Results and Discussion

4. RESULT AND DISCUSSION

4-1- Survey of mineral fertilizers:

4-1-1- Nitrogen fertilizers:

Data presented in Table 11 and illustrated in Fig. 1 show that the studied nitrogen fertilizers contained heavy metals (total, AB-DTPA and water extract) in different concentrations.

Total concentration of the investigated heavy metals in the ammonium nitrate produced by both Talkha and Abu-Keir Companies followed in descending order: Pb> Co> Ni> Cd whereas in the ammonium nitrate produced by El-Delta Company, the pattern of total concentration of these metals ions was different somewhat from that characterized in the similar fertilizer produced by Talkha and Abu-Keir Companies where found in descending order as shown: Pb> Ni> Cd> Co.

On the other hand, the investigated companies producing such fertilizer could be arranged with regard to the content of heavy metals in their product in the following descending order:

1- Abu-Keir Company> Talkha Company> El-Delta Company regarding content of total Pb as well as Co.
2- El-Delta Company> Abu- Keir Company> Talkha Company regarding contents of total Ni.
3- Talkha Company> El-Delta Company> Abu-Keir Company regarding contents of total Cd. T

Table (11) Total, AB-DTPA and water extract of Pb, Ni, Cd and Co from nitrogen fertilizers

Fertilizer	Company	Pb Concentration (mg kg^{-1})				Ni Concentration (mg kg^{-1})				Cd Concentration (mg kg^{-1})				Co Concentration (mg kg^{-1})			
		Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$
Amonium nitrote	Tolkha	4.52	1.05	0.00	0.0118	1.36	0.00	0.00	0.0115	1.25	0.00	0.00	0.0105	2.25	0.00	0.00	0.0115
Urea	Talkha	4.08	0.26	0.00	0.0013	0.60	0.37	0.00	0.2378	0.00	0.00	0.00	0.0001	0.00	0.00	0.00	0.0001
Amonium nitrate	Abu-Keir	4.68	0.66	0.00	0.0124	1.65	0.13	0.00	0.0124	0.46	0.00	0.00	0.0115	2.84	0.27	0.00	0.0124
Urea	Abu-Keir	6.84	0.56	0.00	0.0124	2.41	0.44	0.00	0.0124	0.79	0.05	0.00	0.0124	1.95	0.09	0.00	0.0124
Amonium nitrate	El-Delta	3.75	0.00	0.00	0.0115	2.35	1.69	0.00	0.0133	0.75	0.00	0.00	0.0115	0.62	0.00	0.00	0.0117

Note: Digest extract: indicates total content of the element.
Water extract: indicates extractable element.
AB-DTPA extract: indicates ammonium bicarbonate-DTPA extractable element.

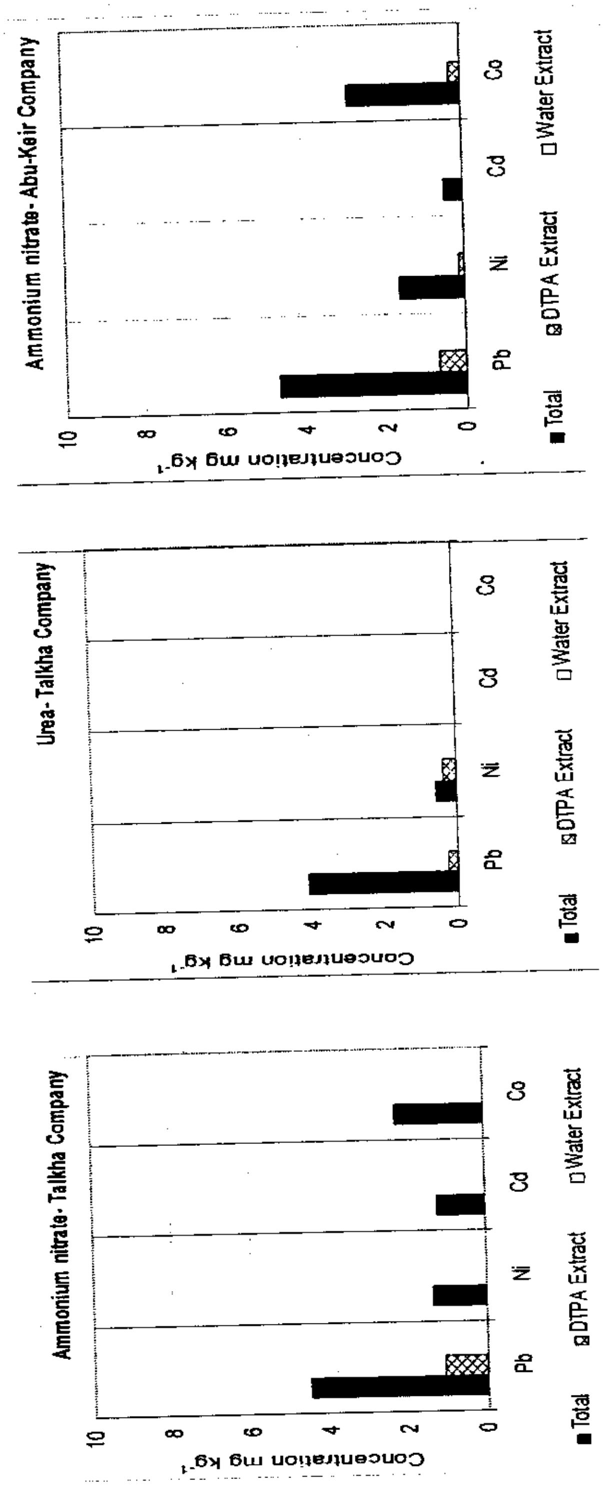
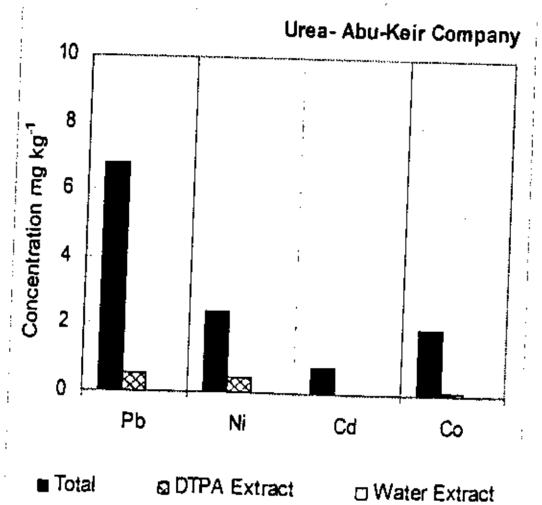


Fig. (1) Heavy metal contents of the investigated nitrogen fertilizers.



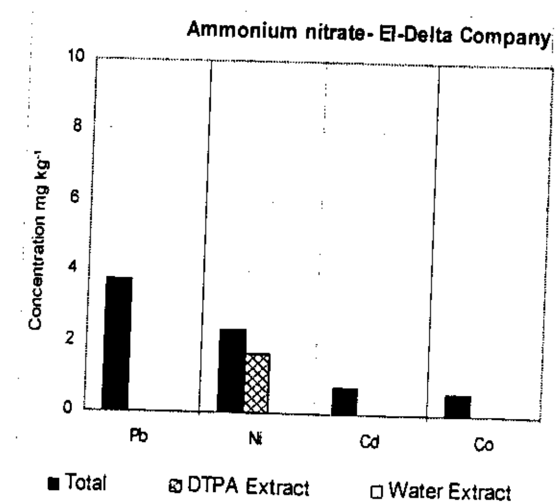


Fig. (1) Continue Heavy metal contents of the investigated nitrogen fertilizers.

4- The AB-DTPA extractable heavy metals in the ammonium nitrate fertilizer produced by different Companies show in the following descending orders:

In the ammonium nitrate fertilizer produced by Talkha Company, there was no Ni, or Cd or Co, but there were contents of Pb.

In the ammonium nitrate fertilizer produced by El-Delta Company there were contents of Ni, none of Pb, Co, or Cd concerning water extract heavy metals, none was detected in the ammonium nitrate fertilizers produced by the different Companies under study.

metals in the urea fertilizers results show that urea produced by Talkha Company indicate the following descending order:

Pb> Ni with no presence of Cd or Co.

Regarding urea of Abu-Keir Company the pattern was as follows: Pb> Ni> Co> Cd.

Concerning to the AB-DTPA extractable contents of the heavy metals in the urea fertilizer produced by Talkha Company results show the following order: Ni> Pb> Cd= Co.

In the urea fertilizer produced by Abu-Keir Company the following descending order: Pb> Ni> Co> Cd characterized the AB-DTPA extractable contents of the investigated metal ions.

None of the investigated metal ions could be detected in the water extract of the urea fertilizer produced by either of the two Companies' under study.

Metals in the urea fertilizers results show that urea produced by Talkha Company indicate the following descending order:

Pb> Ni with no presence of Cd or Co.

Regarding urea of Abu-Keir Company the pattern was as follows: Pb> Ni> Co> Cd.

Concerning to the AB-DTPA extractable contents of the heavy metals in the urea fertilizer produced by Talkha Company results show the following order: Ni> Pb> Cd= Co.

In the urea fertilizer produced by Abu-Keir Company the following descending order: Pb> Ni> Co> Cd characterized the AB-DTPA extractable contents of the investigated metal ions.

None of the investigated metal ions could be detected in the water extract of the urea fertilizer produced by either of the two Companies' under study.

It is worthy to indicate, however, that the urea fertilizer produced by Talkha Company showed lower of the investigated metal ions than Abu-Keir Company.

4-1-2- Phosphate fertilizers:

Data presented in Table 12 and illustrated in Fig. 2 show that phosphate fertilizers contain different concentrations of heavy metals depending on extraction method of heavy metals as well as type of the phosphate fertilizer.

Total contents of the investigated heavy metals in the powdered ordinary super phosphate (P.O.S.P) fertilizer materials produced by Abu-Zabal, El-Malia (Assuit), El-Malia (Kafr-El-Zyat) and El-Nasr (Suze) Companies followed order dominated

Table (12) Total, AB-DTPA and water extractable of Pb, Ni, Cd and Co from phosphatic fertilizers.

Fertilizer	Company	Pb Concentration (mg kg^{-1})				Ni Concentration (mg kg^{-1})				Cd Concentration (mg kg^{-1})				Co Concentration (mg kg^{-1})			
		Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$
P.O.S.P %15	Abu-Zabal	20.00	0.00	0.02	0.1155	47.00	8.85	12.3	0.129	42.00	1.75	1.85	0.1291	7.00	0.60	1.13	0.1291
A.O.S.P 15%	Abu-Zabal	19.00	0.00	0.90	0.1154	38.00	13.21	13.75	0.137	35.00	2.37	2.70	0.1291	6.00	1.35	2.22	0.1291
A.T.S.P 37%	Abu-Zabal	14.00	0.00'	0.00	0.1189	74.00	21.57	21.57	0.1291	36.00	3.69	7.90	0.1291	15.00	4.35	4.80	0.5882
P.O.S.P %15	El-Malia Assuit	12.80	0.00	0.00	0.1153	278.67	9.38	10.15	1.2348	6.56	1.00	1.48	0.0592	3.89	0.10	1.07	0.0942
A.O.S.P 15%	El-Malia Assuit	8.26	0.00)	0.00	0.0115	194.00	9.24	10.15	0.1191	3.21	0.90	1.43	0.059	1.56	0.00	1.14	0.0124
P.O.S.P %15	El-Malia Kafr-El-Zyat	14.00	0.00	0.00	0.129	160.00	8.44	9.30	0.1291	6.28	1.20	1.33	0.0592	12.68	0.00	0.89	0.0476
A.O.S.P 15%	El-Malia Kafr-El-Zyat	10.00	0.00	0.00	0.1153	148.00	7.16	9.60	0.5882	4.68	1.45	1.71	0.0592	5.32	0.02	0.77	0.0124
P.O.S.P %15	El-Nasr Suiss city	7.70	0.00	0.00	0.0577	113.55	11.80	12.02	0.0592	6.30	1.80	1.85	0.0937	6.90	0.25	1.38	0.0592
A.O.S.P 15%	El-Nasr Suze city	6.42	0.00	0.00	0.0115	86.30	10.90	11.13	0.001	5.70	1.55	1.71	0.0592	5.75	0.25	1.37	0.0592

Note: Digest extract: indicates total content of the elemen

Water extract: indicates extractable element.

