4. RESULTS AND DISCUSSION

It is recognized that change in one or more of soil components is usually associated with variations in the morphological, physical and chemical properties of soils. Accordingly, influence of irrigating soils of El-Gabal El-Asfar farm with sewage waters, on morphological, chemical, and physical properties was evaluated.

4.1. Morphological Properties of Soils As Influenced by Irrigation With Sewage Waters:

The variations in morphological features of soil profiles can be detected from the morphological description of the investigated profiles, each of which received sewage water for a distinct period of time (Fig. 3 and Table 1).

The field observation and morphological features of the investigated area are as follows.

Profile No : 1 (not yet put under irrigation)

Location : About 200 m east of the farm.

Land use : Fallow.

Natural vegetation: Alhag; maurorum, Hibiscus canabenus.

Topography : Gently sloping.

Water table: At 130 cm depth.

Depth (cm)	:	Description.
0 - 10	:	Very pale brown (10 YR 7/3, dry) to pale brown (10 YR 6/3, moist), sand , single grain, non sticky, non plastic, few fine to medium gravels, moderate effervescence with HCl, clear smooth.
10 - 40	:	Very pale brown (10 YR 7/4 dry) to yellowish brown (10 YR 5/4, moist), fine sand single grain, non sticky, non plastic, few fine gravels, weak effervescence with HCl,
40 - 130	:	Yellow (10 YR 8/4, moist), sand, single grain, non sticky, non plastic, few mottling, weak effervescence with HCl, diffuse smooth.

Profile No	:	2 (irrigated with sewage water for 5 years)
Location	:	About 2 Km Eastern North field No 21 which was represented by profile No. 3.
Land use	:	Field crops (Trifolium Alexandrinum).
Natural vegetation	:	Chenopodium Botrys, Hibiscus Canabenus.
Topogrophy	:	Gently sloping.
water table	:	At 90 cm depth.
Depth (cm)	:	Description.
0 - -10	:	Yellowish brown (10 YR 5/4, moist), fine sand, single grain, friable, non sticky, non plastic, many fine to coarse healthy

		roots, few fine to medium gravels, weak effervescence with HCl, abrupt smooth.
10 - 20	:	Brown (10YR 5/3, moist), fine sand, single grain, friable non sticky, non plastic, moderate fine to medium healthy roots, weak effervescence with HCl, clear smooth.
20 - 50	:	Light yellowish brown (10 YR 6/4, moist), sand, single grain, non sticky, non plastic, very friable, few fine healthy roots, weak effervescence with HCl, clear smooth.
50 - 90	:	Pale brown (10 YR 6/3, moist), sand, single grain, non sticky non plastic, very friable, moderate effervescence with HCl, few soft carbonate concretion.

Profile No. : 3 (irrigated with sewage water for ten years)

Location : Field No, 21.

Land use : Caria pecana, Citrus sp.

Natural Vegetation: Datura, Malva parivflora,

Topogrophy : Gently sloping.

Water table : At 90 cm depth.

Depth (cm)	:	Description.
0 - 30	:	Dark brown (10 YR 3/3, moist), fine sand, dark spots of humified materials, single grain, nom sticky, non plastic,many fine to coarse healthy roots, slightly efferve-scence with HCl, abrupt smooth.

30 - 60 : Brown (10 YR 5/3 moist), fine sand, single grain, very friable, non sticky, non plastic, moderate fine to coarse healthy roots, few fine to medium gravels, slightly effervescence with HCl, clear smooth.

60 - 90 : Brown (10 YR 5/3, moist), fine sand, single grain, very friable, non sticky, non plastic, few fine healthy roots, few fine to coarse gravels, slightly effervescence with HCl.

Profile No, : 4 (irrigated with sewage water for 20 years)

Location : Field No, 3.

Land use : Citrus sinences

Natural vegetation: Datura, Hibiscus Canabenus,

Topogrophy : Gently sloping

Water table : Not detected.

Depth (cm) : Description

0 - 10 : Dark brown (10 YR 4/3 moist), loamy sand, dark spots humified materials, single grain, very friable, non sticky, non plastic, many fine to coarse healthy roots, slightly effervescence with HCl, few medium decayed roots, diffuse smooth.

10 - 40 : Yellowish brown (10 YR 5/6 moist), fine sand, single grain, non sticky, non plastic, many fine to coarse healthy roots, slightly

effervescence with HCl diffuse smooth.

40 - 150 : Very pale brown (10 YR 7/4 moist), fine sand, single grain, very friable, non sticky, non plastic, few fine dead roots, slightly effervescence with HCl.

Profile No, : 5 (irrigated with sewage water for 30 years)

Location : Field No, 96.

Land use : Neval citrus sinences.

Natural vegetation: Hibiscus conabenus, lolium temulentum.

Topogrophy : Gently sloping.

Water table : Not detected.

Depth (cm) : Description.

0 - 35 : Very dark grayish brown (1oYR 3/2 moist), loamy sand, dark spots of humified materials, friable, single grain, non sticky, non plastic, many fine to coarse healthy roots, slightly effevescence with HCl, abrupt smooth.

35 - 80 : Brown (7.5 YR 5/4 moist), fine sand, few fine to coarse gravels, single grain, non sticky, non plastic, moderate fine to medium healthy or dead roots, slightly effervescence with HCl, abrupt smooth.

80 - 150 : Light yellowish brown (10 YR 6/4 dry), to yellowish brown (10 YR 5/4 moist), fine sand, moderate fine to coarse gravels, massive, non sticky, non plastic, slightly effervescence with HCl.

Profile No.	:	6 (irrigated with sewage water for 40 years)
Location	:	Field No, 105.
Land use	:	Neval citrus sinences.
Natural vegetation:		Datura, syperas sp.
Topogrophy	:	Gently sloping
Water table	:	Not detected.
Depth (cm)	:	Description
0 - 10	:	Dark brown (10 YR 3/3 moist), Loamy sand, dark spots of humified materials, friable, single grain, non sticky non plastic, many fine to coarse healthy roots, slightly effervescence with HCl, abrupt smooth.
10 - 30	:	Dark brown (10 YR 3/3 moist), fine sand, moderate fine to coarse.gravels, single grain, non sticky, non plastic, many fine to coarse healthy roots, slightly effervescence with HCl, clear smooth.
30 - 70	:	Brown (7.5YR 5/4 moist), fine sand, single grain, non sticky, non plastic, few fine lime, moderate fine healthy or dead roots, moderate effervescence with HCl, clear smooth.
70 - 150	:	Brown (10 R 5/3 moist), sand, friable,single grain, non sticky, non plastic, moderate fine $CaCO_3$ concertion, strong effervescence with HCl.

Profile No, : 7 (irrigated with sewage water for 50 years).

Location : Field No, 73.

Land use : Guava, orange, Movus alla.

Natural vegetation: Hibiscus canabenus, cynodon daclylan

Topography : Gently sloping.

Water table : Not detected.

Depth (cm)	:	Description.
0 - 25	:	Brown (10YR 4/3 dry), to dark brown (10YR3/3 moist), loamy sand, dark spots of humified materials, single grain, friable, non sticky, non plastic, many fine to coarse healthy roots, slightly effervescence with HCl, abrupt diffuse.
25 - 65	:	Brown (7.5 YR 5/4 moist), fine sand, single grain, friable, non sticky, non plastic, moderate fine to medium healthy roots, moderate lime concertion, moderate effervescence with HCl, clear smooth.
65 - 150	:	Yellowish brown (10YR 5/4 moist), fine sand, single grain, friable, non sticky, non plastic, highly fine lime concertion, strong effervescence with HCl, few fine to coarse gravels.

4.2. PHYSICAL PROPERTIES OF SOILS AS INFLUENCED BY IRRIGATION WITH SEWAGE WATERS .

4.2.1. PARTICLE SIZE DISTRIBUTION:

The effects due to irrigation with sewage waters for different time periods on particle size distribution of EL Gabal EL-Asfar soils are shown in table (3) and Fig (1). From the results obtained, it is clear that before application of sewage water (control treatment), the soils were sandy in texture through all the different layers of the profile. Also, irrigating these soils with sewage water for 5 and 10 years, materially did not affect the soil texture . However, the changes in texture of the surface soils began to be obvious and shifted to loamy sand in those soils watered with sewage water for 20 years or more. The percentage of clay in surface layers gradually increased from 1.3 in untreated soil up to 3.4 in those irrigated with sewage water for 30 years. Such changes are quite limited to the surface layer and practically no textural changes were observed in the sub-surface layer due to sewage water usage.

4.2.2. Bulk DENSITY :

Table (3) and Fig (2) show the bulk density of El-Gabal El-Asfar soil under various periods of irrigation with sewage water. Itis noticed that bulk density of the unirrigated soil ranged between 1.63 and 1.66 g/cm^3

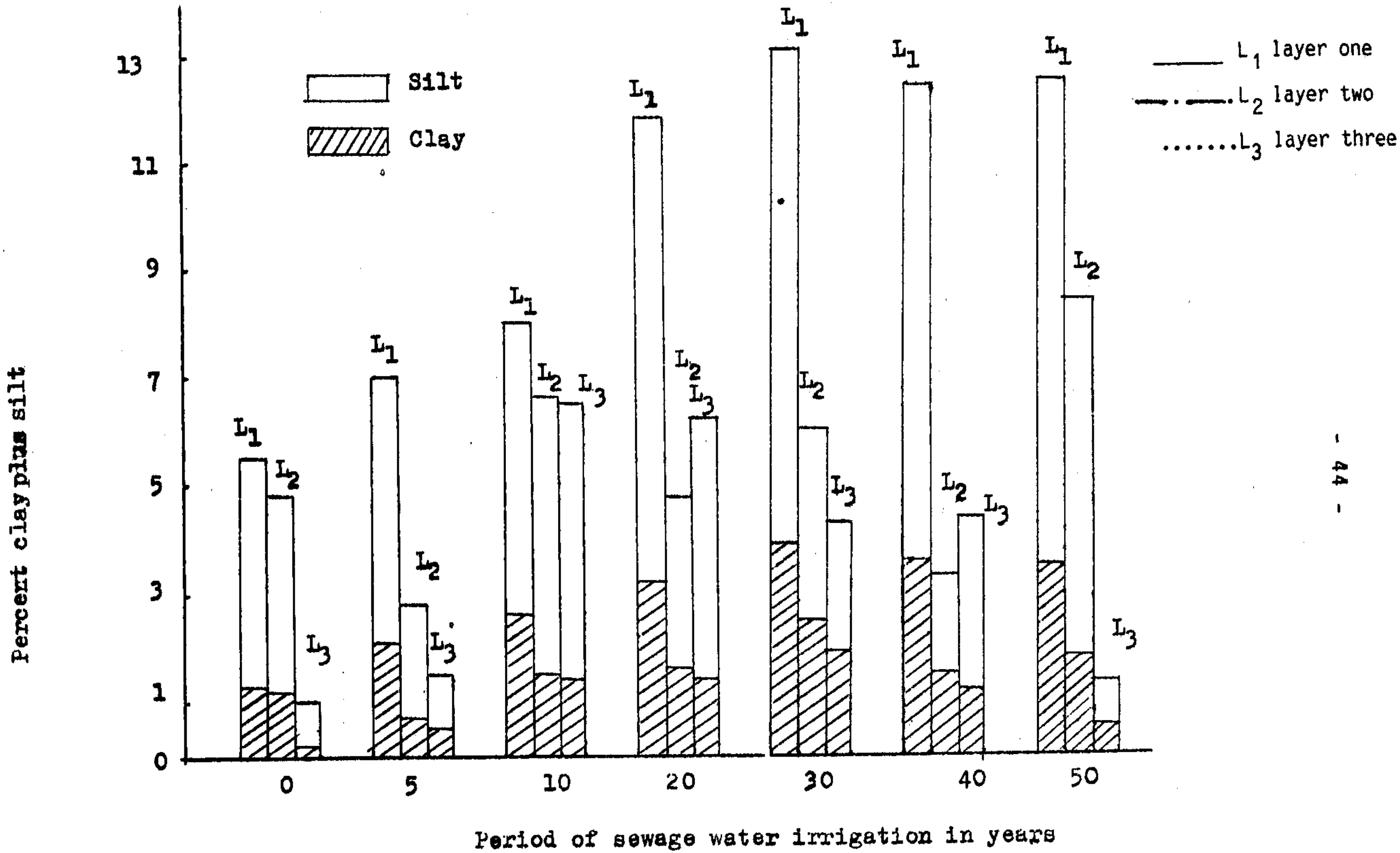

Fig.(1): Distribution of clay and silt of the different layers of El-Gabal El-Asfar soils.

