

# **GEOGRAPHIC DISTRIBUTION OF SOME HEAVY METALS IN FAYOUM DISTRICT SOILS**

**By**

Mahmoud Abd Elgawad; Mahmoud, M. Shendi; Hamdi, A. A. Mohamed; and  
Samir, I. Ghabour

Soil and Water Dept., Faculty of Agric., Fayoum Univ., Fayoum, Egypt

*Corresponding Author: Mahmoud Mohamed Shendi*

*E-mail: [mmshendi@yahoo.com](mailto:mmshendi@yahoo.com)*

## **ABSTRACT**

Objective of the present work was to map the status of some heavy metals (Cd, Ni and Pb) in soils of Fayoum District, Governorate of Fayoum. Egypt. One hundred sixty one soil samples were collected from eighty one sites during following a grid system at distances of 2 kilometers to represent Fayoum District soils. Levels and distribution of the studied heavy metals throughout Fayoum District area were identified and mapped using the capabilities of ILWIS Geographic Information System "GIS".

It was found that the concentrations of total Cd in soils greatly exceeded the maximum permissible limits listed by several developed countries. The concentrations of total Ni in soils slightly exceeded the maximum recommended critical limits. Although the concentrations of total Pb in soils all over the area of Fayoum District were generally below the maximum permissible limits. There is evidence of Pb concentration increases in few spots particularly in soil surface near the main roads and urban areas. Total and DTPA extractable metals concentrations were considerably greater in the surface layers (0-30 cm) in comparison with those of subsoils (30-60 cm). This indicated that top soils of Fayoum have been subjected to heavy metals contaminants. No correlation was found between the total content of each of Cd, Pb and Ni in soils and their DTPA-extractable concentrations. This could be expected since all Fayoum District soils are alkali in reaction and almost rich in CaCO<sub>3</sub>, therefore most of the total amounts of metals are found in unavailable forms which are less toxic to plants. Results of the present investigation emphasized the need to further research work in order to identify the main sources of top soil contamination with heavy metals in Fayoum, suitable remediation methods and to find out suitable standards in terms of extractable metal amounts with DTPA or other extractants together with their total contents for the evaluation of pollution with heavy metals in agricultural soils of Egypt.

## 1-INTRODUCTION

Sustainable agriculture is mainly related to environmental, agronomic, ethical and socioeconomic issues. One aspect of sustainability is accumulation of heavy metals in soils which may cause serious problems if certain levels are exceeded.

Metals can enter the environment as a result of both natural and anthropogenic activities, so, they are found ubiquitously in both polluted and unpolluted soils. The natural sources include processes of pedogenesis lead to mineral breakdown and translocation of the products, as well as accessions from dust storms, volcanic eruptions and forest fires. Anthropogenic sources comprise all contributions made by mankind including industrial processes that contribute to both atmospheric and land depositions, mining and metallurgy, urban and industrial wastes, sewage and fertilizer applications in agricultural areas (**Tiller *et al.*, 1995, Gimeno-Garcia *et al.*; 1996; Grant *et al.*, 1998; McLaughlin *et al.*, 1999**).

According to United Nation Environmental Program (UNEP) **Percy *et al.* (1997)** reported that although the number of heavy metals in earth are about 40, arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg) and nickel (Ni) are the most common heavy metals pollutants. **Cheng *et al.* (2006)** stated that among heavy metals, cadmium (Cd), arsenic (As), chromium (Cr), nickel (Ni), and lead (Pb) are commonly considered as toxic to both plants and humans.

Cadmium, Nickel and Lead exist in soils with low concentrations. **Lindsay *et al.* (1979)** reported that their total contents in soils range between (0.01 – 0.7) for Cd, (5-500) for Ni and (2-200) mg/kg soil for Pb, however their concentrations in earth crust are 0.2, 100 and 16 mg/kg respectively.

The levels of some heavy metals in agricultural soils of Egypt were detected by some investigators. **Aboulroos *et al.* (1996)** found that DTPA extractable-Pb concentrations in 82 soil samples collected from different locations in Egypt range from 0.51 to 2.88 mg Pb Kg<sup>-1</sup>. They also found that the background levels of DTPA-extractable Cd in the same locations varies widely from non detected values to 0.06 mg/kg soil with an average of 0.018 ± 0.002 mg/kg soil. Studies of **Rabie (1984)** showed that the average amounts of Ni extracted by DTPA are 0.78, 0.59 and 0.47 mg Kg<sup>-1</sup> for heavy alluvial, calcareous and highly calcareous soils, while in sandy soils it ranges from 0.28

to 0.88 mg Ni Kg<sup>-1</sup>. Investigations of **El-Leithi (1986)** showed that Ni content in the industrial areas of Nile Delta varies from one site to another depending upon the nature and composition of industrial wastes as the total Ni contents in the surface layer of soils range between 88.5 and 1444 mg Kg<sup>-1</sup>, while DTPA-extractable amounts of Ni range between 0.02 and 1.76 mg Kg<sup>-1</sup>. **El-Rashidi et al. (1997)** found that the total content of Pb in 71 soil samples collected from 14 saline sodic soil profiles in Nile Delta range from 25 to 100 mg Pb Kg<sup>-1</sup>. **Abdel-Shakour (1982)** obtained a lower range of Pb from 8 to 21 mg Pb Kg<sup>-1</sup> in the cultivated Nile alluvial soils.

The concentrations of some heavy metals were detected by some other investigators in some parts of Egypt (**Samira, 2004, Rabie et al. 1996 and Abdellah, 1995**) but there is still real need for more systematic research work to survey and to produce geographical distribution map for most common metal pollutants all over the country.

Objective of the present work was to study the status of some heavy metals namely nickel "Ni", lead "Pb" and cadmium "Cd", in addition to total soluble salts and pH in Fayoum District in order to detect the levels, distribution and degree of contamination with these components throughout Fayoum District. The levels of CaCO<sub>3</sub>, organic matter and soil texture was also studied.

## 2-MATERIALS AND METHODS

One hundred and sixty one soil samples were collected from eighty one sites representing Fayoum District soils following the grid system at distances 2 kilometers. Locations of the studied sites were identified using a "GPS" (Model German) as shown in (figure 1). Two samples were taken from each site: the first from the surface soil layer at depth 0 – 30 cm (top soil) and the second represented the subsurface soil layer at depth 30– 60 cm (sub soil).

Collected soil samples were air-dried, crushed with a wooden hummer, passed through a 2 mm sieve and stored in plastic bottles. Soil samples were analyzed for the following determinations:

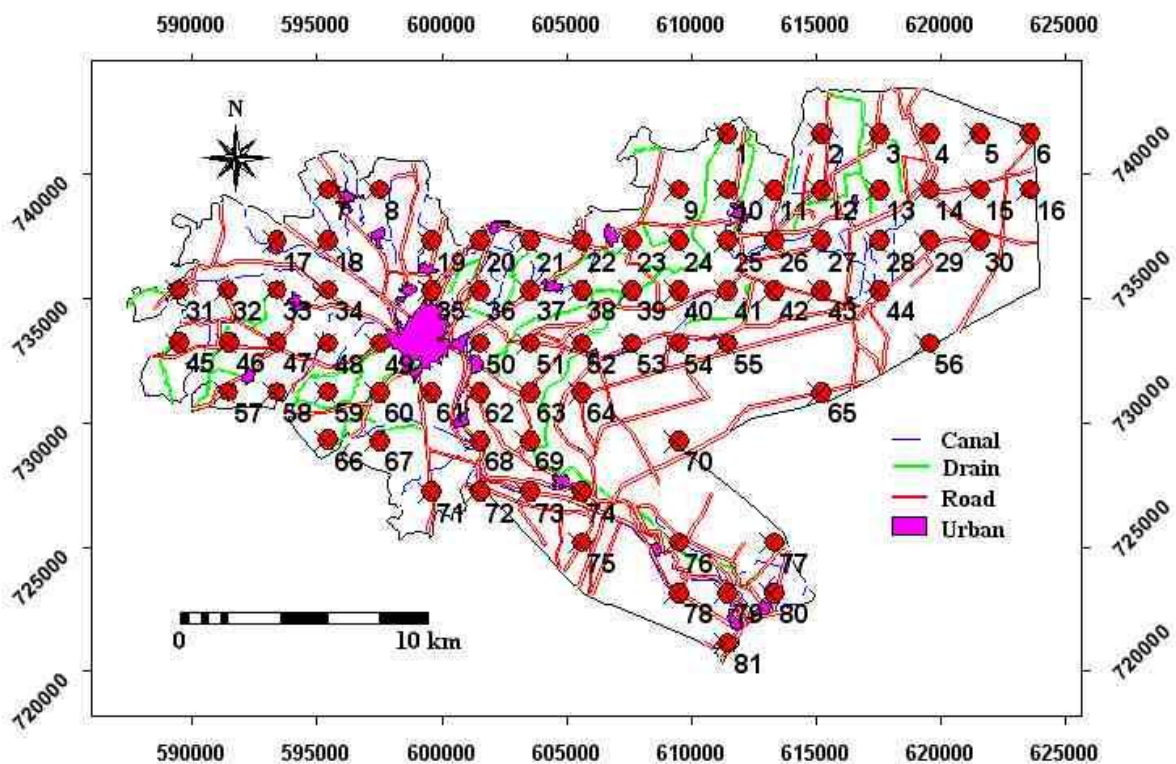
**Particle size distribution**, by the hydrometer method (ASTM No. 152 H Temp.) using sodium hexametaphosphate - sodium carbonate as dispersing agents (**Piper, 1950**), **Calcium carbonate content**, volumetrically using Scheibler's calcimeter (**Wright 1939**), **Soil (pH)** in soil paste using a pH meter. **Electrical conductivity (ECe) in the saturation paste extract** using a conductivity bridge as described by **U.S. Salinity Lab. Staff (1969)**.

