4- RESULTS AND DISCUSSION

Results of the effect of putting the soil under conditions of fish farming will be discussed in relation to the following soil properties :

- Physical properties as represented by particle size distribution.
- Soil pH.
- Soil salinity.
- Soluble ions which include cations of (sodium, potassium, calcium, and magnesium) and anions of (chloride, sulphate, carbonate, and bicarbonate).
- Cation exchange capacity.
- Exchangeable cations of sodium, potassium, calcium, and magnesium.
- SAR and ESP values.
- Available phosphorus.
- Soil organic matter.

4-1- The effect on particle size distribution of the soil:

The data obtained for particle size distribution are shown in table (3). As a result of fish farming which incurred leaching and flooding processes, the fine fractions of clay and silt were slightly increased. Such an increase was particularly marked in El- Serew farm

Table 2: Particle size distribution, and calcium carbonate content (%) before leaching and after drying.

Location	Depth	Before leaching (t_1) Clay %	Silt	Fine sand	Coarse sand	Soil texture	$CaCO_3$ %	After flooding and drying (t_5) Clay %	Silt %	Fine sand	Coarse sand	Soil texture	$CaCO_3$ %
	0-25	22.15	13.20	59.69	5.16	Sandy clay loam	7.23	34.18	15.79	42.49	7.54	Sandy clay loam	6.44
Al- Raswa	25-50	28.15	10.44	55.11	6.30	Sandy clay loam	5.96	29.24	26.30	42.51	1.95	Sandy clay loam	7.52
Port- Said	50-80	38.05	13.91	35.98	12.78	Sandy clay	7.66	33.99	15.01	49.91	1.20	Sandy clay loam	8.58
	80-120	26.45	12.47	53.91	7.17	Sandy clay loam	11.49	35.91	9.01	51.69	3.39	Sandy clay	10.12
	0-25	25.80	21.14	50.25	2.81	Sandy clay loam	2.56	31.18	21.48	45.76	1.58	Sandy clay loam	2.34
	25-50	39.05	14.90	43.56	2.49	Sandy clay	2.13	34.48	22.83	41.62	1.02	Clay loam	2.55
El- Wahal	50-80	37.76	19.77	41.58	0.87	Sandy clay loam	2.67	31.45	19.17	46.99	2.39	Sandy clay loam	2.02
Kafr El-Shaikh	80-120	29.39	23.52	45.95	1.14	Sandy clay loam	2.02	35.22	19.07	43.76	1.95	Clay loam	2.19
	0-25	26.79	16.49	45.55	11.17	Sandy clay loam	4.26	32.22	22.56	40.66	4.55	Sandy clay loam	3.72
El- Serow	25-50	35.74	22.83	35.10	6.33	Clay loam	2.66	47.91	28.57	23.29	0.23	Clay	3.72
Dakahlia	50-80	47.68	30.04	21.90	0.38	Clay	3.72	55.00	23.85	21.04	0.11	Clay	3.40
	80-120	24.86	23.92	50.02	1.20	Sandy clay loam	1.60	35.34	25.74	36.17	2.75	Clay loam	3.19

where fresh Nile water had been used for flooding the ponds, therefore, this increase is most probably due to the precipitation of the clay and silt particles which may have been suspended in the water used for flooding the ponds of the farms. Besides, some of the coarse particles represented by calcium carbonates may have undergone a reduction in size as a result of dissolution under water abundance during flooding. The soil was thus made finer in texture which may have incurred a reduction in its porosity and infiltration rate that may encourage more precipitation of fine particles to be lodged within the soil profile. Contents of clay particles in samples representing virgin soil before utilizing the lands as fish farms ranged between 22.15 % and 38.05 % in Al- Raswa, and between 25.8 % and 39.05 % at El- Wahal, and between 26.79 % and 47.68 % in El- Serow. As a result of flooding, the clay contents in all farms increased particularly in the surface layer. In Al-Raswa, El-Wahal, and El-Serow, clay in the surface layer increased from 22.15 % to 34.18% from 25.8 % to 31.18 % and from 26.79 % to 32.22 % respectively. Similar pattern was observed regarding silt content.

On the other hand, sand content underwent a decrease; it decreased in the surface layer of the same farms from

64.85 to 50.03 %, from 53.06 % to 47.34 % and from 56.72 to 45.21 %, respectively. These results are in agreement with Fathi et al. (1971) who reported that the coarse textured sandy sediments were gradually changed to more finer textured soils. They added that this change was accompanied by a relative organic matter accumulation which increased with the increase in the time of irrigation and cultivation. Concerning the deeper layers, the general pattern show also that fine particles (clay and silt) increased while coarse particles (sand) decreased upon the utilization of land as fish farm.

The relative increase in fine fractions in the deep layers was observed in the soil both before as well as after utilization. The pattern of increase with depth was particularly apparent after utilization. Flooding must have carried fine particles of clay and silt deep down the soil profile particularly the 80- 120 cm layer in the three farms, and the 50-80 cm layer at El- Serow farm. These results agree with these of Fathi et al. (1971), who showed that the fine fractions migrate down the profile with increasing land use period. However, the results are in agreement with these of Boyd (1976), and Boyd (1977) who found that, in fish ponds as clay and silt increased with depth,sand and gravel content decreased in almost equal proportions.

Therefore, it can concluded that, irrespective of the nature of the flooding water, submerging the land of the fish farms caused an increase in the fine fractions of soil particles in both sufrace and subsurface layers of soils at the expense of the coarse fractions.

4-2- Effect on soil pH :

The data representing the pH values of the investigated soil samples are recorded in table (4) and Fig. (3).

The increase in pH values were noticed particularly in Al- Raswa and El- Wahal farms which received saline water. While in El-Serow an decrease in pH was noticed in three of the four soil layers . The initial pH values at (t_1) of the various soil layers in El-Wahal ranged between 6.83 and 6.95, but at the end of the study, the pH values increased in the 0- 25 cm, 25- 50 cm, and 80- 120 cm layers from 6.95 to 7.15, from 6.92 to 7.02, and from 6.83 to 7.17, respectively.

In the third layer (50- 80 cm) there was a slight decrease in the pH value, probably due to the increase in organic matter content originally presented in this layer. The increase in pH values as a result of water flooding was also reported by Rodrigo and Pollard(1962), Redman and Patrick (1965), Mukherjee and Basu (1971) , Mahapatra (1968) , and Ghosh et al. (1976).

During flooding t_4, the soil surface showed a slightly lower pH than at the end of flooding except in El- Serow farm where no clear changes could be detected.

Detailed data on Al- Raswa farm (table 4 A) show that pH increased because of leaching and flooding. It increased at each of the 4 layers as follows : from 7.0 to 7.25, from 7.08 to 7.22, from 6.95 to 7.15, and from 6.85 to 7.02 in the four successive layers starting from the surface to the deepest layer respectively. These results are in agreement with those obtained by Patrick and Mikkelsen (1971).

The increase in pH values was probably due to the predominance of sodium and magnesium ions in the soil as shown from the results of exchangeable cations (tables, 9 and 10). The decrease in pH caused by flooding in most layers of El- Serow farm could be related to the accumulation of organic matter as a result of fish farming ,and addition of organic manures to ponds. Organic matter would thus decompose producing organic acids that reduce

Table 4: Soil pH and EC as affected by fish farming .

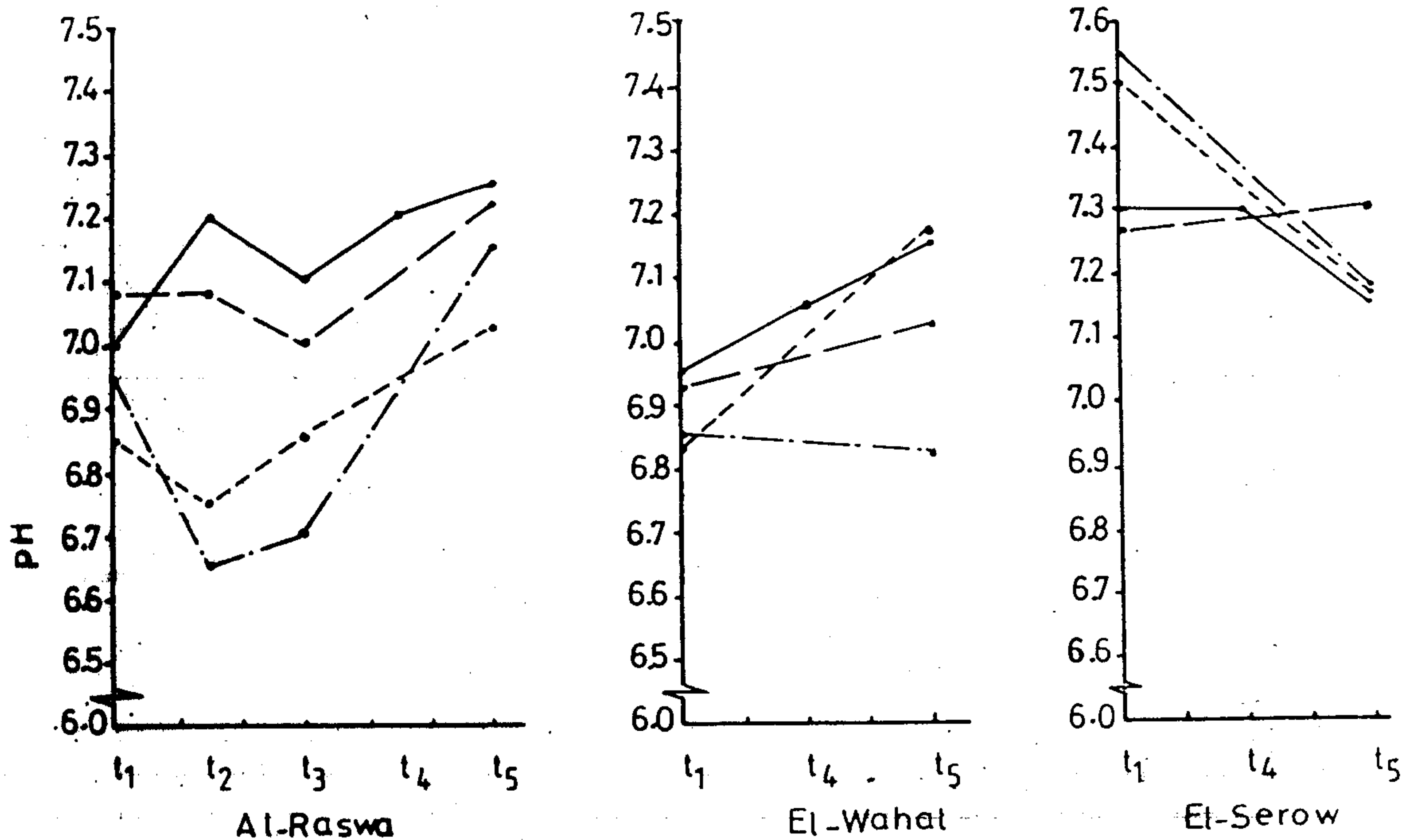
(4- A): Changes in different depths at various stages at Al- Raswa farm.

Depth	pH					EC				
	t_1	t_2	t_3	t_4^x	t_5	t_1	t_2	t_3	t_4^x	t_5
0- 25	7.00	7.20	7.10	7.20	7.25	230.0	46.5	50.0	24.0	31.5
25- 50	7.08	8.08	7.00	-	7.22	92.5	90.0	66.5	-	32.0
50- 80	6.95	6.65	6.70	-	7.15	190.0	130.0	80.0	-	51.5
80- 120	6.85	6.75	6.85	-	7.02	140.0	159.0	120.0	-	64.0

(4-B^{xx}): Changes in different depths at initial, under flooding and at final stage at El- Wahal and El- Serow farms.

Location	Depth	pH			E C		
		t_1	t_4^x	t_5	t_1	t_4^x	t_5
	0- 25	6.95	7.05	7.15	75.0	21.0	19.5
El- Wahal	25- 50	6.92	-	7.02	70.0	-	21.0
Kafr El-Shaikh	50- 80	6.85	-	6.82	90.5	-	35.5
	80-120	6.83	-	7.17	80.0	-	59.5
	0- 25	7.30	7.30	7.15	7.6	5.0	5.0
El- Serow	25- 50	7.27	-	7.30	9.6	-	5.5
Dekahlia	50- 80	7.55	-	7.18	10.5	-	5.8
	80-120	7.50	-	7.17	9.6	-	7.2

t_1: Initial pre-farming soil; t_2: Soil after leaching; t_3: Soil before flooding.
xt_4: Soil during the flooding (only surface layer were taken for analyses).
t_5: Final stage (after drying).
xx : Samples of t_2 and t_3 were not taken at El-Wahal and El-Serow farms.



————	d_1	depth	0 — 25 cm
— — —	d_2	depth	25 — 50 cm
—·—·—	d_3	depth	50 — 80 cm
- - - - - -	d_4	depth	80 — 120 cm

t_1 : Time before leaching.
t_2 : Time after leaching.
t_3 : Time before flooding.
t_4 : Time during flooding.
t_5 : Time after flooding & drying

Fig.(3) Changes in pH values at various stages in soil layers of three farms.

pH value. This conclusion is in agreement with the data of soluble HCO_3 (table 7), which showed a marked accumulation of bicarbonate ions in the soils of low pH decreased. These results agree with those obtained by Mukhopadhyay *et al.* (1967), Hochmuth (1967), Ponnamperuma (1972), and Aboulroos *et al.* (1981).

In most cases, the decrease in pH values with depth may be due to the accumulation of CO_2 produced by anaerobic bacteria that found in the rather deep layers of soil.

4-3- Effect on soil salinity:

Leaching and flooding processes had a pronounced effect in reducing the salinity of the soil. The decreases in salinity is certainly dependent on the conductivity of the applied water and the rate at which it moves through the soil profile. George (1959) reported that when soil is flooded by rain water, its salinity would be decreased considerably.

The initial soil salinity (t_1) was very high in the two farms of Al- Raswa and El- Wahal. The EC values in these farms ranged between 70 to as high as 230 mmhos/cm. This reflects the highly saline nature of the soil in these two areas.

