RESULTS AND DISCUSSION

4-RESULTS AND DISCUSSION

4.1. Effect of irrigation with sewage effluents and industrial waste waters on soil properties and its content of heavy metals:

4.1.1. Physical properties of soils:

1- Particle size distribution;

The particle size distribution of the soils under investigation is shown in Table (4). The three locations (profiles, 1,2, and 3) differed slightly in their particle size distribution. Results show that all the untreated soils and all the tested soil layers were sandy in texture. Irrigating these soils with sewage for twenty or sixty years just increased the clay content in the top 5 Cm from 1.5 to 6.47 and 7.20, respectively.

Accordingly the textural class of this layer was shefted to loamy sand instead of sand for both treatments.

These results are in agreement with those given by Abdel Naime *et al.* (1982 and 1986),Allam (1986), El-Nashar (1985), and Khalil (1990) who suggested that prolonged periods of irrigation with sewage water over 20 years were associated with slight change in soil texture of the surface layer, (from sand to loamy sand), and with no obvious changes in the texture of subsurface layers.

The texture of the soils irrigated with industrial waste water (profiles 4 and 5) is clay and did not change significantly with depth.

4.1.2. Chemical properties of soils:

1- Total calcium carbonate:

Table (4) presents the values of calcium carbonate content of the soils. The soil profiles contain relatively low amounts of calcium carbonate ranging from 0.10 to 1.70%. In soils treated with sewage water, the $CaCO_3$ content differed somewhat among the three profiles. In the untreated soil the $CaCO_3$ content was 0.8% in the top layer and decreased to 0.5 and 0.2 % in the same layer of soils treated for 20 and 60 years, respectively. The slight reduction of $CaCO_3$ content in treated soils may be due to the acidifying effect of such effluents on solubility of CaCO3 and hence its distribution through the soil profile.

2- Organic matter:

Data in Table (4) showed that in El-Gabal El-Asfar soils (profiles 1-3) which were irrigated with sewage water, there was a considerable accumulation of organic matter due to the liquid sewage application. That ranged from 0.05 to 31.40. The highest value was found in the surface layer of soil irrigated for 60 years with sewage water. This is probably because the sewage water was untreated and contained high proportion of sludge which provided the soil with organic compounds containing appreciable amounts of rather coarse and hardly disposable materials which upon application were deposited on the surface layer while the relatively decomposiable and fine parts passed to the subsurface layers. This result is in agreement with those of El-Gamal (1980) and Khalil (1990).

For the soils irrigated with industrial waste water (profiles 4 and 5), organic matter content ranged from 0.74 to 4.02% showing a generally decreasing trend of organic matter content with soil depth.

3- Soil reaction (pH).

Concerning the soils treated with sewage water (profiles 1-3), the results indicated that the pH values of soils treated with sewage effluents for different periods of time were sharply lower than the corresponding untreated soil, specially in surface layer (Table 5). Such decrease in pH values could be attributed of the organic and inorganic acids introduced into the soil system through the decomposition processes organic residues applied to the soil.

The pH values sharply decreased from 7.90 in untreated soil to 5.45 in soil irrigated with sewage effluents. It appears that a higher content of organic matter was accompanied with lower values of pH, such negative relation can be noticed clearly by comparing values of the surface layers with those of lower ones.

These results are in agreement with those obtained by El-Gamal (1980), Allam (1986) and Khalil (1990).

The pH values in the other two profiles (4,5) irrigated with industrial waste waters were ranged from 7.72 to 8.47 indicating alkaline reaction.

4. Soil salinity:

Data of total soluble salts are presented in Table (5). These data indicate that total soluble salts as expressed by electrical conductivity (E.C) in the sewage irrigated soils (profiles 2,3) are below their levels in the control

Table (4):Orgnic matter ,calcium carbonate and particle size distribution in soils irrigated with sewage and industrial waste waters.

Prof. No.	Depth Cm	O.M. %	CaCO3 %	Particle size distribution.				Textural class
				C.sand	F.sand	Silt	Clay	
	00-05	01.00	0.80	70.00	24.00	04.50	01.50	Sand
	05-10	00.80	0.70	65.00	25.00	04.00	05.90	Sand
1	10-25	00.50	0.20	32.00	64.00	03.40	00.60	Sand
	25-60	00.10	0.10	210.50	70.00	04.80	03.70	Sand
	60-100	00.05	0.10	20.00	72.40	03.20	04.40	Sand
	00-05	10.85	0.50	38.30	46.90	08.33	06.47	*L.S
	05-10	06.50	0.50	15.65	80.00	03.00	01.20	Sand
2	10-25	02.84	0.40	32.00	64.00	02.00	02.00	Sand
	25-60	00.47	0.60	33.85	61.25	02.50	02.40	Sand
	60-100	00.10	0.20	34.00	60.00	03.90	02.10	Sand
	00-05	31.40	0.20	25.70	58.21	08.90	07.20	*L.S
	05-10	28.38	0.30	16.00	75.00	06.00	03.00	Sand
3	10-25	15.78	0.10	14.00	77.10	05.85	03.05	Sand
	25-60	01.27	0.80	22.00	72.60	01.80	03.06	Sand
	60-100	00.47	0.50	23.00	72.00	01.00	04.00	Sand
	00-05	04.02	0.89	02.80	18.10	30.37	48.73	Clay
	05-10	00.74	1.10	01.11	18.70	29.98	50.21	Clay
4	10-25	03.82	1.70	01.95	17.93	28.81	51.31	Clay
	25-60	01.14	0.95	01.30	19.94	29.40	49.36	Clay
	60-100	00.80	0.76	00.55	15.95	31.20	52.30	Clay
	00-05	03.82	1.17	02.47	16.22	29.23	52.10	Clay
	05-10	03.95	1.00	01.88	17.48	31.25	49.39	Clay
5	10-25	03.95	0.97	00.97	17.21	33.20	48.62	Clay
	25-60	01.61	1.20	01.09	21.34	27.97	49.60	Clay
	60-100	01.14	1.00	00.27	19.11	30.62	50.00	Clay

*L.S= Loamy Sand.

soil (profile 1) which could be due to the leaching process. In this respect Kutera (1963) found that there was no salt accumulation upon utilizing sewage water in irrigation of light textured soils.

Relatively high EC values in profiles (4,5) irrigated with industrial waste water could be attributed to relatively high salt content of such waters.

5. Soluble cations and anions:

Sodium and calcium were found in relatively higher amounts than Mg^{++}, while K^{+} was present as a minor constituent (Table 5). Concerning anions, sulphate was dominant and followed by chloride in sewage treated soils that is because the leachiability of Cl ions is higher than of sulphates under such conditions. It is worthy to observe a quite different battern in the soils irrigated with industrial waste waters where Cl dominated followed by SO4 which represent a normal pattern in arid regions.

There was a generally decreasing patterns for cations or anions distribution with depth in the studied profiles. The concentration of soluble cations was high in untreated soil and decreased sharply in treated ones especially that treated for 20 years. It could be noticed that there was a tendency for salt accumulation in soils irrigated for 60 years particalarly in the deep layers that may be due to the salt input through the sewage effluents used for prolonged period (60 years).

6. Cation exchange capacity and exchangeable cations:

The results of CEC (Table 6) revealed that the untreated soil (profile 1) has a lower CEC ranging from 5.2 to 8.71 me/100g through the soil profile. These lower CEC values were due to the lack of silt and clay fractions and the organic matter content. The CEC was increased in the top three layers (0-25 cm) in both soils irrigated for 20 and 60 years. Application of sewage water for 20 years resulted in an increase in the CEC which was ranged from 8 to 20 me/100g along the depth. The same trend was obtained with using sewage water in irrigation for 60 years with appreciable increase in the CEC. The highest CEC value in the layers was 29.9 me /100g. It is clear from the results that the irrigation with sewage water for long period increased soil content of organic materials which in turn increased the CEC of the soil.

Concerning the CEC of soils irrigated with industrial waste water (profiles 4,5), no appreciable effect could be detected.

Data of exchangeable cations (Table 6) are show that the exchangeable cations in the surface layer were increased with increasing the time of irrigation. Soil irrigated for 60 years contained more exchangeable cations than that irrigated for 20 years.While, the untreated ones contained the least amount of exchangeable cations.

Soils irrigated with industrial waste water showed high exchangeable cations content as expected.

Table (5): PH, EC and soluble cations and anions (me /L.) in soils irrigated with sewage and industrial waster waters

Prof. No	depth cm	PH 1:2.5	EC m.moh /cm	Soluble cations (me/L) Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Soluble anions (me/L) CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
	00-05	7.60	14.98	30.49	16.79	96.75	05.75	0.0	2.25	117.2	30.33
	05-10	7.60	14.80	30.00	16.90	95.97	05.80	0.0	2.30	116.9	29.47
1	10-25	7.70	11.48	27.89	11.81	69.15	05.75	0.0	2.50	085.8	26.32
	25-60	7.80	06.10	14.85	06.29	36.80	03.10	0.0	1.40	45.70	13.94
	60-100	7.90	03.60	09.65	03.91	20.61	01.85	0.0	3.78	22.56	09.98
	00-05	5.75	00.89	03.00	02.80	01.96	00.49	0.0	1.20	000.9	06.15
	05-10	5.77	01.16	05.40	01.60	03.70	00.37	0.0	1.30	001.4	08.37
2	10-25	5.47	00.60	01.80	01.20	02.16	00.31	0.0	0.30	001.0	04.62
	25-60	6.22	00.40	01.60	00.80	01.52	00.20	0.0	0.30	000.7	03.12
	60-100	7.01	00.30	01.00	00.70	00.87	00.24	0.0	0.20	00.7	01.91
	00-05	5.45	03.75	28.20	14.80	03.48	01.20	0.0	3.20	006.0	38.48
	05-10	5.66	02.30	15.00	07.40	03.91	01.00	0.0	2.20	004.2	20.91
3	10-25	6.12	01.20	06.70	04.30	03.04	00.98	0.0	3.00	003.0	08.92
	25-60	6.56	00.90	04.50	02.60	02.17	00.80	0.0	3.20	002.0	03.87
	60-100	6.34	00.80	03.70	01.90	03.00	00.82	0.0	1.70	002.5	05.72
	00-05	7.80	07.55	26.70	09.80	30.50	01.31	0.0	3.70	051.6	13.01
	05-10	7.88	00.70	03.00	01.40	03.48	00.15	0.0	1.20	001.1	05.73
4	10-25	8.47	01.48	02.50	01.10	05.65	00.29	0.0	0.60	008.0	00.94
	25-60	8.08	00.80	01.50	00.30	11.00	00.18	0.0	0.80	003.8	08.38
	60-100	7.76	01.90	05.0	02.60	12.00	00.25	0.0	1.40	010.0	07.65
	00-05	7.78	10.00	31.60	13.40	82.00	01.67	0.0	2.20	090.5	35.79
	05-10	7.72	12.00	40.60	16.40	91.00	01.59	0.0	2.10	084.5	26.99
5	10-25	7.98	07.00	19.40	08.60	63.00	01.22	0.0	2.10	042.4	47.72
	25-60	7.77	04.80	13.80	06.90	40.10	00.50	0.0	1.80	029.4	30.10
	60-100	7.77	04.00	11.40	06.60	33.12	00.29	0.0	1.50	026.0	23.91

Table (6): Cation exchange capacity and exchangeable cations (me/100g) in soils irrigated with swage and industrial waste waters.

Prof. No	Depth cm	CEC me/100g	Exchangeable cations (me/100g)			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
1	00-05	08.71	04.20	02.69	1.08	0.23
	05-10	07.59	03.41	02.52	0.75	0.52
	10-25	06.50	04.71	01.30	0.25	0.20
	25-60	06.22	04.09	00.95	0.52	0.17
	60-100	05.20	03.00	01.80	0.13	0.14
2	00-05	20.60	11.92	06.35	0.69	0.68
	05-10	13.10	06.62	04.40	0.99	0.49
	10-25	09.70	05.18	03.26	0.58	0.47
	25-60	08.70	06.71	01.64	0.34	0.31
	60-100	08.30	04.20	02.69	1.08	0.23
3	00-05	26.40	16.69	06.36	0.89	0.80
	05-10	29.90	17.29	09.29	1.53	0.80
	10-25	10.52	05.38	03.26	0.58	0.47
	25-60	07.59	03.41	02.52	0.75	0.52
	60-100	06.92	04.62	01.48	0.39	0.20
4	00-05	43.20	28.00	09.20	5.30	0.41
	05-10	25.00	18.80	05.20	0.70	0.09
	10-25	37.00	24.80	08.00	4.00	0.33
	25-60	41.80	28.00	08.40	4.15	0.20
	60-100	44.00	30.0	09.20	4.17	0.20
5	00-05	48.00	28.00	12.00	8.00	0.51
	05-10	43.00	26.00	06.00	8.00	0.49
	10-25	43.00	24.40	11.60	6.08	0.49
	25-60	35.00	22.40	09.20	4.52	0.20
	60-100	42.00	23.00	14.00	4.52	0.15

4.1.3. Status of heavy metals in the studied soil profiles:

4.1.3.1. Copper (Cu):

Table (7) and Fig (1):

4.1.3.1.1. Total copper:

Copper is relatively an immobile element in soils particularly in presence of organic materials . Accordingly it is a common characteristic of Cu to accumulate in the top horizons. This phenomenon is an effect of various factors, it may reflects the bioaccumulation of the metal and also the recent anthropogenic sources of the element.

Results in table (7) show that total, avilable and all determined fractions showed a very distinict decreasing pattern with soil depth particularly in the soils treated with sewage effluents. Such a trend is expected because of the high affinity of organic molecules to bind with Cu.

Contents of total Cu in different layers of profiles (1,2,3) under investigation. Contents of total Cu in the upper 5 cm of treated soils werefrom 25.0 to 475.0 mg/kg. In site 2 which was irrigated for 20 years the concentration of total Cu was about 24 mg/kg in the top 10 cm, whereas the concentration of total Cu in site 3 irrigated for 60 years increased to about 485 mg/kg at the same depth. The concentration of total Cu decreased sharply with increasing depth.

Regarding the total Cu content in the other two sites (4,5) irrigated with industrial waste water, the results also indicate an accumulation in the top layers. In site 4 the highest value was 114 and the lowest one was 60 mg/kg. The same trend was found in site 5. The total Cu distribution decreased with soil depth .

The threshold value of 100 ppm Cu in soils reported by El-Bassam and Titjen (1977) had been exceeded in site 3 which was irrigated with sewage effluents for 60 years and in sites 4 and 5 irrigated with industrial waste water.

4.1.3.1.2. DTPA-extractable Cu:

The available Cu concentration in the irrigated soils (profiles 2 and 3) ranged from 9.82 to 16.2 mg/kg in the upper layer (5 cm), 6.88 to 15.6 mg/kg in the 5-10 cm depth. The available Cu was increased with increasing the period of irrigation with sewage effluents, as soil irrigated for 60 years contained the highest values of this Cu phase. The DTPA-extractable Cu decreased with depth through soil profile.

The available Cu in profiles 4 and 5 was mor pronounced in the above 25 cm and decreased sharply with increasing depth.

4.1.3.1.3. Cu fractions:

occurance of Cu in the seven fractions vary widely in soils and most of the soil Cu existed in the PYR- fraction. This fraction constituted 20 and 39% of total in soils unirrigated or irrigated with sewage water, respectively. However, in the soils affected by industrial waste water, the residual form comprised about 40% of the total Cu in the top 10 cm, followed by the PYR-Cu fraction.

Non specific adsorbed Cu (Cu- CA).

This fraction which represents the exchangeable form constituted the least amount of Cu in soils (0.01 to 9.0 mg/kg) in the first three profiles irrigated with sewage water. Site 3 had the highest value of exchangeable Cu (9.0 mg/kg). The concentration of this fraction in the soils received industrial waste water was lower than those irrigated with sewage water. The distribution pattern of this fraction in soil profile was similar to that of the total and available Cu. Occlusion, co-precipitation and substitution are involved in the non specific adsorption of Cu.

Specifically adsorbed Cu (Cu-AC):

The specific adsorbed Cu fraction which was extracted by the acetic acid was somewhat higher in soils irrigated with sewage water for 60 years specially in the top 10 cm (13 mg/kg) compared to that in soils irrigated for 20 years (0.5 mg/kg). This fraction comprised about 2.13 % of the total Cu in treated and untreated soils. This fraction constituted about 2.27% of the total Cu in soils irrigated with industrial waste water. The high levels of specifically adsorbed Cu in site 3 (irrigated for 60 years) may have resulted from the dissolution of some precipitated Cu by acetic acid (Table 7) . This explanation is coincided with previous reports indicating that acetic acid extracts quantities of ions greater than those present on the exchange sites of oxide (Mckenzie, 1957) and clay minerals (Hodgson, 1960). Mitchell *et al.*, (1957) and Mclaren and Crawford (1973) reported that, this reagent extracts mainly inorganically bound ions.

Organically bound Cu (PYR- Cu):

This fraction is one of the most important soil Cu fractions, since there is a great affinity of organic compounds to bind soil Cu. This fraction was very low in unirrigated soil and increased with increasing soil organic matter as a result of using sewage effluents. The highest value of this fraction was found in the top 10 cm in profile 3 irrigated for 60 years (186 and 192 mg/kg).

The Cu-PYR fraction ranged between 0.10 to 192.0 mg/kg which corresponding with 10.0 to 40.42% of total Cu in soil. In soils irrigated with industrial waste water this fraction amount to 25 mg/kg in the top 25 cm

Mn oxide bound Cu (Cu-HAH):

This fraction represents Cu occluded on Mn oxides. In the first three profiles, there was no difference between the unirrigated and irrigated for 20 years. However, with increasing the irrigation period to 60 years, this fraction was increased to be 6 mg/kg in the upper 10 cm. In general, this fraction constituted a little proportion of total Cu. Regarding the distribution of this fraction in soils irrigated with industrial waste water, there was no clear trend.

Al and Fe oxides bound Cu (Cu- OX):

This fraction represents Cu occluded on amorphous Fe and Al oxides. In profiles (1,2 and 3), this fraction varied from 0.03 to 39.20 mg/kg which constituted about 3.0 to 8.7 % of total soil Cu. As observed with the above mentioned fractions profile 3 was the richest one in its content of this fraction. In profiles 4 and 5 the of Cu-OX fraction in the upper 25 cm raged from 4.01 and 9.9 mg/kg .

Crystalline Fe and Al oxides bound Cu (Cu- OXA):

This fraction represents the portion of Cu occluded on crystalline Fe and Al oxides. In soils irrigated with sewage water, this fraction ranged from 0.08 to 67.23 mg/kg which corresponded to 8.0 to 17.83% of total Cu in these soils.

Table (7): Total, DTPA and Copper fractions (mglkg) in soils irrigated with sewage and industrial waster waters.

Prof. No	Depth	Total	DTPA	Copper fractions (mg/kg)						
				Cu-CA	Cu-AC	Cu-PYR	Cu-HAH	Cu-OX	Cu-OXA	Cu-RES
1	00-05	10.00	00.90	0.10	00.21	002.00	1.00	00.80	01.60	004.29
	05-10	10.00	00.81	0.09	00.13	001.98	1.00	00.70	01.50	004.60
	10-25	06.21	00.55	0.03	00.07	000.90	0.40	00.38	01.00	003.43
	25-60	03.00	00.30	0.01	00.03	000.39	0.10	00.18	00.50	001.79
	60-100	01.00	00.10	0.01	00.01	000.10	0.40	00.03	00.08	000.37
2	00-05	025.00	09.82	0.50	00.65	010.00	0.50	02.09	04.20	007.06
	05-10	023.00	06.88	0.37	00.44	009.00	1.00	02.00	04.10	006.09
	10-25	011.00	01.58	0.11	00.18	002.88	1.00	00.90	01.54	004.39
	25-60	005.50	00.66	0.04	00.03	000.40	0.19	00.11	00.20	001.03
	60-100	002.00	00.68	0.09	00.10	001.00	0.50	00.40	00.70	002.71
3	00-05	475.00	16.20	8.00	12.00	192.00	6.00	28.00	66.50	162.50
	05-10	490.00	15.60	9.00	13.00	186.20	5.00	39.20	67.23	170.37
	10-25	195.00	14.80	1.22	03.20	050.70	2.50	14.82	25.85	096.71
	25-60	026.50	06.50	0.50	00.45	005.60	1.00	01.88	03.64	013.43
	60-100	006.50	01.72	0.09	00.10	000.89	0.49	00.40	01.04	003.49
4	00-05	100.00	24.40	1.00	02.59	028.39	3.00	07.23	16.21	041.58
	05-10	060.00	03.32	0.62	01.78	017.21	2.22	04.01	11.28	022.88
	10-25	114.00	19.40	0.78	02.46	025.69	4.00	10.00	18.94	052.13
	25-60	077.50	05.70	0.36	01.48	016.71	2.87	05.50	12.01	038.57
	60-100	066.50	04.78	0.11	00.98	014.76	2.24	05.22	12.29	030.90
5	00-05	110.50	17.20	1.12	02.56	028.98	4.10	09.22	18.52	046.00
	05-10	105.50	18.40	0.96	01.28	024.30	4.19	09.98	19.95	044.84
	10-25	107.50	16.20	0.83	01.23	025.01	4.07	09.87	19.84	046.65
	25-60	076.00	05.94	0.21	01.09	016.04	3.06	07.59	15.00	033.01
	60-100	067.00	03.98	0.11	01.05	012.00	2.99	06.20	13.80	030.85

Residual Cu fraction (Cu- RES):

This fraction is considered as the primary form of native Cu in soil. In soils treated with sewage effluents it was increased sharply with increasing the time of irrigation. This fraction ranged from 0.37 to 170.37 mg/kg which represents 28.24 - 73.0 % of total Cu in soil.

The results of Cu fractions in the studied soils (El-Gabal El-Asfar) revealed that Cu was concentrated in the three fractions, Cu- RES , Cu- PYR, Cu-OXA which represent ~ 50.00, ~ 25.21 and ~ 13.92% of the total Cu in soils, respectively. While the soluble and exchangeable (Cu-Ca), inorganically bound (Cu-AC), occluded on Mn oxides (Cu-HAH), and occluded with amorphous Fe, Al oxides (Cu-OX) fractions represent only ~ 1.01, ~ 1.99, ~ 5.51, and ~ 6.47 of the total Cu in these soils, respectively.

From the previous results, it could be concluded that continuous irrigation with sewage water increased the soil content of total, available and all other Cu fractions. Moreover, contents of soil Cu was much greater in the upper layers than in the lower ones, due to the comparatively low organic matter contents in the deep layers.

4.1.3.2. <u>Zinc (Zn):</u>

Table (8) and Fig. (1):

4.1.3.2.1. <u>Total Zn:</u>

Data of total Zn in different layers of the profiles (1,2, and 3) under investigation are presented in Table (8). Contents of total Zn in the upper 5 cm of treated soils (20 and 60 years) ranged from 418 to 10750 mg/kg. In the second layer (5-10 cm), Zn varied from 376 to 4445 mg/kg, and materially decreased in the subsequent layers, The previous data revealed that the total Zn accumulated mostly in the upper 3 layers (0 - 25 cm), and with increasing the period of irrigation with sewage water the total Zn content of soils was obviously increased. Total Zn content after 60 years of sewage use was about 263 times that of the control. Zn concentration decreased with depth. These results are in agreement with those obtained by El-Gamal (1980),Ellis and Kenzek (1972) and Khalil (1990).

Regarding the soil irrigated with industrial waste water (profiles 4 and 5), total Zn content ranged from 148 to 264 mg/kg soil. A generally decreasing pattern of Zn distribution with soil depth was observed with soil depth.

El-Bassam and Tiejen (1977) reported that the maximum tolerable level of Zn in soils is 300 mg/kg. Data in Table (8) indicate that Zn content in soils irrigated with sewage effluents for 60 years exceeded that maximum tolerable level.

4.1.3.2.2. DTPA-extractable Zn:

Values of available Zn concentration in the treated soils (profiles 2,3) ranged from 69.0 to 5000.00 in the upper 5cm layer, 360 to 1140 in the 5-10 cm layer, 17.0 to 196 in the 10-25 cm layer, and sharply decreased with increasing soil depth. The data indicated that the available Zn concentrations increased as the period of sewage effluents application increased, particularly in upper layers of the soils. These results are in agreement with those obtained by El-Gamal (1980), Ellis and Knezek (1972) and Khalil (1990).

Regarding soils irrigated with industrial waste water (profiles 4 and 5), DTPA-extractable Zn ranged from 1 to 17 mg/kg soil. The distribution of available (DTPA-extractable) Zn followed the same decreasing trend with depth.

4.1.3.2.3. Zn fractions:

The **Zn-CA** Data showed that this fraction constituted the least amount of total soil Zn, the range being from 0.1 to 354.8 mg/kg comprising 0.03 - 0.42 percent of total Zn.

The Zn- AC fraction was somewhat higher than expected, it ranged from 0.14 to 354.75 mg/kg which represents 1.2- 3.3 percent of total soil Zn. These higher values probably resulted from the dissolution of some precipitated Zn by the acetic acid extract.

Zn-PYR fraction constituted relatively high portion of the total soil Zn and ranged between 1.16 to 3117.5 mg/kg , being equal to 10.29 - 29.24 percent of total Zn in soil.

Zn- HAH fraction ranged from 0.26 to 350.45 mg/kg representing about 2.22 - 3.84 percent of total Zn in soil.

The Zn-OX fraction was also relatively high, varying from 0.58 to 597.7 mg/kg, representing 4.65 - 5.63 percent of total.

The Zn-OXA was also high and ranged from 2.08 to 2590.75 mg/kg which comprised 18.24 - 24.20 percent of total soil Zn.

The Zn-RES fraction constituted the highest portion of soil Zn. It ranged from 7.05 to 3693.70 mg/kg which corresponded to 34.36 - 62.54 percent of total soil Zn. This fraction may be considered as the primary form of the native Zn in these soils.

From the above mentioned results, it could be concluded that, continuous irrigation with sewage effluents increased very much soil content of total, DTPA-extractable Zn, and other Zn fractions. Soil content of Zn and its concentrated in the top layers than in the deep ones, due to the comparatively lower organic matter content in the deep layers.

Regarding the soil irrigated with industrial waste water(Table 8 and Fig.4), the Zn-CA, Zn-AC, Zn-HAH, and Zn-OX fractions constituted the least amount of Zn ranged from 0.15 to 0.61, 3.73 to 8.77, 3.24 to 8.41 and 7.29 to 13.86 mg/kg soil, respectively. On the other hand the Zn- OXA, Zn-PYR, Zn- RES constituted the highest portions of soil Zn fractions ranging from 28.4 to 60, 34 to 17.4 and 69.2 to 112.6 mg/kg, respectively.

The results of Zn fractions in the studied soil profiles revealed that Zn is concentrated mainly in the residual freaction (Zn- RES), occluded on crystalline Fe and Al oxides (Zn- OXA), and organically bound (Zn-PYR) which represent ~ 51.27, ~ 20.27, ~ 19.76% of total soil Zn respectively. The soluble and exchangeable (Zn-CA), inorganically bound (Zn-AC),occluded on Mn oxides (Zn-HAH), and occluded amorphous Fe and Al oxides (Zn-OX) fractions represented ~ 0.22, ~2.27, 2.96 and ~ 4.37% of total soil Zn, respectively.

Table (8): Total, DTPAand Zinc fractions (mg/kg) in soils irrigated with sewage and industrial wate waters.

