# RESULTS AND DISCUSSION

# 4. RESULTS AND DISCUSSIONS

## 4.1. Effect of intermittent leaching using different elution sequence on salinity and ionic composition of the different segments of soil columns:

As mentioned before, this experiment included five eluting solutions i.e. tap water ($W_0$), El-Bostan drain water ($W_1$), Seedy Ghazy drain water ($W_2$), El-Hedaya irrigation canal ($W_3$) and Haris drain water ($W_4$) applied under four sequences (***Sq₁***, ***Sq₂***, ***Sq₃*** and ***Sq₄***).

The tested sequences different in the number of applications of used sources of irrigation water i.e. $Sq_1$, tap water one time followed by one time of each other irrigation source. $Sq_2$, tap water one time followed by two times of each irrigation source, three times of each irrigation source following the tap water one time and four times of each of all irrigation sources for $Sq_3$ and $Sq_4$, respectively.

Data presented in Tables (5 to 12) and Figs. (2 to 9) illustrate the redistribution of salinity and its components through the different depths of soils as influenced by leaching using the different elution sequences. Better understanding of the effect of each elution sequence requires imposing the changes that may take place in the considered soil properties due to usage of such an elution sequence.

### 4.1.1. Effect on soil salinity (EC) in soil saturation extract:

EC values of the different segments of each soil column are shown in Table (5) and Fig. (2).

- ***Tap water as an eluting solution:***

It is obvious that leaching soil by means of the tap water resulted in a decrease in EC values of all the studied soils. The reduction in EC (ΔEC) averaged -1.36, -9.27 and -3.82 $dSm^{-1}$ in Badrashin, El Nobaria and El Ismailia soils, respectively corresponding to rate of the change of reduction percentages (RC%) of 58.99, 84.24 and 86.82 % respectively. These results indicate that using tap water under the tested conditions is quite efficient to leach salts out of the three studied soils, yet it is worthy to note that the leachability of the clayey soil (El Badrashin) was the least while that of the sandy soil (EL Ismailia) was the highest. Such variation in soil salt leachability is the final product of the soil–water relationship and can be attributed mainly to the pore size distribution of each soil. The drainable pores of the sandy soil are expected to be more than those of the other two soils and hence more water was though to be moved at each time unit through the sandy soil columns carrying more dissolved salts out of these columns. It is worthy to refer here that such observed trend for soils leachability is in consistence with soil hydraulic conductivity (K) (Table 2) which amounted to 0.5, 1 and 22 for clay (alluvial), calcareous (SCL) and sandy soils, respectively.

Depthwise distribution of salts (EC values) indicates that intermittent leaching caused EC values to be highest in the surface layers probably due to reverse movement of saline water during intervals between successive water applications. Such an observation was more obvious in the sandy clay loam soil than the other ones which give further support to the above mentioned observation.

As for the other irrigation water sources, it is clear that the intermittent leaching under the different elution sequences ($Sq_1$, $Sq_2$, $Sq_3$) seemed to be of pronounced effect on reducing salinity of El Nobaria and El Ismailia soils (the sandy clay loam and the sandy soils), yet $Sq_1$ and $Sq_2$ only the tap water, alternatively applied with El Bostan drain water ($W_1$) and Seedy Ghazy drain water ($W_2$) exhibited the same effect, *Table ( 5 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble salts (EC $dSm^{-1}$ ) in saturation paste extract of soils columns.*

| Locations | | [ A ] Badrashin soil | | | | | | [ B ] El-Nobaria soil | | | | | | [ C ] El-Ismailia soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation water | Treatments | Depth (cm) | | | | | | | | | | | | | | | | | |
| | | 0-15 | 15-30 | 30-45 | Average | △ EC | %RC | 0-15 | 15-30 | 30-45 | Average | △ EC | %RC | 0-15 | 15-30 | 30-45 | Average | △ EC | %RC |
| $W_0$ | Control | 1.08 | 0.97 | 0.78 | 0.94 | -1.36 | 58.99 | 2.00 | 1.50 | 1.70 | 1.73 | -9.27 | 84.24 | 0.70 | 0.42 | 0.62 | 0.58 | -3.82 | 86.82 |
| $W_1$ | $Sq_1$ | 1.80 | 1.60 | 1.35 | 1.58 | -0.72 | 31.16 | 3.00 | 2.20 | 2.25 | 2.48 | -8.52 | 77.42 | 1.10 | 0.80 | 0.80 | 0.90 | -3.50 | 79.55 |
| | $Sq_2$ | 2.35 | 1.65 | 1.55 | 1.85 | -0.45 | 19.57 | 3.65 | 2.50 | 2.55 | 2.90 | -8.10 | 73.64 | 1.25 | 1.10 | 1.05 | 1.13 | -3.27 | 74.24 |
| | $Sq_3$ | 2.65 | 2.00 | 1.65 | 2.10 | -0.20 | 8.70 | 4.00 | 3.00 | 3.40 | 3.47 | -7.53 | 68.48 | 1.40 | 1.10 | 1.20 | 1.23 | -3.17 | 71.97 |
| | $Sq_4$ | 3.30 | 2.15 | 1.95 | 2.47 | 0.17 | 7.25 | 4.65 | 3.80 | 4.10 | 4.18 | -6.82 | 61.97 | 1.90 | 1.20 | 1.20 | 1.43 | -2.97 | 67.42 |
| $W_2$ | $Sq_1$ | 2.15 | 1.80 | 1.60 | 1.85 | -0.45 | 19.57 | 3.00 | 2.30 | 2.55 | 2.62 | -8.38 | 76.21 | 1.80 | 1.05 | 1.30 | 1.38 | -3.02 | 68.56 |
| | $Sq_2$ | 2.45 | 2.10 | 1.80 | 2.12 | -0.18 | 7.97 | 3.80 | 2.75 | 2.75 | 3.10 | -7.90 | 71.82 | 2.00 | 1.40 | 1.50 | 1.63 | -2.77 | 62.88 |
| | $Sq_3$ | 2.60 | 2.40 | 2.25 | 2.42 | 0.12 | 5.07 | 4.65 | 3.80 | 4.05 | 4.17 | -6.83 | 62.12 | 2.30 | 1.60 | 1.60 | 1.83 | -2.57 | 58.33 |
| | $Sq_4$ | 3.30 | 2.70 | 2.50 | 2.83 | 0.53 | 23.19 | 5.90 | 4.20 | 4.35 | 4.82 | -6.18 | 56.21 | 2.50 | 1.85 | 1.60 | 1.98 | -2.42 | 54.92 |
| $W_3$ | $Sq_1$ | 3.25 | 2.50 | 2.30 | 2.68 | 0.38 | 16.67 | 4.70 | 4.05 | 4.30 | 4.35 | -6.65 | 60.45 | 2.00 | 1.50 | 1.50 | 1.67 | -2.73 | 62.12 |
| | $Sq_2$ | 3.75 | 2.70 | 2.40 | 2.95 | 0.65 | 28.26 | 7.40 | 4.45 | 4.65 | 5.50 | -5.50 | 50.00 | 2.25 | 1.70 | 1.55 | 1.83 | -2.57 | 58.33 |
| | $Sq_3$ | 2.25 | 2.80 | 2.60 | 2.55 | 0.25 | 10.87 | 8.20 | 4.75 | 5.40 | 6.12 | -4.88 | 44.39 | 2.90 | 1.95 | 1.95 | 2.27 | -2.13 | 48.48 |
| | $Sq_4$ | 4.70 | 4.05 | 3.65 | 4.13 | 1.83 | 79.71 | 8.70 | 5.25 | 6.20 | 6.72 | -4.28 | 38.94 | 3.55 | 2.20 | 2.20 | 2.65 | -1.75 | 39.77 |
| $W_4$ | $Sq_1$ | 5.45 | 4.35 | 4.25 | 4.68 | 2.38 | 103.62 | 6.70 | 5.50 | 6.00 | 6.07 | -4.93 | 44.85 | 2.40 | 2.00 | 1.90 | 2.10 | -2.30 | 52.27 |
| | $Sq_2$ | 7.05 | 5.30 | 5.30 | 5.88 | 3.58 | 155.80 | 9.85 | 8.05 | 8.25 | 8.72 | -2.28 | 20.76 | 3.65 | 2.45 | 2.40 | 2.83 | -1.57 | 35.61 |
| | $Sq_3$ | 9.35 | 7.15 | 6.10 | 7.53 | 5.23 | 227.54 | 12.00 | 10.05 | 10.15 | 10.73 | -0.27 | 2.42 | 4.35 | 3.15 | 2.70 | 3.40 | -1.00 | 22.73 |
| | $Sq_4$ | 9.65 | 8.70 | 7.75 | 8.70 | 6.40 | 278.26 | 14.80 | 10.35 | 11.00 | 12.05 | 1.05 | 9.55 | 5.05 | 4.20 | 3.80 | 4.35 | -0.05 | 1.14 |
| M | $Sq_1$ | 3.16 | 2.56 | 2.38 | 2.70 | 0.40 | 17.39 | 4.35 | 3.51 | 3.78 | 3.88 | -7.12 | 64.73 | 1.83 | 1.34 | 1.38 | 1.51 | -2.89 | 65.63 |
| e | $Sq_2$ | 3.90 | 2.94 | 2.76 | 3.20 | 0.90 | 39.13 | 6.18 | 4.44 | 4.55 | 5.05 | -5.95 | 54.05 | 2.29 | 1.66 | 1.63 | 1.86 | -2.54 | 57.77 |
| a | $Sq_3$ | 4.21 | 3.59 | 3.15 | 3.65 | 1.35 | 58.70 | 7.21 | 5.40 | 5.75 | 6.12 | -4.88 | 44.36 | 2.74 | 1.95 | 1.86 | 2.18 | -2.22 | 50.38 |
| n | $Sq_4$ | 5.24 | 4.40 | 3.96 | 4.53 | 2.23 | 97.10 | 8.51 | 5.90 | 6.41 | 6.94 | -4.06 | 36.89 | 3.25 | 2.36 | 2.20 | 2.60 | -1.80 | 40.81 |