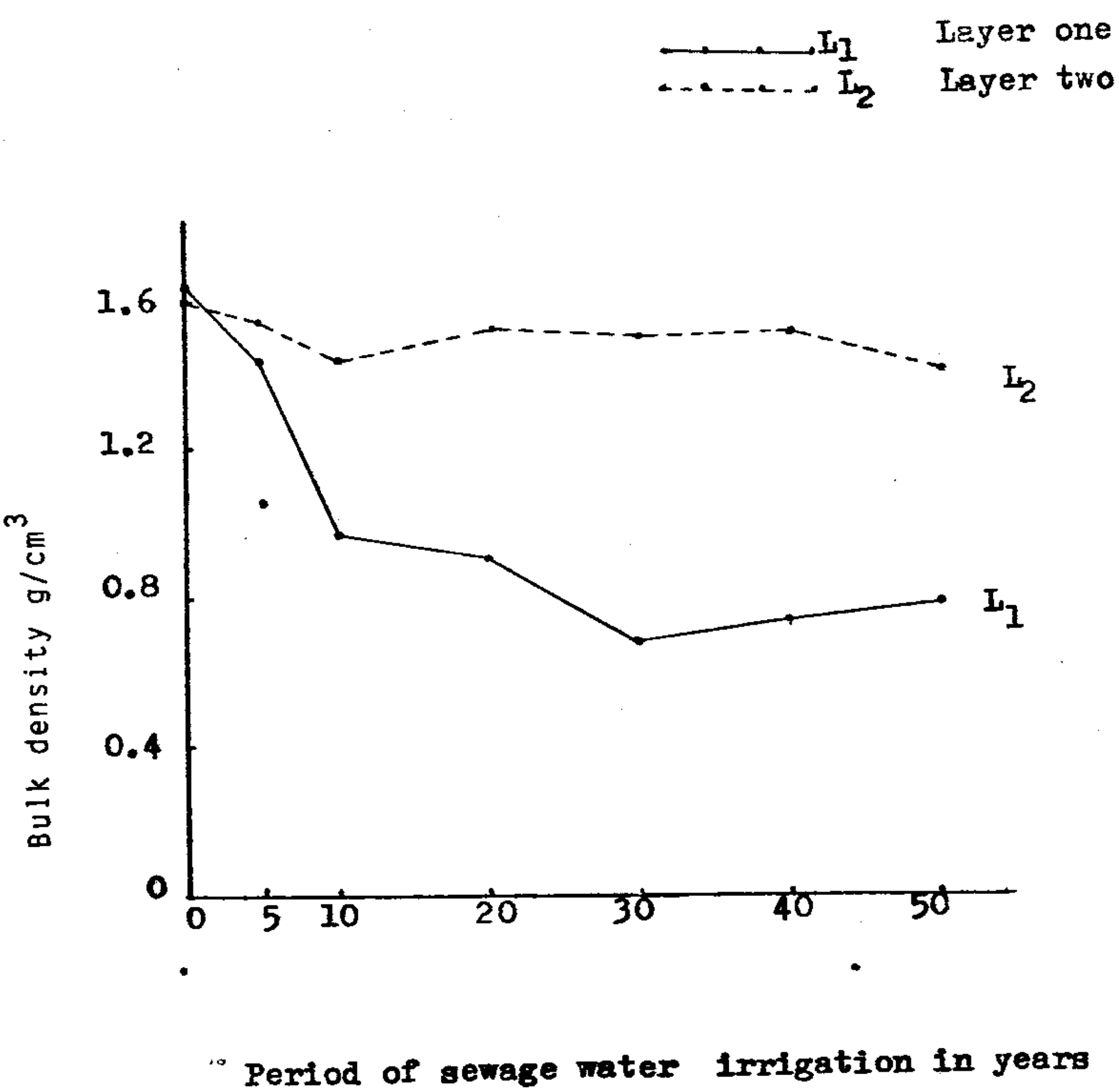

Fig. (2): Bulk density of soil layers of El-Gabal El-Asfar Soils.

in the different layers of the profile.

Prolonging period of irrigation with sewage water up to 30 years led to a gradual decrease in the bulk density specially in the surface layers. This decrease of bulk density could be mainly due to the increase in organic material carried to the soil in sewage water. This is in agreement with Webber (1979) who found that bulk density of soil decreased as increment of solid waste was added.

The bulk densities of the subsurface layers were generally higher than those of the surface ones. Their values ranged between 1.45 and 1.6 g/cm^3 and are comparable to the control soils (1.3-1.6 g/cm^3).

On the other hand, bulk densities of the soils irrigated for 40 or 50 years with sewage water were slightly higher than the corresponding values of the soils which were irrigated for only 30 years, but were still lower than those of the unirrigated soil. This increase in the bulk density may be refered to the compaction that could have resulted as a consequence of the prolonged usage of these soils.

Table (3): Particle size distribution, total soluble salts, Ca CO_3, organic matter and bulk density as influenced by sewage water use

Period of irrigation with sewage water (in years)	profile No,	soil Depth (cm)	T.S.S %	$CaCO_3$ %	O.M %	Bulk density G/cm_3	Sand % coarse	Sand % fine	Silt %	Clay %	Soil texture
0	1	0-10	0.2	0.9	0.06	1.66	70	23.4	4.2	1.3	Sandy
		10-40	0.16	0.1	0.05	1.65	30	65	3.6	1.2	"
		40-130	0.05	0.1	0.03	1.63	61.35	37.45	0.8	0.2	
5	2	0-10	0.08	0.1	1.34	1.37	21.5	70	4.8	2.1	Sandy
		10-20	0.02	0.2	0.33	1.58	27	69.75	2.	0.8	"
		20-50	0.03	0.2	0.30	1.53	80.85	17.15	1.	0.5	"
		50-90	0.03	0.6	0.13	1.56	70.9	27.1	1.1	0.1	"
10	3	0.30	0.11	0.2	3.16	0.93	20.4	70	5.4	2.6	Sandy
		30-60	0.02	0.1	0.20	1.45	23.65	69.35	5.1	1.5	"
		60-90	0.02	0.4	0.21	1.55	18.5	74.15	5.1	1.4	
20	4	0-10	0.15	0.1	3.89	0.9	20	63	9.6	3.2	Loamy sand
		10-40	0.30	0.4	0.32	1.54	20.25	74.2	3.2	1.6	Sandy
		40-150	0.03	0.2	0.13	1.6	9.65	83.75	4.8	1.4	"
30	5	0-35	0.1	0.5	4.53	0.69	36.1	45.75	9.22	3.9	Loamy sand
		35-80	0.03	0.6	0.29	1.54	14.25	78.8	3.5	2.5	Sandy
		80-150	0.03	0.2	0.26	1.54	33.85	61.25	2.5	1.9	"

Table (3).(Cont)

40	6	0-10	0.08	0.2	4.24	0.74	28.1	55	8.8	3.6	Loamy sand
		10-30	0.03	0.2	0.91	1.5	26.1	70	1.8	1.5	Sandy
		30-70	0.02	0.9	0.29	1.6	20	74.4	3.2	1.2	"
		70-150	0.02	3.2	0.23	1.5	45	50.4	0.2	0.1	"
50	7	0-30	0.06	0.2	3.22	0.79	25	59	9	3.5	Loamy sand
		30-60	0.03	1.2	0.36	1.41	147	76.9	6.6	1.8	Sandy
		60-150	0.02	4.4	0.35	1.4	22.1	72.3	0.8	0.5	"

4.3- CHEMICAL PROPERTIES OF SOILS INFLUENCED BY IRRIGATION WITH SEWAGE WATER :-

4.3.1. ORGANIC MATTER :-

Data presented in table (3) and Fig (3) revealed a considerable accumulation of organic matter in soil profiles due to application of sewage water. This accumulation was pronounced in the soil surface layer than in the subsurface ones. This is probably because the sewage water contains appreciable amounts of rather coarse and hardly decomposable materials, which upon application was deposited on the surface layer and the relatively decomposable and fine parts pass to the subsurface layers. This finding is in agreement with those of Abdel Baqi (1973) and El-Gamal (1980).

Generally, increasing time of sewage application up to 30 years resulted in an enormous increase in organic material content of the soil. However, increasing time of application beyond 30 years and up to 50 years slightly decreased the soil content of organic material. Such behaviour is agreeable with the results obtained by El-Gamal (1980) and may be attributed to the enhanced decomposition of such organic materials due the increased activity of the different types of soil microbes.

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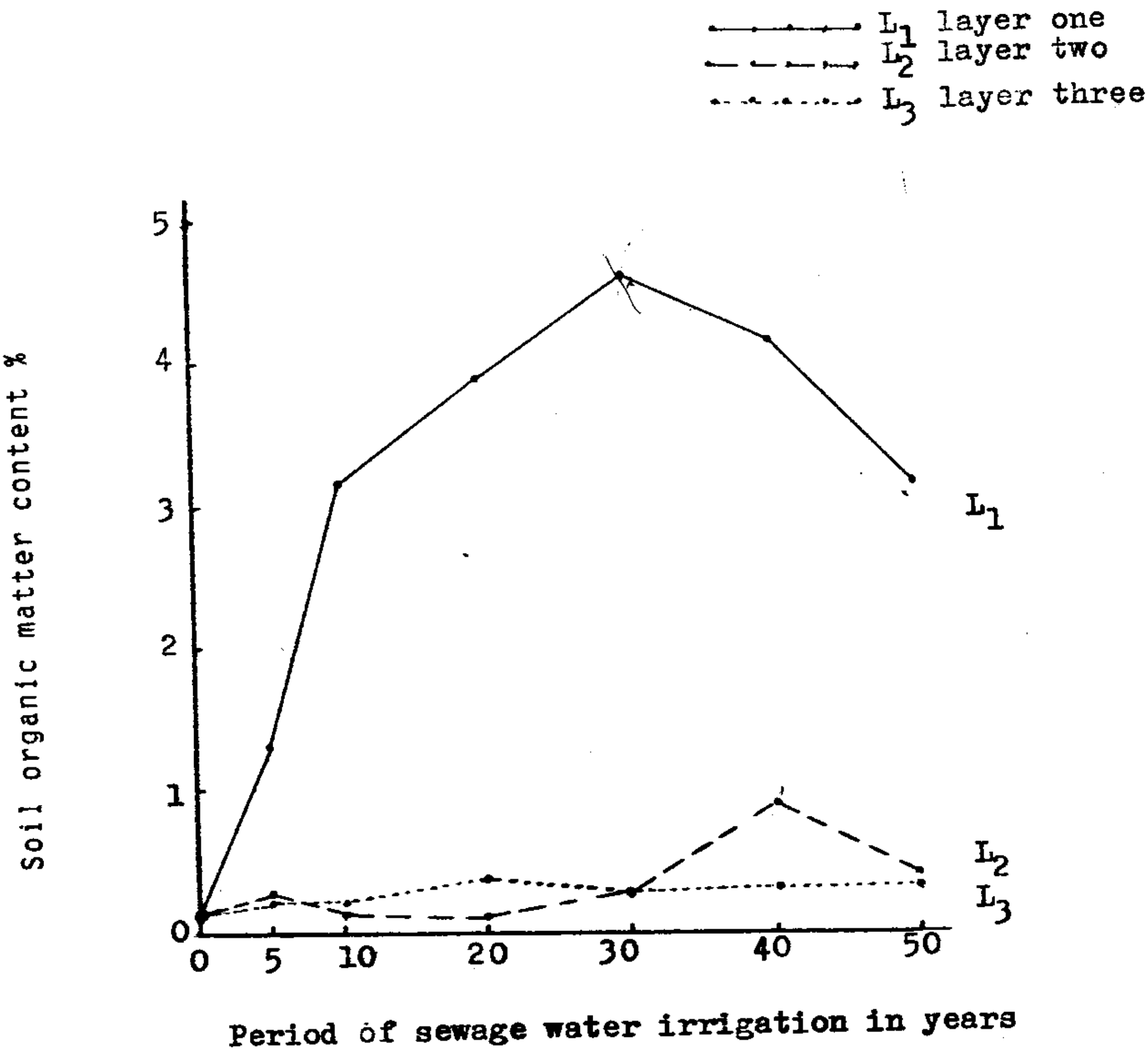

Fig.(3): Organic matter content of the different layers of El-Gabal El-Asfar Soils.

4.3.2. SOIL CALCIUM CARBONATE :-

The values of calcium carbonate content of the soil irrigated for different periods with sewage water are shown in table (3). It is quite clear that prolonging period of application of sewage water upto 50 years affected slightly the calcium carbonate content of almost all the soil layers. No constant trend, however, could be noticed in this concern. Such an effect may be attributed to precipitation of Ca as Ca CO_3 through reaction between biologically produced CO_2 and soluble Ca in the soil solution. This conclusion could be confirmed by the marked decrease in soil content of soluble Ca (table 4) which could not be attributed only to the leaching effect but also, as mentioned above, to its precipitation as Ca CO_3.

