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BASELINE DATA FOR SOME HEAVY METALS IN SOILS OF El-FERDAIN, EGYPT

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ABSTRACT: Seventy eight soil samples from 39 representative agricultural soil in El-Ferdain in west of Suez Canal were establish baseline concentration of Fe, Mn, Zn, Cu, Cd, Ni and Pb. The total and available content of heavy metals was determined. Geometric means and ranges (in brackets) of the total element concentrations in soils studied were (mg/kg, dry wt.): Fe 4640 (1025-28903), Mn 201.60 (173.44-357.54), Zn 39.47 (29.05-75.39), Cu 14.64 (9.51-39.98), Cd 1.25 (0.33-6.73), Ni 2.55 (0.29-14.86) and Pb 1.68 (0.59-11.95). While, the baseline values for heavy metals in soils studied were (mg/kg, dry wt.): Fe 605-35595; Mn 102.85-395.13; Zn 16.89-92.39; Cu 5.37-39.85; Cd 0.270-5.778; Ni 0.737-8.821 and Pb 0.342-8.251. Therefore, baseline concentrations of heavy metals in soils are proposed to be used as the reference values for the evaluation of soil contaminated by heavy metals. The expected ranges of Cd, Ni and Pb contents of the studied soils were markedly higher than the observed concentrations. The highly expected range of Cd, Ni and Pb reflects a significant anthropogenic impact on its concentration in topsoils. Baseline of Cd, Ni and Pb content of surface soils show an increase of the metal in the south-east part of El-Ferdain soils. According to pollution class of heavy metals in surface soil samples, the data of pollution class level revealed that the tested surface soils: Cd, 69.23, 25.64; Ni, 92.3, 7.73; Pb 87.17, 12.83% were in class 2 (light pollution), and class 3 (moderate pollution), respectively, but only 5.13% of pollution level of Cd in class 4 (heavy pollution). The pollution level of other elements in tested soils (Zn and Cu) was in class 2 (light pollution). The biological absorption coefficient (BAC) was calculated in order to relate elemental content in soil to plant uptake. Essential elements (Fe, Mn, and Zn) present higher BAC values than non essential ones (Cd, Ni and Pb), and they decrease logarithmically with increasing soil elemental concentrations,

suggesting that plants are able to control essential mineral uptake. This suggests that Fe, Mn and Zn were more available to plants under the prevailing conditions.

INTRODUCTION

Trace elements have received increasing attention in recent years in Egypt. Many questions arise concerning their presence in soils, plants, water, and the food chain. Information concerning trace element distribution in the environment, micronutrients uptake by plants, and the relationships with human health, however, is still lacking in several countries.

Existing data on elemental concentrations in soils and plants are widely scattered in the literature, and usually refer to only a few elements. Pb, Cd, Zn, Cu, Cr, and Ni are the most studied, since some of them are toxic to humans, while others may by phyototoxic or induce deficiency symptoms in cultivated plants (Angelone and Bini, 1992).

Baseline elemental composition data are considered to be useful in environmental geochemistry primarily in assessing current biogeochemical conditions as a base for evaluation of changes in cycling of elements, and of possible future alterations. Baseline values in element composition of plant and soil samples throughout the world are the foremost prerequisite in establishing reliable worldwide distribution of the element concentrations in various environmental settings (Kabata-Pendias and Dudka,1991, and Dudka, 1993).

The aim of this work is to investigate the baseline data for ranges, heavy metals (Fe, Mn, Zn, Cu, Cd, Ni and Pb), descriptive statistics of soil contamination by heavy metals and their status in agricultural new reclaimed soils in El-Ferdain under wheat cultivation.

MATERIALS AND METHODS

In order to study the baseline data of heavy metals (Fe, Mn, Zn, Cu, Cd, Ni and Pb) in agricultural soils in El-Ferdain, 39 representative soils were selected from El-Ferdain soil under wheat cultivation.

Surface soil samples (0-10 cm) and subsurface ones (10-30 cm) were collected from 39 locations in agricultural soils in El-Ferdain.. Soil sampling was replicated three times at the two depth for every site.

The soil samples were mixed in the field, air dried at the room temperature (about 20 to 25 °C), then crushed with a wooded hammer and roller. After that soil samples were passed through a 2 mm sieve and mixed thoroughly in a plastic bag, and then stored in a plastic container.

The soil samples were digested with concentrated H_2SO_4, HNO_3, and $HClO_4$. The total content of Fe, Mn, Zn, Cu, Cd, Ni, and Pb were determined according to Hesse (1963).

Also, chemically extracted amounts of trace element were carried out by DTPA solution according to Lindsay and Norvell (1978). The available and total of these trace elements were measured by Atomic absorption spectrophotometer (HGA-5000 graphite furnace).

Particle size distribution was carried out according to Piper (1950). Bulk density was determined according to the core method as described by Blake (1986).

The water extract components were determined in the soil paste extract, and the following determinations were carried out using the standard methods of analysis according to Jackson (1969). The total soluble salts were determined electrical conductivity. Soil reaction (pH) was determined in the soil paste, according to Richards (1954). Collin's calcimeter was used for $CaCO_3$ determination according to Wright (1939).

Plant samples of wheat grain were taken at the full maturity phase from plants grown on the studied locations, air dried and oven dried. One gram of wheat grain material was digested with a mixture of concentrated H_2SO_4 HNO_3, and $HClO_4$ acids as described by Jackson (1967). Then trace element were determined using the Atomic absorption spectrophotometry (HGA-5000 graphite furnace).

Statistical analysis and data representation

All element contents are presented on a dry matter basis. These values were transformed to logarithms (base 10) because they hand positively-skewed frequency distributions. Since the data were assumed to be approximately log-normally distributed, the central tendency and variation of data were expressed as the geometric means (GM) and geometric deviations (GD), respectively. The GM and GD were used to estimate the range of variation expected for element content of the material being studied. About 95% of the samples in a randomly selected suite would be expected to fall within the limits defined by GM/GD^2 and $GM x GD^2$. The range of concentrations between the calculated GM/GD^2 and $GM x GD^2$

are considered to be 'baseline' values (Tidball and Ebens, 1976). These ranges are a better measurement of the variation of results than the observed ranges since the distorting effects of the few high values are minimized. In order to get better insight into variability of the data, the percentiles of element content were calculated (Koch and Link, 1970).

RESULTS AND DISCUSSION

The area under investigation is bordered in the east by the Suez Canal, in the west by Nile Delta, in the north El-Hssania Plain, and south by the Ismaleiya Canal. Topography of the area under investigates represented by microcatchment Fig. (1) that combined the elevation, longitude and latitude distance of the area under investigation.

