlings Aquatic plant (Barnyard grass)	(Oryza sativa) (Panicum cms galli)	7.94 5.53
5	Nile water	Vegetable marrow Watermelon	(Cucurbita pepo) (Citullus vulgaris)	5.88 1.82
6	Nile water	Fodder (Napier grass)	(Pinnestum purpurium)	9.12
8	Nile water	Corn Eggplant Eggapple	(Zea mays) (Solanum melongena)	2.71 6.56 4.52
9	Combined drainage	Rice seedlings Watermelon	(Oryza sativa) (Citullus vulgaris)	25.98 6.27

Therefore, rice tends to accumulate Cr more than all grown plants encountered in the studied soils while watermelon and corn are the least accumulators of Cr.

The Cr in rice plants is mainly rendered to aquatic media of its roots which stimulates Cr availability together with growth stage, soil and plant factors which stimulates Cr availability, uptake, distribution, transport and accumulation in rice plants. This result disagrees with Grubinger *et al.* (1994) who mentioned that dicots are Cr hyperaccumulator.

Regarding the range of Cr in plants, Pendias and Pendias (1992) reported a range from 0.03 to 5 ppm while the range 5-30 ppm is considered as contaminated plants. Also, the toxic levels of Cr previously reported by Macnicol and Beckett (1985) are in the range of 1-10 ppm (D.W.). Accordingly, one can conclude that almost all the grown plants lie in the contaminated or toxic range according to Macnicol and Beckett (1985) and Pendias and Pendias (1992) and of poor quality because of the high contents of Cr (Mikula, 1996), except for corn and watermelon. Nevertheless, most of these grown plants have no phytotoxic concentration according to Davies *et al.* (1978), Gough *et al.* (1979) and Kitagishi and Yamane (1981).

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الكروم في الأرض والمياه والغطاء النباتي لبيئة بحر البقر – مصر (نظرة متعمقة)

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تناولت الدراسة حالة عنصر الكروم ومسلكه في عينات التربة السطحية وتحت السطحية لعشرة قطاعات أرضية ممثلة للمواقع التى تروى بمياه النيل وأيضاً مياه النيل المخلوطة بمياه الصرف. أوضحت النتائج أن الأراضى المدروسة ذات قوام طمي طيني إلى طيني والسعة التبادلية الكاتيونية للتربة مرتفعاً نوعاً. ومحتوى المادة العضوية للتربة منخفض وملوحة التربة مرتفعة فيما عدا قطاع رقم ١ والأراضي قلوية خفيفة إلي قلوية.

ويتراوح محتوي الكروم الكلي في التربة بين ١١,٢ و ٤٣,٤٨ جزء في المليون. وأظهرت النتائج تجمع الكروم في الطبقة السطحية للتربة او بالقرب منها تبعاً لمنشأ التربة ومادة الأصل وصفات التربة وعمليات الخدمة والمحاصيل المنزرعة ونوع مياه الري . كما قدر المحتوي الكلي والمستخلص كيميائياً لعناصر الحديد ، المنجنيز ، الزنك ، النحاس ، الكوبلت، النيكل ، الرصاص ، الكادميوم في الاراضي المدروسة. واظهر التحليل الإحصائي ان محتوي الكروم الكلي في الطبقة السطحية للتربة ذو ارتباط موجب المعنوية مع المحتوي الكلي للحديد ومعنوي موجب مع محتوي الكوبلت الكلي بينما يرتبط ارتباطا معنويا سالبا مع محتوي النحاس الكلي والكبريتات بينما يرتبط محتوي الكروم في الطبقة تحت السطحية للتربة ارتباطاً معنوياً موجبا مع الحديد والكوبلت والنيكل والزنك.

ويختلف محتوي الكروم المستخلص كيميائيا اختلافا واضحا إذ يكون ٠,٠٢ – ٠,٣ في الأراضي المروية بمياه النيل بينما يتراوح بين ٠,٠١ و ٠,١٤ في الأرض المروية بمياه الصرف المخلوطة . واظهر التحليل الإحصائي ان الكروم المستخلص كيميائيا يرتبط ارتباطا موجبا عالي المعنوية مع المحتوي المستخلص كيميائيا للزنك والكوبلت والنيكل في كلا الطبقتين السطحية وتحت السطحية للتربة وكذا الحديد المستخلص من الطبقة تحت السطحية بينما كان معنويا مع الحديد المستخلص من الطبقة السطحية. كما يرتبط الكروم المستخلص ارتباطا معنويا موجبا مع الرمل الناعم في الطبقة السطحية وتحت السطحية بينما يرتبط الكروم المستخلص ارتباطا معنويا موجبا مع الكلوريد الذائب في الطبقة تحت السطحية. ومعامل التيسر للكروم المستخلص كيميائيا يتراوح بين ٠,١ و ٢,٧ من المحتوي الكلي للكروم في الاراضي المروية بمياه النيل بينما يتراوح بين ٠,١ و ٠,٧ من الكروم الكلي في الاراضي المروية بمياه الصرف المخلوطة.

وبدراسة كيمياء المياه ومدي صلاحيتها للري في عشر عينات من المواقع المختلفة لمنطقة الدراسة تبين ان عينات المياه تحت الدراسة هامشية لري معظم المحاصيل. ويختلف محتوي العناصر الثقيلة بالمياه اختلافا واضحا وقد كان أعلي تركيز لهذه العناصر في المياه المخلوطة بمياه الصرف فيما عدا الكروم ، الرصاص ، النيكل الذي يزداد تركيزها في مياه النيل.

وقد تمت دراسة محتوي الكروم في بعض محاصيل الحقل والخضر والمراعي النامية في ١٥ عينة عشوائية بأراضي المنطقة المدروسة بالإضافة إلي النبات المائي الدنيبة الذي ينمو مع نبات الأرز . وبينت النتائج أن محتوي الكروم يختلف بدرجة واضحة من محصول لأخر بل وفي نفس المحصول.