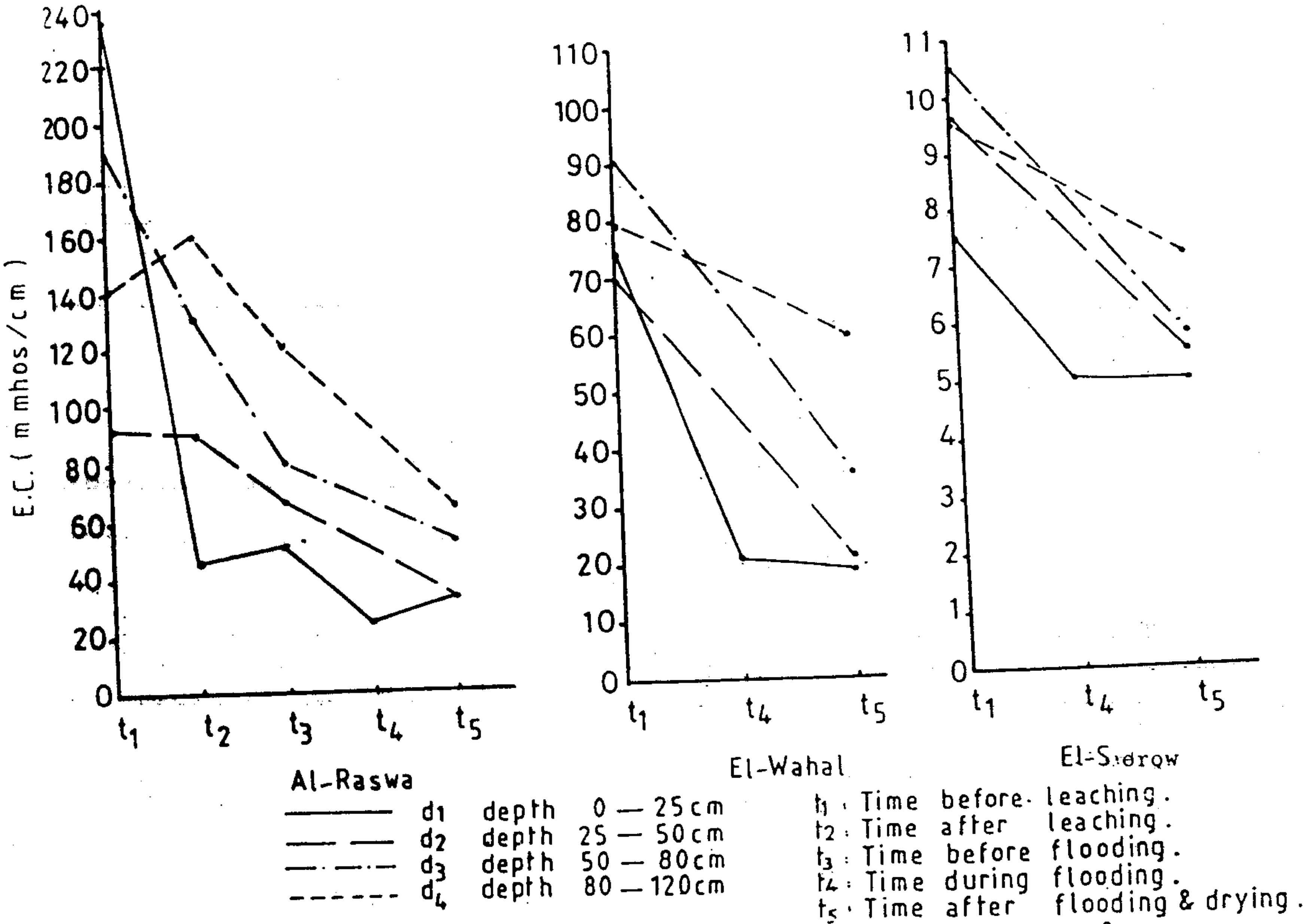


Fig.(4)Changes in electrical conductivity (m mhos / cm at 25°c) at various stages in soil layers of three farms.

On the other hand the initial salinity (t_1) of the site of El-Serow farm was far below that of any of the other two farms. The EC values in this farm ranged between 7.6 and 10.5 mmhos/ cm. (table 4 B).

Following leaching and flooding, the salinity of the first two farms decreased to levels ranging from 19.5 to 64.0 mmhos/ cm. Comparable level in the third farm ranged between 5.0 and 7.2 mmhos/ cm at 25°C was observed.

Initially (t_1), the rather deep layer 50-80 cm of the soil profile contained higher salt contents than the other layers. There was one exception at Al-Raswa which showed extremely high contents of salts in the surface layer, due to salt accumulation characterizing such areas. High salts in that particular subsurface 50-80 cm layer reflects a build-up of salinity at such depth caused by downward movement of salt by means of occasional seasonal rain fall which usually occur there. Besides, in such North Delta areas neighbouring water and sea lakes as well water table with high salinity would be not far from the soil surface. Hence a rise of saline water from such saline water sources would contribute to further accumulation of salts in the 50-80 cm. layer. These two factors may explain why this particular layer contained salts in amounts exceeding at Al- Raswa. The saturation extract of the 0- 25 cm surface soil sample, in this farm, while being flooded (t_4), had an E.C. of 24 mmhos/ cm/ 25^oC which is nearly the average E.C. of the flooding water used.

The rise in E.C. following flooding and land drying (t_5) is due to capillary rise of salts dissolved in soil water beneath the surface. Accumulation of salts due to capillary rise was reported by Banerjee et al., (1976). At the other two farms, an equilibrium between the flooded surface and the flooding water must have occurred during flooding. However, the salinity of the submerged surface upon drying may indicate little salt rise by capillarity. The waters used in these two farms were less saline, the immediate subsurface in these farms (25- 50 cm) after drying was not much differ in salinity from the surface while submerged with water.

Considering the detailed pattern of soil salinity changes in Al- Raswa (table 4 A) results show that, in nearly all soil layers, salinity decreased with time as a results of the action of leaching and flooding. Following every stage of leaching and flooding, there was a decline in soil salinity in every layer along the the 120 cm. depth. The only case where a temperary slight rise in salinity occurred in the surface layer after leaching and directly before flooding (t_3). This rise means that when- following leaching- the soil was left to dry, some salts must have moved up to the surface from its subsurface by means of capillarity. Leaching rendered salinity of soil surface to decrease to nearly one fifth of its original status. The two underlying subsurface layers, however, showed only a slight decrease where as the deepest one exhibited an increase. Such phenomena (t_2) are clear demonstrations of the downward migration of excess salts dissolved from the surface soil layer under the effect of added water. At (t_3) time, i.e. following termination of the leaching operation and allowing for a spell of time, more of the subsurface and deep layers contained salts less than the original content.

It seems that the as actual leaching " operation " was stopped, leaching " action " continued to take place within the region beyond the 25 cm depth where soil must have been still saturated with water.

4-4- Effect on soluble cations and anions of soil solution :

As shown by results on the physical properties of soil texture, soil chemical properties i.e. pH and salinity changed by leaching and fish farming which incurred flooding these changes envolved the 120 cm depth.

As the 3 studied fish farms were established in saline areas, these soils contained high concentrations of soluble cations and anions in their saturated paste extracts.

4-4-1- Soluble sodium :

Sodium ions were perdominant in the soil extracts of all farms at either the beginning or at the end of study, except in El- Serow farm at the end of the study where Mg was present in amounts exceeding those of sodium.

The data representing soluble sodium are shown in table (5) and Fig. (5). From these data it is evedent that, at the end of the study, the concentration of Na decreased considerably in all farms. For example, it decreased from 3524 to 244 meq./L. in the surface layer of Al- Raswa farm thus ending with contents of less than one tenth of the original.

The other layers also showed a decrease in soluble Na, though less pronounced, ending up with content equivalent to between about one-fifth to two-fifths of the original contents.

Table 5: Soluble sodium and potassium meq/ L. in soil paste extract as affected by fish farming*.

(5- A): Changes in different depths at various stages at Al- Raswa farm.

Depth	Na meq/ L.					K meq / L.				
	t_1	t_2	t_3	t_4^{x}	t_5	t_1	t_2	t_3	t_4^{x}	t_5
0- 25	3524	521	679	190	244	34.4	18.4	6.5	2.5	2.8
25- 50	1100	1087	761	-	291	16.6	12.3	6.6	--	3.1
50- 80	2929	1739	978	-	516	38.9	20.5	7.9	-	4.4
80-120	1850	2065	1630	-	788	30.3	36.4	15.3	-	6.2

Table (5- B^{xx}): Changes in different depths at initial, under flooding and at final stage at El- Wahal and El- Serow farms.

Location	Depth	Na meq/ L.			K meq/ L.		
		t_1	t_4^{x}	t_5	t_1	t_4^{x}	t_5
	0- 25	1087	123	166	6.0	5.3	6.90
Ell- Wahal	25- 50	897	-	201	6.6	-	5.70
Kafr El-Shaikh	50- 80	1049	-	413	6.9	-	5.80
	80-120	978	-	1051	6.3	-	10.20
	0- 25	53	10	13	1.9	1.3	1.51
El- Serow	25- 50	75	-	18	2.8	-	1.70
Dakahlia	50- 80	85	-	22	2.5	-	1.90
	80-120	75	-	35	3.6	-	3.90

See foot note table (4),

x Only surface layer samples were taken for analyses.

xx Samples of t_2 and t_3 were not taken at El- Wahal and El- Serow farms.

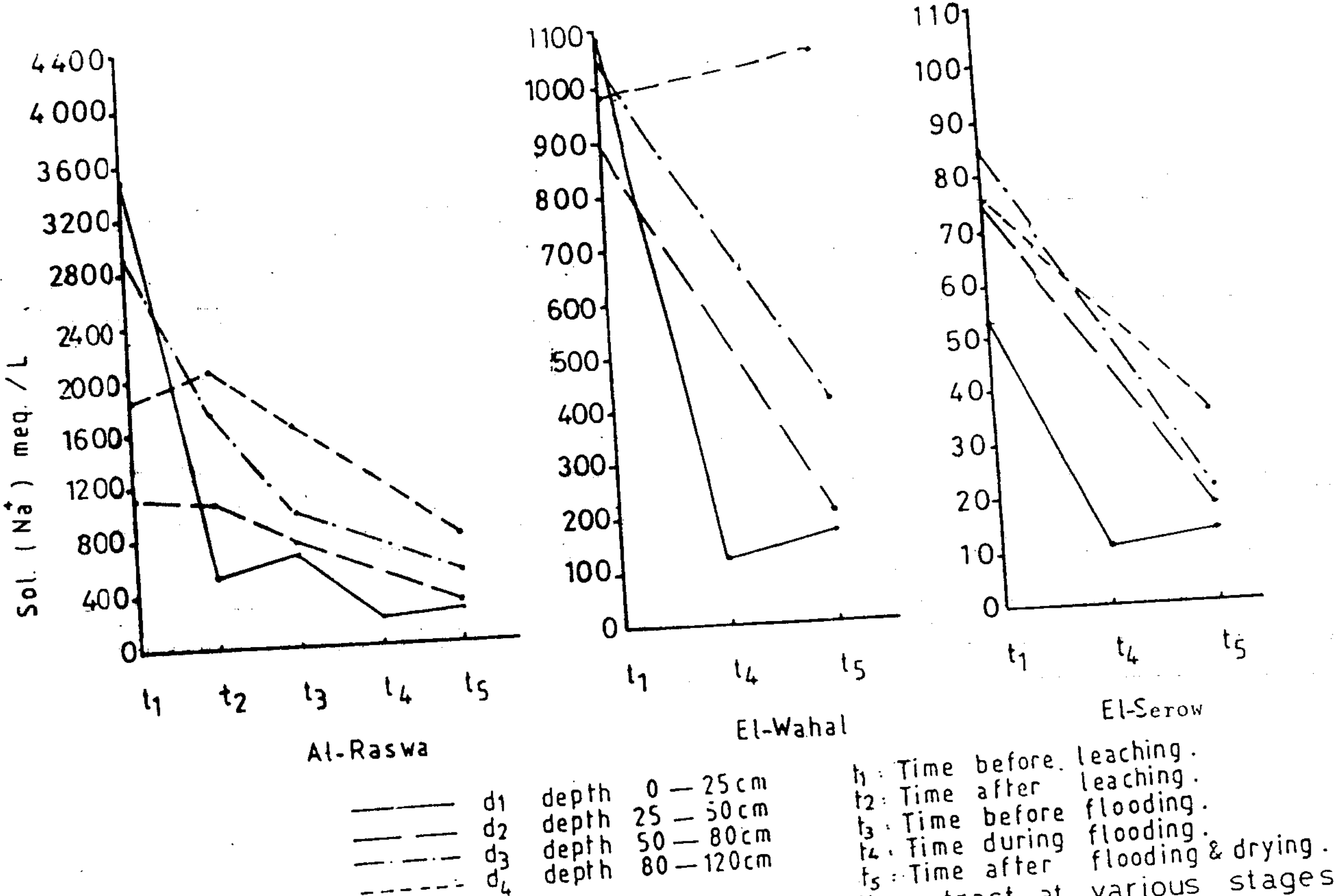


Fig.(5)Changes in soluble sodium(meq/l.) of soil extract at various stages in soil layers of three farms.

The amount of soluble Na in the other two farms i.e., El- Wahal and El- Serow showed, in general, the same behaviour as in Al- Raswa farm. In El- Wahal, soluble Na decreased to about 15 % of the original contents in the surface layer and between about 17- 42 % of the original content in the underlying layers at the end of study, while in the deepest layer, 80- 120 cm sodium concentration increased from 978 to 1051 meq/L. Apparently, there was an accumulation of sodium ions which moving mainly from the overlying layers by means of percolating water.

In El- Serow farm soluble Na ending up with content equivalent to 24.5 %, 23.9 %, 25.5 %, and 46.8 %, of the original contents in the 0-25, 25-50, 50-80, and 80-120 cm layers respectively.

The sodium concentration was decreased to its minimum value during flooding (t_4) when the soil was submerged (table 5). Following flooding and after drying ponds (t_5) there was an increase apparently due to the rise of soluble Na along with water by the cation of capillary property during drying.

Considering the detailed pattern of soluble Na changes in Al- Raswa (Fig. 5-A), it can be noticed that this pattern was similar to that of salinity (Fig. 4-A). A progressive decrease occurred along all the four sampling dates at all depths with one exception when there was a temporary increase in the deepest layer at Al-Raswa farm. As occurred in the surface layer, Na in the subsurface layers decreased from 1100 to 1087 then to 761 meq/L. by leaching and 291 meq/L. after flooding, drainage the ponds and drying the farm as shown in the 25-50 cm layer. In the 50-80 cm layer Na decreased from 2929 to 1739 then to 978 by leaching and to 516 meq/L. after drying the farm. In the deepest layer 80- 120 cm Na first increased from 1850 to 2065 meq/L. upon leaching. This increase was due to migration of soluble Na from the upper layers. Thenafter, sodium decreased progressively to 1630 after a while (t_3), then to 788 meq/L. after flooding, drainage the ponds, and drying the farm at the end of growth season.

4-4-2- <u>Soluble potassium :</u>

Soluble potassium followed a pattern similar to that of the sodium. Contents of potassium were far less of those of Na. The decrease in soluble K upon leaching and flooding the farm is due to the removal of considerable amounts of soluble salts.

Data shown in table (5 A,B) and Fig. (6) show that contents of soluble K at the initial stage (t_1) in all layers of the three farms ranged between 1.9 to 38.9 meq/L. At the end of fish farming season (t_5)(following leaching and flooding) K contents decreased to low levels ranging between 1.5 and 10.2 meq /L.

Comparing the three stages, initial (t_1), flooding (t_4) and final (t_5) stages, (table 5 A, B), contents of soluble K in soil surface of all farms were low when the soils were under flooding (t_4). This is in agreement with the similar pattern occurred with salinity as well as with soluble Na. After drying the farms (t_5) K^+ concentration in soil surface increased by 10- 31 % compared with that under flooding.

These results are in disagreement with those of Islam and Islam (1973) who reported that potassium concentration in soil solution at submerged soils (In Bangladesh) increased rapidly with time of submergence, and reached its maximum after 9 weeks of submergence followed by a gradual decrease. While the decrease in K concentrations in this study followed by a slightly increase may be due to that, the soils at initial stage (t_1) contained high level of K. Besides, Islam and Islam (1973) carried out their studies in a greenhouse experiment.

Detailed pattern of soluble K changes along the 4 stages t_1, t_2, t_3, and t_5 at Al- Raswa (table 5 A) show a pattern which is rather similar to that of Na except that there was no temperary increase in all layers at any stage with one exception. Along all the entire 4 sampling stages, soluble K decreased progressively with one exception when a temporary increase occurred in the deepest 80- 120 cm layer upon leaching. The reason behind the different behaviours of Na and K may be due to the smaller water hull that surrounds K ions thus rendering them less affected by upward movement of water during drying.

The increase of K concentration in the 80- 120 cm layer which occurred upon leaching (t_2) is due to the translocation of K to the deep layer.

The decrease in soluble K at the end of the growing fish seasen, are in agreement with both, Pratt (1978) who found that the higher the volume of leachate, the greater was the amount of leached K, and Abd el-Aal (1981) who reported that the rate of loss of potassium by leaching increased upon increasing water head.

4-4-3- Soluble calcium :

Initially, the investigated area contained high levels of soluble calcium. After leaching and flooding a large decrease in soluble Ca occurred, and the concentration of soluble Ca at the end of study was between one to nine tenth of the original levels. The effect of flooding was very much evident in the surface layer and less pronounced with depth.