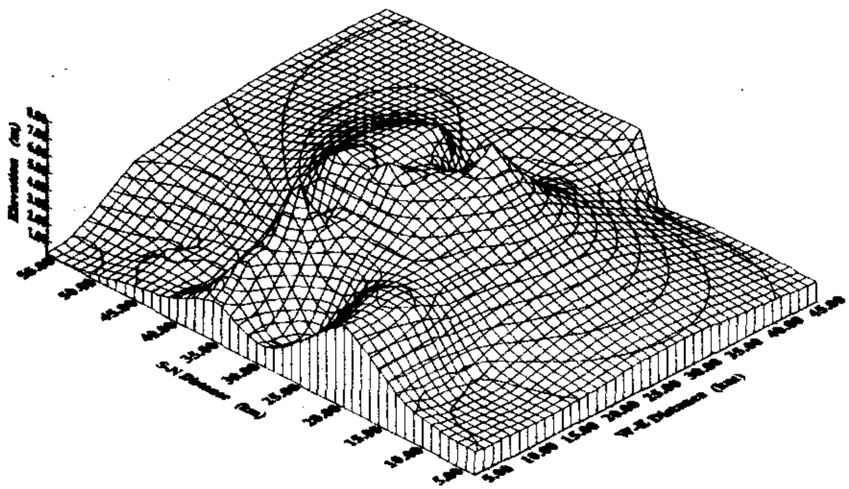

Fig. (1): Microcatchment of topography of the area under investigation.

The physical and chemical characteristics of the studied soils are shown that the texture of the samples varied widely (sandy, loamy sand, sandy loam, sand clay loam, Loamy, clay loam, and clay). The organic matter content, at less than 1.5%, was very low for 32 soil samples, while seven soils showed a higher value of organic matter content (> 1.5%).

Calcium carbonate content of the soils varied from 0.10 to 6.50%. The studied soils are either non-saline or saline soils as indicated by their EC_e values which range from 0.24 to 13.10 dS/m and have pH values ranging from 7.10 to 8.30.

The cation exchange capacity (CEC) values of the soils varied widely from 4.18 to 50.00 meq/100g soil. The high values of CEC are mainly affected by the clay content throughout the layers of the soil. The bulk density values of the soils varied widely from 1.21 to 1.64 g/cm^3.

Distribution of heavy metals of the selected thirty-nine representative soils are shown in Table (1), Results indicate that the amount of seven heavy metals in the tow layers of the tested soils is different which shows the uniform distribution pattern for heavy metals in these representative soils. Also, the data showed that the soils of El-Ferdain varied considerably in their heavy metal content from one location to another and even from surface samples to subsurface samples in the same location. In most locations higher content of certain heavy metals (e.g. Fe, Mn, Zn, Cu, Cd, Ni and Pb) have been observed in the layers having high clay and silt contents than other ones. This may due to the parent materials of the studied soils and soil management.

From the above mentioned results it could be noticed that there is no clear trend in the contents of the different heavy metals which can be used in distinction between the thirty-nine representative soils. In this connection, it is of interest to discuss each of the investigated heavy metals separately as follows:

Iron

Data presented in Table (1) showed that total Fe content in the studied soils ranged between 1025 and 28903 ppm with an average of 7511 ppm and was increased with increasing the content of clay and silt in the soil, while the average amounts in surface samples of soils ranged from 1260 to 28903 ppm with an average 8117 ppm. The highest values are recorded for the heavy textured layers, while the lowest for the sandy ones.

Concerning the content of available Fe in the studied soils, data in Table (2) also showed that the available content ranged from 1.73 to 35.68 ppm, with an average value of 9.64 ppm.

According to the critical levels reported by Lindsay and Norvell (1978) the data in Table (2) of DTPA-available Fe levels showed that 15.38 % (6 samples) of the tested surface soils (39 samples) are deficient, 23.07% (9 samples) are within the margin and 61.15% (24 samples) are adequate. The deficient soils are characterized by sandy texture. Similar results were reported by Abou Yuossef (1999).

Table (1): Total heavy metals contents in the studied soils (ppm).

Sample No		Fe	Mn	Zn	Cu	Cd	Ni	Pb
1	a	11881	246.97	45.49	16.86	3.19	8.24	3.59
	b	3760	210.25	39.32	13.78	1.95	3.88	1.02
2	a	6721	219.59	44.09	14.67	2.68	4.65	4.61
	b	6921	210.35	34.22	13.49	1.34	5.02	0.74
3	a	11567	260.89	44.91	24.40	5.20	6.13	5.62
	b	25048	357.54	75.39	35.75	2.89	12.91	1.82
4	a	13315	250.47	47.73	19.53	2.38	7.94	4.45
	b	19530	343.05	64.27	39.98	2.46	7.50	2.01
5	a	19618	217.57	57.17	29.39	2.55	9.51	5.26
	b	21416	220.03	61.45	28.83	2.64	10.62	1.19
6	a	1675	189.01	33.66	11.92	1.73	1.33	0.87
	b	1881	195.58	34.54	12.13	1.78	1.67	0.88
7	a	1351	190.21	34.66	11.95	1.74	1.66	1.46
	b	1889	186.82	32.58	11.25	1.68	0.92	1.46
8	a	5307	219.60	42.08	16.75	1.89	2.97	1.88
	b	1165	179.09	31.03	10.40	1.62	0.44	0.69
9	a	1556	177.07	31.28	10.34	1.64	0.75	1.29
	b	1981	176.79	31.68	10.41	1.68	1.23	0.66
10	a	5402	195.06	37.52	13.41	1.82	2.55	1.63
	b	2173	177.35	31.99	11.08	1.01	0.83	0.72
11	a	1369	185.67	31.49	11.27	1.68	1.02	1.70
	b	1597	177.75	31.05	11.04	0.71	0.29	0.67
12	a	1280	173.55	30.41	10.04	1.94	0.41	1.30
	b	1425	176.45	31.23	10.32	0.84	0.76	0.68
13	a	2720	173.44	30.50	10.13	1.97	0.62	1.34
	b	1311	175.92	31.53	10.65	0.54	0.91	0.69
14	a	28903	245.18	54.54	36.25	6.58	14.80	3.30
	b	28222	236.80	52.53	36.73	2.09	13.25	1.53
15	a	5597	228.47	43.33	16.04	3.48	4.04	2.24
	b	3001	204.28	38.09	11.47	0.97	3.67	0.96
16	a	4562	213.34	40.77	13.85	1.57	3.71	1.87
	b	2554	203.76	37.21	14.10	0.40	2.23	0.95
17	a	15435	219.30	60.48	24.04	2.29	1.45	2.66
	b	14687	215.58	59.83	26.99	0.64	7.38	1.44
18	a	14276	213.96	57.47	20.10	2.30	8.77	2.21
	b	4536	202.57	41.76	16.08	1.60	4.06	1.16
19	a	1734	173.97	30.37	9.51	1.13	0.47	1.30
	b	1463	175.41	30.37	9.84	0.33	0.38	1.08
20	a	2913	192.14	34.12	12.04	1.29	1.69	1.20
	b	4520	190.75	31.13	10.16	0.35	0.82	0.99

Table (1) : Cont.