**Available forms of Cadmium (Cd), Nickel (Ni) and Lead (Pb)** in soil were extracted using Diethylene Triamine Penta Acetic acid (DTPA) at pH 7.3 according to **Lindsay and Norvell (1969)** and determined with atomic absorption spectrophotometer.

**Total content of heavy metals** in soil samples (0.5g of soil) were digested with hydrofluoric (HF), perchloric (HClO<sub>4</sub>) and hydrochloric (HCl) acids using Teflon flasks (**Jackson, 1979**).

**Organic matter content** was determined according to Walkely and Black method as described by (**Jackson, 1979**).

The obtained concentrations of total and DTPA extractable metals were classified into different levels (ranges), their geographical distributions throughout the whole area of Fayoum District were identified and mapped using the moving average interpolation capabilities of ILWIS Geographic Information System.



**Figure 1. Location map of collected soil samples, Fayoum District.**

### 3-RESULTS AND DISCUSSION

#### 3.1. Soil Texture, pH Values, ECe, Organic Matter and CaCO<sub>3</sub> Contents.

The authors had obtained detailed data for particle size distribution, ECe values, organic matter and CaCO<sub>3</sub> contents for all the studied soil samples. Such obtained data were not presented here because of the limited paper space, however, the geographical distribution of soil pH, ECe values, CaCO<sub>3</sub> and clay contents within the top 30 cm of soils are presented in figures 2, 3, 4 and 5.

It could be observed from the obtained maps that about 64% of the District soils had pH values between 8-8.5 and about 10% were of pH > 8.5 and only about 26 % of the studied soils were below pH 8 (figure 2).

According to ECe values about 56.5% of soils were considered saline (ECe values more than 4 dS/m).

The organic matter contents of soils ranged between 0.13 and 1.96%. With respect to CaCO<sub>3</sub> contents, it was found that about 68% of soils contained 5-10% CaCO<sub>3</sub> and 30% had > 10% CaCO<sub>3</sub> (Fig. 4). Results also indicated that about 60% of soils are clayey with more than 40% clay.

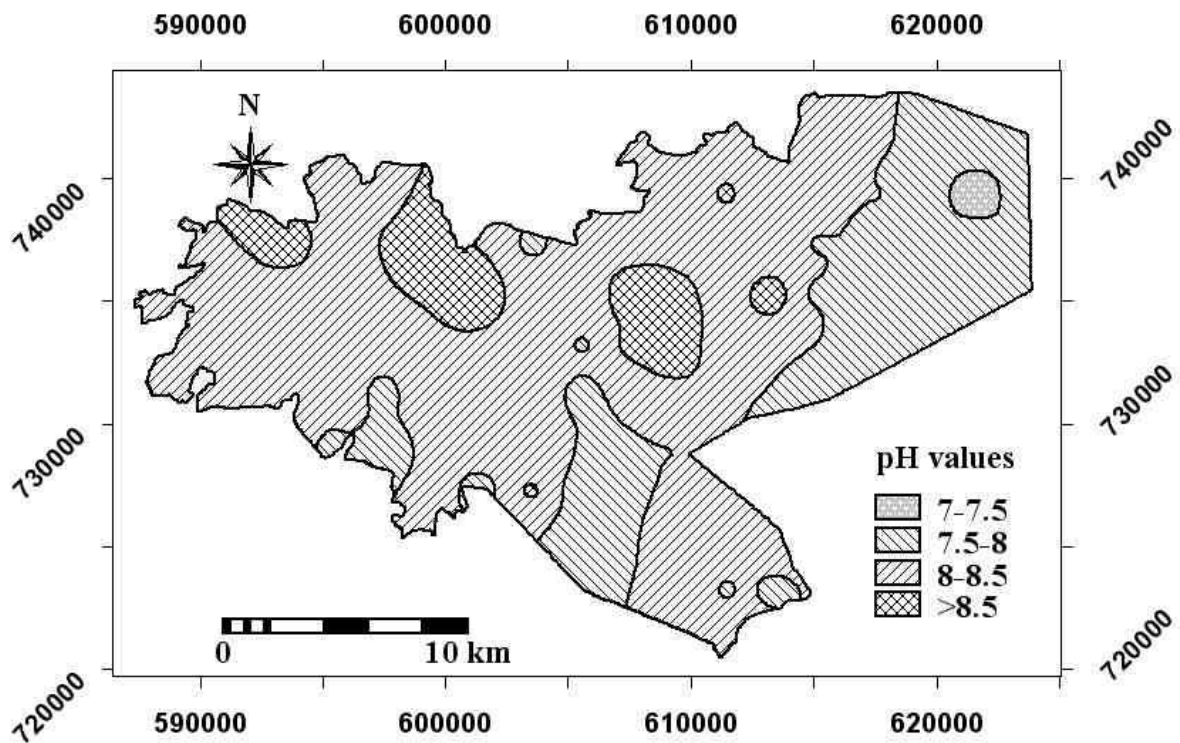
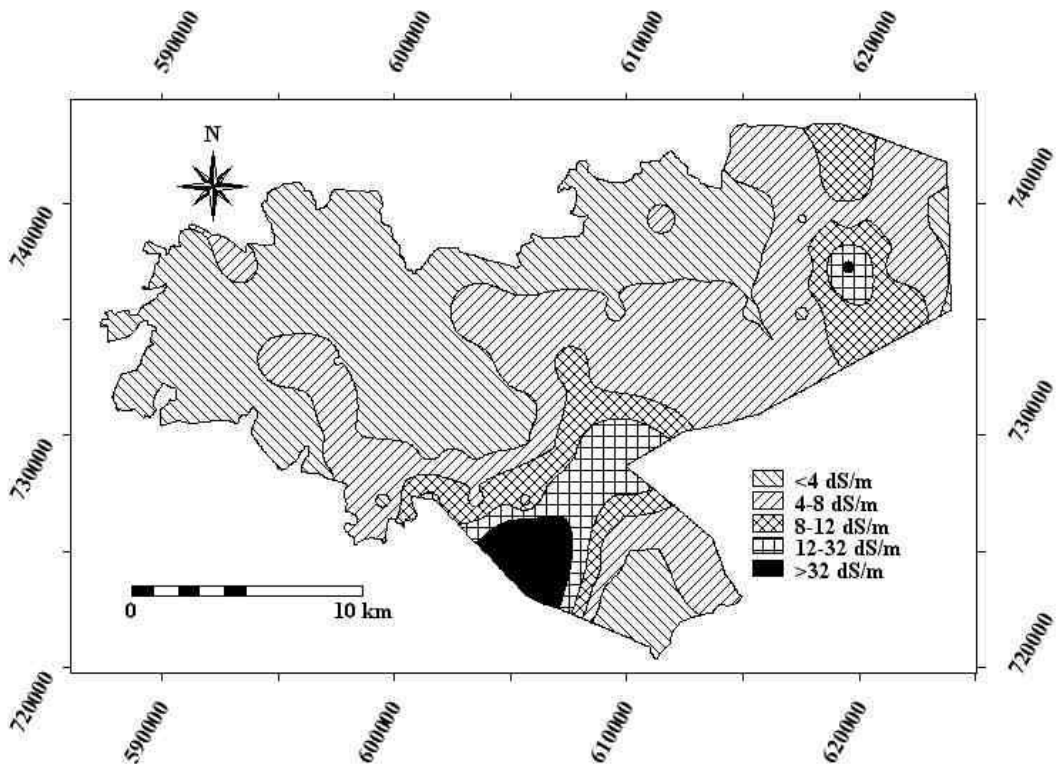
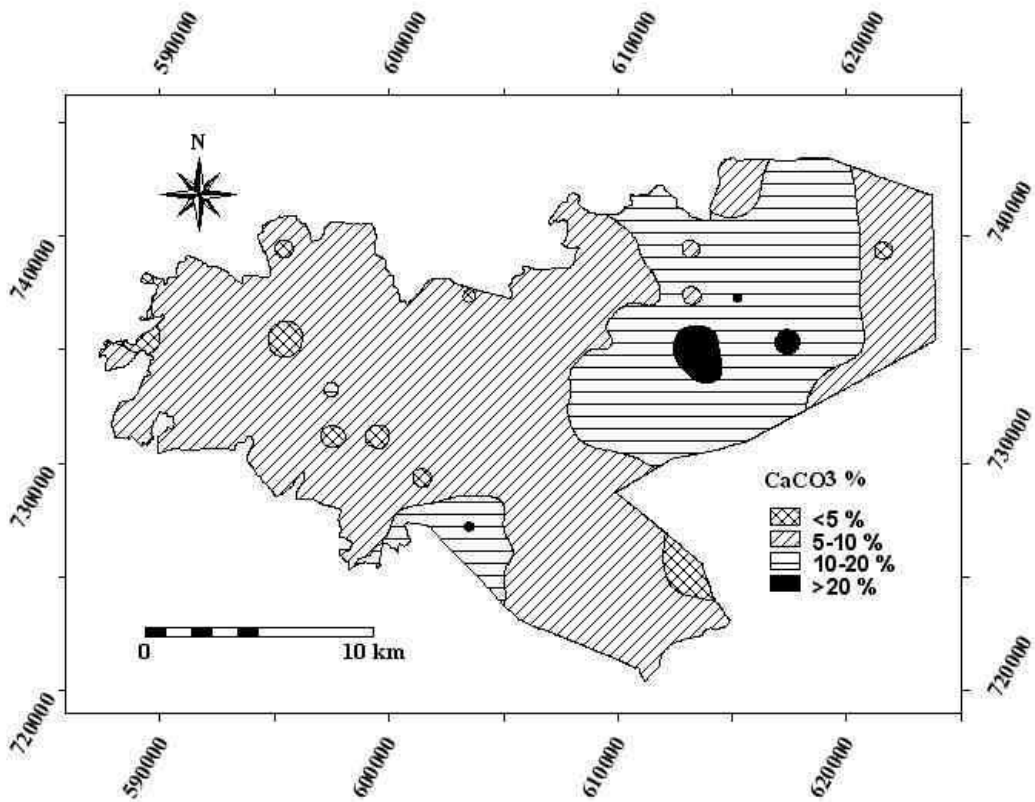