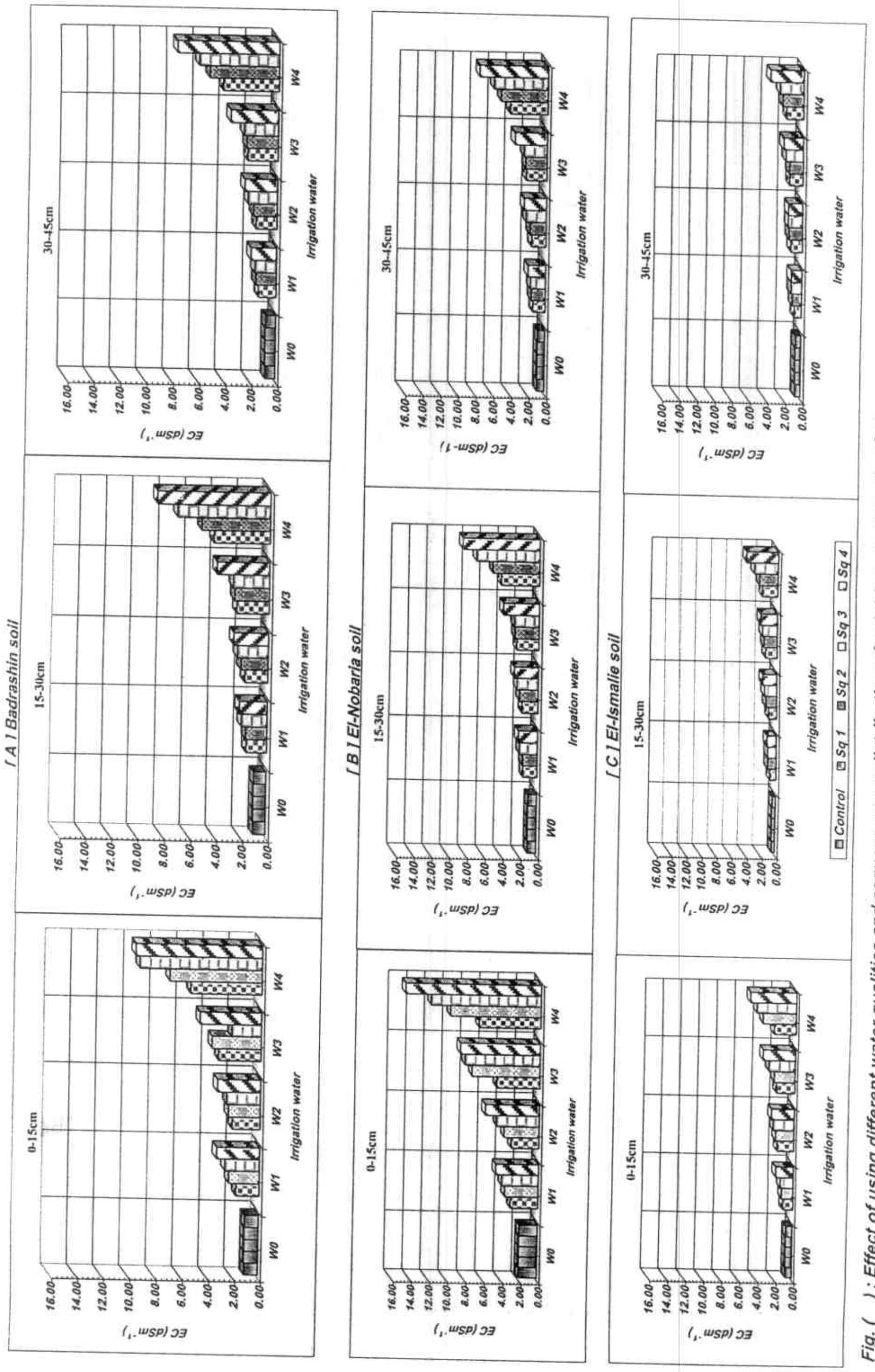


Fig. (  ) : Effect of using different water qualities and sequency on redistribution of soluble salts (EC $dSm^{-1}$) in paste extract of soils columns.

but to a lesser extent, in El Badrashin soil (the clay soil). Intermittent leaching using the elution sequence ***$Sq_3$*** was of positive effect on reducing salinity of the clayey soil when the water alternatively applied with the tap water was that of El Bostan drain water (***$W_1$***) only.

The elution sequence (***$Sq_4$***) generally resulted in accumulation of soluble salts in the clayey soil. The accumulation of salts herein is a consequence of the relatively high moisture content retained by the clayey soil at the field capacity which means application of salts equivalent to the amount of water retained at this moisture constant multiplied by concentration of salts in the used water. Unlike what occurred in the clays soil, the elution sequence (***$Sq_4$***) caused soluble salts to be leached out of the sandy clay loam and sandy soils probably due to the low retentively of such soils for water at the field capacity.

Depthwise distribution of the soluble salts due to intermittent leaching using the different elution sequences indicated relatively higher accumulation of the uppermost surface layers of all the studied soils than the layers below.

It could be concluded from data presented in Table (5) and the aforementioned discussion that the amount of salts removed from the soil columns increased with increasing the initial soil salt content. Also, the fine textured soil (the clayey) lost (if it did) less amount of their salt than the coarser textured ones. Such findings stand in well agreement with those of ***Balba (1995)*** who stated that the clay soils retains greater amounts of water hence the amount of salt retained from the saline water was greater and that removed was less than the corresponding amounts leached from the coarser textured soils.

An overlook on results in the aforementioned Table (5) makes us deduce that the ability of the applied solution to carry the soil salt in its passage through the soil columns decreases with the increase in the salt concentration of the applied water. This might be also explained as being due to a decrease in the water's ability to dissolve salts with the increasing its original content of salts as suggested by ***Balba and Bassiuni (1977)*** in their studies on salts movement under leaching process using tracer techniques and ***Ballba (1990)***.

However, it may be concluded that the probable hazard of saline irrigation water could be very much restricted by introducing another irrigation source of better quality though the course of soil irrigation management.

The probable reduction in initial soil EC would be induced with better irrigation water quality and higher initial soil salinity such as the (calcareous soil tested).

### 4.1.2. Effect on soluble ions:

#### 4.1.2.1. Effect on soluble anions:

#### *A: Soluble bicarbonate ($HCO^-_3$):*

It can be shown from data presented in Table (6) and Fig. (3) that although the control water (tap-water) generally showed no clear effect on the whole $HCO^-_3$ content of the clayey soil, yet it reduced that of the sandy clay loam and sandy soils by 41.88 and 17.67 %, respectively. All the elution sequences resulted in serious reduction in $HCO^-_3$ content of both the clayey and sand clay loam (calcareous) soils but on the other hand, caused general increase in $HCO^-_3$ content of the sandy soil except for some few cases where $HCO^-_3$ content either remained almost constant or tended to be slightly decreased.

$HCO^-_3$ distribution with depth did not show a fixed pattern where its content in the different soil segments differed from a soil to another and also within each soil due to the type of the water used for leaching beside of the elution sequence.

*Table ( 6 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble bicarbonate ($meL^{-1}$) in saturation paste extract of soils columns.*

| Locations | | [A] Badrashin soil | | | | | | [B] El-Nobaria soil | | | | | | [C] El-Ismailia soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Depth (cm) | | | | | | | | | | | | | | | | | |
| Irrigation water | Treatments | 0-15 | 15-30 | 30-45 | Average | △ $HCO_3^-$ | %RC | 0-15 | 15-30 | 30-45 | Average | △ $HCO_3^-$ | %RC | 0-15 | 15-30 | 30-45 | Average | △ $HCO_3^-$ | %RC |
| $W_0$ | Control | 3.64 | 2.60 | 2.86 | 3.03 | 0.02 | 0.66 | 2.22 | 2.78 | 3.05 | 2.68 | -0.91 | 41.88 | 2.08 | 1.56 | 1.56 | 1.73 | -0.07 | 17.67 |
| $W_1$ | $Sq_1$ | 1.94 | 2.78 | 2.31 | 2.34 | -0.50 | 22.23 | 3.89 | 3.33 | 3.61 | 3.61 | -0.47 | 21.81 | 3.05 | 2.50 | 3.05 | 2.87 | 0.14 | 36.17 |
| | $Sq_2$ | 1.94 | 2.78 | 2.50 | 2.41 | -0.46 | 20.13 | 4.44 | 3.33 | 3.89 | 3.89 | -0.34 | 15.82 | 3.05 | 2.78 | 3.33 | 3.05 | 0.18 | 45.03 |
| | $Sq_3$ | 2.78 | 3.05 | 2.50 | 2.78 | -0.18 | 7.85 | 4.44 | 3.89 | 3.89 | 4.07 | -0.26 | 11.78 | 3.05 | 2.78 | 3.89 | 3.24 | 0.22 | 53.90 |
| | $Sq_4$ | 2.78 | 3.33 | 2.50 | 2.87 | -0.11 | 4.76 | 4.44 | 3.89 | 4.44 | 4.26 | -0.17 | 7.80 | 3.89 | 2.78 | 4.44 | 3.70 | 0.30 | 75.91 |
| $W_2$ | $Sq_1$ | 2.50 | 1.94 | 2.50 | 2.31 | -0.53 | 23.23 | 2.50 | 2.50 | 2.78 | 2.59 | -0.95 | 43.83 | 3.33 | 2.78 | 3.33 | 3.15 | 0.20 | 49.47 |
| | $Sq_2$ | 2.50 | 1.94 | 2.78 | 2.41 | -0.46 | 20.13 | 3.33 | 3.05 | 3.33 | 3.24 | -0.65 | 29.90 | 3.61 | 2.78 | 3.33 | 3.24 | 0.22 | 53.90 |
| | $Sq_3$ | 2.78 | 1.94 | 2.78 | 2.50 | -0.39 | 17.04 | 3.89 | 3.89 | 4.16 | 3.98 | -0.30 | 13.80 | 3.05 | 3.33 | 3.89 | 3.42 | 0.25 | 62.61 |
| | $Sq_4$ | 2.78 | 2.50 | 2.78 | 2.69 | -0.25 | 10.84 | 3.89 | 4.16 | 4.16 | 4.07 | -0.26 | 11.85 | 3.61 | 3.05 | 3.61 | 3.42 | 0.25 | 62.61 |
| $W_3$ | $Sq_1$ | 1.67 | 1.94 | 1.94 | 1.85 | -0.87 | 38.61 | 3.05 | 3.05 | 2.78 | 2.96 | -0.78 | 35.89 | 3.89 | 2.50 | 3.61 | 3.33 | 0.23 | 58.33 |
| | $Sq_2$ | 2.50 | 2.50 | 1.94 | 2.31 | -0.53 | 23.23 | 3.05 | 3.05 | 3.61 | 3.24 | -0.65 | 29.90 | 4.16 | 3.05 | 4.16 | 3.79 | 0.32 | 80.03 |
| | $Sq_3$ | 2.50 | 2.50 | 2.22 | 2.41 | -0.46 | 20.13 | 3.33 | 3.33 | 3.61 | 3.42 | -0.56 | 25.85 | 4.16 | 3.33 | 4.16 | 3.88 | 0.34 | 84.46 |
| | $Sq_4$ | 3.89 | 3.05 | 2.22 | 3.05 | 0.03 | 1.33 | 3.05 | 3.61 | 4.16 | 3.61 | -0.47 | 21.88 | 4.16 | 3.38 | 4.42 | 3.99 | 0.36 | 89.37 |
| $W_4$ | $Sq_1$ | 1.67 | 1.94 | 1.94 | 1.85 | -0.87 | 38.61 | 2.50 | 3.05 | 4.16 | 3.24 | -0.65 | 29.90 | 1.56 | 1.56 | 1.82 | 1.65 | -0.09 | 21.78 |
| | $Sq_2$ | 1.94 | 2.22 | 1.94 | 2.03 | -0.74 | 32.52 | 3.90 | 2.08 | 3.90 | 3.29 | -0.62 | 28.67 | 2.08 | 1.56 | 1.82 | 1.82 | -0.05 | 13.55 |
| | $Sq_3$ | 1.94 | 2.22 | 2.08 | 2.08 | -0.70 | 30.97 | 4.16 | 2.20 | 4.16 | 3.51 | -0.52 | 24.05 | 2.08 | 2.08 | 2.08 | 2.08 | 0.00 | 0.00 |
| | $Sq_4$ | 1.94 | 2.50 | 2.22 | 2.22 | -0.60 | 26.33 | 4.16 | 3.89 | 4.16 | 4.07 | -0.26 | 11.85 | 3.64 | 2.08 | 2.08 | 2.60 | 0.09 | 23.50 |
| Mean | $Sq_1$ | 1.95 | 2.15 | 2.17 | 2.09 | -0.69 | 30.67 | 2.99 | 2.98 | 3.33 | 3.10 | -0.71 | 32.86 | 3.10 | 3.20 | 3.04 | 3.11 | 0.19 | 47.88 |
| | $Sq_2$ | 2.22 | 2.36 | 2.29 | 2.29 | -0.54 | 24.00 | 3.68 | 2.88 | 3.68 | 3.41 | -0.57 | 26.07 | 2.46 | 2.45 | 2.90 | 2.60 | 0.09 | 23.66 |
| | $Sq_3$ | 2.50 | 2.43 | 2.40 | 2.44 | -0.43 | 19.00 | 3.96 | 3.33 | 3.96 | 3.75 | -0.41 | 18.87 | 2.95 | 2.94 | 3.35 | 3.08 | 0.19 | 46.30 |
| | $Sq_4$ | 2.85 | 2.85 | 2.43 | 2.71 | -0.23 | 10.15 | 3.89 | 3.89 | 4.23 | 4.00 | -0.29 | 13.35 | 3.48 | 2.57 | 3.22 | 3.09 | 0.19 | 46.78 |