Sample No		Fe	Mn	Zn	Cu	Cd	Ni	Pb
21	a	26192	229.51	51.93	26.89	3.09	13.94	2.96
	b	12965	216.47	49.90	24.89	2.50	6.88	1.47
22	a	2910	200.37	37.08	13.81	1.72	3.22	1.01
	b	2100	193.94	35.83	12.48	0.86	2.28	0.82
23	a	3313	202.61	38.26	12.25	2.52	3.37	0.98
	b	4898	202.74	40.21	13.75	1.04	3.33	0.83
24	a	18222	208.34	59.35	21.40	6.73	9.52	8.92
	b	17792	208.10	61.63	21.02	3.05	9.17	4.99
25	a	13203	204.13	55.50	20.57	5.37	7.00	10.55
	b	11695	203.40	53.69	23.59	2.33	5.43	6.93
26	a	17899	206.96	46.19	22.42	4.73	9.01	9.45
	b	11959	195.92	29.05	19.24	2.44	6.09	5.05
27	a	10134	252.83	50.89	22.11	4.67	4.79	11.95
	b	15302	248.86	57.83	17.92	2.85	8.27	4.19
28	a	1958	191.62	35.68	12.12	2.40	1.62	1.72
	b	1531	188.74	34.86	11.99	1.90	1.33	0.83
29	a	2120	187.78	35.34	12.35	1.68	1.83	1.15
	b	1352	183.24	33.96	11.64	1.93	1.61	0.91
30	a	1025	179.49	32.89	10.77	2.03	1.08	2.00
	b	1603	185.32	34.61	11.80	1.88	1.35	0.74
31	a	9230	224.67	47.98	14.58	2.92	5.53	2.15
	b	4697	199.22	39.83	13.06	1.92	2.91	0.80
32	a	10398	235.24	49.88	19.01	2.90	5.31	2.90
	b	3473	198.44	37.99	14.34	0.44	1.88	0.86
33	a	10676	193.48	33.15	19.86	4.33	5.25	4.14
	b	5059	184.67	32.45	17.62	2.16	2.39	1.03
34	a	9747	242.59	42.80	21.47	4.72	4.33	5.07
	b	8701	206.17	39.02	12.27	1.24	5.27	0.59
35	a	9983	195.08	50.06	21.01	4.87	4.66	9.00
	b	8511	192.70	47.13	16.09	1.21	4.85	0.95
36	a	1260	179.27	33.66	11.15	1.64	1.12	1.35
	b	1374	184.05	34.20	11.67	0.74	1.24	0.76
37	a	9106	225.96	47.49	17.96	1.99	4.50	4.23
	b	4225	201.64	39.28	14.07	1.81	2.57	0.91
38	a	1443	182.68	34.17	11.65	1.66	1.19	2.32
	b	1066	182.54	33.70	11.39	1.02	1.12	0.64
39	a	1436	179.32	32.84	10.71	1.91	0.95	1.33
	b	1044	178.32	32.52	10.87	1.00	0.77	0.62

a: Surface sample 0 – 10 cm
b: Subsurface sample 10 – 30 cm

Table (2): The available fraction of different heavy metals in the studied soils (ppm).

Sample No		Fe	Mn	Zn	Cu	Cd	Ni	Pb
1	a	11.73	3.72	1.11	0.486	0.119	0.066	0.051
	b	5.07	2.46	0.87	0.396	0.033	0.036	0.015
2	a	7.42	3.06	0.97	0.414	0.080	0.040	0.043
	b	6.54	2.82	0.81	0.371	0.023	0.041	0.024
3	a	17.10	5.19	1.12	0.695	0.229	0.057	0.069
	b	33.12	8.25	1.90	1.055	0.234	0.113	0.104
4	a	14.50	4.42	1.14	0.550	0.108	0.065	0.063
	b	33.79	8.68	1.68	1.172	0.225	0.084	0.098
5	a	25.36	5.78	1.45	0.838	0.181	0.083	0.098
	b	25.91	5.82	1.53	0.821	0.189	0.090	0.086
6	a	3.31	1.99	0.72	0.335	0.013	0.019	0.007
	b	3.51	2.05	0.75	0.347	0.017	0.021	0.009
7	a	2.47	2.15	0.72	0.329	0.017	0.019	0.013
	b	3.25	1.90	0.68	0.314	0.008	0.014	0.006
8	a	8.45	3.34	0.94	0.475	0.058	0.033	0.032
	b	2.28	1.69	0.64	0.286	0.001	0.011	0.003
9	a	2.27	1.73	0.63	0.279	0.001	0.011	0.006
	b	2.39	1.76	0.63	0.277	0.002	0.013	0.003
10	a	6.70	2.54	0.79	0.366	0.031	0.026	0.019
	b	3.28	1.88	0.65	0.297	0.010	0.013	0.005
11	a	2.91	1.77	0.66	0.317	0.002	0.014	0.006
	b	3.04	1.85	0.63	0.299	0.020	0.009	0.004
12	a	2.06	1.63	0.61	0.269	0.010	0.009	0.004
	b	2.19	1.70	0.63	0.279	0.010	0.012	0.002
13	a	3.43	1.64	0.61	0.271	0.011	0.010	0.004
	b	2.10	1.79	0.63	0.285	0.010	0.013	0.003
14	a	35.34	7.27	1.63	1.050	0.386	0.123	0.120
	b	33.68	7.39	1.59	1.058	0.225	0.115	0.115
15	a	8.17	3.07	1.00	0.472	0.111	0.041	0.031
	b	3.11	1.98	0.84	0.334	0.049	0.034	0.011
16	a	5.77	2.64	0.91	0.398	0.027	0.035	0.024
	b	4.88	2.55	0.81	0.401	0.010	0.026	0.015
17	a	19.47	4.52	1.45	0.705	0.133	0.076	0.069
	b	21.26	4.95	1.45	0.793	0.083	0.071	0.067
18	a	15.53	3.90	1.33	0.581	0.110	0.072	0.058
	b	7.24	2.63	0.96	0.475	0.034	0.039	0.022
19	a	2.24	1.51	0.61	0.258	0.012	0.010	0.003
	b	2.28	1.56	0.62	0.269	0.010	0.010	0.003
20	a	4.99	1.73	0.77	0.360	0.082	0.002	0.007
	b	6.01	1.41	0.69	0.304	0.004	0.015	0.001

Table (2) : Cont.