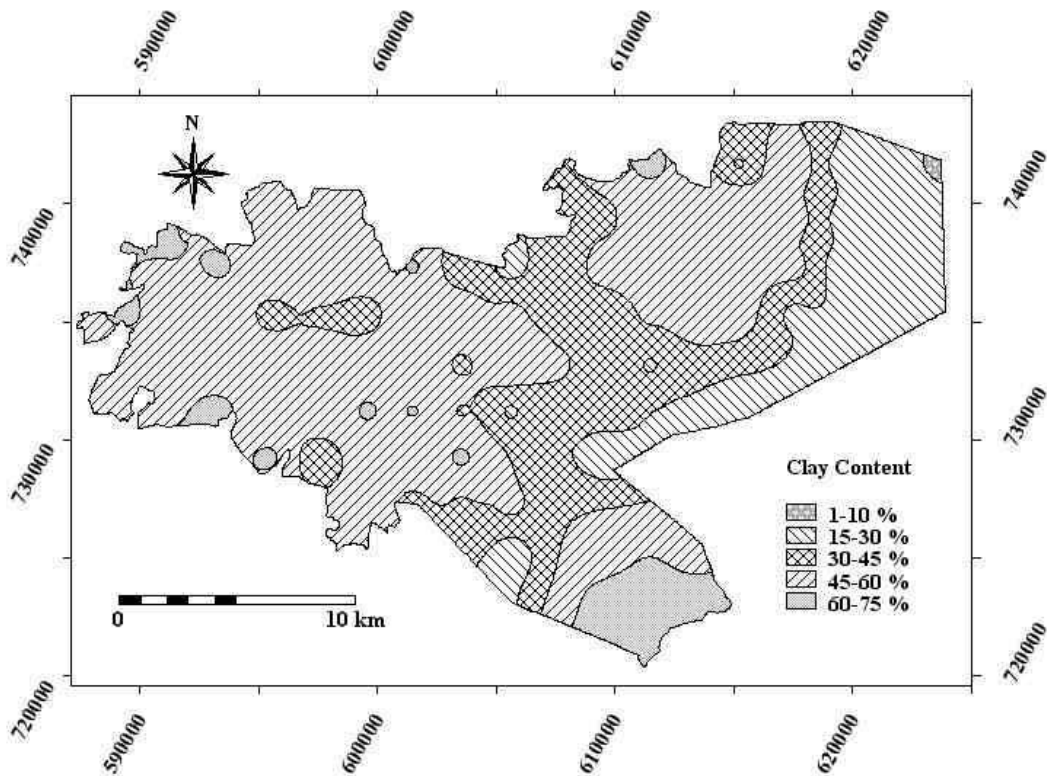
Figure 2. Soil pH values of the top 30 cm.



**Figure 3. ECe values in the top 30 cm. of Soils**



**Figure 4. CaCO<sub>3</sub>% in the top 30 cm of soils**



**Figure 5. Clay content of the top 30 cm of soils**

### **3.2. Cadmium Status in Soils.**

#### **3.2.1. Total Cadmium Content.**

The concentrations and geographical distribution of Cd in Fayoum District soils are given in table (1) and figure (6). Total Cd concentrations in the surface layers of Fayoum District soils ranged from 15.5 to 215 with a mean value of 40.8 mg kg<sup>-1</sup> soil. Corresponding values for the subsurface layers were from 2.3 to 38.5 with an average value of 18.89 mg kg<sup>-1</sup> soil. The overall mean content of the top 60 cm layer were 29.73 mg kg<sup>-1</sup> soil.