Prof. No	Depth Cm	Total	DTPA	Zinc fractions (mg/kg)						
				Zn-CA	Zn-AC	Zn-PYR	Zn-HAH	Zn-OX	Zn-OXA	Zn-RES
1	00-05	0073	0002	001.3	001.3	011.9	001.6	003.8	014.6	039.9
	05-10	0062	0002	001.1	001.1	010.2	00.8	03.5	011.3	034.2
	10-25	0031	0001	000.5	000.5	004.7	000.9	001.6	005.7	017.9
	25-60	0026	0001	000.4	000.4	003.2	000.9	001.4	005.0	015.5
	60-100	0011	00.40	000.1	000.1	001.2	000.3	000.6	002.1	007.1
2	00-05	0418	0069	012.9	012.9	109.8	013.8	021.4	092.4	166.0
	05-10	0376	0036	011.3	011.3	097.2	011.5	017.9	084.6	152.0
	10-25	0236	0017	007.0	007.0	057.2	006.0	010.9	051.2	102.6
	25-60	0038	0006	000.7	000.7	008.0	001.3	002.0	008.8	017.8
	60-100	0075	0003	001.3	001.3	013.8	002.9	003.8	017.2	036.3
3	00-05	10750	5000	354.8	354.8	3117	350.4	598.0	2590	3694
	05-10	04445	1140	137.8	137.8	1299	155.1	217.4	1075	1541
	10-25	03015	0196	090.5	090.5	757.4	090.2	157.7	0714	1193
	25-60	00167	0009	005.3	005.3	038.0	004.8	008.6	0035	070.4
	60-100	00089	0004	002.5	002.5	0016	002.7	004.2	0021	042.6
4	00-05	00248	0017	008.2	008.2	065.3	008.3	012.9	054.5	097.2
	05-10	00148	0008	004.7	004.7	038.4	005.6	007.4	032.5	048.5
	10-25	00257	0014	008.2	008.2	059.0	008.3	012.8	054.1	11.6
	25-60	00161	0002	004.8	004.8	037.2	005.7	008.4	033.8	070.8
	60-100	00151	0001	004.4	004.3	034.0	004.5	007.3	029.1	071.8
5	00-05	.00264	0015	008.8	008.8	071.4	008.4	013.9	059.8	100.6
	05-10	00258	0017	007.7	007.7	069.3	008.3	013.3	055.4	103.0
	10-25	00258	0014	007.8	007.8	065.2	007.6	012.9	051.1	112.6
	25-60	00158	0002	004.8	004.7	039.5	003.5	008.0	029.2	073.3
	60-100	00148	0001	003.7	003.7	035.9	003.2	007.4	028.4	069.2

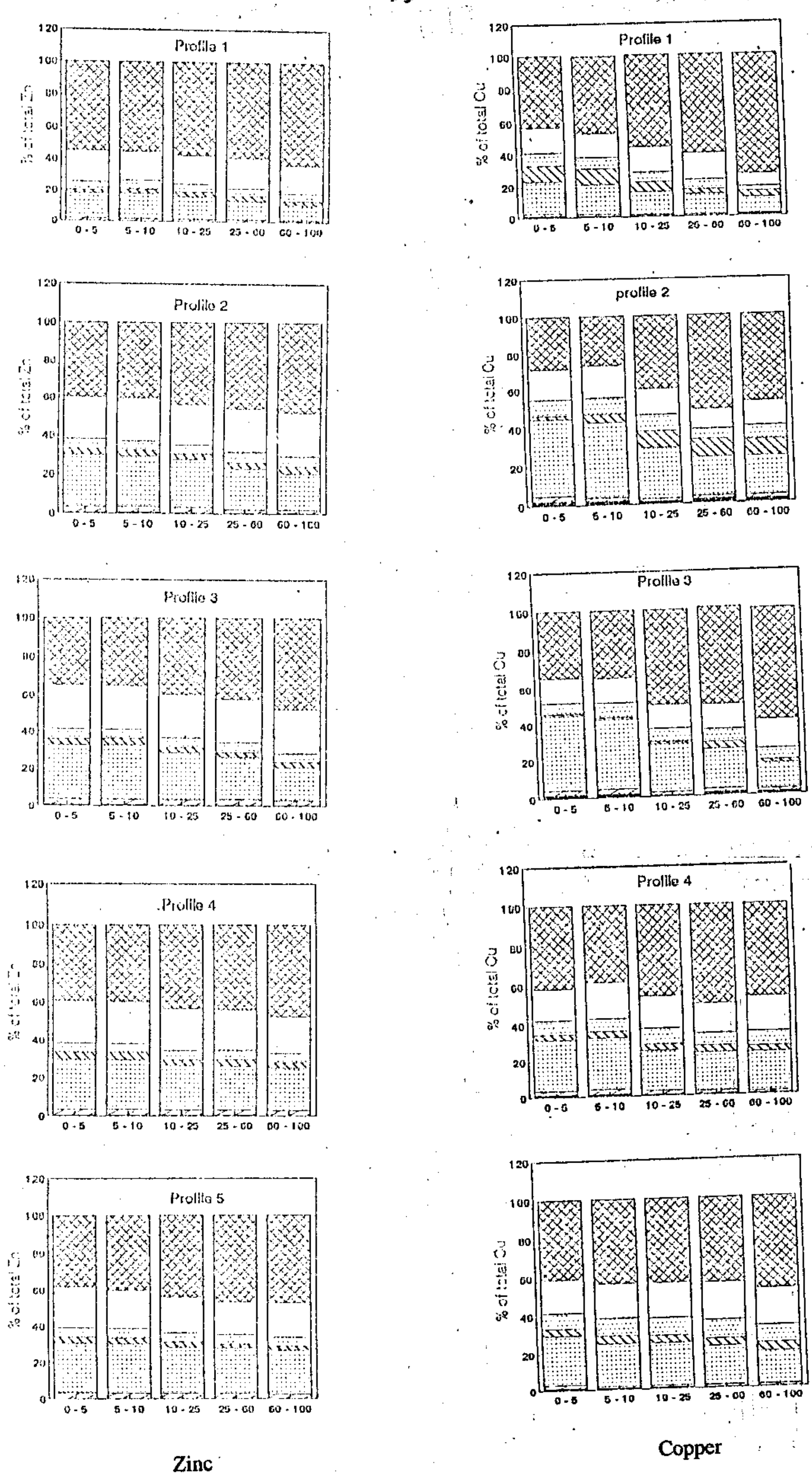


Fig. (1): Copper and zinc fractions in soils irrigated with sewage and industrial waste waters.

R-CA R-CAA R-PYR R-HAH R-COX R-COA R-RES

4.1.3.3. Lead (Pb):

Table (9) and Fig. (2):

4.1.3.3.1. Total lead:

Results show that total Pb in soil not irrigated with sewage water (profile 1) was practically nil (traces). Lead accumulated in surface layers of sewage treated soils in relatively higher amount than the subsurface ones and it decreased with depth of soil profile. It ranged from 53.5 to 226 mg/kg in the upper 5 cm, from 50 to 176.5 mg/kg in the 5-10 cm, from 32 to 63 mg/kg in the 10-25 cm, and decreased to reach 17 mg/kg in the (60-100 cm) layer. This increase could be due to the high content of Pb in sewage water, it may indicate that lead is relatively an immobile metal in the soils (Garicia-Miragaya, 1981) and thus accumulates at or near the soil surface. Also, data revealed that increasing the period of irrigation with sewage water increased total Pb content in the soils, indicating that sewage water could be the source of lead pollution in the soils irrigated with this water. These results are in agreement with the findings of Abdel-Naime *et al.* (1982), El-Nennah *et al.* (1982), and Khalil (1990).

With respect to soils irrigated with industrial waste water (profiles 4 and 5), results showed that the total Pb content varies from 33.5 to 98.0 mg/kg soil .The distribution of total Pb showed a regular decreasing pattern with depth through soil profile, due to the relative immobility of this metal in the soil (Garia-Miragaga, 1981).

The present results show considerable Pb content in the investigated soils as compared with previous results reported by Abdel-Shakour (1982), El-Sokkary (1978) and El-Sokkary and Lag (1980) for uncontaminated Egyptian soils. They reported an average values of 11.8, 7.0 and 14.0 mg/kg as total soil Pb, respectively. This contamination is most probe due to the effect of sewage water in case of soils El-Gabal El-Asfar and to industrial waste water in the soils of Bahteem.

The threshold value of 100 mg Pb/kg soil as reported by El-Bassam and Tietjen (1977) was sharply exceeded in profile 3 irrigated with sewage water for 60 years. Soils of profiles 4 and 5 irrigated with industrial waste water contained amounts of Pb that are close to that mentioned as threshold value.

4.1.3.3.2. <u>DTPA extractable lead:</u>

The DTPA-extractable Pb, was traces in control (profile 1), but it ranged from 10.1 to 18.3 mg/kg in the upper 5 cm, 6.3 to 8.1 mg/kg in the 5-10 cm depth, 1.8 to 1.9 mg/kg in the 10-25 cm depth, 0.4 to 1.7 mg/kg in the 25-60 cm, and 0.1 to 0.2 in the deep layer (60-100 cm)

Data indicated that the available Pb materially accumulated in the surface soil layers in amounts relative higher than those in subsurface ones, and decreased sharply with soil depth. Again these results assumed that sewage effluents represent the main source of lead contamination in suchsoils and that Pb accumulation increased with prolonging the period of irrigation. These results also are in agreement with the results of Abdel-Naime *et al* (1982), El-Nennah *et al.* (1981), and Khalil (1990).

DTPA-extractable Pb in the soils irrigated with industrial waste water (profiles 4 and 5) ranged from 0.24 to 19.24 mg/kg soil .

El-Sokkary (1978) reported average values of DTPA-extractable Pb of 1.1 mg/kg in normal soils. Accordingly, the present results show considerable

Pb contamination in the investigated soils. This may be due to integration effects of sewage water and industrial waters.

4.1.3.3.3. Lead fractions:

Data show that, all the Pb fractions are traces in the profile 1 (soil not irrigated with sewage water). However, in the other two profiles irrigated with sewage water, the **Pb-CA** fraction constituted the least amount of soil Pb in the soils ranged from 0.04 to 1.6 mg/kg which corresponded to 0.2-0.7 percent of total Pb in the soils. The **Pb-AC** fraction, on the other hand, was relatively high and ranged from 2.9 to 63.8 mg/kg which represents 17-28.2 percent of total soil Pb.

The **Pb-PYR** fraction constituted relatively high portion of the total soil Pb and ranged from 4.3 to 98 mg/kg which corresponded about 30-43.3 percent of the total soil Pb. It represents the lead specifically bound to soil macromolecules, according to Mclaren and Crawford (1973).

The **Pb-HAH, Pb-OX, Pb-OXA** fractions constituted the lowest amount of soil Pb. They ranged from 0.1 to 0.9, 0.1 to 2.1 and 0.2 to 5.7 mg/kg, respectively, constituting 0.2 - 0.4, 0.7-0.9 and 1.1-2.5 percent of total soil Pb , respectively.

The **Pb-RES** fraction constituted the highest portion of Pb as it ranged from 8.4 to 54 mg/kg representing 23.9-49.3 percent of total soil Pb.

Regarding the soil irrigated with industrial waste water (profiles 4 and 5), the data in Table (9) show that the Pb- CA fraction constituted the lowest

Table(9) :Total, DTPA and Lead fractions (mg/ kg) in soils irrigated with sewage and industrial waste waters.

Prof. No	Depth Cm	Total	DTPA	Lead fractions.						
				Pb-CA	Pb-AC	Pb-PYR	Pb-HAH	Pb-COX	Pb-COA	Pb-RES
	00-05	T	T	T	T	T	T	T	T	T
	05-10	T	T	T	T	T	T	T	T	T
1	10-25	T	T	T	T	T	T	T	T	T
	25-60	T	T	T	T	T	T	T	T	T
	60-100	T	T	T	T	T	T	T	T	T
	00-05	050.0	10.1	0.3	11.1	19.1	0.14	0.33	1.00	18.00
	05-10	053.5	09.3	0.3	10.7	19.3	0.11	0.39	1.03	21.70
2	10-25	032.0	01.8	0.1	06.0	11.0	0.08	0.26	0.64	13.95
	25-60	019.0	00.38	0.1	03.8	06.1	0.06	0.14	0.36	09.02
	60-100	017.0	00.2	0.04	03.0	04.3	0.06	0.12	0.18	08.39
	00-05	226.0	04.1	1.58	63.8	98.0	0.90	2.08	5.70	53.97
	05-10	167.5	18.3	1.12	45.8	65.0	0.62	1.57	3.80	49.37
3	10-25	063.0	01.9	0.32	12.0	20.9	0.14	0.52	1.18	25.50
	25-60	029.5	01.7	0.09	05.6	08.9	0.11	0.24	0.52	14.09
	60-100	017.5	00.1	0.04	03.2	05.3	0.07	0.13	0.35	08.40
	00-05	091.0	19.2	0.47	18.4	28.0	0.30	0.66	2.48	40.72
	05-10	088.5	14.1	0.38	17.7	27.4	0.26	0.63	1.98	40.18
4	10-25	036.0	01.1	0.15	06.9	10.1	0.08	0.25	0.77	17.70
	25-60	034.0	00.7	0.14	06.4	09.2	0.10	0.23	0.68	17.23
	60-100	033.5	00.2	0.13	05.8	08.4	0.10	0.22	0.60	18.31
	00-05	098.0	16.9	0.5	20.8	30.4	0.13	0.69	2.57	42.74
	05-10	092.0	16.7	0.5	19.2	28.5	0.28	0.63	2.32	40.68
5	10-25	075.0	16.0	0.3	14.4	21.8	0.20	0.46	1.61	36.16
	25-60	035.0	01.3	0.1	05.9	09.3	0.10	0.25	0.66	18.71
	60-100	034.0	00.3	0.1	05.0	08.8	0.07	0.24	0.65	18.66

amount of soil Pb ranging from 0.13 to 0.49 mg/kg with an average of 0.25 to 0.31 mg/kg

The Pb-AC and Pb-PYR fractions which represent the Pb specifically adsorbed and organically bound, respectively, constituted relatively high amount ranged from 5.44 to 20.8, and from 8.4 to 30.4 mg/kg

The Pb-HAH, Pb-OX and Pb-OXA fractions constituted also low amounts of Pb ranging from 0.1 to 0.3, 0.2 to 0.7 and from 0.6 to 2.52 mg/kg, respectively.

The Pb-RES fraction constituted the highest portion of soil Pb as it ranged from 17.2 to 42.7 mg/kg.

The results of Pb fractions in the studied soil profiles revealed that soil Pb concentrated mainly in the residual fraction (Pb-RES), organically bound (Pb-PYR) and specifically adsorbed (Pb-AC), while Pb-CA, Pb-OX, Pb-OXA fractions represent quite low amounts of total Pb in soil.

4.1.3.4. Cadmium:

Table (10) and Fig (2):

4.1.3.4.1. Total Cadmium:

Data represent values of total Cd in different layers of profiles (1,2,3) under investigation. No Cd was detected in soils which did not receive sewage effluents for irrigation (profile 1). The values of total Cd were ranged from 4 to 13 mg/kg in the upper 5 cm, from 3.5 to 11 mg/kg in the 5-10 cm layer, from 3 to 9.5 mg/kg in the 10-25 cm layer, from 3 to 9.3 mg/kg in the 25-60 cm layer, and from 3 to 8.5 in the deep layer (60-100 cm). The increase in Cd content in these soils could be due to the high content of Cd in sewage water. Increasing the period of irrigation with sewage water increased the total Cd content of soils. Using sewage water in irrigation for 60 years led to an increase in total Cd content in the upper layer to reach 13 times that of the control. Total Cd concentration decreased with depth through the soil profile. These results are in agreement with the findings of El-Gamal (1980), El-Nashar (1985), and Khalil (1990).

Results also indicated that the decrease in Cd content with depth was not sharp but gentle. Comparing sublayers content of the element with those of top layers revealed that Cd is more leachable and more mobile. These results are in agreement with those of Kuo *et al.* (1983) who reported that Cd was more leachable than Cu or Zn under western Washington conditions.

Regarding soil irrigated with industrial waste water (profiles 4 and 5) the results indicate that the total Cd content varies from 9.0 to 10.9 mg/kg soil and decreased gently with depth, confirming the relatively high mobility of this element (Table 10 and Fig. 2).

The values of total Cd in the studied polluted soils are seriously higher than those found by Abdel-Aziz (1983) and Baghdady and Sippola (1984b) in Egyptian alluvial soils (0.19 and 0.26 mg/kg) , those of Bahteem soils (0.23 mg/kg) reported by Abdel-Haleem (1984), and also those of Ismailia soils (0.3-2.3 mg/kg) and Sinai soils (0.3 - 0.8 mg/kg) reported by El-Sikhry (1985) and those of some industrial areas (2.3 - 7.6 mg/kg) reported by El-Leithi (1986).

Soils irrigated with sewage effluents for 60 years and those irrigated with industrial waste water showed relatively high Cd content thatexceeded 5 mg /kg which considered as maximum tolerable level , as reported by El-Bassam and Tietjen (1977).

4.1.3.4.2. <u>DTPA-extractable cadmium:</u>

Cadmium was not detected in soils which did not receive sewage water (profile 1). Contents of available Cd in treated soils ranged from 0.12 to 1.4 mg/kg in the upper 5 cm, from 0.1 to 0.9 in the 5-10 cm, from 0.04 to 0.47 mg/kg in the 10-25 cm, from 0.03 to 0.05 mg/kg in the 25-60 cm layer, and from 0.01 to 0.03 mg/kg in the 60-100cm layer. The obtained results indicate that available Cd accumulated largely in the surface layers as a result of prolonged utilization of sewage water in irrigation and tended to decrease sharply with soil depth. These results are in agreement with the findings of El-Gamal (1980), El-Nashar (1985) and Khalil (1990).

DTPA-extractable Cd in the soils that received industrial waste water (profiles 4 and 5) ranged from 0.03 to 0.19 mg/kg, with an intendency to decrease gently with soil depth.

4.1.3.4.3. <u>Cadmium fractions:</u>

Non of the tested Cd fractions was detected in soil which did not receive sewage water (profile 1). However, in the soils received sewage water **Cd-CA** fraction constituted a relatively high portion of total soil Cd ranging between 0.4 to 3.9 mg/kg which corresponded to 13.3 - 30 percent of the total Cd in soil.

The results indicate that the continuous use of sewage water in irrigation increased the soluble and exchangeable Cd fraction which increased from 0.8 to 3.9 mg/kg with increasing the period of irrigation from 20 to 60 years

. Comparing Cd-CA with those of same fraction of Zn and Cu revealed that the exchangeability and or solubility of Cd were much greater than these of Zn and Cu which agreed with El-Sokkary and Lag (1978), and Kuo *et al.* (1983).

The **Cd-AC** fraction ranged from 0.1 to 1.0 mg/kg representing 3.3 - 8.4 percent of total soil Cd . The results indicate that the amount of this fraction was very low and increased with increasing the period of irrigation with sewage water.

The **Cd-PYR** fraction constituted relatively high proportion of the total soil Cd and ranged between 0.4 to 3.9 mg/kg which corresponded to 15-30 percent of total Cd in the soil. The Cd-HAH fraction in the soil profiles (1-3) was nil (undetected).

The **Cd-OX** and **Cd-OXA** fractions are very low and ranged from 0.2 to 0.7 and 0.2 to 1.0 mg/kg. These two fractions constituted 3.5-7 and 6.7 - 9.9 percent of total soil Cd respectively. This fraction was increased with increasing the period of irrigation with sewage water.

Concerning the soils irrigated with industrial waste water (profiles 4 and 5), the showed that Cd-CA fraction constituted a relatively high proportion of total soil Cd and ranged from 1.8 to 3.2 decreasing with soil depth.

Table (10): Total, DTPA and Cadmium fractions (mg / kg)in soils irrigated with sewage and industrial waste waters.

Prof. No	Depth Cm	Total	DTPA	Cadmium fractions						
				Cd-CA	Cd-AC	Cd-PYR	Cd-HAH	Cd-OX	Cd-OXA	Cd-RES
1	00-05	T	T	T	T	T	T	T	T	T
	05-10	T	T	T	T	T	T	T	T	T
	10-25	T	T	T	T	T	T	T	T	T
	25-60	T	T	T	T	T	T	T	T	T
	60-100	T	T	T	T	T	T	T	T	T
2	00-05	04.0	0.12	0.8	0.3	0.8	T	0.2	0.3	1.6
	05-10	03.5	0.10	0.7	0.2	0.7	T	0.2	0.3	1.4
	10-25	03.0	0.04	0.5	0.1	0.5	T	0.2	0.2	1.5
	25-60	03.0	0.03	0.4	0.1	0.5	T	0.2	0.3	1.5
	60-100	03.0	0.03	0.4	0.1	0.4	T	0.2	0.2	1.7
3	00-05	13.0	1.40	3.9	1.0	3.9	T	0.7	1.0	2.5
	05-10	11.0	0.90	3.2	0.9	3.3	T	0.7	0.9	2.0
	10-25	09.5	0.47	2.4	0.8	2.4	T	0.6	0.8	2.5
	25-60	09.3	0.05	1.9	0.6	1.7	T	0.6	0.8	3.7
	60-100	08.5	0.01	1.4	0.6	1.4	T	0.6	0.7	3.8
4	00-05	10.7	0.19	3.0	0.8	2.4	0.2	0.5	0.7	3.1
	05-10	10.3	0.13	2.7	0.7	2.2	0.2	0.5	0.6	3.4
	10-25	10.0	0.05	2.4	0.5	2.0	0.1	0.5	0.5	4.0
	25-60	09.5	0.05	1.9	0.4	1.8	0.1	0.4	0.5	4.4
	60-100	09.0	0.03	1.8	0.3	1.6	0.1	0.4	0.4	4.4
5	00-05	10.9	0.16	3.2	0.8	2.5	0.2	0.5	0.7	3.0
	05-10	10.5	0.15	3.0	0.6	2.4	0.2	0.5	0.7	3.1
	10-25	10.0	0.12	2.5	0.6	2.0	0.2	0.5	0.5	3.7
	25-60	10.0	0.06	2.5	0.4	1.9	0.1	0.4	0.5	4.2
	60-100	09.5	0.03	2.2	0.3	1.6	0.1	0.4	0.5	4.4

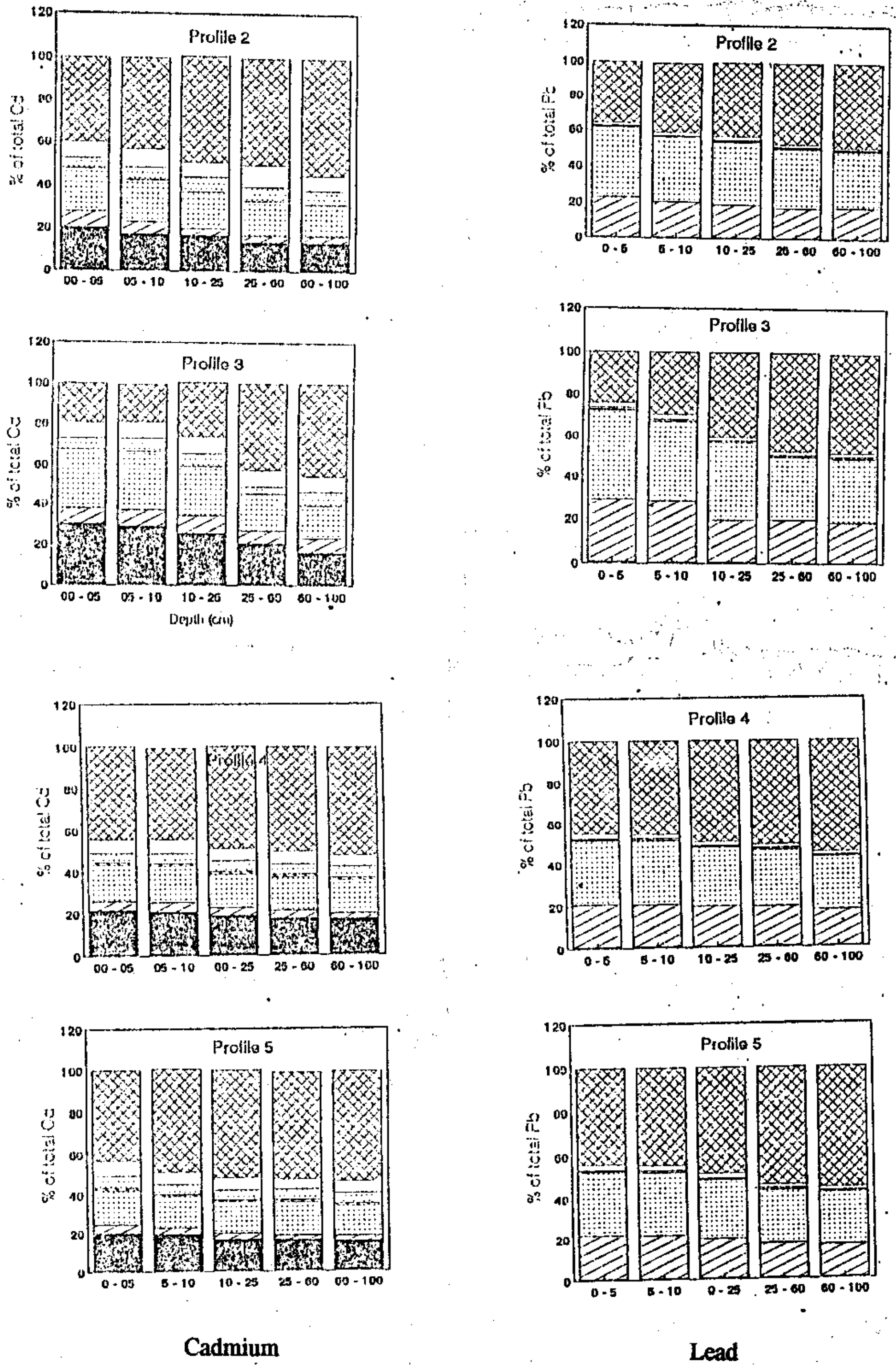


Fig. (2): Lead and cadmium fractions in soils irrigated with sewage and industrial waste waters.

R-CA R-CAA R-PYR R-HAH R-COX R-COA R-RES

The **Cd-AC** fraction constituted low portion of total Cd ranging from 0.3 to 0.8 mg/kg soil. However the **Cd-PYR** fraction constituted relatively high proportion of the total soil Cd ranged from 1.6 to 2.5 mg/kg .

The **Cd-HAH,Cd-OX,** and **Cd-OXA** were found in low amounts ranging from 0.1 to 0.2, 0.4 to 0.5 and from 0.4 to 0.7, respectively.

The **Cd-RES** fraction constituted the highest proportion of soil Cd, as it ranged from 3.0 to 4.4 mg/kg. This fraction was increased with increasing soil depth.

4.1.3.5. Nickel (Ni):

Table (11) and Fig (3):

4.1.3.5.1. Total Nickel:

Data show that no nickel was detected in soil which did not receive sewage water (profile 1), while total Ni contents in the treated soils ranged from 34.0 to 87.6 in the upper 5 cm, from 32.0 to 81.9 soil in the 5-10 cm, and from 25.0 to 48.1 in the 10-25cm then and decreased to reach value from 8.0 to 14.9 mg/kg in the 60-100cm layer.

From the obtained results, it could be noticed that the prolonged application of sewage water led to an obvious increase in total Ni which decreased with soil depth. These results are in agreement with the findings of El-Gamal (1980) and Khalil (1990).

Regarding the total Ni in the soils irrigated with industrial waste water (profiles 4 and 5), it varied from 85.2 to 104.4 mg/kg soil. No regular distribution for total Ni with soil depth was obtained.

In general, the values of total Ni content in the studied soils were higher than those found by Mills and Zwarich (1975) and Whitby *et al.* (1978) for uncontaminated Manitoba and Ontario agricultural soils. However, values of total Ni in the studied soils may be comparable with those found in contaminated soils of Ontario (1.3 - 65.60 mg/kg soil with a mean of 15.9 mg/kg soil), and polluted soils in Belgium (mean of 106.6 mg/kg soil) as reported by Frank *et al.* (1976) and Cottenie *et al.* (1982), respectively.

The threshold value of 100 mg Ni /kg soil reported by El-Bassam and Tietjen (1977) was exceeded in soils irrigated with industrial waste water.

4.1.3.5.2. <u>DTPA-extractable nickel:</u>

DTPA-extractable Ni in soil not irrigated with sewage water (profile 1) was nil .

Concerning the distribution of DTPA-extractable Ni in sewage treated soils, it ranged from 2.8 to 33.3 mg/kg soil in the upper 5 cm, 2.4 to 32.0 mg/kg in the 5-10 , 0.8 to 25.0 mg/kg in the 10-25 cm, 0.6 to 0.8 mg/kg in the 25-60 cm and 0.4 mg/kg in the deep layer (60-100 cm), as a result of irrigation with sewage water for 20 and 60 years, respectively.

The concentration of available Ni increased as the period of sewage water application increased particularly in the surface layers, but decreased with increasing soil depth. These results are in agreement with those of El-Gamal (1980) and Khalil (1990).

DTPA-extractable Ni in the soils irrigated with industrial waste water (profiles 4 and 5) ranged from 0.4 to 1.2 mg/kg . Nickel extracted by DTPA in industrially contaminated soils at Ontario, Canada ranged from 0.2 to 168 mg/kg with an average of 11.2 mg/kg (Heq *et al.* 1980). However around some industrial areas in Egypt, it ranged from 0.02 to 1.76 mg/kg soil (El-Leithi, 1986).