4.3.3. SOIL REACTION (p^H):

The data presented in table (4) and Fig (4) show that pH values of the soils treated with sewage water for different periods of time were lower than the corresponding ones of the unirrigated soils specially in surface layers. These results are in agreement with those obtained by El-Gamal (1980). Such decrease in pH values could be attributed partially to the production of CO_2 produced as a result of decomposition of organic residues through microbial activity and also to the organic and inorganic acids introduced into the soil

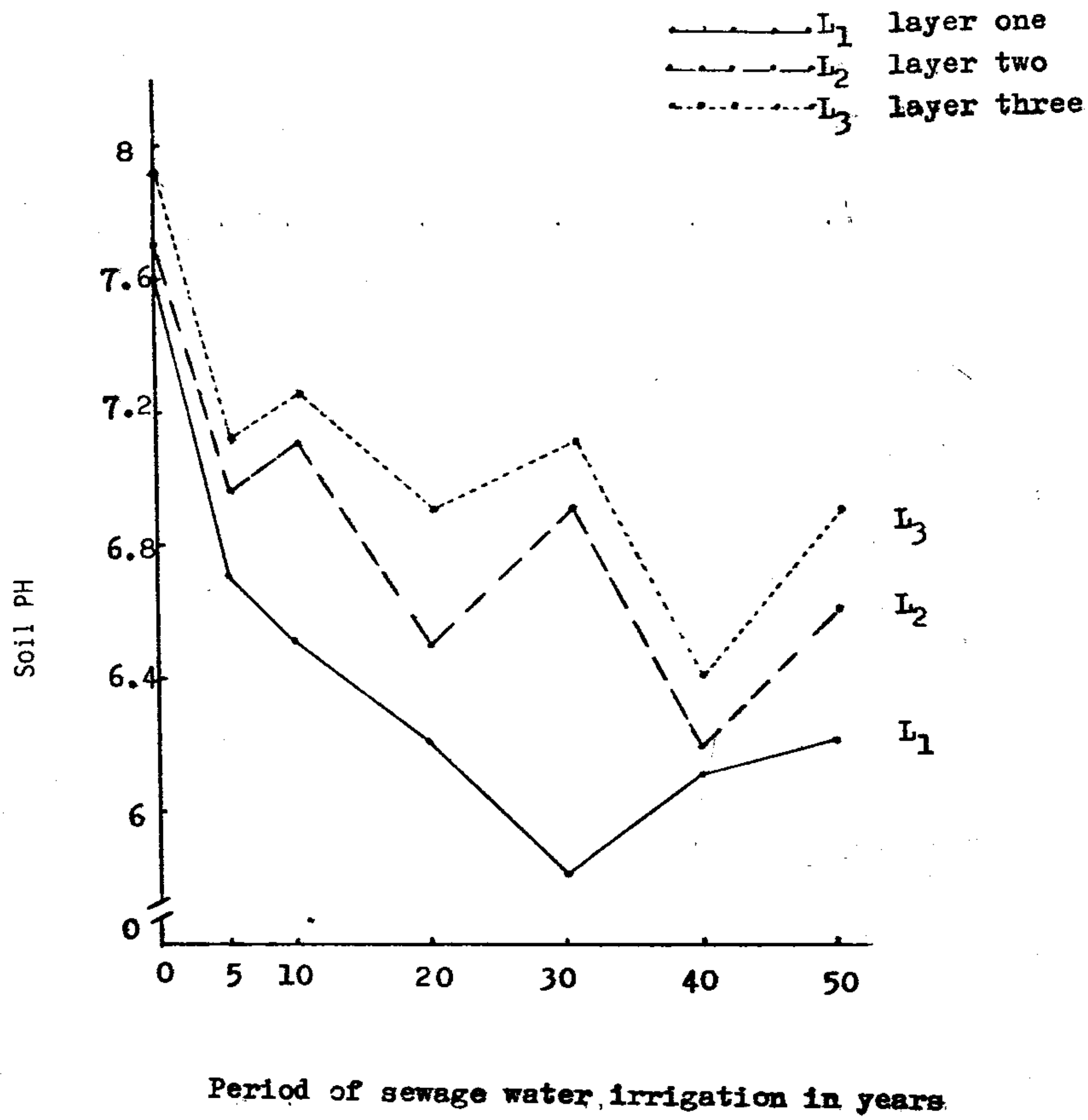

Fig. (4): pH values of the different layers of El-Gabal El-Asfar Soils.

system through the decomposition processes (Bouwer and Chaney 1974).

Considering the distribution of the organic matter (table3) through the soil profiles, a relation between pH and organic matter centent that the tendency could be drawn, layers of higher content of orgnic matter persisted to show lower values of pH. Such negative relation can be noticed clearly upon comparing the values of the surface layers with those of lower ones.

4,3,4 ELECTRICAL CONDUCTIVITY (E.C).

Data in table (4) and Fig (5) show that continuous irrigation with sewage water decreased soil salinity as reflected on EC of soil extracts. This decrease was more pronounced by prolonging period of application was of sewage water, mostly due to the increased leaching of salts out from the soil profile .

Salinity was, generally, higher in the surface layers than the layers below. This may be due to the reverse upward movement of soil solution during intervals between the successive irrigations, and evaporation of water from this solution in the surface layer leading to accumulation of salts.

However, comparing values of EC of the surface layers of the untreated soil which was about 14.98 mm hos/Cm/25 $^{\circ}$C

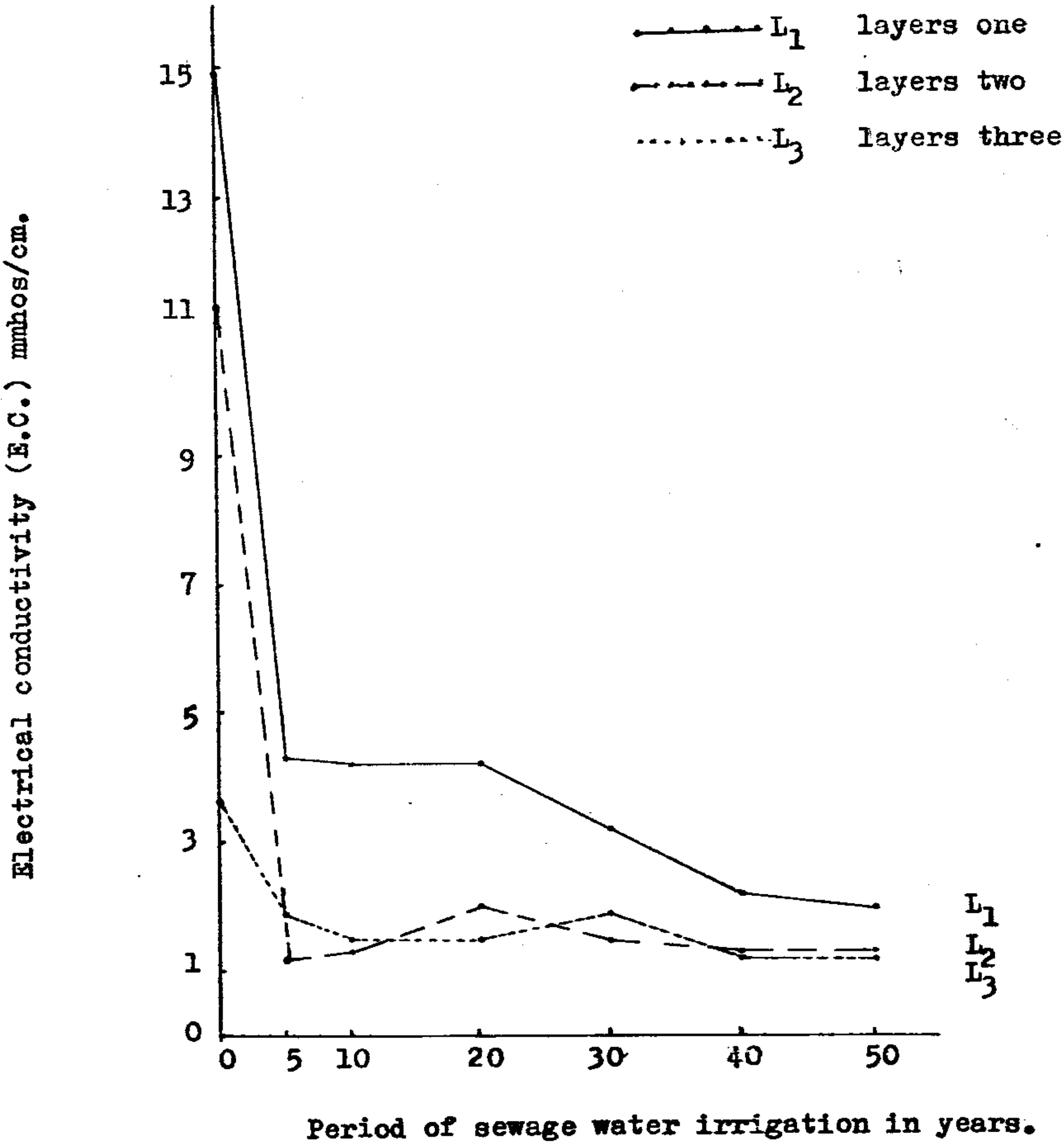

Fig. (5): Electrical conductivity of the different layers of El-Gabal El-Asfar Soils.

with that of the applied sewage water which is about 1.12 mmhos /cm /25°C may give an indication to the possibility of using sewage waters for leaching out the soluble salts from such salt affected sandy soils. Note-worthy, in this regard, to mention that using sewage waters for irrigating the investigated soils diminished EC values oftheir surfaces to about one third of their initial levels after 5 years of irrigation only.

4.3.5 SOLUBLE CATIONS AND ANIONS:

Data in table (4) and Fig (6) show soil contents of soluble cations and anions through the different layers of soil profiles due to the successive irrigation with sewage water for different periods. It is obvious that irrigation with sewage water, generally, decreased soil contents of soluble Ca, Mg, Na, and K through leaching these cations out of the profile. However, Ca and Na were found in the different layers in relatively higher amounts than Mg and K. This may be due to the presence of Ca and Na in the sewage water, which is considered not only as a leaching agent but also as a source of resupplying soil with soluble ions, in higher concentrations than Mg and K.

The ascending decrease in soil content of soluble cations as a result of prolonging period of irrigation is expected since

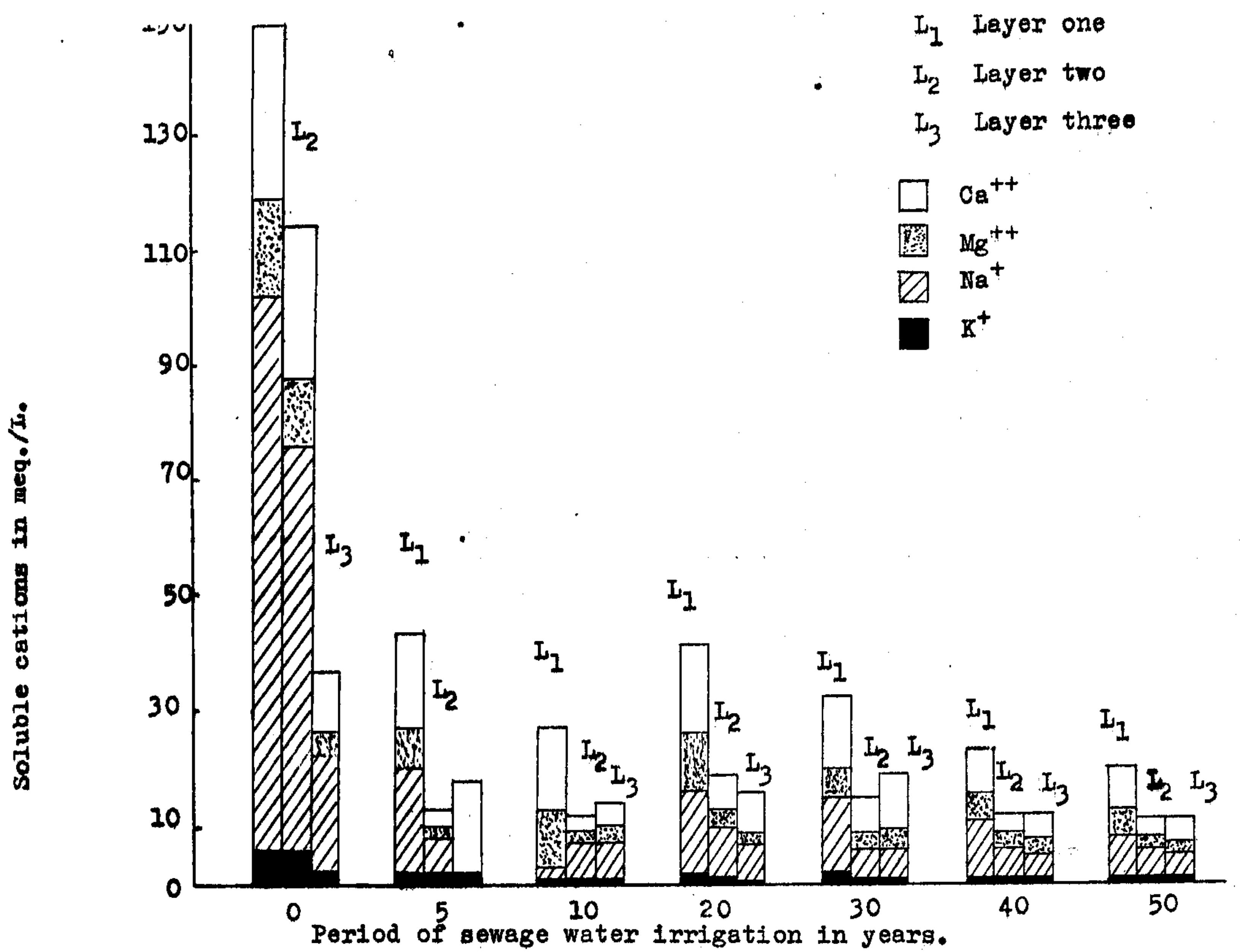

Fig.(6): Distribution of soluble cations of the different layers of El-Gabal El-Asfar Soils.