Sample No		Fe	Mn	Zn	Cu	Cd	Ni	Pb
21	a	27.21	5.75	1.48	0.769	0.212	0.111	0.103
	b	18.68	4.52	1.27	0.731	0.137	0.066	0.059
22	a	4.18	2.54	0.78	0.381	0.022	0.027	0.013
	b	3.15	2.28	0.75	0.344	0.003	0.023	0.012
23	a	3.74	2.26	0.83	0.347	0.051	0.031	0.014
	b	5.80	2.75	0.86	0.377	0.010	0.031	0.021
24	a	19.02	4.47	1.40	0.605	0.303	0.079	0.102
	b	16.64	4.41	1.43	0.596	0.163	0.077	0.084
25	a	15.74	3.95	1.29	0.590	0.231	0.064	0.093
	b	17.27	4.32	1.27	0.681	0.125	0.056	0.078
26	a	19.66	4.60	1.22	0.634	0.231	0.077	0.105
	b	14.03	3.75	0.87	0.541	0.113	0.056	0.066
27	a	15.31	4.67	1.19	0.638	0.201	0.051	0.093
	b	14.82	4.41	1.30	0.498	0.133	0.068	0.070
28	a	3.25	2.20	0.76	0.337	0.046	0.021	0.016
	b	2.92	2.15	0.74	0.331	0.026	0.019	0.011
29	a	3.40	2.21	0.74	0.338	0.018	0.022	0.012
	b	2.42	2.00	0.70	0.317	0.021	0.020	0.008
30	a	1.73	1.88	0.67	0.290	0.022	0.015	0.012
	b	2.66	2.17	0.71	0.319	0.025	0.017	0.011
31	a	9.00	3.29	1.06	0.409	0.101	0.048	0.042
	b	5.41	2.62	0.85	0.358	0.042	0.030	0.021
32	a	12.98	4.15	1.12	0.532	0.122	0.051	0.051
	b	5.67	2.79	0.81	0.394	0.010	0.024	0.020
33	a	13.75	3.77	0.91	0.558	0.182	0.050	0.602
	b	8.98	3.08	0.80	0.495	0.072	0.030	0.029
34	a	14.52	4.59	1.04	0.607	0.200	0.046	0.063
	b	6.91	2.86	0.88	0.326	0.026	0.043	0.030
35	a	14.30	3.89	1.15	0.597	0.205	0.048	0.080
	b	9.83	3.02	1.06	0.456	0.040	0.046	0.036
36	a	2.07	2.00	0.69	0.298	0.012	0.016	0.011
	b	2.47	2.12	0.71	0.316	0.109	0.017	0.010
37	a	11.52	3.89	1.05	0.499	0.080	0.044	0.053
	b	5.93	2.74	0.85	0.390	0.040	0.029	0.020
38	a	2.51	2.12	0.70	0.313	0.015	0.017	0.010
	b	2.09	2.04	0.69	0.308	0.010	0.016	0.008
39	a	2.18	1.87	0.67	0.289	0.018	0.014	0.009
	b	1.98	1.90	0.66	0.292	0.011	0.013	0.006

a: Surface sample 0 – 10 cm

b: Subsurface sample 10 – 30 cm

Manganese

Data in Table (1) revealed that the total Mn content in the studied soils ranged between 173.44 and 357.54 ppm, with an average 206.17 ppm. Values of DTPA extractable-Mn varied from 1.41 to 8.68 ppm, with an average of 3.19 ppm. This value is in accordance with that obtained by El-Gala, et.al. (1990) who found that available Mn extracted by DTPA solution ranged from 0.7 to 10.8 ppm. The values of Mn were mostly greater in soils having high clay or silt content than that characterized by light texture ones.

According to the critical levels reported by Lindsay and Norvell (1978) the data in Table (2) showed that 20.51% of the tested surface soil are contained moderate amount of available Mn (1–2 ppm) and the remaining 79.49% of surface samples contained high amounts of available Mn.

Zinc

The results presented in Table (1) showed that the total content of zinc in the studied soils ranged from 29.05 to 75.39 ppm, with an average of 41.48 ppm. On the other hand, values of DTPA extractable Zn (Table 2) in the studied soils ranged from 0.61 to 1.90 ppm, with an average of 0.95 ppm.

About 38.46% of the surface samples were Zn deficient (< 0.8 ppm), 58.97% contained moderate amount of available Zn (0.8 – 1.6 ppm), and the remaining 2.56% of surface samples contained high amounts of available Zn.

Copper

The data presented in Table (1) showed that total content of Cu in the studied soils ranged from 9.51 to 39.98 ppm, with an average of 16.52 ppm. On the other hand, available Cu extracted by DTPA (Table 2) ranged from 0.25 to 1.17 ppm, with an average of 0.46 ppm.

Extractable Cu in the surface soil samples ranged from 0.25 to 1.05 ppm, with an average of 0.47 ppm. About 58.97% of the surface soil samples were Cu deficient (< 0.5 ppm), 35.89% contained moderate amount of available Cu (0.5 – 1 ppm), and the remaining 5.14% of surface samples contained high amounts of available Cu.

Cadmium

The total Cd content in the studied soils are presented in Table (1). The data show that the total Cd ranged between 0.33 and 6.73 ppm, with an average of 2.18 ppm. The values of Cd were mostly greater in soils having high clay or silt content than that characterized by light texture ones

The studied 39 soils are taken from normal soils not subjected to any sources of pollution other than the normal agricultural management practices. Thus, the enrichment of the surface layer with Cd could be attributed to the annual applications of the phosphate fertilizers. This added Cd tends to accumulate in the surface layer of the soil due to its low mobility (Andersson and Nilsson, 1972).

Concerning available Cd content in the studied soils, data also revealed that available content ranged from 0.001 to 0.386 ppm, with an average of 0.081 ppm.

Nickel

Data of nickel (Table 1) showed that the total Ni varied widely among the layer of the studied soils as it ranged from 0.29 to 14.80 ppm, with an average value of 4.17 ppm.