In the surface layer 0-25 cm contents of Ca at the end of the study were equivalent to 11 %- 39 % of the original levels at the first stage of study and comparatively less decrease occurred with depth. For example, in the 50- 80 cm layer soluble Ca in the soil at end of experiments ranged between 31 to 58 % of its original initial levels. In the deepest layer contents of soluble Ca in the soil ranged between about one half to nine tenths of the original initial contents. These results agree with Assia (1976) who noticed that most leached soluble salts accumulated in the deep layers.

Comparing the three farms, results show that the effect of flooding on soluble Ca was more pronounced in Al- Raswa farm. Results of the surface layer of the three

Table 6 : Soluble calcium and magnesium meq /L. in soil paste extract as affected by fish farming.

(6- A): Changes in different depths at various stages at Al- Raswa farm .

Depth	Ca meq/ L.					Mg meq / L.				
	t_1	t_2	t_3	t_4^{x}	t_5	t_1	t_2	t_3	t_4^{x}	t_5
0- 25	58.5	30.3	47.3	6.8	6.5	339	70	98	65	39
25- 50	44.5	61.2	51.8	-	8.8	184	116	100	-	44
50- 80	71.3	69.5	54.5	-	22.0	245	181	104	-	88
80-120	72.0	78.8	69.8	-	33.2	175	212	166	-	176

Table (6- B[xx]): Changes in different depths at initial, under flooding and at final stage at El- Wahal and El- Serow farms.

Location	Depth	Ca meq/L.			Mg meq /L.		
		t_1	t_4^{x}	t_5	t_1	t_4^{x}	t_5
	0- 25	73.5	23.7	21.0	157	25	34
El- Wahal	25- 50	35.8	-	27.5	119	-	35
Kafr El-Saikh	50- 80	60.0	-	34.0	185	-	78
	80-120	55.5	-	49.2	169	-	82
	0- 25	36.3	20.0	14.5	22	19	21
El- Serow	25- 50	24.5	-	12.8	26	-	24
Dakahlia	50- 80	24.5	-	14.3	28	-	26
	80-120	22.0	-	15.7	226	-	31

See foot note table (4),

x Only surface layer samples were taken for analyses.

xx Samples of t_2 and t_3 were not taken at El- Wahal and El- Serow farms.

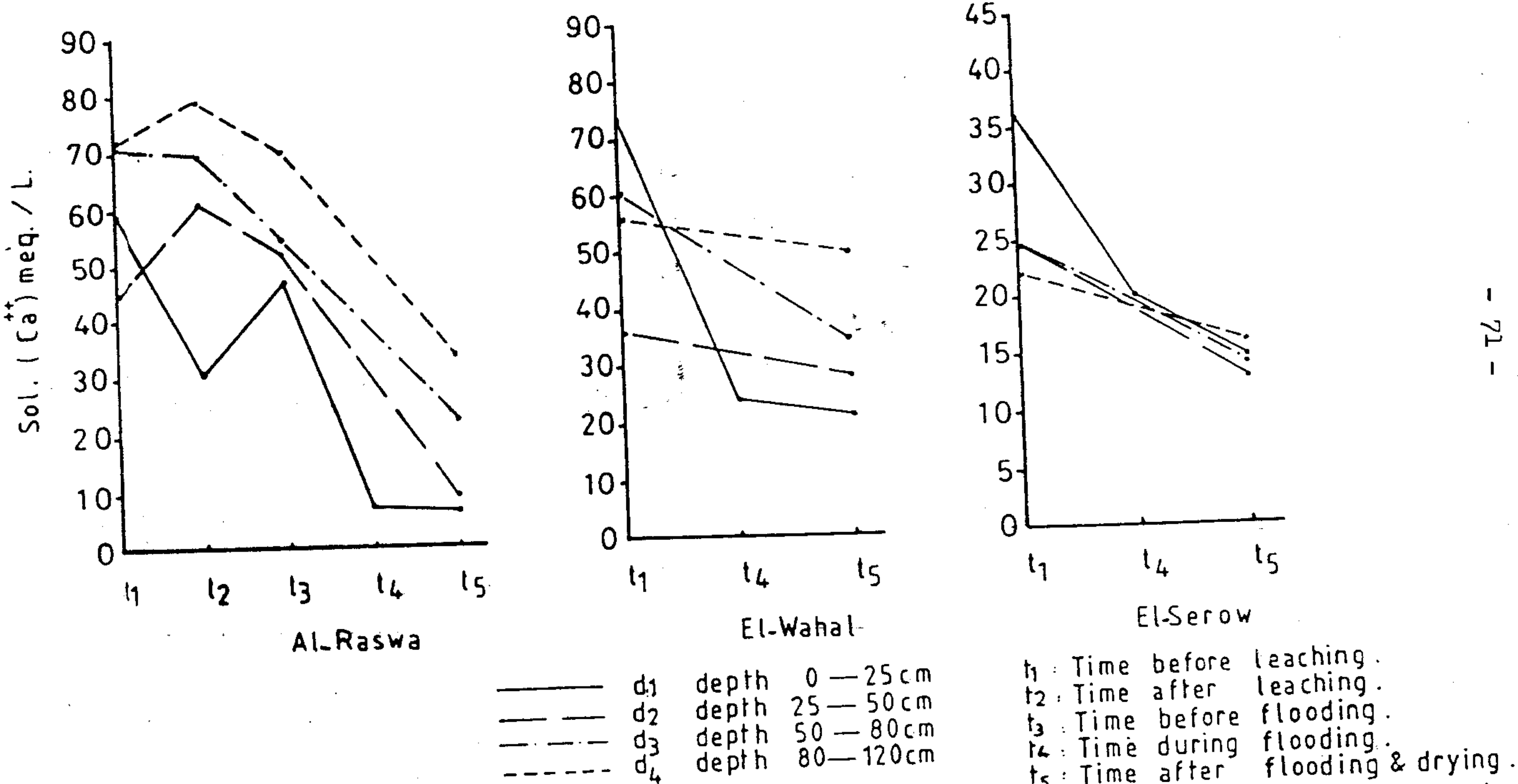


Fig (7) Changes in soluble calcium (meq/l.) of soil extract at various stages in soil layers of three farms.

farms (table 6 A, B) show that, when the soil was under flooding (t_4), soluble Ca was decreased to 6.8 meq/L. (at t_4) as a result of leaching and flooding. (t_4) certainly higher than after drying and following flooding (at t_5). While under water submergence soil contained more soluble Ca probably due to dissolution of calcareous materials.

Detailed results carried out in Al- Raswa during the four sampling stages along the period of investigation (table 6 A) show that leaching operation lowered the contents of soluble Ca in some depths of the soil profile as contents at t_2 sampling show. After termination of leaching operation and allowing the soil same time (t_3), it seems that during this time and within the subsurface 25- 120 cm soil, the action of downward movement of soluble Ca persisted to occur thus giving yet lower values of Ca at t_3 sampling as compared with t_2 stage.

In the surface layer 0-25 cm however, Ca was accumulated due to the upward movement of soil moisture by means of capillary and moisture evaporation from soil surface. Following flooding (t_5) and at all depths of profile results showed a markedly less content of soluble Ca. These results are in agreement with those of Assia (1976) who reported that most soluble salts leached from the surface layer tended to accumulate in the deep layers. But the results disagree with the finding of Rahmatulah et al. (1976) who observed an increase in the concentration of soluble Ca after the flooding of calcareous soils for different incubation periods.

4-4-4- Soluble magnesium :

Results of soluble magnesium followed, in general, a pattern similar to that of soluble Ca. The content of soluble Mg as compared with those of soluble Ca was much higher particularly in Al- Raswa and El- Wahal farms because the soils of both farms are more saline comparing with El- Serow farm.

Data showing the ultimate effect of leaching , flooding, and using the soil as fish farms (table 6 A,B) indicate a remarkable decrease of magnesium at the end of experiment particularly in the two most saline lands of Al- Raswa and El- Wahal, especially in the upper three layers in Al- Raswa. In the deepest layer it seems that the downward movement of magnesium rendered no decrease in Mg at such depth. In El- Serow farm the decrease in Mg content in the upper layers, was less pronounced at the end of study, and the deepest layer gained more magnesium amounting to 25 % of what was

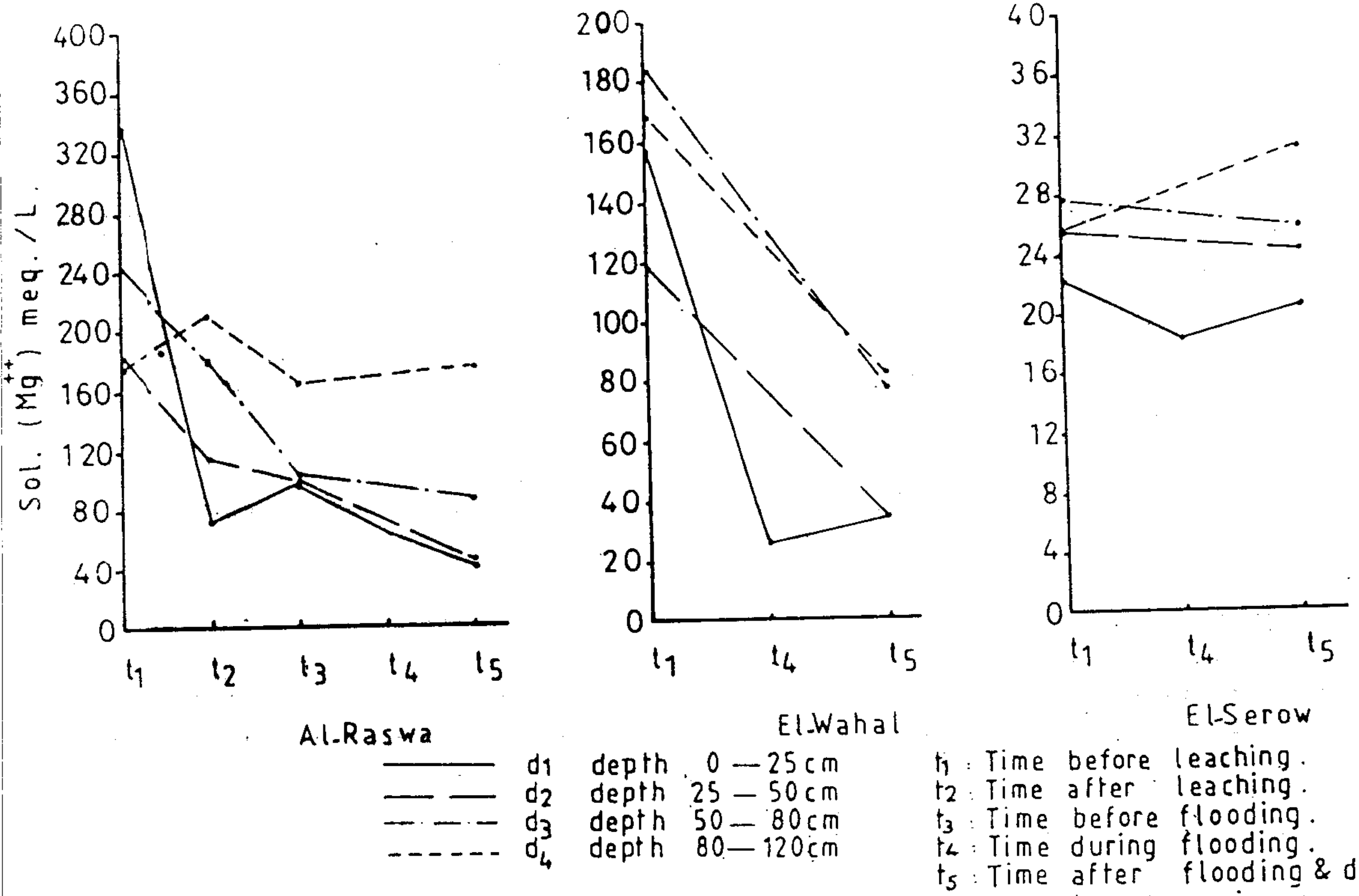


Fig.(8)Changes in soluble magnesium (meq/l.) of soil extract at various stages in soil layers of three farms.

originally found in the soil . This is an evident indication of downward movement of soluble Mg under the effect of the percolating water.

Results of Mg contents in soil surface while under water submergence show a markedly low content of Mg when the soil was flooded with water (t_4) as compared with initial Mg-content (t_1) (table 6). At end of study i.e., after flooding and drying both EL- Wahal and El- Serow farms showed an increase of Mg content in upper layers. This finding may be due to soil drying and subsequent Mg accumulation due to upward movement. At Al- Raswa however, Mg content in the surface layer at end of experiment was smaller than that found under flooding the surface. It seems that at the time of sampling, the soil surface contained a considerable Mg contents which not yet leached down.

Results obtained from Al- Raswa farm (table 6 A) show that leaching and flooding processes caused a considerable decrease in soil contents of soluble Mg in nearly every layers of the profile. At the surface layer, and between the end of leaching and the beginning of flooding it seems that some Mg moved down to cause an increase in Mg content at t_3 as compared with t_2.

Before utilization the lands as fish farms, high Mg content was found in the soil solution near the soil surface, while the reverse occurred after utilization i.e. there was high Mg content in the deeper layers. This pattern is in agreement with those noticed in the cases of salinity, soluble Na, and soluble K, but not like that of soluble Ca which maintained one pattern before and after utilization i.e. increase with depth.

The pattern of the relative concentration of Mg in various layers before utilization reflects the con-tainued build-up of this cation due to evaporation. Magne-sium concentration in the layers of 25- 50 cm, 50- 80 cm, and 80- 120 cm decreased after flooding. These results disagree with Fathi et al. (1976) who showed that soluble Mg increased by land use for some periods then maintained a constant level, and soluble Ca content behaved in an opposite way.

Mg contents in the other two farms showed the same behaviour as Al- Raswa farm, where Mg decreased with time.

Table 7 : Soluble chloride, sulphate and bicarbonate meq/ L. of soil paste extract as affected by fish farming.

Table (7- A): Changes in different depths at various stages at Al- Raswa farm .

Depth	Cl^- meq/ L.					$SO_4^=$ meq/ L.					HCO_3^- meq/ L.				
	t_1	t_2	t_3	t_4^x	t_5	t_1	t_2	t_3	t_4^x	t_5	t_1	t_2	t_3	t_4^x	t_5
0- 25	3570	505	665	165	220	383	132	163	97	69	3.0	2.3	2.5	2.2	3.3
25- 50	1000	1115	800	-	270	343	160	117	-	75	2.5	2.0	2.2	-	1.5
50- 80	2730	1700	955	-	545	551	308	188	-	84	3.0	2.0	1.5	-	1.5
80-120	1800	2115	1610	-	805	325	275	270	-	196	1.9	1.40	1.3	-	2.5

Table (7- B^xx^): Changes in different depths at initial , under flooding and at final stage at El- Wahal and El- Serow farms.

Location	Depth	Cl^-			SO_4^-			HCO_3^-		
		t_1	t_4^x	t_5	t_1	t_4^x	t_5	t_1	t_4^x	t_5
	0- 25	1105	128	150	217	48	76	1.5	1.5	2.5
El- Wahal	25- 50	920	-	190	137	-	77	1.5	-	2.5
Kafr El-Shaikh	50- 80	1030	-	450	268	-	78	1.5	-	3.0
	80-120	970	-	1090	237	-	100	1.9	-	2.3
	0- 25	64	19	38	48	28	9	2.0	3.0	3.5
El- Serow	25- 50	63	-	47	62	-	5	2.3	-	4.5
Dekahlia	50- 80	79	-	50	48	-	11	2.0	-	2.8
	80-120	62	-	73	61	-	10	4.0	-	4.5

See foot note table (4) ,

x Only surface layer samples were taken for analyses.

xx Samples of t_2 and t_3 were not taken at El- Wahal and El- Serow farms.