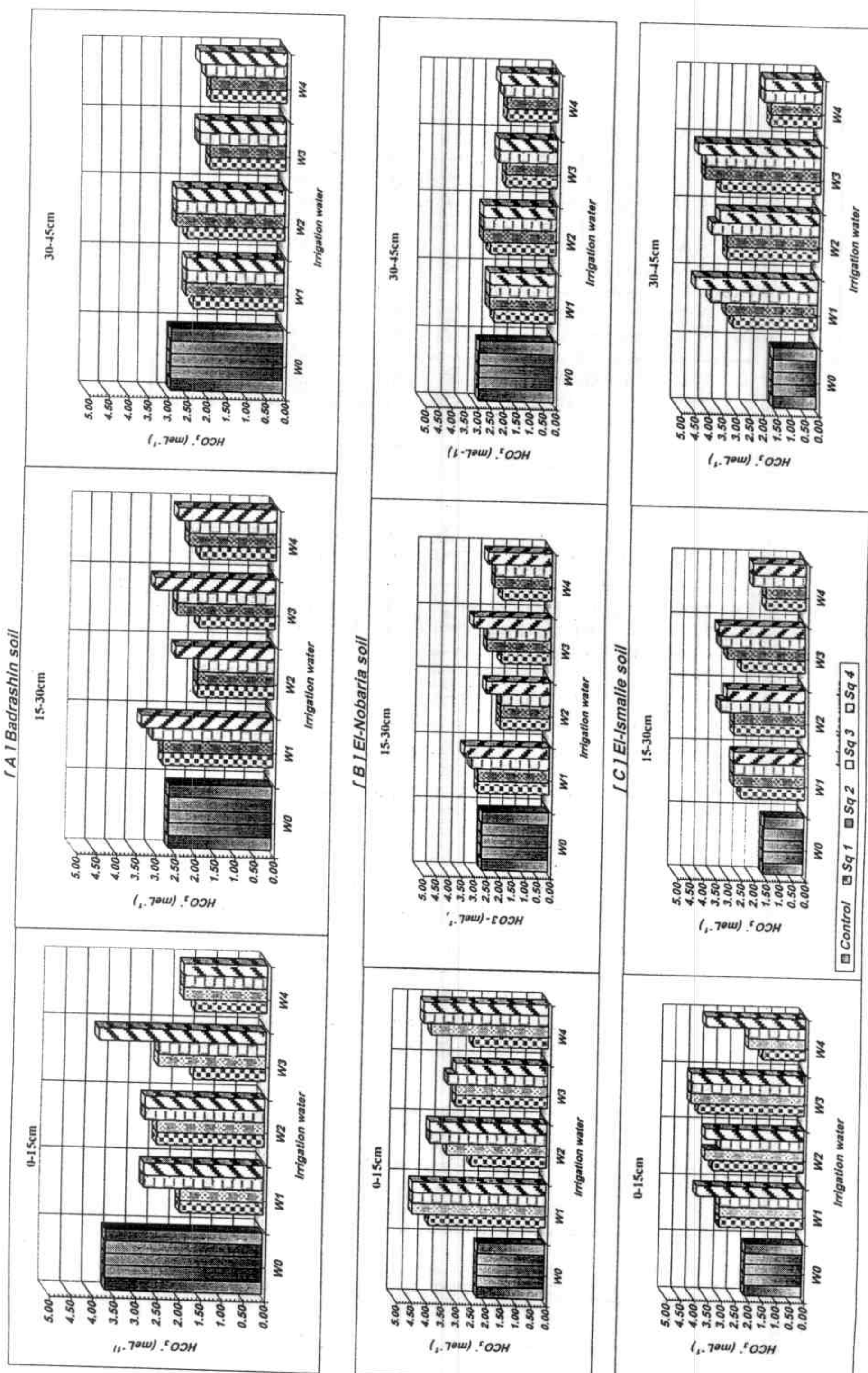


Fig. ( 3 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble bicarbonate ($meL^{-1}$) in saturation paste extract of soils columns.

Such trend could be attributed to the high velocity of $HCO^{-}_{3}$ movement either down ward or upward. The prolonged moisture maintenance of the heavier textural soil under saturation or over saturation conditions may encouraged the not down movement of soil solution and hence the more soluble ions like the $HCO^{-}_{3}$.

***B: Soluble chloride ($Cl^{-}$):***

As it is shown from Table (7) and Fig. (4) intermittent leaching using the control water, $W_0$ reduced the values of soluble $Cl^{-}$ in all the investigated soils and within all soil depths. Relative reduction in soluble $Cl^{-}$ averaged 78.94, 94.05 and 94.38 % in the clayey, sand clay loam and sandy soils, respectively. The efficiency of this method of leaching seemed to be higher in leaching soluble $Cl^{-}$ out of the relatively coarse textured soils the sandy clay loam (calcareous) and the sandy (noncalcareous) soils than the heavy textured one the clayey (alluvial) soil. This is probably attributed to the higher retentive power of the clayey soil for the saline water than the other two soils.

The observed variation between $HCO^{-}_{3}$ and $Cl^{-}$ could be because of the common ion effect where the bicarbonate ion concentration is controlled by the soil lime content that supplies $HCO^{-}_{3}$ instead of that leached out to maintain the equilibrium state rather constant.

Leaching of all the soils using the elution sequence $Sq_1$, $Sq_2$ and $Sq_3$ in which El Bostan drain water ($W_1$) was alternatively applied with the tap water ($W_0$) resulted in a reduction in soluble $Cl^{-}$ values within the different depths of all the investigated soils. Values of relative reduction in $Cl^{-}$ contents of the clayey soil due to these elution sequences seemed far lower than those achieved due to application of the control water. The corresponding values of relative reduction in $Cl^{-}$ contents of the sandy clay loam (calcareous) and sandy soils achieved due to these

Table ( 7 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble coloride ($meL^{-1}$) in saturation paste extract of soils columns.

| Locations | | [A] Badrashin soil | | | | | | [B] El-Nobaria soil | | | | | | [C] El-Ismailia soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation water | Treatments | Depth (cm) | | | | | | | | | | | | | | | | | |
| | | 0-15 | 15-30 | 30-45 | Average | △ Cl⁻ | %RC | 0-15 | 15-30 | 30-45 | Average | △ Cl⁻ | %RC | 0-15 | 15-30 | 30-45 | Average | △ Cl⁻ | %RC |
| $W_0$ | Control | 1.88 | 1.88 | 0.94 | 1.57 | -4.41 | 78.94 | 3.92 | 1.96 | 2.94 | 2.94 | -33.59 | 96.05 | 0.94 | 0.94 | 1.88 | 1.25 | -4.00 | 94.38 |
| $W_1$ | $Sq_1$ | 3.92 | 3.92 | 3.92 | 3.92 | -2.64 | 47.31 | 6.86 | 3.92 | 5.88 | 5.55 | -32.36 | 92.54 | 1.96 | 1.96 | 1.96 | 1.96 | -3.87 | 91.22 |
| | $Sq_2$ | 6.86 | 2.94 | 2.94 | 4.25 | -2.40 | 42.92 | 7.84 | 5.88 | 5.88 | 6.53 | -31.90 | 91.22 | 1.96 | 1.96 | 1.96 | 1.96 | -3.87 | 91.22 |
| | $Sq_3$ | 5.88 | 4.25 | 3.92 | 4.68 | -2.07 | 37.05 | 8.82 | 4.90 | 6.86 | 6.86 | -31.75 | 90.78 | 2.94 | 1.96 | 2.94 | 2.61 | -3.74 | 88.29 |
| | $Sq_4$ | 8.82 | 3.92 | 3.92 | 5.55 | -1.42 | 25.36 | 13.72 | 4.90 | 6.86 | 8.49 | -30.98 | 88.58 | 3.92 | 1.96 | 2.94 | 2.94 | -3.68 | 86.83 |
| $W_2$ | $Sq_1$ | 7.84 | 5.88 | 4.90 | 6.21 | -0.93 | 16.58 | 7.84 | 5.88 | 4.90 | 6.21 | -32.05 | 91.66 | 4.90 | 1.96 | 2.94 | 3.27 | -3.62 | 85.36 |
| | $Sq_2$ | 7.84 | 6.86 | 4.90 | 6.53 | -0.68 | 12.19 | 7.84 | 6.86 | 4.90 | 6.53 | -31.90 | 91.22 | 4.90 | 3.92 | 3.92 | 4.25 | -3.43 | 80.97 |
| | $Sq_3$ | 7.84 | 7.84 | 7.84 | 7.84 | 0.30 | 5.38 | 7.84 | 7.84 | 7.84 | 7.84 | -31.29 | 89.46 | 4.90 | 3.92 | 4.90 | 4.57 | -3.37 | 79.51 |
| | $Sq_4$ | 10.78 | 7.84 | 6.86 | 8.49 | 0.79 | 14.16 | 10.78 | 7.84 | 6.86 | 8.49 | -30.98 | 88.58 | 6.86 | 3.92 | 4.90 | 5.23 | -3.25 | 76.58 |
| $W_3$ | $Sq_1$ | 7.84 | 6.86 | 6.86 | 7.19 | -0.19 | 3.41 | 7.84 | 6.86 | 6.86 | 7.19 | -31.59 | 90.34 | 3.92 | 2.94 | 3.92 | 3.59 | -3.56 | 83.90 |
| | $Sq_2$ | 9.80 | 6.86 | 7.84 | 8.17 | 0.55 | 9.77 | 9.80 | 6.86 | 7.84 | 8.17 | -31.13 | 89.02 | 6.79 | 3.76 | 3.76 | 4.77 | -3.33 | 78.63 |
| | $Sq_3$ | 12.74 | 7.84 | 7.84 | 9.47 | 1.53 | 27.33 | 12.74 | 7.84 | 7.84 | 9.47 | -30.52 | 87.27 | 9.40 | 8.46 | 7.84 | 8.57 | -2.61 | 61.61 |
| | $Sq_4$ | 15.68 | 10.78 | 11.76 | 12.74 | 3.98 | 71.24 | 15.68 | 10.78 | 11.76 | 12.74 | -28.98 | 82.88 | 12.19 | 9.40 | 8.46 | 10.02 | -2.34 | 55.11 |
| $W_4$ | $Sq_1$ | 41.16 | 24.44 | 28.20 | 31.27 | 17.87 | 320.25 | 41.16 | 24.44 | 28.20 | 31.27 | -20.27 | 57.98 | 6.58 | 5.64 | 4.70 | 5.64 | -3.17 | 74.73 |
| | $Sq_2$ | 47.00 | 33.32 | 27.44 | 35.92 | 21.36 | 382.80 | 47.00 | 33.32 | 27.44 | 35.92 | -18.09 | 51.72 | 13.16 | 6.58 | 4.70 | 8.15 | -2.69 | 63.49 |
| | $Sq_3$ | 47.00 | 41.16 | 39.00 | 42.39 | 26.21 | 469.71 | 47.00 | 41.16 | 39.00 | 42.39 | -15.05 | 43.03 | 15.98 | 11.28 | 9.40 | 12.22 | -1.92 | 45.24 |
| | $Sq_4$ | 64.68 | 52.64 | 60.76 | 59.36 | 38.94 | 697.85 | 64.68 | 52.64 | 60.76 | 59.36 | -7.07 | 20.22 | 22.56 | 21.84 | 18.80 | 21.07 | -0.24 | 5.60 |
| Mean | $Sq_1$ | 15.19 | 10.28 | 10.97 | 12.15 | 3.53 | 63.24 | 15.93 | 10.28 | 11.46 | 12.55 | -29.07 | 83.13 | 4.34 | 3.13 | 3.38 | 3.62 | -3.55 | 83.80 |
| | $Sq_2$ | 17.88 | 12.50 | 10.78 | 13.72 | 4.71 | 84.36 | 18.12 | 13.23 | 11.52 | 14.29 | -28.25 | 80.80 | 6.70 | 4.06 | 3.59 | 4.78 | -3.33 | 78.58 |
| | $Sq_3$ | 18.37 | 15.27 | 14.65 | 16.10 | 6.49 | 116.34 | 19.10 | 15.44 | 15.39 | 16.64 | -27.15 | 77.64 | 8.31 | 6.41 | 6.27 | 6.99 | -2.91 | 68.66 |
| | $Sq_4$ | 24.99 | 18.80 | 20.83 | 21.54 | 10.57 | 189.47 | 26.22 | 19.04 | 21.56 | 22.27 | -24.50 | 70.07 | 11.38 | 9.28 | 8.78 | 9.81 | -2.38 | 56.03 |