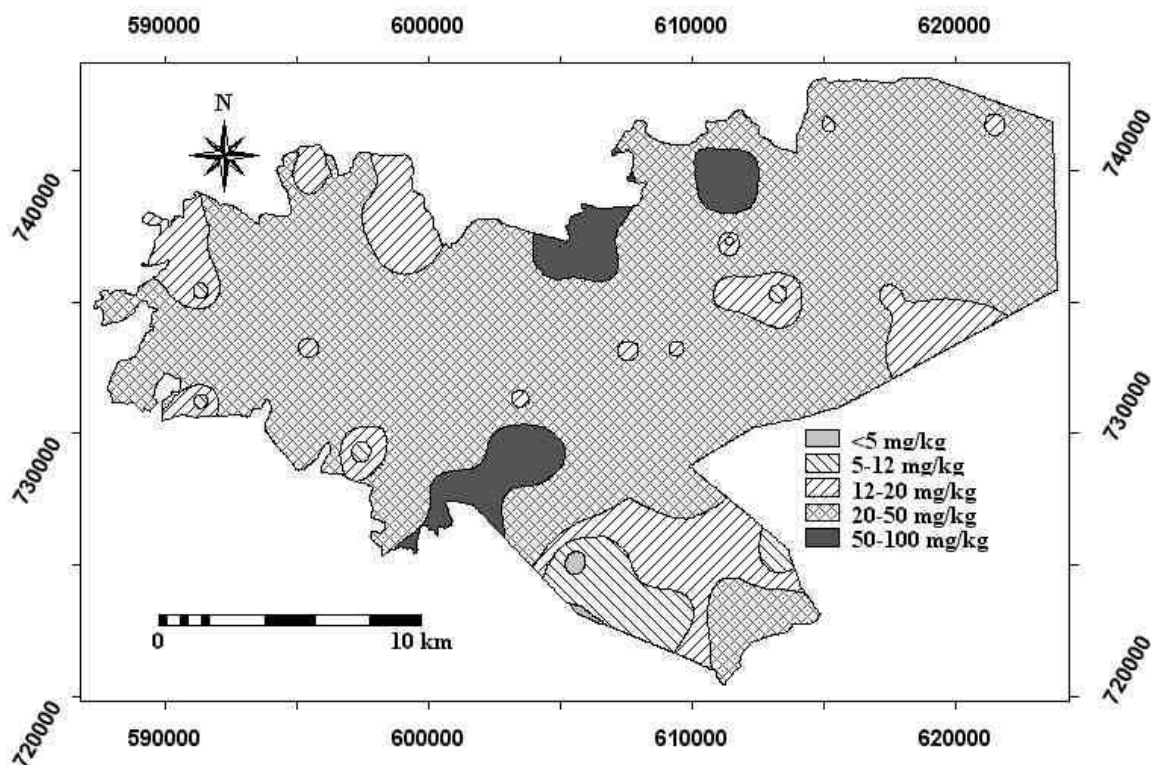
These results indicate that the surface layers of Fayoum District soils contain greater amounts of Cd in comparison with subsurface layers.

**Chen *et al.* (1999)** reported that the mean total concentrations of Cadmium in rural soils of several countries in mg kg<sup>-1</sup>soil are 0.4 for Sweden; 0.8 for Denmark; 1.0 for Norway; 1.5 for Italy; 2.0 for France, Australia, and S. Africa; 3.0 for U.K and Canada; 4.0 for Taiwan; 5.0 for Germany; 12.0 for Belgium; 20.0 for china; 20.0 and 39.0 for USA before and after using sewage sludge. In comparison with data presented in table (1), it could be noticed that, soils of Fayoum District generally contain greater concentrations of total Cd than rural soils of all the above mentioned countries.

For the assessment and evaluation of Cd status in Fayoum District soils, with regard to soil contamination, the obtained results of the total element concentrations were compared with recommended international standards and permissible critical limits developed by the Governments in several countries. **De Vries and Bakker (1998)** reported that the critical soil total contents of Cd according to environmental regulations of several countries are 0.3 ppm in both Denmark and Finland; 0.4 in Czech Republic; 0.5 in Canada; 0.8 in both Netherlands and Switzerland; 0.4 for clay soils and 1.5 for sandy soils in Germany; 0.1 in Ireland; and 0.2 ppm in Eastern Europe.

The obtained data in the present work (Table 1) indicated that the total Cd contents in all the studied soils representing the whole area of Fayoum District greatly exceeds the permissible critical limits (limit of contamination) of all the above mentioned countries.

The geographic distribution and status of total Cadmium throughout the whole area of Fayoum District soils were identified using ILWIS (GIS). The obtained map (Figure 6) indicated the following:



**Figure 6. Total Cadmium content in the top 30 cm of soils.**

0.19 % of the District area contains < 5 ppm Cd (192 feddans).

3.62 % of the District area contains from 5-12 ppm Cd (3658 feddans).



13.91 % of the District area contains from 12-20 ppm Cd (14079 feddans).  
 76.81 % of the District area contains from 20-50 ppm Cd (77763 feddans).  
 5.47 % of the District area contains from 50-100 ppm Cd (5540 feddans).  
 Total studied area  $\approx$  101235 feddans.

With respect to the Netherlands developed system as reported by (Chen *et. al.* 1999) the limit at which soils should be remediated is 12.ppm, therefore about 96% of Fayoum District soils should be remediated from Cd pollution.

**Table 1. Concentrations of Cadmium, Nickel, Lead in soils of Fayoum district**

Site No.	Soil depth (cm)	Concentration, mg kg <sup>-1</sup> (on dry weight basis)					
		Cd		Ni		Pb	
		Ext.	Total	Ext.	Total	Ext.	Total
1	0-30	0.12	22.00	0.83	16.50	1.56	19.0
	30-60	0.27	18.5	0.46	11.00	0.50	16.00
2	0-30	0.23	28.50	0.27	34.50	2.09	12.50
	30-60	0.11	19.00	0.04	21.50	1.94	4.50
3	0-30	0.16	49.5	0.79	100.50	2.01	20.00
	30-60	0.06	29.50	0.40	58.00	0.02	18.50
4	0-30	0.31	38.5	0.43	41.00	2.67	6.00
	30-60	0.23	28	0.35	5.50	1.13	5.00
5	0-30	0.66	16.50	0.08	19.50	1.19	18.00
	30-60	0.08	15.00	0.03	16.50	0.67	5.00
6	0-30	0.22	28.00	0.04	305.00	0.68	20.50
	30-60	0.11	25.00	0.02	2.500	0.41	5.50
7	0-30	0.32	26.00	0.50	7.00	2.14	12.50
	30-60	0.24	19.50	0.45	5.00	1.34	8.00
8	0-30	0.12	44.50	0.64	66.00	3.46	33.50
	30-60	0.10	20.50	0.44	43.00	1.22	18.50
9	0-30	0.21	24.00	0.33	197.00	2.75	9.00
	30-60	0.12	6.00	0.13	8.00	0.59	5.00

Ext. = DTPA extractable-Cd, Ni and Pb

**Table 1. Continued**

Site No.	Soil depth (cm)	Concentration, mg kg <sup>-1</sup> (on dry weight basis)					
		Cd		Ni		Pb	
		Ext.	Total	Ext.	Total	Ext.	Total
10	0-30	0.18	142.0	0.36	147.50	2.34	11.00
	30-60	0.09	28.00	0.31	58.00	2.16	10.00
11	0-30	0.35	22.00	1.27	58.50	2.58	15.50
	30-60	0.05	20.50	0.33	5.00	1.09	12.50
12	0-30	0.10	19.50	0.75	82.50	2.00	29.50
	30-60	0.06	20.50	0.64	49.50	1.58	19.00
13	0-30	0.24	18.00	0.32	9.50	2.22	12.00
	30-60	0.12	35.00	0.19	5.00	0.69	11.50
14	0-30	0.29	32.00	0.52	11.50	1.17	15.00
	30-60	0.12	23.50	0.35	6.50	0.07	8.50
15	0-30	0.10	34.50	0.06	5.00	1.46	3.00
	30-60	Limestone layer					
16	0-30	0.60	27.0	0.03	130.00	1.08	13.00
	30-60	0.04	26.0	0.03	119.00	0.39	6.50
17	0-30	0.23	31.0	0.44	74.00	2.14	37.50
	30-60	0.15	27.5	0.40	59.50	1.05	19.50
18	0-30	0.13	23.50	0.48	53.00	2.42	13.50
	30-60	0.07	12.00	0.21	5.00	1.53	11.50
19	0-30	0.12	24.00	0.63	59.00	3.04	8.50
	30-60	0.06	20.50	0.42	6.00	0.88	5.50
20	0-30	0.19	15.50	0.49	71.50	2.52	29.00
	30-60	0.13	14.00	0.31	17.50	0.61	10.50
21	0-30	0.16	21.00	0.23	424.00	0.98	17.00
	30-60	0.07	20.00	0.14	198.00	0.70	9.50
22	0-30	0.22	123.0	0.08	56.00	1.97	5.50
	30-60	0.08	22.00	0.02	11.50	1.15	5.00
23	0-30	2.40	215.0	0.23	82.50	1.19	7.50
	30-60	0.13	18.00	0.09	5.00	0.53	7.00
24	0-30	0.19	23.00	0.34	127.00	1.99	13.00
	30-60	0.08	3.00	0.22	11.00	1.10	9.00
25	0-30	0.11	41.00	0.41	75.00	2.52	24.00
	30-60	0.09	27.00	0.34	13.00	0.15	12.50
26	0-30	0.10	22.50	0.53	82.50	2.30	11.00
	30-60	0.06	4.00	0.14	74.00	0.95	8.50