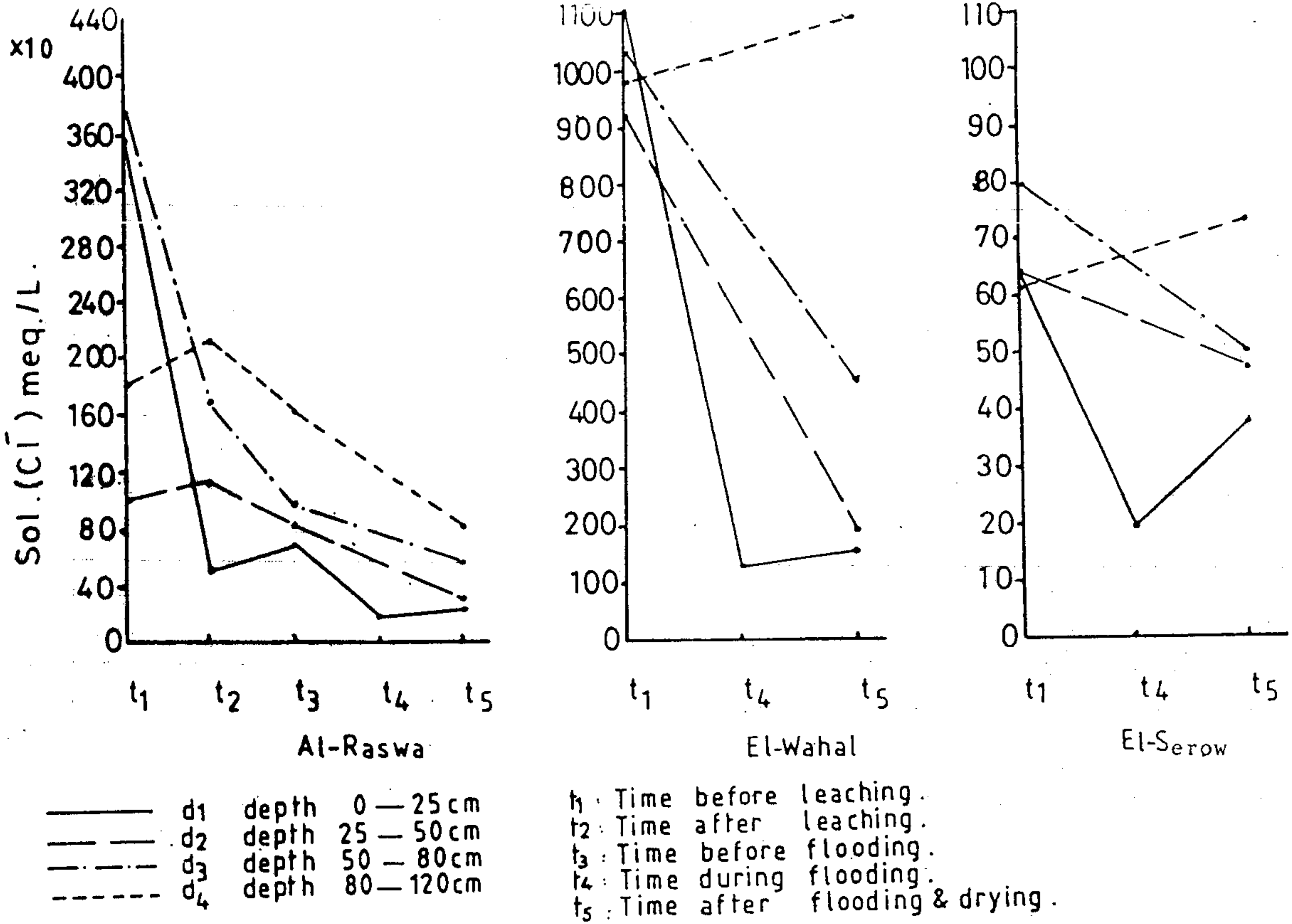


Fig (9) Changes in soluble chloride (meq/l.) of soil extract at various stages in soil layers of three farms.

Salt was accumulated in the deep layer. This particular pattern was particularly observed with the easily soluble and preponderant cations of Na, Mg, and K.

Thus the decrease in Cl^- concentration in the cases where it occurred is due to leaching. The increase in the cases where it occurred is due to accumulation from upper layers. This reflects the very easy and high solubility and diffusion of Cl^-.

At (t_5) i.e. after flooding and drying processes all profiles showed an increase of Cl^- with depth thus showing the leaching action of water. The decrease in Cl contents agree with the observations and results of Habib (1962), Hassanein and Rushdi (1975) and Pratt (1978) who found that the leached chloride increased with increase in the volume of leachate. They also agree with those obtained by Reitemeier(1946) who explained the decrease in amounts of Cl^- on dilution as a result of the existence of anion gradient within the soil colloid suspension.

When the soil was under flooding t_4 (table 7, A,B) the surface layers of the soil showed the lowest Cl concentration at any time during stages of utilization of the land as a fish farm. This finding indicates the easy mobilization of the chloride ions within the soil profile under the effect of water downward movement.

Detailed study on Al- Raswa farm (table 7 A) show that leaching the soil led to a considerable decrease of Cl^- in the upper layers, and high accumulation of this anion in the subsurface layers. Following the actual leaching operation, and as the soil was left for some time (up to flooding time) data of soil Cl^- content at this stage (t_3) indicated the upward as well as the downward movement of Cl^-. The upward movement is reflected in temporary rise in Cl^- content in the surface layer, due to drying of surface. The downward movement is reflected in the fall in Cl^- contents in the deeper layers at this stage as compared with the percedent stage (t_2).

Thus the apparent action of leaching was well demonstrated even after a while after the actual operation was carried out. Flooding was the greatest effect in reducing the contents of Cl^- in all layers since it led to a substantial reduction of Cl concentration as shown by data of (t_5) stage.

On the other hand, Cl^- concentration at (t_5) stage increased gradually with depth in all farms, where it increased from 220 to 805 meq/L., from 150 to 1090 meq/L. and from 38 to 73 meq/L. in Al- Raswa, El-Wahal and El- Serow farms respectively.

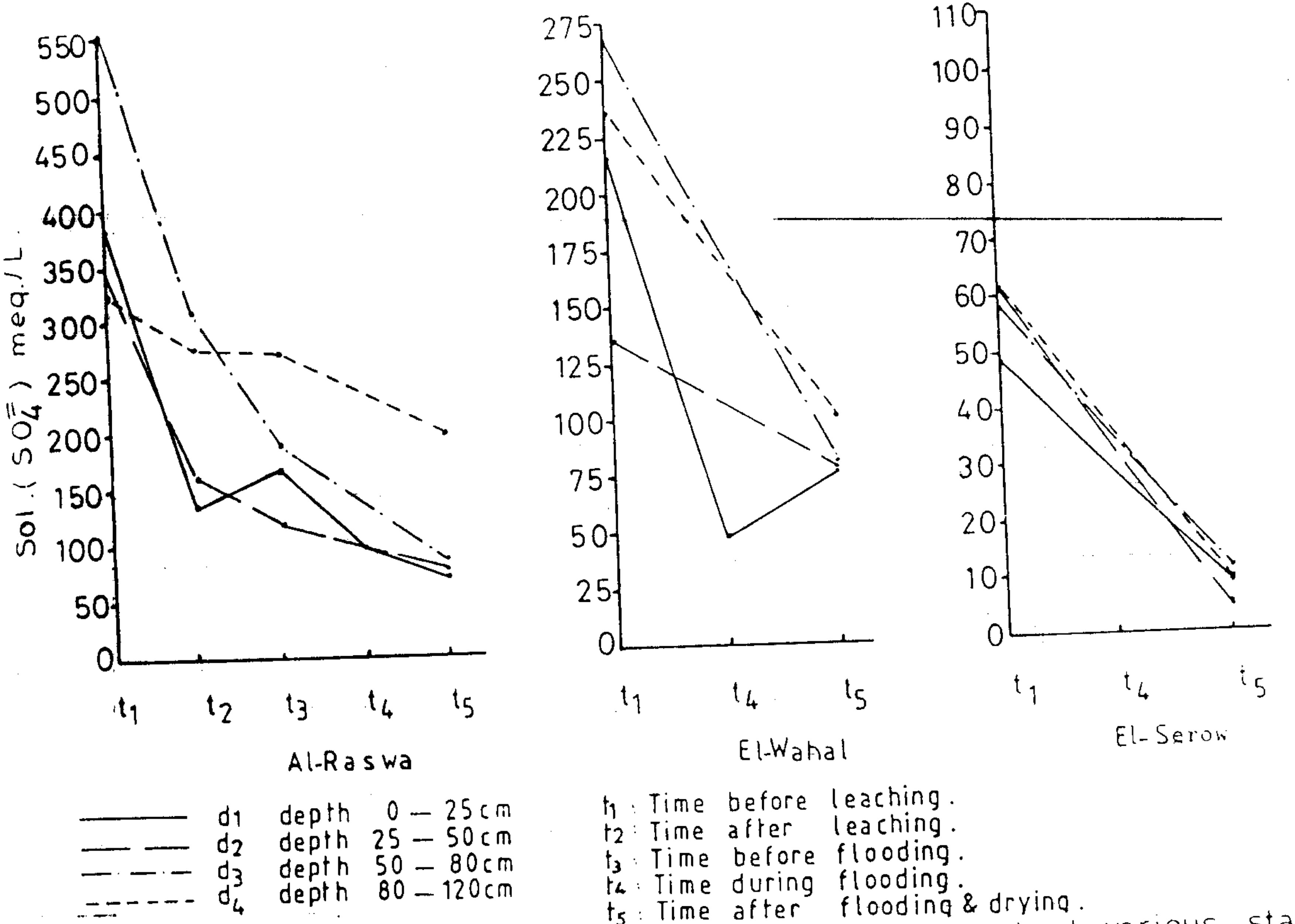
4-4-6- Soluble sulphate :

Data presented in table (7 A, B) and Fig. (10) show that; in all farms and in all soil layers, $SO_4^=$ was decreased upon utilization of the land as fish ponds. The effects of soil leaching and soil flooding on removing a substantial proportion of soluble $SO_4^=$ are apparent in all sites and all soil depths.

Initially sulphate showed its highest contents in the deep layers within the layer of 50 to 120 cm depth.

Sulphate are, thus, not as easily mobile as chloride which desplayed highest content in the soil surface in all cases.

At the end of season, the pattern of $SO_4^=$ distirbution within the soil profile show the increase in its concentration with depth. In this respect, downward movement and effect of leaching are well demonstrated as occurred in the case of total salts, Ca, Mg, Na, K, and Cl^-.



Fig(10) Changes in soluble sulphate (meq/l.) of soil extract at various stages in soil layers of three farms.

When the soil surface was flooded with water (t_4) soluble $SO_4^=$ in the surface was far below as compared with their initial contents (table 7 A, B). Only in one farm (El- Wahal) that after drying (t_5) there was more sulphate than while flooding, due to the upward movement of water.

The detailed data of Al- Raswa farm (table 7 A) show that in no time during the course of the study did any subsurface layer show any temperary build up of sulphate. This is unlike the pattern of distribution in the deep layers due to a build- up of salts under downward movement to deep layers under the effect of leaching and flooding water.

With SO_4, however, it seems that such temporary accumulation did not occurr due to a substantial reduction of SO_4 by means of chemical reduction to meet the demand of organisms in the waterlogged or flooding conditions. Therefore, beside loss by leaching, there were losses by reduction occurring to the soluble sulphates.

The decreases in SO_4 during the course of this study disagree with Eaton and Sokoloff (1935) who found that $SO_4^=$ tended to increase with dilution, and they added that this increase is due to the dissolution of

$CaSO_4$ upon dilution. But these results agree with those of Hassanein and Rushdi (1975) who found a sharp drop in $SO_4^=$ concentration in the upper layer of the profile, and $SO_4^=$ were accumulated at first in the lower half of the profile, after which it was leached out gradually.

4-4-7- Soluble carbonate and bicarbonate :

It was found that, there was no measurable contents of soluble CO_3 in the soil solution, in all soils under study.

Bicarbonate contents at the start of experiment ranged between 1.5 to 4.0 meq/L. With El- Wahal site being the lowest, there was no particular pattern of distribution within the profile, (table 7 A, B). Generally, at the end of study (t_5) the contents of bicarbonates were increased between one tenth to one fold, apparently due to the flooding and waterlogging and activity of micro-organisms.

Under flooding conditions (t_4) the soil surface contained less bicarbonates than in the case of drying followed flooding (table 7 A, B). The higher bicarbonates in soil surface after flooding is a demonstration of

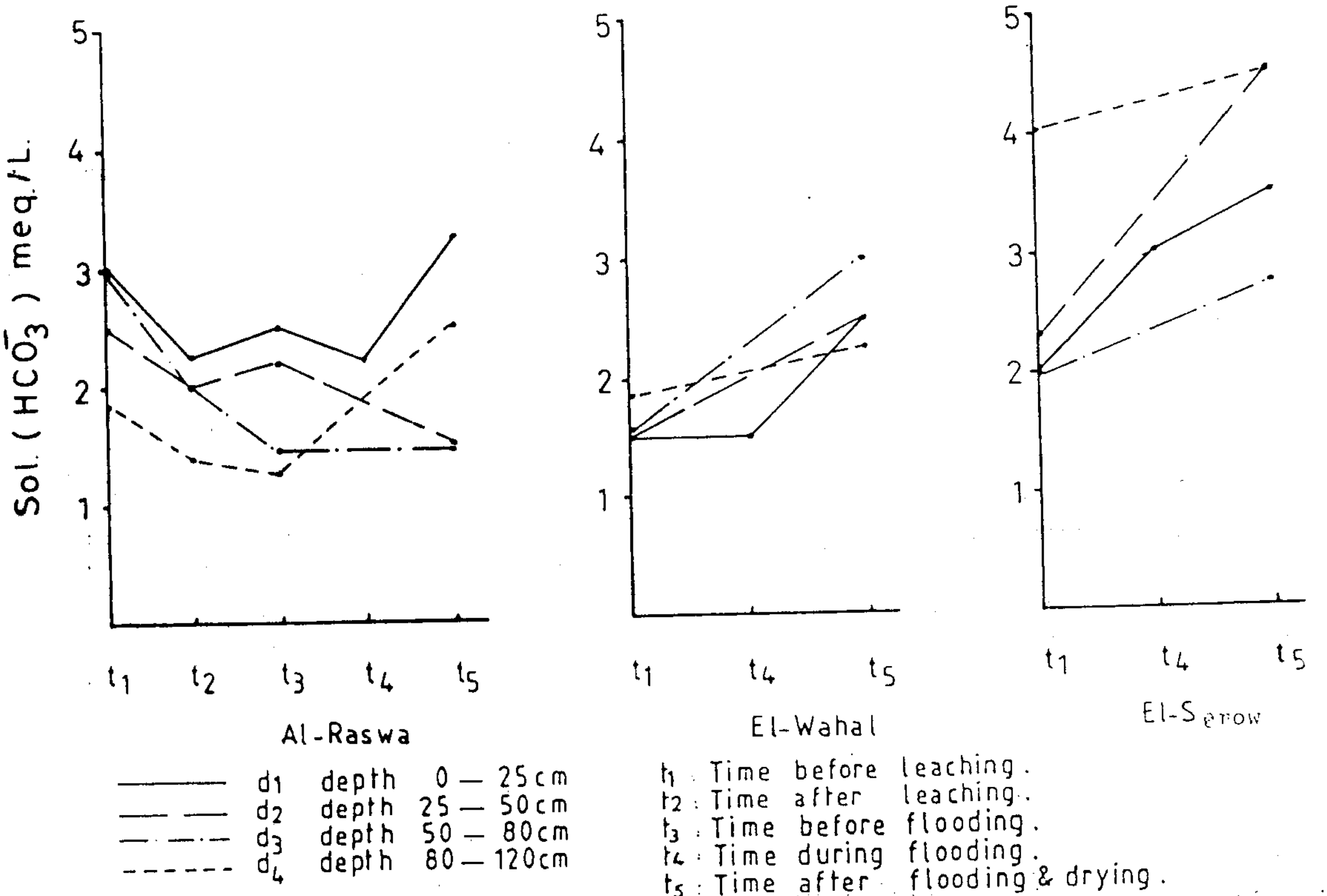


Fig. (11) Changes in soluble bicarbonate (meq/l.) of soil extract at various stages in soil layers of three farms.

a greater biological activity in the soil in presence of ample moisture. Apparently, the increase in organic matter due to organic residues and its decomposition led to the formation of much CO_2 and consequently more soluble HCO_3^- .