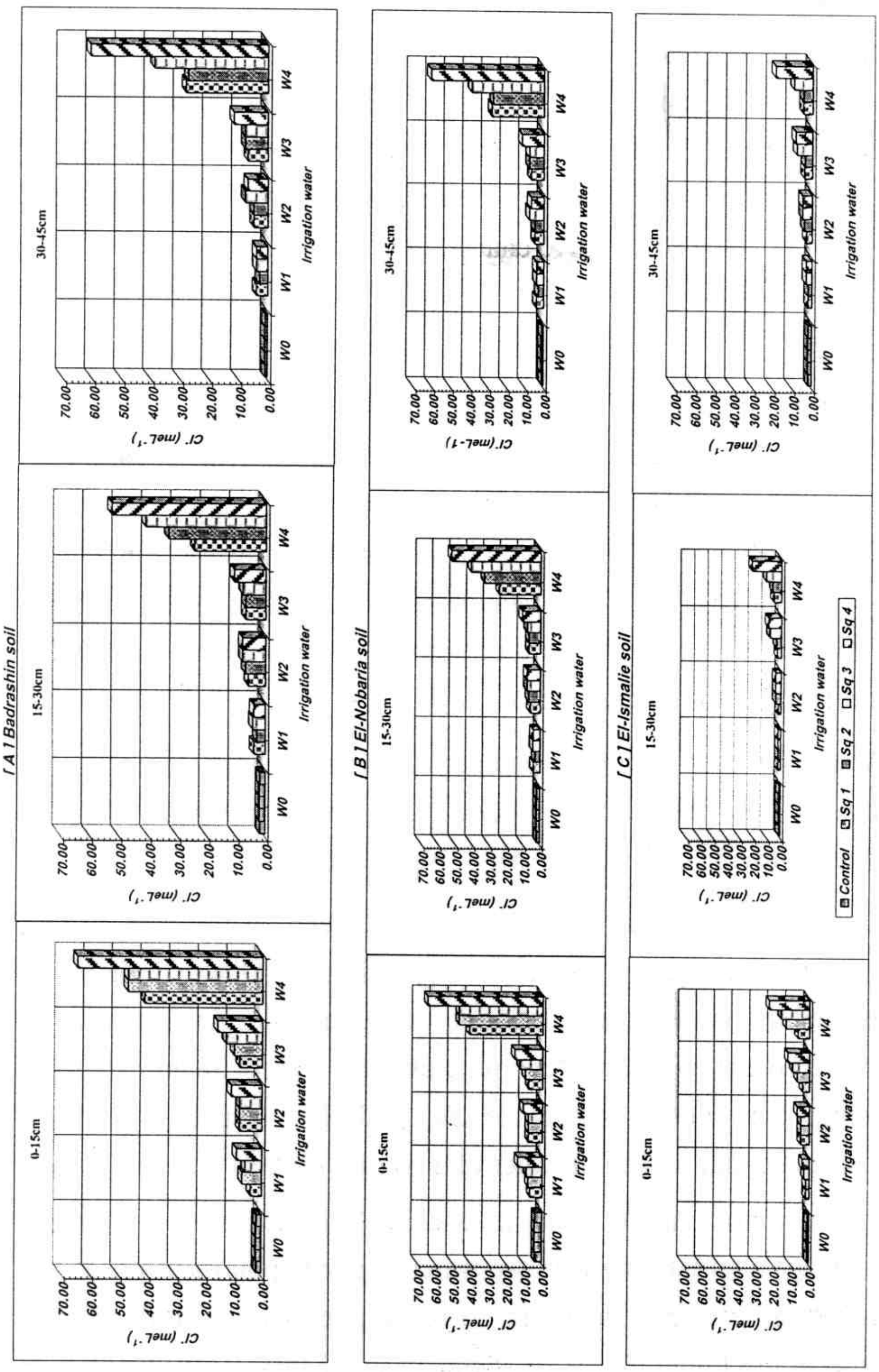


*Fig. ( 4 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble chloride (meL $^{-1}$ ) in saturation paste extract of soils columns.*

elution sequences tended to be somewhat the lower than those achieved due to intermittent leaching using the control water. The efficiency of the used elution sequences seemed to be highest with (***$Sq_1$***) and lowest with (***$Sq_3$***). Using El Bostan drain water (***$W_1$***) for intermittent leaching of all the investigated soils was also of reducing effect on soils contents of soluble **$Cl^-$**, yet values of relative change in **$Cl^-$** contents were lower than those achieved due to the other sequences specially in case of the clayey soil.

Expect for ***$Sq_3$*** and ***$Sq_4$*** in case of the clayey soil, intermittent leaching using the elution sequences ***$Sq_1$, $Sq_2$, $Sq_3$*** and ***$Sq_4$*** in which the control water (***$W_0$***) was applied alternatively with Seedy Ghazy drain water (***$W_2$***) resulted general reduction in values of soluble **$Cl^-$** contents of all the investigated soils. The relative reduction change in **$Cl^-$** values seemed higher in the light textured soils (the sandy clay loam and the sand loam soils) than the clayey one.

Also, the used elution sequences can be arranged descendingly according to their efficiency in leaching **$Cl^-$** ions out of the investigated soils in the following order: ***$Sq_1 > Sq_2 > Sq_3 > Sq_4$***.

Unlike what occurred in the light textured soils, intermittent leaching using the elution sequence ***$Sq_3$*** and Seedy Ghazy drain water (***$W_2$***) resulted in more accumulation of soluble chloride. The relative increases in the clayey soil content of soluble **$Cl^-$** were 5.38 and 14.16 % upon using the elution sequences ***$Sq_3$*** and ***$Sq_4$***, respectively. Such findings indicate that irrigation water of a quality such as that of Seedy Ghazy drain water can be used in leaching light texture soils whether upon its usage alternatively with tap water or even upon its usage solely for intermittent leaching. However, it is of importance to avoid usage of such water in leaching ***$Cl^-$*** out of the clayey soil. Moreover using elution sequences in which such water is applied alternatively with tap water should be conducted conditioned that the times of application of such water does not exceed two times per each one of tap water.

Using water of El Hedaya irrigation canal ($W_3$) alternatively with the tap water ($W_0$) resulted in a similar effect on reducing soluble $Cl^-$ contents of the investigated soils to that achieved upon usage of Seedy Ghazy drain water especially in the sandy clay loam and sandy soils. However, in case of the clayey soil, although the effect of the elution sequence $Sq_1$ was similar to that attained in the sandy clay loam and sandy soils, yet the elution sequence $Sq_2$ resulted in soluble $Cl^-$ to accumulate in such a soil. The elution sequences $Sq_3$ and $Sq_4$ were of more pronounced effect on accumulation of soluble $Cl^-$ in the clayey soil.

All the elution sequences i.e. $Sq_1$, $Sq_2$, $Sq_3$ and $Sq_4$ resulted from alternative application of Haris drain water with the tap water ($W_0$), were of positive effect on reducing $Cl^-$ contents of the light textured soils (the sandy clay loam and the sandy soils). Values of the relative reduction in $Cl^-$ ions in both the soils followed the order: $Sq_1 > Sq_2 > Sq_3 > Sq_4$.

This order is expected due to the higher $Cl^-$ content of Haris drain water ($W_4$) 80.16 $meL^{-1}$ than the tap water ($W_0$) 0.49 $meL^{-1}$. On the other hand, these elution sequences caused soluble $Cl^-$ ions to accumulate in the clayey soil. The high retentively of water in this soil may account for accumulation of $Cl^-$ in such soil.

Regarding depthwise distribution of soluble $Cl^-$, it could be seen that $Cl^-$ ions followed a pattern of distribution with depth similar to a great extent, to that of soluble salts as expressed in EC values. Thus, $Cl^-$ ions were higher in the surface layers of all the investigated soils that the layers below.

## *C: Soluble sulphate ($SO_4^{2-}$):*

Data in Table (8) and Fig. (5) reveal the distribution of soluble $SO_4^{2-}$ among the different depths of the investigated soils due to intermittent leaching of these soils using the proper elution sequences.

Intermittent leaching of the investigated soils using tap water only caused $SO_4^{2-}$ contents of these soils to decrease. Average absolute value of decrease was highest in the sandy clayey loam soil, lowest in the sandy one and came in between in the clayey soil. However, value of relative change in $SO_4^{2-}$ content was highest in the sandy soil, lowest in the clayey one and came in between in the sandy clay loam soil.

Intermittent leaching using elution sequences formed of tap water ($W_0$) alternatively applied with El Bostan drain water i.e. $Sq_1$, $Sq_2$ and $Sq_3$ caused amounts of soluble $SO_4^{2-}$ to decrease in all depths of both the sandy clay loam and sandy soil. The relative change (RC) in amounts of soluble $SO_4^{2-}$ averaged 66.31, 60.78 and 49.49 % upon usage of the elution sequence $Sq_1$, $Sq_2$ and $Sq_3$ respectively in the sandy clay loam soil. The corresponding (RC) values in the sandy soil were 77.62, 67.89 and 66.95% respectively. Successive applications of El Bostan drain water only through the intermittent leaching process of both the sandy clay loam and the sandy soils although caused relative removal of $SO_4^{2-}$ anions, yet this removal occurred to a lesser extent as compared with that occurred due to intermittent leaching using the elution sequences $Sq_1$, $Sq_2$ or $Sq_3$. The relatively higher content of soluble $SO_4^{2-}$ in the drain water as compared with the control water (***tap water***) may account for such an observation. Once again, it could be observed that the effect of all the studied elution sequences on reduction of amount of soluble $SO_4^{2-}$ was more pronounced in the sandy clay loam soil than the sand one, however the relative change in amounts of soluble $SO_4^{2-}$ was higher in the latter than the former.