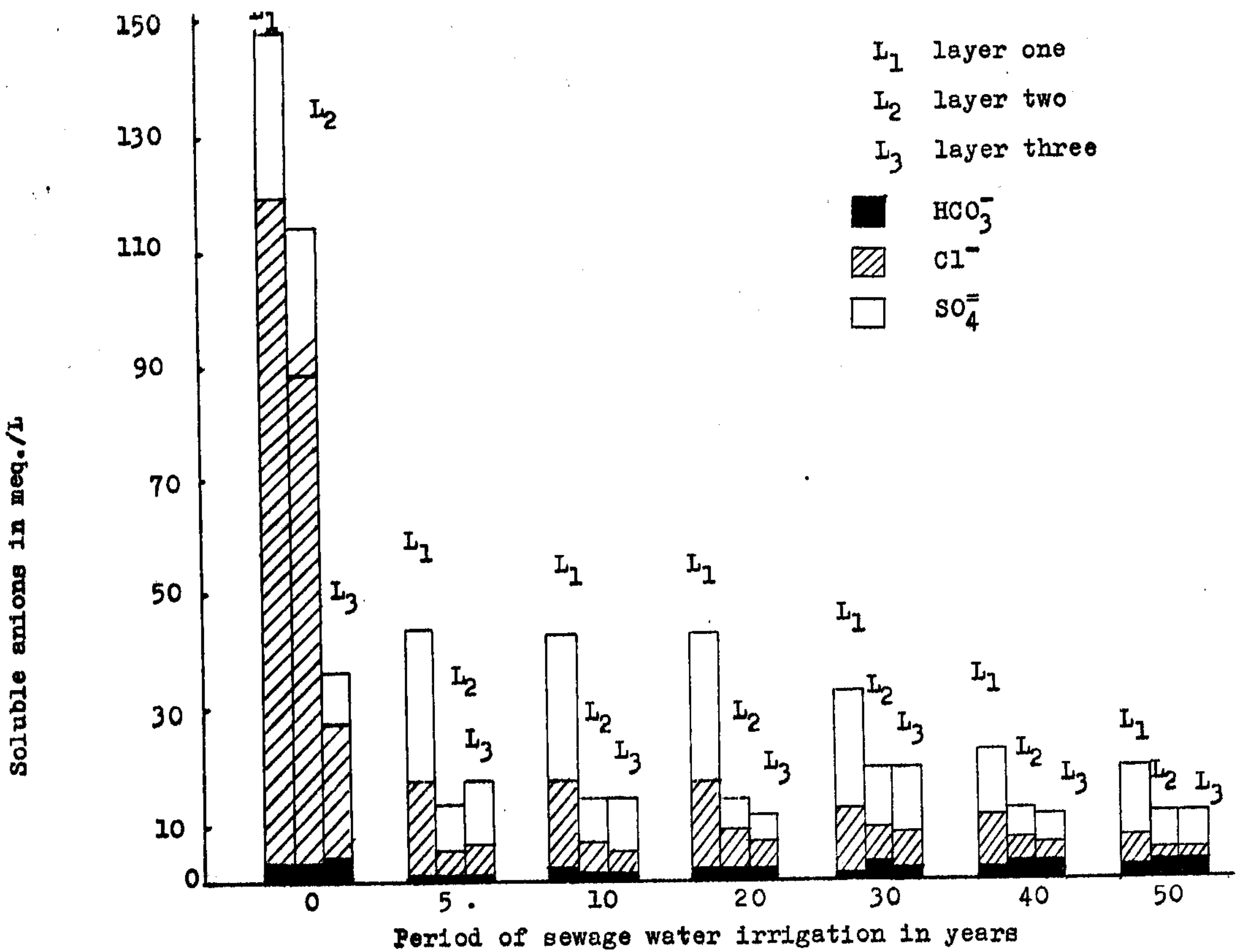

Fig. (7): Distribution of soluble anions of the different layers of El-Gabal El-Asfar soils.

more applications of sewage water means more leaching and more loss of these cations out of the soil profiles.

Distribution of soluble cations through the soil profiles followed a pattern similar to that of soluble salts, i.e. highest in the upper layers and lowest in the bottom ones.

Concerning the anionic composition of the investigated soil, the data in table (4)and Fig (7) reveal that using sewage water for irrigating soil decreased its contents of soluble HCO_3, Cl, and SO_4. However, sulfate was the predominant anion followed by chloride and bicarbonate while carbonate was not found in any detectable concentration. The predominancy of sulfate may be attributed to oxidizing organic sulfur in the sewage water through mineralization process into sulfate as a final product, as reported by Alexander (1961).

From the aforementioned discussion we may conclude that the dominant salts in the studied soil are sodium sulfate followed by sodium chloride and calcium and magnesium sulfates.

4.3.6. CATION EXCHANGE CAPACITY (C.E.C):

Effect of irrigation with sewage waters for different periods on cation exchange capacity is shown in table (4) and Fig (8).

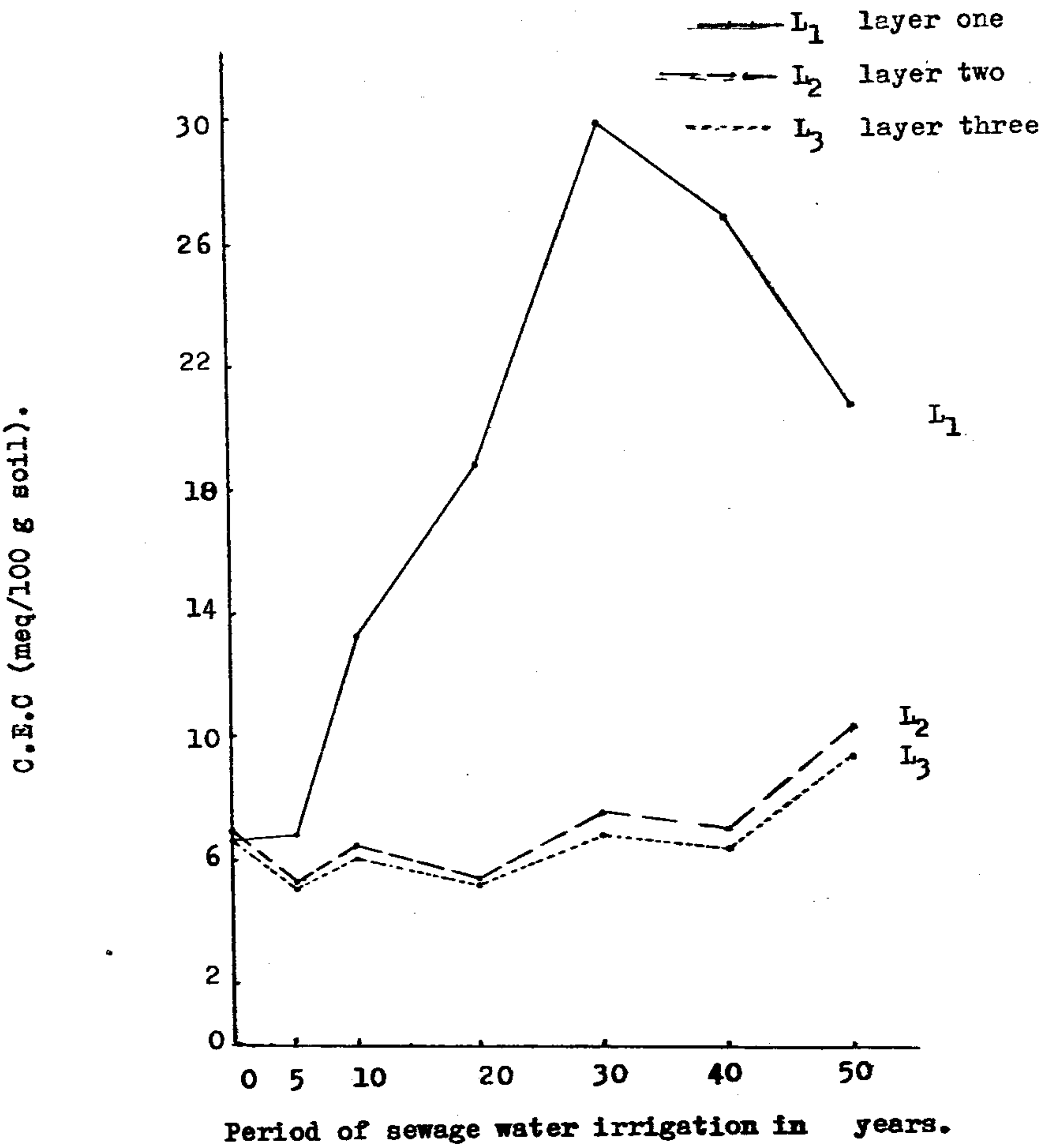

Fig.(8): Cation Exchange Capacity of the different layers of El-Gabal El-Asfar Soils.

Data clearly show that, the cation exchange capacity of the untreated soils (control) ranged between 6.22 and 6.63 meq/100 g soil. Irrigation with sewage water was associated with an increase in cation exchange capacity of soil, especially, in surface layers where it ranged between 6.7 and 29.9 meq/100 g soil. This increase in cation exchange capacity could be mainly attributed to the increase in soil content of organic matter of relatively high cation exchange copacity. These results agree with those of El-sayed (1975) who reported that in sandy soils the organic fraction was found to furnish about 55% of the total exchange capacity inspite of its presence in small amounts.

However, cation exchange capacities of the subsurfce layers were affected to a lesser extent by irrigating soils with sewage waters where they ranged between 5 and 10.4 meq/100g soil. Such limited effect is expected due to the poverty of the subsurface layers in both organic matter and clay.