AB-DTPA extract: indicates ammonium bicarbonate-DTPA extractable element.

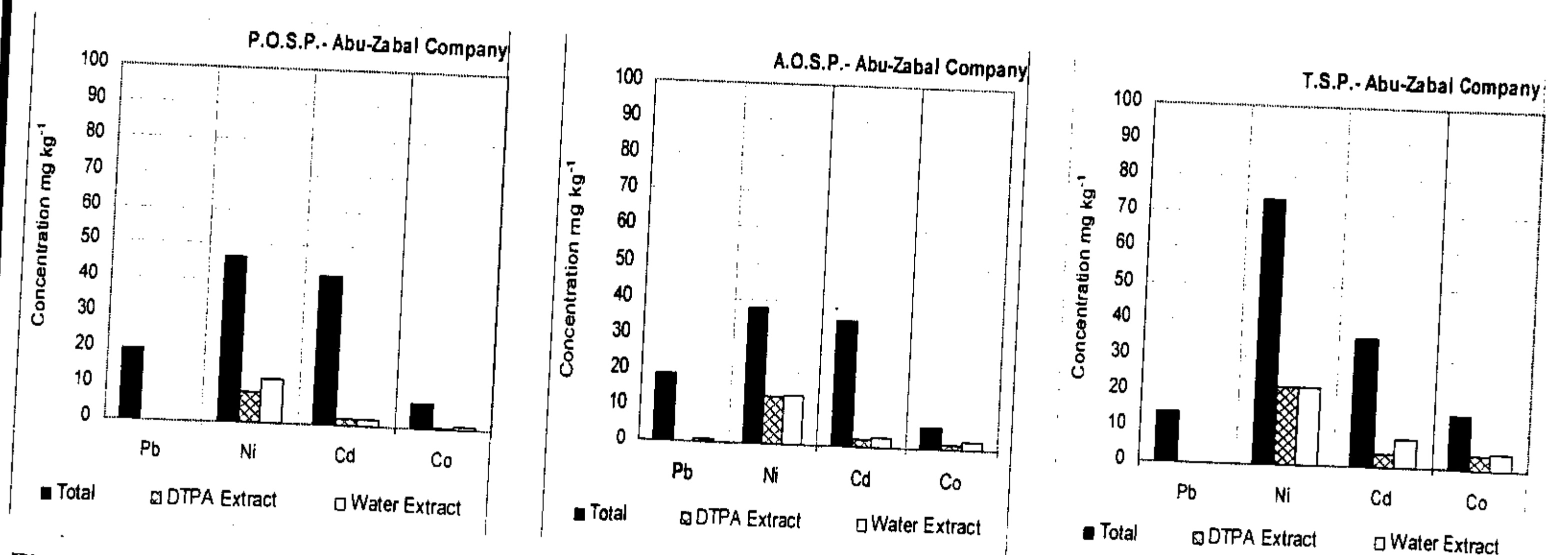


Fig. (2) Heavy metal contents of the investigated phosphatic fertilizers.

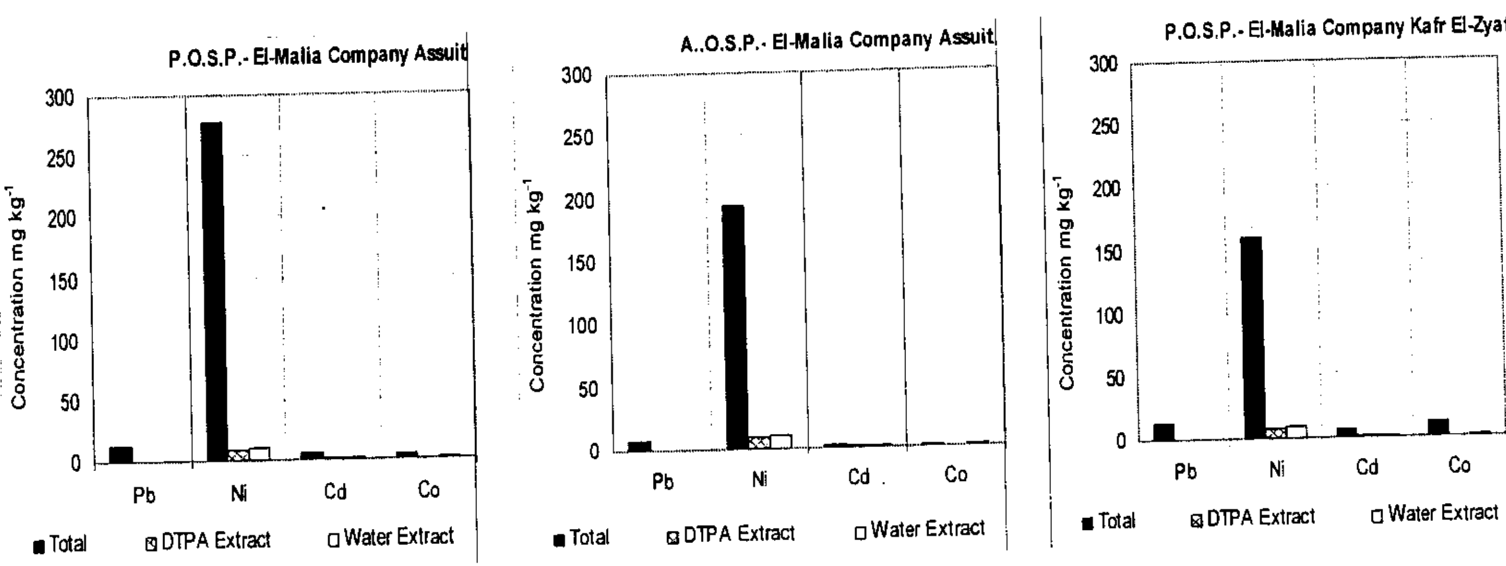


Fig. (2) Continue Heavy metal contents of the investigated phosphatic fertilizers.

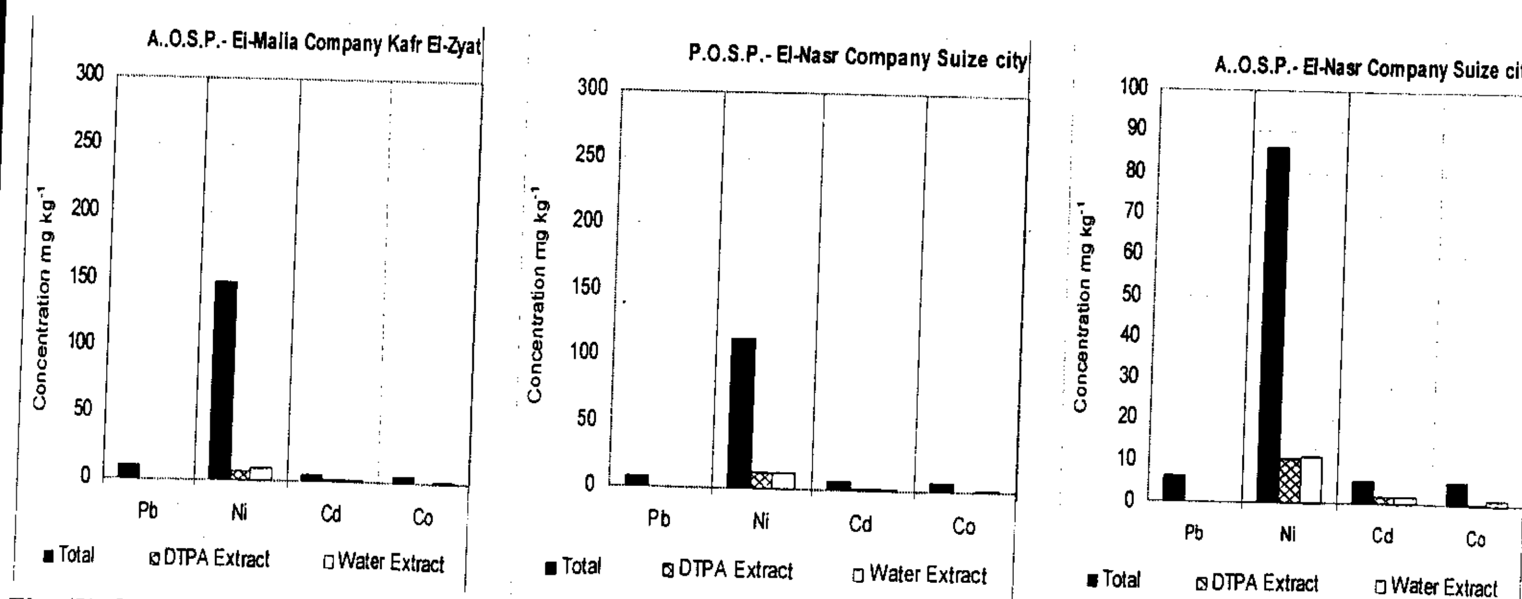


Fig. (2) Continue Heavy metal contents of the investigated phosphatic fertilizers.

by Ni which was found in contents much higher than the other studied ones, yet Cd come in the second order followed by Pb and finally Co in the (P.O.S.P) fertilizer produced by Abu-Zabal Company. However, in the rest of (P.O.S.P), Pb was the second dominant heavy metal followed by Cd and finally Co in the (P.O.S.P) fertilizer produced by El-Malia (Assuit) Company while Co come next to Pb and finally Cd in the (P.O.S.P) fertilizer produced by both of El-Malia (Kafr El-Zyat) and El-Nasr Companies.

AB-DTPA extractable Pb was not found in any detectable concentrations in any of the investigated phosphate fertilizers whereas Ni is dominated in this form followed by Cd and finally Co. Generally, Pb was not detected in the water extract form in any pronounced content, the other investigated elements metal ions followed a descending order which coincide with that characterized their presence in the AB-DTPA extractable form i.e. Ni> Cd> Co.

Regarding to the total contents of the investigated heavy metals, in the aggregated ordinary super phosphate (A.O.S.P.) fertilizers produced by Abu-Zabal, El-Malia (Assuit), El-Malia (Kafr El-Zyat) and El-Nasr Companies. Data in Table 12 reveal that Ni was dominant followed by Cd then Pb and finally Co in the fertilizer produced by Abu-Zabal Company while in the (A.O.S.P.) fertilizer produced by the other Companies Ni dominated followed by Pb, and Cd was detected in the third order among the heavy metals polluting the A.O.S.P. fertilizer produced by El-Malia (Assuit) Company whereas it was the least one in the A.O.S.P. fertilizer produced by El-Malia (Kafr El-

Zyat) and El-Nasr Companies, in which Co was detected in high concentration than Cd.