4.1.3.5.3. Nickel fractions:

Regarding the soils of El-Gabal El-Asfar not irrigated with sewage effluentsand where no Ni could be detected. It is naturally to find no detectable Ni fractions under such conditions. Irrigating these soils with sewage effluents led to the follwing results: **Ni-CA** fraction constituted relatively low portion of total Ni and ranged from 0.3 to 8.6 mg/kg soil which corresponded to 3.8 - 9.8 percent of total Ni in soils irrigated for 20 and 60 years, respectively. The soluble and exchangeable Ni fraction was increased from 1.7 to 8.6 mg/kg in the surface layer (0-5 cm) with increasing the period of irrigation from 20 to 60 years, respectively.

The **Ni-AC** fraction constituted high proportion of total soil Ni, ranging from 1.1 to 17.5 mg/kg soil representing 13.8 and 20.0 percent of total Ni in the soils irrigated for 20 and 60 years, respectively. This fraction showed a decreasing pattern with soil depth.

The **Ni-PYR** fraction also constituted a relatively high portion of the total soil Ni and ranged between 0.5 to 12.6 mg/kg soil which represents 6 to 14.4 percent of total Ni in soil. The results show that the Ni-PYR increased with increasing the period of irrigation with sewage water as result of increasing the content of soil organic matter but decreased with the soil depth.

Ni-HAH fraction was not detected in any measurable quantity in all the studied profile. The **Ni-OX** and **Ni-OXA** fractions were very low and ranged from 0.7 to 4.6 and 1.0 to 11.7 mg/kg soil, respectively. both fractions were increased with increasing the period of irrigation with sewage water.

The **Ni-RES** constituted a high portion of total Ni in the soil ranged from 4.7 to 32.6 mg/kg soil which represented 37.2 - 58.8 percent of total Ni in the soil.

Regarding the soils irrigated with the industrial waste water (profiles 4 and 5), the results indicate that, the **Ni-AC** and **Ni-PYR** constituted relatively high proportion of total Ni, ranged from 15.6 -18.1 and 7.2 to 9.7 percent of total Ni in the soils, respectively.

The **Ni-HAH** fraction in the soil profiles (4 and 5) was nil (traces).

The **Ni-OX** and **Ni-OXA** fractions ranged from 4.5 to 5.5 and from 9.3 to 11.7 mg/kg soil, respectively. The Ni-OX and Ni-OXA comprised from 10.5 - 11.4 percent of total Ni in soil.

The **Ni-RES** fraction constituted a high proportion of total Ni in soil, ranged from 43.2 to 57.2 which represents from 49 - 57.1 percent of total Ni in the soil. This fraction was increased with increasing the period of irrigation with waste water and with soil profile depth.

Table (11): Total, DTPA and Nickel fractions (mg / kg) in soils irrigated with sewage and industrial waste waters.

Prof. No	Depth Cm	Total	DTPA	Nickel fractions.						
				Ni-CA	Ni-AC	Ni-PYR	Ni-HAH	Ni-COX	Ni-COA	Ni-RES
1	00-05	T	T	T	T	T	T	T	T	T
	05-10	T	T	T	T	T	T	T	T	T
	10-25	T	T	T	T	T	T	T	T	T
	25-60	T	T	T	T	T	T	T	T	T
	60-100	T	T	T	T	T	T	T	T	T
2	00-05	34.0	02.8	1.7	5.5	3.5	T	1.7	3.9	17.7
	05-10	32.0	02.4	1.6	5.0	3.2	T	1.5	3.8	16.9
	10-25	25.0	00.8	1.1	3.6	2.4	T	1.3	2.8	13.8
	25-60	18.0	00.6	0.7	2.6	1.2	T	0.9	2.2	10.4
	60-100	08.0	00.4	0.3	1.1	0.5	T	1.4	1.0	04.7
3	00-05	87.6	33.3	8.6	17.5	12.6	T	4.6	11.7	32.6
	05-10	81.9	32.0	7.4	16.0	11.4	T	4.4	11.2	31.5
	10-25	48.1	25.0	3.6	08.7	05.6	T	2.6	06.3	21.3
	25-60	19.7	00.8	0.8	02.9	01.3	T	1.0	02.5	11.2
	60-100	14.9	00.4	0.6	02.1	00.9	T	0.7	01.9	08.7
4	00-05	85.2	01.2	5.2	14.6	8.4	T	4.5	9.3	43.2
	05-10	104.4	00.4	7.0	17.1	9.9	T	5.4	11.7	53.3
	10-25	96.6	00.6	6.7	15.7	8.4	T	4.9	10.3	50.6
	25-60	103.2	00.4	5.1	16.8	8.2	T	5.2	11.2	56.7
	60-100	100.2	00.4	4.2	15.6	7.4	T	5.4	10.6	57.0
			00.6							
5	00-05	99.0	01.0	6.2	17.9	9.6	T	5.5	11.3	48.5
	05-10	98.4	01.0	6.5	17.3	9.2	T	5.5	11.0	48.9
	10-25	101.4	00.8	5.3	17.1	8.9	T	5.0	11.0	54.1
	25-60	100.8	00.6	5.0	16.1	8.5	T	4.7	10.6	55.9
	60-100	100.2	00.6	4.0	15.9	7.2	T	4.9	11.0	57.2

4.1.3.6. Cobalt (Co):

Table (12) and Fig (3):

4.1.3.6.1. Total cobalt:

Data in Table (12) show that there was no detectable Co in control soil (profile 1). Total Co in soil irrigated with sewage effluents ranged from 36.75 to 46.0 mg/kg in the upper 5 cm, from 30.75 to 44.0 mg/kg in the (5-10 cm layer) and ranged from 30.0 to 43 in the 10-25 cm depth, from 26.5 to 42.5 mg/kg in the 25-60 cm layer, and from 22.0 to 42.0 in the deep layer (60-100).

The above mentioned results revealed that the prolonged irrigation with sewage effluents up to 60 years led to an increase in total Co contents in soils. The highest deposition of the organic compounds was mainly in the surface layers and gradually decreased with soil depth. These results are in agreement with the findings of El-Gamal (1980), El-Nashar (1985) and Khalil (1990).

With respect to soils irrigated with industrial waste water (profiles 4 and 5), total Co varied from 30.50 to 48.0 mg/kg soil.

In general the values of total Co in the studied soils were higher than those found by Cotteine *et al.* (1982) in Belgium polluted soils (16.4 mg/kg) and higher than those of Egyptian alluvial soils reported by Rabie (1984) and El-Sokkary and Lag (1980) who found average values of 27.2 and 15.8 -20.3 mg/kg, respectively.

However, the content of Co in investigated soils did not exceed the maximum tolerable level (50 mg/kg soil) reported by El-Bassam and Tietjen (1977).

4.1.3.6.2. DTPA-extractable cobalt:

There was no detected Co in the control soil (profile, 1). Concentrations of available Co in all profiles were less than 2.5 mg/kg level which considered as a maximum level allowed to be in arable soils.

With respect to soils irrigated with industrial waste water (profiles 4 and 5), DTPA-extractable Co ranges from 0.54 to 0.78 mg/kg and decreased with soil profile depth.

The values of DTPA-extractable Co were lower than those found by Williams *et al.* (1980) who found that available Co in surface layers of untreated soils and those received 180 ton sludge was 3.6 and 4.5 mg/kg, respectively.

The amounts of Co extracted by DTPA were much higher than those recorded for some Egyptian soils in the other studies where the average values of DTPA-extractable Co in calcareous soils, light alluvial and heavy alluvial soils were 0.033, 0.037 and 0.055 mg/kg, respectively, Rabie (1984).

4.1.3.6.3. Cobalt fractions:

The **Co-CA**, **Co-OX**, **Co-AC** and **Co-OXA** fractions constituted relatively low portions of total Co and ranged from 0.06 to 0.41, 0.13 to 0.40, 0.15 to 0.41 and from 0.35 to 1.01 mg/kg soil, respectively. These values corresponded to 0.3-0.9, 0.6-0.9, 0.7-1.2 and 1.4-2.4 percent of total Co in the soils, respectively. The **Co-PYR** fraction constituted high portion ranged

Table (12): Total, DTPA and cobalt fractions (mg/kg) in soils irrigated with sewage and industrial waste waters.

Prof no	Depth Cm	Total	DTPA	Cobalt fractions.						
				Co-CA	Co-AC	Co-PYR	Co-HAH	Co-OX	Co-OXA	Co-RES
	00-05	T	T	T	T	T	T	T	T	T
	05-10	T	T	T	T	T	T	T	T	T
1	10-25	T	T	T	T	T	T	T	T	T
	25-60	T	T	T	T	T	T	T	T	T
	60-100	T	T	T	T	T	T	T	T	T
	00-05	36.75	0.48	0.15	0.30	6.15	T	0.21	0.43	23.5[illegible]
	05-10	30.75	0.46	0.18	0.33	7.35	T	0.26	0.59	28.04
2	10-25	30.00	0.42	0.12	0.24	5.70	T	0.18	0.45	23.3[illegible]
	25-60	26.50	0.38	0.11	0.18	4.80	T	0.16	0.37	20.88
	60-100	22.00	0.16	0.06	0.15	3.96	T	0.13	0.35	17.35
	00-05	46.00	0.90	0.41	0.55	12.42	T	0.37	0.92	31.3[illegible]
	05-10	44.00	0.78	0.35	0.53	11.88	T	0.40	0.92	29.92
3	10-25	43.00	0.84	0.30	0.43	10.32	T	0.34	0.90	30.7[illegible]
	25-60	42.50	0.78	0.17	0.38	9.77	T	0.30	0.94	30.94
	60-100	42.50	0.82	0.17	0.38	9.66	T	0.34	1.01	30.2[illegible]
	00-05	30.50	0.78	0.18	0.21	5.49	T	0.30	1.10	23.22
	05-10	38.00	0.64	0.19	0.30	6.84	T	0.34	1.52	28.8[illegible]
4	10-25	40.50	0.64	0.16	0.24	6.88	T	0.36	1.62	31.24
	25-60	40.50	0.66	0.16	0.24	6.88	T	0.40	1.70	31.1[illegible]
	60-100	41.00	0.62	0.16	0.29	7.36	T	0.41	1.68	31.08
	00-05	40.00	0.78	0.24	0.28	8.00	T	0.32	1.48	29.68
	05-10	41.50	0.68	0.21	0.29	7.47	T	0.41	1.62	31.50
5	10-25	44.50	0.62	0.22	0.36	8.01	T	0.40	1.78	33.7[illegible]
	25-60	47.00	0.56	0.19	0.33	7.99	T	0.47	1.93	36.09
	60-100	48.00	0.54	0.19	0.29	8.16	T	0.38	1.97	37.0[illegible]

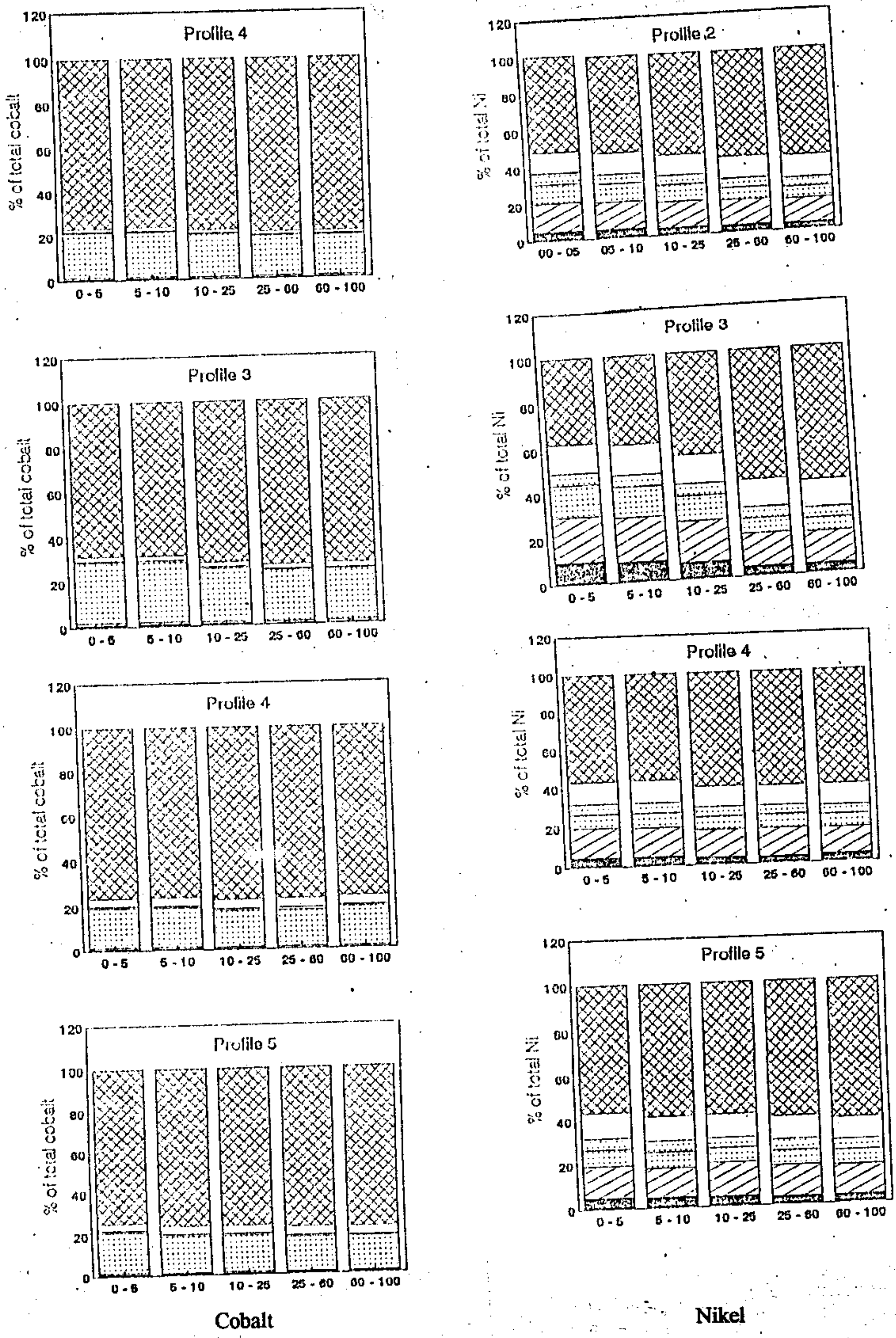


Fig. (3): Nikel and cobalt fractions in soils irrigated with sewage and industrial waste waters.

R-CA R-CAA R-PYR R-HAH R-COX R-COA R-RES

from 3.96 to 12.42 mg/kg which represents 18 to 27 percent of total Co in soil.

The **Co-RES** fraction was the predominant fraction of Co in soil ranged from 17.35 to 31.33 representing 68-79 percent of total Co in the soils. The occurance of Co fractions in soils increased with increasing the period of irrigation with sewage effluents.

Regarding the soils irrigated with industrial waste water profiles (4 and 5), the residual fraction representing the highest proportion of total Co representing 74.2 - 77.1 percent of total Co. The PYR phosphate (Co-PYR) constituted a high portion of total Co in the soil (17-20 percent of total Co), while the other fractions (Co-CA, Co-OX, Co-AC and Co-OXA fractions) represent lower portions of total Co in soil.

4-1-4-Heavy metal fractions v. s. soil properties: (Table 13)

4-1-4-1-Copper

Relationships between Cu fractions and soil properties were evaluated by calculating the pairwise correlation. In soils irrigated with sewage water for 20 and 60 years, the nonspecific (Cu- Ca) and specific adsorbed Cu (Cu-AC) were inversely related to soil pH (r= -0.473, -0.396, respectively).

Since the non specific adsorption of Cu includes occlusion and coprecipitation, decreasing soil pH will increase the solubility and release of Cu.

In case of using industrial waste water in irrigation, the specifically adsorbed Cu was related directly with soil pH. This fraction comprises soil Cu held by specific forces like covalent bonding.

The Cu fractions were affected positively and significantly by soil organic matter in the first three sites located in El-Gabal El-Asfar farm. This result indicated that all fractions were related to soil organic matter, either adsorbed on the active sites or combined with the constituents of soil organic matter. Similar trend was found in the other two profiles irrigated with industrial waste water.

4-1-4-2-Zinc:

The effect of soil organic matter on total, DTPA-extractable Zn and Zn fractions was highly significant. The availability of Zn was affected negatively by soil CaCO3 and soil pH. The negative effect of soil pH on the occurrence of Zn in the different fractions was greater than that of CaCO3 as revealed from the values of the correlation coefficient .

4-1-4-3-Lead:

The correlations between soil organic matter content with total Pb as well as all the Pb fractions except that of DTPA - extractable Pb were significant . The insignificant relationship between avaliable Pb and soil organic matter may be attributed to the formation of Pb - organic complexes and the organic matter should be considered as the important sink of Pb in polluted soils . An adverse effect of soil pH on the distribution of Pb in different phases was obvious with non specifically adsorbed, organically bound and Pb occluded on Al and Fe oxides . The negative effect of pH on Pb fractions could be due to the high soil pH values at which Pb precipitates as hydroxides, phosphate , or carbonate, as well as the formation of Pb - organic complexesis promoted.

4-1-4-4- Cadmium:

Total Cd as well as most of Cd fractions correlated positively and significantly with soil organic matter content. The DTPA-extractable Cd was highly correlated with soil organic matter (r = 0.901). However, the DTPA-extractable Cd was affected negatively by soil CaCO3 and soil pH.

4-1-4-5-Nickle:

The most available form of Ni, i.e, DTPA-extractable Ni, nonspecific adsorbed Ni were correlated positively and significantly with soil organic matter. Also, most of Ni fractions were correlated positively and significantly with soil calcium carbonate, except the DTPA-extractable Ni.

4-1-4-6- Cobalt:

Soil organic matter seams to be the most effective soil parameter on the chemistry of Co in soils irrigated with sewage effluents and industrial waste waters. In addition, soil pH was correlated negatively and significantly with Co forms.

Table (13): Correlation coefficients (r) between the chemical fractions of heavy metals and some parameters of soils irrigated with sewage and industrial waste waters.

Soil parameter	Total	DTPA-extractable	Non specific adsorbeded (CA)	Specific adsorbeded (AC)	Organically bound (PYR)	Mn oxide bound (HAH)	Al and Fe oxide bound (OX)	Crystalline Fe and Al Oxide bound (OXA)	Residual (RES)
Cu									
O.M	0.930***	0.416*	0.928***	0.927***	0.945***	0.612***	0.891***	0.902***	0.908***
CaCO3	-0.117	0.406*	-0.252	-0.154	-0.205	0.402*	-0.05	-0.036	-0.079
pH	-0.362	0.070	-0.473*	-0.396*	-0.434*	0.074	-0.309	-0.299	-0.310
CEC	0.377	0.688***	0.155	0.272	0.239	0.765***	0.396*	0.424*	0.379
Zn									
O.M	0.906***	0.573**	0.897***	0.897***	0.895***	0.912***	0.889***	0.906***	0.910***
CaCO3	-0.339	-0.316	-0.331	-0.331	-0.327	-0.337	-0.33	-0.341	-0.357
pH	-0.513**	-0.466	-0.506*	-0.506*	-0.522*	-0.513*	-0.502*	-0.514*	-0.525*
CEC	0.054	-0.73	0.057	0.057	0.038	0.059	0.052	0.051	0.046
Pb									
O.M	0.846**	0.330	0.902***	0.891***	0.904***	0.746***	0.897***	0.818***	0.646***
CaCO3	0.002	0.2480	-0.114	-0.092	-0.127	-0.220	-0.090	0.012	0.241
pH	-0.369	-0.024	-0.43*	-0.42	-0.461*	-0.397	-0.432	-0.327	-0.179
CEC	0.454	0.541	0.345	0.356	0.313	0.203	0.357	0.459	0.656
Cd									
O.M	0.422*	0.901***	0.527**	0.620***	0.657***	-0.207	0.523**	0.211	0.003
CaCO3	0.481*	-0.212	0.432*	0.024	0.300	0.711***	0.307	0.394*	0.634***
pH	0.012	-0.460*	0.017***	-0.178**	-0.126	0.600***	-0.192	-0.058	0.196
CEC	0.743***	0.191	0.750	0.533	0.657***	0.827***	0.538**	0.501**	0.720***
Ni									
O.M	0.247	0.959***	0.531**	0.343	0.529**	----	0.258	0.364	0.11
CaCO3	0.643***	-0.404*	0.48*	0.589**	0.462*	----	0.614***	0.572**	0.68***
pH	0.289	-0.573**	0.110	0.237	0.083	----	0.283	0.198	0.351
CEC	0.933**	0.021	0.803***	0.922***	0.839***	----	0.934***	0.905***	0.944***
Co									
O.M	0.369	0.471*	0.759***	0.674***	0.596**	--	0.325	0.028	0.299
CaCO3	0.421	0.336	0.131	0.103	0.192	--	0.504*	0.712***	0.466*
pH	-0.218	-0.253	-0.405	-0.509*	-0.428*	--	-0.030	-0.33	-0.175
CEC	0.627**	0.571**	0.517	0.394	0.456*	--	0.743***	0.855***	0.694***

*, *, and *** Significant at the 0.05, 0.01, and 0.001 probability levels, respectively.

4-1-5- Concentrations of heavy metals in plants grown on soils irrigated with sewage effluents or industrial waste waters.

The results of concentrations of heavy metals (μg/g) in plants are shown in Table (14), and can be summarized as follows:

4-1-5-1-Copper:

The critical toxicity range of Cu in plant tissues is 15-20 μg/g as reported by Sauerbeck (1982). Cu concentration in plants grown on soils of El-Gabal El-Asfar irrigated with sewage water for 0, 20 and 60 years was 8.3, 13.2, and 18.5 μg/g respectively. Cu concentration tended to be toxic when soils were irrigated for 60 years. Cu content in plants grown on soils irrigated with industrial waste water was also high and averaged 12.2 μg/g.

4-1-5-2-Zinc:

The critical toxicity range for Zn in growing plants is 150 - 200 μg/g as reported by Sauerbeck (1982). This range had not been exceeded by the concentrations of Zn in plants grown on soils irrigated with sewage and industrial waste waters. Zn concentration was increased in plants of soils irrigated for 60 years being 105.4 mg/kg.

4-1-5-3-Lead:

The concentration of Pb in plants grown on soils irrigated with sewage effluents was increased with increasing the period of irrigation. Plants of soils irrigated for 60 years contained 20 μg/g Pb and those of soils irrigated for 20 years contained 18 μg/g, while those of control soils contained only 6 μgPb/g.. The concentrations of Pb in plants grown on soils irrigated with sewage effluents were high and even toxic,especially in those of soils irrigated for 60 years. Plants irrigated with industrial waste water contained about 12.5

μg/g which located within the range of toxicity (10-20 μg/g as reported by Sauerbeck, 1982).

4-1-5-4-Cadmium:

The concentration of Cd in plants grown on soils irrigated with sewage effluents and industrial waste waters was 2.5 in those grown on untreated soils (Prof. 1) raised to 4 μg/g in those irrigated for 20 years and the highest value was found in those irrigated for 60 years (7.3 μg/g). The highest concentration wasgoing to reach the toxic level (10 μg/g) reported by Sauerbeck,(1982) . Plants grown on soils irrigated with industrial waste water contained about 4.6 μg/g which is close to the lower level of toxicity range.

4-1-5-5-Nickel:

The concentrations of Ni in grown crops ranged from 7.0-14.3 μg/g were higher than those of the normal Ni content in plant material (0.1-5 μ g/g). However, such concentrations are less the level of toxicity (30 μg/g) reported by Sauerbeck (1982). The highest Ni content was observed in corn plants grown on soils irrigated with sewage effluents and industrial waste waters (14.3 μg/g).

4-1-5-6-Cobalt:

The critical toxicity range of Co in plants is 10 - 20 μg/g as reported by Sauerbeck (1982), the toxicity is ensured at the high level. The concentrations of Co in plants grown on soils irrigated with sewage effluents were increased gradually with increasing the period of irrigation. The highest value of 9.3 μ g/g was found in those of soils irrigated for 60 years. This high level of Co is comparable to the margin of the critical toxic range (10-20 μg/g).

Table (14): Concentrations of heavy metals in leaves of plants grown on soil irrigated with sewage and industrial waste waters.

Prof. No	Cultivated crops	Location	Concentration of heavy metals (μg/g).					
			Cu	Zn	Pb	Cd	Ni	Co
1	Orange	El-Gabal	8.3	49.7	6.0	2.5	7.0	4.4
2	Pecan	El-Asfar	13.2	70.4	18.0	4.0	11.0	6.2
3	Corn	~ ~	18.5	105.4	20.0	7.3	14.3	9.3
4	Taro	Bahteem	12.0	30.2	12.0	4.7	6.6	7.2
5	Taro	~ ~	12.4	37.7	13.0	4.5	7.0	7.3

4.2. Effect of industry fall-out on status of heavy metals in soils and plants:

The fall-out derived from different chemical plants did not affect the physical properties of soils. accordingly the discussion of this part of study is restricted to such effects on the status of heavy metalsin soils which has been affected to a large extent as shown in the discussion of this chapter.

4.2.1. Status of heavy metals in the soils around the chemical plants and smelters:

4.2.1.1. Copper (Cu):

Table (15) and Fig. (4):

4.2.1.1.1. Total copper:

The results in Table (15) indicate that total Cu in soils around the chemical plants (profiles 6 - 15) ranged from 10 to 110.5mg/kg

The results, in general, show that soil Cu was mostly concentrated in the upper 25 cm of soil profile, except in profile 14 where the distribution of Cu was mostly homenous..

The values of total Cu in the studied areas indicate that soils are relatively contaminated since these contents are relatively higher than those of normal Egyptian soils and also higher than those reported by El-Sokkary and Lag (1980) and El-Sikhry (1985). The soils adjacent to the smelters (profiles 12 and 13) located at Qalyoub site were more seriously affected by the Cu pollution, probably because copper was involved in the activities carried on in such smelters. The Cu content in these soils was ranged from 62 to 110.5 mg/kg soil. The highest Cu concentrations were existed mostly in the top 25 cm. Soils of profiles 6, 7, 8 and 9 represinting the soils around chemical and fertilizers Co. and El-Ahlia metalic Co. contained high amounts of Cu as compared with those of around the Aluminum Sulfate Co. (profile 10 and 11).

It seems that industrial pollution has no obvious role on the Cu accumulation in the rest of soils. These results are in agreement with those of El-Leithi (1986).

Data in table (15) showed that the highest amount of Cu was found in soils around smelters. The Cu content in these soils was surpassed in some layers of profile the maximum tolerable level (100 mg Cu /kg) reported by El-Bassam and Tietjen (1977).

4.2.1.1.2. DTPA-extractable copper:

DTPA-extractable Cu ranged from 0.24 to 31.8 mg/kg and constituted 5.8 - 50.5 percent of total Cu. The distribution with either distance from the source or soil depth was irregular.

4.2.1.1.3. Copper fractions:

The **Cu-CA** fraction constituted the least amount of Cu in the soils (ranged from 0.01 to 1.37 mg/kg) which corresponded with 0.16-2.04 percent of total Cu in the soil. The **Cu-AC** fraction was slightly higher than Cu-CA fraction and ranged from 0.01 to 2.99 mg/kg soil which comprised about 0.66-2.97 percent of total Cu in soil. The **Cu-PYR** fraction constituted relatively high proportion of the soil Cu ranged between 0.18 and 20.3 mg/kg which represents 11.59 - 33.02 percent of total Cu in soil.

The **Cu-HAH** fraction varying from 0.04 to 4.27 mg/kg which comprised about 1.10 - 5.87 percent of total Cu in soil. The **Cu-OX** fraction was also relatively high, varying from 0.06 to 11.9 mg/kg which represents about 5.20-9.98 percent of total Cu in soil.

Table (15) Total, DTPA and Cu fractions (mglkg) in the soils around the chemical plants and smelters.