Ext. = DTPA extractable-Cd, Ni and Pb

**Table 1. Continued**

Site No.	Soil depth (cm)	Concentration, mg kg <sup>-1</sup> (on dry weight basis)					
		Cd		Ni		Pb	
		Ext.	Total	Ext.	Total	Ext.	Total
27	0-30	0.21	37.50	1.16	83.00	2.05	45.00
	30-60	0.15	26.00	0.35	10.50	1.87	8.50
28	0-30	0.22	38.50	1.24	46.50	2.22	31.00
	30-60	0.14	30.50	0.24	39.50	1.69	26.00
29	0-30	0.26	35.0	0.67	52.50	1.10	14.50
	30-60	0.19	31.50	0.16	20.50	0.80	8.00
30	0-30	0.17	22.00	0.12	27.00	1.11	27.50
	30-60	0.13	21.00	0.03	5.00	0.61	3.50
31	0-30	1.82	27.50	0.62	57.50	1.32	11.00
	30-60	0.27	8.50	0.30	15.50	1.05	3.00
32	0-30	0.61	21.50	0.95	243.5	2.27	6.50
	30-60	0.16	20.50	0.16	86.50	1.12	5.50
33	0-30	0.14	20.50	0.88	14.50	2.72	21.50
	30-60	0.10	4.50	0.53	5.00	0.52	10.50
34	0-30	0.24	33.50	0.42	404.0	3.13	26.50
	30-60	0.17	20.50	0.28	46.50	2.86	9.50
35	0-30	0.28	30.00	0.28	56.00	1.81	11.50
	30-60	0.24	26.50	0.23	39.50	1.15	9.50
36	0-30	0.15	20.00	0.61	162.5	3.68	14.50
	30-60	0.12	5.50	0.43	55.50	2.08	5.50
37	0-30	0.14	139.0	0.77	86.00	1.37	19.00
	30-60	0.11	25.50	0.28	80.50	0.98	11.50
38	0-30	0.11	26.50	0.33	87.50	3.48	14.50
	30-60	0.09	21.50	0.23	63.00	1.35	13.00
39	0-30	0.23	35.50	0.21	48.00	2.69	6.50
	30-60	0.06	16.00	0.11	4.00	1.56	5.50
40	0-30	0.14	51.00	0.61	32.00	0.65	17.00
	30-60	0.06	24.00	0.33	12.00	0.50	6.50
41	0-30	0.11	30.50	0.64	59.50	1.66	35.00
	30-60	0.08	21.00	0.23	15.50	0.06	16.50
42	0-30	0.12	17.50	0.66	159.0	1.42	22.50
	30-60	0.03	16.00	0.43	48.00	0.88	12.00
43	0-30	0.10	22.00	0.37	26.00	1.81	9.50
	30-60	0.06	4.50	0.23	5.00	0.81	8.00

Ext. = DTPA extractable-Cd, Ni and Pb

**Table 1. Continued**

Site No.	Soil depth (cm)	Concentration, mg kg <sup>-1</sup> (on dry weight basis)					
		Cd		Ni		Pb	
		Ext.	Total	Ext.	Total	Ext.	Total
44	0-30	0.09	30.00	0.52	83.50	2.77	9.50
	30-60	0.06	17.50	0.48	78.50	1.30	6.00
45	0-30	0.09	140.0	0.52	54.00	1.24	9.00
	30-60	0.08	17.00	0.43	10.00	0.46	5.00
46	0-30	0.22	26.00	0.45	23.50	2.19	17.50
	30-60	0.14	20.00	0.16	9.00	1.48	8.00
47	0-30	0.16	51.00	0.74	99.50	0.77	40.00
	30-60	0.07	24.50	0.51	7.00	0.35	10.50
48	0-30	0.33	35.50	0.48	97.50	2.05	17.00
	30-60	0.30	10.00	0.41	9.50	1.62	4.50
49	0-30	0.13	34.50	0.39	44.00	3.68	8.50
	30-60	0.05	14.00	0.22	9.00	2.44	7.00
50	0-30	0.07	23.00	0.31	74.00	3.42	20.50
	30-60	0.04	18.00	0.24	41.50	1.42	7.50
51	0-30	0.16	27.50	1.48	9.00	1.87	18.50
	30-60	0.10	22.00	0.42	5.00	0.93	1.50
52	0-30	0.23	33.00	0.43	115.5	1.87	26.00
	30-60	0.07	16.50	0.36	79.50	1.32	9.50
53	0-30	0.24	23.50	0.61	353.5	2.23	9.00
	30-60	0.09	21.50	0.45	33.00	1.14	8.50
54	0-30	0.20	27.50	0.45	41.50	0.79	11.00
	30-60	0.14	16.00	0.36	18.00	0.56	4.50
55	0-30	0.10	17.50	0.08	46.50	1.31	9.00
	30-60	0.04	5.50	0.06	33.00	0.75	8.00
56	0-30	0.23	144.5	0.37	44.00	1.31	11.00
	30-60	0.10	38.50	0.08	28.50	1.13	8.00
57	0-30	0.17	44.00	0.51	69.00	2.39	10.50
	30-60	0.09	12.50	0.29	5.00	1.32	9.00
58	0-30	0.17	34.50	0.27	79.50	2.22	10.50
	30-60	0.05	6.00	0.23	23.00	0.41	9.00
59	0-30	0.34	32.00	0.29	15.00	1.32	8.50
	30-60	0.23	19.50	0.25	6.00	1.16	6.50
60	0-30	0.06	32.00	0.29	313.0	0.89	23.00
	30-60	0.02	27.00	0.17	296.0	0.32	5.50

Ext. = DTPA extractable-Cd, Ni and Pb

**Table 1. Continued**

Site No.	Soil depth (cm)	Concentration, mg kg <sup>-1</sup> (on dry weight basis)					
		Cd		Ni		Pb	
		Ext.	Total	Ext.	Total	Ext.	Total
61	0-30	0.10	29.00	0.19	179.5	2.80	18.00
	30-60	0.06	22.00	0.12	5.50	2.28	12.50
62	0-30	0.16	26.50	0.40	22.50	2.21	16.00
	30-60	0.10	20.00	0.31	5.00	0.21	6.00
63	0-30	0.17	31.00	0.76	31.00	1.35	21.00
	30-60	0.12	19.50	0.29	27.50	1.20	4.50
64	0-30	0.08	21.00	0.27	30.00	1.05	6.00
	30-60	0.05	6.50	0.15	14.50	0.09	5.00
65	0-30	0.26	30.00	0.21	7.50	2.04	20.00
	30-60	0.12	28.00	0.20	6.50	1.70	18.50
66	0-30	0.14	30.50	0.31	165.5	0.75	18.50
	30-60	0.09	24.50	0.19	42.50	0.43	9.00
67	0-30	0.13	41.00	0.24	489.5	1.18	27.50
	30-60	0.05	33.00	0.07	156.0	0.87	7.50
68	0-30	0.29	40.50	0.45	24.50	1.72	7.00
	30-60	0.14	4.00	0.42	23.00	1.35	6.50
69	0-30	0.14	28.00	0.48	112.0	2.70	11.50
	30-60	0.05	20.50	0.30	98.50	1.56	6.50
70	0-30	0.32	132.0	0.27	41.00	1.27	10.50
	30-60	0.27	29.50	0.12	37.00	0.35	9.00
71	0-30	0.27	28.50	0.39	11.50	1.81	29.50
	30-60	0.06	6.50	0.36	5.00	0.72	9.50
72	0-30	0.23	35.00	0.38	35.00	2.04	23.00
	30-60	0.11	19.50	0.14	32.50	0.94	11.50
73	0-30	0.22	120.5	0.56	51.00	1.37	16.00
	30-60	0.09	34.00	0.54	5.00	0.63	9.50
74	0-30	0.13	30.50	0.73	367.5	1.46	45.00
	30-60	0.06	17.50	0.06	7.50	0.39	21.00
75	0-30	0.27	21.50	0.33	14.00	2.66	23.50
	30-60	0.14	21.00	0.26	5.00	1.77	7.50
76	0-30	0.12	30.00	0.34	6.00	1.48	18.50
	30-60	0.07	2.30	0.31	5.00	0.70	7.50
77	0-30	0.20	23.50	0.43	16.00	1.18	9.50
	30-60	0.07	19.50	0.09	5.00	0.44	8.50