Data of Table (2) showed that the amount of Ni extracted by DTPA from studied soils ranged from 0.010 to 0.123 ppm, with an average value of 0.040 ppm. Moreover, the amount of available Ni in the studied surface soil samples ranged between 0.009 and 0.123 ppm, with an average value of 0.043 ppm.

Lead

Surveying data of (Table 1) showed that the total lead in the studied soils ranged from 0.596 to 11.952 ppm, with an average value of 2.403 ppm.

Concerning the content of available Pb in the studied soils, data in Table (2) also revealed that available Pb ranged between 0.001 and 0.602 ppm, with an average value 0.037 ppm, while, the available lead from the surface soil samples ranged from 0.004 to 0.602, with an average value of 0.043 ppm.

Descriptive statistics of soil contamination by heavy metals

Concentrations of the examined elements in the soils were in broad ranges of concentrations (Table 3). Inspection of the data showed positive skewing in frequency distribution for most of the variables. Therefore, the data were normalized accordingly by log-transformation. From the normalized data the 95% expected ranges were calculated. These ranges (baselines) are a better measure of the variation of the results than the observed ranges since the distorting effects of the few high values are minimized. Berrow and Reaves (1984) estimated the typical mean concentration of several elements in uncontaminated soils worldwide. Also, Berrow and Reaves (1984) proposed the following mean concentrations (in mg Kg^{-1}, dry wt.): Mn 450; Zn 40; Cu 12; Cd 0.40; Ni 25; Pb 15. Although the mean concentration of Mn, Zn, Cu, Cd, Ni, and Pb in the EL-Ferdian soils (Table 3) were similar to or even lower than the typical values in the soils of the World.

The expected ranges of element contents of the studied soils were markedly narrower than the observed concentrations, particularly those of Cd, Ni and Pb (Table 3). These ranges give a good estimate of the element levels in El-Ferdian soils. The differences between observed and expected ranges of element concentrations (Cd, Ni and Pb) reflect the presence of a small proportion of high values resulting from environmental contamination.

Table (3): Total elements contents in soil samples presented as Mean, geometric mean (GM) and geometric deviation (GD).

Metal	Mean	GM	GD	Observed range	95% Expected range*
Fe	7544	4640	2.769	1025 - 28903	605 - 35595
Mn	206.17	201.60	1.400	173.44 - 357.53	102.85 – 395.13
Zn	41.48	39.47	1.530	29.04 - 75.39	16.89 - 92.39
Cu	16.52	14.64	1.650	9.50 - 39.97	5.37 - 39.85
Cd	2.18	1.25	2.150	0.328 - 6.732	0.270 - 5.778
Ni	4.17	2.55	1.861	0.286 - 14.798	0.737 - 8.821
Pb	2.40	1.68	2.215	0.596 - 11.951	0.342 - 8.251

* Calculated as flows : $GM/GD^2 - GM \times GD^2$.

The highly elevated Pb and Cd content of both observed and expected ranges reflects a significant anthropogenic impact on its concentration in surface samples. It has been proposed that the average natural Cd content of soils should not exceed 0.5 mg kg^{-1} (Kabata-Pendias and Pendias, 1992 and Kabata-Pendias and Dudka, 1991).

Relatively low mean concentrations of the elements studied in the soils of El-Ferdain are apparently a result of a greater proportion of light sandy soils.

Also, extreme variations in the spatial distribution of available Fe, Mn, Zn, Cu, Cd, Ni and Pb concentrations in El-Ferdain soils are evident, with the grouping of highest values found in south-east part of the area.

Evaluation of present soil pollution:

Soil is a natural system, the accumulated heavy metal cannot move easily through it. When the load (heavy metal in soil) surpasses the limit which the soil can carry, the residual toxicity will harm the plants, hinder growth, and endanger its biological quality. Soil is necessary to get the ecological effect defined before assessing the polluted soil, but there is no universal soil standard as yet (Xuexun and Linhai, 1991). Also, the same author use the individual soil pollution index is as follows:

$$I = 1/n \sum I_I$$

Where $I_I = (C_I - B) / (C_{i0} - B)$

C_I : concentration of any heavy metal in soil,

B : soil background value of a heavy metal,

C_{i0} : soil criterion of a heavy metal.

The pollution of soil is mainly exhibited by soil-plant systems: One is the effect of a soil heavy metal on crops, including hinderence of its growth, damaging symptoms and decrease of its yield, another is the damage of its edibility by plant accumulated heavy metals. Based on these, soil pollution was divided into 5 classes (Table 4) (Xuexun and Linhai, 1991).

This depends on the equation mentioned above by Xuexun and Linhai (1991), the data in Table (5) and Figs.(2, 3 and 4) showed that the pollution class of Cd, Ni and Pb : 69.23, 92.3, and 87.17% of studied soils were in class 2 of pollution, respectively. While, 25.64, 7.73 and 12.83% of studied soils were in class 3, respectively, but only 5.13% of studied soils were within the class 4 of Cd pollution. The pollution level of other elements (Zn and Cu) in class 2.

Extreme variations in the spatial distribution the class pollution of Cd and Ni concentrations in El-Ferdain soils are evident (Figs. 2, 3 and 4), with the grouping of highest-class values found in north-east part of the area. While, highest-class values of Pb found in north-east part of the area.

Heavy metals content in wheat grains

The content of heavy metals in wheat grain shown in Table (6). The concentration of Fe in wheat grain ranged from 32.71 to 72.59 ppm, with an average of 45.88 ppm. While, the concentration of Mn ranged from 22.18 to 33.08 ppm, with an average of 28.22 ppm. However, the concentration of Zn and Cu ranged from 4.95 to 9.32 ppm and 0.37 to 1.04 ppm, with an average of 7.06 and 0.70 ppm, respectively.

Table (4): Classification of soil pollution after (Xuexun and Linhai, 1991).