AB-DTPA extractable Pb was not detected in the A.O.S.P. fertilizer, however, the other AB-DTPA extractable heavy metals (i.e. Ni, Co and Cd) were found in the A.O.S.P. in the descending order: Ni> Cd> Co in all fertilizers.

Water- extract metal ions were found in the descending order of: Ni> Cd> Co> Pb in the aggregated triple super phosphate (A.T.S.P.) fertilizer (produced by Abu-Zabal Company).

4-1-3 Potassium fertilizers:

Data presented in Table 13 and illustrated in Fig. 3 show that potassium fertilizers varied in their contents of the heavy metals. Total Cd was the dominant pollutant in all the investigated potassium fertilizers. The total contents of the other investigated heavy metal elements were found in less content than Ni but followed different sequences according to type of the fertilizer and the company producing it. In the KCl fertilizer marketed by Tradelink Company the following sequence was achieved for the total form: Cd> Ni> Pb> Co while in the same fertilizer of the Agro Farm Company it was Cd> Pb> Ni> Co. and there were no AB-DTPA or water –extractable forms. The pattern for the Egypt Growth Company which was: Cd> Ni> Co> Pb.

However the pattern was Cd> Pb> Co> Ni characterized the K_2SO_4 fertilizers of Egypt Growth and Bio for New Agriculture Companies, respectively. No AB-DTPA or water extractable forms were detectedAlthough no heavy metal was detected in the AB-DTPA or water extract, there was one exception for Ni

Table (13) Total, AB-DTPA and water extractable of Pb, Ni, Cd and Co from potassium fertilizers

Fertilizer	Company	Pb Concentration (mg kg^{-1})				Ni Concentration (mg kg^{-1})				Cd Concentration (mg kg^{-1})				Co Concentration (mg kg^{-1})			
		Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$	Digest extract	AB-DTPA	water	$L.S.D_{0.05}$
KCl 48%	Tradelink	4.03	0.00	0.00	0.0702	10.10	0.40	0.00	0.1154	13.21	0.00	0.00	0.0115	3.53	0.00	0.00	0.0333
KCl 48%	Agrofarm	21.03	0.00	0.00	0.0702	10.30	0.00	0.00	0.0702	22.00	0.00	0.00	0.1153	3.55	0.00	0.00	0.0001
K_1SO_4 58-62%	Egypt Growth	2.00	0.00	0.00	0.1153	11.00	2.32	0.00	0.1154	15.36	0.00	0.00	0.1335	3.55	0.00	0.00	0.0001
K_2SO_4 58-62%	Bio-for new agriculture	5.21	0.00	0.00	0.0115	1.37	0.00	0.00	0.0115	22.20	0.00	0.00	0.1153	3.56	0.00	0.00	0.0001

Note: Digest extract: indicates total content of the element.

Water extract: indicates extractable element.

AB-DTPA extract: indicates ammonium bicarbonate-DTPA extractable element.

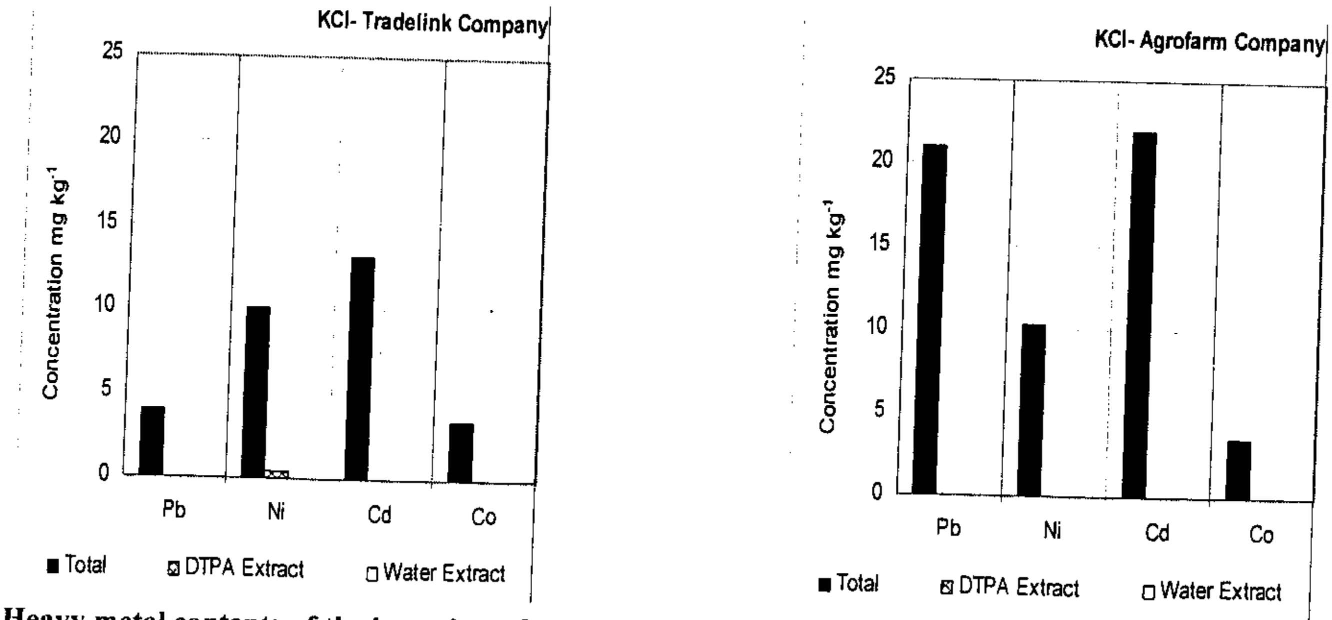
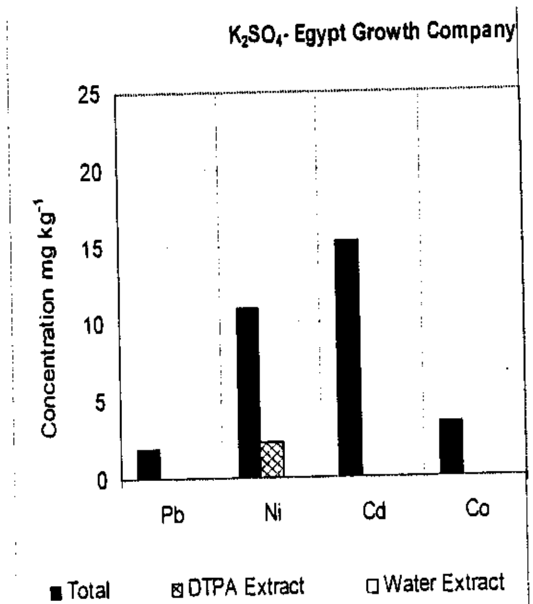


Fig. (3) Heavy metal contents of the investigated potassium fertilizers.



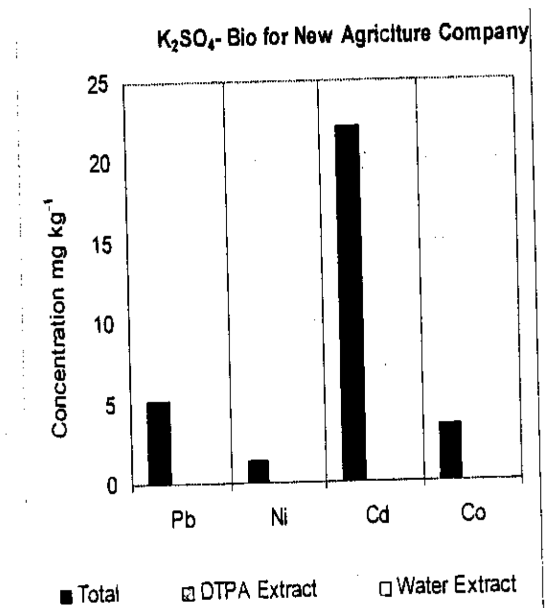


Fig. (3) Continue Heavy metal contents of the investigated potassium fertilizers.

which was found at very minute concentrations in the fonner form of the KCl marketed by Tradelink Company and K_2SO_4 marketed by Egypt Growth Company.

Data presented in Table 14 summarize the total contents of the investigated heavy metals that were found as impurities in the fertilizers and considered pollutants of the soils.

It could be noticed that there were significant differences among the nitrogen, phosphatic and potassium fertilizers in their contents of the different heavy metals and even among the different fertilizers within the same fertilizer type. Generally, the following observations should be highlighted regarding to the contents of heavy metals in the different groups of mineral fertilizers:

1- Content of total Pb:

Potassium fertilizers> Phosphatic fertilizers> Nitrogen fertilizers

2- Content of total Ni:

Phosphatic fertilizers> potassium fertilizers> Nitrogen fertilizers

3- Content of total Cd:

Potassium fertilizers> Phosphatic fertilizers> Nitrogen fertilizers

5- Content of total Co:

Phosphatic fertilizers> potassium fertilizers> Nitrogen fertilizers.

Values of the water-extractable heavy metals from the phosphate fertilizers were, generally, higher than those of the AB-DTPA extractable ones. Such a finding conflicts with what is expected which is that AB-DTPA extractable form is usually greater than the water soluble form the pH of the water-extracts of the phosphatic fertilizer was lower than that of the AB-DTPA

Table (14) L.S.D. test for investigated heavy metals in nitrogen, phosphatic, and potassium fertilizers.

Fertilizer		Company	Concentration mg kg^{-1}			
			Pb	Ni	Cd	Co
Nitrogen fertilizers	Ammonium nitrate	Talkha Company	4.52	1.36	11.25	2.25
	Urea	Talkha Company	4.075	0.60	0.001	0.00
	Ammonium nitrate	Abu-Keir Company	4.68	1.65	0.46	2.84
	Urea	Abu-Keir Company	6.84	2.41	0.79	1.95
	Ammonium nitrate	El-Delta Company	3.75	2.35	0.75	0.62
Phosphate fertilizers	P.O.S.P. %15	Abu-Zabal Company	20.00	47.00	42.00	15.00
	A.O.S.P. 15%	Abu-Zabal Company	19.00	38.00	35.00	6.00
	A.O.S.P. 37%	Abu-Zabal Company	14.00	74.00	36.00	15.00
	P.O.S.P 15%	El-Malia Assuit Company	12.80	278.67	6.56	3.89
	A.O.S.P. 15%	El-Malia Assuit Company	8.26	194.00	3.21	1.56
	P.O.S.P. 15%	El-Malia company Kafr-El-Zyat	14.00	160.00	6.28	12.68
	A.O.S.P. 15%	El-Malia Kafr-El-Zyat Company	10.00	148.00	4.68	5.32
	P.O.S.P 15%	El-Nasr Suiss city Company	7.70	113.55	6.30	6.90
	A.O.S.P. 15%	El-Nasr Suiss city Company	6.42	86.30	5.70	5.75
Potash fertilizers	KCl 48%	Tradelink Company	4.03	10.10	13.21	3.53
	KCl 48%	Agrofarm Company	21.03	10.03	22.00	3.55
	K_2SO_4 58-62%	Egypt Growth Company	2.00	11.00	15.36	3.55
	K_2SO_4 58-62%	Bio-for New Agriculture Company	5.21	1.37	22.00	3.55
$L.S.D_{0.05}$			0.118	0.4333	4.518	0.0696

extracts. Tables 15, 16 and 17 might account for such an observation. This occurred regardless of the type of the phosphatic fertilizers. Results indicate that although all the fertilizer types differ in their contents of heavy metals, yet they are expected to contribute in an accumulation these heavy metals of the agricultural soils.