Ext. = DTPA extractable-Cd, Ni and Pb

**Table 1. Continued**

Site No.	Soil depth (cm)	Concentration, mg kg <sup>-1</sup> (on dry weight basis)					
		Cd		Ni		Pb	
		Ext.	Total	Ext.	Total	Ext.	Total
78	0-30	0.12	31.50	0.31	261.0	1.52	9.00
	30-60	0.02	6.00	0.29	41.50	0.56	7.50
79	0-30	0.16	25.50	0.51	71.00	2.83	14.50
	30-60	0.13	3.00	0.47	5.00	0.61	13.00
80	0-30	0.31	31.00	0.26	62.00	1.64	10.00
	30-60	0.16	15.50	0.22	8.50	0.92	6.50
81	0-30	0.19	42.50	0.32	33.00	1.97	17.50
	30-60	0.04	27.00	0.24	5.00	1.42	9.00

Ext. = DTPA extractable-Cd, Ni and Pb

### 3.2.2 DTPA-extractable cadmium.

The concentrations of DTPA-extractable Cd are given in Table (1). Extractable values of Cd ranged between 0.06 and 2.40 mg kg<sup>-1</sup> soil in the top 30cm layer with a mean value of 0.25 mg kg<sup>-1</sup> soil. Values in subsoil (30-60 cm) ranged from 0.02 to 0.30 with an average of 0.11 mg kg<sup>-1</sup> soil. The overall mean value of the top 60 cm layer was 0.18 mg kg<sup>-1</sup> soil.

It is worthy to mention in this respect that there are no available international standards or documented critical limits in the literature in terms of DTPA-extractable heavy metals. The documented standards till now are mostly based on the total contents of heavy metals among which is cadmium, therefore the evaluation of soil contamination with cadmium was based in this work on the total content in soil.

### 3.3. Lead Status in Soils.

#### 3.3.1. Total Lead Content.

The concentrations and geographical distribution of total Pb in the top 30 cm (surface) and within the 30-60cm (subsurface) layers of Fayoum District soils are given in table (1) and figure (7). Total Pb concentrations in the surface layers of soils ranged from 3 to 45 with a mean value of 17.05 mg kg<sup>-1</sup> soil. Corresponding values for the subsurface layers ranged from 1.5 to 26 with an average value of 9.12mg kg<sup>-1</sup>. The overall mean content of the top 60 cm layer was 14.78 mg Pb kg<sup>-1</sup> soil.

It was reported by **Chen et al. (1999)** that the mean total concentrations of Lead in rural soils of several countries are 40 ppm for Sweden; 50 ppm and 100 ppm for Norway before and after using sewage sludge; 56 ppm for S.Africa; 100 ppm for each of Italy; France, Australia and Taiwan; 120 ppm for Denmark; 150 ppm and 300 ppm for USA before and after using sewage sludge; 300 ppm for U.K; 375 ppm for Canada; 600 ppm for Belgium and 1000 ppm for both Germany and China.

A comparison of such values with data presented in table (1), indicated that, soils of Fayoum District generally contains greater concentrations of Pb than rural soils of most of the above mentioned countries.

For the assessment and evaluation of Pb status in Fayoum District soils with respect to soil contamination, the obtained results of the total element concentrations were compared with recommended international standards and permissible critical limits developed by environmental authorities all over the world. **De Vries and Bakker (1998)** reported that the critical soil total contents of Pb according to environmental regulations of several countries are 25 ppm in Canada; 32 ppm in Eastern Europe; 38 ppm in Finland; 40 ppm in Denmark; 40 ppm for clay soils and 100 ppm for sandy soils in Germany; 50 ppm in both Switzerland and Ireland; 70 ppm in Czech Republic and 85 ppm in Netherlands.

Comparing the levels of total Pb in Fayoum District soils with permissible critical limits recommended in most of the above mentioned countries, it could be stated that the concentrations of total lead all over the District are below such permissible limits, however there is evidence of Pb accumulation in some sites particularly in soil surface in the vicinity of main roads (sites No. 24, 27, 47 and 74).

The obtained map (figure 7) shows the geographical distribution of total Pb with respect to the element concentrations in the top 30 cm of soils throughout the different parts of Fayoum District. The obtained data and map indicated the following:

12.21 % of the District area contains <10 ppm Pb (12362 fed.).

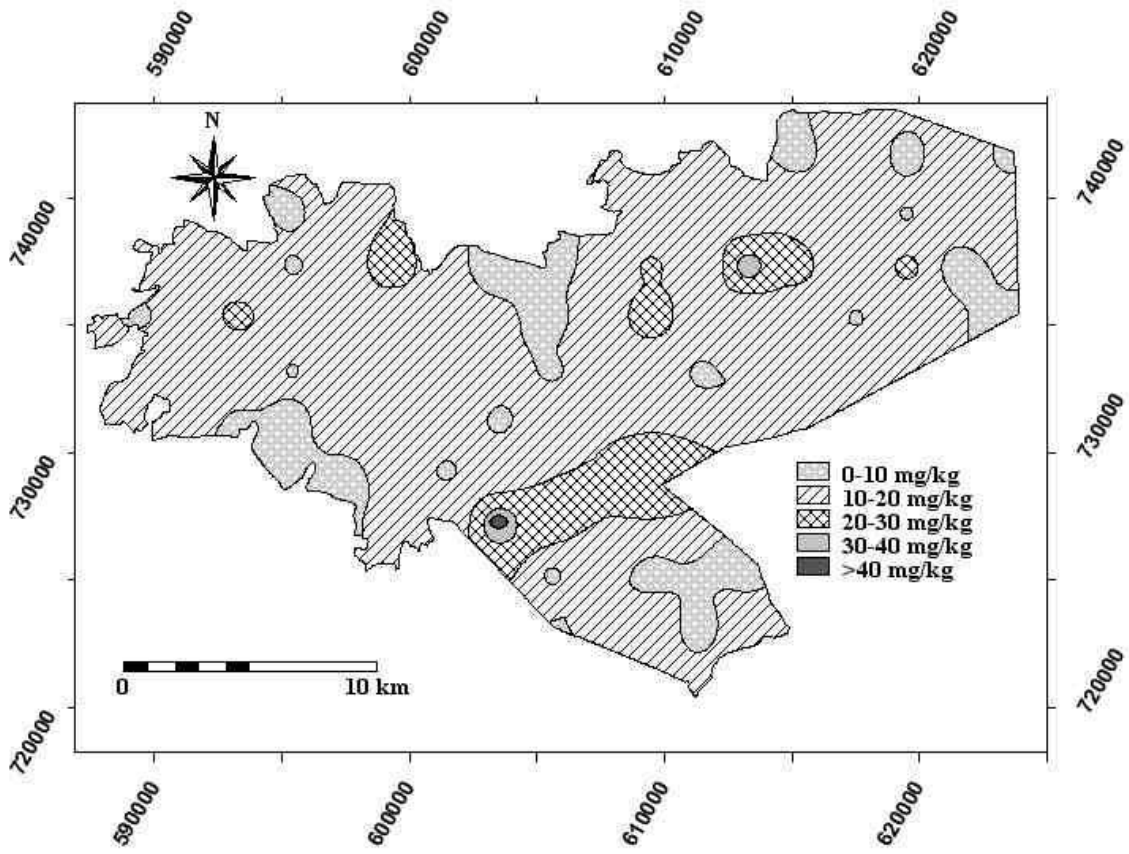
78.30 % of the District area contains from 10-20 ppm Pb (79270 fed.).

9.02 % of the District area contains from 20-30 ppm Pb (9126 fed.).