The detailed results of Al- Raswa farm (table 7 A) indicate in general that, welting of the soil caused a decrease in bicarbonates as shown by comparing values of HCO_3 at (t_2) with those at (t_1). Such was the case when (t_4) is compared with (t_1) (table 7 A, B). However, drying the soil after wetting caused an increase in bicarbonate contents as shown by comparing the values of HCO_3 at t_3, with that at t_2. Such was the case when t_5 is compared with t_4 (table 7).

The reduction in sulphate contents due to waterlogging (while flooding) would produce carbonate and bicarbonate. But biological oxidation of organic compounds under the activity of microorganisms would render HCO_3^- to decrease indicating the precipitation of $CaCO_3$ and $MgCO_3$ (Yossef 1974), these results are in disagreement with those obtained by Eaton and Sokoloff (1935) who attributed the increase in HCO_3^- with dilution to the dissolution of carbonate, of Ca and Mg. But the increase in HCO_3 content at t_3 agree with those of Hassanein and Rushdi (1975) and Reitemeier (1946).

4-5- Cation exchange capacity (CEC) and soil organic matter :

4-5-1- Cation exchangeable capacity :

The cation exchange capacity of the farm soils generally increased as a result of putting the land under conditions of fish farming. Such type of land use certainly implies an increase in organic matter and consequently colloidal organic matter. These materials are the product of water living organisms and organic residues. Increase in colloidal contents incur increase in CEC. Increases which ranged from about one tenth to nearly 52 % of the original initial CEC are clear by comparing t_5 with t_1 (table 8 A, B). Beside the increase of colloidal organic matter by fish farming, colloidal mineral matter was also increased. The soil being submerged with water would allow for deposition into the soil of particles as clay fraction. As shown in table (3), clay content was increased by putting the soil under fish farming conditions.

Table 8 : Cation exchange capacity meq / 100 g and organic matter content as affected by fish farming.

(8- A): Changes in different depths at various stages at Al- Raswa farm.

Depth	C.E.C. meq /100 g					O.M. %				
	t_1	t_2	t_3	t_4^{x}	t_5	t_1	t_2	t_3	t_4^{x}	t_5
0- 25	32.6	37.6	38.2	39.2	41.6	2.15	1.69	1.99	2.10	2.15
25- 50	36.1	34.4	36.8	-	46.0	1.99	1.64	1.85	-	2.66
50- 80	33.4	24.2	31.8	-	39.5	2.87	1.97	0.97	-	2.05
80-120	20.1	22.1	27.3	-	30.7	2.10	2.05	2.15	-	1.59

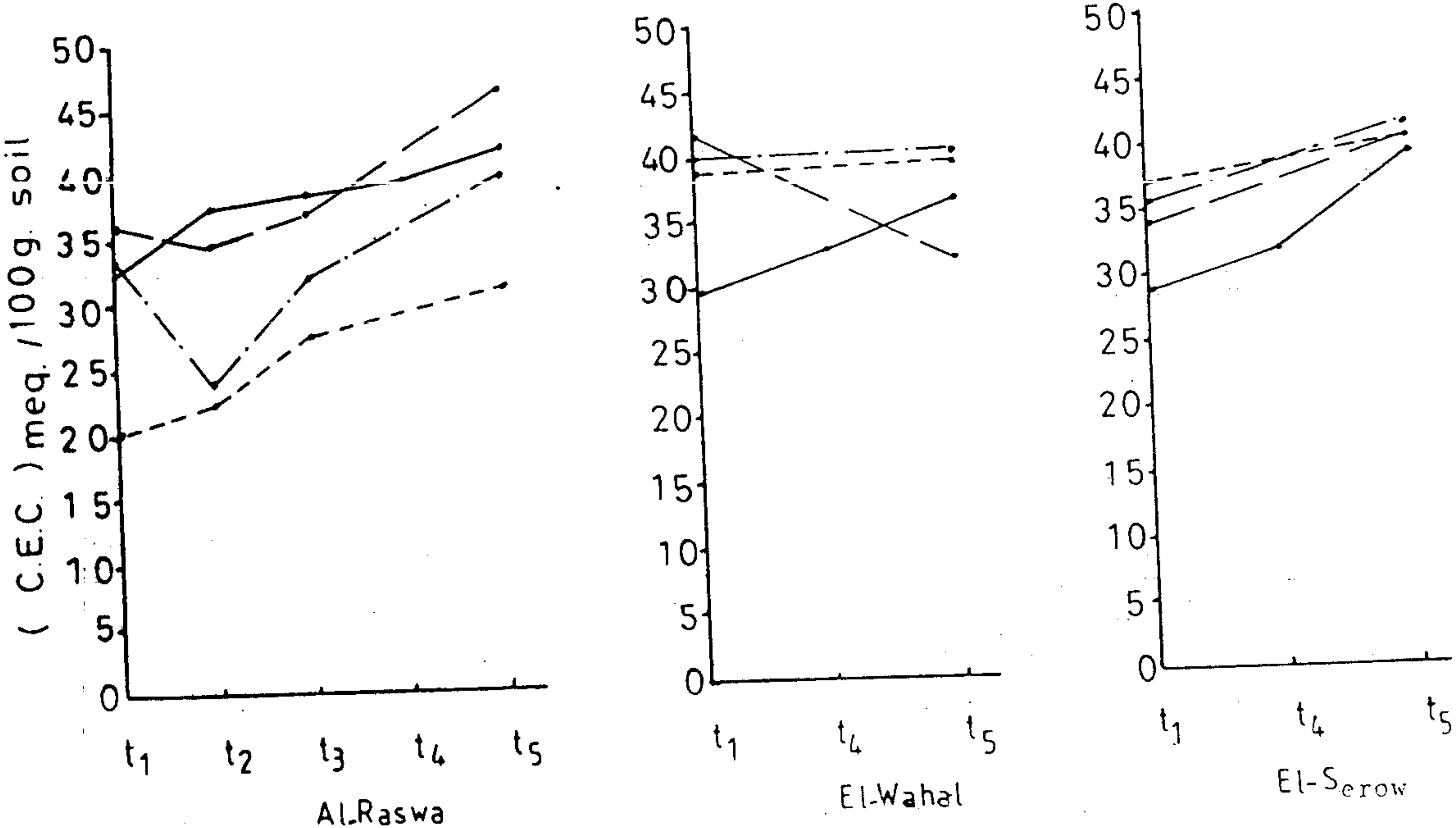
Table (8- B[xx]): Changes in different depths at initial, under flooding and at final stage at El-Wahal and El- Serow farms.

Location	Depth	C'E C meq/100 g			O. M. %		
		t_1	t_4^{x}	t_5	t_1	t_4^{x}	t_5
	0- 25	29.4	32.6	36.6	0.75	1.03	1.08
El- Wahal	25- 50	41.1	-	32.2	0.56	-	1.28
Kafr El-Shaikh	50- 80	39.9	-	40.3	0.72	-	1.08
	80-120	38.4	-	39.9	0.97	-	1.18
	0- 25	28.7	32.0	38.9	2.60	3.25	5.17
El- Serow	25- 50	34.0	-	40.1	2.34	-	4.77
Dekahlia	50- 80	35.5	-	41.2	3.50	-	4.97
	80-120	36.9	-	40.4	1.95	-	4.26

See foot note table 4,

x Only surface layer samples were taken for analyses.

xx Samples of t_2 and t_3 were not taken at El- Wahal and El- Serow farms.



d1 depth 0 — 25 cm
d2 depth 25 — 50 cm
d3 depth 50 — 80 cm
d4 depth 80 — 120 cm

t_1 : Time before leaching.
t_2 : Time after leaching.
t_3 : Time before flooding.
t_4 : Time during flooding.
t_5 : Time after flooding & drying

Fig(12) Changes in cation exchange capacity (CEC) (meq/100g) at various stages in soil layers of three farms.

For example, the initial CEC, in the surface layer of Al- Raswa, was 32.6 meq/ 100 g and it increased to 41.6 meq/100 g at t_5 . Also CEC of the underlying layers increased from 36.1 to 46.0 meq/100 g in the 25- 50 cm layer. Similar trend is found in the other layers.

In El- Wahal, the surface layer, in particular, desplayed this trend. In El- Serow, all layers showed this increase in CEC. The soil while being under water submergence (t_4), still exhibited a rise in CEC as compared with its initial state (table 8 A, B). After drying the ponds, the CEC of the soil still desplayed, yet a further increase in CEC indicating the possitive effect of flooding time on raising CEC. High organic matter content was also originated from adding fertilizers to the farm beside the fish residues, and the decomposition of the tissues of soil and water microorganisms.

Concerning Al- Raswa farm, the detailed data on CEC along the various stages of fish farming (table 8 A), show a general trend of increase of CEC with time.

From these results it can be conclude that, in general, waterlogging the soil increased its cation exchange capacity due to the deposition of clay particles from the flooding water as well as the increase in organic matter content originating from the addition of fertilizers and accumulation of organic residues. These results agree with those obtained by Kobayashi, (1957), Kobayashi and Shinagawa, (1957), Lunin et al. (1964), and Patrick, (1964).

4-5-2- Organic matter :

From the data shown in table (8) and Fig. (13), it is clear that there was a considerable increase in the quantity of organic matter in nearly all cases especially in El- Wahal and El- Serow farms as a result of utilizing the soil as fish farms.

Under flooding, and comparing the content of organic matter at unitial (t_1) and during flooding (t_4) it is clear that organic matter increased by flooding , this may be due to addation of some organic material as well as decomposition of some fish, and at the end of study there was more organic matter in the surface layer of the three studied farms.

However, considering the follow-up of organic matter content during the course of time and as a result

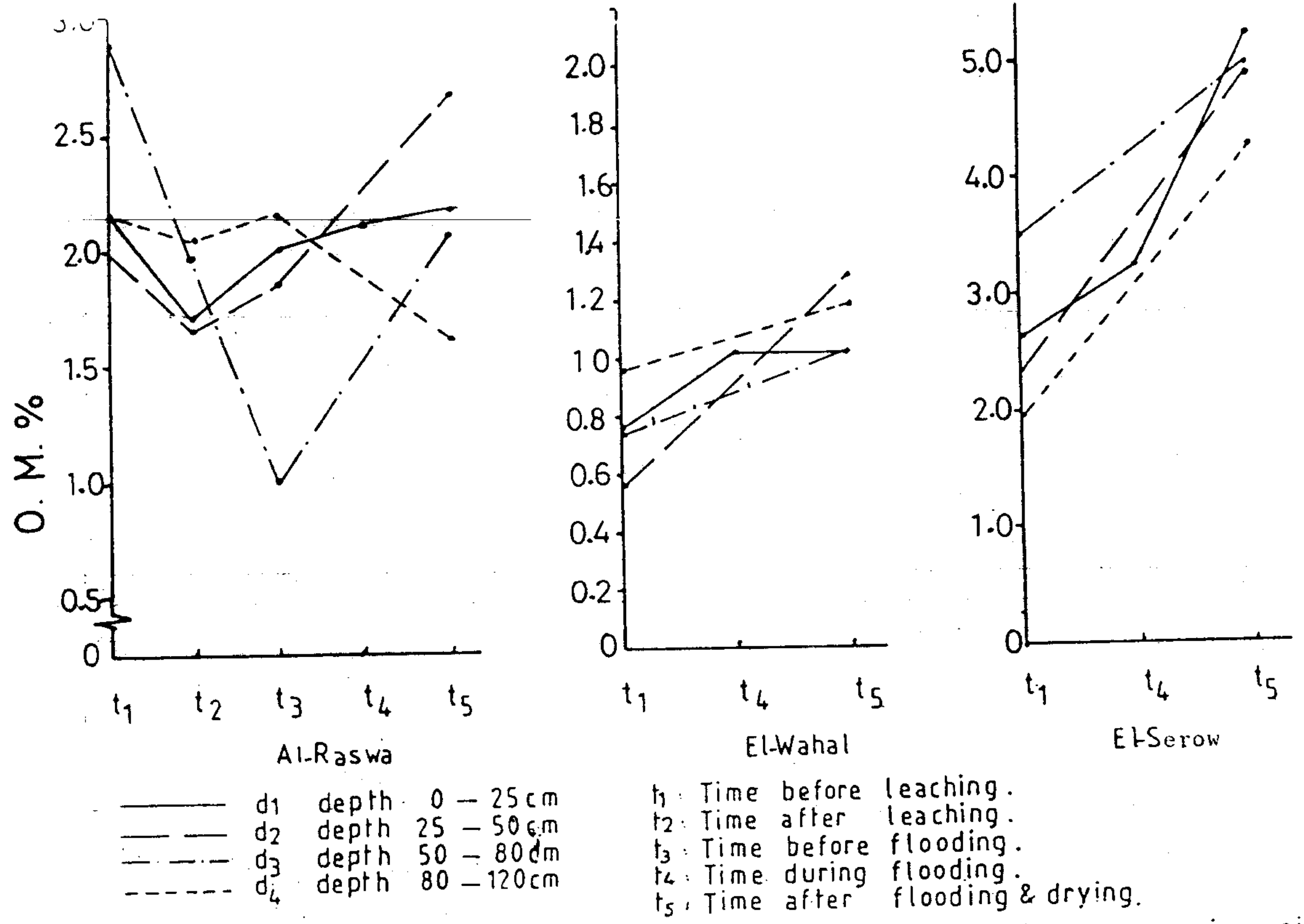


Fig.(13) Changes in organic matter content (%) at various stages in soil layers of three farms.

of the various stages in Al- Raswa farm organic matter decreased by leaching operation. This is certainly due to the loss of soil organic matter incurred by leaching. Allowing the ponds to contain fish (i.e. flooding) therefore, receiving considerable additions of organic matter (fish food, fish residues, organic fertilization , water organisms) that increase the organic matter in the soil.

However, from the detailed data of table (8 A) it is clear that organic matter increased with depth only at samplings stages followed leaching i.e. t_2 and t_3 . This means that leaching displaced organic matter and carried it from the surface to the deeper layers.

Organic matter percentage in El- Serow fish farm was ranged between 4.26 to 5.17 % which is substantially higher than their percentages in the other two farms (between 1.08 to 2.66 %). This may be due to that El- Serow farm received fresh water which enhanced the growth of pond vegetation, also due to the accumulation of the death microorganisms and fish residues and their decomposition.

4-6- Effect on soil exchangeable cations :

4-6-1- Exchangeable Na^+ :

Initially (t_1), both Al- Raswa and El- Wahal sites contained high exchangeable Na and each contained nearly twice as much as El- Serow site. This reflected the higher salinity and soluble sodium in the soils of both sites (see tables 4 and 5). Water used in Al-Raswa was high saline and water used in El- Wahal was saline. Both waters were more saline, and contained more Na in comparison with water used in El- Serow.