More over, the fertilizers that contain heavy metals in more soluble forms represent an additional source of pollution for the ground water. Therefore, minimizing usage of mineral fertilizers and looking for more suitable kinds of fertilizers may be helpful in avoiding contamination of soils and ground water with heavy metals. An important note that should be drown in this concern is the extent to which soils subjected to pollution with these metals vary widely depending not only on the kind of the mineral fertilizer applied to the soil but also on type of soil and plant grown thereon.

Table (15) pH values of nitrogen fertilizer extracts:

Fertilizer	Company	pH	
		AB-DTPA	Water- extract
Ammonium nitrate NH_4NO_3	Talkha Company	8.63	7.04
Urea $Co(NH_2)_2$	Talkha company	9.03	8.79
Ammonium nitrate NH_4NO_3	Abu-Keir Company	8.75	8.02
Urea $Co(NH_2)_2$	Abu-Keir Company	9.32	8.62
Ammonium nitrate NH_4NO_3	El-Delta Compay	8.67	7.88
Mean		8.88	8.07

Table (16) pH values of phosphatic fertilizer extracts:

Fertilizer	Company	pH	
		AB-DTPA	Water- extract
P.O.S.P. 15%	Abu-Zabal Company	5.54	3.22
A.O.S.P. 15%	Abu-Zabal Company	5.05	3.40
A.O.S.P. 37%	Abu-Zabal Company	4.08	2.05
P.O.S.P. 15%	El-Malia Assuit Company	4.68	2.89
A.O.S.P. 15%	El-Malia Assuit Company	4.95	2.91
P.O.S.P. 15%	El-Malia Kafr-El-Zyat Company	4.26	2.65
A.O.S.P. 15%	El-Malia Kafr-El-Zyat Company	5.06	3.42
P.O.S.P. 15%	El-Nasr Suiss city Company	4.11	3.05
A.O.S.P. 15%	El-Nasr Suize city Company	4.29	2.91
Mean		4.667	2.94

Table (17) pH values of potassium fertilizer extracts:

fertilizer	Company	pH	
		AB-DTPA	Water extract
KCl 48%	Tradelink Company	6.67	9.31
KCl 48%	Agrofarm Company	6.78	8.65
K_2SO_4 58-62%	Egypt growth Company	5.65	8.21
K_2SO_4 58-62%	Bio-for New Agriculture Company	6.78	8.60
Mean		6.470	8.693

4-2- Effect of long term use of mineral fertilizers *in* different cultivated soils on their contents of N, P, K and heavy metals:

4-2-1- Total contents of the investigated elements:

Data presented in Table 18 and 19 reveal that prolonging the period of cultivation of the studied sandy and calcareous soils was associated, generally with pronounced increase in total contents of the investigated elements. The mineral fertilization practices are though to be the most important factors in this concern; however, the contents attained of these elements varied, with variation in physical, chemical and biological properties of soils, beside the variations in the chemical behaviors of the investigated elements themselves.

Regarding effect of cultivation and fertilization practices on the sandy soil, data in Table 18 reveal that the fertilizer elements of N, P and K were higher in the cultivated sandy soils compared with non-cultivated sandy soil of the control treatment which was represented by El-Bostan soil.

However, distribution of N, P and K with in different soil depths did not follow a single pattern. The cultivation of the sandy soil for less than 5 years up to 10 years caused N, P and K to be highest in the surface layers, lowest in the deepest one and come in between in the subsurface one. Only one exception was shown regarding K distribution upon cultivation of the soil for a period of less than 5 years where it was highest in the deepest layer and lowest in the subsurface one and come in between in the surface layer.

Table (18) Total content of the investigated elements in the studied sandy soils.

cultivation period	Season	Depth (cm)	Concentration g kg^{-1}			Concentration mg kg^{-1}			
			N	P	K	Pb	Cd	Co	Ni
Control- Zero time		0-30	0.01	0.01	0.10	0.00	0.00	0.17	0.91
		30-60	0.01	0.01	0.01	0.00	0.00	0.137	0.90
		60-120	0.01	0.000	0.01	0.00	0.00	0.08	0.76
<5 years	1st season	0-30	1.03	0.11	0.20	1.35	0.11	1.58	2.21
		30-60	0.80	0.04	0.20	1.05	0.09	1.27	2.12
		60-120	1.00	0.02	0.12	0.98	0.06	0.83	1.78
	2nd season	0-30	1.32	0.12	0.26	2.11	0.12	1.71	4.70
		30-60	1.10	0.09	0.21	1.22	0.11	1.29	3.48
		60-120	1.40	0.01	0.12	1.12	0.09	1.01	2.09
10 years	1st season	0-30	2.07	0.12	0.31	4.46	0.22	2.11	4.59
		30-60	1.10	0.12	0.27	3.41	0.2	1.83	4.01
		60-120	1.30	0.04	0.58	3.52	0.2	1.91	4.24
	2nd season	0-30	3.21	0.13	0.36	6.21	0.31	2.63	4.92
		30-60	2.30	0.14	0.31	4.05	0.21	2.05	4.11
		60-120	2.41	0.06	0.63	4.24	0.20	2.12	4.25
>20 years	1st season	0-30	3.90	0.13	0.35	6.32	0.29	2.58	6.38
		30-60	2.00	0.17	0.74	5.07	0.2	2.27	3.58
		60-120	2.10	0.63	0.98	4.90	0.16	2.32	3.61
	2nd season	0-30	4.10	0.24	0.41	7.23	0.30	2.78	6.64
		30-60	3.00	0.16	0.83	6.84	0.22	3.01	5.01
		60-120	3.65	0.08	1.12	6.57	0.23	2.65	5.64

Cultivation of the sandy soil for more 20 years was associated with accumulation of N in the surface layer in percentage higher than the subsurface or the deepest layer; however, both P and K were detected in highest concentration in the deepest layer.

The accumulation of N in the surface layer might be attributing to the presence of N in soil in an organic form beside of the mineral applied one. On the other hand, N was probably found in soil in concentrations which exceeded those taken up by the grown plants and hence the residual content seemed highest in the surface where the irrigation water was not quite enough to leach N.

The presence of both K and P in highest concentrations in the deepest layer might be attributed to uptake of such nutrients from the surface and sub surface layers by the grown shallow rooted plants of maize and wheat.

The pattern of distribution of the investigated heavy metals was more consistent where these metals were accumulated in highest concentrations in the surface of soil and tended to decrease depth wise. Such a trend is probably due to one or more of the followings: (i) the presence of these metal ions as impurities in the surface applied fertilizers and this agreement with ***Mortvedt et al., (1977)***; ***Zee et al., (1990)*** and/or (ii) formation of insoluble compounds among these metal ions and the different soil components and this agreement with ***Jones, (1998); Gaad, (1999)*** and/or (iii) the relatively high pH of soil which enhance precipitation reaction and this agreement with ***Ming-Kuo Lee* and James A. Saunders, (2003).***

It worth to indicate, that Pb and Ni were detected in much higher concentrations than Co and Cd. These finding do not reflect exactly the contents of these metal ions in the fertilizers of the study and may indicate additions of such metals to soils with these metal ions, particularly Pb, by some other sources,

Data presented in Table 19 show total contents of the investigated elements in the loamy calcareous soils of the control treatment (represented by profile in El-Nubaria Research village) and those soils cultivated for less than five years, ten years and more than twenty years.

Initial concentration of the investigated elements in the calcareous soils seemed, generally, less than in the corresponding ones of the sandy soil. Putting these soils under cultivation was associated with increase in soil contents of these elements and the increases were more obvious in soils of prolonged periods of cultivation and this agreement with ***Alina Kabata-Pendias, and Henryk Pendias (2000)***. The most effective source of increasing these elements, (as it was the case in the sandy soils) is expected for the applied mineral fertilizers

It is importance to notice, generally that all the investigated elements tended to be highest in the surface layers and tended to decrease with depth. This was true in all soils of all periods of cultivation. Also, contents of the investigated elements were obviously higher in the calcareous soils than the sandy one as shown in Figs. 4 and 5 which illustrated the mean values of profile contents of the investigated elements in the studied soils and present the differences between the accumulation of the

Table (19) Total content of the investigated elements in the *loamy* calcareous soils.

cultivation period	Season	Depth (cm)	Concentration g kg^{-1}			Concentration (mg kg^{-1})			
			N	P	K	Pb	Cd	Co	Ni
Control- Zero time		0-30	0.02	0.02	0.12	0.02	0.01	0.185	2.05
		30-60	0.02	0.04	0.10	0.01	0.01	0.180	1.24
		60-120	0.04	0.06	0.13	0.00	0.01	0.100	1.1
<5 years	1st season	0-30	2.30	0.32	1.10	4.89	0.32	2.259	9.81
		30-60	2.10	0.31	0.90	2.51	0.10	2.091	8.77
		60-120	1.96	0.11	0.60	2.06	0.09	0.890	8.09
	2nd season	0-30	2.95	0.43	1.40	5.65	0.38	3.410	11.51
		30-60	2.30	0.33	1.20	3.01	0.11	2.110	8.96
		60-120	2.00	0.11	0.71	2.11	0.10	0.970	8.14
10 years	1st season	0-30	3.60	0.57	2.56	6.21	0.51	4.110	12.93
		30-60	2.50	0.40	1.87	4.52	0.31	3.220	10.51
		60-120	2.80	0.25	1.10	2.67	0.15	1.050	10.05
	2nd season	0-30	3.90	0.62	3.02	9.14	0.59	5.010	14.09
		30-60	2.60	0.41	2.21	5.010	0.371	3.310	11.060
		60-120	2.81	0.25	1.30	3.110	0.172	1.080	10.210
>20 years	1st season	0-30	5.03	0.62	3.51	10.140	0.713	6.880	17.660
		30-60	3.27	0.48	2.73	7.640	0.521	6.400	14.740
		60-120	3.77	0.32	2.73	7.240	0.232	3.210	14.620
	2nd season	0-30	7.21	0.80	4.45	12.430	0.914	7.090	19.510
		30-60	3.29	0.48	2.79	8.110	0.541	6.890	15.810
		60-120	3.78	0.32	2.81	7.420	0.235	3.230	14.580