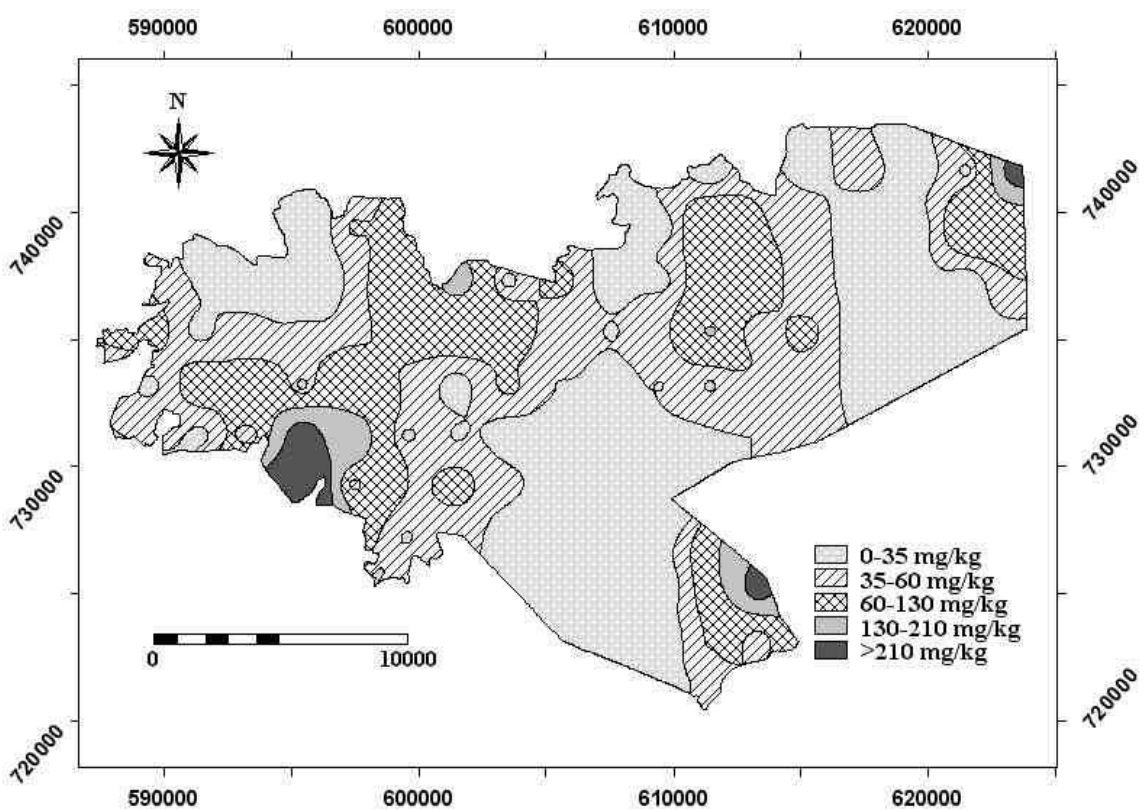
0.41 % of the District area contains from 30-40 ppm Pb (415 fed.).

0.06 % of the District area contains >40 ppm Pb (62 fed.).

Total studied area  $\approx$  101235 feddans.



**Figure 7. Soil total Lead content in the top 30 cm.**



**Figure 8. Soil total Nickel content in the top 30 cm.**



### 3.3.2. DTPA-extractable Lead.

The concentrations of DTPA-extractable Pb are given in table (1). DTPA extractable values of Pb ranged between 0.65 and 3.68 in the top 30cm layer with a mean of 1.39 mg kg<sup>-1</sup> soil. Values in subsoil (30-60 cm) ranged from 0.02 to 2.86 with an average of 0.99. The overall mean value of the top 60 cm layer was 1.19 mg kg<sup>-1</sup> soil.

Since there are no available information in the literature in terms of DTPA-extractable heavy metals, the assessment of soil contamination with Pb depended in this work on the total contents of metal in soil.

### 3.4. Nickel in Soils.

#### 3.4.1. Total Nickel Content.

The concentrations and geographical distribution of Ni levels in Fayoum District soils are given in table (1) and (Figure 8). Total Ni concentrations in the surface layers ranged from 5 to 489.5 with a mean value of 93.51 mg kg<sup>-1</sup> soil. Corresponding values for the subsurface layers ranged from 2.5 to 269 with an average value of 32.49 mg kg<sup>-1</sup> soil. The overall mean content of the top 60 cm layer were 62.8 mg kg<sup>-1</sup> soil.

The mean total concentrations of Nickel in rural soils of some countries in mg kg<sup>-1</sup> soil as reported by **Chen et al. (1999)** were 15 for S.Africa; 20 for china; 30 for Sweden and Denmark; 30 and 80 for Norway before and after using sewage sludge; 50 for France; 60 for Australia; 75 for Italy; 100 for Belgium; 120 for Taiwan; 150 for Canada; 200 for Germany; 300 for U.K; 210 and 420 for USA before and after using sewage sludge.

Nickel concentrations either in surface or subsurface layers of Fayoum District soils are almost similar to the levels of the above mentioned countries, expect in some sites that had greater concentration than those of USA (sites No 21 and 67).

For evaluating of the degree of soil contamination in Fayoum District, the obtained results of the total element concentrations were compared with recommended international standards and permissible critical limits. **De Vries and Bakker (1998)** reported that the critical soil total contents of Ni according to some environmental regulations all over the world are 10 ppm in Denmark; 15 for clay soils and 70 ppm for sandy soils in Germany; 20 ppm in Canada; 30 ppm in Ireland; 35 ppm in Netherlands; 40 ppm in Finland; 50 ppm in

Switzerland; 60 ppm in both Taiwan and Czech Republic; and 85 ppm in Eastern Europe. In comparison with these limits, it could be observed that the mean Ni values of the top soil of Fayoum District soils are generally greater than the standards of these countries. According to Netherlands Developed system (**Chen *et al.* 1999**) the cleanup limit of Ni total content at which soils should be remediated is 210 ppm, therefore soil at sites No 6, 21, 32, 34, 53, 60, , 67, 74 and 78 should be remediated from Ni pollution.

### **3.4.2. DTPA-extractable Nickel.**

The concentrations of DTPA-extractable Ni in soils of Fayoum District are given in table (1). DTPA extractable values of Ni ranged between 0.03 and 1.48 mg kg<sup>-1</sup> soil in the top 30 cm layer with a mean of 0.47 mg/kg soil. Values in subsoil (30-60 cm) ranged from 0.02 to 0.64 with an average of 0.27 mg kg<sup>-1</sup> soil. The overall mean value of the top 60 cm layer was 0.06 mg kg<sup>-1</sup> soil. Data of DTPA extractable Ni were not used in the evaluation of soil contamination with Ni since there are no available international standards or documented critical limits in the literature in terms of DTPA-extractable Ni. Investigations of **Rashad *et al.* (1995)** showed that DTPA extractable Ni contents range from 0.38 to 1.04 mg Ni kg<sup>-1</sup> with an average of 0.66 mg Ni Kg<sup>-1</sup> in recent Nile alluvial soils, while in coastal barrier plain soils (sandy soils) they range from 0.2 to 0.4 with an average of 0.31 mg Ni Kg<sup>-1</sup>.

### **3.5. Conclusions and Recommendations.**

As shown in table 1, the concentrations of both total and DTPA extractable-Cd, Pb and Ni in Fayoum District soils were generally greater in the surface (0-30cm) in comparison with those of the subsurface layers (30-60cm), with some exceptions in some sites. The general means of total Cd, Pb and Ni in top soils were 2.16, 1.87 and 2.88 times those of the subsurface layer. Corresponding ratios of DTPA extractable-metals were 2.27, 1.4 and 1.74 for Cd, Pb and Ni respectively. These results may lead to the conclusion that the surface layer of Fayoum District soils has been subjected to contaminants by the three metals that may be originated from atmospheric depositions, applied commercial fertilizers (phosphatic in particular), pesticides, manures, waste disposals and may be discharge of untreated domestic sewage.

Results of the present investigation emphasized the real need to more systematic research work in order to identify the main resources as well as the degree and the geographical distribution of soil contamination with heavy metals not only throughout Fayoum Governorate but also all over the country.

Statistical analysis of data indicated that the correlation coefficients between total and DTPA-extractable amounts of metals were of no trend. This could be expected since all Fayoum soils are alkali in reaction and almost rich in  $\text{CaCO}_3$ , therefore most of the total amounts of metals are found in unavailable form which are less toxic to plants. This emphasizes further research work in order to find out suitable standards in terms of DTPA-extractable amounts of metals with DTPA or other extractants in addition to their total contents for evaluation of pollution with heavy metals in agricultural soils of Egypt.

The most suitable remediation methods should be identified and precautions must be taken in order to minimize the degree of soil contamination with heavy metals.