Prof. No	Depth Cm	Total	DTPA	Copper fractions						
				Cu-CA	Cu-AC	Cu-PYR	Cu-HAH	Cu-OX	Cu-OXA	Cu-RES
6	00-05	40.25	06.32	0.60	0.81	13.29	2.26	06.12		11.05
	05-10	72.75	06.54	1.20	1.20	20.17	4.27	11.88		22.15
	10-25	39.50	07.56	0.70	0.60	10.66	2.35	06.39		12.41
	25-60	22.50	03.30	0.09	0.42	05.01	1.69	04.00		07.29
	60-100	03.75	00.40	0.02	0.04	00.80	0.32	00.62		01.33
7	00-05	44.00	14.60	0.80	0.80	14.20	2.00	02.86	07.11	16.23
	05-10	45.00	15.60	0.78	0.91	13.00	1.50	03.00	07.22	18.59
	10-25	49.00	15.60	0.11	0.01	10.70	2.50	03.00	06.91	25.77
	25-60	01.50	00.70	0.01	0.61	00.26	0.08	00.09	00.18	00.27
	60-100	34.50	08.28	0.60	1.00	04.60	2.00	02.18	05.00	19.12
8	00-05	39.25	03.96	0.80	1.00	10.99	2.00	2.84	5.21	16.41
	05-10	39.75	05.60	0.60	1.01	10.10	1.50	2.44	4.97	17.11
	10-25	23.50	02.84	0.25	0.67	05.30	1.30	1.66	3.71	10.61
	25-60	18.00	01.46	0.09	0.48	05.84	0.50	1.28	2.98	06.92
	60-100	03.00	00.32	0.02	0.08	00.67	0.09	0.25	0.51	01.06
9	00-05	23.50	03.32	0.30	0.65	06.13	1.77	1.42	.03.28	09.95
	05-10	20.00	03.08	0.21	0.48	05.79	1.20	1.20	03.01	08.11
	10-25	16.50	02.60	0.11	0.30	02.20	1.11	0.98	02.00	09.80
	25-60	05.50	01.18	0.01	0.09	01.50	0.33	0.38	00.91	02.28
	60-100	01.50	00.36	0.01	0.08	00.18	0.13	0.10	00.24	00.76
10	00-05	15.00	00.98	0.21	0.33	04.73	0.88	0.92	02.28	05.65
	05-10	11.75	00.90	0.13	0.25	03.10	0.62	0.72	01.68	05.25
	10-25	09.25	00.82	0.09	0.10	02.20	0.38	0.53	01.20	04.75
	25-60	05.50	00.32	0.06	0.08	01.50	0.25	0.30	00.78	02.53
	60-100	01.00	00.24	0.01	0.02	00.18	0.06	0.06	00.15	00.52
11	00-05	02.50	00.54	0.02	0.06	00.80	0.14	0.15	00.40	00.93
	05-10	02.50	00.52	0.01	0.16	00.72	0.13	0.13	00.42	00.93
	10-25	02.50	00.44	0.01	0.05	00.60	0.11	0.14	00.38	01.21
	25-60	04.00	00.48	0.13	0.09	01.00	0.18	0.28	00.51	01.81
	60-100	01.50	00.34	0.01	0.03	00.27	0.04	0.08	00.19	00.88
12	00-05	81.00	11.00	1.01	2.08	20.30	1.83	5.67	14.00	36.11
	05-10	77.50	10.12	1.00	2.10	02.20	1.51	5.40	13.38	51.92
	10-25	108.50	10.60	1.37	1.98	19.88	2.98	9.99	21.08	38.78
	25-60	063.00	31.80	0.90	1.12	13.10	1.22	4.01	12.45	30.20
	60-100	062.00	04.20	0.27	0.98	13.75	1.50	4.50	12.10	28.90
13	00-05	065.50	03.88	0.97	1.70	19.97	1.44	5.00	12.12	24.30
	05-10	066.00	05.00	0.80	1.78	17.13	1.29	5.50	12.00	27.58
	10-25	110.50	21.20	1.93	2.99	20.29	2.10	9.21	.18.98	55.00
	25-60	67.50	04.60	0.98	1.02	14.70	1.27	5.21	13.38	30.94
	60-100	069.50	06.60	0.09	0.97	12.98	1.23	5.21	13.42	34.60
14	00-05	024.50	03.56	0.37	0.71	6.92	0.94	1.73	3.01	10.82
	05-10	025.50	03.52	0.24	0.72	6.32	0.83	2.00	4.01	11.38
	10-25	022.50	03.36	0.18	0.06	5.94	0.91	1.85	2.96	10.60
	25-60	010.00	01.54	0.10	0.18	2.69	0.11	0.68	0.41	05.83
	60-100	025.00	00.76	0.28	0.56	3.22	0.72	1.99	4.63	13.60
15	00-05	006.00	03.90	0.08	0.16	1.82	0.18	0.33	0.69	02.74
	05-10	022.00	03.46	0.09	0.60	5.25	0.41	1.67	4.00	09.98
	10-25	024.00	03.78	0.17	0.66	4.17	0.51	1.98	4.23	12.26
	25-60	018.50	04.20	0.11	0.31	2.94	0.50	1.75	3.69	09.20
	60-100	009.50	02.08	0.01	0.18	1.53	0.19	0.68	0.71	06.20

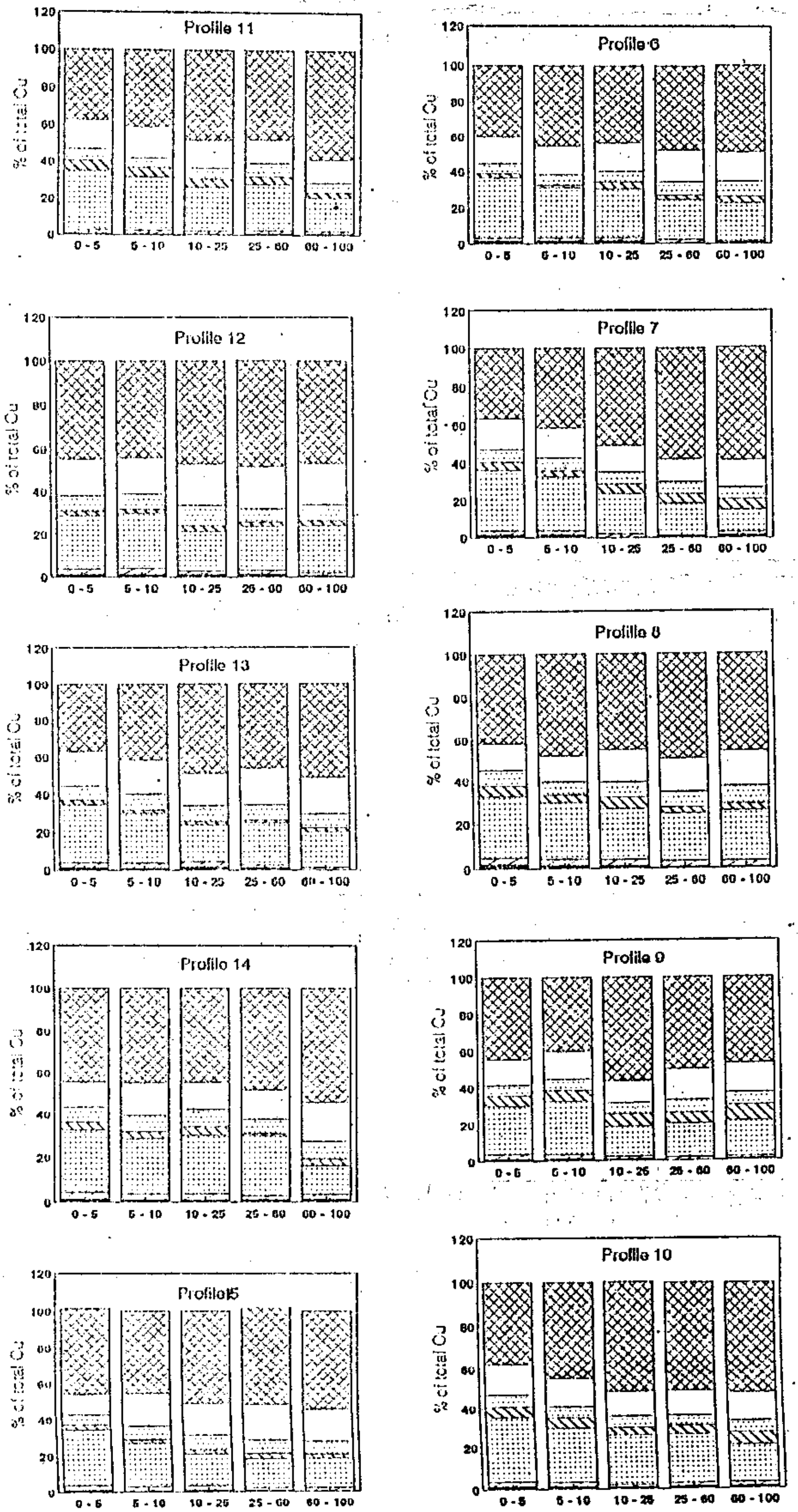


Fig. (4): Coppert fractions as the percentage of total in soils around chemical plants and smelter

Cu-CA Cu-CA Cu-PYR Cu-HAH

Cu-COX Cu-COA Cu-RES

The **Cu-OXA** fraction was high and varied from 0.15 to 21.1 mg/kg which represents 12.00 - 19.79 percent of total Cu in soil. The **Cu-RES** fraction constituted the highest proportion of soil Cu ranged from 0.27 to 55.00 mg/kg comprised about 37.40-58.82 percent of total Cu in soil.

From the above mentioned results , it could be concluded that total soil Cu was concentrated in the fractions: Residual (Cu-RES), organically bound (Cu-PYR), occluded with iron oxides (Cu-OXA).

4.2.1.2. Zinc (Zn):

Table (16) and Fig (5)

4.2.1.2.1. Total Zinc:

Results show that total soil Zn content tended to accumulate somewhere through the upper 25 cm and mostly decreased sharply with soil depth. However, this decreasing trend was gently in profiles 11, 13 and 15. Total Zn was positively affected by the distance from the source in some cases, i.e., around the Egyptian Alum factories, Al-Ahlia metallic and Qalyoub smelters.

The average of total Zn content in soils increased with increasing the distance from the factory as discussed above. This means that the pollution effect may extend to more than 100 m. This findings agree with those obtained by El-Leithi (1986) and El-Sokkary (1980) who recorded that industry fallout was effective beyond 10 km from the source. On the other hand, samples collected far from the source of pollution around Abu-Zaabal fertilizers and chemicals plant, as well as these collected far from cement Portland at Helwan showed lower content than the nearest ones.

It is obvious that the soils under investigation have much higher Zn content than normal uncontaminated soils, El-Sokkary (1978) reported that an average of 64.5 mg/kg in the normal Egyptian soils. As a result of the considerable contamination took place in these soils the relatively high total Zn in the studied soils could be attributed to considerable Zn pollution due to the air borne particulate and fumes evolved from industrial processes carried out.

Results in Table (16) show that the maxmium content of total Zn in the investigated soils (286 mg/ kg) are less than the maximum level (300 mg/kg) proposed by El-Bassam and Tietjen (1977). However, the contents of total Zn around smelters were also relatively high.

4.2.1.2.2. DTPA-extractable zinc:

DTPA-extractable Zn around industrial factories ranged from 0.22 to 11.0 mg/kg soil which comprises from 0.22-10 percent of total Zn in the soils. The DTPA-extractable Zn was increased with distance in the most studied profiles (6, 7; 10, 11; 13 and 14), except around the smelters and ammonium sulphate Co. plant which decreased with the distance. Extractable Zn decreased with the depth in most soil profiles except in the profiles 12-15 no regular trend was noticed.

4.2.1.2.3. Zinc fractions:

The **Zn-CA** fraction constituted the least amount of Zn in the soils ranged from 0.03 to 0.3 mg/kg representing about 0.05 - 0.21 percent of total

Table (16) : Total, DTPA and Zn fractions (mg/kg) in the soils around the chemical plants and smelters.

Prof. No	Depth cm	Total	DTPA	Zn fractions						
				Zn-CA	Zn-AC	Zn-PYR	Zn-HAH	Zn- OX	Zn-OXA	Zn-RES
	00-05	111.25	05.40	0.11	3.47	22.37	2.33	5.25	23.47	54.25
	05-10	198.25	05.00	0.22	5.95	36.14	4.80	8.43	41.04	99.70
6	10-25	079.50	04.20	0.08	2.30	13.74	2.44	3.98	16.77	40.19
	25-60	073.50	03.80	0.07	1.67	12.01	1.90	3.60	15.35	38.90
	60-100	068.50	00.90	0.05	1.37	12.41	1.70	3.36	113.6	35.90
	00-05	142.0	07.40	0.14	4.12	29.99	3.10	7.19	30.10	67.34
	05-10	133.50	08.40	0.16	4.29	26.89	3.79	6.65	28.16	63.57
7	10-25	130.00	05.80	0.10	2.83	23.53	4.17	6.18	27.43	65.75
	25-60	065.00	00.22	0.05	1.48	10.54	2.11	3.00	13.13	34.68
	60-100	083.00	01.60	0.07	2.02	12.65	2.28	4.14	16.68	45.16
	00-05	100.25	07.00	0.13	2.79	20.30	3.01	5.11	21.15	47.76
	05-10	127.75	05.40	0.15	3.85	23.17	3.77	6.71	26.06	64.44
8	10-25	107.50	02.80	0.11	3.22	17.38	3.35	5.38	21.47	56.80
	25-60	055.01	01.02	0.05	1.46	08.38	1.69	2.70	10.99	29.57
	60-100	033.50	00.80	0.03	0.80	05.40	0.99	1.46	06.59	18.26
	00-05	124.00	02.00	0.21	3.64	23.86	3.29	6.51	25.66	61.39
	05-10	103.00	01.98	0.16	2.40	20.71	3.04	5.41	20.57	50.70
9	10-25	112.00	01.90	0.16	3.36	20.44	3.49	5.60	24.64	54.31
	25-60	062.50	00.66	0.07	1.43	10.07	1.92	3.06	13.13	32.83
	60-100	053.50	00.24	0.05	1.13	09.21	1.59	2.33	09.71	29.48
	00-05	080.00	01.71	0.14	2.26	16.18	2.73	4.26	14.52	39.90
	05-10	055.0	01.80	0.10	1.65	11.55	1.80	2.95	10.83	26.12
10	10-25	040.00	01.26	0.04	1.21	07.13	1.25	2.09	07.86	20.52
	25-60	039.00	00.46	0.04	0.85	07.07	1.16	2.00	07.88	20.25
	60-100	030.00	00.40	0.03	0.66	04.99	0.85	1.46	05.70	16.32
	00-05	074.50	07.40	0.16	2.23	15.81	2.54	3.97	14.31	35.78
	05-10	072.50	01.94	0.14	2.07	13.88	2.37	3.89	13.73	36.92
11	10-25	072.50	01.16	0.12	2.13	13.88	2.25	3.78	14.75	36.22
	25-60	054.00	00.40	0.08	1.16	08.78	1.60	2.69	11.18	29.17
	60-100	053.00	00.22	0.07	1.19	07.69	1.50	2.57	09.54	30.21
	00-05	231.50	02.20	0.28	4.86	46.53	6.97	11.51	44.35	116.0
	05-10	214.00	11.00	0.30	4.52	38.73	5.76	10.89	40.89	112.9
12	10-25	210.00	10.60	0.21	4.16	40.61	5.82	10.94	39.88	108.4
	25-60	158.50	08.80	0.14	2.74	25.63	3.46	07.97	31.70	086.4
	60-100	159.00	01.32	0.13	2.97	28.64	4.77	07.78	31.83	083.0
	00-05	187.50	02.20	0.21	4.20	37.39	4.29	09.79	36.00	95.62
	05-10	191.50	03.60	0.25	4.17	38.45	5.42	08.00	38.51	96.70
13	10-25	286.00	05.20	0.29	5.38	47.50	8.61	11.41	51.88	160.9
	25-60	153.00	00.92	0.12	2.71	28.93	5.09	05.95	29.21	081.0
	60-100	176.00	02.00	0.11	3.38	31.22	5.16	07.81	29.92	098.0
	00-05	121.00	01.78	0.14	3.63	24.51	2.55	07.21	20.82	65.80
	05-10	112.00	01.82	0.09	3.40	20.35	2.40	03.56	21.32	60.87
14	10-25	108.00	01.56	0.08	3.22	20.76	3.09	05.03	21.60	54.23
	25-60	138.00	00.30	0.04	3.20	12.03	2.05	06.84	27.65	72.76
	60-100	074.50	00.45	0.07	2.00	23.79	3.67	03.62	14.90	39.86
	00-05	075.00	02.00	0.08	2.31	15.94	2.23	03.21	15.75	35.48
	05-10	118.00	07.20	0.13	3.86	23.92	3.13	05.18	24.67	57.31
15	10-25	128.50	01.54	0.10	3.59	24.52	2.61	06.63	22.88	68.17
	25-60	097.50	01.28	0.07	2.57	17.69	3.03	05.08	17.70	51.36
	60-100	077.50	00.66	0.07	1.77	12.57	2.51	03.82	15.50	41.26

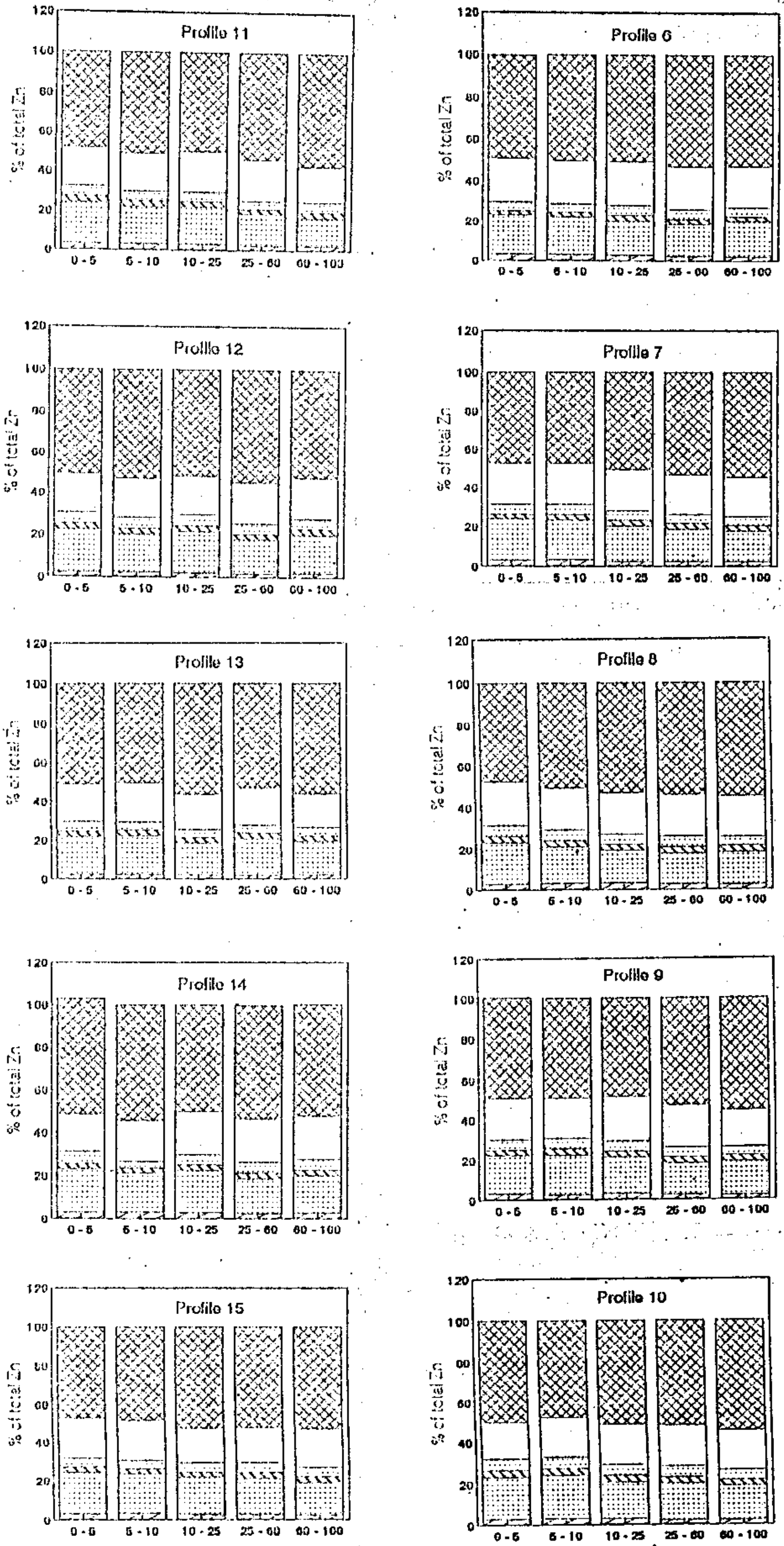


Fig. (5): Zinc fractions as the percentage of total in soils around chemical plants and smelter

Zn-CA Zn-AC Zn-PYR Zn-HAH Zn-COX Zn-COA Zn-RES

Zn in the soils. This may be attributed to alkaline reaction of these soils throughwhich solubility Zn decreased .

The **Zn-AC** fraction was higher than Zn-CA fraction ranged from 0.66 to 6.00 mg/kg which represents 1.73-3.12 percent of total Zn in soil.

The **Zn-PYR** fraction constituted relatively high portion of the total soil Zn ranged from (5.0 to 47.5 mg/kg) which represents 14.5-21.25 percent of total Zn in soil.

The **Zn-HAH** fraction varied from 0.85 to 8.61 mg/kg which corresponded to 2.7 percent of total Zn in the soils.

The **Zn-OX** fraction was also relatively high varied from 1.5 - 11.5 mg/kg representing 5.1 percent of total Zn in soil.

The **Zn-OXA** fraction constituted high portion of total Zn varied from 5.70 to 52 mg/kg which represents 18.4 - 22.0 percent of total Zn in soil.

The **Zn-RES** fraction constituted the highest portion of soil Zn ranged from 16.3 to 161 mg/kg representing about 52 percent of total Zn in the soils.

4.2.1.3. Lead (Pb):

Table (17) and Fig (6).

4.2.1.3.1. Total lead:

With respect to soil samples collected from industrial areas (profiles 6-15), results show that the total Pb content varied from 13.5 to 52,87 mg/kg.

The results show also that except in the soils around the Aluminum sulphate Co. of Egypt (profiles 8 and 9). The total Pb content increased with increasing the distan. The distribution of total Pb with soil depth show regular pattern, it decreased with soil profile depth in all studied profiles. These may be explained as lead is immobile metal in the soils (Garcia - Miragaya, 1981).

One of the remarkable observation is that the total Pb contents differ from one area to another. This may be due to the significant variation in Pb concentration in the fall-out of different factories. It is also obvious that the Pb content in soils around the industrial areas depends on the nature and type of industry.

Data are in harmony with those reported by El-Sokkary (1980) who found marked accumulation of Pb in toxic levels to plants by air - borne particulate from industrial activities at Alexandria. Abdel-Shakour (1982) found that the average Pb concentration in the soils at Shoubra El-Kheima area was more than 100 mg/kg. This concentration reach more than 700 mg/kg near a group of complex foundries and smelters. Also, she added that there was a marked decrease in the Pb concentration with the depth of soil profiles. She concluded that the concentration of Pb in cultivated soil in the vicinity of industrial processes were varied from one site to another according to the nearby source of pollution.

Comparing these results with those of El-Sokkary (1978), El-Sokkary and Lag (1980) and Abdel-Shakour (1982) in which the average values of total Pb in uncontaminated Egyptian soil were 11.8, 7.00 and 14.00 mg/kg, respectively, revealed that a considerable Pb contamination took place in the investigated soils. These contamination may be due to integration effects of industrial wastes and fertilizers and pesticides application.

The contents of total Pb in soils around the chemical plants are in the normal level and did not surpass the maximum tolerable level (100 mg Pb/kg soil) reported by El-Bassam and Tietjen (1977).

4.2.1.3.2. DTPA-extractable Pb:

DTPA-extractable Pb around the chemical factories ranged from 0.02 to 17.8 mg/kg soil representing from 0.17 to 42.3 percent of total Pb in the soils. The results show that DTPA-extractable Pb did not follow specific trend with the distance from the factories, in some locations the extractable Pb decreased with increasing the distance (profiles 6,7, 8, 9, 14 and 15). However, in the others it increased with the distance.

4.2.1.3.3. Lead fractions:

The **Pb-CA** fraction constituted the low amount of Pb in soil ranged from 0.03 to 0.3 mg/kg which represents about 0.35 percent of total Pb in the soil.

The **Pb-AC, Pb-PYR** fractions which represent the Pb specifically adsorbed, and organically bound, respectively, constituted relatively high portion ranged from 2.5 to 11.3 and from 4 to 17.0 mg/kg, representing 18.5 and 29.6 percent of total Pb in soil, respectively.

The **Pb-HAH, Pb-OX** and **Pb-OXA** fractions constituted low amount of Pb in the soil ranged from 0.03 to 0.2, 0.07 to 0.5 and 0.2 to 1.1 mg/kg, and representing 0.3, 0.6 and 2.1 percent of the total Pb, respectively.

Table (17)Total,DTPA and lead fractions (mg/kg) in the soils around the chemical plants and smelters.