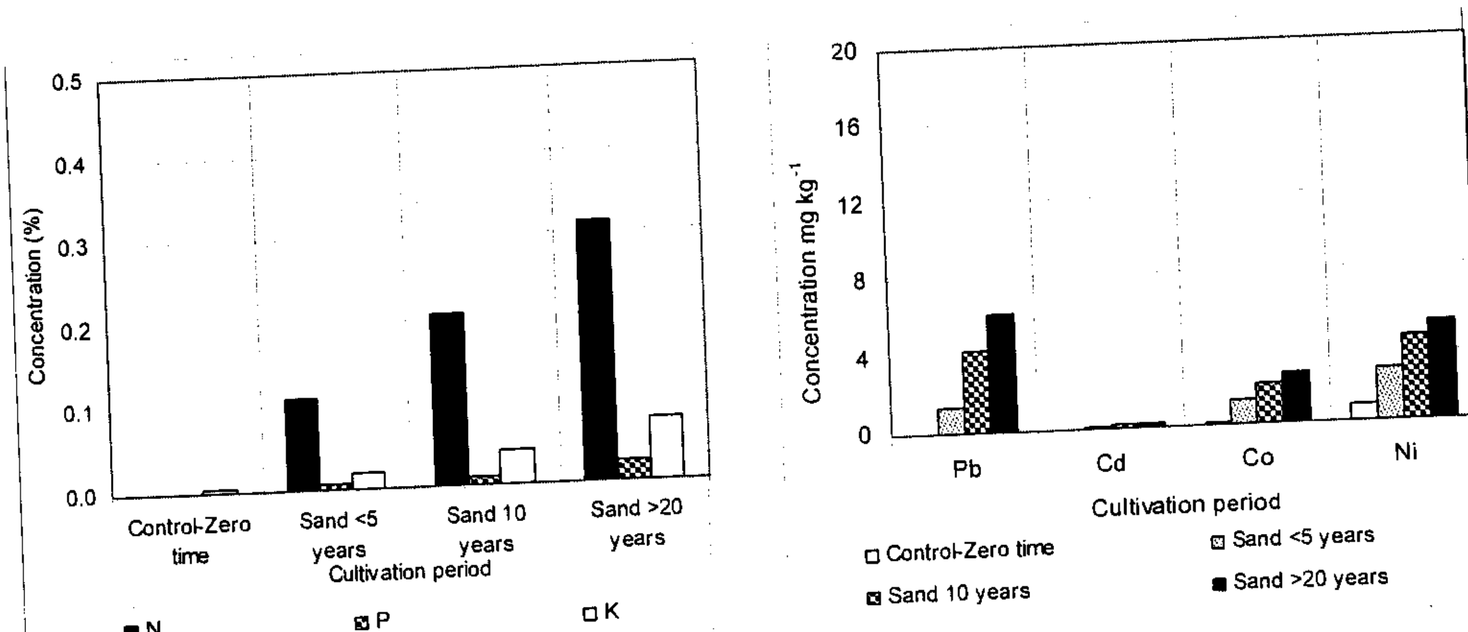
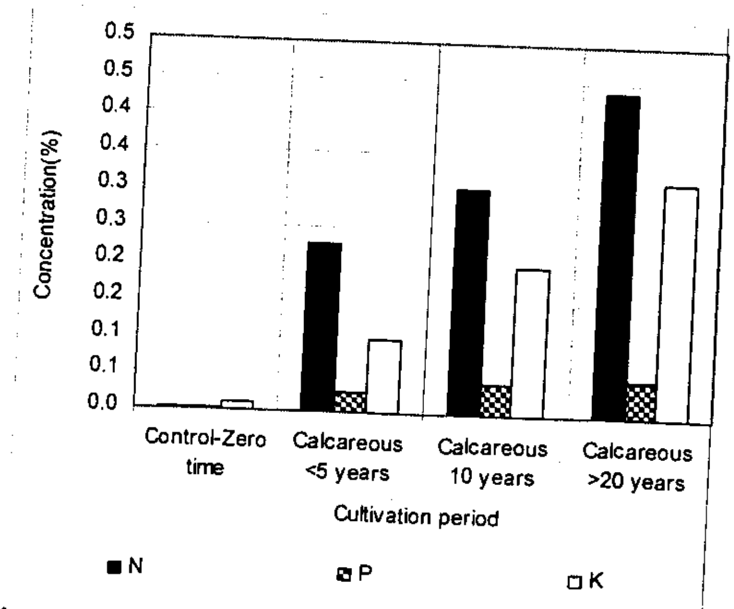


Fig.(4) Mean values concentrations of the investigated elements in the sandy soils.



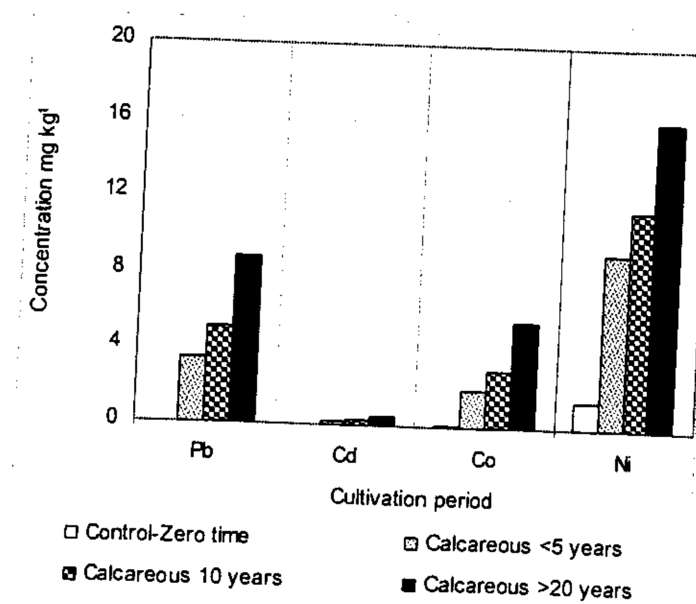


Fig. (4) Continue, Mean values concentrations of the investigated elements in the loamy calcareous soils.

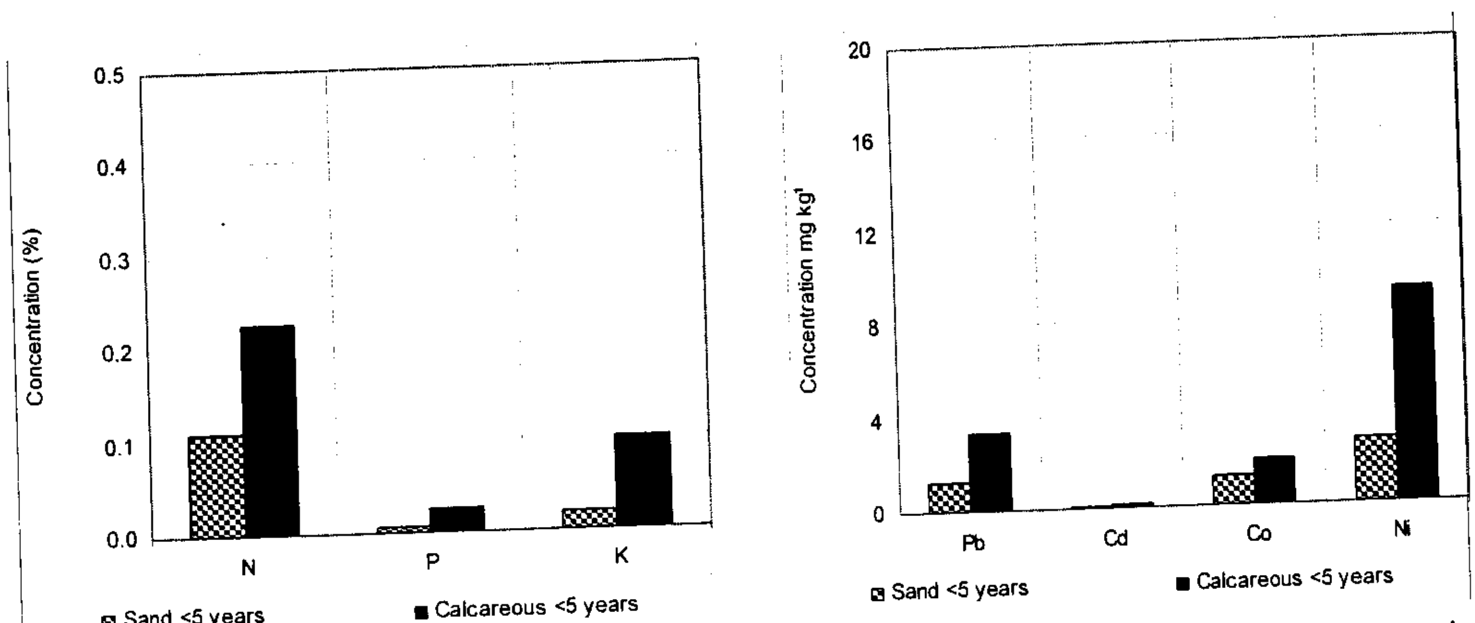


Fig. (5) Mean values of the investigated elements in sandy and loamy calcareous soils in different cultivation period.

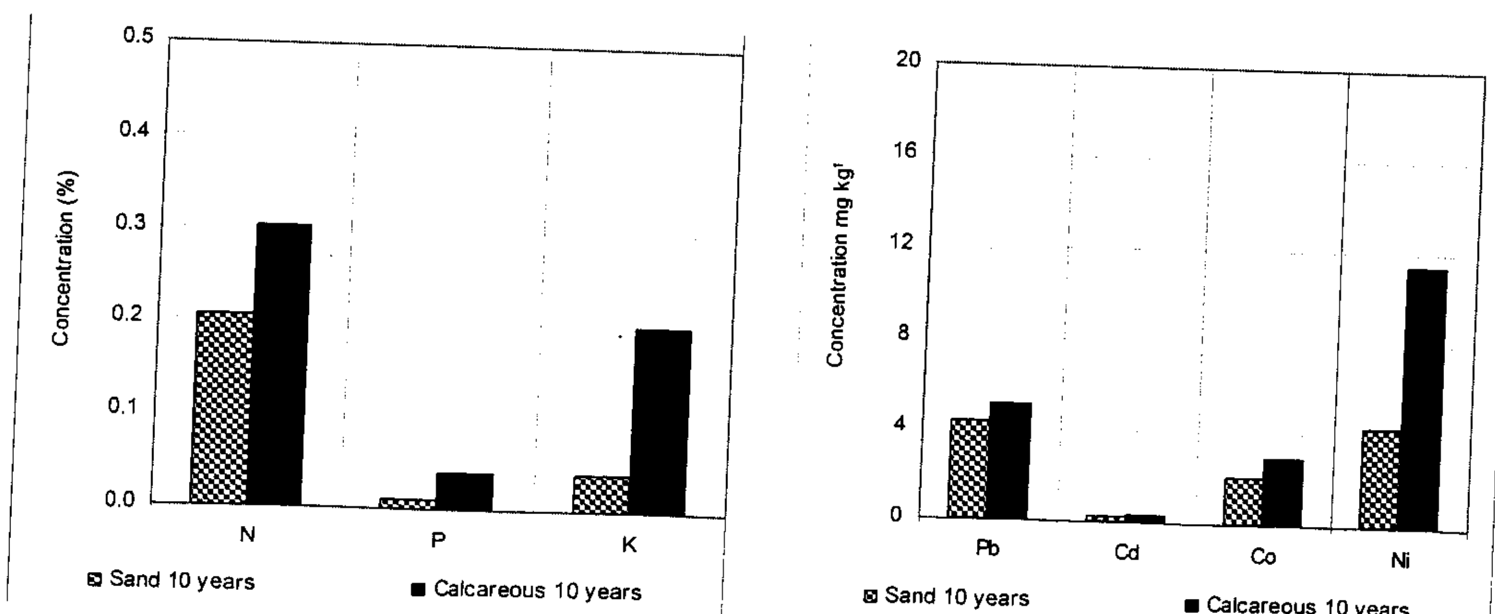


Fig. (5) Continue, Mean values of the investigated elements in sandy and loamy calcareous soils in different cultivation period.