## الملخص العربي

أجريت هذه الدراسة بغرض وضع خرائط التوزيع الجغرافي لبعض العناصر الثقيلة وهي الكاديوم "Cd"، النيكل "Ni" و الرصاص "Pb" وتقييم حالتها ومستوياتها في أراضي مركز الفيوم وذلك لتقدير درجة تلوث التربة بهذه العناصر الثلاثة، ولتحقيق هذا الهدف فقد تم جمع ١٦١ عينة تربة من ٨١ موقع تمثل أراضي مركز الفيوم باستخدام النظام الشبكي "Grid System" على مسافات ٢ كم ، حيث أُخذت عينتان من كل موقع: الأولى من طبقة التربة السطحية على عمق (٠ - ٣٠) سم و الثانية تمثل طبقة التربة تحت السطحية على عمق (٣٠ - ٦٠) سم، وتم تحديد مواقع أخذ العينات باستخدام جهاز نظام تحديد الموقع العالمي "GPS".

أعدت عينات التربة للتحليل، وقدر بها كل من الكاديوم "Cd" والنيكل "Ni" والرصاص "Pb" الكلي و كذلك المستخلص بثنائي الإيثيلين ثلاثي الأمين خماسي حامض الخليك "DTPA"، وقدر محتوى التربة من كربونات الكالسيوم، والمادة العضوية وكذلك قدر الرقم الهيدروجيني pH والتوصيل الكهربائي لمستخلص عينة التربة المشبعة.

تم توقيع التوزيع الجغرافي لحالة العناصر الثقيلة المدروسة ومستويات تركيزها في التربة على خرائط لمركز الفيوم باستخدام برنامج "ILWIS" لأنظمة المعلومات الجغرافية "GIS".

أشارت النتائج إلى أن محتوى الكاديوم الكلي في أراضي مركز الفيوم قد تجاوز كثيراً الحدود القصوى التي أوصت بها أغلب الدول، وعلى العكس من ذلك كانت تركيزات الرصاص الكلي في أراضي مركز الفيوم عموماً أقل من الحدود الحرجة المستخدمة في أكثر الدول، إلا أنه قد ظهرت زيادة واضحة في تركيز الرصاص في بضعة مواقع خصوصاً في الطبقة السطحية للتربة بالقرب من الطرق الرئيسية والمناطق السكنية، وذلك مقارنة بالمتوسط العام لتركيزه في بقية المواقع، وقد تجاوز التركيز الكلي للنيكل في الأراضي الحدود الحرجة القصوى الموصى بها في أكثر البلدان.

أشارت النتائج إلى ارتفاع تركيزات العناصر الثلاثة الكلية و الميسرة في الطبقة السطحية (٠ - ٣٠ سم) وذلك مقارنة بتركيزاتها في الطبقة تحت سطحية (٣٠ - ٦٠ سم) مع وجود بعض الاستثناءات في بعض المواقع.

هذا ولم يلاحظ وجود أي ارتباط إحصائي بين المحتوى الكلي لكل من الكاديوم والرصاص والنيكل في التربة وتركيزات تلك العناصر المستخلصة بمحلول ثنائي الإيثيلين ثلاثي الأمين خماسي حامض الخليك "DTPA". تحت ظروف أراضي الفيوم القلوية والغنية في معظمها بكربونات

الكالسيوم، وهذا يؤكد الحاجة الماسة إلى دراسات أخرى لتحديد المستويات الحرجة القياسية لتركيزات هذه العناصر المستخلصة بمحلول ثنائي الإيثيلين ثلاثي الأمين خماسي حامض الخليك "DTPA" وغيرها من محاليل الاستخلاص الأخرى وذلك لتقييم درجة تلوث التربة بهذه العناصر إلى جانب محتوى التربة الكلي من العناصر. وأكدت نتائج هذه الدراسة أيضا على أهمية القيام بمزيد من البحوث من أجل عمل خرائط لمستويات العناصر الثقيلة وتوزيعها ودرجة تلوث الأراضي بها ليس فقط في الفيوم بل في سائر أجزاء مصر بالاستعانة بنظم المعلومات الجغرافية.

## REFERENCES

- Abdellah, H.A. (1995)** Chemical Studies on the effect of irrigation by polluted water on some Egyptian soils. Ph.D. Thesis, Fac. of Agric., Moshtohor, Zagazig Univ., Egypt.
- Abdel-Shakour. E. A. (1982).** Physiological studies on the contamination and toxicity of some plants by certain heavy metals. Ph.D. thesis, Fac. of Agric., Cairo, Egypt.
- Aboulroos, S.A.A.; Holah, Sh. Sh.; and Badawy S.H.,(1996).** Background levels of some heavy metals in soil and corn in Egypt. *Egypt. J. Soil Sci.* 36:(4-1). 83-97.
- Chen, Z.S., D.Y. Lee, C.F. Lin, S.L. Lo, and Y.P. Wang. (1999).** Contamination of rural and urban soils in Taiwan. In: *Contaminants and the Soil Environment in the Australasia-Pacific Region*, R. Naidu, R.S. Kookuna, D.P. Oliver, S. Rogers, M.J. McLaughlin (Eds.). Kluwer Academic Publishers, Boston, London, pp. 691-709.
- Cheng, W.D.; Zhang, G.; YAO, H.; WU, W.; XU, M., (2006)** Genotypic and environmental variation in cadmium, chromium, arsenic, nickel, and lead concentrations in rice grains. Department of Agronomy, Zhejiang University, Hangzhou 310029, China. 2Jiaxing Academy of Agricultural Sciences, Jiaxing 314016, China. 3Zhejiang Provincial Seed Management Centre Station, Hangzhou 310016, China
- De Vries and Bakker, (1998)** Manual for calculating critical loads of heavy metals for terrestrial ecosystem: Guidelines for critical limits, calculation methods and input data TNO Institute of Environmental Sciences, Energy Research and Process Innovation. Den Helder, The Netherlands. 144pp.
- El-Leithi, A. A. E.(1986).** Pedological status of heavy metals in the vicinity of some industrial and highway areas in soils of Nile Delta. Ph. D. Thesis, Fac. of Agric., Alex. Univ., Egypt.
- El-Rashidi, M. A.; Shehata, A. and Wahab, M. (1997).** Contents of zinc, cobalt, nickel and lead in saline alkali soils. *Agrchemic*, 23:245-253. [c. f. *Soil and Fer.* 44(10527), 1998].
- Gimeno-García, E., Andreu, V., Boluda, R., 1996.** Heavy metals incidence in the application of inorganic fertilizers and pesticides to rice farming soil. *Environ. Pollut.* 92(1):19-25.
- Grant, C.A.; Buckley, W.T.; Bailey, L.D. Selles, F., (1998).** Cadmium accumulation in crops. *Can. J. Plant Sci.*, 78:1-17.

- Jackson, M. L. (1979).** Soil chemical analysis. Prentice-Hall, Inc. N. J. USA.
- Lindsay, W. L. (1979).** Chemical equilibria in soil. John Wiley and Sons, New York. 449p.
- Lindsay, W.L. and Norvell, W.A. (1969)** Equilibrium relationships of Zn, Fe, Ca and H with EDTA and DTPA in soils. Soil Sci. Amer. Proc. 33:62-68.
- McLaughlin, M. J.; Parker, D. R. and Clarke, J. M. (1999).** Metals and micronutrients-food safety issues. Field Crops Res., (60(1-2):143-163.
- Piper, C. S. (1950).** Soil and plant analysis. Inter-Science Publisher, New York, USA.
- Rabie, M. H. (1984).** studies on some heavy metals in soils of A.R.E. Ph. D. Thesis, Fac. Of Agric., Ain Shams Univ. Egypt.
- Rabie, F.; Rashad, M.H.; Khader, M.Y. and Hussein, W. (1996)** Contents of biogenic and non-biogenic heavy metals in El-Saff soil as related to different pollution sources. Egypt J. Soil Sci. 36 (1-4):165-177.
- Rashad, I.F.; Abdel-Nabi, A.O.; El-Hemely, M.E. and Khalaf, M.A. (1995).** Background levels of heavy metals in the Nile Delta soils. Egypt. J. Soil Sci., 35:239-252.
- Samira, Y.T (2004).** Status of some heavy metals in soils of Qalubia Governorate. . Ph.D. Thesis, Fac. of Agric., Moshtohor, Zagazig Univ., Egypt.
- Tiller, K. G.; Oliver, D. P.; McLaughling, M. J. and Naidu, R., (1995).** Managing cadmium contribution of agriculture land In: Iskanar, I.K. & Adriano, D. C. (eds.). Remediation of soils contaminated by metals. Science and Technology Letters, Northwood, Middlesex.
- Wright, C. H. (1939).** Soil Analysis. Thomas Murby and Co., London.