When exchangeable Na at end of study (t_5) is compared with the initial content (t_1) (table 9 A, B) it is shown that at Al- Raswa an increase occurred this increase is due to the extremely high salinity and high sodium content of used water. In El- Wahal and El- Serow the increase occurred only in the deepest layer, while in the other layers, there was a slight to moderate decrease in exchangeable Na.

Under flooding (t_4), surface soil layers in all farms, contained the least amount of exchangeable Na as compared with either the initial state (t_1) or the final stage (t_5) after drying of ponds (table 9).

Table 9 : Exchangeable sodium and potassium meq / 100 g soil as affected by fish farming .

(9- A): Changes in different depths at various stages at Al- Raswa farm.

Depth	Na meq / 100 g					K meq / 100 g				
	t_1	t_2	t_3	t_4^x	t_5	t_1	t_2	t_3	t_4^x	t_5
0- 25	17.1	15.2	13.0	14.3	18.3	2.95	4.29	4.19	4.86	5.11
25- 50	14.8	10.4	13.5	-	21.3	3.37	3.99	3.63	-	5.01
50- 80	16.1	6.1	12.2	-	16.9	1.33	1.64	3.63	-	3.63
80-120	2.8	4.8	7.8	-	11.7	1.33	2.51	3.37	-	2.51

Table(9- B[xx]): Changes in different depths at initial, under flooding and at final stage at El- Wahal and El- Serow farms.

Location	Depth	Na meq/ 100 g			K meq / 100 g		
		t_1	t_4^x	t_5	t_1	t_4^x	t_5
El- Wahal Kafr El-Shaikh	0- 25	13.4	10.9	12.2	3.78	2.97	3.07
	25- 50	18.8	-	12.7	3.78	-	2.46
	50- 80	18.1	-	16.9	3.84	-	3.07
	80-120	15.9	-	11.7	2.09	2.19	2.49
El- Serow Dekahlia	0- 25	4.6	3.8	5.7	2.09	2.19	2.49
	25- 50	8.9	-	8.2	2.31	-	2.95
	50- 80	10.0	-	10.1	2.97	-	3.03
	80-120	11.3	-	13.2	3.07	-	3.48

See foot note table (4)

x Only surface layer samples were taken for analyses.

xx Samples of t_2 and t_3 were not taken at El- Wahal and El- Serow farms.

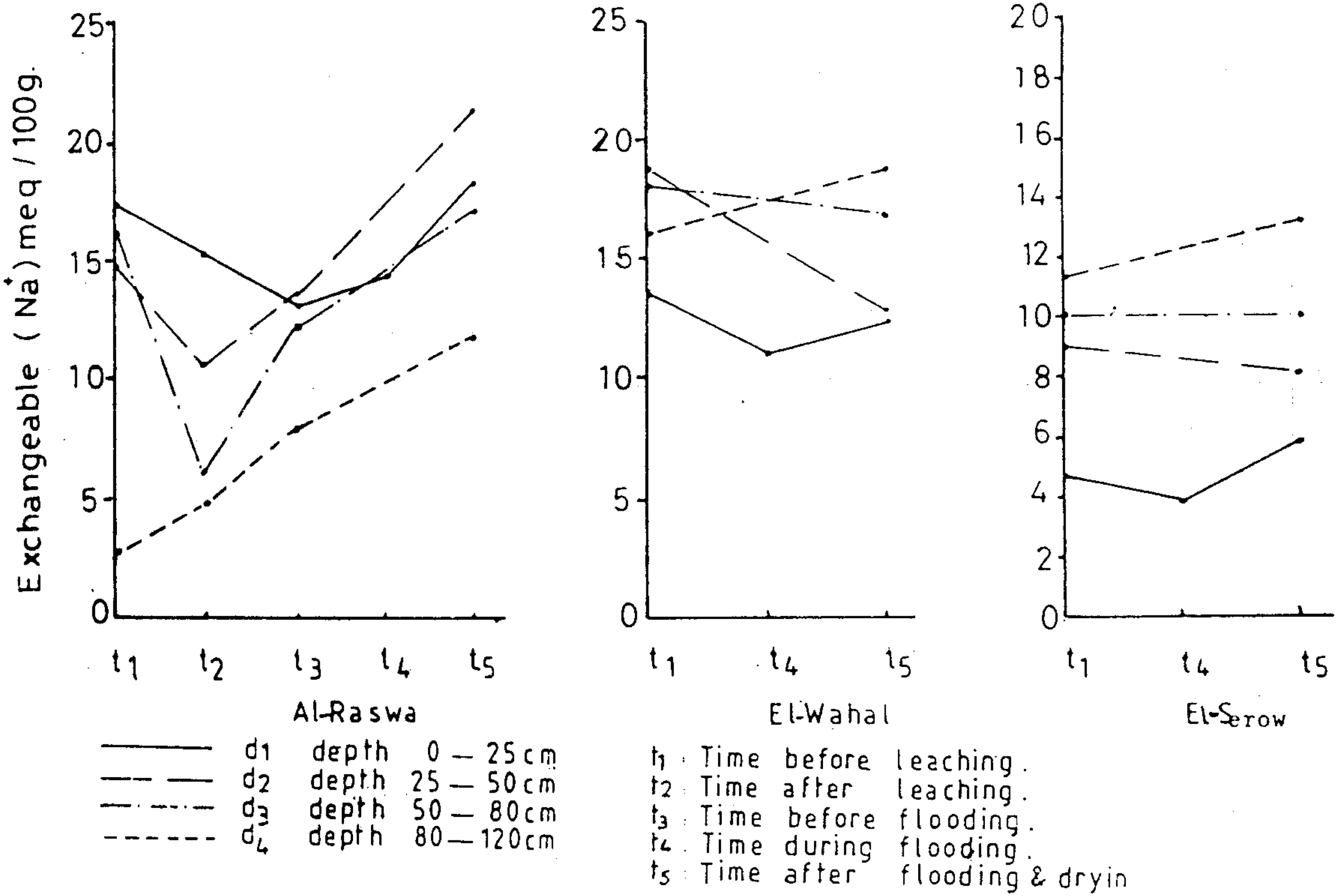


Fig.(14) Changes in exchangeable sodium (meq/100g.soil) at various stages in soil layers of three farms

The change of exchangeable Na at Al- Raswa during the various stages of fish farming (table 9 A) shows that it decreased in all upper layers but it increased in the deepest layer (80- 120 cm) upon leaching. This is a manifestation of Na leaching, as well as replacement of exchangeable Na by Ca and Mg as well as by K which is clearly demonstrated by the results of the other exchangeable cations.

This shows that the build-up of Na which was washed down the soil profile and accumulated in the deepest layers thus leading to a marked adsorption of Na in the place of Ca and Mg. This is clearly shown by the concurent decrease in Ca and Mg on the exchange complex of this deep layer soil (see table 10 A). These results agree with those obtained by Ravikovich and Muravsky (1958), Lunin et al. (1964) and Abed (1975).

When the soil was left after leaching (t_3), only its surface layer exhibited yet farther decrease in exchangeable Na. Apparently more exchangeable Ca and Mg displaced Na on the soil adsorption sites of the top soil as seem in table (10 A). The top soil seemed to receive more soluble Ca from the subsurface layers through upward movement of moisture during drying following termination of leaching operation thus making further displacement of adsorbed Na. In the subsurface and deep layers exchangeable Na increased, this is a manifestation of Na, accumulation through translocation from the soil surface upon dissolation by water. Following the duration period of soil flooding with water, all parts of the soil profile underwent a substantial increase in their content of exchangeable Na. Contents of adsorbed Na showed increases of between about one third to two thirds of what they were immediately before flooding. However, in view of the concurrent decrease in exchangeable Ca, but not Mg or K, the rise in exchangeable Na is not totally due to its replacing of Ca. The rise in exchangeable Na is more than the decrease in exchangeable Ca (table 10 A). This is certainly due to the advent of more exchangeable sites during the creation of the pond. These extra exchangeable sites are represented by mineral colloids represented by clay as well as organic ones represented by organic matter, both of which were increased upon utilization of the land as fish ponds. These results agree with Youssef (1974) who found that exchangeable Na increased with time under the logging conditions.

4-6-2- Exchangeable potassium :

The pattern of change in exchangeable K in the three sites upon their utilization as fish farms was rather similar to that of the exchangeable Na. From results shown in table (9 A, B) and illustrated in Fig. (15) it clear that there are an rise in exchangeable K in Al-Raswa farm in particular. At El- Wahal there was a slight decrease, and at El- Serow there was an increase as compared the exchangeable K at initial (t_1)with its contents at final stage t_5. The increase in exchangeable K is attributed to the increase in salinity of the water used for leaching and flooding, and also with the increase in exchange surface of the soil colloids, that formed from the increase in the amount of clay particles.

In the two sites where such an increase occurred, it is worth noting that a highly saline water was used in one site (Al- Raswa, see table 1) and a marked rise in organic matter, hence organic colloids, occurred conspicuously in the other site (El- Serow- see table 8).

Except at Al- Raswa where the flooded surface showed no decrease in its exchangeable K, the other two

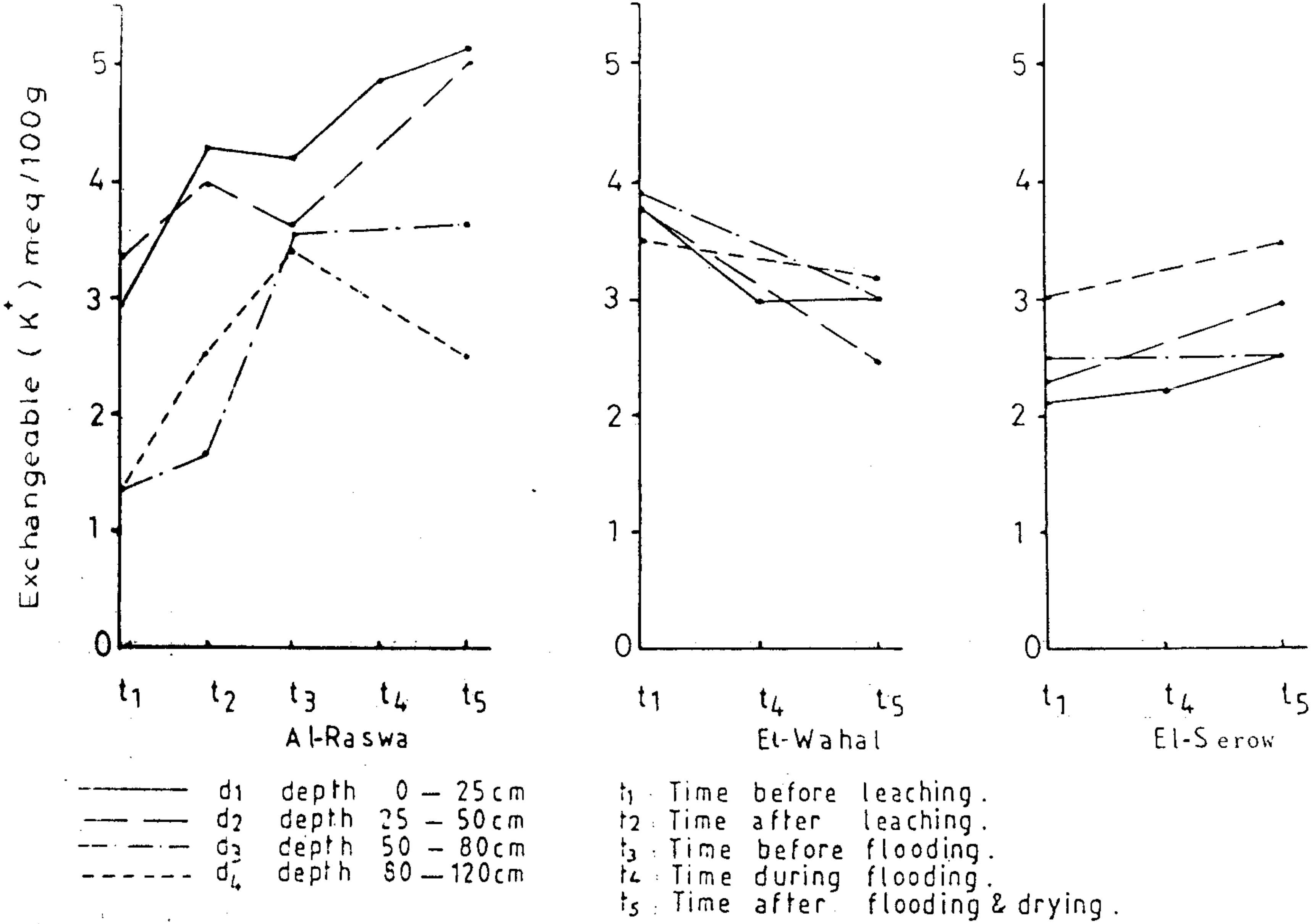


Fig.(15) Changes in exchangeable potassium (meq/100g soil) at various stages in soil layers of three farms.

farms exhibited a decrease in exchangeable K in thier surface while submerged with water (t_4) (table 9 A,B).

Detailed follow up of exchangeable K in the soil profile as affected by leaching, drying, and flooding is presented in Al- Raswa farm, soluble potassium cations in the water used for leaching replaced part of the adsorbed sodium by the soil colloids. Therefore, all layers of soil at t_2 exhibited more exchangeable K as compared with the initial pre-leaching status (t_1). Leaving the soil for a while, after the leaching operation caused replacement of some of that exchangeable K by Ca, Mg, and Na cations especially within the surface layer (0- 25 cm). In this layer exchangeable K was low at t_3 in comparison with t_2 due to the upward moving moisture during that time may have contributed in building up the soil surface with soluble cations of Ca, Mg, and Na. At t_3, the soil surface underwent a consistent increase in its soluble Ca, Mg, and Na in comparison with t_2 (see tables 5 A and 6 A). In the deep and very deep layers the exchangeable K continued to rise.

At the end of study (t_5), nearly all layers showed an increase in the exchangeable K. The accumulation of organic matter as a result of fish farming provided the soil with some colloidal particles i.e. more exchangeable surface. These results are in full-agreement with those of Lunin et al. (1964), and Russel (1973), who stated that waterlogging the soil increase the amounts of exchangeable K in the soil.

The increase in exchangeable K, may have been associated with the increase in the fine fractions as well as with a possible hydrolysis of some minerals that contain potassium element.

On the other hand, El- Wahal farm showed an opposite pattern, i.e., exchangeable K decreased in all layers at the end of study (t_5).

This decrease may be due to that exchangeable K replaced by calcium and magnesium of the flooding water. The water used for flooding this particular site was taken from a drain canal and had high soluble Ca and Mg since it was drained from an arable region (see table 1).

4-6-3- **Exchangeable calcium :**

Utilization of the soil as fish farms led to an eventual decrease in exchangeable Ca in Al-Raswa farm and in the two deep layers of El- Serow site. Water of Al- Raswa contained ample contents of soluble magnesium

Table 10 : Exchangeable calcium and magnesium meq/ 100 g soil as affected by fish farming .
(10- A): Changes in different depths at various stages at Al- Raswa farm .