Prof. No	Depth Cm	Total	DTPA	Lead fractions.						
				Pb-CA	Pb-AC	Pb-PYR	Pb-HAH	Pb-OX	Pb-OXA	Pb-RES
6	00-05	40.50	2.74	0.16	8.15	13.45	0.17	0.31	1.12	17.14
	05-10	28.75	2.44	0.11	5.50	8.98	0.07	0.19	0.47	13.13
	10-25	22.50	1.78	0.09	4.28	6.75	0.08	0.14	0.38	10.79
	25-60	22.00	0.57	0.07	3.97	6.54	0.08	0.13	0.37	10.84
	60-100	13.87	0.30	0.03	2.52	4.04	0.05	0.08	0.23	06.89
7	00-05	33.00	1.82	0.13	6.96	10.52	0.11	0.19	0.59	14.49
	05-10	31.00	1.82	0.12	6.26	9.67	0.08	0.22	0.56	13.16
	10-25	29.50	2.00	0.10	5.89	8.80	0.10	0.18	0.52	13.91
	25-60	24.00	1.32	0.05	4.41	7.01	0.05	0.14	0.41	11.93
	60-100	14.00	0.04	0.03	2.52	4.01	0.05	0.09	0.30	07.00
8	00-05	52.87	3.66	0.27	11.26	16.55	0.13	0.34	1.06	23.26
	05-10	41.00	2.60	0.24	10.23	15.33	0.16	0.37	1.03	23.62
	10-25	50.62	2.10	0.22	9.81	14.29	0.20	0.35	1.00	24.76
	25-60	25.50	0.20	0.11	4.72	7.39	0.10	0.14	0.42	12.71
	60-100	13.50	0.12	0.06	4.43	3.89	0.05	0.08	0.22	06.77
9	00-05	33.50	1.48	0.17	7.02	10.14	0.10	0.22	0.70	15.14
	05-10	30.50	1.54	0.10	6.29	9.49	0.07	0.22	0.61	13.72
	10-25	29.50	1.44	0.12	5.79	8.83	0.09	0.17	0.51	13.99
	25-60	27.00	0.46	0.12	4.95	8.01	0.09	0.16	0.48	13.19
	60-100	22.50	0.04	0.09	3.82	6.30	0.07	0.13	0.38	11.71
10	00-05	30.00	1.52	0.12	5.62	8.78	0.10	0.16	0.39	14.97
	05-10	23.50	1.30	0.08	4.32	6.62	0.07	0.14	0.38	11.90
	10-25	16.50	0.86	0.05	2.80	4.64	0.05	0.10	0.21	08.66
	25-60	16.50	0.06	0.05	2.65	4.61	0.06	0.08	0.24	08.81
	60-100	15.00	0.02	0.05	2.99	4.08	0.03	0.07	0.22	08.12
11	00-05	30.00	2.26	0.12	5.32	8.97	0.12	0.18	0.48	14.50
	05-10	28.50	2.12	0.14	5.37	8.41	0.11	0.16	0.46	13.85
	10-25	27.00	1.06	0.10	4.42	7.47	0.07	0.12	0.47	14.35
	25-60	22.00	0.30	0.09	3.57	6.20	0.11	0.09	0.38	11.45
	60-100	18.50	0.22	0.06	2.98	5.11	0.06	0.10	0.31	09.88
12	00-05	27.00	3.76	0.12	4.85	7.89	0.11	0.20	0.52	13.32
	05-10	26.50	4.18	0.11	4.60	7.72	0.10	0.16	0.50	13.21
	10-25	26.00	4.66	0.10	4.66	7.34	0.08	0.18	0.47	13.16
	25-60	25.00	0.60	0.10	4.38	6.58	0.09	0.12	0.45	13.28
	60-100	23.00	0.24	0.06	3.70	5.78	0.08	0.13	0.46	12.55
13	00-05	42.00	17.76	0.17	7.60	12.15	0.17	0.18	0.72	21.00
	05-10	30.00	3.50	0.12	5.44	08.43	0.12	0.15	0.49	15.25
	10-25	26.50	2.76	0.06	4.51	07.19	0.08	0.16	0.40	14.09
	25-60	26.00	1.76	0.08	4.21	6.82	0.08	0.15	0.39	14.26
	60-100	26.00	0.42	0.07	4.45	6.50	0.08	0.15	0.39	14.10
14	00-05	33.50	1.96	0.14	6.10	9.41	0.13	0.16	0.54	17.01
	05-10	30.50	1.26	0.13	5.50	8.57	0.12	0.13	0.49	15.56
	10-25	27.50	1.24	0.11	4.93	7.90	0.10	0.49	0.41	13.83
	25-60	24.00	0.74	0.09	3.92	6.63	0.07	0.14	0.38	12.84
	60-100	23.00	0.44	0.05	3.66	6.24	0.07	0.14	0.37	12.48
15	00-05	40.00	1.40	0.16	7.53	11.20	0.14	0.22	0.64	20.12
	05-10	29.50	1.22	0.10	4.81	8.18	0.09	0.15	0.44	15.43
	10-25	28.00	0.98	0.10	4.76	7.15	0.08	0.17	0.45	15.00
	25-60	27.50	0.78	0.07	4.74	7.27	0.05	0.11	0.44	14.77
	60-100	27.00	0.28	0.05	4.40	7.07	0.08	0.11	0.43	14.88

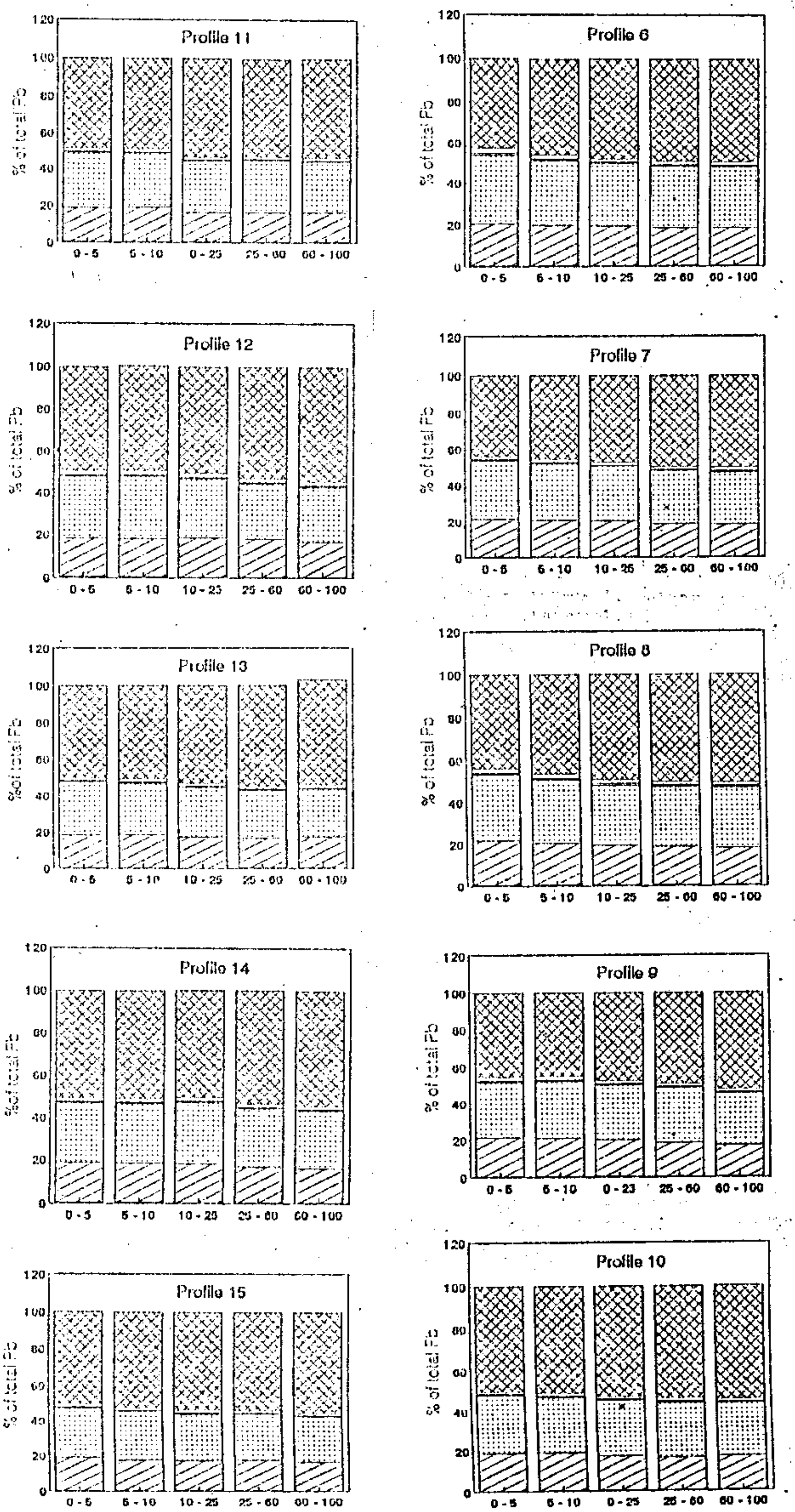


Fig. (6): Lead fractions as the percentage of total in soils around chemical plants and smelter

Pb-CA Pb-AC Pb-PYR Pb-HAH Pb-COX Pb-COA Pb-RES

The **Pb-RES** fraction constituted the highest portion of Pb ranged from 6.8 to 24.8 mg/kg corresponded to about 42.3 to 57.2 percent of total Pb in soil.

4.2.1.4. Cadmium (Cd):

Table (18) and Fig (7)

4.2.3.4.1. Total cadmium:

Results indicate that the total Cd content varied from 3.5 to 10.5 mg/kg. The highest values (10.5mg) were found in the surface layers of profiles (9, 10 and 12), while the lowest value (3.5mg) was obtained in the profile 6 (Abu-Zaabal fertilizers and chemicals factory). Concerning the distribution with distance, data show that the mean values of total Cd is almost similar near and far from the factories in most studied soil profiles. Concerning the distribution with depth, data show that the total Cd decreased gradually with soil depth in most studied soil profiles which means that Cd is more mobile and leachable (Kuo *et al.* 1983).

The values of total Cd in studied soils are higher than those found by Abdel-Aziz (1983) and Baghdady and Sippola (1984b) in Egyptian alluvial soils (0.26 and 0.19 mg/kg) and higher than those of Bahteem soils (0.23 mg/kg), El-Marge soils (0.30 mg/kg) and Mostord contaminated soils (3.4 mg/kg) as reported by Abdel-Haleem (1984) and also higher than those of Ismaillia soils (0.3-2.3 mg/kg) and Sinai soils (0.3-0.8 mg/kg) as reported by El-Sikhry (1985) and contaminated soils around some factories 2.3 - 7.6 mg/kg, El-Leithi, (1986).

The threshold value of 5 mg/kg soil reported by El-Bassam and tietjen (1977) was exceeded in soils around chemical plants and smelters. In conclusion total Cd in these soils is high and the soils are highly polluted.

This element is mobile and more leachable and the main source of contamination in these profiles is the volatile wastes of factories.

4.2.1.4.2. DTPA-extractable cadmium:

DTPA-extractable Cd around plants ranged from 0.01 to 0.19 mg/kg representing 0.1 to 1.8 percent of total Cd in the soil, without any regular distribution patterns with distance from the plants, while it decreased gradually with soil depth. These results are in agreement with the findings of El-Leithi (1986).

The values of DTPA-extractable Cd are higher than those found by Baghdady and Sippola (1984b) in Egyptian alluvial soils (0.03 ppm, extracted by NH4OAC-EDTA) and higher than those of Ismaillia soils (0.02 ppm, extracted by 0.5 N HOAC) which was reported by El-Sikhry (1985). This variation actually, due to the use of different extractants.

4.2.1.4.3. Cadmium fractions:

The **Cd-CA** fraction constituted relatively high portion of total soil Cd and ranged between 0.7 and 2.4 mg/kg which represented 15.6 - 25 percent of total Cd in the soil. Concerning the distribution of Cd-CA fraction with distance, data show that the mean values are almost similar near and far from the factories in most studied profile, and gradually decreased with the soil profile depth. The comparison between Cd and other elements revealed that Cd exchangeability was much greater than those of the other elements examined and these results agree with the findings of Kuo *et al.* (1983). The

Table (18): Total, DTPA and Cd fractions (mg/kg) in the soils around the chemical plants and smelters.

Prof. No	Depth Cm	Total	DTPA	Cadmium fractions. Cd-CA	Cd-Ac	Cd-PYR	Cd-HAH	Cd-OX	Cd-OA	Cd-RES
6	00-05	09.00	0.12	2.3	0.6	1.7	0.2	0.4	0.7	3.1
	05-10	07.50	0.10	1.7	0.4	1.3	0.2	0.4	0.6	2.9
	10-25	06.00	0.08	1.2	0.3	1.0	0.1	0.3	0.5	2.6
	25-60	05.50	0.06	1.1	0.2	0.9	0.1	0.4	0.4	2.4
	60-100	03.50	0.04	0.7	0.1	0.6	0.1	0.3	0:3	1.4
7	00-05	08.50	0.14	2.1	0.5	1.6	0.2	0.4	0.6	3.1
	05-10	08.50	0.12	1.9	0.5	1.4	0.2	0.4	0.6	3.5
	10-25	08.00	0.12	1.5	0.4	1.3	0.1	0.3	0.5	3.9
	25-60	07.50	0.04	1.4	0.3	1.2	0.1	0.3	0.4	3.8
	60-100	07.00	0.02	1.2	0.2	1.0	0.1	0.3	0.4	2.8
8	00-05	10.20	0.19	2.4	0.6	1.8	0.2	0.5	0.7	4.0
	05-10	09.40	0.17	1.9	0.6	1.7	0.2	0.4	0.6	4.0
	10-25	09.00	0.14	1.7	0.5	1.5	0.2	0.4	0.5	4.2
	25-60	08.50	0.09	1.5	0.4	1.4	0.1	0.3	0.5	4.3
	60-100	07.00	0.06	1.2	0.3	1.1	0.1	0.3	0.4	3.6
9	00-05	10.50	0.10	2.4	0.5	1.9	0.2	0.5	0.7	4.3
	05-10	09.50	0.09	1.9	0.5	1.7	0.2	0.4	0.6	4.2
	10-25	08.50	0.09	1.5	0.4	1.4	0.2	0.4	0.6	4.0
	25-60	08.00	0.03	1.6	0.4	1.3	0.1	0.3	0.5	3.8
	60-100	07.80	0.01	1.7	0.3	1.2	0.1	0.3	0.4	4.3
10	00-05	10.50	0.06	2.2	0.4	1.9	0.2	0.5	0.7	4.6
	05-10	07.50	0.05	1.5	0.4	1.4	0.1	0.4	0.6	3.1
	10-25	07.50	0.05	1.5	0.3	1.3	0.1	0.4	0.5	3.4
	25-60	07.50	0.04	1.5	0.3	1.2	0.1	0.4	0.5	3.5
	60-100	06.40	0.03	1.2	0.2	1.0	0.1	0.4	0.5	3.0
11	00-05	08.50	0.03	1.9	0.4	1.6	0.1	0.4	0.6	3.5
	05-10	08.50	0.03	1.7	0.3	1.5	0.1	0.4	0.6	3.9
	10-25	07.50	0.03	1.4	0.3	1.2	0.1	0.4	0.5	3.6
	25-60	07.00	0.02	1.2	0.2	1.1	0.1	0.3	0:4	3.7
	60-100	07.00	0.02	1.1	0.2	1.1	0.1	0.3	0.4	3.8
12	00-05	10.50	0.13	2.1	0.5	1.9	0.2	0.5	0.7	4.6
	05-10	09.50	0.13	1.9	0.5	1.6	0.2	0.5	0.7	4.1
	10-25	09.50	0.11	1.8	0.4	1.6	0.2	0.4	0.6	4.5
	25-60	08.50	0.04	1.6	0.4	1.4	0.2	0.4	0.5	4.0
	60-100	08.00	0.04	1.4	0.3	1.3	0.1	0.4	0.5	4.0
13	00-05	10.50	0.15	2.2	0.5	2.0	0.2	0.5	0.7	4.4
	05-10	10.50	0.08	2.2	0.4	1.8	0.2	0.5	0.7	4.7
	10-25	10.00	0.08	1.9	0.4	1.7	0.2	0.4	0.6	4.8
	25-60	09.50	0.07	1.8	0.3	1.5	0.1	0.4	0.5	4.9
	60-100	08.50	0.04	1.5	0.2	1.3	0.1	0.4	0.4	4.6
14	00-05	09.00	0.06	1.9	0.4	1.6	0.1	0.4	0.6	4.0
	05-10	08.50	0.06	1.8	0.4	1.5	0.1	0.4	0.6	3.7
	10-25	08.00	0.05	1.5	0.3	1.3	0.1	0.4	0.5	3.9
	25-60	08.00	0.02	1.4	0.3	1.3	0.1	0.4	0.5	4.0
	60-100	07.50	0.01	1.3	0.2	1.2	0.1	0.4	0.4	3.9
15	00-05	08.50	0.06	1.7	0.4	1.5	0.1	0.5	0.6	3.7
	05-10	08.50	0.04	1.6	0.3	1.4	0.1	0.4	0.5	4.2
	10-25	08.50	0.04	1.4	0.3	1.4	0.1	0.4	0.5	4.4
	25-60	08.00	0.03	1.3	0.2	1.4	0.1	0.4	0.4	4.1
	60-100	07.00	0.03	1.1	0.2	1.1	0.1	0.4	0.4	3.7

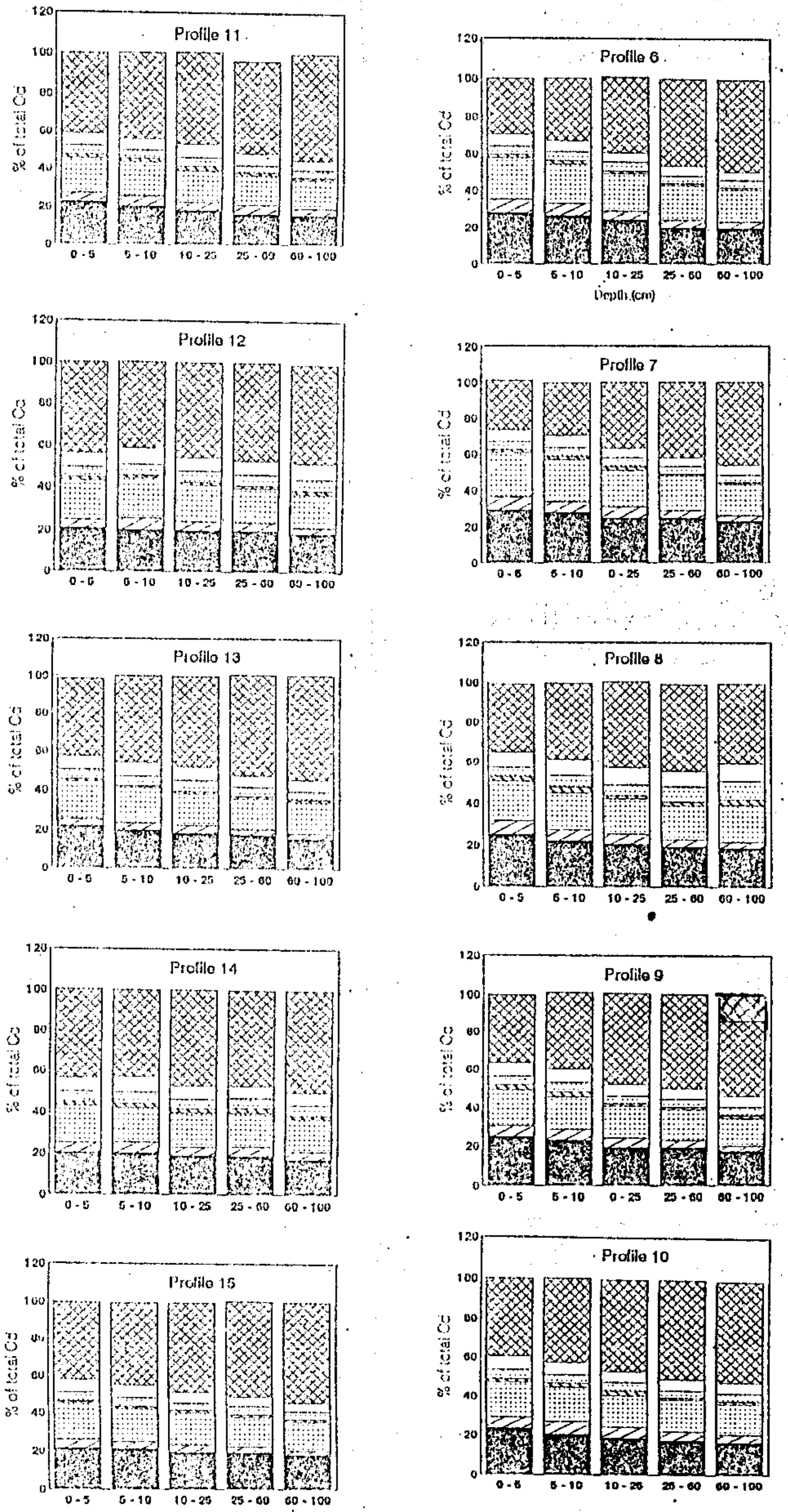


Fig. (7): **Cadmium fractions as the percentage of total in soils around chemical plants and smelter**

Cd-CA Cd-AC Cd-PYR Cd-HAH
Cd-COX Cd-COA Cd-RES

Cd-AC fraction constituted low amount ranged from 0.1 to 0.6 mg/kg which represents 2.5-6.7 percent of total Cd in soil.

The **Cd-PYR** fraction constituted relatively high portion of the total soil Cd and ranged between 0.6 and 2.0 mg/kg which comprised 14.3-19 percent of total Cd in soil.

The **Cd-HAH, Cd-OX,** and **Cd-OXA** fractions were found in low amount, ranged from 0.1-0.2, 0.3-0.5 and 0.3-0.7 mg/kg, respectively, which corresponded about 1.1-2.7, 3.5-8.6 and 4.7-8.3 percent of total Cd in soil, respectively.

The **Cd-RES** fraction constituted the highest portion of soil Cd, ranged from 1.4 to 4.9 mg/kg constituting 34.4 - 55.1 percent of total Cd in the soils. The data show that this fraction was increased with increasing soil profile depth.

4.2.1.5. Nickel (Ni):

Table (19) and Fig. (8):

4.2.1.5.1. Total Nickel:

Total Ni content in soils adjacent to the chemical plants was varied from 4.4 to 109.2 mg/kg soil. The highest values were obtained around the smelters (profiles 12 and 13) where it was ranged from 100 to 101.3 mg/kg. However, the lowest average content was in Abu-Zaabal area (profiles 6-11), it did not exceed 35.8 mg/kg soil.

The comparison between total Ni contents near and far from the plants showed that the total Ni was decreased with increasing the distance from the plants.

In general, the values of total Ni content in the studied soils are higher than those of Mills and Zwarich (1955) and Whitby *et al.* (1978) for uncontaminated Manitoba and Ontario agricultural soils. However, values of total Ni in the studied profiles may comparable with those found in contaminated soils of Ontario (ranged from 1-3 to 6560 mg/kg, with a mean of 15.9 mg/kg), and polluted soils in Belgium (mean of 106.6 mg/kg) as reported by Frank *et al.* (1976) and Cottenie (1982), respectively.

Also, data indicate that the studied soils have much lower Ni content than those in soils derived from ultra basic rocks and studied by Anderson *et al.* (1972) and Crooke (1956), who reported that total Ni was 1000 mg/kg in serpentine soils and values as high as 3410 mg/kg were existed in soil developed from ultra basic rocks.

Total Ni content did not exceed the threshold value (100 mg/kg) suggested by El-Bassam and Tietjen (1977) except in soils around the smelters (Qalub area) especially in the nearest profile to smelters.

According to these results, it could be stated that smelters represent an affective source of Ni pollution either in atmosphere or soil itself. Surpassing the mentioned maximum tolerable level of Ni (100 mg) due to such industrial activites should paid attention at least to minimize the probable hazads due to Ni pollution in air, soil, plants and hence animals and humanbings.

4.21.5.2. <u>DTPA-extractable Nickel:</u>

DTPA-extractable Ni in soils around the plants (profiles 6-15) ranges from 0.2 to 1.2 mg/kg soil (Table 19). The highest values were obtained in profiles (12, 13) around the smelters while the lowest values were in soils around the plants at Abu-Zaabal.

However, the values of nickel extracted by DTPA in contaminated soils at Ontario (Canada) ranged from 0.2 to 168.0 mg/kg with an average of 11.2 mg/kg (Heq *et al.* 1980).

According to the high level of Ni in the soils bordering industrial areas, these soils could be considered contaminated. The source of pollution may be the wastes of plants, Also, polluted air through atmospheric emission fumes may be considered as another source of Ni contaminations.

<u>4.2.1.5.3. Nickel fractions:</u>

The **Ni-CA** fraction constituted the least amount of Ni in the soil ranged from 0.2 to 5.2 mg/kg. The **Ni-AC, Ni-PYR** fractions constituted relatively high portion of total Ni ranged from 2.2 to 15.2 and from 0.3 to 8.4 mg/kg soil, respectively.

The **Ni-HAH** was not detectable (terraces). The **Ni-OX, Ni-OXA** fractions ranged from 0.2 to 4.9 and from 0.5 to 11.6 mg/kg soil, respectively.

The **Ni-RES** fraction constituted the high portion of total Ni in the soil ranged from 4.4 to 62.2 mg/kg .

Table (19): Total,DTPA and Ni fractions (mg/kg) in the soils around the chemical plants and smelters.

Prof. No	Depth Cm	Total	DTPA	Nickel fractions. Ni-CA	Ni-AC	Ni-PYR	Ni-HAH	Ni-OX	NI-OXA	Ni-RES
6	00-05	33.8	0.8	1.4	5.1	2.5	T	1.6	3.5	19.7
	05-10	48.5	0.8	2.0	6.8	3.5	T	2.3	5.2	28.7
	10-25	33.8	0.6	1.6	4.5	2.1	T	1.6	3.8	20.2
	25-60	28.8	0.6	1.1	4.0	1.8	T	1.3	3.0	17.6
	60-100	07.3	0.4	0.3	1.0	0.5	T	0.3	0.8	04.4
7	00-05	18.9	0.8	0.8	2.8	1.4	T	1.0	2.1	10.8
	05-10	18.2	0.8	0.9	2.5	1.3	T	0.9	2.0	10.6
	10-25	20.2	0.8	0.8	2.8	1.3	T	1.0	2.1	12.2
	25-60	04.4	0.2	0.2	0.6	0.3	T	0.2	0.5	10.1
	60-100	16.4	0.4	0.6	2.2	1.0	T	0.7	1.8	09.3
8	00-05	50.1	1.2	2.6	7.5	4.2	T	2.4	6,1	27.3
	05-10	50.4	1.0	2.3	7.4	4.1	T	2.4	6.1	28.1
	10-25	38.7	0.8	1.5	5.1	2.4	T	1.7	4.6	23.4
	25-60	23.4	0.6	1.0	3.3	1.6	T	1.0	2.7	13.8
	60-100	16.5	0.4	0.7	2.3	1.0	T	0.8	1.8	09.9
9	00-05	33.7	0.6	1.8	4.9	2.8	T	1.7	4.2	18.3
	05-10	28.4	0.6	1.4	4.0	2.2	T	1.3	3.4	16.1
	10-25	28.8	0.4	1.4	4.0	2.1	T	1.2	3.4	16.7
	25-60	16.3	0.3	0.6	2.3	1.1	T	1.7	1.9	09.7
	60-100	07.9	0.2	0.3	1.1	0.5	T	0.3	0.9	04.8
10	00-05	40.5	0.6	1.9	6.0	3.1	T	1.7	4.3	23.5
	05-10	22.8	0.6	1.0	3.1	1.6	T	1.1	2.4	13.6
	10-25	17.1	0.4	0.8	2.6	1.2	T	0.9	1.9	09.7
	25-60	15.6	0.4	0.7	2.1	1.0	T	0.7	1.7	09.4
	60-100	08.1	0.2	0.3	1.0	0.5	T	0.4	0.9	05.0
11	00-05	12.6	0.4	0.6	1.9	1.0	T	0.6	1.4	07.1
	05-10	19.6	0.2	0.7	2.9	1.5	T	1.0	2.2	11.3
	10-25	13.1	0.2	0.6	2.1	0.8	T	0.6	1.4	07.6
	25-60	24.3	0.2	1.0	3.5	1.5	T	1.1	2.7	14.5
	60-100	15.5	0.2	0.6	2.2	0.9	T	0.8	1.6	09.4
12	00-05	100.2	0.6	5.2	14.8	8.4	T	4.7	10.7	56.4
	05-10	097.8	1.0	5.2	14.7	8.1	T	4.5	10.7	54.6
	10-25	105.0	0.8	4.3	14.5	7.6	T	5.2	11.1	62.1
	25-60	102.0	1.4	3.8	12.9	7.1	T	5.2	11.1	61.8
	60-100	101.4	0.6	3.7	13.6	6.9	T	4.9	10.1	62.2
13	00-05	97.8	0.6	4.7	15.2	8.0	T	4.8	10.0	55.1
	05-10	97.2	0.8	4.9	13.8	7.9	T	4.9	10.7	55.0
	10-25	91.2	0.8	4.2	11.9	6.5	T	4.2	10.4	54.0
	25-60	109.2	0.6	4.0	15.9	7.9	T	4.9	11.6	64.9
	60-100	98.4	0.6	3.8	14.0	6.5	T	4.8	10.6	58.7
14	00-05	34.8	0.6	1.6	5.2	2.5	T	1.8	3.9	19.8
	05-10	36.6	0.6	1..7	5.4	2.6	T	2.0	4.2	20.7
	10-25	35.4	0.6	1.3	4.9	2.4	T	1.7	3.8	21.3
	25-60	22.8	0.4	0.8	3.2	1.6	T	1.0	2.4	13.8
	60-100	33.6	0.4	1.4	4.4	2.2	T	1.5	3.7	20.4
15	00-05	25.6	0.8	1.3	3.7	1.9	T	1.3	2.9	14.5
	05-10	35.8	0.6	1.7	4.7	2.6	T	1.8	4.0	21.0
	10-25	35.8	0.6	1.6	5.4	2.4	T	1.6	3.8	21.0
	25-60	27.4	0.4	1.0	3.8	1.8	T	1.4	2.9	16.5
	60-100	22.2	0.4	0.8	3.0	1.4	T	1.1	2.2	13.7

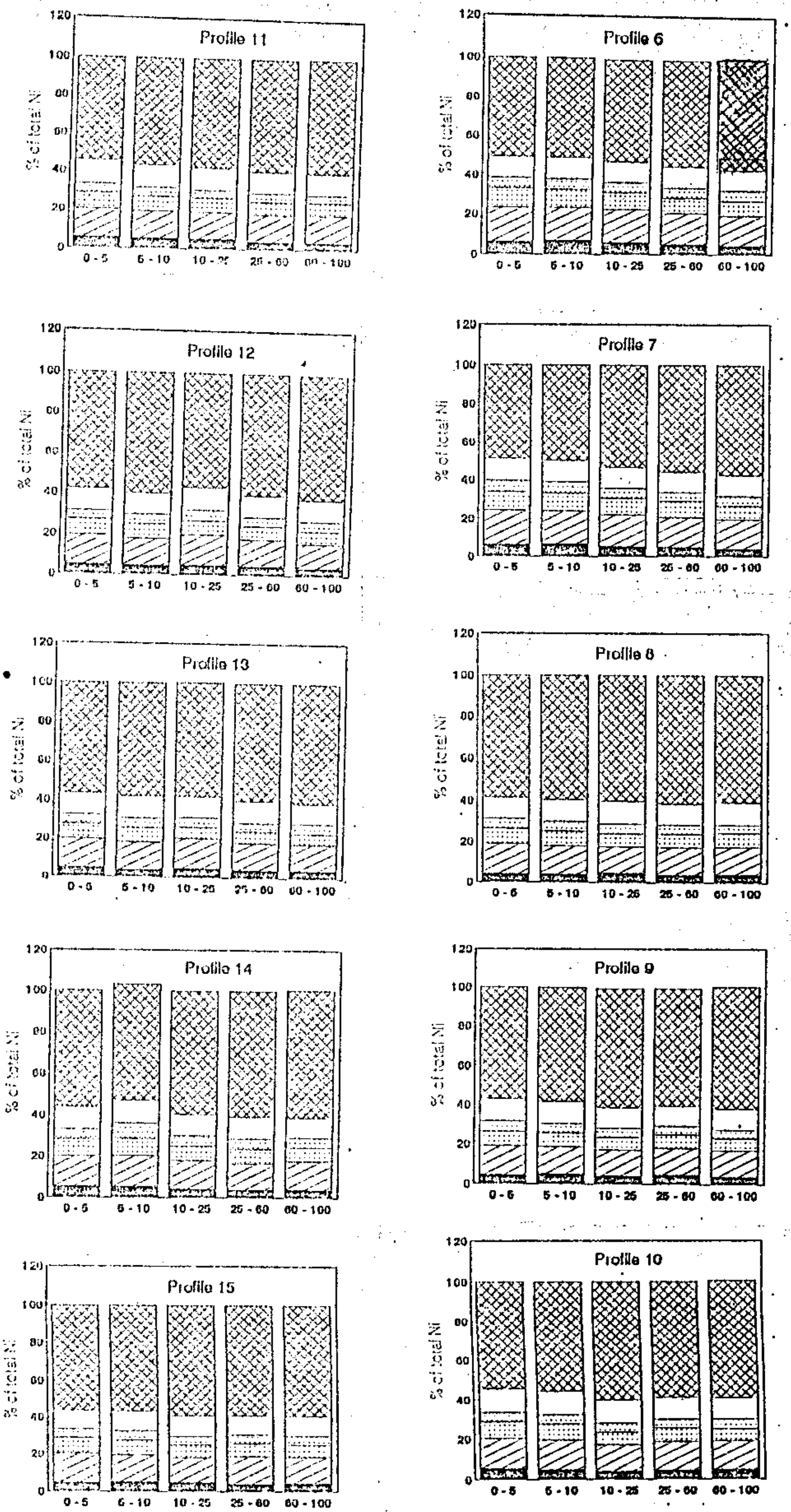


Fig. (8): Nickel fractions as the percentage of total in soils around chemical plants and smelter.