Pollution Index	Pollution Class	Foundation of classification
< 0	No pollution (1)	Plant grows normally, concentration of pollutions in seed is within the extent of their background value
0 – 0.3	Light (2)	Plant growth lightly hindered in seeding period, concentration of heavy metals in seed is little higher than class 1
0.3 – 0.6	Moderate (3)	Weight of dried material aboveground decreases, yield decreased by 5%, concentration of heavy metals in seed is 50% of food sanitation standard
0.6 – 1.0	Heavy (4)	Damagging symptoms appear, weight of dried material drops obviously, yield decreased by 10%, concentration of heavy metals in seed is a high as the standard
> 1.0	Serious (5)	Plants is dwarfed, weight of dried material drops rapidly, yield decreased by 20%, even dead, concentration of heavy metals in seed excesses the standard

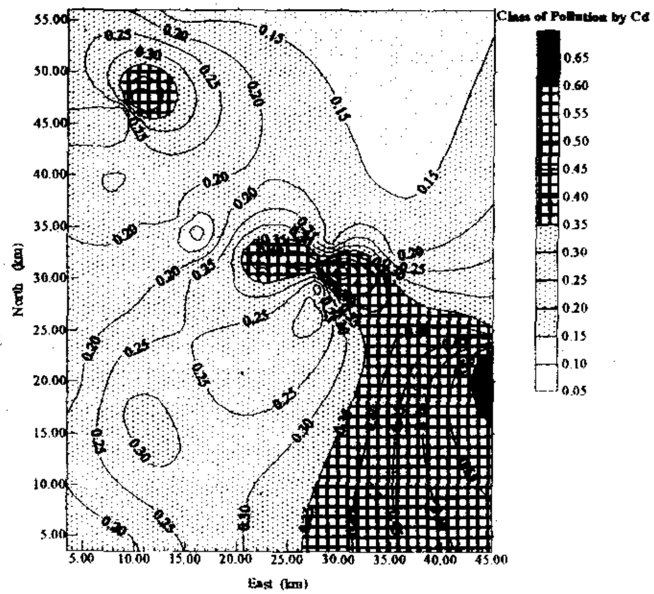

Fig. (2): Contour for class of pollution by Cd under different positions

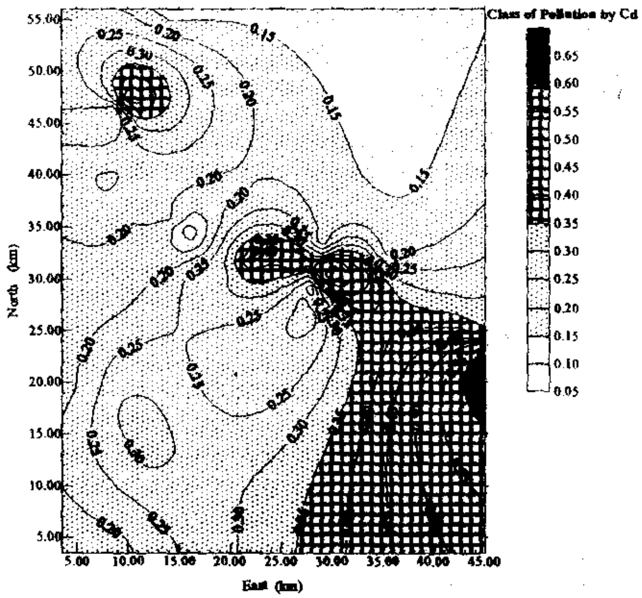

Fig. (3): Contour for class of pollution by Ni under different positions

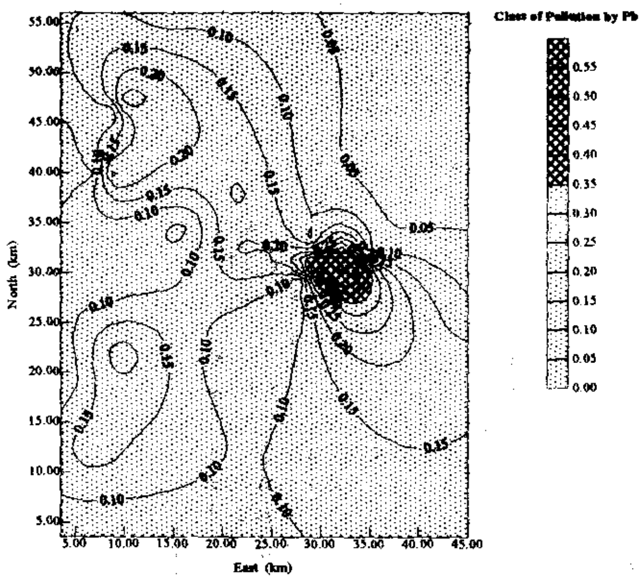

Fig. (4): Contour for class of pollution by Pb under different positions.

Table (5): Soil pollution index of the studied soil samples (0 - 10 cm).

Sample No.	Individual pollution index				
	Zn	Cu	Cd	Ni	Pb
1	0.0910	0.1055	0.3195	0.2746	0.1793
2	0.0882	0.0917	0.2680	0.1549	0.2304
3	0.0898	0.1525	0.5203	0.2045	0.2812
4	0.0955	0.1221	0.2377	0.2648	0.2226
5	0.1143	0.1837	0.2551	0.3170	0.2630
6	0.0673	0.0745	0.1729	0.0440	0.0434
7	0.0693	0.0747	0.1743	0.0554	0.0729
8	0.0842	0.1047	0.1891	0.0091	0.0939
9	0.0626	0.0646	0.1638	0.0249	0.0646
10	0.0750	0.0838	0.1816	0.0849	0.0817
11	0.0630	0.0704	0.1680	0.0339	0.0852
12	0.0608	0.0627	0.1946	0.0136	0.0650
13	0.0610	0.0633	0.1971	0.0208	0.0675
14	0.1091	0.2265	0.6577	0.4933	0.1651
15	0.0867	0.1003	0.3480	0.1347	0.1122
16	0.0815	0.0865	0.1576	0.1236	0.0937
17	0.1220	0.1483	0.2450	0.3025	0.1821
18	0.1149	0.1256	0.2298	0.2924	0.1105
19	0.0607	0.0594	0.1110	0.0158	0.0652
20	0.0685	0.0747	0.1346	0.0625	0.0686
21	0.1039	0.1680	0.3091	0.4649	0.1345
22	0.0742	0.0863	0.1720	0.1076	0.0505
23	0.0765	0.0766	0.2525	0.1124	0.0491
24	0.1187	0.1338	0.6733	0.3176	0.4463
25	0.1110	0.1286	0.5387	0.2335	0.5278
26	0.0924	0.1401	0.4726	0.3006	0.4726
27	0.1018	0.1382	0.4672	0.1598	0.5976
28	0.0714	0.0757	0.2403	0.0540	0.0863
29	0.0707	0.0772	0.1683	0.0613	0.0577
30	0.0714	0.0765	0.0440	0.0539	0.0330
31	0.0960	0.0911	0.2928	0.1884	0.1078
32	0.0998	0.1188	0.2901	0.1771	0.1452
33	0.0663	0.1241	0.4340	0.1752	0.2073
34	0.0856	0.1342	0.4722	0.1444	0.2537
35	0.1001	0.1313	0.4879	0.1554	0.4503
36	0.0673	0.0697	0.1649	0.0376	0.0675
37	0.0950	0.1123	0.1993	0.1503	0.2119
38	0.0683	0.0728	0.1660	0.0397	0.1165
39	0.0657	0.0670	0.1914	0.0319	0.0669

Table (6): Concentration of heavy metals in wheat grain samples taken from location of the studied soils.