Depth	Ca meq / 100 g					Mg meq / 100 g				
	t_1	t_2	t_3	t_4^x	t_5	t_1	t_2	t_3	t_4^x	t_5
00- 25	6.00	8.8	10.0	6.0	5.3	6.5	9.3	11.0	14.0	13.0
25- 50	6.8	11.5	8.5	-	4.5	11.2	8.5	11.2	-	15.2
50- 80	7.3	5.5	7.5	-	7.5	8.8	11.0	8.5	-	11.5
80-120	8.5	7.8	8.3	-	6.5	7.5	7.0	7.8	-	10.0

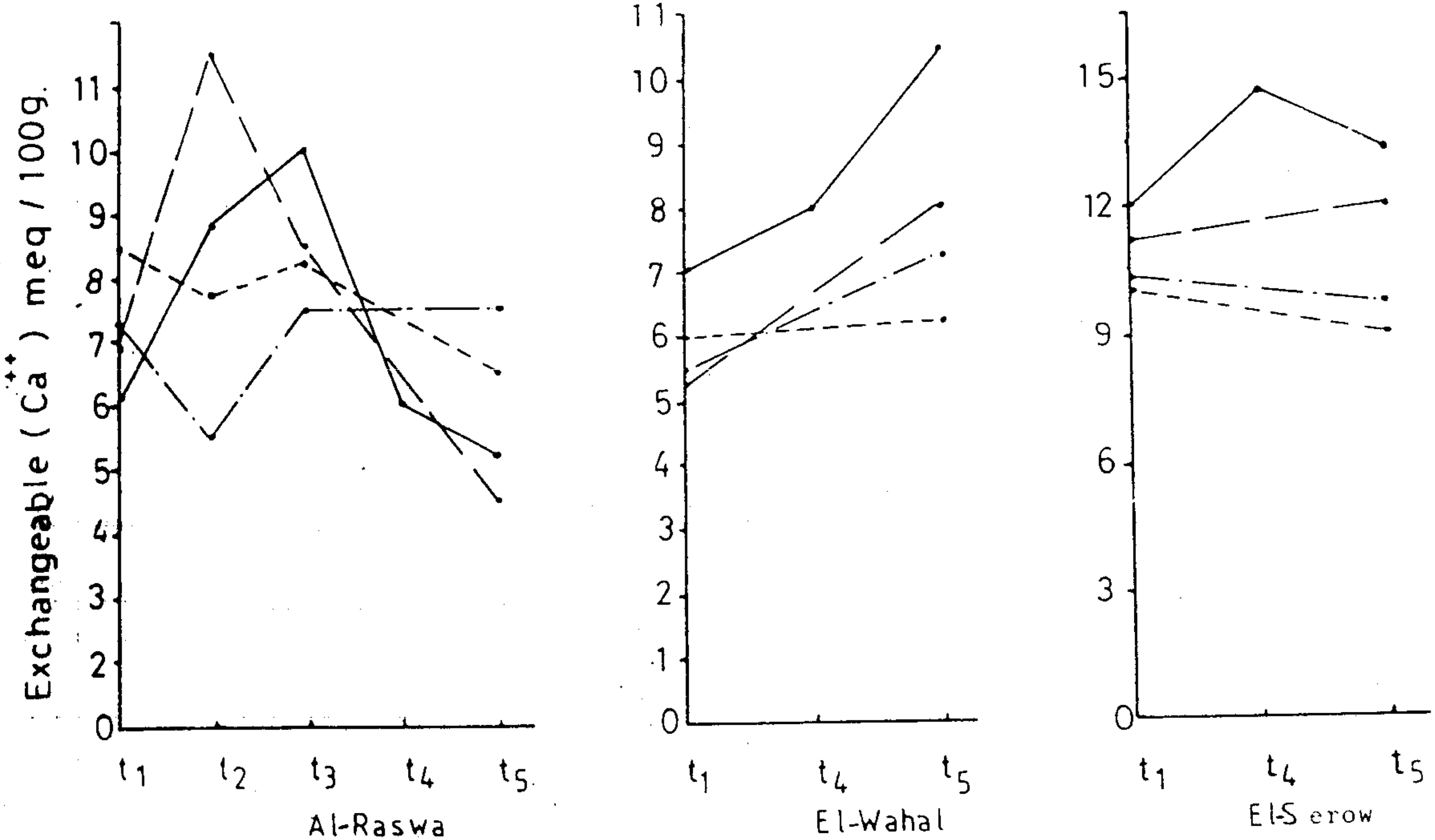
Table(10- B[xx]) : Changes in different depths at initial, under fooding and at final stage at El- Wahal and El- Serow farms.

Location	Depth	Ca meq/ 100 g			Mg meq/ 100 g		
		t_1	t_4^x	t_5	t_1	t_4^x	t_5
	0- 25	7.0	8.0	10.5	5.3	10.7	10.8
El- Wahal	25- 50	5.3	-	8.0	13.3	-	9.0
Kafr El- Shaikh	50- 80	5.5	-	7.3	12.5	-	13.0
	80-120	6.0	-	6.3	13.0	-	11.7
	0- 25	12.0	14.7	13.2	10.0	11.3	17.5
	25- 50	11.3	-	12.0	11.5	-	17.0
El- Serow	50- 80	10.2	-	9.8	12.3	-	18.3
Dekahlia	80-120	10.0	-	9.0	12.5	-	14.7

See foot note table (4) :

x Only surface layer samples were taken for analyses.

xx Samples of t_2 and t_3 were not taken at El- Wahal and El- Serow farms.



———	d_1	depth 0 — 25cm
— —	d_2	depth 25 — 50cm
—·—·—	d_3	depth 50 — 80cm
- - - -	d_4	depth 80 — 120cm

t_1 . Time before leaching.
t_2 : Time after leaching.
t_3 : Time before flooding.
t_4 : Time during flooding.
t_5 : Time after flooding & drying

Fig. (16) Changes in exchangeable calcium (meq/100g. soil) at various stages in soil layers of three farms.

(about 34 meq/L.) as well as sodium which must may be the cause of the decrease in exchangeable Ca. This agree with Lunin et al. (1964) who reported that exchangeable Ca decreased by flooding the soil with saline water.

The accumulation of soluble cations such as Na and Mg contributed to the decrease in exchangeable Ca in the deep soil layers of El- Serow site.

But the increase of exchangeable Ca in El-Wahal soil is a manifestation to the dissolving of calcium salt by added water and bringing Ca^{++} into solution which in turn displace other cations on the exchange surface as compared the exch. Ca at t_1 with its amount at (t_5) in the three farms.

Under flooding (t_4) surface layers showed a greater contents of exchangeable Ca than initially (t_1), and the contents were even more so at the end of the season (t_5) except in Al- Raswa where there was a decrease in exchangeable Ca.

Detailed data on Al- Raswa (table 10 A) show that leaching increased Ca only in the exchange complex of the soil surface and subsurface layers (0- 50 cm). While exchangeable Ca decreased in the deepest layers (50- 120 cm). The increase of exch. Ca in the surface layers is an indication of the substitution of other exchangeable cations by Ca cation. The deeper layers where salts were accumulated gave away some of its exchangeable Ca due to replacement by other cations such as Na and Mg. Allowing the soil to dry after leaching (t_3) caused more Ca on the exchange complex of the leached soil layers.

Generally, an increase reaching to about one third of contents of exchangeable Ca in the layers was observed especially in the surface layers along with the 2 deepest layers was noticed from comparison exch. Ca at t_2 with its amount at (t_3) stages.

Flooding the soil for the duration of the season (t_4) caused the decrease of exchangeable Ca in the surface layer which apparently compersated by an increase in exchangeable Mg, this is due to that the used water is a saline sea water which high in Mg. These results are in agreement with Lunin et al. (1964).

4-6-4- Exchangeable magnesium (table 9 and Fig. 17):

From data presented in table (10) and illustrated in Fig. (17) it is clear that exchangeable Mg increased in nearly all farms, where the leaching and flooding were done

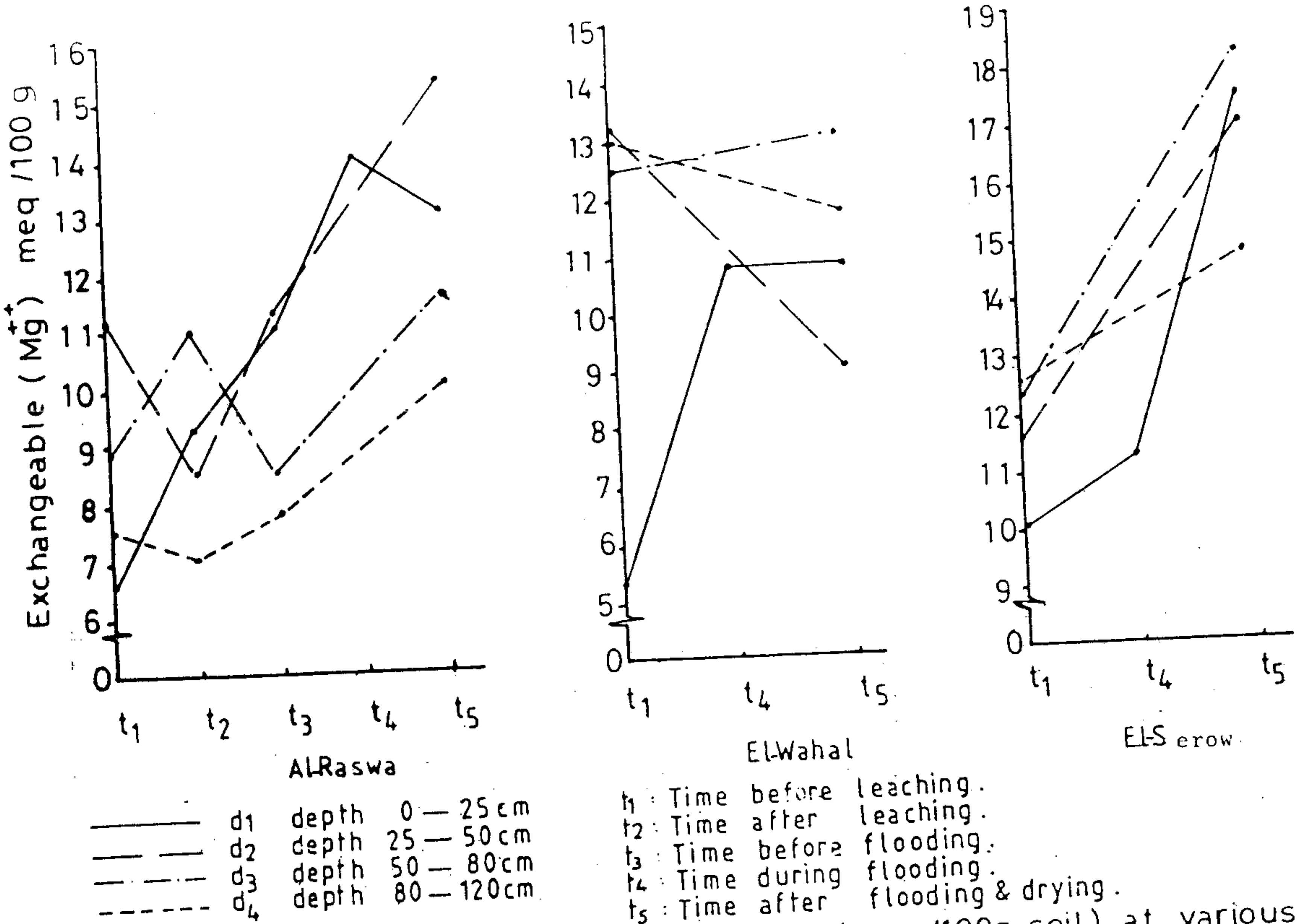


Fig.(17) Changes in exchangeable magnesium (meq/100g soil) at various stages in soil layers of three farms.

either by saline water or fresh water.

At Al- Raswa farm exchangeable Mg increased from 6.5 to 13.0 meq/100 g in the surface layer (0-25 cm). In the other layers the values of exch. Mg ranged between 7.5 to 11.2 meq/ 100 g at the beginning of the study (t_1) and increased to about 10 and 15.2 meq/100g at the end of study (t_5). Similar trends were found in the other two farms, where exch. Mg increased between about 75 % to one fold in the surface layer at the end. of study. However, the other layers showed similar trend of the increase in exch. Mg.

When the soil was flooded with water (t_4), surface layers showed a greater content of exch. Mg than initially (t_1) and at the end of study (t_5) in Al-Raswa and El- Wahal, but was less than its content in El-Serow at end of the study.

Detailed data in Al- Raswa farm show that at all stages exchangeable Mg continued to increase in most soil layers particularly when a comparison is carried between exch. Mg at (t_1) with its amount at end of the study(t_5).

The increase in exchangeable Mg may be due to that the high salinity and certainly the high Mg content of the flooding water as well as the dissolution of magnesium salts in the soil caused adsorption of some magnesium on the exchange sites of the soil colloids.

These results are in agreement with those of Russel (1973) who found that, waterlogging of the soil increased its exchangeable Mg.

4-7- Effect on SAR of the soil solution and ESP on the exchange complex :

4-71-1- SAR of the soil solution :

Data in table (11) show that the SAR values of soil solution in all sites were drastically decreased by utilization the soil as fish farm. Values of SAR in the most saline sites, i.e., Al- Raswa, were initially very high and ranged from about 103 to 250 and reduced to the range between about 51 and 77. In El- Wahal farm the initial SAR values were ranged between about 92 to 102 and reached to about 32 to 55 in the three upper layers at the end of study, concerning the third site i.e., El- Serow it was relatively less than the other to sites and its initial values were about 10- 17 and ended up with low values of about 3-7.

Table 11 : Sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) as affected by fish farming .

(11- A): Changes in different depths at various stages at Al- Raswa farm.

Depth	SAR					ESP				
	t_1	t_2	t_3	t_4*	t_5	t_1	t_2	t_3	t_4*	t_5
0- 25	250	74	80	32	51	52.4	40.4	34.0	36.5	44.0
25- 50	103	115	87	-	57	40.9	30.2	36.7	-	46.3
50- 80	233	155	109	-	70	48.1	25.2	38.4	-	42.8
80-120	166	171	150	-	77	13.9	21.8	28.6	-	38.1

Table (11- Bxx**): Changes in different depths at initial, under flooding and at final stage at El- Wahal and El- Serow farms.**

Location	Depth	SAR			ESP		
		t_1	t_4*	t_5	t_1	t_4*	t_5
	0- 25	101	25	32	45.4	33.4	33.3
El-Wahal	25- 50	102	-	36	45.6	-	39.4
Kafr El-Shaikh	50- 80	95	-	55	45.3	-	41.9
	80-120	92	-	130	41.4	-	46.9
	0- 25	10	2	3	16.0	11.9	14.7
El- Serow	25- 50	15	-	4	26.2	-	20.4
Dekahlia	50- 80	17	-	5	28.2	--	24.5
	50-120	15	-	7	30.6	-	32.7

See foot not table (4) :

*** Only surface layer samples were taken for analyses.**

xx Samples of t_2 and t_3 were not taken at El- Wahal and El- Serow farms.