Ni-CA Ni-CAA Ni-PYR Ni-HAH Ni-COX Ni-COA Ni-RES

4.2.1.6. Cobalt (Co):

Table (20) and Fig. (9):

4.2.1.6.1. Total cobalt:

Total Co in soil samples taken from the industrial areas varied from 22.80 to 54.0 mg/kg soil. Total Co increased with soil depth in most studied soil profiles. However, it decreased gradually with depth in some profiles (6-10). The other profiles show almost homogenous distribution of Co through the diffrent soil layers.

In general, the values of total Co in the studied soils are higher than those found by Cottenie *et al.* (1982) in Belgium polluted soils (16.4 ppm) and higher than those in Egyptian alluvial soils reported by Rabie (1984) and El-Sokkary and Lag (1980) who found an average of 27.2 and 15.8-20.3 mg/kg, respectively.

The threshold value of 50 mg/kg was not exceeded in soils around the chemical plants and smelters. However, the soils represented by profiles 7 and 9 (Abou Zaabal area) were the most ones going to reach that maximum tolerable level.

4.2.1.6.2. DTPA-extractable cobalt:

DTPA-extractable Co ranged from 0.42 to 1.28 mg/kg soil. DTPA-extractable Co was decreased with increasing the distance from the plants in some profiles (7,9, and 11) while it increased with the distance from the plant in the other profiles (13 and 15). DTPA-extractable Co did not follow any regular trend with soil profile depth. These values are lower than those found by Anderson *et al.* (1973) in contaminated soils, where Co extracted by

HOAC ranged from less than 2.5 to 32 ppm. Also, Williams *et al.* (1980) found that DTPA-extractable Co of surface soils of untreated plots and those treated with 180 ton sludge was 3.6 and 4.5 ppm, respectively. The amount of Co extracted by DTPA are much higher than those recorded for some Egyptian soils in other studies. where the average values of DTPA-extractable Co in calcareous soils, light alluvial and heavy alluvial soils were 0.033, 0.037 and 0.055 ppm, respectively. (Rabie ,1984). It was also higher than those obtained by El-Sokkary and Lag (1980) who found the DTPA-extractable Co ranged from 0.11 to 0.23.

4.2.1.6.3. Cobalt fractions:

The **Co-CA**, **Co-OX** and **Co-AC** fractions represent soluble and exchangeable, occluded on amorphous Fe and Al oxides and specifically adsorbed fractions, respectively were constituted the low amount of Co in soil represented 0.5-0.8, 0.7-1.0 and 0.7-1.0 percent of total Co in soil. The **Co-PYR** fraction represents the organically bound constituted relatively high portion of total Co ranged from 4.1 to 11.34 mg/kg representing 17-22 percent of total Co in soil.

The residual fraction (**Co-RES**) constituted high proportion of total Co in soil varying from 17.29 to 39.36 mg/kg and representing 72.0-77.2 percent of total Co in soil.

Table (20): Total, DTPA and Cobalt fractions (mg/kg) in soils around chemical plants and smelters.

prof. No	Depth cm	Total	DTPA	Cobalt fractions. Co-CA	Co-AC	Co-PYR	Co-HAH	Co-OX	Co-OXA	Co-RES
6	00-05	30.0	0.84	0.24	0.30	6.60	T	0.30	0.96	21.6
	05-10	54.0	0.92	0.43	0.50	11.3	T	0.43	1.94	39.4
	10-25	28.5	1.02	0.20	0.26	5.98	T	0.23	1.00	20.8
	25-60	26.4	1.00	0.16	0.21	5.28	T	0.18	1.00	19.6
	60-100	22.8	1.08	0.14	0.16	4.10	T	0.20	0.91	17.3
7	00-05	42.5	0.70	0.34	0.38	9.35	T	0.38	1.44	30.6
	05-10	41.6	0.80	0.29	0.37	8.32	T	0.33	1.22	31.1
	10-25	44.5	0.86	0.27	0.36	8.45	T	0.36	1.29	33.8
	25-60	41.0	0.72	0.25	0.29	7.38	T	0.37	1.35	31.4
	60-100	37.0	0.68	0.15	0.26	6.29	T	0.37	1.41	28.5
8	00-05	36.0	1.10	0.25	0.25	7.56	T	0.29	1.33	26.3
	05-10	34.5	1.18	0.24	0.28	7.59	T	0.24	1.24	24.9
	10-25	34.5	1.18	0.14	0.24	6.21	T	0.21	1.34	26.4
	25-60	28.5	1.28	0.23	0.23	4.84	T	0.26	1.14	21.8
	60-100	26.5	1.18	0.19	0.19	4.77	T	0.24	1.10	20.0
9	00-05	43.5	0.76	0.35	0.30	9.57	T	0.60	1.57	31.4
	05-10	44.5	0.68	0.40	0.36	9.34	T	0.36	1.69	32.3
	10-25	43.5	0.82	0.30	0.30	8.26	T	0.35	1.74	32.5
	25-60	40.0	0.70	0.24	0.36	8.00	T	0.36	1.64	29.4
	60-100	37.0	0.78	0.22	0.26	6.66	T	0.33	1.55	28.0
10	00-05	33.0	1.22	0.26	0.30	6.93	T	0.30	1.16	24.0
	05-10	32.0	1.28	0.22	0.30	7.00	T	0.32	1.21	22.9
	10-25	31.0	1.24	0.19	0.25	5.58	T	0.31	1.21	23.5
	25-60	28.2	1.20	0.20	0.20	5.36	T	0.25	1.18	21.0
	60-100	28.0	1.20	0.17	0.20	5.32	T	0.28	1.15	20.9
11	00-05	33.5	0.60	0.27	0.34	7.37	T	0.30	0.94	24.3
	05-10	35.0	0.60	0.25	0.35	7.35	T	0.35	1.01	25.7
	10-25	35.0	0.62	0.21	0.31	6.65	T	0.28	1.12	26.2
	25-60	37.5	0.66	0.26	0.34	7.50	T	0.30	1.35	27.7
	60-100	35.0	0.66	0.24	0.28	6.30	T	0.28	1.19	26.7
12	00-05	37.0	0.70	0.26	0.33	8.14	T	0.30	1.11	26.9
	05-10	35.5	0.66	0.25	0.32	7.46	T	0.28	1.14	26.0
	10-25	38.0	0.66	0.23	0.30	7.60	T	0.27	1.56	28.0
	25-60	38.0	0.50	0.23	0.27	6.46	T	0.23	1.56	29.2
	60-100	37.5	0.68	0.19	0.30	6.37	T	0.34	1.58	28.7
13	00-05	33.0	0.76	0.23	0.30	6.93	T	0.30	1.06	24.2
	05-10	33.5	0.84	0.25	0.36	7.10	T	0.28	1.21	26.3
	10-25	30.5	0.84	0.18	0.24	5.19	T	0.27	1.13	23.5
	25-60	35.5	0.62	0.21	0.26	6.39	T	0.36	1.14	27.1
	60-100	35.5	0.68	0.19	0.28	6.39	T	0.36	1.35	26.9
14	00-05	31.0	0.44	0.25	0.31	6.82	T	0.19	1.12	22.3
	05-10	32.5	0.50	0.26	0.29	6.50	T	0.23	1.14	24.1
	10-25	34.5	0.42	0.21	0.31	7.25	T	0.31	1.24	26.2
	25-60	34.5	0.48	0.21	0.28	6.21	T	0.34	1.28	26.2
	60-100	35.0	0.44	0.18	0.22	6.30	T	0.35	1.30	26.6
15	00-05	35.0	0.52	0.25	0.28	7.00	T	0.25	1.19	26.0
	05-10	35.0	0.56	0.21	0.25	7.35	T	0.25	1.12	25.8
	10-25	37.0	0.54	0.22	0.26	6.29	T	0.30	1.37	28.4
	25-60	38.0	0.62	0.19	0.34	6.84	T	0.30	1.48	28.8
	60-100	36.0	0.62	0.18	0.29	6.48	T	0.32	1.48	27.2

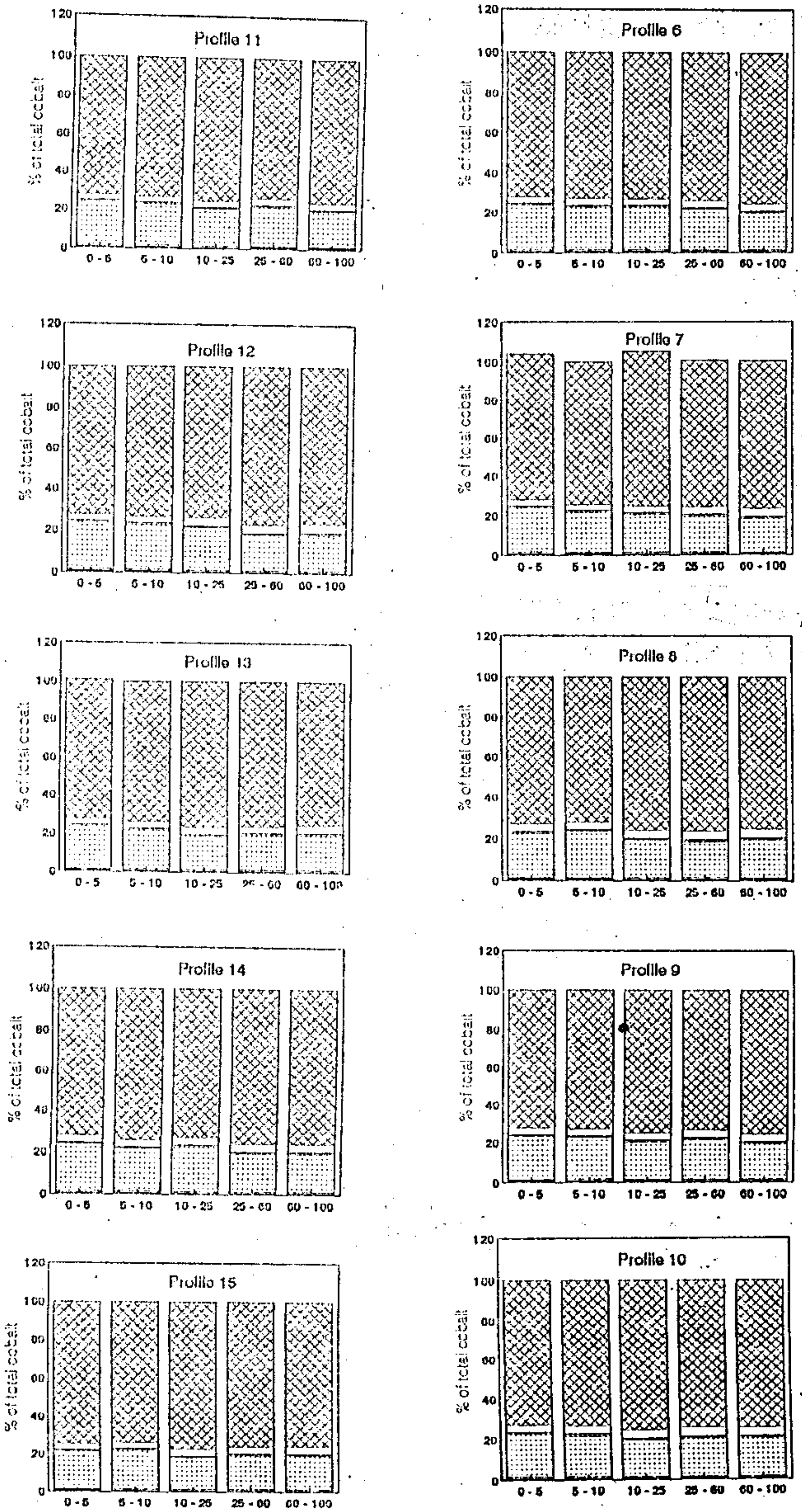


Fig. (9): Cobalt fractions as the percentage of total in soils around chemical plants and smelter.

Co-CA Co-CAA Co-PYR Co-HAH
Co-COX Co-COA Co-RES

4-2-2- Heavy Metal fractions v. s. soil properties: (Table, 21):

4-2-2-1-Copper:

Values of correlation coefficients between the Cu fractions and some soil parameters, show that the fractions were correlated positively and significantly with soil organic matter and cation exchange capacity of soils, and negatively with soil pH.

4-2-2-2-Zinc:

Soil organic matter is still the more effective soil property on the availability of soil Zn and its distribution among the different phases. The availability of Zn was affected negatively by soil pH as a result of the reduction in Zn solubility.

4-2-2-3-Lead:

Positive and significant relationships were exsited between total Pb as well as most of the Pb fractions with soil organic matter. However a poor relationship was found between DTPA-extractable Pb and soil organic matter. Lead fractions were affected negatively, but not significantly with soil pH .

4-2-2-4- Cadmium:

Soil Cd and its fractions were correlated positively and significantly with both soil organic matter and soil carbonate. However, the solubility and distribution of Cd among the different phases were negatively affected by soil pH.

Table(21): Correlation coefficients (r) between the chemical fractions of heavy metals and some parameters of soils around some chemical plants and smelters.

Soil parameter	Total	DTPA-extractable	Non specific adsorbeded (CA)	Specific adsorbed (AC)	Organically bound (PYR)	Mn oxide bound (HAH)	Al and Fe oxide bound (OX)	Crystalline Fe and Al Oxide bound (OXA)	Residual (RES)
Cu									
O.M	0.742***	0.555**	0.786***	0.762***	0.746***	0.592***	0.663***	0.627***	0.69***
CaCO3	0.062	-0.008	0.069	0.202	0.072	-0.112	-0.09	0.154	0.10
pH	-0.342*	-0.306*	-0.355**	-0.34*	-0.391**	-0.456***	-0.34*	-0.217	-0.282*
CEC	0.508***	-0.309*	0.385**	0.475***	0.429**	0.137	0.419**	0.553***	0.517***
Zn									
O.M	0.763***	0.652***	0.733***	0.835***	0.812***	0.708***	0.764***	0.784***	0.744***
CaCO3	0.245	0.166	0.41**	0.289*	0.283	0.159	0.248	0.201	0.178
pH	-0.287	-0.339*	-0.31*	-0.287	-0.284	-0.291*	-0.301*	-0.314	-0.238
CEC	0.542***	0.223	0.345*	0.514***	0.559***	0.491***	0.518***	0.531***	0.587***
Pb									
O.M	0.558***	0.12	0.493***	0.528***	0.555***	0.475***	0.444**	0.499***	0.512***
CaCO3	0.395**	-0.032	0.425**	0.32*	0.342*	0.479***	0.066	0.266	0.399**
pH	-0.254	-0.093	-0.245	-0.319*	-0.311*	-0.214	-0.199	-0.331	-0.156
CEC	0.166	-0.069	0.027	0.028	0.037	0.175	0.045	0.017	0.276
Cd									
O.M	0.329*	0.397**	0.668***	0.656***	0.651***	0.666***	0.54***	0.67***	0.30*
CaCO3	0.46**	0.335*	0.605***	0.451**	0.656***	0.227	0.615***	0.646***	0.393**
pH	-0.131	-0.139	-0.318*	-0.462**	-0.236	-0.401**	0.002	-0.265*	-0.13
CEC	0.343*	0.194	0.161	0.013	0.31*	0.063	0.343*	0.143	0.498
Ni									
O.M	0.573***	0.686***	0.642***	0.587***	0.607***	--	0.568***	0.594***	0.547***
CaCO3	0.228	0.189	0.332*	0.266	0.299*	--	0.243	0.237	0.192
pH	-0.174	-0.291*	-0.218	-0.193	-0.207	--	-0.165	-0.175	-0.186
CEC	0.622***	0.34*	0.59***	0.615***	0.594***	--	0.617***	0.615***	0.62***
Co									
O.M	0.201	-0.096	0.306*	0.325*	0.362*	--	-0.047	-0.025	0.195
CaCO3	0.049	-0.0263	0.303*	0.208	0.267	--	0.027	-0.201	-0.012
pH	-0.260	-0.171	-0.250	-0.284	-0.280	--	-0.166	0.018	-0.239
CEC	0.022	-0.431**	-0.103	0.069	-0.018	--	-0.204	0.010	0.048
						--			

***, **, and *** Significant at the 0.05, 0.01, and 0.001 probability levels, respectively**

4-2-2-5- Nikle:

The most important soil parameters affecting the solubility and distribution of soil Ni among the different chemical phases were soil organic matter, CEC, and soil pH.

4-2-2-6- Cobalt:

The nonspecific, specific adsorbed and organically bound Co fractions were correlated positively and significantly with soil organic matter. However, the effect of soil pH on Co fractions was negative .

4-2-3-Concentrations of heavy metals in plants grown on soils around industrial areas:

The concentrations of heavy metals in plants grown on soils around industrial areas are shown in Table (22). The results can be summarized as follows:

4-2-3-1-Copper:

Copper contents of plants grown on soils around the chemical plants were ranged from 8.4 to 16.0 μg/g. The highest values were found in soils around smelters (16 μg/g). This level was within the critical toxicity rnage (15-20 μg/g) proposed by Sauerbeck (1982).

4-2-3-2-Zinc:

No hazards are expected from the concentrations of Zn in plants grown on soils around the chemical plants, since their contents of Zn were low.

4-2-3-3-Lead:

The levels of Pb in plants around chemical factories range between 5.5 to 9.2 μg/g .The higher levels tended to reach the lower level of the critical toxicity range (10-20 μg/g) proposed by Sauerbeck (1982).

4-2-3-4-Cadmium:

Monitoring the concentrations of Cd in plants grown on soils around the chemical plants and smelters revealed that the concentrations range from 3.7 to 5 μg/g. The highest values were found around El-Ahlia metallic Co. and cement Portland factory. These higher levels are comparable to those of the critical toxicity range (5-10 μg/g) reported by Sauerbeck (1982).

4-2-3-5-Nickel:

Nickel concentrations in plants grown on soils around the chemical factories ranged from 6.0-8.2 μg/g dry matter and were comparable to the higher limit of the normal Ni content (5 μg/g). These concentrations are still beyond the toxic level of 30 μg/g.

4-2-3-6-Cobalt:

No hazards are expected from the Co in plants grown around the chemical plants, since their contents did not reach that of the toxic level reported by Sauerbeck (1982).

Table (22): Concentrations of heavy metals in plants grown on soils around chemical plants and smelters.

Prof. No	Cultivated crops	Location	Concentrations of heavy metals (µg/g).					
			Cu	Zn	Pb	Cd	Ni	Co
6	Peanut	Abu-Zaabal	15.0	33.0	6.0	4.7	7.2	6.2
7	Grasses	~ ~	14.4	34.2	5.5	3.7	7.0	6.7
8	Orange	Abu-Zabal	14.4	17.4	7.7	4.5	6.0	6.7
9	~ ~	~ ~	14.6	14.2	7.0	4.5	6.4	5.5
10	Orange	Abu-Zaabal	15.2	22.0	8.0	4.2	6.2	6.0
11	Peas	~ ~	8.5	25.0	6.5	5.0	7.0	3.2
12	Peas	Smelters	16.0	18.2	6.7	4.2	7.7	6.4
13	~ ~	~ ~	15.8	19.1	7.0	4.2	6.2	5.6
14	Corn	Cement	12.0	40.2	9.2	4.5	8.2	6.2
15	Peanut	Portland	8.4	41.5	8.0	4.7	8.0	6.2

4.3. Effect of motor vehicle exhausts on the status of heavy metals in the studied soils and plants:

4.3.1. Status of heavy metals in soils adjacent to the agricultural highway:

4.3.1.1. Copper (Cu):

Table (23) and Fig (10):

4.3.1.1.1. Total copper:

Total Cu content of soils bordering the heavy traffic highway (profiles 16-21) ranged between 40.25 and 70.00 mg/kg. In general, the total Cu distribution with soil depth or distance from the road showed no obvious pattern.

The maximum tolerable level of Cu (100 mg/kg) was not exceeded in soils adjacent to the highway.

4.3.1.1.2. DTPA-extractable copper:

DTPA-extractable Cu ranged from 0.28 to 15.40 mg/kg which represents 7.02 - 23.87 percent of total Cu. The distribution with either distance from the source or soil depth showed no clear pattern.

4.3.1.1.3. Copper fractions:

.The **Cu-CA** fraction constituted the least amount of Cu in these soils. It ranged from 0.01 to 0.31 mg/kg which represents 0.02 - 0.06 percent of total Cu in soil.

The **Cu- PYR** fraction constituted relatively high portion and ranged between 10.85 and 15.89 mg/kg representing 15.67 - 30.06 percent of total Cu in soil.

Table (23): Total, DTPA and copper fractions (mg/kg) in soils adjacent to the highway.

Prof no	Depth cm	Total	DTPA	Copper fractions.						
				Cu-CA	Cu-AC	Cu-PYR	Cu-HAH	Cu-OX	Cu-OXA	Cu-RES
16	00-05	40.25	5.46	0.27	1.11	12.10	2.00	3.60	07.96	13.21
	05-10	50.25	7.54	0.23	1.03	12.22	2.20	3.82	09.88	20.87
	10-25	55.50	5.98	0.11	1.24	11.98	2.98	3.93	10.10	25.29
	25-60	59.25	4.96	0.18	1.22	11.77	2.78	3.91	11.10	28.29
	60-100	59.00	4.14	0.06	1.00	10.00	2.68	4.10	11.00	30.16
17	00-05	46.00	5.00	0.19	1.21	13.20	2.22	4.50	08.95	15.73
	05-10	57.00	5.34	0.17	1.08	12.51	2.94	4.91	09.22	26.17
	10-25	54.00	6.92	0.11	1.20	12.22	2.21	4.41	09.81	24.04
	25-60	48.00	5.38	0.08	1.00	10.85	2.00	4.62	05.05	24.40
	60-100	70.00	8.38	0.07	1.40	10.97	3.00	5.01	12.01	37.54
18	00-05	64.50	15.4	0.31	1.28	15.82	3.10	5.21	10.98	27.80
	05-10	59.00	4.82	0.22	1.21	15.11	2.92	4.21	11.00	24.33
	10-25	61.00	5.90	0.12	1.00	13.21	3.00	5.40	12.01	26.26
	25-60	65.00	5.26	0.09	0.98	14.22	3.00	6.01	10.95	29.75
	60-100	66.00	4.68	0.06	1.10	12.00	2.98	6.01	13.55	30.30
19	00-05	63.50	6.66	0.26	1.63	15.89	2.10	5.42	12.01	26.19
	05-10	63.50	6.84	0.20	1.52	15.21	3.50	5.30	12.22	25.55
	10-25	63.50	7.30	0.18	1.24	14.92	3.30	5.25	13.00	25.61
	25-60	63.00	7.62	0.09	1.09	13.21	2.95	5.00	10.50	30.16
	60-100	63.00	4.98	0.03	1.00	12.00	3.01	5.40	10.50	31.06
20	00-05	62.00	5.28	0.22	1.62	15.22	3.10	6.01	12.09	23.74
	05-10	63.00	5.50	0.20	1.62	14.38	3.20	6.00	11.54	26.06
	10-25	66.00	6.86	0.18	1.59	16.10	3.40	5.96	13.00	25.77
	25-60	61.50	5.42	0.10	1.19	15.60	3.08	5.84	12.00	23.69
	60-100	62.50	5.98	0.09	1.10	12.33	3.09	6.00	12.37	27.52
21	00-05	58.00	5.36	0.16	1.24	14.62	3.23	5.96	11.00	21.79
	05-10	62.50	7.00	0.12	1.18	13.88	3.38	6.21	11.32	26.41
	10-25	63.50	7.47	0.10	1.18	12.21	3.53	5.11	13.00	28.37
	25-60	63.50	6.64	0.09	1.15	13.50	3.82	5.21	12.90	28.83
	60-100	64.00	5.38	0.01	1.00	13.00	4.77	6.18	12.11	26.93

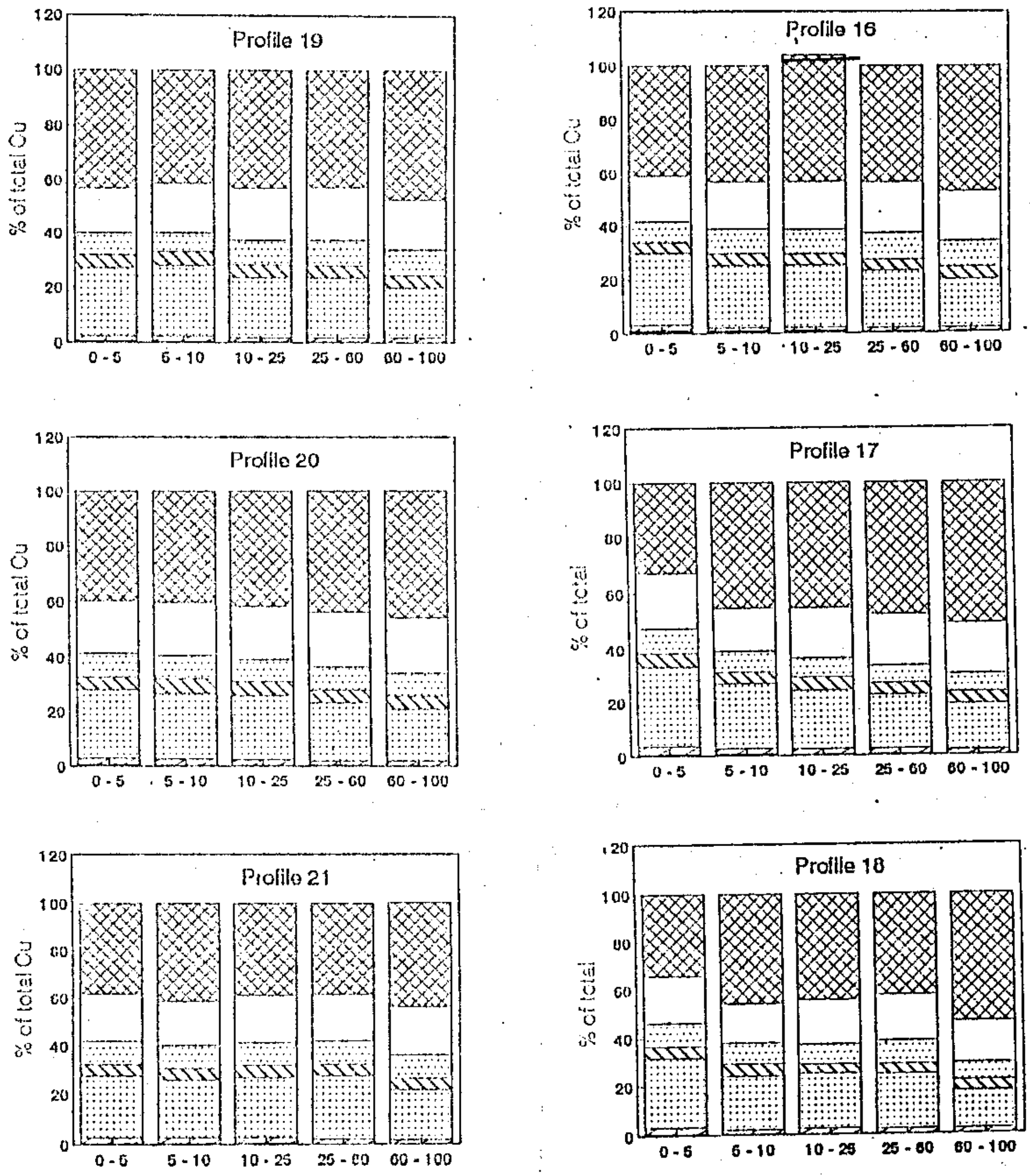


Fig. (10): Copper fractions as the percentage of total in soils adjacent to the highway.