4.3.7. EXCHANGEABLE CATIONS:

Data of exchangeable cations as affected by irrigation with sewage water for different periods are shown in table (4) and Fig (9). It is quite clear that continuous irrigation with sewage water was associated

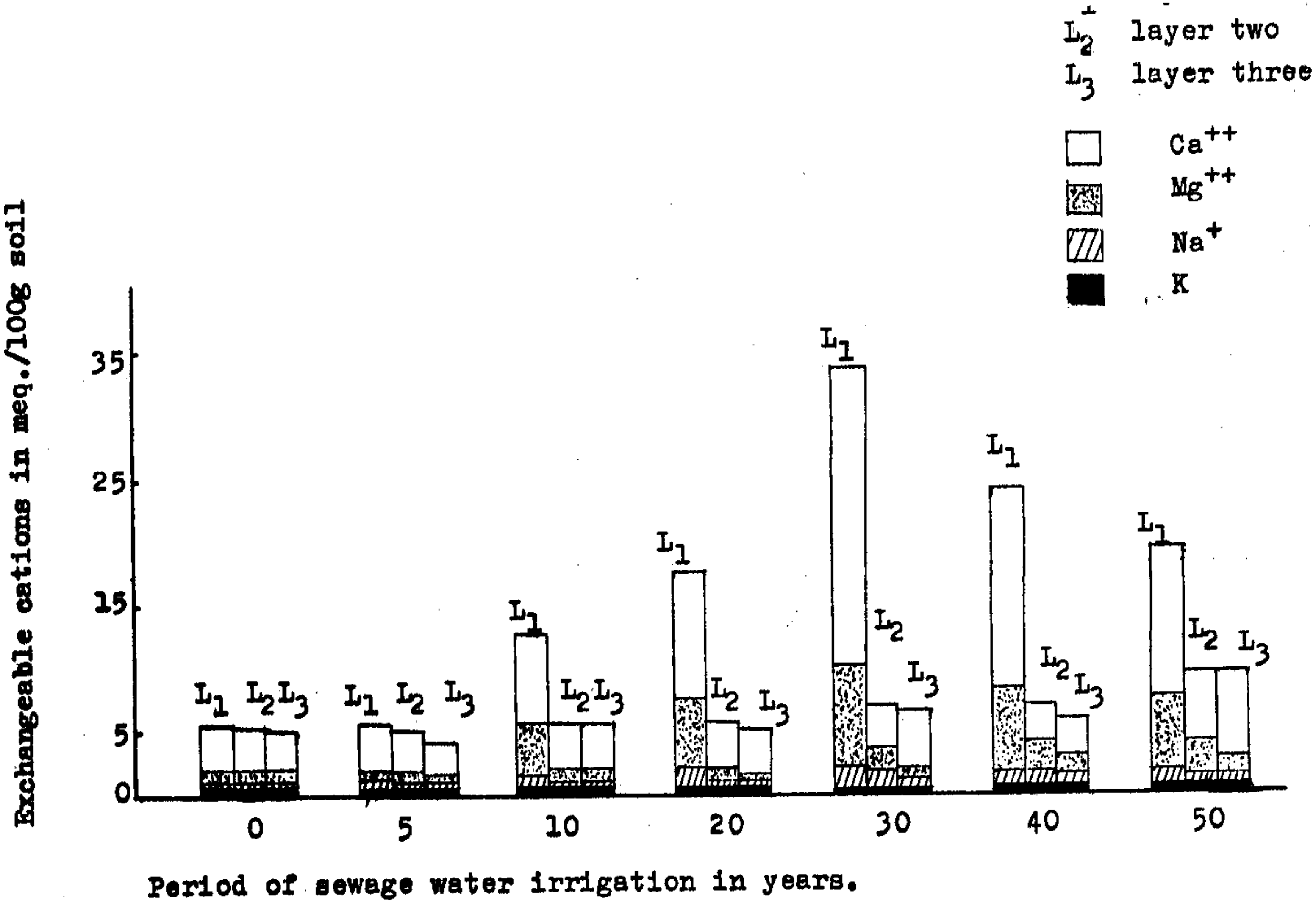

Fig. (9): Distribution of exchangeable cations of the different layers of El-Gabal El-Asfar Soils.

with an increase in exchangeable cations especially in surface layers of profiles. In subsurface layers, exchangeable cations (at all periods) slightly changed but values were still over those of control treatment. Generally, it is revealed that exchangeable Ca and Mg dominated the exchangeable cations compared with Na and K. This could be attributed to the higher affinity of the investigated soils for Ca and Mg than Na and K. Such conclusion is in agreement with those of Balba (1971) and Abbas (1985).

Also, it is shown from data in table (4) that prolonging period of irrigation with sewage water increased soil content of exchangeable cations, specially in the surface layers, due to the increase in capacity of these layers for exchanging cations and as a result of increasing their contents of fine particles, both organic and inorganic.

According to the aforementiomed discussion it is conculded that continuous application of sewage waters was, generally, associated with an increase in organic materials and clay fraction which led consequently to increase the cation exchange capacity, exchangeable cations and availability of macro and micro nutrients. However, using sewage waters for a long time led to a decrease in electrical conductivity, pH, and bulk density.

Table (4): Some chemical characterstics of the investigated soil profiles of El-Gabal El-Asfar

Period of irrigation with sewage water (in years)	Profile No.	Depth cm	S.P	pH	E.C mmhos/cm at 25°C	C.E.C meq/100 g soil	Soluble ions in saturation extract: Anions (meq/L) $CO_3^{=}$	HCO_3^-	Cl^-	$SO_4^{=}$	Cations (meq/L) Ca^{++}	Mg^{++}	Na^+	K^+	Exchangeable cations as (meq./100g soil) Ca	Mg	Na	K
0	1	0 - 10	20.7	7.6	14.98	6.5	-	2.25	117.2	30.33	30.49	16.79	96.75	5.75	4.71	1.3	0.25	0.2
		10 - 40	22.3	7.7	11.48	6.63	-	2.5	85.78	26.32	27.89	11.81	69.15	5.75	4	1.07	0.85	0.18
		40 -130	21.1	7.9	3.6	6.22	-	3.78	22.56	9.98	9.65	3.91	20.61	1.85	4.09	0.95	0.52	0.17
5	2	0 - 10	28.1	6.7	4.29	6.7	-	1.5	15.64	25.79	15.82	6.86	19.0	1.25	4.2	1.33	0.29	0.34
		10 - 20	26.0	6.95	1.33	5.2	-	1.53	3.76	8.21	3.08	2.22	7.05	1.15	4.1	0.53	0.2	0.18
		20 - 50	27.3	7.1	1.85	5.0	-	1.25	4.21	13.02	6.66	4.32	6.35	1.15	3.16	0.95	0.33	0.1
		50 - 90	24.3	7.3	1.92	5.2	-	0.92	5.2	12.89	6.85	4.48	6.56	1.12	3.0	1.8	0.13	0.14
10	3	0 - 30	40.8	6.5	4.2	13.1	-	1.8	15.18	24.82	15.7	10.0	15.0	1.1	6.62	4.4	0.99	0.49
		30 - 60	23.3	7.1	1.27	6.3	-	1.25	5.58	5.84	3.61	2.06	6.5	0.5	4.06	1.35	0.34	0.31
		60 - 90	23.7	7.25	1.42	6.02	-	1.5	5.25	7.45	4.2	3.0	6.2	0.8	4.31	1.01	0.48	0.19
20	4	0 - 10	55.0	6.2	4.2	18.92	-	2.3	15.21	24.3	15.08	10.01	14.7	2.02	10.06	5.5	1.29	0.69
		10 - 40	26.3	6.5	1.95	5.4	-	2.27	6.4	10.63	6.7	2.58	9.0	1.02	4.0	1.21	0.1	0.19
		40 -150	23.3	6.9	1.66	5.33	-	1.75	4.88	9.7	7.46	1.82	6.7	0.35	3.6	1.09	0.13	0.18
30	5	0 - 35	47.7	5.8	3.19	29.9	-	1.25	10.63	20.0	11.94	4.84	13.4	2.0	17.22	9.29	1.53	0.8
		35 - 80	29.0	6.9	1.54	7.59	-	1.5	6.86	9.99	6.99	1.82	6.2	0.35	3.41	2.52	0.75	0.52
		80 -150	25.7	7.1	1.94	6.92	-	2.23	6.76	10.21	9.81	2.93	5.98	0.48	4.62	1.48	0.39	0.2

Table (4): Some chemical characterstics of the investigated soil profiles of El-Gabal El-Asfar

Period of irrigation with sewage water (in years)	Profile No.	Depth cm	S.P	pH	E.C mmhos/cm at 25°C	C.E.C meq/100 g soil	Soluble ions in saturation extract: Anions (meq/L)				Cations (meq/L)				Exchangeable cations as (meq/100g soil)			
							$CO_3^{=}$	HCO_3^-	Cl^-	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^+	K^+	Ca	Mg	Na	K
40	6	0-10	58.5	6.1	2.24	26.4	-	1.75	8.46	12.57	6.42	5.5	9.9	0.96	16.69	6.36	0.89	0.8
		10-30	36.3	6.2	1.2	7.54	-	2.35	4.7	4.93	3.99	2.55	5.26	0.18	3.2	2.56	0.97	0.47
		30-70	27.3	6.4	1.18	6.2	-	2.75	4.58	4.44	3.36	3.23	5	0.18	2.88	2.06	0.63	0.23
		70-150	21.7	6.6	1.26	8.7	-	2	3.52	7.07	3.28	2.68	6.3	0.33	4.2	2.69	1.08	0.23
50	7	0-30	46.5	6.2	1.98	20.6	-	1.5	6.1	12.0	6.56	4.99	7.2	0.85	11.92	6.35	0.69	0.68
		30-60	35.0	6.6	1.12	10.4	-	2.5	2.21	6.46	2.87	2.52	5.4	0.38	5.18	3.26	0.58	0.47
		60-150	31.7	6.9	1.1	9.7	-	2.5	2.58	5.89	3.38	2.46	4.8	0.33	6.71	1.64	0.34	0.31

4.4. STATUS OF THE NUTRIENTS IN EL-GABAL EL-ASFAR SOILS:

4.4.1. MACRO NUTRIENTS:

4.4.1.1. Nitrogen:

The values of soluble nitrogen in soils as affected by continuous irrigation with sewage waters are presented in table (5) and illustrated in Fig, (10) Data reveal that irrigation with sewage water for 10 years increased slightly soils content of the soluble nitrogen, while it was markedly increased with the successive irrigation up to 30 years. This result is in agreement with those obtained by Lunt (1953). Ramati and Mor (1966), Webber (1963), and El-Gamal (1980). However, the magnitude of soluble nitrogen increase tended to be diminished gradually with prolonging the irrigation period beyond 30 years.

The increase in soil content of soluble nitrogen is a direct result of applying sewage water, which contained about 48 ppm of soluble nitrogen, into the soil..The organic matter in the soil is another additional and important source for providing soil with soluble nitrogen through mineralization of the organic nitrogen which form about 5% of the organic matter itself. Consequently, surface layers contained higher amounts of soluble nitrogen than the layers below since soil

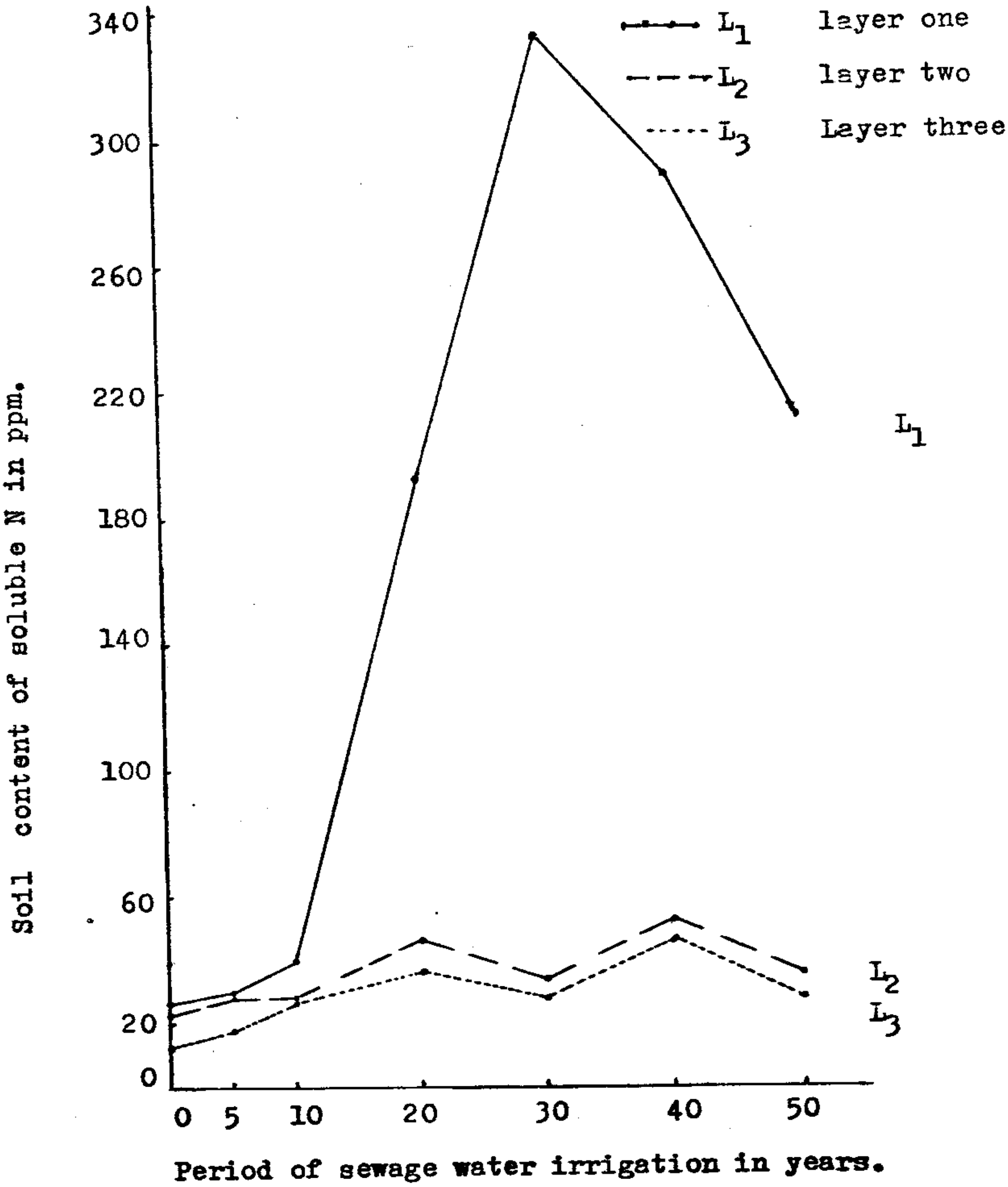

Fig.(10): Distribution of soluble Nitrogen of the different layers of El-Gabal El-Asfar soils.

surface content of organic matter was higher than the subsurfac one . This finding agrees with those of Gantimurov (1955), Zabek (1956) Kelling et al. (1977) and El-Gamal (1980).