Sample No	Fe	Mn	Zn	Cu	Cd	Ni	Pb
	(ppm)						
1	34.95	27.70	7.89	0.612	0.067	0.027	0.048
2	33.96	26.28	6.58	0.909	0.058	0.024	0.051
3	36.36	29.69	5.65	0.832	0.086	0.013	0.054
4	35.32.	27.99	7.95	0.638	0.064	0.027	0.051
5	33.54	25.09	9.08	1.041	0.078	0.024	0.053
6	35.44	22.18	7.19	0.513	0.029	0.029	0.040
7	36.05	28.82	7.21	0.879	0.032	0.024	0.042
8	32.79	26.50	6.53	0.815	0.051	0.029	0.043
9	34.13	27.28	4.99	0.861	0.012	0.028	0.042
10	35.67	26.81	7.34	0.529	0.041	0.029	0.043
11	34.70	27.38	6.06	0.756	0.016	0.024	0.044
12	51.78	25.94	4.95	0.742	0.027	0.014	0.042
13	41.29	21.52	6.94	0.689	0.028	0.022	0.042
14	33.87	32.97	9.32	0.972	0.104	0.028	0.047
15	32.71	28.94	7.73	0.603	0.065	0.023	0.044
16	54.48	29.94	7.56	0.678	0.038	0.026	0.043
17	38.45	30.04	8.37	0.727	0.070	0.026	0.046
18	36.48	20.16	7.04	0.793	0.065	0.014	0.044
19	33.68	25.99	4.96	0.736	0.028	0.029	0.042
20	55.13	27.35	7.30	0.658	0.058	0.023	0.041
21	42.12	31.89	9.12	0.863	0.083	0.028	0.046
22	40.04	29.98	7.32	0.899	0.036	0.026	0.041
23	32.63	28.91	7.42	0.713	0.048	0.025	0.037
24	72.59	29.14	8.31	0.747	0.059	0.026	0.064
25	71.60	27.97	6.99	0.629	0.086	0.027	0.068
26	53.65	28.69	5.76	0.712	0.083	0.026	0.065
27	58.22	33.08	8.02	0.648	0.082	0.028	0.073
28	60.97	26.81	7.90	0.858	0.047	0.026	0.073
29	57.48	25.31	6.21	0.370	0.033	0.029	0.043
30	48.56	26.69	5.17	0.635	0.037	0.024	0.041
31	40.83	31.63	7.83	0.781	0.063	0.027	0.040
32	71.85	30.73	8.60	0.510	0.067	0.028	0.044
33	58.10	27.24	7.57	0.699	0.078	0.027	0.046
34	61.36	32.31	6.68	0.665	0.081	0.028	0.050
35	49.16	27.59	5.61	0.734	0.082	0.023	0.053
36	53.87	24.86	7.12	0.486	0.028	0.029	0.064
37	65.83	29.92	7.81	0.524	0.058	0.026	0.042
38	49.38	25.79	6.13	0.584	0.031	0.029	0.050
39	41.12	25.85	5.06	0.643	0.033	0.014	0.045

The data also showed that the content of Cd in the wheat grain ranged from 0.012 to 0.104 ppm, with an average of 0.056 ppm. The Cd content lies within the normal concentration range e.g. < 0.3 ppm as given by Huffman and Hodgson (1973). Also, Gartrell, et. al., (1986) found that Cd concentration in wheat flour averaged 0.023 $\mu g\ g^{-1}$.

Concerning the concentration of Ni and Pb in the wheat grain, data in Table (6) also revealed that the values of Ni ranged from 0.013 to 0.029 ppm, with an average of 0.025 ppm. The values of Ni to be within the normal concentration range of 0.05 to 5.0 ppm as reported for field grown plants (Cottenie, et. al. 1979 and El-Falaky and Hussein, 1989). While, the concentration of Pb ranged from 0.037 to 0.073 ppm, with an average of 0.047 ppm, being within the normal concentration range of Pb in different plants reported by Page. et. al., (1971) and Aboulroos et. al. (1996).

In general, element concentrations in wheat grains (Table 6) were in ranges of values blew phytotoxicity levels (Kabata-Pendias and Pendias, 1992 and Dudka, et. al., 1995). So phytotoxicity caused by excessive concentrations of elements in plant tissue does not seem to be a problem. The main concern is related to high crop levels of Cd and Pb, two of the most toxicologically dangerous heavy metals. The data in Table (6) shown that about 100% of the wheat grain had concentration below 0.5 $\mu g\ g^{-1}$, which is the level of Cd in feed that can be chronically toxic (Witek, et.al., 1991).

Lead is also to be one of the toxicologically dangerous trace metals. The Pb concentrations higher than 1 $\mu g\ g^{-1}$ are considered to provide consumers with excessive amounts of Pb (Witek, et. al., 1992). Although, it should be remembered that Pb in diet is hardly ever the source of this metal to humans.

Soil-Plant Ratios

The biological absorption coefficient (BAC = element concentration in plant/element concentration in soil) was calculated in order to relate elemental content in soil to plant uptake (Table 7). In many cases, this ratio is an important tool in understanding the relative available of trace elements to plants (Bini, et. al., 1995). The BAC values for the elements considered are higher than those quoted in the Literature (Brooks, 1983). Essential elements (Fe, Mn, and Zn) present higher BAC values than non essential ones (Cd, Table (7): The biological absorption coefficient of the heavy metals in the studied area.