The **Cu-HAH** fraction was ranged from 2.00 to 4.77 mg/kg which represents 4.38 - 5.89 percent of total Cu in soil. The **Cu-OX** fraction ranged from 3.60 to 6.21 mg/kg which comprised 6.59 - 9.94 percent of total Cu in soil.

The **Cu-OXA** fraction constituted high portion varied from 5.05 to 13.55 mg/kg which constituted 15.68 - 19.84 percent of total Cu in soil.

The **Cu-RES** fraction constituted the highest portion of Cu in these soils, ranged from 13.21 to 37.54 mg/kg comprising 32.83 - 53.64 percent of total in the soil.

4.3.1.2. Zinc (Zn):

Table (24) and Fig (11) :

4.3.1.2.1. Total Zinc:

Total Zn content of soil adjacent to the heavy traffic highway (profiles 16 - 21) varies between 135 and 204 mg/kg soil. The total Zn distribution with soil depth showed no obvious pattern except in profile (20) which decreased with soil depth.

The relatively high total Zn content in soil adjacent to the highway was observed in most of studied soil profiles. There was an increase in total Zn with decreasing the distance from the highway (source of pollution), except in profile (18) which located at 150 m from the eastside of the road. Increasing the total Zn content in that profile is reflecting the influence of the prevailing northwestern wind which below nearly all the year.

Generally, the high recorded values of Zn in the soils may be attributed mainly to the abrasion of tires rubber and the combustion of fuel (Lagerwerff and Spechat, 1970).

The comparison between the content of Zn in soils adjacent to the highway with the maximum tolerable level revealed that Zn content in these soils did not exceed the maximum tolerable level (300 mg/kg) reported by El-Bassam and Tietjen (1977).

4.3.1.2.2. <u>DTPA-extractable zinc:</u>

DTPA-extractable Zn in the soils around the agricultural highway ranged from 1.00 to 5.00 mg/kg represents 0.43 - 2.45 percent of the total Zn in soil. The available Zn distribution with depth has no regular trend. DTPA-extractable Zn increased with increasing the distance up to 150 m from the road in the east side but it decreased with the distance in the other side reflecting the effect of wind below.

<u>4.3.1.2.3. Zinc fractions:</u>

The **Zn-CA** fraction constituted the least amount of Zn in these soils. It ranged from 0.13 to 0.57 representing 0.09 - 0.28 percent of total Zn in soil.

The **Zn-AC** fraction was slightly higher than **Zn-CA** fraction and ranged from 2.88 to 6.58 mg/kg which comprised 2.12 - 3.24 percent of total Zn in soil.

Table(24): Total, DTPA and zinc fractions (mg/kg) in soils adjacent to the highway.

Prof. no	Depth cm	Total	DTPA	Zinc fractions.						
				Zn-CA	Zn-Ac	Zn-PYR	Zn-HAH	Zn-OX	Zn-OXA	Zn
16	00-05	178.9	1.60	0.36	5.12	46.13	5.12	8.87	36.24	7
	05-10	171.4	1.40	0.31	4.75	42.26	3.86	8.36	54.07	7
	10-25	186.8	1.44	0.32	4.0	43.14	5.86	9.34	37.29	8
	25-60	193.1	1.18	0.29	4.09	40.94	5.74	10.1	37.95	9
	60-100	189.0	1.16	0.19	3.78	39.69	5.44	9.11	34.32	9
17	00-05	165.0	2.00	0.36	4.95	42.24	5.02	8.02	34.85	6
	05-10	187.1	1.60	0.39	5.99	44.53	6.01	8.96	38.62	8
	10-25	154.1	1.70	0.28	4.61	34.55	4.59	6.15	33.40	7
	25-60	177.8	1.28	0.16	4.86	35.55	4.76	7.43	35.53	8
	60-100	192.4	2.00	0.13	5.39	37.19	5.29	8.25	34.57	1
18	00-05	204.0	5.00	0.49	6.30	50.18	6.34	9.30	44.31	8
	05-10	203.0	1.00	0.57	6.58	47.44	6.68	8.67	42.81	9
	10-25	171.5	1.94	0.21	4.73	36.41	4.92	8.59	31.19	8
	25-60	180.5	1.24	0.18	5.36	35.96	5.27	8.97	32.38	9
	60-100	180.5	1.30	0.16	3.93	32.74	4.53	8.77	32.78	9
19	00-05	182.0	2.80	0.47	5.90	47.34	6.01	7.97	41.13	7
	05-10	182.5	4.20	0.40	5.68	46.39	6.04	9.09	39.24	7
	10-25	173.0	2.00	0.36	5.12	39.80	5.14	7.89	34.43	8
	25-60	186.5	2.00	0.32	5.60	36.80	5.54	9.72	35.17	9
	60-100	162.0	1.12	0.19	4.15	30.78	4.86	8.10	30.60	8
20	00-05	164.0	1.82	0.39	4.99	42.33	5.51	8.22	34.44	6
	05-10	141.5	1.72	0.28	4.13	33.97	4.40	7.37	31.14	6
	10-25	138.0	1.60	0.21	3.74	27.86	4.14	6.80	27.49	6
	25-60	137.5	1.16	0.18	3.59	27.38	3.84	6.59	26.52	6
	60-100	134.5	1.16	0.15	2.88	24.25	2.91	5.73	25.55	7
21	00-05	141.5	1.72	0.30	4.25	34.12	4.25	7.80	28.58	6
	05-10	130.5	1.60	0.25	3.63	30.32	3.73	6.41	27.59	5
	10-25	159.0	1.80	0.24	4.80	33.06	4.80	7.73	31.64	7
	25-60	134.5	1.44	0.27	3.17	27.95	3.43	6.70	25.22	6
	60-100	146.6	1.00	0.20	3.34	29.20	4.40	6.13	26.39	7

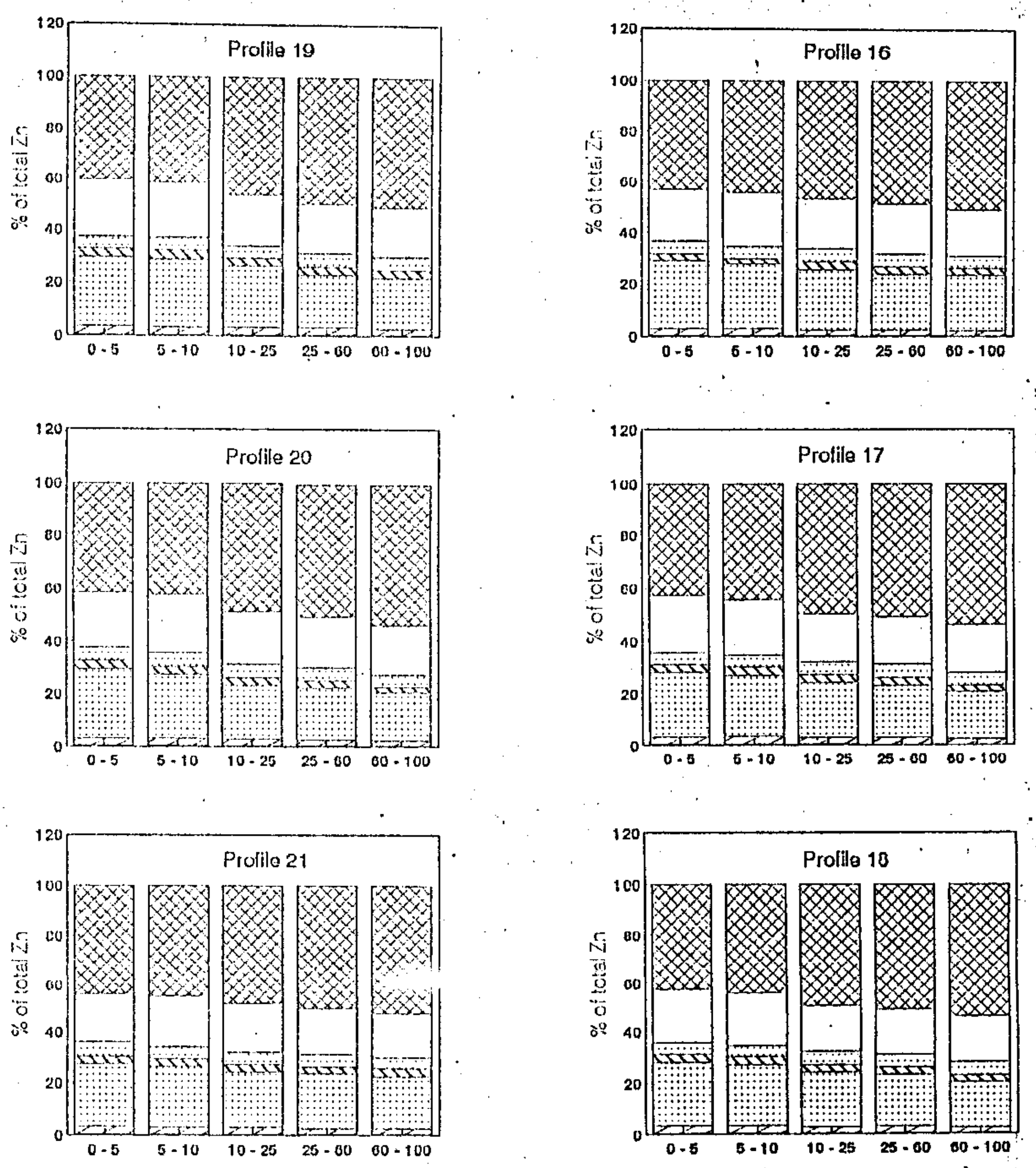
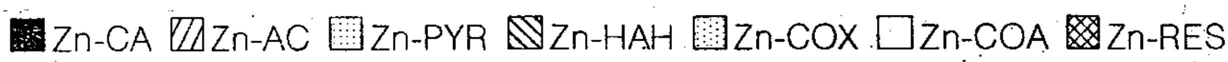


Fig. (11): Zinc fractions as the percentage of total in soils adjacent to the highway.



The **Zn-PYR** fraction constituted relatively high portion ranged between 24.25 to 50.18 mg/kg which corresponded to about 18.03 - 26.01 percent of total Zn in soils.

The **Zn-HAH** fraction ranged from 2.91 to 6.68 mg/kg which represents 2.25 - 3.36 percent of total Zn in soil. The **Zn-OX** fraction ranged from 5.73 to 10.1 mg/kg which corresponded about 3.99 - 5.51 percent of total Zn in soil.

The **Zn-OXA** constituted high portion of Zn varying from 25.22 to 54.07 mg/kg which comprised 17.94 - 22.60 percent of total Zn in soil.

The **Zn-RES** fraction constituted the highest portion of Zn in these soils. It ranged from 58.58 - 101.55 mg/kg which represents 41.46 - 53.70 percent of total Zn in soil.

The total Zn increased with decreasing the distance from the highway especially on the east side of the road and the distribution with soil depth was not clear in most studied profiles. However, DTPA-extractable Zn increased with increasing the distance from the east side, but it decreased with the distance on the other side and the distribution with depth has no regular trend

4.3.1.3. <u>Lead (Pb):</u>

Table (25) and Fig (12):

4.3.1.3.1. <u>Total lead:</u>

Total content of Pb in soil bordering the heavy traffic highway (profiles 16-21) varied between 13.00 and 45.50 mg/kg. Total Pb was decreased with the distance from the highway, as well as with soil depth in all the studied profiles. The highest content of total Pb in the surface layers may be explained as lead is an immobile metal in soils and accumulates at or near the surface (Garcia-Miragaya, 1980). These results are in agreement with those reported by El-Leithi (1986) and El-Sokkary and Meshref (1984).

Data in Table (25) indicated that the total content of Pb in soils adjacent to the highway still within the permissible level and did not exceed that of the threshold value of Pb (100 mg/kg) reported by El-Bassam and Tietjen (1977).

4.3.1.3.2. DTPA-extractable lead:

Concerning the DTPA-extractable Pb, the results followed almost similar trend to that found with total lead. DTPA-extractable Pb ranged from 0.22 to 6.02 mg/kg which comprised 1.33 - 14.52 percent of total Pb in soil and decreased with increasing the distance from the road and DTPA-extractable Pb decreased with increasing the soil depth. These results are in agreement with those reported by Agrawal et al., (1980), El-Leithi (1986) and El-Molla (1980).

4.3.1.3.3. Lead fractions:

The **Pb-CA** fraction constituted the lowest amount of Pb in the soils ranged from 0.05 to 0.3 mg/kg representing about 0.45 percent of total Pb in soil.

The **Pb-AC, Pb-PYR** fractions represent the relatively high amount of Pb in the soil ranged from 2.3 to 8.6 and 3.5 to 13.1 mg/kg, respectively. representing 18 and 27.5 percent of total Pb in soil, respectively.

Table (25): Total, DTPA and Lead fractions (mglkg) in soils adjacent to the highway.

Prof no	Depth cm	Total	DTPA	Lead fractions.						
				Pb-CA	Pb-Ac	Pb-PYR	Pb-HAH	Pb-OX	Pb-OXA	Pb-RES
	00-05	40.0	1.74	0.21	7.53	12.04	0.13	0.21	0.90	18.98
	05-10	39.5	1.14	0.20	7.47	11.09	0.13	0.20	0.84	19.57
16	10-25	33.5	0.88	0.16	6.37	09.42	0.12	0.16	0.73	16.54
	25-60	32.5	0.44	0.12	5.53	08.67	0.09	0.16	0.64	17.29
	60-100	13.0	0.36	0.05	2.25	03.47	0.04	0.07	0.26	06.86
	00-05	42.5	0.98	0.21	7.74	12.88	0.14	0.22	0.91	20.39
	05-10	28.0	0.78	0.20	6.84	11.46	0.13	0.20	0.76	18.41
17	10-25	33.5	0.72	0.16	5.70	09.78	0.10	0.17	0.66	16.92
	25-60	28.0	0.46	0.10	5.02	07.77	0.07	0.13	0.44	14.46
	60-100	25.0	0.42	0.10	4.08	06.27	0.06	0.12	0.43	13.94
	00-05	24.5	0.82	0.12	4.41	07.39	0.08	0.12	0.49	11.88
	05-10	23.5	0.52	0.10	4.23	06.87	0.07	0.12	0.42	11.68
18	10-25	23.0	0.44	0.09	3.96	06.75	0.05	0.12	0.44	11.58
	25-60	20.0	0.40	0.08	3.40	05.62	0.05	0.09	0.27	10.49
	60-100	16.5	0.22	0.06	2.65	04.48	0.04	0.08	0.30	08.88
	00-05	45.5	6.02	0.25	8.56	13.13	0.16	0.27	0.96	22.17
	05-10	41.3	6.0	0.21	7.85	12.46	0.13	0.23	0.89	19.95
19	10-25	37.5	4.12	0.17	6.72	11.25	0.11	0.21	0.82	18.22
	25-60	23.0	2.90	0.10	3.92	06.44	0.06	0.12	0.41	11.95
	60-100	22.0	0.78	0.09	3.74	05.50	0.05	0.12	0.39	12.11
	00-05	41.6	2.96	0.18	7.58	12.53	0.13	0.22	0.82	20.14
	05-10	39.0	2.74	0.19	7.02	12.16	0.12	0.21	0.72	18.59
20	10-25	35.0	1.84	0.14	6.20	09.89	0.10	0.18	0.70	17.78
	25-60	28.0	0.80	0.11	4.82	07.31	0.08	0.14	0.44	15.10
	60-100	24.0	0.54	0.09	3.90	06.10	0.07	0.11	0.43	13.30
	00-05	36.0	1.60	0.16	6.77	10.77	0.11	0.18	0.72	17.28
	05-10	31.0	1.58	0.15	5.65	09.02	0.09	0.16	0.48	15.45
21	10-25	31.0	1.56	0.13	5.30	08.75	0.10	0.16	0.60	15.97
	25-60	28.0	1.48	0.11	4.83	07.60	0.07	0.14	0.50	14.76
	60-100	24.0	0.62	0.09	4.14	06.56	0.06	0.12	0.44	12.59

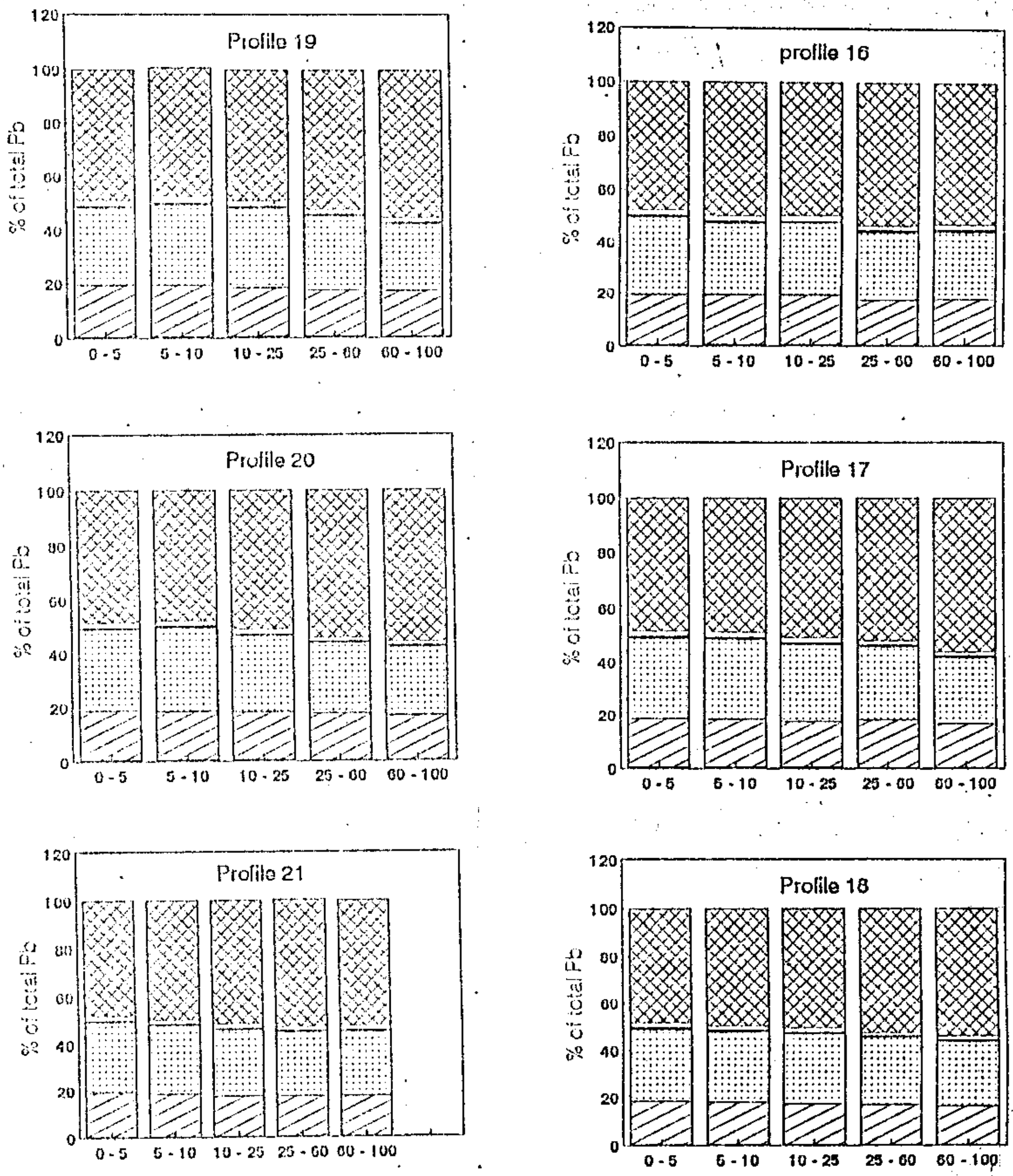


Fig. (12): Lead fractions as the percentage of total in soils adjacent to the highway.

Pb-CA Pb-AC Pb-PYR Pb-HAH Pb-COX Pb-COA Pb-RES

The **Pb-HAH, Pb-OX,** and **Pb-OXA** fractions constituted the least amount of Pb ranged from 0.04 to 0.2, 0.07 to 0.3, and 0.3 to 1 mg/kg soil comprising 0.2 - 0.4, 0.4 - 0.6 and 1.4 - 2.2 percent of the total Pb in the soils.

The **Pb-RES** represents the highest portion of Pb ranged from 6.9 to 22.2 mg/kg constituting 47.4 - 55.8 percent of the total Pb in soils.

4.3.1.4. Cadmium (Cd):

Table (26) and Fig. (13):

4.3.1.4.1. Total cadmium:

Data show that the total Cd content varied between 8.5 and 11.7 mg/kg soil, the highest values were found in the surface layer (0-5 cm) of profile 16) which located at 5 m east of the road. The mean values of total Cd were almost similar near and far from the highway. With respect to the distribution of Cd with soil depth, the total Cd decreased with depth, and these results supported the other findings of (Kuo *et al.*, 1983) in which Cd is more leachable and mobile in soil.

In general, the record values of total Cd in the studied Egyptian soils are relatively higher than those found by Davies and Robert (1973) in Danish uncontaminated agricultural soils (2.4 mg/kg) and also higher than those of upper Austria soils, 0.07 - 2.4 mg/kg (Aichberger et al., 1982). Comparing these results with those previously reported by El-Sokkary and Lag (1982) for uncontaminated Egyptian soils indicated that the soils under consideration were highly polluted, since the reported average values were 0.2 mg/kg as total (El-Sokkary, 1978). However, El-Sokkary, (1980), El-Sokkary and

Mesherf (1984) showed considerable contamination in some Egyptian soils at Alexandria by Cd where it varied from 0.28 to 2.0 mg/kg. The degree of contamination could be attributed to traffic densities. Pollution with Cd metal along roadside was mainly due to abrasion of tires rubber. Some factors may be influence the Cd accumulation in the soils. These factors include : length of exposure time, average daily traffic, direction of prevailing wind, and type of driving (Lagerwerff and Specht, 1970).

The value of 5 mg/kg soil considered to be the threshold value by El-Bassam and Tietjen (1977) had been exceeded in soils adjacent to the highway.

4.3.1.4.2. DTPA-extractable cadmium:

DTPA-extractable Cd in soils around the highway ranged from 0.03 to 0.1 mg/kg represents 0.4 - 0.9 percent of total Cd in soil, it was gently decreased with the distance from the roadside and with the soil profile depth.

4.3.1.4.3. Cadmium fractions:

The **Cd-CA** fraction constituted relatively high portion of total soil Cd, and ranged from 1.6 to 2.7 mg/kg which corresponded to 18.8 - 23.6 percent of total Cd in soil. Concerning the distribution of Cd-CA with distance, a gently decrease with increasing distance from the highway and with soil profile depth was found.

The **Cd-AC** constituted low amount ranged from 0.3 to 0.6 mg/kg representing 2.2 - 5.7 percent of total Cd in soil.

Table (26): Total, DTPA and Cd fractions (mglkg) in soils adjacent to the highway.

Prof	Depth	Total	DTPA		Cadmium Fractions.					
no	cm			Cd-CA	Cd-Ac	Cd-PYR	Cd-HAH	Cd-OX	Cd-OXA	Cd-RES
	00-05	11.7	0.10	2.7	0.6	2.2	0.2	0.5	0.7	4.8
	05-10	10.5	0.07	2.4	0.6	1.8	0.1	0.4	0.6	4.6
16	10-25	10.5	0.06	2.3	0.5	1.8	0.1	0.4	0.6	5.1
	25-60	10.0	0.06	2.2	0.4	1.6	0.1	0.4	0.5	4.8
	60-100	08.5	0.05	1.7	0.3	1.3	0.1	0.4	0.5	4.2
	00-05	11.2	0.08	2.6	0.5	2.1	0.2	0.5	0.7	4.6
	05-10	11.0	0.07	2.4	0.5	2.0	0.1	0.5	0.7	4.8
17	10-25	10.0	0.06	2.0	004	1.7	0.1	0.5	0.7	4.6
	25-60	09.5	0.06	1.9	0.4	1.6	0.1	0.4	0.6	4.5
	60-100	09.0	0.05	1.8	0.2	1.5	0.1	0.4	0.6	4.4
	00-05	10.5	0.07	2.3	0.5	1.9	0.1	0.9	0.7	4.5
	05-10	10.5	0.06	2.2	0.4	1.8	0.1	0.4	0.6	5.0
18	10-25	10.0	0.06	2.0	0.4	1.7	0.1	0.5	0.7	4.6
	25-60	09.0	0.06	1.8	0.2	1.4	0.1	0.3	0.6	4.6
	60-100	09.0	0.04	1.7	0.2	1.4	0.1	0.4	0.6	4.7
	00-05	11.0	0.07	2.6	0.6	2.0	0.2	0.5	0.7	4.4
	05-10	10.5	0.06	2.4	0.5	1.9	0.2	0.3	0.6	4.6
19	10-25	10.0	0.06	2.0	0.4	1.7	0.2	0.4	0.6	4.7
	25-60	09.0	0.06	1.8	0.3	1.5	0.1	0.4	0.5	4.4
	60-100	09.0	0.03	1.7	0.2	1.5	0.1	0.4	0.5	4.6
					0.4					
	00-05	10.5	0.06	2.3	0.5	1.9	0.2	0.4	0.7	4.5
	05-10	10.5	0.05	2.2	0.4	1.9	0.1	0.3	0.6	5.0
20	10-25	09.5	0.05	1.9	0.4	1.6	0.1	0.5	0.6	4.4
	25-60	09.0	0.05	1.8	0.3	1.5	0.1	0.5	0.6	4.2
	60-100	09.0	0.04	1.7	0.2	1.4	0.1	0.4	0.6	4.6
	00-05	10.0	0.06	2.1	0.5	1.8	0.2	0.5	0.7	4.2
	05-10	09.5	0.04	1.9	0.3	1.6	0.1	0.4	0.7	4.5
21	10-25	09.0	0.04	1.8	0.3	1.5	0.1	0.4	0.6	4.3
	25-60	09.0	0.04	1.7	0.2	1.5	0.1	0.4	0.6	4.5
	60-100	08.5	0.04	1.6	0.2	1.4	0.1	0.4	0.5	4.3

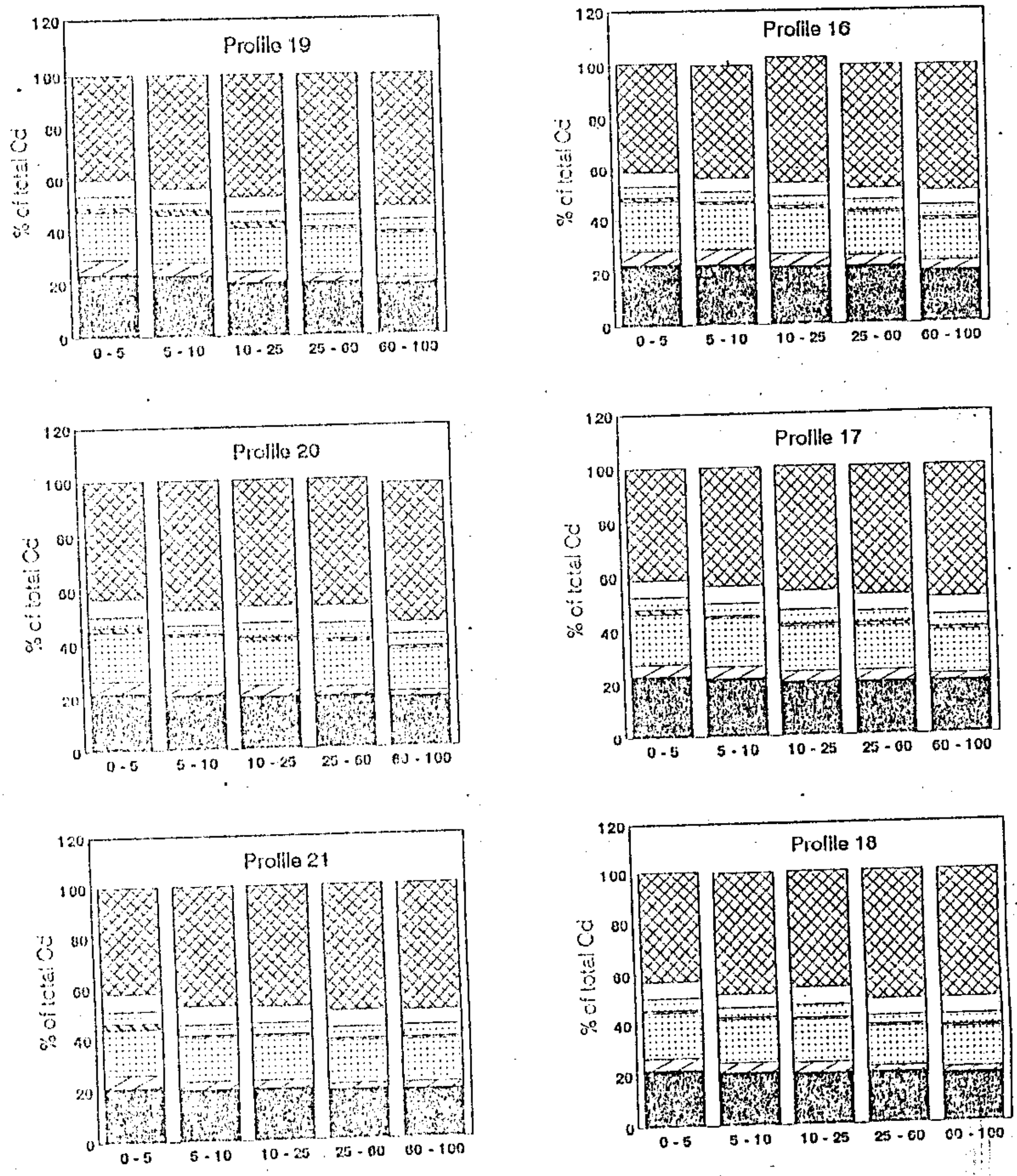
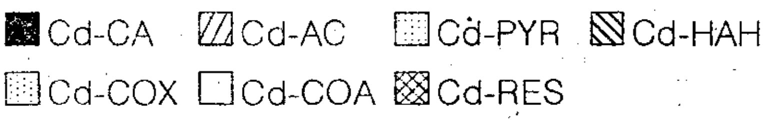


Fig. (13): Cadmium fractions as the percentage of total in soils adjacent to the highway.