The decrease in soluble nitrogen in soil by pro-longing period of irrigation over 30 years may be att-ributed partially to decmposition of soil organic matter or to one or more of the factors that reduce soil con-tent of soluble nitrogen such as leaching of nitrate form out of the profile, volatilization of ammonia, den-itrification or even fixation of ammonium ions by soil colloids.

4.4.1.2. Available phosphorus:

Data in table (4) and Fig (11) show that ava-ilable phosphorus extracted from the investigated soils by 0.5 N sodium bicarbonate (Olsen et al, 1954) incr-easd, generally, as a result of irrigating these soils with sewage waters. Such an increase may be attributed to an associated increase in soil contents of organic matter and also to the amounts of phosphorus added into the soils with each irrigation since phosphorus concentration in these waters was about 0,35 ppm .Simi-lar results were obtained by Warrington (1952), and Trenel (1961) who found that secondary

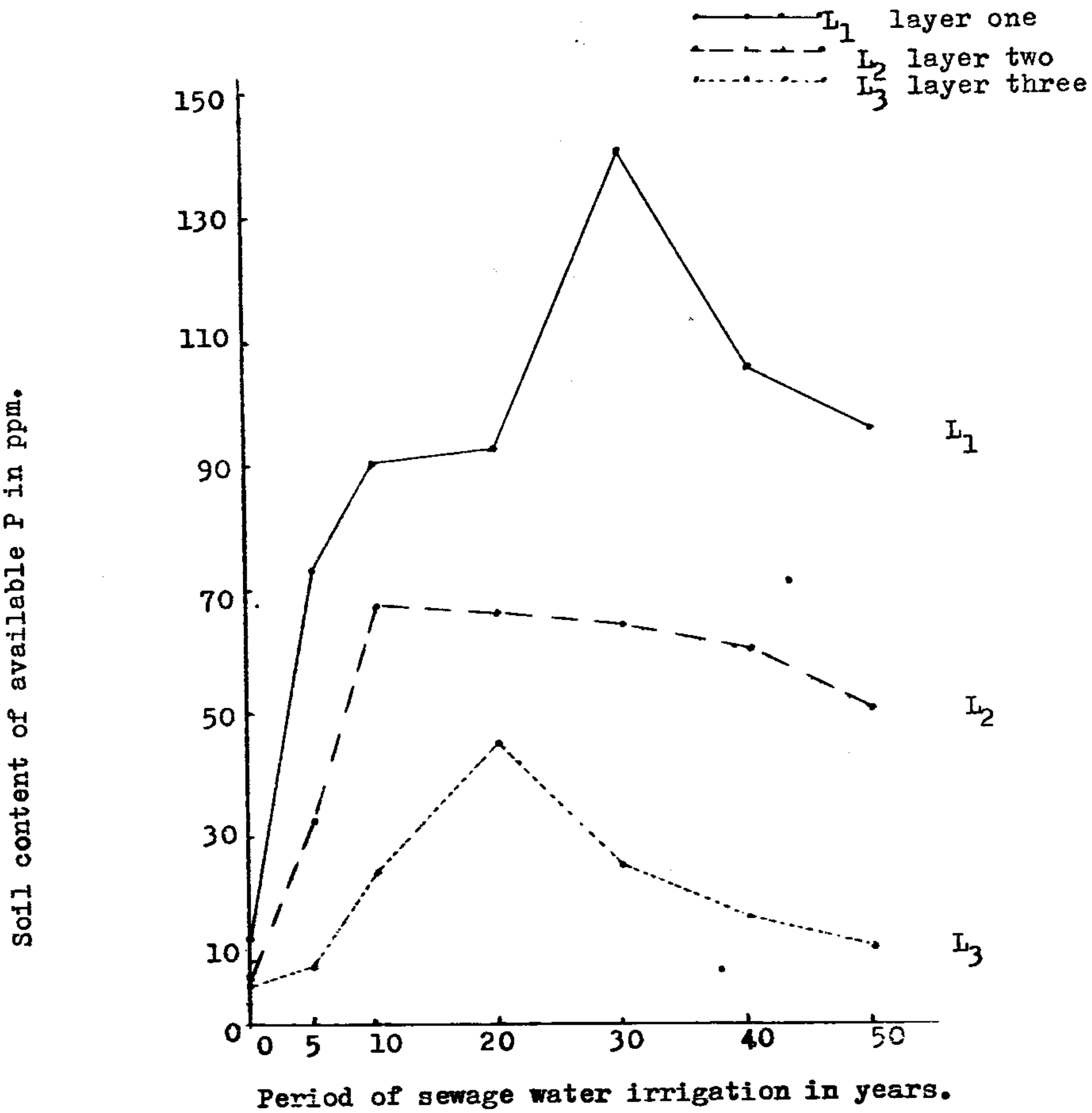

Fig. (11): Distribution of available P of the different layers of El-Gabal El-Asfar soils.

effluent contained phosphate in concentrations varying from 0.5 to 40 PPm.

However, prolonging period of irrigation with sewage water over 30 years decreased slightly availability of phosphorus, but inspite of this, irrigated soils remained containing soluble phosphorus in amounts greater than the untreated one.

4.4.1.3. Available Potassium :

Table (5) and Fig (12) show the values of the availalble potassium extracted from soils by ammonium acetate (Jackson, 1967). It is clear that prolonging period of irrigating the investigated soils with sewage waters up to 40 years was associated with a gradual increase in these soils content of available potassium, but when period of irrigation was prolonged to 50 years, there was an observed decrease in the available potassium, probably due to excessive leaching or fixation by soil colloids.

Concerning distribution of potassium through the different layers of the soil profile, it was noticed

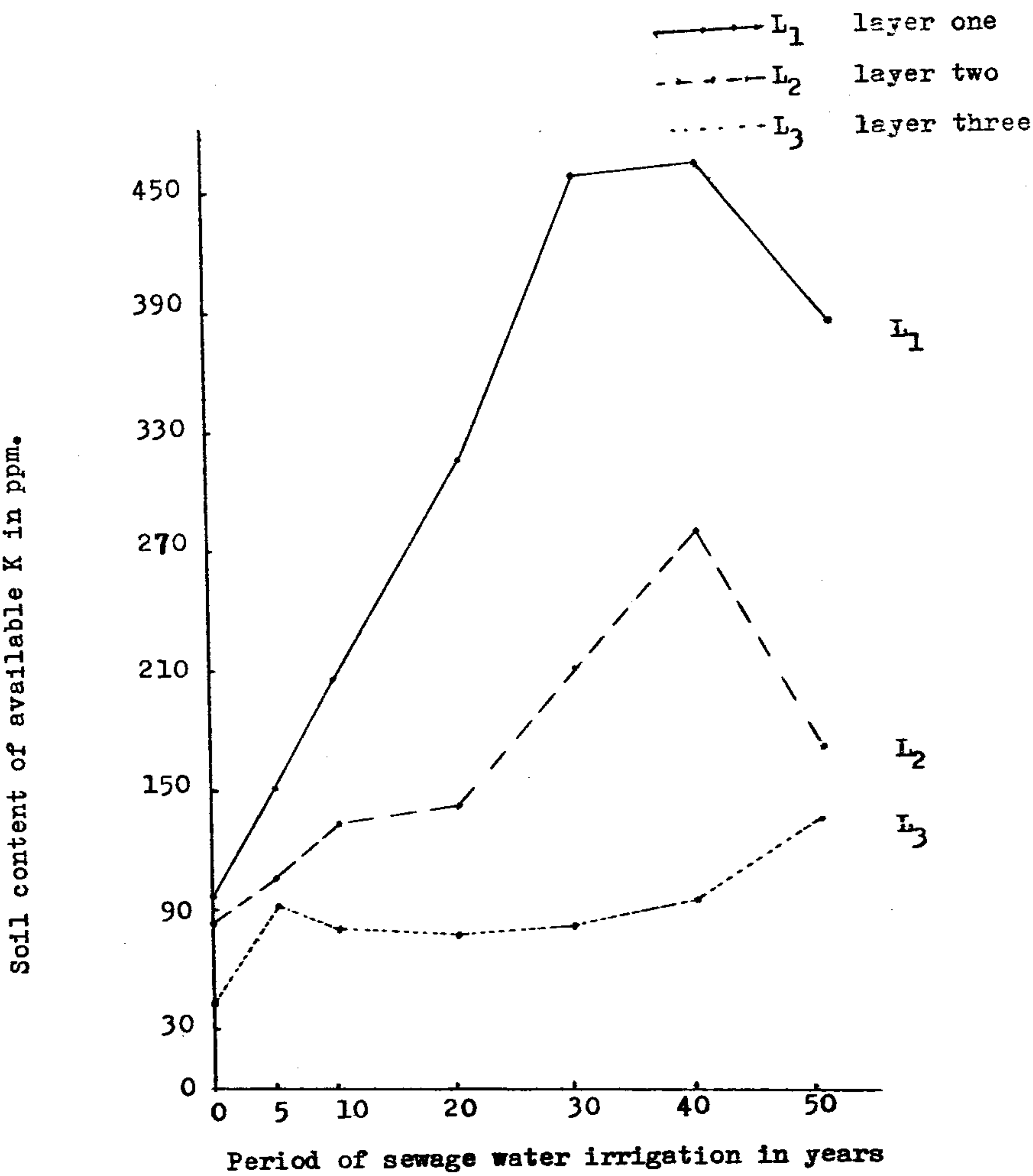

Fig. (12): Distribution of available K of the different layers of El-Gabal El-Asfar soils.

Table (5): Soluble Nitrogen, available phosphorus and available potassium in the different layers of the investigated soil of El-Gabal El Asfar.

Peroid of irrigation with sewage water(in years)	Profile No,	Depth of soil layer (cm)	Soluble N ppm	Available P ppm	Available K ppm
0	1	0-10	27	14	101.1
		10-40	23	8	84.9
		40-130	13	7	44.9
5	2	0-10	28.8	72	150.3
		10-20	28.8	32	106.8
		20-50	19.2	8	91.2
		50-90	12.1	7	78
10	3	0-30	40.3	90	199.9
		30-60	28.8	67	132.6
		60-90	28.8	24	75.8
20	4	0-10	192	92	316.3
		10-40	48	67	145.3
		40-150	38.4	45	76.3
30	5	0-35	326.4	140	453.4
		35-80	38.4	64	210.6
		80-150	28.8	25	84.4
40	6	0-10	288	105	463.1
		10-30	51.9	60	282.8
		30-70	48	43	97.1
		70-150	38.4	18	82.9
50	7	0-30	115.2	95	386.1
		30-60	38.4	50	167
		60-150	28.8	12	135.9

Table (6) Annual increments of N. P, K, and organic matter in top soils of El-Gabal El-Asfar due to irrigation with sewage water for different periods.

Period of irrigation with sewage water (in years).	N ppm	P ppm	K ppm	organic matter %
5	0.36	11.6	9.84	0.26
10	1.33	7.6	9.8	0.31
20	8.25	3.9	10.78	0.19
30	9.98	4.2	11.74	0.15
40	6.53	2.28	9.05	0.11
50	1.76	1.62	5.7	0.06
Means	4.7	5.2	9.49	0.18

that available potassium accumulated in the surface layers in relatively higher amounts than the subsurface ones. Such distribution is similar to that of total salinity and may be also attributed to the upward movement of water in the periods of dryness between the successive irrigations. Data in table (6) show that the annual increment of potassium to the soil surface layer due to irrigation with sewage waters averaged about 9.49 PPm. These relatively high increments are expected since concentration of K in the applied sewage waters reached about 42.9 PPm.

4.5 ACCUMULATION OF HEAVY METALS IN SOILS IRRIGATED WITH SEWAGE WATERS:

It is recognized that irrigation with sewage waters is associated with an increase in availability of some heavy metals in soils. Such an increase is reflected on plants uptake from these metals, and consequently may causes hazards to man in the long run. Therefore it is necessary in this study to throw lights on contents ility of Fe, Cu, Zn, Mn, and Pb in the investigated soils as a result of irrigating these soils with sewage waters.