Table ( 8 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble sulphate ($meL^{-1}$) in saturation paste extract of soils columns.

| Locations | | [A] Badrashin soil | | | | | | [B] El-Nobaria soil | | | | | | [C] El-Ismailia soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation water | Treatments | Depth (cm) | | | | | | | | | | | | | | | | | |
| | | 0-15 | 15-30 | 30-45 | Average | $\triangle SO_4^{2-}$ | % RC | 0-15 | 15-30 | 30-45 | Average | $\triangle SO_4^{2-}$ | % RC | 0-15 | 15-30 | 30-45 | Average | $\triangle SO_4^{2-}$ | % RC |
| $W_0$ | Control | 5.28 | 5.24 | 4.07 | 4.86 | -6.40 | 63.71 | 15.27 | 10.40 | 11.66 | 12.44 | -16.88 | 74.27 | 4.73 | 2.44 | 3.09 | 3.42 | -3.21 | 83.17 |
| $W_1$ | $Sq_1$ | 12.58 | 9.33 | 7.75 | 9.89 | -2.64 | 26.22 | 20.16 | 15.13 | 13.59 | 16.29 | -15.07 | 66.31 | 6.48 | 3.96 | 3.42 | 4.62 | -2.98 | 77.26 |
| | $Sq_2$ | 14.99 | 11.12 | 10.20 | 12.10 | -0.97 | 9.68 | 24.94 | 15.83 | 16.13 | 18.97 | -13.82 | 60.78 | 7.58 | 6.33 | 5.66 | 6.52 | -2.62 | 67.89 |
| | $Sq_3$ | 18.08 | 12.84 | 10.32 | 13.75 | 0.26 | 2.59 | 27.70 | 22.12 | 23.46 | 24.43 | -11.25 | 49.49 | 8.02 | 6.62 | 5.50 | 6.71 | -2.58 | 66.96 |
| | $Sq_4$ | 21.57 | 14.74 | 13.45 | 16.59 | 2.39 | 23.78 | 38.70 | 30.16 | 31.20 | 33.35 | -7.05 | 31.03 | 11.19 | 7.39 | 5.40 | 7.99 | -2.34 | 60.65 |
| $W_2$ | $Sq_1$ | 11.40 | 10.55 | 8.87 | 10.27 | -2.35 | 23.33 | 19.73 | 14.19 | 17.36 | 17.09 | -14.70 | 64.66 | 10.65 | 6.24 | 6.87 | 7.92 | -2.36 | 61.02 |
| | $Sq_2$ | 14.20 | 12.27 | 10.78 | 12.42 | -0.74 | 7.34 | 26.49 | 19.48 | 19.30 | 21.76 | -12.50 | 55.01 | 11.89 | 8.27 | 7.88 | 9.35 | -2.08 | 53.99 |
| | $Sq_3$ | 15.87 | 14.65 | 11.97 | 14.16 | 0.57 | 5.70 | 39.05 | 29.13 | 27.78 | 31.99 | -7.70 | 33.86 | 15.26 | 8.81 | 7.98 | 10.68 | -1.83 | 47.41 |
| | $Sq_4$ | 19.84 | 16.83 | 15.80 | 17.49 | 3.07 | 30.52 | 44.85 | 30.65 | 32.30 | 35.93 | -5.84 | 25.70 | 14.77 | 11.89 | 8.42 | 11.69 | -1.64 | 42.44 |
| $W_3$ | $Sq_1$ | 23.40 | 16.64 | 14.31 | 18.12 | 3.54 | 35.20 | 37.56 | 30.03 | 35.69 | 34.43 | -6.55 | 28.81 | 13.05 | 9.98 | 7.60 | 10.21 | -1.92 | 49.74 |
| | $Sq_2$ | 25.25 | 17.69 | 14.53 | 19.16 | 4.32 | 42.96 | 55.60 | 36.25 | 39.00 | 43.62 | -2.23 | 9.81 | 11.91 | 10.83 | 7.79 | 10.18 | -1.93 | 49.91 |
| | $Sq_3$ | 29.85 | 18.30 | 16.70 | 21.62 | 6.16 | 61.32 | 67.31 | 41.53 | 50.51 | 53.12 | 2.23 | 9.83 | 16.36 | 7.80 | 7.84 | 10.67 | -1.83 | 47.50 |
| | $Sq_4$ | 31.89 | 28.16 | 22.77 | 27.61 | 10.66 | 106.02 | 66.28 | 42.91 | 53.04 | 54.08 | 2.69 | 11.82 | 20.50 | 10.03 | 9.37 | 13.30 | -1.33 | 34.53 |
| $W_4$ | $Sq_1$ | 19.12 | 19.91 | 15.12 | 18.05 | 3.49 | 34.70 | 49.99 | 40.94 | 45.97 | 45.63 | -1.28 | 5.64 | 16.61 | 13.82 | 12.53 | 14.32 | -1.14 | 29.51 |
| | $Sq_2$ | 30.99 | 21.59 | 28.95 | 27.18 | 10.33 | 102.81 | 72.15 | 61.48 | 55.23 | 62.95 | 6.86 | 30.17 | 22.19 | 17.09 | 16.30 | 18.53 | -0.34 | 8.81 |
| | $Sq_3$ | 59.50 | 41.93 | 26.58 | 42.67 | 21.95 | 218.43 | 81.28 | 80.40 | 67.63 | 76.44 | 13.20 | 58.05 | 30.02 | 18.72 | 16.30 | 21.68 | 0.26 | 6.72 |
| | $Sq_4$ | 46.14 | 44.09 | 24.15 | 38.13 | 18.55 | 184.53 | 88.14 | 84.66 | 69.14 | 80.65 | 15.17 | 66.76 | 31.95 | 21.55 | 17.66 | 23.72 | 0.65 | 16.76 |
| M | $Sq_1$ | 16.63 | 14.11 | 11.51 | 14.08 | 0.51 | 5.09 | 31.86 | 25.07 | 28.15 | 28.36 | -9.40 | 41.36 | 11.70 | 8.50 | 7.61 | 9.27 | -2.10 | 54.38 |
| e | $Sq_2$ | 21.36 | 15.67 | 16.12 | 17.71 | 3.24 | 32.19 | 44.80 | 33.26 | 32.42 | 36.82 | -5.42 | 23.86 | 13.39 | 10.63 | 9.41 | 11.14 | -1.74 | 45.15 |
| a | $Sq_3$ | 30.83 | 21.93 | 16.39 | 23.05 | 7.24 | 72.01 | 53.84 | 43.30 | 42.35 | 46.49 | -0.88 | 3.87 | 17.42 | 10.49 | 9.41 | 12.44 | -1.50 | 38.79 |
| n | $Sq_4$ | 29.86 | 25.96 | 19.04 | 24.95 | 8.66 | 86.21 | 59.49 | 47.10 | 46.42 | 51.00 | 1.24 | 5.46 | 19.60 | 12.72 | 10.21 | 14.18 | -1.17 | 30.22 |

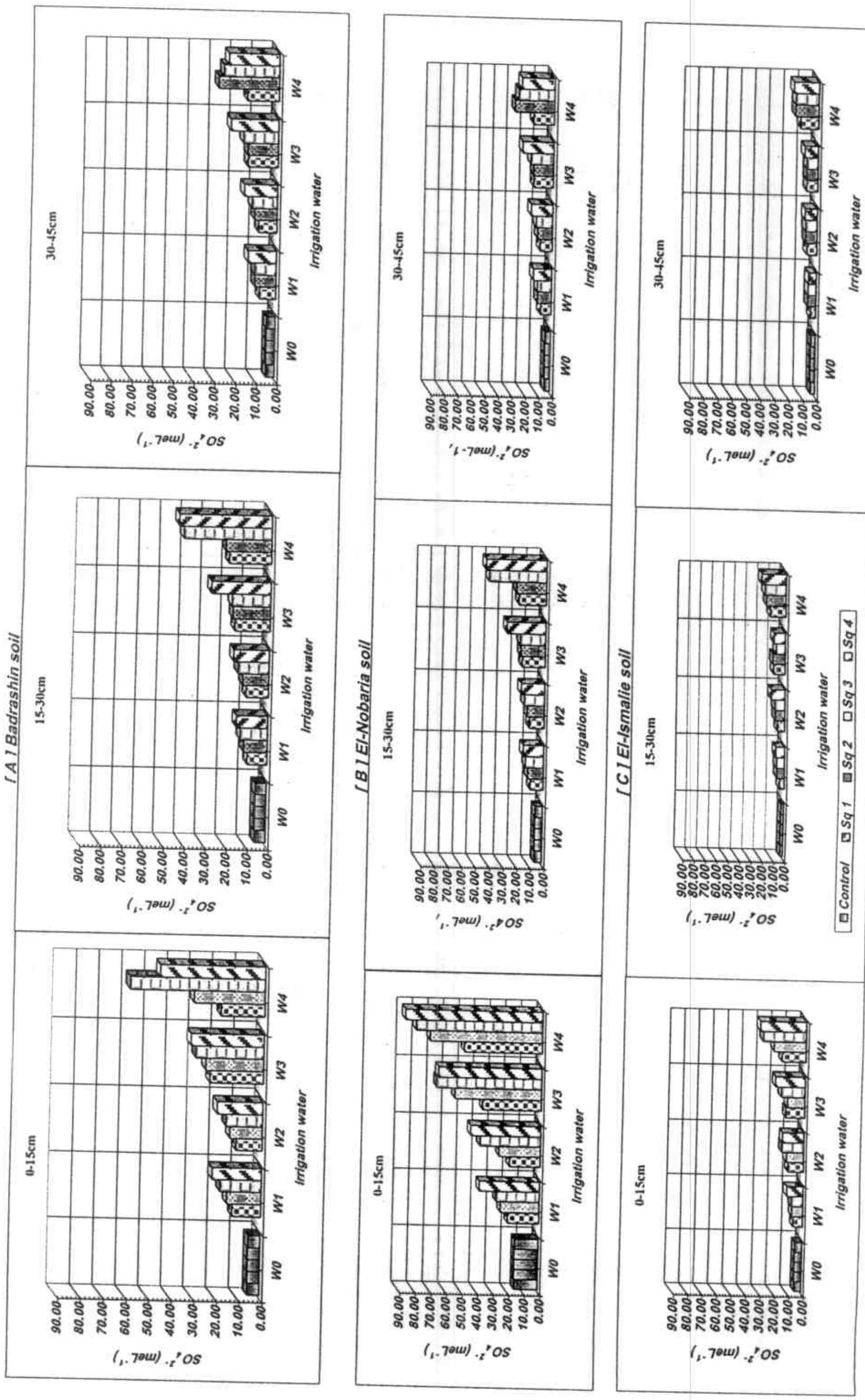


*Fig. ( 5 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble sulphate (meL⁻¹) in saturation paste extract of soils columns.*

Regarding effect of the aforementioned elution sequences on redistribution of soluble $SO_4^{2-}$ in the clayey soil, it could be noticed that the sequences $Sq_1$ and $Sq_2$ only were of positive effect on reducing amount of soluble $SO_4^{2-}$ in the different depths of this soil. Unlike $Sq_1$ and $Sq_2$, the elution sequences $Sq_3$ and $Sq_4$ caused soluble $SO_4^{2-}$ to accumulate in the clayey soil.