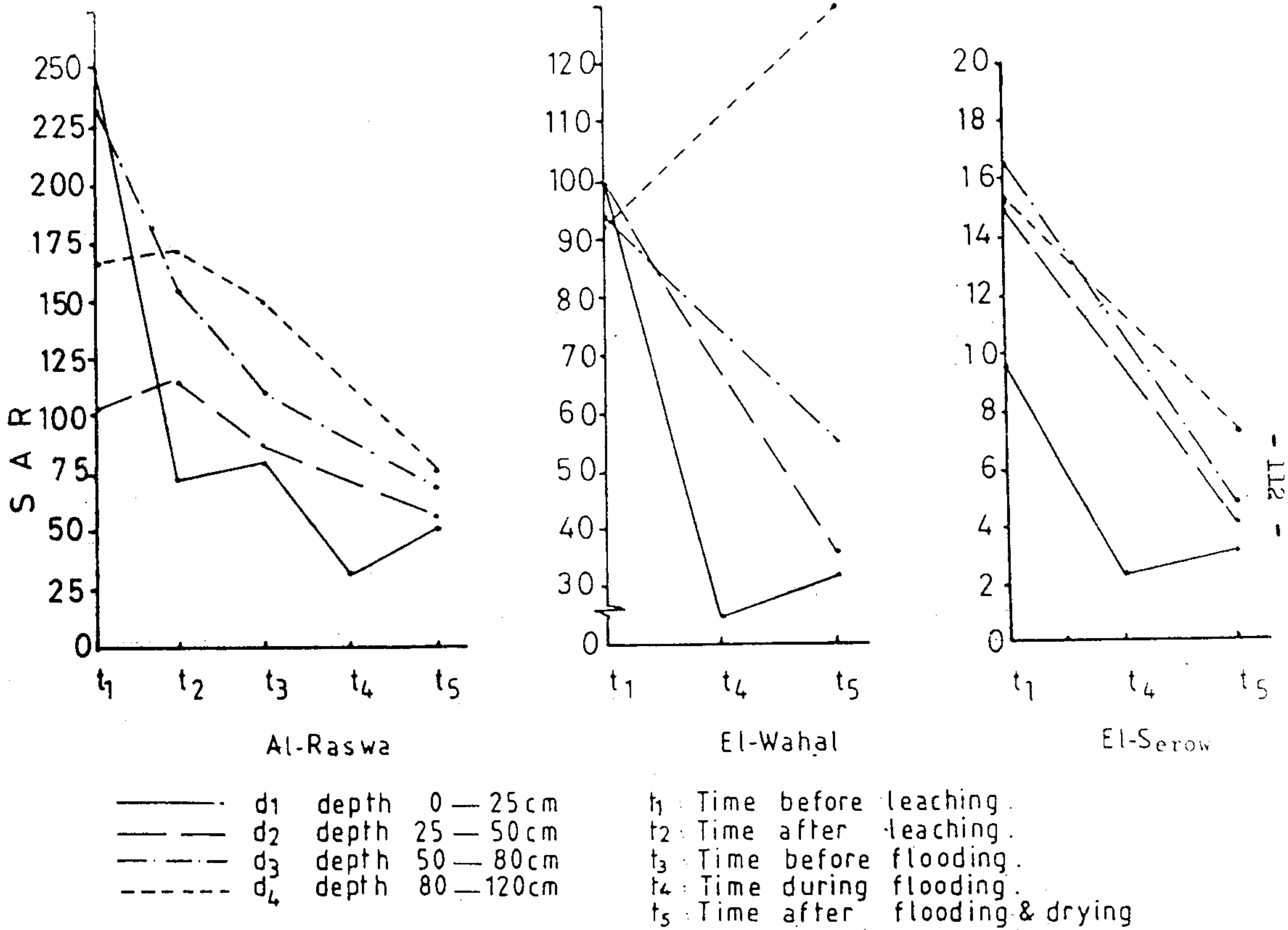


Fig. (18) Changes in sodium adsorption ratio (SAR) at various stages in soil layers of three farms.

The final SAR values obtained for the three sites are in line with the quality of used water. The greater the salinity of the used water, the greater was the SAR of the soil solution that was equilibrated with flooding water. The increase in the SAR that noticed in the deepest layer (80- 120 cm) in El- Wahal may be due to the translocation of soluble Na salts from the upper layers at the expense of soluble Ca and Mg salts.

While under flooding water (t_4), the surface soils was having a comparatively lower SAR as compared with its initial values and at the end of the study when it was subject to drying and the upward movement of soluble Na salts.

The detailed results obtained for Al- Raswa show that, leaching reduced SAR particularly in the surface layer. And the high SAR which noticed in the subsurface layer in particular was due to downward movement of salts including sodium salts. Even after leaving the soil for a while following leaching operation, (t_3) the SAR, generally continued to decrease. The action of downward movement persisted even after termination of leaching operation. At the end of study (t_5) and because of the pro -

-found effect of flooding water, SAR values decreased to the minimum values after drainage ponds of the farm at the end of season fish growth.

4-7-2- ESP on the exchangeable complex :

Concerning the ESP, the obtained pattern of ESP was rather similar, in most cases, to that of SAR. The ESP values of both saline soils Al- Raswa and El- Wahal were rather comparable, particularly at the start and before initiation of the farms. Concerning the third site of El- Serow soil, its initial ESP values were nearly half those of either of the other two sites. At the end of study, most soil layers showed a decrease in the ESP values, particularly with the surface and sub-surface layers but in the deepest layer (80- 120 cm) and as a result of the increase in soluble Na in this layer and consquently the increase in exchangeable Na was more than the increase in the other exchangeable cations and consquently an increase in ESP values were noticed.

The ESP values in the surface layer decreased to their lowest level when the soil was under flooding (t_4), due to that the decrease in exchangeable Na was more than the decrease in the other cations, but at the end of the study and due to the high amount of exchangeable Na at

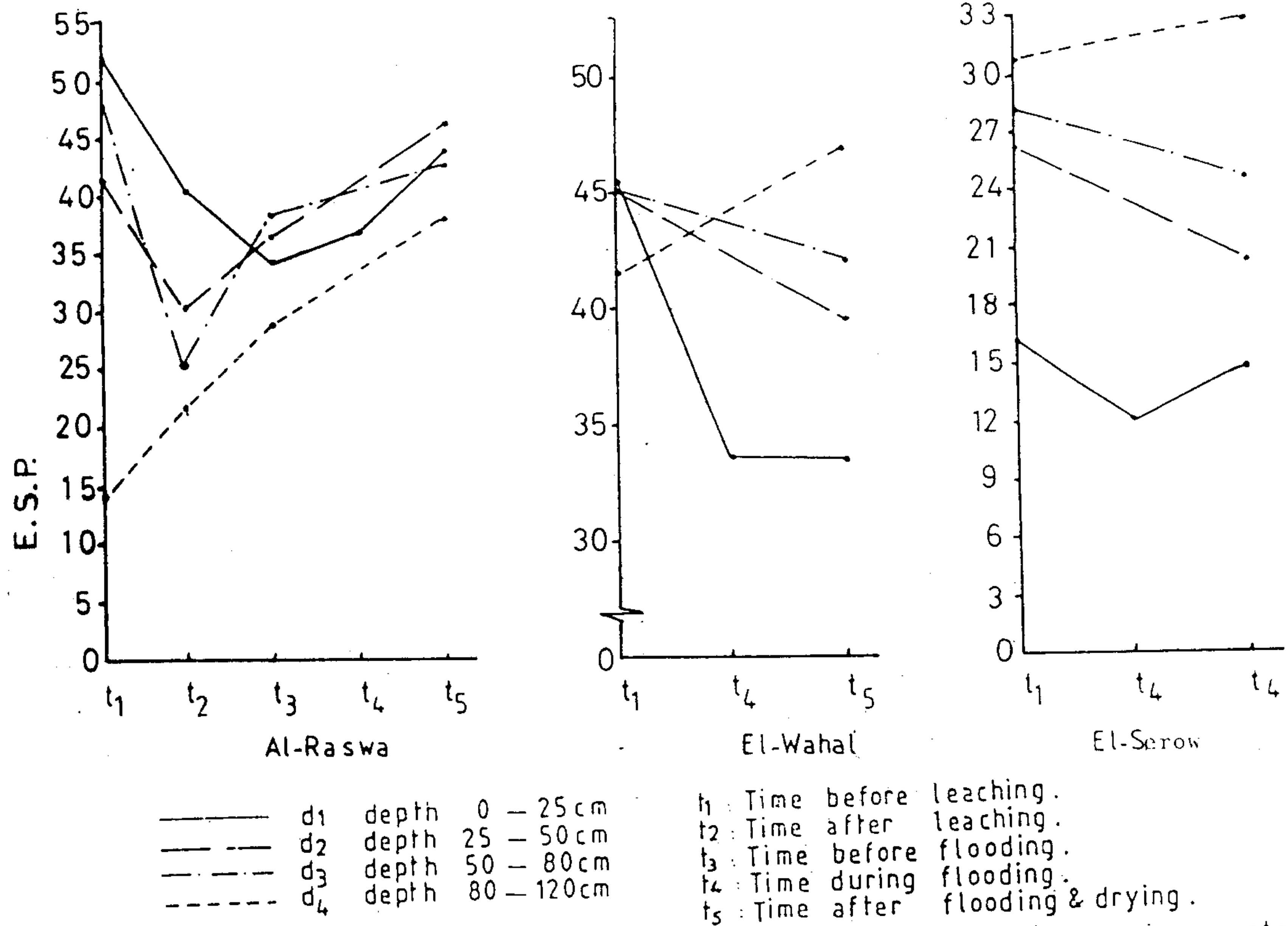


Fig.(19) Changes in exchangeable sodium percent (ESP) at various stages in soil layers of three farms.

the expance of the other cations the ESP values were increased to about one fifth as compared with its values under effect of flooding.

At Al- Raswa, detailed follow- up data (table 11 A) show first a decrease in ESP upon leaching, due to removal of considerable amounts of Na at (t_2). Thenafter, an increase in ESP occurred upon leaving the soil to dry after leaching (t_3), especially in the subsurface and deep layers as a result of the upward movement of sodium salts that raised the ESP after drying. Thus at the end of study (t_5) the ESP was even higher.

Data in table (11) show a positive relation between SAR and ESP in El- Wahal and El- Serow, where the ESP values were decreased with the decrease of SAR in all soil layers, except the deepest ones. These results are in agreement with Jackson (1967) who reported that there is a good relation between SAR and ESP of the soil, where the ESP increased with the increasing SAR and concentration of salts in solution.

4-8- Effect of flooding and fertilizing on phosphorus availability :

Since the soil of the ponds contained from 18.1 to 50.7 ppm available P at the start of fish farming and contained from 38.0 to 84.1 ppm after drying of ponds

Table 12: Available Phosphorus (ppm) as affected by fish farming.

(12-A): Changes in different depths at various stages at Al-Raswa farm.

Depth	Available P (ppm)				
	t_1	t_2	t_3	t_4	t_5
0-25	26.4	46.1	52.4	65.1	75.1
25-50	24.4	32.6	20.4	-	75.1
50-80	21.7	21.7	29.1	-	43.4
80-120	24.7	38.0	27.1	-	62.4

(12-B)[xx]: Changes in different depths at initial, under flooding and at final stage at El-Wahal and El-Serow farms

Location	Depth	Available P (ppm)		
		t_1	t_4[x]	t_5
	0-25	18.1	24.4	38.0
El- Wahal	25-50	24.4	-	67.8
Kafr El- Sheikh	50-80	50.7	-	70.6
	80-120	24.4	-	46.1
	0-25	21.7	65.1	84.1
El- Serow	25-50	35.3	-	70.5
Dekahlia	50-80	43.4	-	54.3
	80-120	29.8	-	67.8

See foot note table (4) :

xx Samples of t_2 and t_3 were not taken at El- Wahal and El- Serow farms.

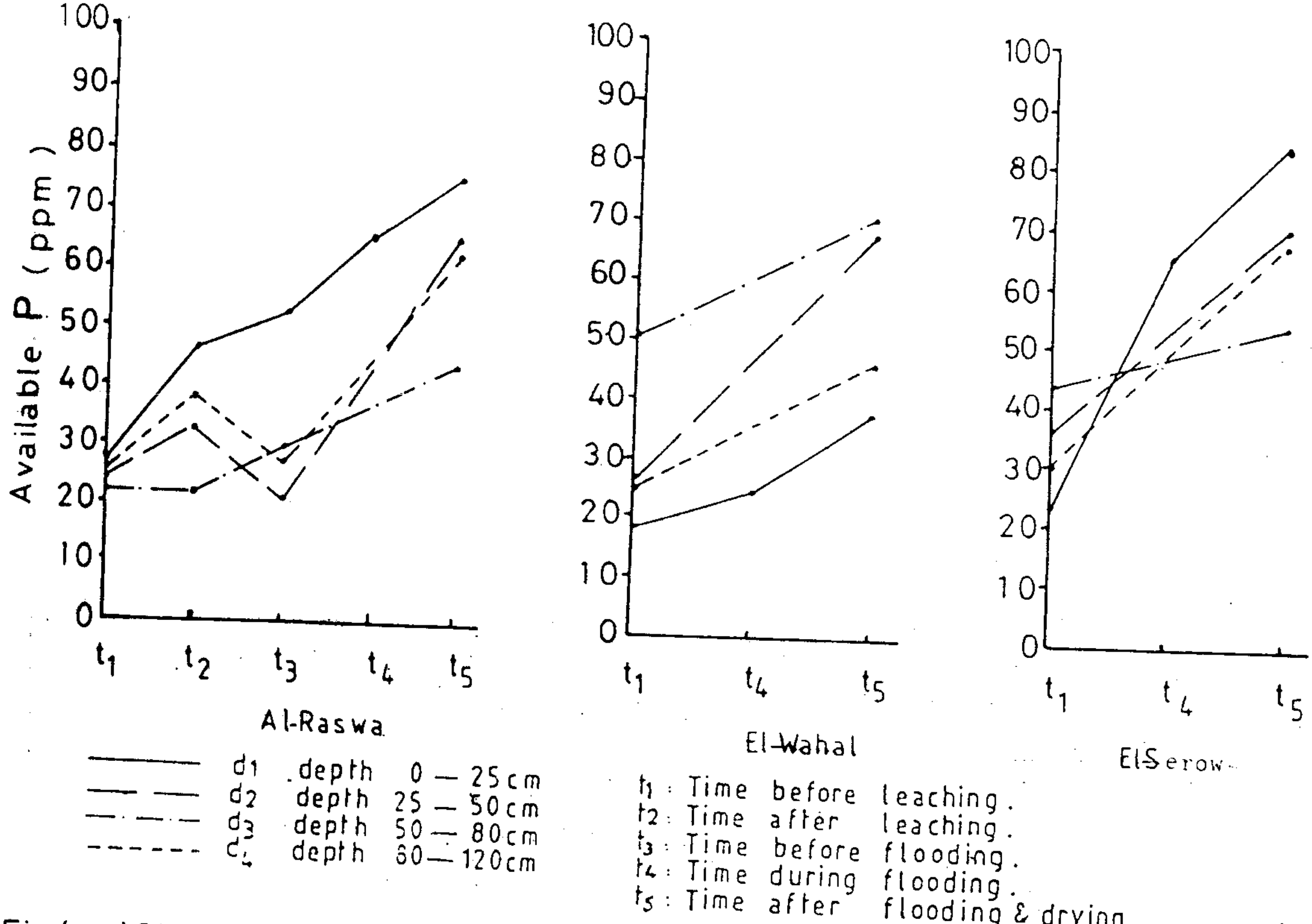


Fig.(20)Changes in available phosphorus (ppm) at various stages in soil layers of three farms.

(table 12 A), it is clear that using the soil as fish farm led to substantial rise in available P. Application of inorganic fertilizers including P- fertilizers, was practiced to increase available P and fish production. The amount of available P extracted was higher during flooding as compared with start of fish farming, this may be due to : (1) an increase in solubility of phosphates as a result of a decrease in pH caused by accumulation of CO_2 in El- Serow farm, (2),an increase in solubility of phosphates as a result of hydrolysis of iron and aluminium phosphate due to an increase in pH in Al- Raswa and El- Wahal farm, (3) a release of phosphorus from organic matter added as a fertilizers.

Available phosphorus increased after leaching in all the studied farms . An even higher increase was noticed during flooding (t_4) and the highest available P was shown after drying the farms (t_5). The increase in the available P was more evident in the upper layers than in the deepest one, for example, in Al- Raswa fish farm available P at the end of season increased from 26.4 to about 75 ppm in the surface layer. In the underlying layers increases were rather similar, through with relatively smaller rates.

Detailed flow - up of Al- Raswa show that the available P continued to increase at all stages of fish farming. According to some workers (Boreshart et al., 1965, Mahapatra and Patrick 1971, Islam and Islam 1973, Pattrick and Reddy 1976, Ghosh et al. 1976, Davide 1960, Bacher, 1955, and Willett, 1982) flooding the soil increases available P, however, the farm fertilizers (include P) will increase available P also.

The presence of an ample supply of organic matter encourages the development of strongly reducing conditions in flooded soils. This state of soil would solubilize materials such as ferric oxyhydroxide and similar coatins, This would lead to increasing phosphorus availability (Shapiro 1958, and Mandal and Kan 1977).