The data in table (7) show concentrations of these heavy metals in El-Gabal El-Asfar soil due to extraction with DTPA. Generally, available Fe increased by prolonging period of irrigation with sewage waters. For example, while available Fe in the surface layer of the untreated soil was 2.6 PPm, it ranged between 50 and 167 PPm with an average of 119.66 ppm in the surface layers of the soils irrigated with sewage waters.

Data in table (8) reveal that the average of the annual increment of Fe in top soils was 5.8 PPm as a result of irrigating these soils with sewage waters. These increments are of course due to high content of Fe in the used sewage waters.

Available Cu varied from 0.4 to 52.0 PPm in surface layers with an average of 24.14 PPm, whereas that of subsurface layers ranged from 0.2 to 33.0 PPm with an average of 11.1 PPm. The annual addition of Cu to the soil was 1.2 ppm.

Available zn in surface layers varied from 0.4 to 231.0 PPm with an average of 126.46 PPm. The corresponding values of the subsurface layers ranged from 0,4 to 130.0 PPm with an average of 31.33 PPm. The annual increment of Zn was 5.82 ppm.

Also, data revealed that available Mn in surface layers ranged from 4.6 to 67.1 PPm with an average of 44.3 pp m, and the corresponding values of the subsurface layers ranged from 0.4 to 42.0 PPm, with an average of 16.38. The annual increase of Mn in top soils was 2,59 PPm in average.

From the abovementioned results, it can be seen that continuous irrigating with sewage water increased the soil content of the chemically available metal elements. More over, availability of these metals was much greater in the surface layers than the subsurface ones. Decrease of these metals in the subsurface layers may be due to the relatively low organic matter content in these layers. These findings are in agreement with those obtained by Ellis and Knezek (1972) and El-Gamal (1980).

Also, it can be seen from table (7) that increasing time of irrigation with sewage water from 40 to 50 years, decreased avilability of these metals in both surface and subsurface layers, but inspite of this decrease these metals were still found in higher amounts in the treated soils than the untreated ones. Such decrease may be attributed to decomposition of organic matter as well as to the reactions between Ca CO_3 and the available forms of these elements with the results that they become nonavailable or restricted or precipitated. These results coincide with those obtained by El-Gamal (1980) who found that increasing period of irrigation with liquid sewage sludge for more than 47 years decreased markedly soils content of the chemically available

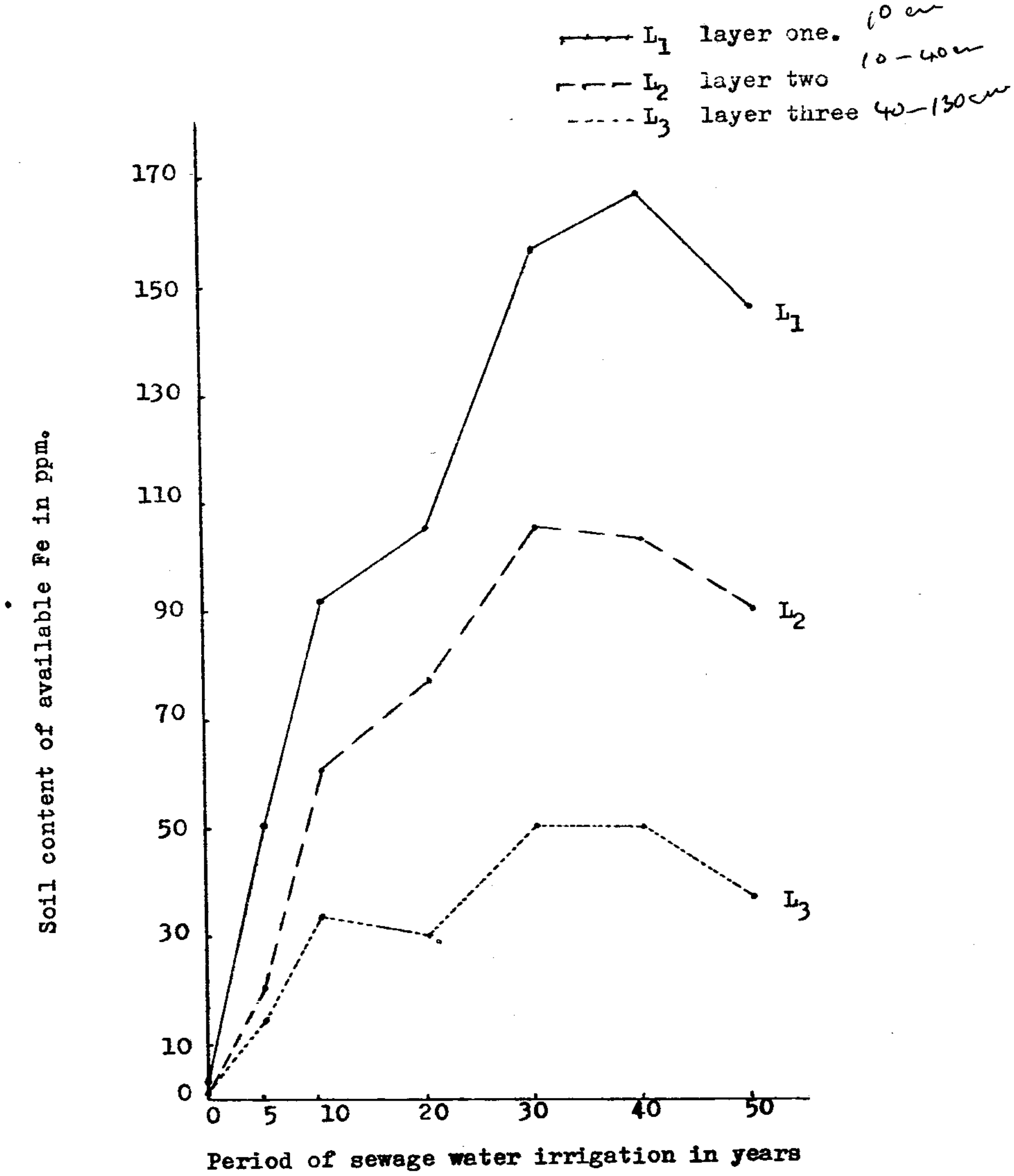

Fig. (13): Distribution of available Fe of the different layers of El-Gabal El-Asfar soils.

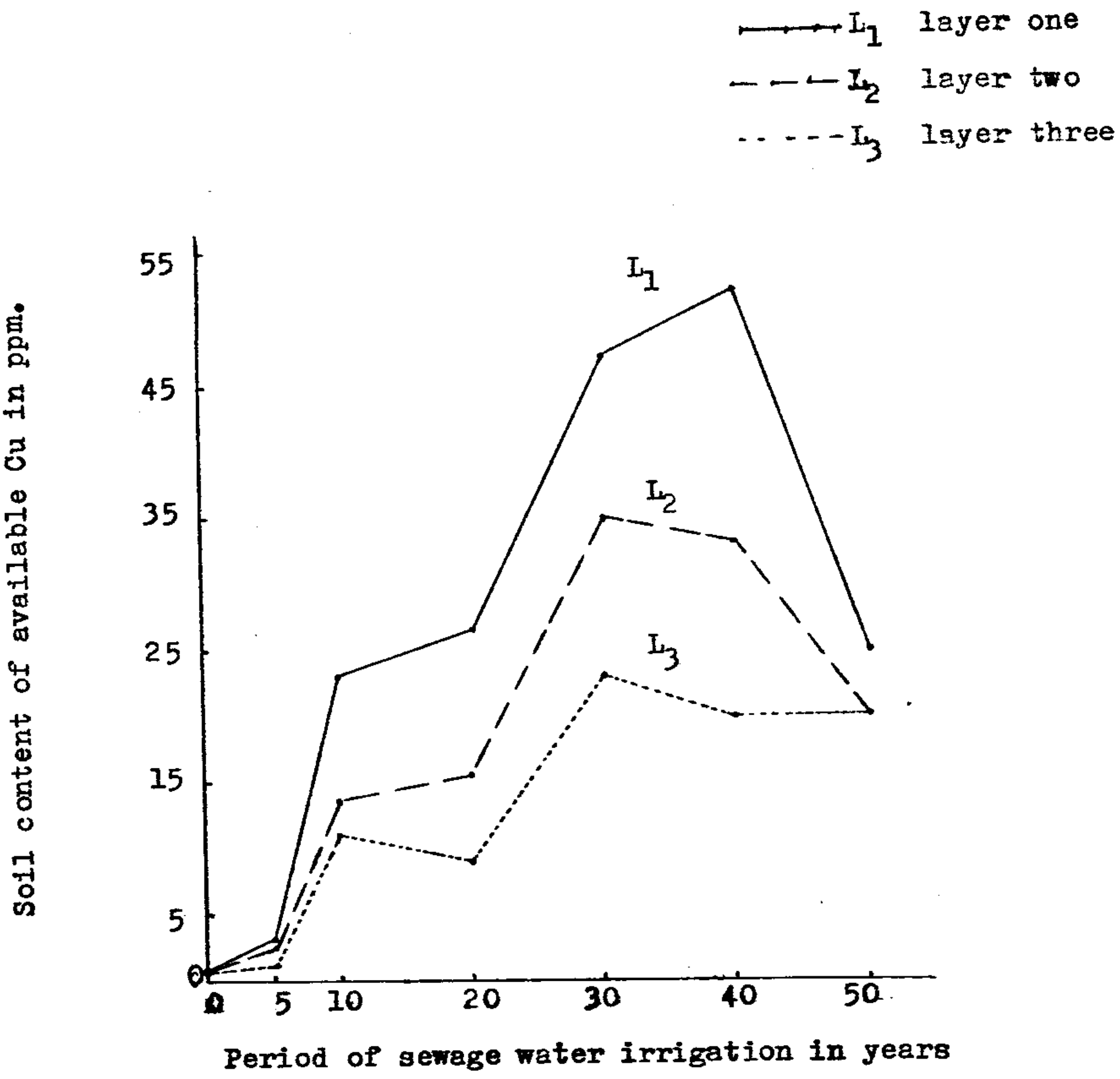

Fig. (14): Distribution of available Cu of the different layers of El-Gabal El-Asfar Soils.

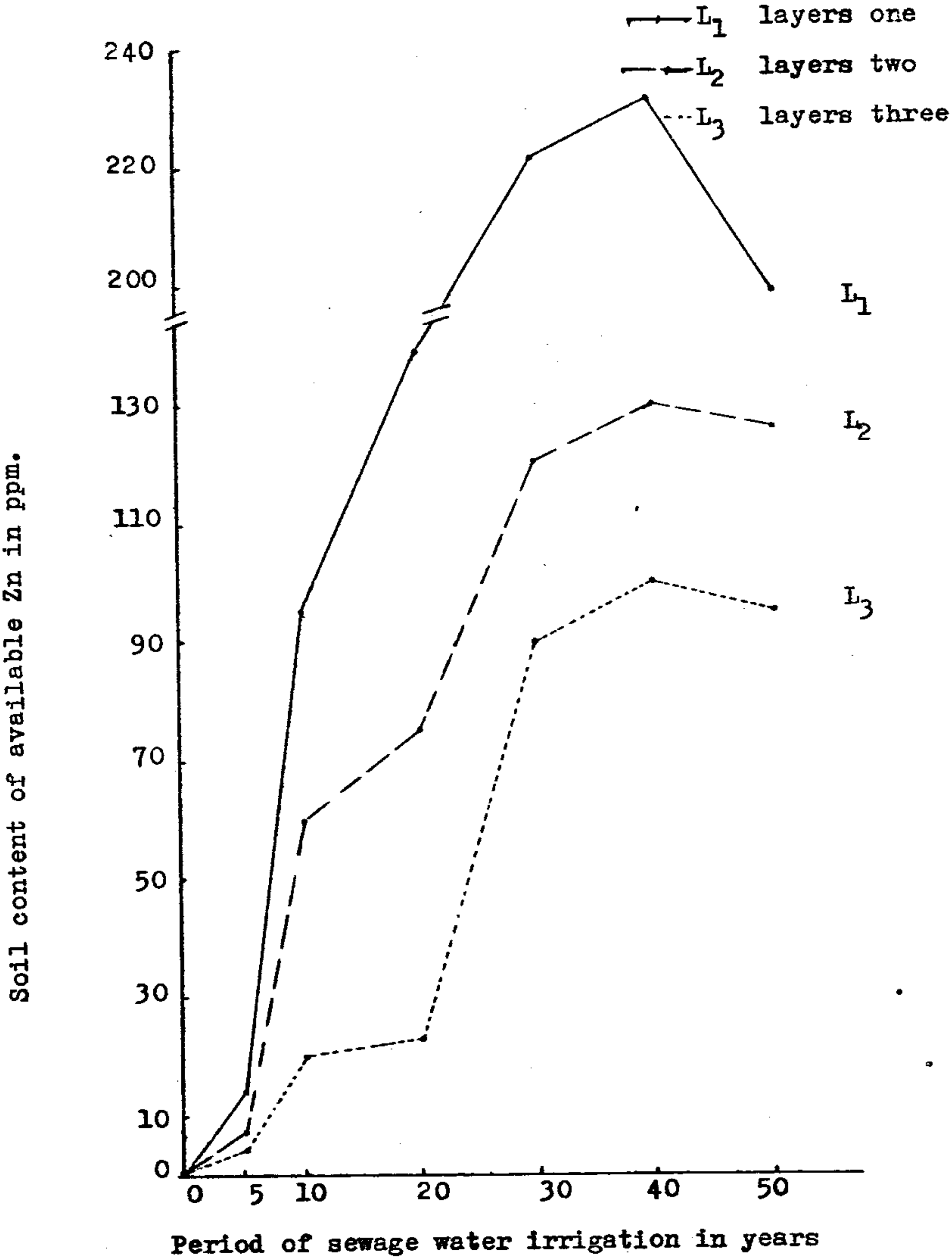

Fig. (15): Distribution of available Zn of the different layers of El-Gabal El-Asfar soils.