Intermittent leaching using the tap water ($W_0$) alternatively with Seedy Ghazy drain water although resulted in similar effect to that of El-Bostan drain on redistribution of the soluble $SO_4^{2-}$ within the different depths of the clayey, sandy clay loam and sand soils, yet removal of $SO_4^{2-}$ in both the sandy clay loam and sandy soils was less pronounced. Also, removal of soluble $SO_4^{2-}$ from the clayey soil upon usage of the sequences $Sq_1$ and $Sq_2$ was less pronounced. On the other hand, the elution sequences $Sq_3$ and $Sq_4$ resulted in more accumulation of soluble $SO_4^{2-}$ in all depths of the clayey soil.

Intermittent leaching of the investigated soils using El Hedaya Irrigation canal ($W_3$) seemed to be of less effect on removal of soluble $SO_4^{2-}$ out of the different depths of these soils. Moreover, the elution sequences $Sq_3$ and $Sq_4$ resulted in accumulation of soluble $SO_4^{2-}$ in both the clayey and sandy clay loam soils while these elution sequences caused soluble $SO_4^{2-}$ contents of the sandy soil to be reduced. The elution sequences $Sq_1$ and $Sq_2$ were also of a similar effect on removal of soluble $SO_4^{2-}$ out of the sandy soil but to a relatively larger extent than $Sq_3$ or $Sq_4$.Alternative application of the tap water ($W_0$) with Haris drain water ($W_4$) resulted in accumulation of the soluble $SO_4^{2-}$ in the different depths of the studied soils expect for the elution sequence $Sq_1$ which caused soluble $SO_4^{2-}$ to be reduced in both the sandy clay loam and the sandy soils.

#### 4.1.2.2.Effect on soluble cations:

Data presented in Tables (9,10,11 and 12) reveal redistribution of soluble cations within the different depths of the investigated soils due to intermittent leaching of these soils with different elution sequences of tap water with either of the different used sources of water ($W_1$,$W_2$,$W_3$ ,$W_4$).

*A: Soluble ($Ca^{2+}$):*

Data presented in Table (9) and Fig. (6) reveal that intermittent leaching of the investigated soils with the tap water resulted in general reduction in soil contents of soluble $Ca^{2+}$. The effect was highest in the sandy clay loam soil, lowest in the clayey one and came in between in the sandy soil. Values of relative change in soluble $Ca^{2+}$ were 73.04, 83.89 and 82.23 % in the clayey, sandy clay loam and sandy soils, respectively.

Intermittent leaching using the different elution sequences $Sq_1$, $Sq_2$, $Sq_3$ and $Sq_4$ generally resulted in reduction in soluble $Ca^{2+}$ contents of both the sandy clay loam and sandy soils whatever the water applied alternatively with the tap water was.

However, intermittent leaching of the clayey soil resulted in contradictory results depending on type of the sequence used besides of type of the water used in this sequence. For example, upon using El Bostan drain water ($W_1$) alternatively with the tap water, the elution sequences $Sq_1$ and $Sq_2$ reduced the clayey soil content of soluble $Ca^{2+}$ by 40.6 and 25.58 %, respectively while the elution sequences $Sq_3$ and $Sq_4$ resulted in increases in soil content of the soluble $Ca^{2+}$ by 1.69 and 32.93%, respectively.

When Seedy Ghazy drain water ($W_2$) was used alternatively with the tap water, all the elution sequences were able to reduce soluble $Ca^{2+}$

*Table ( 9 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble calcium ($meL^{-1}$) in saturation paste extract of soils columns.*

| Locations | | [ A ] Badrashin soil | | | | | | [ B ] El-Nobaria soil | | | | | | [ C ] El-Ismailia soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation water | Treatments | Depth (cm) | | | | | | | | | | | | | | | | | |
| | | 0-15 | 15-30 | 30-45 | Average | $\triangle Ca^{2+}$ | % RC | 0-15 | 15-30 | 30-45 | Average | $\triangle Ca^{2+}$ | % RC | 0-15 | 15-30 | 30-45 | Average | $\triangle Ca^{2+}$ | % RC |
| $W_0$ | Control | 2.04 | 2.04 | 1.02 | 1.70 | -3.46 | 73.04 | 5.67 | 4.64 | 6.18 | 5.50 | -13.46 | 83.89 | 3.57 | 2.04 | 3.06 | 2.89 | -2.54 | 82.23 |
| $W_1$ | $Sq_1$ | 4.12 | 3.61 | 3.61 | 3.78 | -1.90 | 40.06 | 8.24 | 6.70 | 5.67 | 6.87 | -12.81 | 79.87 | 3.61 | 2.58 | 2.58 | 2.92 | -2.53 | 82.02 |
| | $Sq_2$ | 5.15 | 4.64 | 4.29 | 4.69 | -1.21 | 25.58 | 11.81 | 7.21 | 6.18 | 8.40 | -12.09 | 75.39 | 4.12 | 3.61 | 3.09 | 3.61 | -2.40 | 77.82 |
| | $Sq_3$ | 7.39 | 6.70 | 5.15 | 6.41 | 0.08 | 1.69 | 12.36 | 9.79 | 7.73 | 9.96 | -11.36 | 70.82 | 4.64 | 3.61 | 4.12 | 4.12 | -2.31 | 74.65 |
| | $Sq_4$ | 11.85 | 6.87 | 6.43 | 8.38 | 1.56 | 32.93 | 15.97 | 11.85 | 9.27 | 12.36 | -10.23 | 63.77 | 6.64 | 4.12 | 4.12 | 4.96 | -2.15 | 69.50 |
| $W_2$ | $Sq_1$ | 4.64 | 4.64 | 3.09 | 4.12 | -1.64 | 34.62 | 7.73 | 7.73 | 6.70 | 7.39 | -12.57 | 78.36 | 4.64 | 2.58 | 4.47 | 3.90 | -2.35 | 76.04 |
| | $Sq_2$ | 5.76 | 5.76 | 4.64 | 5.39 | -0.69 | 14.59 | 13.05 | 9.79 | 7.73 | 10.19 | -11.25 | 70.14 | 4.47 | 3.81 | 4.09 | 4.12 | -2.31 | 74.65 |
| | $Sq_3$ | 5.67 | 5.67 | 5.15 | 5.50 | -0.61 | 12.84 | 15.45 | 10.30 | 9.27 | 11.67 | -10.55 | 65.80 | 5.67 | 4.47 | 4.64 | 4.93 | -2.15 | 69.71 |
| | $Sq_4$ | 6.18 | 6.18 | 5.67 | 6.01 | -0.22 | 4.70 | 17.17 | 12.88 | 10.82 | 13.62 | -9.64 | 60.08 | 5.67 | 4.64 | 5.32 | 5.21 | -2.10 | 67.96 |
| $W_3$ | $Sq_1$ | 7.73 | 6.18 | 5.67 | 6.53 | 0.16 | 3.49 | 14.42 | 11.01 | 12.91 | 12.78 | -10.03 | 62.55 | 5.10 | 4.59 | 4.08 | 4.59 | -2.22 | 71.78 |
| | $Sq_2$ | 9.27 | 6.70 | 6.18 | 7.38 | 0.81 | 17.07 | 20.09 | 12.88 | 14.42 | 15.80 | -8.62 | 53.71 | 6.12 | 4.08 | 4.18 | 4.79 | -2.18 | 70.53 |
| | $Sq_3$ | 10.82 | 7.73 | 7.73 | 8.76 | 1.84 | 38.90 | 22.66 | 16.48 | 19.06 | 19.40 | -6.92 | 43.15 | 7.65 | 5.10 | 4.64 | 5.80 | -1.99 | 64.36 |
| | $Sq_4$ | 12.88 | 12.88 | 8.67 | 11.48 | 3.88 | 81.98 | 24.24 | 18.03 | 20.69 | 20.99 | -6.18 | 38.51 | 8.76 | 5.67 | 5.10 | 6.51 | -1.85 | 59.97 |
| $W_4$ | $Sq_1$ | 11.73 | 10.30 | 9.69 | 10.57 | 3.20 | 67.65 | 18.87 | 13.77 | 13.26 | 15.30 | -8.85 | 55.17 | 5.61 | 3.57 | 3.60 | 4.26 | -2.28 | 73.81 |
| | $Sq_2$ | 12.88 | 11.85 | 11.73 | 12.15 | 4.39 | 92.71 | 27.54 | 24.54 | 20.91 | 24.33 | -4.60 | 28.71 | 9.18 | 5.10 | 4.59 | 6.29 | -1.89 | 61.32 |
| | $Sq_3$ | 21.63 | 16.48 | 10.71 | 16.27 | 7.48 | 158.03 | 31.11 | 27.03 | 21.93 | 26.69 | -3.50 | 21.79 | 11.22 | 6.12 | 5.10 | 7.48 | -1.67 | 54.01 |
| | $Sq_4$ | 23.18 | 20.40 | 16.48 | 20.02 | 10.29 | 217.44 | 31.11 | 28.56 | 26.60 | 28.76 | -2.52 | 15.74 | 13.26 | 8.67 | 5.10 | 9.01 | -1.38 | 44.60 |
| M | $Sq_1$ | 7.06 | 6.18 | 5.52 | 6.25 | -0.04 | 0.89 | 12.32 | 9.80 | 9.64 | 10.58 | -11.07 | 68.99 | 4.74 | 3.33 | 3.68 | 3.92 | -2.35 | 75.91 |
| e | $Sq_2$ | 8.27 | 7.24 | 6.71 | 7.40 | 0.82 | 17.40 | 18.12 | 13.61 | 12.31 | 14.68 | -9.14 | 56.99 | 5.97 | 4.15 | 3.99 | 4.70 | -2.20 | 71.08 |
| a | $Sq_3$ | 11.38 | 9.15 | 7.19 | 9.24 | 2.20 | 46.45 | 20.40 | 15.90 | 14.50 | 16.93 | -8.08 | 50.39 | 7.30 | 4.83 | 4.63 | 5.58 | -2.03 | 65.68 |
| n | $Sq_4$ | 13.52 | 11.58 | 9.31 | 11.47 | 3.87 | 81.91 | 22.12 | 17.83 | 16.85 | 18.93 | -7.14 | 44.52 | 8.58 | 5.78 | 4.91 | 6.42 | -1.87 | 60.51 |