The **Cd-PYR** fraction constituted relatively high portion of the total soil Cd and ranged between 1.3 to 2.2 mg/kg and corresponded about 17 percent of total Cd in soil.

The **Cd-HAH, Cd-OX, Cd-OXA** fractions were found in low amounts ranged from 0.1 - 0.2, 0.3 - 0.9 and 0.5 - 0.7 mg/kg respectively, which represent 1-2, 2.9-5.6, and 5-7 percent of total Cd in soil, respectively.

The **Cd-RES** fraction constituted high portion of Cd in the soils, it ranged from 4.2 - 5.0 mg/kg which comprised 42.0 - 51.1 percent of total Cd in the soils.

4.3.1.5. Nickel (Ni):

Table (27) and Fig. (14):

4.3..5.1. Total Nickel:

The results show that the total Ni content in the soils around the highway (profiles 16-21) ranged from 43 to 162 mg/kg soil. Nickel content was decreased with increasing the soil depth. Total Ni was decreased with increasing the distance from the roadsides. These results are in agreement with those of El-Leithi (1986).

El-Sokkary (1978) reported that the average content of total Ni in uncontaminated Egyptian soils was 30.5 mg/kg soil, and he considered the soils around roads which contained 56 mg Ni/kg soil as contaminated soils. Accordingly the soils under investigation are relatively highly contaminated. The source of Ni accumulation in these soils is mainly the fuel exhaust, since

Ni may be added as additive in traces for gasoline improvement (Hilal *et al.* 1984).

The threshold value of 100 mg Ni/kg soil reported by El-Bassam and Tietjen (1977) had been exceeded in profiles 16 and 17 located on the east side of the road as well as in profiles 19 and 20 located on the west side of the road.

4.3.1.5.2. <u>DTPA-extractable Nickel:</u>

The DTPA-extractable Ni in the soils varied from 0.4 to 1.0 mg/kg soi. It decreased with increasing both of soil profile depth and the distance from the roadside.

4.3.1.5.3. <u>Nickel fractions:</u>

Data show that the **Ni-HAH** fraction was undetectable.

The **Ni-CA** and **Ni-OX** fractions constituted the low amount of Ni in the soil ranged from 1.7 to 7.6 and from 1.9 to 8.4 mg/kg soil.

The **Ni-PYR** fraction ranged from 2.8 to 12.8 mg/kg soil.

The **Ni-AC** and **Ni-OXA** fractions constituted relatively high portion of total Ni in soil ranged from 6.1 to 24.9 and from 4.3 to 17.8 mg/kg soil, respectively.

The **Ni-RES** fraction constituted high portion of total Ni in the soil ranged from 26.1 to 90.5 mg/kg soil.

Table (27) Total ,DTPA and nickel fractions (mg/kg) in soils adjacent to the highway .

Prof. No	Depth cm	Total	DTPA	Nickle fractions. Ni-CA	Ni-AC	Ni-PYR	Ni-HAH	Ni-OX	Ni-OXA	Ni-RES
16	00-05	162.0	1.0	7.6	24.9	12.8	T	8.4	17.8	90.5
	05-10	153.5	0.8	6.6	21.9	11.7	T	7.2	16.4	89.7
	10-25	137.0	0.6	5.2	19.2	10.0	T	6.7	14.2	81.7
	25-60	125.5	0.6	4.5	17.1	08.7	T	5.8	12.8	76.6
	60-100	110.5	0.4	3.6	15.5	07.2	T	5.5	11.0	67.7
17	00-05	142.2	1.0	6.5	21.3	11.1	T	6.5	15.5	81.3
	05-10	134.0	0.8	5.1	19.3	10.0	T	6.8	14.7	57.2
	10-25	128.0	0.6	5.4	18.7	08.8	T	6.4	13.7	75.0
	25-60	098.5	0.6	3.9	13.0	06.7	T	4.7	10.0	58.6
	60-100	065.5	0.4	2.3	08.5	03.9	T	3.1	07.2	40.5
18	00-05	089.0	0.8	4.0	13.2	06.8	T	4.5	9.3	51.2
	05-10	084.0	0.6	3.2	11.9	06.4	T	3.9	8.7	49.9
	10-25	075.0	0.4	2.7	10.4	05.6	T	3.9	7.7	44.7
	25-60	077.5	0.6	3.2	10.4	05.3	T	3.9	7.8	46.9
	60-100	061.5	0.4	2.5	08.6	04.2	T	3.0	6.1	37.1
19	00-05	126.1	1.0	5.8	19.5	09.8	T	6.7	14.1	70.2
	05-10	100.1	1.0	4.7	14.4	07.8	T	5.2	11.1	56.9
	10-25	106.0	1.0	4.1	14.4	07.6	T	5.3	11.3	63.3
	25-60	099.5	0.8	3.8	14.1	06.7	T	4.6	10.5	59.8
	60-100	094.0	0.6	4.0	13.3	06.5	T	4.5	09.5	57.1
20	00-05	119.6	1.0	5.4	17.9	09.2	T	5.6	12.8	68.7
	05-10	105.3	1.2	4.4	15.4	07.9	T	4.8	11.0	61.8
	10-25	090.0	0.8	2.9	12.4	06.2	T	3.9	10.0	54.6
	25-60	102.7	0.6	3.8	14.4	06.8	T	4.6	11.3	61.8
	60-100	042.9	0.6	1.7	06.1	02.8	T	1.9	04.3	26.1
21	00-05	100.1	0.8	4.7	14.9	07.5	T	5.0	10.2	57.8
	05-10	098.2	0.8	4.1	14.4	07.3	T	5.0	11.2	56.2
	10-25	097.5	0.6	4.5	14.6	06.8	T	4.6	10.6	56.4
	25-60	097.0	0.6	3.9	12.6	06.7	T	4.5	09.9	59.4
	60-100	090.0	0.6	3.6	12.1	06.3	T	4.5	09.4	54.1

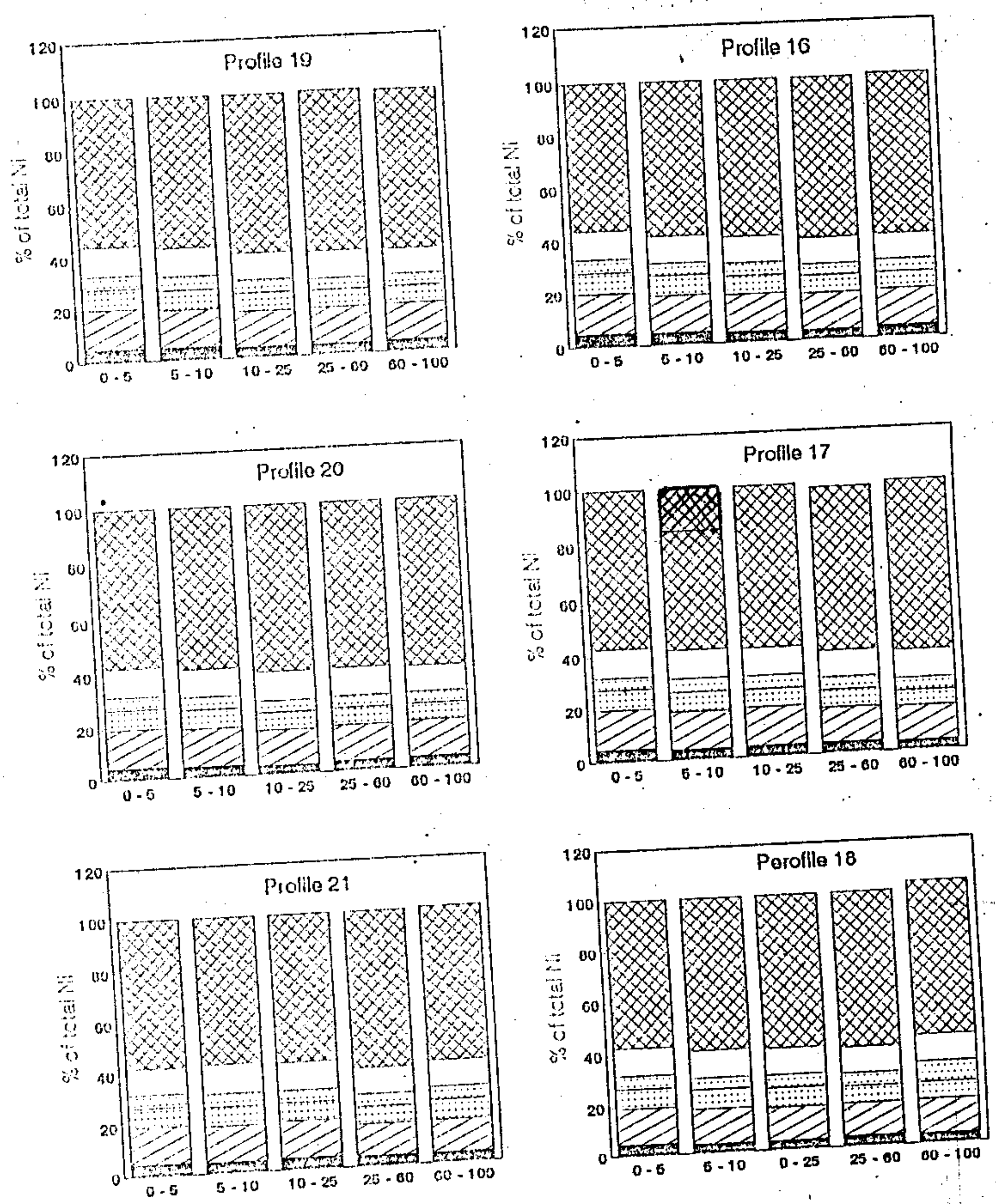


Fig. (14): Nickel fractions as the percentage of total in soils adjacent to the highway.

Ni-CA Ni-CAA Ni-PYR Ni-HAH Ni-COX Ni-COA Ni-RES

4.3.1.6. Cobalt (Co):

Table (28) and Fig (15):

4.3.1.6.1. Total cobalt:

Data indicate that the total Co content ranged from 19 to 39.5 mg/kg soil. The highest values were found in the east side of the road. The average total Co content decreased with increasing distance from the roadside in most studied profiles.

Total Co content in soils adjacent to the highway did not exceed the permissible level of 50 mglkg soil suggested by El-Bassam and Tietjen (1977).

4.3.1.6.2. DTPA- extractable Co:

DTPA-extractable Co ranged from 0.58 to 1.52 mg/kg soil. The irregular pattern of Co distribution with depth may be attributed to the different levels of fertilization and to mixing through soil management. However, traffic did not consider as source for Co pollution Hilal et al., (1984 in arabic) showed that most of fertilizers contain considerable amount of cobalt which serve as the major source of soil contamination.

4.3.1.6.3. Cobalt fractions:

The **Co-CA, Co-OX** and **Co-AC** fractions constituted the least amounts of Co in soil represented 0.6-0.8, 0.7-1.0 and 0.6-1.0 percent of total Co in soil.

The **Co-PYR** fraction constituted relatively high portion of total Co ranged from 3.23 to 9.02 mg/kg soil, representing 17-23 percent of total Co in soil.

Table (28): Total, DTPA and Cobalt fractions (mg/kg) in soils adjacent to the highway.

Prof. No	Depth cm	Total	DTPA	Cobalt fractions.						
				Co-CA	Co-AC	Co-PYR	Co-HAH	Co-OX	Co-OXA	Co-RES
16	0-5	39.2	1.38	0.31	0.39	9.02	T	0.31	1.25	27.92
	5-10	38.0	1.42	0.27	0.38	8.36	T	0.30	1.29	27.40
	10-25	37.5	1.40	0.26	0.30	8.25	T	0.34	1.50	26.85
	25-60	38.0	1.42	0.23	0.30	7.22	T	0.34	1.52	28.39
	60-100	34.0	1.38	0.20	0.27	6.46	T	0.34	1.36	25.37
17	0-5	38.0	1.43	0.30	0.38	8.36	T	0.30	1.56	27.10
	5-10	34.0	1.44	0.27	0.31	7.14	T	0.27	1.33	24.68
	10-25	38.9	1.42	0.27	0.31	7.00	T	0.27	1.48	29.57
	25-60	36.0	1.52	0.22	0.25	6.48	T	0.25	1.33	27.47
	60-100	39.0	1.24	0.23	0.27	6.63	T	0.35	1.56	29.96
18	0-5	34.5	1.06	0.24	0.28	7.24	T	0.24	1.24	25.26
	5-10	34.0	1.12	0.24	0.27	6.80	T	0.27	1.26	25.16
	10-25	33.5	1.14	0.20	0.23	5.70	T	0.27	1.31	25.79
	25-60	32.0	1.14	0.19	0.22	5.12	T	0.22	1.28	25.20
	60-100	30.0	1.04	0.18	0.21	5.10	T	0.24	1.23	23.04
19	0-5	37.9	1.06	0.30	0.38	8.34	T	0.38	1.48	27.04
	5-10	34.8	1.12	0.28	0.35	7.66	T	0.31	1.39	24.81
	10-25	38.4	1.14	0.27	0.35	7.68	T	0.31	1.42	28.37
	25-60	34.2	1.14	0.24	0.27	6.50	T	0.31	1.26	25.62
	60-100	32.0	1.04	0.19	0.26	5.76	T	0.26	1.22	24.31
20	0-5	33.0	1.22	0.26	0.30	6.93	T	0.30	1.32	23.89
	5-10	28.8	0.94	0.20	0.26	5.76	T	0.26	1.15	21.17
	10-25	30.6	0.64	0.21	0.24	5.20	T	0.24	1.16	23.55
	25-60	30.0	0.60	0.18	0.21	5.40	T	0.21	1.05	22.95
	60-100	29.0	0.58	0.17	0.17	4.93	T	0.17	1.07	22.49
21	0-5	31.0	0.80	0.22	0.25	6..20	T	0.28	1.21	22.84
	5-10	25.2	0.70	0.18	0.18	5.04	T	0.20	0.86	18.74
	10-25	27.0	0.70	0.16	0.19	4.86	T	0.19	1.08	20.52
	25-60	21.0	0.72	0.13	0.13	3.57	T	0.13	0.82	16.22
	60-100	19.0	0.70	0.11	0.11	3.23	T	0.11	0.72	14.72

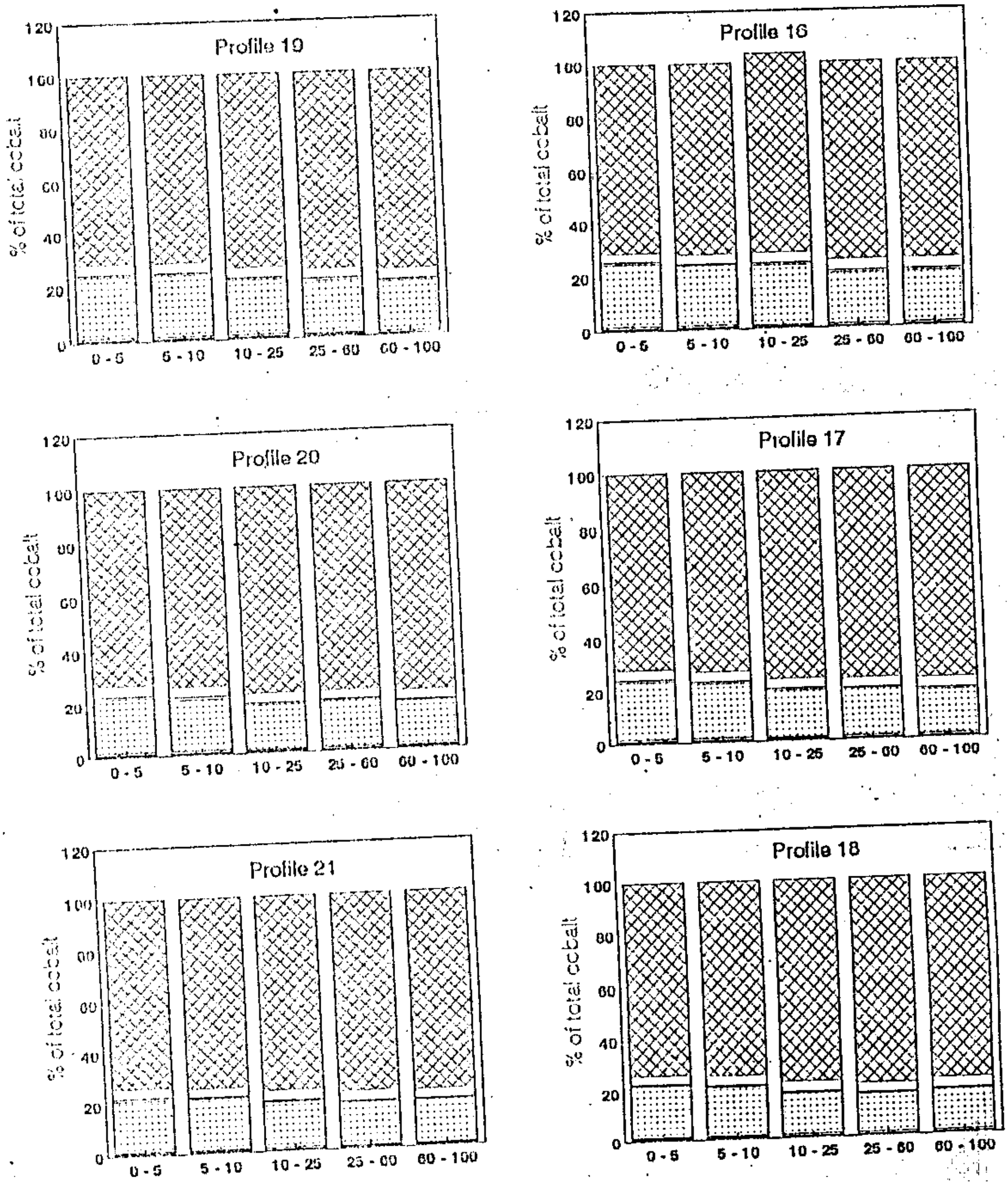


Fig. (15): Cobalt fractions as the percentage of total in soils adjacent to the highway.

Co-CA Co-CAA Co-PYR Co-HAH
Co-COX Co-COA Co-RES

The **Co-RES** constituted high portion of total Co in soil varying from 14.72 to 29.57 mg/kg soil representing 71.2-78 percent of total Co in the soil.

4-3-2-Heavy metal fractions v. s. soil properties: (Table, 29):

4-3-2-1-Copper:

The nonspecifically adsorbed, specifically adsorbed Cu and the organically bound Cu fractions in soils adjacent to the highway were correlated positively and significantly with soil organic matter content indicating that nonspecific and specific adsorption of Cu were bound mainly on the surfaces of soil organic molecules. However, negative relationships were excited between soil organic matter and both of total and DTPA-extractable Cu. Values of soluble Cu included in non-specific adsorbed Cu were decreased with increasing soil pH as indicated through the negative relationship between them.

4-3-2-2-Zinc:

The DTPA-extactable Zn as well as the nonspecifically adsorbed Zn correlated positively and significantly with soil organic matter. Increasing the availability of soil Zn may be due to the role of organic matter in chelting Zn. Soil organic matter is known to be capable of binding Zn in stable forms. However, stability constants of Zn-organic matter in soils are relatively low. The solubility of Zn was decreased with increasing soil pH as indicated from negative relationship.

4-3-2-3-Lead:

The total Pb and all Pb fractions were correlated positively and significantly with soil organic matter. The avalbility of Pb was increased with increasing the content of organic matter. Lead fractions were affected negatively, but not significantly with soil pH.

4-3-2-4-Cadmium:

Positive and significant relationships were found between soil organic matter and most of Cd fractions. The DTPA-extractable Cd was not affected by the occurring of soil organic matter, this trend was indicated through the poor relationship between them. Soil Cd was affected negatively and significantly by soil pH.

4-3-2-5-Nickle:

The results show that soil Ni was correlated positively and significantly with soil organic matter. The highest correlation was fond between soil organic matter and DTPA-extractable fraction.

4-3-2-6-Cobalt:

The behavior of Co was somewhat similar to that of Cd, a poor relationship between DTPA-extractable Co and soil organic matter was found. Also, soil Co was affected negatively and significantly by the soil reaction (pH).

Table (29): Correlation coefficients (r) between the chemical fractions of heavy metals and some parameters of soils adjacent to the highway.

Soil parameter	Total	DTPA-extractable	Non specific adsorbeded (CA)	Specific adsorbed (AC)	Organically bound (PYR)	Mn oxide bound (HAH)	Al and Fe oxide bound (OX)	Crystalline Fe and Al Oxide bound (OXA)	Residual (RES)
Cu									
O.M	-0.212	0.171	0.681***	0.502**	0.514**	-0.114	0.043	-0.04	-0.517**
CaCO3	-0.15	0.098	0.336	0.354	0.174	-0.2	-0.084	-0.235	-0.179
pH	0.363	-0.106	-0.435*	-0.073	0.098	0.448*	0.348	0.398*	0.239
CEC	0.157	0.073	0.257	0.368	0.456*	-0.014	0.268	0.093	-0.096
Zn									
O.M	-0.121	0.468*	0.61***	0.36	0.017	0.179	-0.055	0.201	-0.601***
CaCO3	0.055	0.217	0.324	0.248	-0.072	0.218	-0.148	0.191	-0.206
pH	-0.408*	-0.221	-0.216	-0.417*	-0.406*	-0.404*	-0.405*	-0.357	-0.152
CEC	0.074	0.219	0.224	0.291	-0.099	0.254	0.06	0.184	-0.152
Pb									
O.M	0.725***	0.62***	0.785***	0.762***	0.783***	0.757***	0.766***	0.718***	0.679***
CaCO3	0.257	0.196	0.248	0.261	0.292	0.232	0.24	0.158	0.21
pH	-0.189	0.093	-0.298	-0.33	-0.301	-0.282	-0.198	-0.246	-0.174
CEC	0.244	0.388*	0.274	0.227	0.275	0.274	0.285	0.194	0.21
Cd									
O.M	0.669**	0.041	0.641***	0.685***	0.735***	0.705***	0.179	0.659***	0.005
CaCO3	0.335	-0.036	0.088	0.273	0.313	0.029	-0.036	0.342	0.312
pH	-0.529**	0.129	-0.441*	-0.492**	-0.505**	-0.24	-0.27	-0.529**	-0.196
CEC	0.235	0.069	0.264	0.243	0.231	0.104	-0.058	0.097	0.219
Ni									
O.M	0.409*	0.717***	0.574**	0.489**	0.518**	--	0.464*	0.466*	0.311
CaCO3	0.131	0.269	0.161	0.15	0.167	--	0.142	0.158	0.114
pH	-0.327	-0.12	-0.35	-0.346	-0.363	--	-0.371	-0.316	-0.246
CEC	0.017	0.408*	0.034	0.06	0.068	--	0.019	0.067	-0.014
Co									
O.M	0.140	-0.027	0.504**	0.453*	0.424*	--	0.245	0.085	0.005
CaCO3	0.121	0.233	0.254	0.159	0.182	--	0.065	0.095	0.087
pH	-0.453	-0.537*	-0.467*	-0.427*	-0.482*	--	-0.455	-0.464	-0.410
CEC	0.158	-0.053	0.252	0.237	0.221	--	0.194	0.121	0.121

***, **, and *** Significant at the 0.05, 0.01, and 0.001 probability levels, respectively.**

4-3-3-Concentration of heavy metals in plants grown on soils adjacent to the highway: The results of heavy metals in plants grown on soils adjacent to the highway are shown in Table (30).

4-3-3-1- Copper:

The concentration of Cu in plants grown on soils adjacent to the highway was higher and ranged from 15 to 20 µg/g. The contents of all growing plants were within the toxic range, (15 - 20 µg/g , Sauerbeck, 1982).

4-3-3-2-Zinc:

Concentrations of Zn in plants grown on soils near the motor way were low and within the permissible level.

4-3-3-3-Lead:

The concentrations of Pb in plants grown on soils adjacent to the highway were high, ranged from 13 to 18 µg/g. The higher values were found in those grown on 5 m away from the motor way. The higher values tended to reach the higher level of the critical toxicity range (10-20 µg/g) proposed by Sauerbeck (1982).

4-3-3-4- Cadmium:

The concentration of Cd in plants grown on soils adjacent to the highway (5 m away) and located on the east and west of the road was 6.2 and 6.5 µg/g, respectively. This high concentration is located within the critical toxicity range (5-10 µg/g) reported by Sauerbeck (1982).

4-3-3-5-Nickel:

The contents of Ni in plants grown on soils adjacent to the highway ranged from 7.6 to 9.9 µg/g. The highest concentration was found in plants grown on 5m east of the road. Such concentrations are not harmful to animals.

4-3-3-6-Cobalt:

The concentration of Co in plants grown on roadside soils ranged from 5.0 to 6.5 µg/g. No hazards are expected from such concentrations.

Table (30): Concentrations of heavy metals in plants grown on soils adjacent to the highway.

Prof. No	Cultivated crops	Location	Concentration of heavy metals (µg/g).					
			Cu	Zn	Pb	Cd	Ni	Co
16	Taro	Kaha (east side}	17.0	30.0	18.0	6.2	9.9	5.5
17	~~	~~~	17.7	28.0	16.0	5.3	8.4	6.2
18	Radish	~~~	17.0	30.0	13.0	4.5	7.9	4.7
19	Radish	Kaha (west side)	20.0	34.0	17.0	6.5	7.9	6.5
20	Clover	~~~	15.0	30.0	17.0	5.0	7.6	5.2
21	~~	~~~	18.0	29.0	16.0	4.8	7.6	5.0