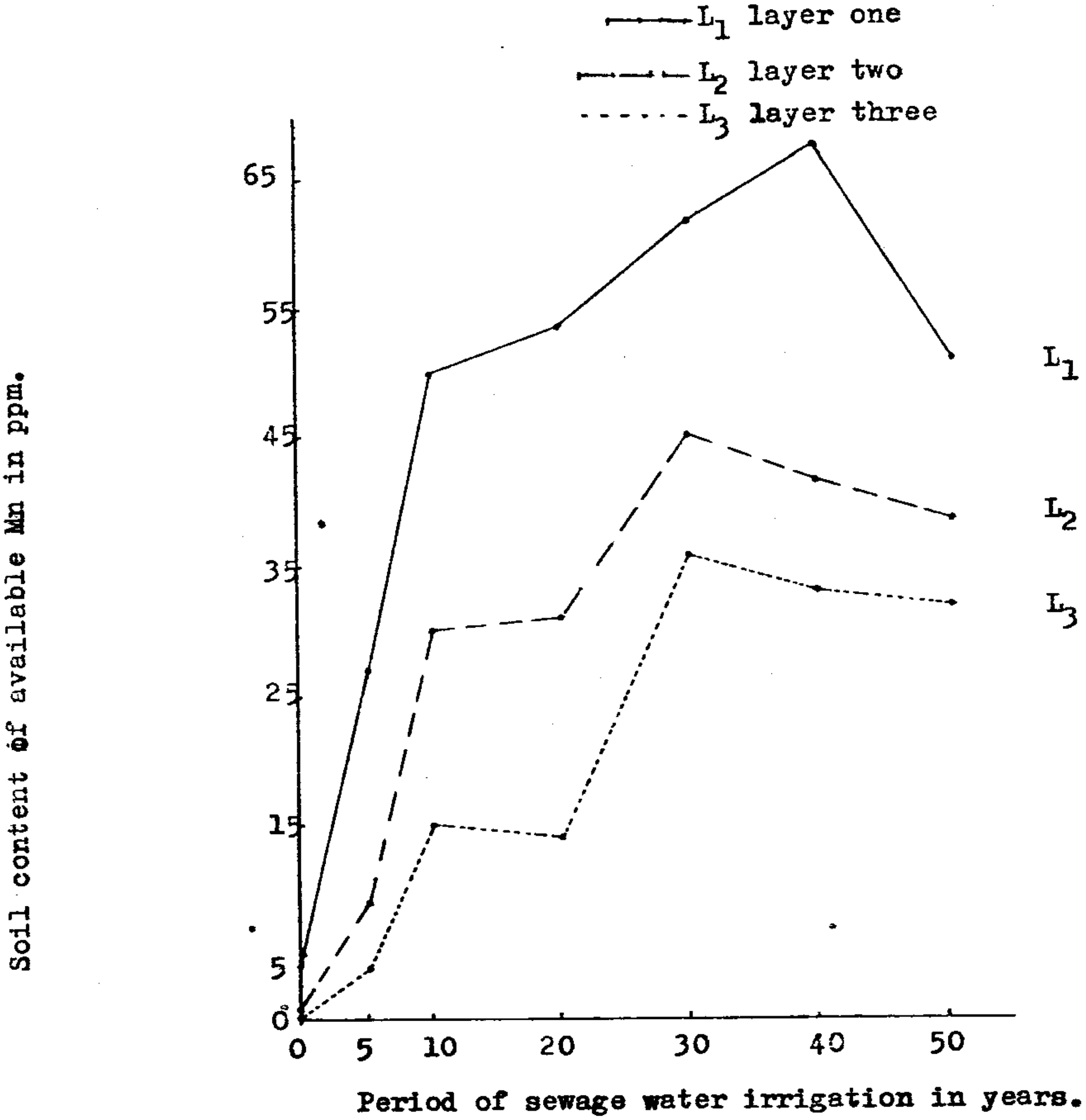

Fig.(16): Distribution of available Mn of the different layers of El-Gabal El-Asfar Soils.

elements under investigation.

4.6. Status of lead (Pb) in soils :

There is a limited information concerning soils content of Pb, mainly due to the lack for sensitive method for detecting the trace amounts of Pb found in soils.

The contents of pb in the different studied locations of El-Gabal El-Asfar soils as affected by application of sewage water for different periods are shown in table (7). It is obvious from this table that prolonging period of application of sewage water was associated with an increase in soil content of Pb extracted with 1N Hcl, however, increasing period of irrigation up to 50 years decreased soil content of Pb but still contained higher amounts of extractable Pb compared with the untreated soil. This decrease in Pb may be due to a decrease in soil content of organic matter at this period. These results are in agreement with those obtained by El-Gamal (1980), who found that increasing time of irrigation with liquid sewage suldge above 47 years markedly decreased Pb content.

Also, Pb extracted with 1N Hcl was higher in surface layers than the subsarface ones. This distribution was the same for all the different periods of irrigation with sewage water.

From table (7), it is quite clear that the amounts of Pb extracted from the investigated soils by N Hcl were relatively small. This may be partially due to combination between Pb and the organic matter or the foundation of Pb in the form of insoluble precipitates. This is an indication to the complexity,and nature of the chemical interaction between Pb and the soil constituents (Abd El Aziz, 1983).

Also, from these results, it is quite clear that the lead content in soil samples of El-Gabal El-Asfar ranged between not detected amounts and 4.5 PPm. These values, however, did not reach toxicity levels, Since Abd El Aziz (1983) in his studies on trace elements in plant and soil, found that the earliest symptoms of lead toxicity commenced at 100 PPm for wheat 150 PPm for corn, clover, and soyabean; and 200 PPm for sunflower.

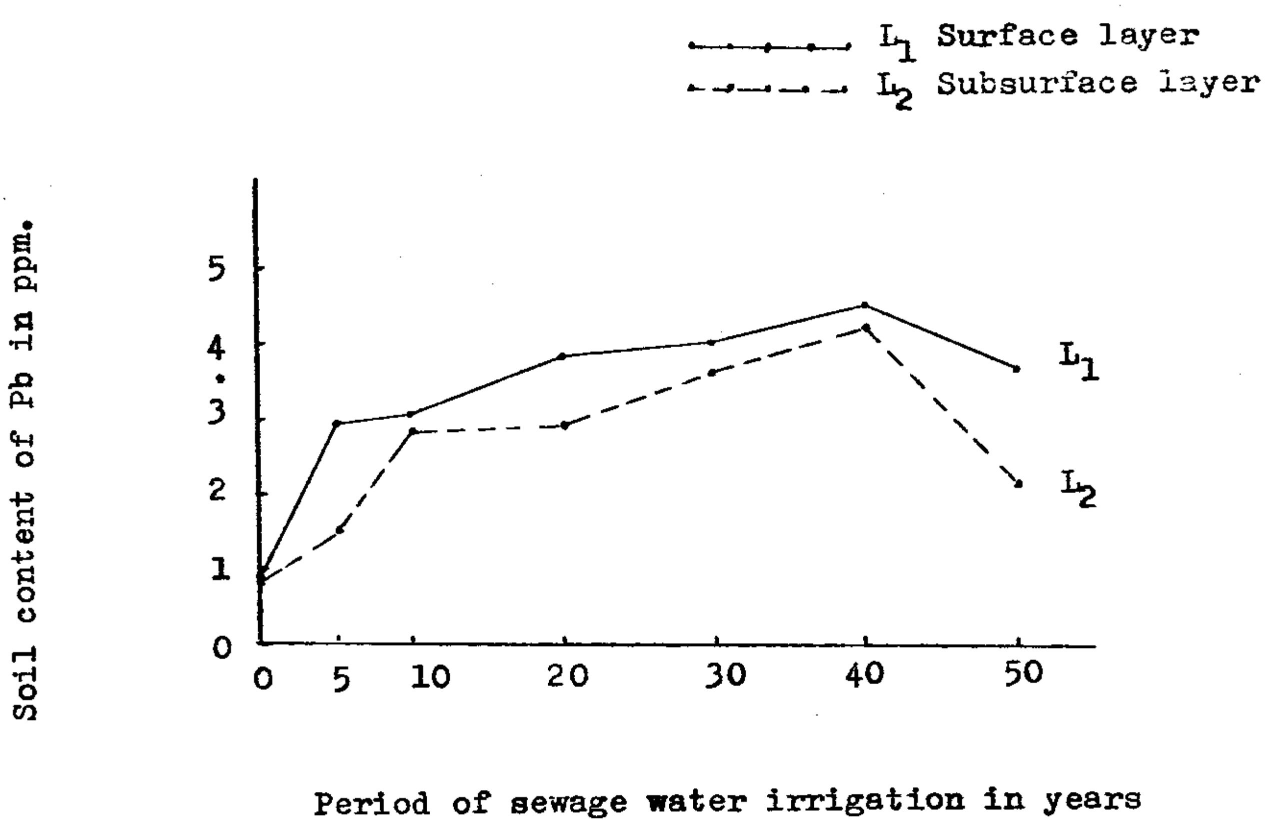

Fig. (17): Distribution of lead (Pb) of the different layers of El-Gabal El-Asfar Soils.

Table (7) Extractable amounts of heavy metals in the investigated soil profiles of El-Gabal El-Asfar Farm.

Peroid of irrigation with sewage water (in years)	Profile No,	Depth cm	Fe ppm	Cu ppm	Zn ppm	Mn ppm	Pb ppm
0	1	0-10	2.6	0.4	0.8	4.6	0.9
		10-40	1.8	0.4	0.4	0.6	0.8
		40-130	1.3	0.2	0.4	0.4	n.d.
5	2	0-10	50	2.8	14.4	27	2.9
		10-20	20	2.4	8	9.8	1.5
		20-50	14	0.8	4	3.8	n.d.
		50-90	8	0.5	3	3.8	n.d.
10	3	0-10	93	23	95	50	3
		10-30	60	14	60	30	2.8
		30-60	33.4	11.6	20	15	2.5
		60-90	25.4	8.8	12.8	10.8	n.d.
20	4	0-10	105	26.2	139	53.2	3.8
		10-40	78.8	15.1	75.8	31.2	2.9
		40-150	30.4	9.8	23.8	14.2	n.d.
30	5	0-10	156	47	221	61	4
		10-35	105	35	120	45	3.6
		35-80	50	22.6	90	36.8	3.1
		80-150	45	12.6	30	25.4	0.5

Table (7) (cont.)

Peroid of irrigation with sewage water (in years)	Profile No,	Depth cm	Fe ppm	Cu ppm	Zn ppm	Mn ppm	Pb ppm
40	6	0-10	167	52	231	67.1	4.5
		10-30	103	33	130	42	4.3
		30-70	50	20	100	33	1.3
		70-150	35	15	20	9.2	n.d.
50	7	0-10	147	25	195	51	3.7
		10-30	90	20	127	38	2.1
		30-60	37	20	95	32	1.7
		60-150	35	10	19	12	n.d.

n.d. = not detected

Table (8) Annual increment of heavy metals in surface soils of El-Gabal El-Asfar Farm.

Period of irrigation with sewage water (years)	Fe ppm	Cu ppm	Zn ppm	Mn ppm	Pb ppm
5	9.48	0.48	2.72	4.48	0.4
10	9.04	2.26	9.42	4.54	0.21
20	5.12	1.29	6.91	2.43	0.15
30	5.11	1.55	7.34	1.88	0.1
40	4.11	1.29	5.76	1.56	0.09
50	2.06	0.35	2.77	0.66	0.04
Means	5.82	1.2	5.82	2.59	0.17