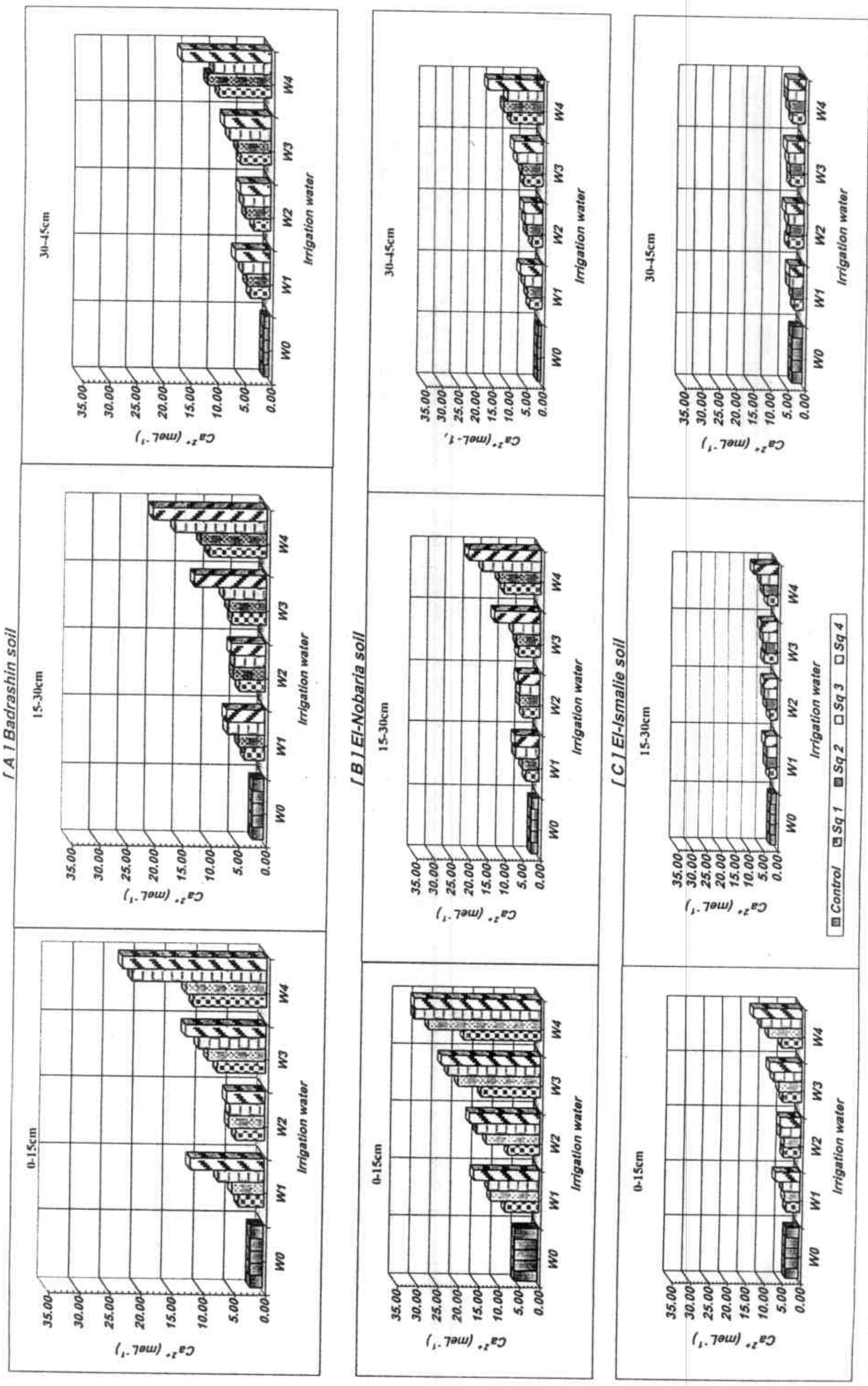


*Fig. ( 6 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble calcium (meL$^{-1}$ ) in saturation paste extract of soils columns.*

content. The reduction was highest upon using the elution sequence $Sq_1$ and tended to be reduced by increasing times of using the drain water in each sequence, hence this reduction was lowest upon using $Sq_4$ in leaching the soil.

Unlike the effect of the elution sequences that were conducted using Seedy Ghazy drain water alternatively with the tap water, all the elution sequences resulted from the alternative usage of the tap water with water of either El Hedaya irrigation canal ($W_3$) or Haris drain resulted in increase in soil content of soluble $Ca^+$. The increase seemed more pronounced upon usage of Haris drain water than El Hedaya irrigation canal. Also, it seemed higher by increasing times of usage of the bad quality water in the studied elution sequences.

***B: Soluble magnesium ($Mg^{2+}$):***

It seems from data presented in Table (10) and Fig. (7) that all the elution sequences resulted from the alternative usage of the tap water with either of El Bostan drain water ($W_1$), Seedy Ghazy drain water ($W_2$) or El Hedaya irrigation canal water ($W_3$) reduced soil content of soluble $Mg^{2+}$. The effect although seemed lower than that resulted due to usage of the tap water only, yet it seemed to be highest by reduction in times of usage the other sources of water i.e. $W_1$, $W_2$ and $W_3$. Also, intermittent leaching through usage of elution sequences in which ($W_1$) was the water to be used alternatively with the tap water was of higher effect on reducing $Mg^{2+}$ content than the corresponding ones in which ($W_2$) or ($W_3$) was used. Intermittent leaching using elution sequences consists of Haris drain water ($W_4$) alternatively with tap water ($W_1$) resulted in contradictory effects on both the sandy clay loam and the sandy soils contents of the soluble $Mg^{2+}$. All the elution sequences expect for $Sq_4$ caused soluble $Mg^{2+}$ to be reduced in the sandy clay loam soil, while $Sq_1$

Table ( 10 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble magnesium ($meL^{-1}$) in saturation paste extract of soils colunms.

| Locations | | [A] Badrashin soil | | | | | | [B] El-Nobaria soil | | | | | | [C] El-Ismailia soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation water | Treatments | Depth (cm) | | | | | | | | | | | | | | | | | |
| | | 0-15 | 15-30 | 30-45 | Average | $\triangle Mg^{2+}$ | %RC | 0-15 | 15-30 | 30-45 | Average | $\triangle Mg^{2+}$ | %RC | 0-15 | 15-30 | 30-45 | Average | $\triangle Mg^{2+}$ | %RC |
| $W_0$ | Control | 2.42 | 0.93 | 0.96 | 1.44 | -2.91 | 72.99 | 3.84 | 3.37 | 5.32 | 4.18 | -11.20 | 85.08 | 1.88 | 0.93 | 0.41 | 1.07 | -0.93 | 81.95 |
| $W_1$ | $Sq_1$ | 2.98 | 2.85 | 2.07 | 2.63 | -2.02 | 50.50 | 3.28 | 2.28 | 3.31 | 2.96 | -11.77 | 89.44 | 1.48 | 1.22 | 0.93 | 1.21 | -0.90 | 79.65 |
| | $Sq_2$ | 3.30 | 2.87 | 2.38 | 2.85 | -1.85 | 46.43 | 4.64 | 2.73 | 3.72 | 3.70 | -11.42 | 86.80 | 1.51 | 1.43 | 1.51 | 1.48 | -0.85 | 75.06 |
| | $Sq_3$ | 4.21 | 3.30 | 2.47 | 3.33 | -1.50 | 37.47 | 5.31 | 4.26 | 4.84 | 4.80 | -10.90 | 82.85 | 1.87 | 1.50 | 1.76 | 1.71 | -0.81 | 71.25 |
| | $Sq_4$ | 5.16 | 3.56 | 2.98 | 3.90 | -1.07 | 26.69 | 5.78 | 4.64 | 5.54 | 5.32 | -10.66 | 81.00 | 2.03 | 1.50 | 1.86 | 1.80 | -0.79 | 69.79 |
| $W_2$ | $Sq_1$ | 3.31 | 2.84 | 2.87 | 3.01 | -1.74 | 43.48 | 5.41 | 3.70 | 5.28 | 4.80 | -10.91 | 82.87 | 2.03 | 1.41 | 1.69 | 1.71 | -0.81 | 71.25 |
| | $Sq_2$ | 3.37 | 2.90 | 3.41 | 3.23 | -1.57 | 39.35 | 7.87 | 4.64 | 5.28 | 5.93 | -10.37 | 78.82 | 2.38 | 1.57 | 1.61 | 1.85 | -0.78 | 68.84 |
| | $Sq_3$ | 3.34 | 3.35 | 3.41 | 3.37 | -1.47 | 36.72 | 10.64 | 9.55 | 10.14 | 10.11 | -8.41 | 63.89 | 3.37 | 2.41 | 1.86 | 2.55 | -0.65 | 57.18 |
| | $Sq_4$ | 4.34 | 3.56 | 4.34 | 4.08 | -0.93 | 23.31 | 13.33 | 9.87 | 12.37 | 11.86 | -7.59 | 57.65 | 4.88 | 2.90 | 1.91 | 3.23 | -0.52 | 45.69 |
| $W_3$ | $Sq_1$ | 5.32 | 3.28 | 3.84 | 4.15 | -0.88 | 22.06 | 10.13 | 8.23 | 10.02 | 9.46 | -8.71 | 66.21 | 2.33 | 1.83 | 1.34 | 1.83 | -0.78 | 69.17 |
| | $Sq_2$ | 5.82 | 3.81 | 4.19 | 4.61 | -0.54 | 13.41 | 12.83 | 9.63 | 10.58 | 11.01 | -7.98 | 60.67 | 2.85 | 2.85 | 1.87 | 2.52 | -0.65 | 57.57 |
| | $Sq_3$ | 6.13 | 3.83 | 4.75 | 4.90 | -0.31 | 7.83 | 13.90 | 10.34 | 12.28 | 12.17 | -7.44 | 56.52 | 3.29 | 2.85 | 2.33 | 2.82 | -0.59 | 52.53 |
| | $Sq_4$ | 6.73 | 4.19 | 5.28 | 5.40 | 0.06 | 1.50 | 14.77 | 10.92 | 13.13 | 12.94 | -7.08 | 53.79 | 6.71 | 4.75 | 2.85 | 4.77 | -0.22 | 19.80 |
| $W_4$ | $Sq_1$ | 12.06 | 7.58 | 10.11 | 9.92 | 3.45 | 86.40 | 15.45 | 11.82 | 14.94 | 14.07 | -6.55 | 49.75 | 4.32 | 2.88 | 2.81 | 3.34 | -0.50 | 43.90 |
| | $Sq_2$ | 13.70 | 9.02 | 13.13 | 11.95 | 4.97 | 124.62 | 21.36 | 15.10 | 16.82 | 17.76 | -4.81 | 36.57 | 5.65 | 3.81 | 3.81 | 4.42 | -0.29 | 25.63 |
| | $Sq_3$ | 17.02 | 9.96 | 13.13 | 13.37 | 6.04 | 151.32 | 28.89 | 20.18 | 25.02 | 24.70 | -1.55 | 11.80 | 10.25 | 4.32 | 3.81 | 6.13 | 0.03 | 3.01 |
| | $Sq_4$ | 18.83 | 15.00 | 17.22 | 17.02 | 8.77 | 219.86 | 41.19 | 22.35 | 27.62 | 30.39 | 1.12 | 8.52 | 13.11 | 10.25 | 7.25 | 10.20 | 0.81 | 71.56 |
| Mean | $Sq_1$ | 5.92 | 4.14 | 4.72 | 4.93 | -0.30 | 7.41 | 8.57 | 6.51 | 8.39 | 7.82 | -9.48 | 72.07 | 2.54 | 1.84 | 1.69 | 2.02 | -0.75 | 65.99 |
| | $Sq_2$ | 6.55 | 4.65 | 5.78 | 5.66 | 0.25 | 6.36 | 11.68 | 8.03 | 9.10 | 9.60 | -8.65 | 65.71 | 3.10 | 2.42 | 2.20 | 2.57 | -0.64 | 56.77 |
| | $Sq_3$ | 7.68 | 5.11 | 5.94 | 6.24 | 0.69 | 17.32 | 14.69 | 11.08 | 13.07 | 12.95 | -7.08 | 53.76 | 4.70 | 2.77 | 2.44 | 3.30 | -0.50 | 44.49 |
| | $Sq_4$ | 8.77 | 6.58 | 7.46 | 7.60 | 1.71 | 42.84 | 18.77 | 11.95 | 14.67 | 15.13 | -6.05 | 45.98 | 6.68 | 4.85 | 3.47 | 5.00 | -0.18 | 15.93 |