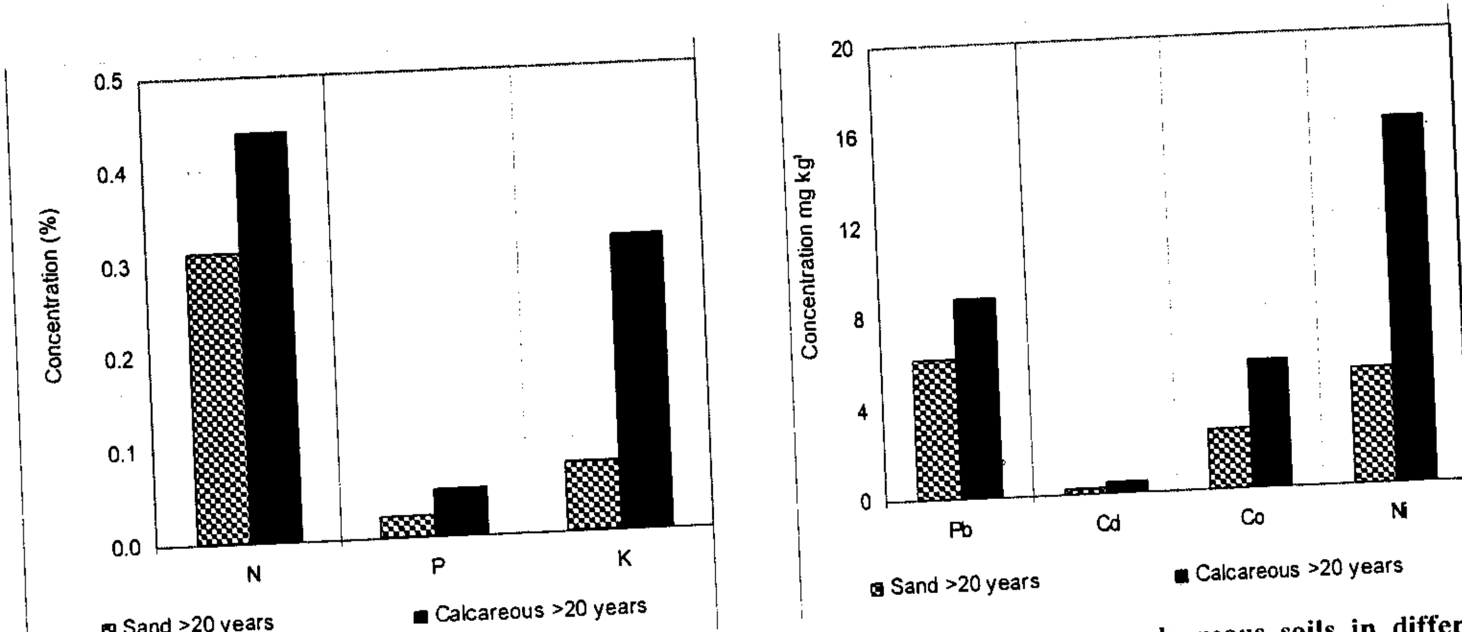


Fig. (5) Continue, Mean values of the investigated elements in sandy and loamy calcareous soils in different cultivation period.

investigated elements in the sandy and loamy calcareous soils with different period of cultivation history.

Retention of elements in the loamy calcareous soils would be great than in the sandy soil since the drain pores and rate of infiltration of the sandy soil would be much higher than in the loamy calcareous soil.

Accordingly, it is expected that losses of the elements would be lower in the loamy soil than in the sandy soils.

4-2-2- AB-DTPA extractable elements:

Data presented in Tables 20 and 21 show values of AB-DTPA extractable elements in the studied soils. Cultivation of the studied soils caused their contents of AB-DTPA extractable elements to increase and the increases were more pounded in soils by prolonged period of cultivation. This occurred in all the studied soils and for all the investigated elements regardless of rate of the applied fertilizers. the control soil to as high as 6.7 and 31.1 mg kg^{-1} soil, NO_3^--N and NH_4^+-N, respectively in the sandy soil cultivated for more than twenty years. Also, AB-DTPA extractable P and K increased from 1.77 and 10.28 mg kg^{-1}, NO_3^--N and NH_4^+-N, respectively in the surface layer of the control sandy soil up to 5.15 and 39.1 mg kg^{-1}, respectively in the surface layer of the sandy soil cultivated for a period more than twenty years.

Pb, Cd, Co and Ni increased from being 0.00, 0.00, 0.005 and 0.035 mg kg^{-1}, respectively in the surface layer of the control sandy soil (the non-cultivated soil) to reach up to 0.51, 0.06, 0.08 and 0.46 mg kg^{-1}, respectively in the surface layer of the sandy

Table (20) AB-DTPA extract of the investigated elements in the sandy soils

cultivation period	Season	Depth (cm)	NO_3^--N	NH_4^+-N	P	K	Pb	Cd	Co	Ni
			Concentration mg kg^{-1}							
Control- Zero time		0-30	2.41	3.90	1.77	10.23	0.00	0.00	0.01	0.04
		30-60	2.53	4.02	0.00	10.25	0.00	0.00	0.00	0.02
		60-120	3.44	4.14	0.00	6.56	0.00	0.00	0.00	0.02
<5 years	1st season	0-30	1.90	16.40	6.05	23.84	0.24	0.02	0.03	0.09
		30-60	1.10	20.60	5.61	23.84	0.15	0.02	0.04	0.08
		60-120	2.21	12.80	3.13	26.74	0.42	0.01	0.03	0.07
	2nd season	0-30	3.50	31.58	20.94	45.54	0.46	0.02	0.09	0.21
		30-60	5.20	33.65	3.83	35.38	0.28	0.02	0.05	0.12
		60-120	4.30	29.80	2.39	56.56	0.31	0.01	0.03	0.12
10 years	1st season	0-30	3.41	16.60	4.88	20.66	0.23	0.02	0.09	0.47
		30-60	1.68	27.90	3.57	41.83	0.26	0.02	0.05	0.65
		60-120	2.56	17.30	1.25	15.64	0.11	0.02	0.04	0.54
	2nd season	0-30	7.30	45.30	8.72	32.48	0.47	0.04	0.10	1.10
		30-60	5.50	45.10	5.32	30.28	0.28	0.04	0.07	0.76
		60-120	5.90	41.40	3.36	35.76	0.12	0.03	0.04	0.58
>20 years	1st season	0-30	6.70	31.10	5.15	39.10	0.51	0.03	0.08	0.46
		30-60	1.90	28.60	2.62	31.28	0.45	0.06	0.07	0.85
		60-120	2.56	31.00	3.03	31.28	0.44	0.05	0.07	0.84
	2nd season	0-30	12.20	49.40	10.36	104.00	0.56	0.08	0.10	1.20
		30-60	4.20	63.50	4.02	34.32	0.51	0.07	0.09	0.97
		60-120	5.70	47.30	5.12	35.44	0.48	0.06	0.08	0.85

soil cultivated for more than twenty years (the first season-summer season). The corresponding values attained in the second season (winter season) were 0.56, 0.08, 0.1 and 1.2 mg kg^{-1}, respectively.

All of the nutritive N, P and K elements and non-nutritive Pb, Cd, Co and Ni elements were in their highest concentration in the surface layers and in the sub surface layers.

This is an eventual result of the surface application of the fertilizers, on and the apparent accumulation of the heavy metals as precipitates in the surface layers due to the high soil pH as well as due to formation of insoluble complex with the different soil components.

Regarding effect of cultivation and consequently fertilization of the loamy calcareous soil data in Table 21 reveal that both available nitrogen forms NO_3^--N and NH_4^+-N increased from 4.65 and 6.25 mg kg^{-1}, respectively in the surface layer (0-30 cm) of the non-cultivated calcareous soil to 8.65 and 37.3 mg kg^{-1}, respectively in the soil cultivated for more twenty years. Also, P, K, Pb, Cd, Co and Ni increased from 2.83, 20.65, 0.10, 0.02, 0.05 and 0.32 mg kg^{-1}, respectively in the surface layers of the non-cultivated soil to of 10.40, 312.8, 0.87, 0.08, 0.12 an 0.68 mg kg^{-1}, respectively in the calcareous soil cultivated for more than twenty years.

Generally, the highest concentrations of the AB-DTPA extractable elements were detected in the surface or the sub surface soil layers whereas the lowest concentrations were

Table (21) AB-DTPA extract of the investigated elements in the loamy calcareous soils.

cultivation period	Season	Depth (cm)	Concentration mg kg^{-1}							
			NO_3^--N	NH_4^+-N	P	K	Pb	Cd	Co	Ni
Control- Zero time		0-30	4.65	6.25	2.83	20.56	0.10	0.02	0.05	0.32
		30-60	4.25	8.25	2.55	16.50	0.11	0.01	0.06	0.31
		60-120	0.00	8.65	1.59	12.57	0.09	0.01	0.04	0.29
<5 years	1st season	0-30	2.70	29.30	7.11	265.88	0.57	0.05	0.04	0.44
		30-60	1.70	24.87	3.30	226.78	0.56	0.05	0.02	0.40
		60-120	1.70	26.87	3.33	220.12	0.36	0.00	0.02	0.40
	2nd season	0-30	42.03	49.87	8.85	205.60	0.63	0.05	0.07	0.46
		30-60	33.43	47.11	5.21	202.41	0.64	0.06	0.03	0.43
		60-120	28.60	51.20	4.58	199.58	0.55	0.00	0.03	0.40
10 years	1st season	0-30	7.10	31.00	9.22	321.00	0.46	0.05	0.09	0.53
		30-60	4.00	26.00	5.58	245.25	0.27	0.03	0.04	0.27
		60-120	3.10	29.60	5.21	210.58	0.29	0.03	0.06	0.21
	2nd season	0-30	30.53	53.80	10.11	261.40	0.76	0.10	0.11	0.69
		30-60	47.53	53.90	6.21	258.80	0.41	0.04	0.09	0.41
		60-120	44.03	57.90	6.05	245.30	0.40	0.04	0.08	0.29
>20 years	1st season	0-30	8.65	37.30	10.40	312.80	0.87	0.08	0.12	0.68
		30-60	6.25	26.70	6.58	226.78	0.43	0.02	0.10	0.46
		60-120	8.12	26.50	5.24	172.04	0.30	0.02	0.04	0.29
	2nd season	0-30	35.77	58.20	29.76	468.40	1.12	0.10	0.16	0.80
		30-60	49.65	61.00	2.83	259.00	0.59	0.04	0.12	0.66
		60-120	52.01	54.40	1.28	242.10	0.35	0.02	0.06	0.34

detected in the deepest layers and this agreement with ***Badawy, (1993).***

Accumulation of N, P and K in the surface layers may be attributed to be down of the plant residues beside of the surface application of the N, P and K fertilizers. Phosphorus in the calcareous soils tended to be adsorbed on $CaCO_3$ particles. It also may react with $CaCO_3$ forming insoluble phosphate compounds. Carbonate apatite may be the final product of this reaction between $CaCO_3$ and phosphorus. These results stand in well agreement with those of ***Jones, (1998); Gaad, (1999).***

4-3- Effect of long term use of mineral fertilizers in different soils on N, P, K and heavy metal contents of plants grown thereon:

Data presented in Tables 22 and 23 show concentration of the investigated elements in the different organs of the maize and wheat plants grown on the studied soils. It can be seen that prolonging the period of cultivation (and consequently fertilization with mineral fertilizers) could increase gradually concentrations of those elements in plant and this agreement with The increases seemed relatively small in the different plants organs of N, P and K, respectively, more obvious increases were observed in Pb, Cd, Co and Ni concentrations. This finding was true in plants grown in the sandy soils as well as those grown in the loamy calcareous soils. It is worthy to mention that concentrations of the investigated heavy metals in the different organs of the plants grown on the sandy soil cultivated for the different studied period seemed almost double the corresponding concentrations of these metal ions in the

Table (22) Total contents of the investigated elements in the plants grown on the sandy soils.

cultivation period	Season	Organ	Concentration g kg^{-1}			Concentration mg kg^{-1}			
			N	P	K	Pb	Cd	Co	Ni
<5 years	1st season Maize plant	Shoot	15.64	0.55	5.89	0.116	0.091	0.177	2.425
		Root	17.58	6.87	6.67	0.212	0.110	0.960	3.900
		Grains	14.25	2.35	5.72	0.116	0.050	0.114	2.550
	2nd season Wheat plant	Shoot	4.02	0.42	21.10	0.187	0.100	0.075	3.146
		Root	4.36	0.21	17.85	0.230	0.110	0.500	3.930
		Grains	20.20	1.02	11.06	0.096	0.091	0.095	1.630
10 years	1st season Maize plant	Shoot	16.70	0.57	6.87	0.220	0.120	0.190	3.887
		Root	18.15	7.01	7.24	0.350	0.120	1.016	4.270
		Grains	16.24	2.51	5.92	0.240	0.061	0.287	3.525
	2nd season Wheat plant	Shoot	4.11	0.56	21.10	0.213	0.100	0.091	4.525
		Root	4.51	0.42	17.85	0.260	0.150	0.875	4.150
		Grains	21.14	1.69	11.06	0.250	0.101	0.210	2.120
>20 years	1st season Maize plant	Shoot	17.99	0.58	7.00	0.272	0.141	0.400	5.670
		Root	18.77	0.71	7.31	0.400	0.190	1.000	7.900
		Grains	16.42	2.53	6.39	0.500	0.083	0.300	5.530
	2nd season Wheat plant	Shoot	4.16	0.55	22.06	0.225	0.175	0.200	6.650
		Root	4.47	0.60	17.49	0.321	0.250	1.000	6.200
		Grains	21.25	1.77	11.03	0.360	0.126	0.250	2.550

ones in the calcareous soil. Thus, it can be deduced that the available content and not the total content of the metal ions is the effective factor in determining the plant content of these elements in plant. As a matter of fact, this finding indicates the importance of $CaCO_3$ in reducing availability of the different elements in soil. The hydrolysis of $CaCO_3$ cause soil pH to be raised and hence the availability to be decreased. These results stand in well agreement with those of ***Bolla, (1975).***

4-4- Effect of long term use of mineral fertilizers in different soils on N, P, K and heavy metal contents of their drained water.

Data presented in Table 24 show that the concentrations of the different investigated elements in the drainage water tended to decrease with increasing period of cultivation regardless of type of the studied soil. However, concentrations of the different elements in the drainage water of the loamy calcareous soil were less than the corresponding ones of the sandy soil regardless of the period of cultivation. These findings refer to more relation of the investigated elements in the loamy calcareous than the sandy one. The higher permeability of the sandy soil is an additional factor for increasing concentrations of the different elements in the drainage water and this agreement with ***Maurice, G. (1999).***

It is noticed that NO_3^--N was detected in higher concentration than NH_4^+-N in the drainage water of both the studied soils. This behavior is expected due to the repulsion between the negative charge of the soil and the NO_3^- ions, and on

Table (24) Drainage water contents of investigated elements in the studied soils (sandy and loamy calcareous soils).

Soil /Cultivation period	Season	mg L^{-1}							
		NO_3^--N	NH_4^+-N	P	K	Pb	Cd	Co	Ni
Sandy/<5 years	1st season	nd.							
	2nd season								
Sandy/10years	1st season	19.45	6.02	4.12	26.35	0.71	0.12	0.91	3.24
	2nd season	14.26	5.01	2.25	18.95	0.41	0.09	0.83	2.02
Sandy/>20 years	1st season	17.05	4.98	2.35	23.5	0.58	0.09	0.74	2.08
	2nd season	10.12	2.35	1.14	17.85	0.26	0.05	0.52	1.00
Calcareous/<5 years	1st season	15.06	4.65	1.05	20.81	0.5	0.03	0.42	1.98
	2nd season	7.89	3.11	0.87	19.86	0.23	0.00	0.35	0.85
Calcareous /10years	1st season	13.26	3.89	0.98	20.68	0.5	0.01	0.35	1.45
	2nd season	11.01	2.01	0.42	18.12	0.24	0.009	0.21	0.92
Calcareous />20 years	1st season	15.06	4.65	1.05	20.81	0.5	0.03	0.42	1.98
	2nd season	7.89	3.11	0.87	19.86	0.23	0.00	0.35	0.85

nd: not detected

the other hand the columbic force between the negatively charged soil particles and the NH_4^+ ions.

The lower concentrations of the phosphorus in the drainage water of the loamy calcareous soils than in the drainage water of the sandy soils may be attributed, as mentioned before, to the higher retention of P in the former soils.

As discussed with regard to contents in soils precipitation of heavy metals in the calcareous soil through reaction with the excess of the hydroxide ions and/or $CaCO_3$ may account for the lower concentrations of these elements in the drainage water of the calcareous soils than the sandy ones.

4-5- Human health aspects:

Data presented in Tables 25 to 30 show the calculated amounts of ingested daily metals from soils and biota (grains of maize and wheat plants) by population groups of Egyptian citizen (adult and children). Data show that there is a high exposure in children health compared to adults in Egyptian population in all of the locations of the study based on the metal concentration trend in soils and biota (grains of maize and wheat plants). Also data show that the main source of hazard from investigated elements for human health in all locations (groups of soil) occurs due to the concentrations of these elements in biota compared with its concentrations in the soils.

The obtained results can be discussed for each location as follow:

4-5-1- Sandy soils (Cultivation period <5 years);

Data presented in Table 25 show that there were Co hazard for children health in both cases (half and quarter consumption of adults consumption from biota, (grains of maize and wheat plants). However there were Ni and Cd, hazards for children health in case of half consumption of biota than adults consumption. No Pb hazard for both adult and child.

4-5-2- Sandy soils (Cultivation period 10 years):

Data presented in Table 26 show that there were Co hazard for both children (in both cases half and quarter consumption) and adults health .There were Cd hazard for children health in both half and quarter consumption, whereas

Table (25) Calculated Average Daily Dose of the investigated heavy metals in the sandy soil (cultivation period <5 years)

Exposure way in Egypt	Element -A.D.D (mg kg^{-1} day^{-1}) and H.I.											
	Cd			Co			Pb			Ni		
	A.D.D	H.I		A.D.D	H.I		A.D.D	H.I		A.D.D	H.I	
Soil Adult	1.29E-08	0.000013	Safe	2.35E-06	0.002350	Safe	2.47E-06	0.000706	Safe	4.94E-06	0.000099	Safe
Soil Child	2.01E-07	0.000201	Safe	3.29E-05	0.032900	Safe	3.46E-05	0.009886	Safe	6.91E-05	0.001383	Safe
Wheat Adult	2.38E-04	0.237571	Safe	5.42E-04	0.541663	Safe	5.51E-04	0.157476	Safe	1.21E-02	0.242323	Safe
Wheat Child - half adult consumption	8.32E-04	0.831500	Safe	1.90E-03	1.895820	Hazard	1.93E-03	0.551166	Safe	4.24E-02	0.848130	Safe
Wheat Child - quarter adult consumption	4.16E-04	0.415750	Safe	9.48E-04	0.947910	Safe	9.65E-04	0.275583	Safe	2.12E-02	0.424065	Safe
Maize Adult	2.77E-04	0.277160	Safe	2.89E-04	0.289343	Safe	2.92E-04	0.083540	Safe	4.96E-03	0.099290	Safe
Maize Child - half adult consumption	9.70E-04	0.970060	Safe	1.01E-03	1.012700	Hazard	1.02E-03	0.292389	Safe	1.74E-02	0.347516	Safe
Maize Child - quarter adult consumption	4.85E-04	0.485030	Safe	5.06E-04	0.506350	Safe	5.12E-04	0.146194	Safe	8.69E-03	0.173758	Safe
Soil+Biota Adult	5.15E-04	0.514744	Safe	8.33E-04	0.833356	Safe	8.46E-04	0.241722	Safe	1.71E-02	0.341712	Safe
Soil+Biota Child -half adult consumption	1.80E-03	1.801761	Hazard	2.94E-03	2.941420	Hazard	2.99E-03	0.853440	Safe	5.99E-02	1.197029	Hazard
Soil+Biota Child -quarter adult consumption	9.01E-04	0.900981	Safe	1.49E-03	1.487160	Hazard	1.51E-03	0.431663	Safe	3.00E-02	0.599206	Safe

Note: A.D.D.: Average daily dose H.I: Hazard index

Table (26) Calculated Average Daily Dose of studied heavy metals in the in the sandy soil (cultivation period 10 years)

Exposure way in Egypt	Element -A.D.D (mg kg^{-1} day^{-1}) and H.I.											
	Cd			Ca			Pb			Ni		
	A.D.D	H.I		A.D.D	H.I		A.D.D	H.I		A.D.D	H.I	
Soil Adult	2.89E-08	0.000029	Safe	3.39E-06	0.003386	Safe	7.62E-06	0.002178	Safe	6.79E-06	0.000136	Safe
Soil Child	4.52E-07	0.000452	Safe	4.74E-05	0.047400	Safe	1.07E-04	0.030497	Safe	9.51E-05	0.001902	Safe
Wheat Adult	2.90E-04	0.289837	Safe	1.36E-03	1.362235	Hazard	1.14E-03	0.325812	Safe	1.67E-02	0.334976	Safe
Wheat Child - half adult consumption	1.01E-03	1.014430	Hazard	4.77E-03	4.767821	Hazard	3.99E-03	1.140343	Hazard	5.86E-02	1.172415	Hazard
Wheat Child - quarter adult consumption	5.07E-04	0.507215	Safe	2.38E-03	2.383911	Hazard	2.00E-03	0.570171	Safe	2.93E-02	0.586208	Safe
Maize Adult	3.08E-04	0.307617	Safe	6.40E-04	0.639600	Safe	7.61E-04	0.217551	Safe	6.46E-03	0.129138	Safe
Maize Child -half adult cansumption	1.08E-03	1.076660	Hazard	2.24E-03	2.238600	Hazard	2.67E-03	0.761429	Safe	2.26E-02	0.451984	Safe
Maize Child - quarter adult consumption	5.38E-04	0.538330	Safe	1.12E-03	1.119300	Hazard	1.33E-03	0.380714	Safe	1.13E-02	0.225992	Safe
Soil+Biota Adult	5.97E-04	0.597483	Safe	2.01E-03	2.005220	Hazard	1.91E-03	0.545542	Safe	2.32E-02	0.464250	Safe
Soil+Biota Child -half adult consumption	2.09E-03	2.091542	Hazard	7.05E-03	7.053821	Hazard	6.76E-03	1.932269	Hazard	8.13E-02	1.626301	Hazard
Soil+Biota Child-quarter adult consumption	1.05E-03	1.045997	Hazard	3.55E-03	3.550611	Hazard	3.43E-03	0.981383	Safe	4.07E-02	0.814102	Safe

Note: A.D.D.: Average daily dos H.I: Hazard index there were Pb and Ni hazards for children health in case of half consumption of biota than adults consumption.