Sample No	Fe	Mn	Zn	Cu	Cd	Ni	Pb
1	2.979	7.446	7.110	1.258	0.562	0.412	0.938
2	4.575	8.914	6.736	2.193	0.720	0.589	1.179
3	1.950	5.715	5.045	1.196	0.374	0.229	0.782
4	2.435	6.324	6.922	1.159	0.599	0.415	0.803
5	1.322	4.684	6.263	1.241	0.433	0.290	0.542
6	10.697	11.104	9.974	1.531	2.177	1.541	5.399
7	14.556	13.359	9.885	2.666	1.860	1.297	3.183
8	3.880	7.922	6.917	1.713	0.822	0.848	1.357
9	14.970	15.685	7.892	3.085	8.827	2.522	6.972
10	5.319	10.532	9.238	1.446	1.286	1.075	2.236
11	11.902	15.464	9.105	2.380	6.058	1.981	7.048
12	25.021	15.846	8.111	2.751	2.555	2.526	9.572
13	12.017	15.515	11.356	2.539	2.487	1.346	10.254
14	0.958	4.533	5.702	0.926	0.276	0.183	0.396
15	4.003	9.743	7.686	1.277	0.588	0.685	1.425
16	9.438	11.236	8.301	1.704	1.412	0.657	1.784
17	1.974	6.638	5.755	1.030	0.525	0.347	0.660
18	2.477	7.716	5.261	1.366	0.591	0.360	0.764
19	14.975	17.200	8.065	2.851	2.371	1.418	11.588
20	11.042	15.795	9.430	1.825	0.709	1.269	5.686
21	1.547	5.547	6.162	1.122	0.393	0.212	0.447
22	9.559	11.772	9.324	2.360	1.582	1.020	3.009
23	8.812	12.779	8.905	2.053	0.959	0.842	2.492
24	3.815	6.520	5.899	1.236	0.315	0.326	0.626
25	4.548	7.073	5.414	1.066	0.373	0.431	0.737
26	2.727	6.230	4.693	1.123	0.372	0.340	0.624
27	3.802	7.077	6.706	1.015	0.406	0.544	0.782
28	18.713	12.146	10.357	1.735	1.011	1.256	2.598
29	16.882	11.453	8.329	1.096	1.793	1.316	3.361
30	14.325	11.563	6.941	1.915	1.530	1.219	3.036
31	4.532	9.600	7.333	1.911	0.624	0.568	1.060
32	5.533	7.394	7.627	0.941	0.556	0.563	0.906
33	4.225	7.224	8.294	1.250	0.433	0.545	0.836
34	4.224	7.009	6.393	1.095	0.407	0.602	0.838
35	3.436	7.087	4.931	1.229	0.401	0.480	0.805
36	25.905	12.396	10.324	1.632	2.323	1.786	3.674
37	5.71	7.677	7.379	1.051	0.720	0.589	0.952
38	19.610	12.396	8.694	1.862	1.998	1.727	2.639
39	18.789	13.755	7.514	2.225	1.829	0.983	4.367

Ni and Pb), and they decrease logarithmically with increasing soil elemental concentrations, suggesting that plants are able to control essential mineral uptake. This suggests that Fe, Mn and Zn were more available to plants under the prevailing conditions. Instead, non essential elements present constant BAC values; therefore, plants seem to be not interested, or not able, to play an adequate control on the uptake of non essential elements. These results are in agreement with those reported by Bini, et. al., (1995).

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القاعدة الأساسية لبيانات بعض العناصر الثقيلة في أراضى الفردان – مصر

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لدراسة القاعدة الأساسية لبيانات بعض العناصر الثقيلة في الأراضي الممثلة لمنطقة الفـــردان غرب قناه السويس تم اخذ عدد ٧٨ عينة تربة من ٣٩ موقع أرضي. وتم تقدير المحتـــوى الكلى و الصورة الميسرة للعناصر التالية Fe, Mn, Zn, Cu, Cd, Ni and Pb. وكان المتوسط الهندسي و المدى (مابين الأقواس) للمحتوى الكلى للعناصر الثقيلة (كجـــزء فـــي المليـــون) كـــالاتي: Fe ٤٦٤٠ (٢٨٩٠٣-١٠٢٥) و Mn ٢٠١,٦٠ (٣٥٧,٥٣-١٧٣,٤٤) و Zn ٩,٤٧ (٧٥,٣٩-٢٩,٠٥) و Cu ١٤,٦٤ (٣٩,٩٨-٩,٥١) و Cd ١,٢٥ (٦,٧٣-٠,٣٣) و Ni ٢,٥٥ (١٤,٨٦-٠,٢٩) و Pb ١,٦٨ (١١,٩٥-٠,٥٩). بينما كانت القـــاعدة الأساســـية لبيانات المحتوى الكلى للعناصر الثقيلة (كجزء في المليون) كـــالاتي : Fe ٣٥٥٩٥-٦٠٥ وMn ٣٩٥,١٣-١٠٢,٨٥ وZn ٩٢,٣٩-١٦,٨٩ وCu ٣٩,٨٥-٥,٣٧ و Cd ٥,٧٧٨-٠,٢٧٠ وNi ٨,٨٢١-٠,٧٣٧ وPb ٨,٢٥١-٠;٣٤٢ .

لذلك يمكن استخدام القاعدة الأساسية لبيانات العناصر الثقيلة كمقترح لتقييـــم تلـــوث التربـــة بالعناصر الثقيلة. ووجد أن القيم المتوقع من Cd, Ni and Pb كانت عالية بالنســـبة لقيـــم التركيزات المقدرة. وتعكس القيم المتوقع من Cd, Ni and Pb معنويـــة تـــأثير النشـــاط

الإنساني لتركيز العناصر في الطبقات السطحية للتربة. وتوضح القاعدة الأساسية لبيانات محتوى التربة من عناصر Cd, Ni and Pb زيادة هذه العناصر في الجزء الجنوبي الشرقي لاراضى القردان.

وطبقا لتصنيف التلوث بالعناصر الثقيلة في عينات الطبقة السطحية تعكس مستوى تصنيف التلوث كالتالي: وجد آن ٦٩,٢٣% من الأراضي المدروسة كان الـ Cd في المستوى الثاني للتلوث (تلوث خفيف)، بينما ٢٥,٦٤% كانت في المستوى الثالث للتلوث (متوسط التلوث) و ٥,١٣% في المستوى الرابع للتلوث (تلوث شديد). بينما وجد ٩٢,٣% من الأراضي المدروسة كان الـ Ni في المستوى الثاني للتلوث (تلوث خفيف)، بينما ٧,٧٣% كانت في المستوى الثالث للتلوث (متوسط التلوث). ووجد ٨٧,١٧٥% من الأراضي المدروسة كان الـ Pb في المستوى الثاني للتلوث (تلوث خفيف)، بينما ١٢,٨٣% كانت في المستوى الثالث للتلوث (متوسط التلوث).

بينما كان مستوى التلوث لباقي العناصر Zn and Cu في المستوى الثاني (تلوث خفيف).

وقد تم حساب معامل الامتصاص البيولوجي (ABC = تركيز العنصر في النبات / تركيز العنصر في التربة). وكانت قيم الـ ABC للعناصر الأساسية (Fe, Mn and Zn) عالية مقارنة بقيم الـ ABC للعناصر الغير الأساسية (Cd, Ni and Pb) وكان الانخفاض في قيم الـ ABC يأخذ الشكل اللوغارتيمى مع زيادة تركيز العنصر في التربة.