4-5-3- Sandy soils (cultivation period >20 years):

Data illustrated in Table 27 show that there were Cd hazard for the children health in both cases of half and quarter consumption of biota than adults consumption. There were Co hazard for both adults and children health, whereas Ni and Pb hazard for children health only in case of half and quarter consumptions of biota than adults consumption

4-5-4- Calcareous soils (Cultivation period <5 years):

Data presented in Table 28 show that there were no Cd and Ni hazards for both adult and children health, whereas there was Co hazard for children health in case of half consumption of biota than adults consumption. However there were Pb hazard for both adults and children health.

4-5-5- Calcareous soils (cultivation period 10 years):

Data presented in Table 29 show that there were Pb hazard for both adults and children health, while, there were Cd, and Ni hazards for children health in case of half consumption of biota than adults consumption. However there was Co hazard for children health in both cases half and quarter consumption of biota than adults consumption.

4-5-6- Calcareous soils (Cultivation period >20 years):

Data presented in Table 30 show that there were Pb and Co hazards for both adults and children health, whereas, there were Cd and Ni hazards for children health in case of half consumption of biota than adults consumption.

Table (27) Calculated Average Daily Dose of studied heavy metals in the in the sandy soil (cultivation period >20 years)

Exposure way in Egypt	Element -A.D.D (mg kg^{-1} day^{-1}) and H.I.											
	Cd			Co			Pb			Ni		
	A.D.D	H.I		A.D.D	H.I		A.D.D	H.I		A.D.D	H.I	
Soil Adult	3.26E-08	0.000033	Safe	3.83E-06	0.003829	Safe	9.68E-06	0.002765	Safe	9.30E-06	0.000186	Safe
Soil Child	5.09E-07	0.000509	Safe	5.36E-05	0.053600	Safe	1.35E-04	0.038706	Safe	1.30E-04	0.002604	Safe
Wheat Adult	3.94E-04	0.394369	Safe	1.43E-03	1.425429	Hazard	2.38E-03	0.678776	Safe	2.63E-02	0.525508	Safe
Wheat Child - half adult consumption	1.38E-03	1.380290	Hazard	4.99E-03	4.989000	Hazard	8.32E-03	2.375714	Hazard	9.20E-02	1.839278	Hazard
Wheat Child - quarter adult consumption	6.90E-04	0.690145	Safe	2.49E-03	2.494500	Hazard	4.16E-03	1.187857	Hazard	4.60E-02	0.919639	Safe
Maize Adult	3.84E-04	0.383760	Safe	7.61E-04	0.761429	Safe	1.07E-03	0.304571	Safe	7.77E-03	0.155331	Safe
Maize Child -half adult consumption	1.34E-03	1.343160	Hazard	2.67E-03	2.665000	Hazard	3.73E-03	1.066000	Hazard	2.72E-02	0.543660	Safe
Maize Child - quarter adult consumption	6.72E-04	0.671580	Safe	1.33E-03	1.332500	Hazard	1.87E-03	0.533000	Safe	1.36E-02	0.271830	Safe
Soil+Biota Adult	7.78E-04	0.778161	Safe	2.19E-03	2.190686	Hazard	3.45E-03	0.986112	Safe	3.41E-02	0.681025	Safe
Soil+Biota Child -half adult consumption	2.72E-03	2.723959	Hazard	7.71E-03	7.707600	Hazard	1.22E-02	3.480420	Hazard	1.19E-01	2.385542	Hazard
Soil+Biota Child- quarter adult consumption	1.36E-03	1.362234	Hazard	3.88E-03	3.880600	Hazard	6.16E-03	1.759563	Hazard	5.97E-02	1.194073	Hazard

Note: A.D.D.: Average daily dose **H.I: Hazard index**

Table (28) Calculated Average Daily Dose of studied heavy metals in the in the loamy calcareous soil (cultivation period <5 years)

Exposure way in Egypt	Element -A.D.D (mg kg^{-1} day^{-1}) and H.I.											
	Cd			Co			Pb			Ni		
	A.D.D	H.I		A.D.D	H.I		A.D.D	H.I		A.D.D	H.I	
Soil Adult	3.85E-08	0.000039	Safe	4.05E-06	0.004049	Safe	7.53E-06	0.002151	Safe	0.000015	0.000305	Safe
Soil Child	6.02E-07	0.000602	Safe	5.67E-05	0.056690	Safe	1.05E-04	0.030114	Safe	0.000213	0.004264	Safe
Wheat Adult	0.00E+00	0.000000	Safe	4.04E-04	0.403871	Safe	4.91E-03	1.402350	Hazard	0.007127	0.142543	Safe
Wheat Child - half adult consumption	0.00E+00	0.000000	Safe	1.41E-03	1.413550	Hazard	1.72E-02	4.908226	Hazard	0.024945	0.498900	Safe
Wheat Child - quarter adult consumption	0.00E+00	0.000000	Safe	7.07E-04	0.706775	Safe	8.59E-03	2.454113	Hazard	0.012473	0.249450	Safe
Maize Adult	1.55E-04	0.155331	Safe	1.01E-04	0.100509	Safe	7.61E-05	0.021755	Safe	0.002406	0.048122	Safe
Maize Child - half adult consumption	5.44E-04	0.543660	Safe	3.52E-04	0.351780	Safe	2.67E-04	0.076143	Safe	0.008421	0.168428	Safe
Maize Child - quarter adult consumption	2.72E-04	0.271830	Safe	1.76E-04	0.175890	Safe	1.33E-04	0.038071	Safe	0.004211	0.084214	Safe
Soil+Biota Adult	1.55E-04	0.155370	Safe	5.08E-04	0.508429	Safe	4.99E-03	1.426256	Hazard	0.009548	0.190970	Safe
Soil+Biota Child -half adult consumption	5.44E-04	0.544262	Safe	1.82E-03	1.822020	Hazard	1.76E-02	5.014483	Hazard	0.033580	0.671592	Safe
Soil+Biota Child- quarter adult consumption	2.72E-04	0.272432	Safe	9.39E-04	0.939355	Safe	8.83E-03	2.522299	Hazard	0.016896	0.337928	Safe

Note: A.D.D.: Average daily dose **H.I: Hazard index**

Table (29) Calculated Average Daily Dose of studied heavy metals in the in the loamy calcareous soil (cultivation period 10 years)

Exposure way in Egypt	Element -A.D.D ($mg\ kg^{-1}\ day^{-1}$) and H.I.											
	Cd			Co			Pb			Ni		
	A.D.D	H.I		A.D.D	H.I		A.D.D	H.I		A.D.D	H.I	
Soil Adult	6.05E-08	0.000060	Safe	6.51E-06	0.006514	Safe	1.10E-05	0.003133	Safe	1.93E-05	0.000386	Safe
Soil Child	9.45E-07	0.000945	Safe	9.12E-05	0.091200	Safe	1.54E-04	0.043857	Safe	2.70E-04	0.005404	Safe
Wheat Adult	1.71E-04	0.171051	Safe	5.27E-04	0.527409	Safe	9.74E-03	2.782980	Hazard	1.02E-02	0.203361	Safe
Wheat Child - half adult consumption	5.99E-04	0.598680	Safe	1.85E-03	1.845930	Hazard	3.41E-02	9.740429	Hazard	3.56E-02	0.711764	Safe
Wheat Child - quarter adult consumption	2.99E-04	0.299340	Safe	9.23E-04	0.922965	Safe	1.70E-02	4.870214	Hazard	1.78E-02	0.355882	Safe
Maize Adult	2.19E-04	0.219291	Safe	3.05E-04	0.304571	Safe	3.35E-04	0.095722	Safe	4.11E-03	0.082234	Safe
Maize Child -half adult consumption	7.68E-04	0.767520	Safe	1.07E-03	1.066000	Hazard	1.17E-03	0.335029	Safe	1.44E-02	0.287820	Safe
Maize Child - quarter adult consumption	3.84E-04	0.383760	Safe	5.33E-04	0.533000	Safe	5.86E-04	0.167514	Safe	7.20E-03	0.143910	Safe
Soil+Biota Adult	3.90E-04	0.390403	Safe	8.38E-04	0.838494	Safe	1.01E-02	2.881835	Hazard	1.43E-02	0.285981	Safe
Soil+Biota Child -half adult consumption	1.37E-03	1.367145	Hazard	3.00E-03	3.003130	Hazard	3.54E-02	10.119314	Hazard	5.02E-02	1.004988	Hazard
Soil+Biota Child- quarter adult consumption	6.84E-04	0.684045	Safe	1.55E-03	1.547165	Hazard	1.78E-02	5.081586	Hazard	2.53E-02	0.505196	Safe

Note: A.D.D.: Average daily dose **H.I: Hazard index**

Table (30) Calculated Average Daily Dose of studied heavy metals in the in the loamy calcareous soil (cultivation period >20 years)

Exposure way in Egypt	Element -A.D.D (mg kg^{-1} day^{-1}) and H.I.											
	Cd			Co			Pb			Ni		
	A.D.D	H.I		A.D.D	H.I		A.D.D	H.I		A.D.D	H.I	
Soil Adult	8.93E-08	0.000089	Safe	9.98E-06	0.009979	Safe	1.61E-05	0.004606	Safe	2.66E-05	0.000531	Safe
Soil Child	1.39E-06	0.001395	Safe	1.40E-04	0.139700	Safe	2.26E-04	0.064486	Safe	3.72E-04	0.007434	Safe
Wheat Adult	1.95E-04	0.194809	Safe	7.13E-04	0.712714	Safe	1.17E-02	3.334145	Hazard	1.66E-02	0.332600	Safe
Wheat Child - half adult consumption	6.82E-04	0.681830	Safe	2.49E-03	2.494500	Hazard	4.08E-02	11.669509	Hazard	5.82E-02	1.164100	Hazard
Wheat Child - quarter adult consumption	3.41E-04	0.340915	Safe	1.25E-03	1.247250	Hazard	2.04E-02	5.834754	Hazard	2.91E-02	0.582050	Safe
Maize Adult	2.28E-04	0.228429	Safe	4.57E-04	0.456857	Safe	3.62E-04	0.103554	Safe	5.78E-03	0.115554	Safe
Maize Child -half adult consumption	8.00E-04	0.799500	Safe	1.60E-03	1.599000	Hazard	1.27E-03	0.362440	Safe	2.02E-02	0.404440	Safe
Maize Child - quarter adult consumption	4.00E-04	0.399750	Safe	8.00E-04	0.799500	Safe	6.34E-04	0.181220	Safe	1.01E-02	0.202220	Safe
Soil+Biota Adult	4.23E-04	0.423326	Safe	1.18E-03	1.179550	Hazard	1.20E-02	3.442306	Hazard	2.24E-02	0.448685	Safe
Soil+Biota Child -half adult consumption	1.48E-03	1.482725	Hazard	4.23E-03	4.233200	Hazard	4.23E-02	12.096434	Hazard	7.88E-02	1.575974	Hazard
Soil+Biota Child- quarter adult consumption	7.42E-04	0.742060	Safe	2.19E-03	2.186450	Hazard	2.13E-02	6.080460	Hazard	3.96E-02	0.791704	Safe

Note: A.D.D.: Average daily dose **H.I: Hazard index**