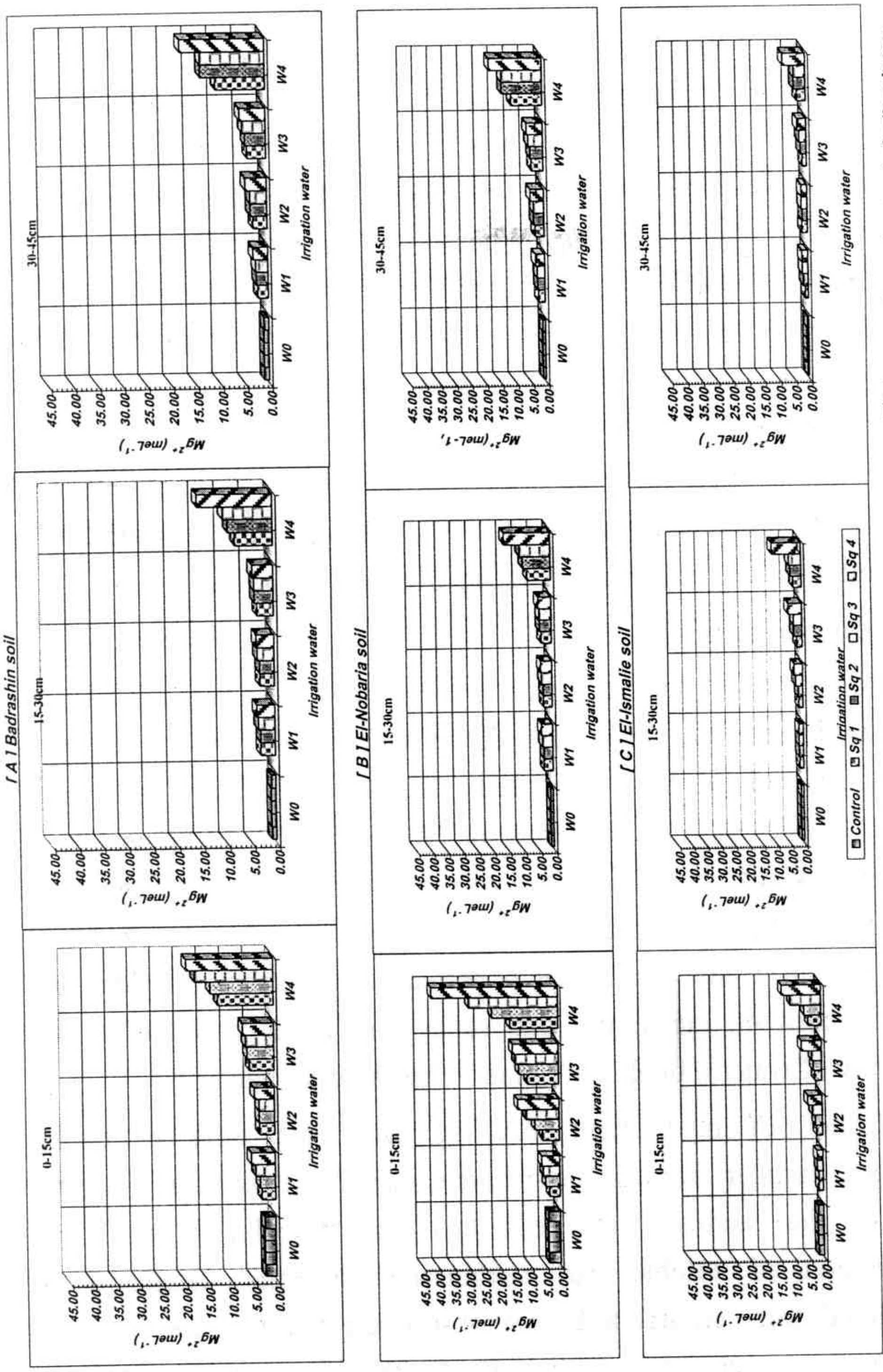


*Fig. ( 7 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble magnesium (meL $^{-1}$) in saturation paste extract of soils columns.*

and $Sq_2$ were the only elution sequence which caused soluble $Mg^{2+}$ to be reduced in the sandy soil.

Intermittent leaching of the clayey soil using all the elution sequences in which $W_1$ or $W_2$ was alternatively applied with $W_0$ was generally of reducible effect on its content of soluble $Mg^{2+}$ with the effect of $Sq_1 > Sq_2 > Sq_3 > Sq_4$. When $W_3$ was used instead of $W_1$ or $W_2$ similar but lower effect on reduction of soluble $Mg^{2+}$ was noticed. This was true upon usage of all the elution sequences expect for $Sq_4$ which caused soluble $Mg^{2+}$ to be very slightly accumulated in the clayey soil. When Haris drain water $W_4$ was applied alternatively with the tap water, soluble $Mg^{2+}$ increased in all layers of the clayey soil, the increase followed the order: $Sq_1 > Sq_2 > Sq_3 > Sq_4$. Such an order seemed to be a final product of the used water contents of soluble $Mg^{2+}$.

***C: Soluble Sodium ($Na^+$):***

As it was expected, data presented in Table (11) and Fig. (8) reveal that intermittent leaching of all the studied soils with the tap water ($W_0$) caused soluble $Na^+$ content to be decreased in all the studied soils, however values of relative reduction (RC) seemed to be highest in the sandy soil which is well known by its relatively high percentage of the drainable pores, lowest in the clayey soil which is well know by its high retentively for water, and came in between in the sandy clay loam soil which is between the clayey and sandy soil in its drainablility and retentively of water though tending more towards the sandy one.

Effect of intermittent leaching using the different elution sequences resulted from the alternative usage of the tap water ($W_0$) with either of the studied water qualities i.e. $W_1$, $W_2$, $W_3$ or $W_4$ on redistribution of soluble $Na^+$ within the different depths of the investigated soils seemed to be similar to some extent, to that shown on soluble $Cl^-$ where general reduction in soluble $Na^+$ content occurred in

Table ( 11 ) : *Effect of irrigation water quality and elution sequence on redistribution of soluble sodium (meL$^{-1}$) in saturation paste extract of soils columns.*

| Locations | | [A] Badrashin soil | | | | | | [B] El-Nobaria soil | | | | | | [C] El-Ismailia soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Depth (cm) | | | | | | | | | | | | | | | | | |
| Irrigation water | Treatments | 0-15 | 15-30 | 30-45 | Average | △ $Na^+$ | %RC | 0-15 | 15-30 | 30-45 | Average | △ $Na^+$ | %RC | 0-15 | 15-30 | 30-45 | Average | △ $Na^+$ | %RC |
| $W_0$ | Control | 6.06 | 6.50 | 5.76 | 6.11 | -4.27 | 48.25 | 10.41 | 5.84 | 4.62 | 6.96 | -25.85 | 88.77 | 2.00 | 1.72 | 2.81 | 2.18 | -3.79 | 90.15 |
| $W_1$ | $Sq_1$ | 10.98 | 9.27 | 8.00 | 9.42 | -1.79 | 20.20 | 17.85 | 11.87 | 12.57 | 14.10 | -22.49 | 77.25 | 6.15 | 4.29 | 4.62 | 5.02 | -3.25 | 77.29 |
| | $Sq_2$ | 14.88 | 9.00 | 8.64 | 10.84 | -0.72 | 8.14 | 19.02 | 13.45 | 14.40 | 15.62 | -21.78 | 74.78 | 6.59 | 5.69 | 6.06 | 6.11 | -3.04 | 72.34 |
| | $Sq_3$ | 14.64 | 9.75 | 8.73 | 11.04 | -0.57 | 6.44 | 21.36 | 15.00 | 20.04 | 18.80 | -20.28 | 69.66 | 7.09 | 5.95 | 6.15 | 6.40 | -2.98 | 71.06 |
| | $Sq_4$ | 15.60 | 11.10 | 10.00 | 12.23 | 0.33 | 3.67 | 28.80 | 20.64 | 25.98 | 25.14 | -17.30 | 59.42 | 9.85 | 6.15 | 6.45 | 7.48 | -2.78 | 66.15 |
| $W_2$ | $Sq_1$ | 13.39 | 10.50 | 9.95 | 11.28 | -0.39 | 4.41 | 14.93 | 10.39 | 12.39 | 12.57 | -23.21 | 79.71 | 11.64 | 6.58 | 6.65 | 8.29 | -2.62 | 62.50 |
| | $Sq_2$ | 15.00 | 12.00 | 10.00 | 12.33 | 0.40 | 4.52 | 16.70 | 12.00 | 13.72 | 14.14 | -22.47 | 77.18 | 13.00 | 9.09 | 9.00 | 10.36 | -2.23 | 53.12 |
| | $Sq_3$ | 16.00 | 15.00 | 13.64 | 14.88 | 2.31 | 26.10 | 24.47 | 17.00 | 20.55 | 20.67 | -19.40 | 66.63 | 13.88 | 9.00 | 9.27 | 10.72 | -2.16 | 51.52 |
| | $Sq_4$ | 22.32 | 17.00 | 15.00 | 18.11 | 4.73 | 53.45 | 33.88 | 19.74 | 21.82 | 25.15 | -17.30 | 59.41 | 14.00 | 10.75 | 9.31 | 11.35 | -2.04 | 48.64 |
| $W_3$ | $Sq_1$ | 19.40 | 15.52 | 13.14 | 16.02 | 3.17 | 35.76 | 25.14 | 21.96 | 22.68 | 23.26 | -18.19 | 62.46 | 12.93 | 8.50 | 9.27 | 10.23 | -2.26 | 53.71 |
| | $Sq_2$ | 21.90 | 16.00 | 13.50 | 17.13 | 4.00 | 45.20 | 48.00 | 24.36 | 26.28 | 32.88 | -13.67 | 46.93 | 13.32 | 10.23 | 9.18 | 10.91 | -2.13 | 50.65 |
| | $Sq_3$ | 27.54 | 16.52 | 13.77 | 19.28 | 5.61 | 63.36 | 56.96 | 26.64 | 29.04 | 37.55 | -11.47 | 39.40 | 18.36 | 11.16 | 12.39 | 13.97 | -1.55 | 36.80 |
| | $Sq_4$ | 31.23 | 24.36 | 22.32 | 25.97 | 10.63 | 120.08 | 60.89 | 27.00 | 35.17 | 41.02 | -9.84 | 33.79 | 20.50 | 11.82 | 13.80 | 15.37 | -1.28 | 30.45 |
| $W_4$ | $Sq_1$ | 37.51 | 27.81 | 24.92 | 30.08 | 13.71 | 154.92 | 40.92 | 35.75 | 38.50 | 38.39 | -11.08 | 38.04 | 14.07 | 14.00 | 12.18 | 13.42 | -1.65 | 39.31 |
| | $Sq_2$ | 52.64 | 35.60 | 32.90 | 40.38 | 21.44 | 242.20 | 63.63 | 52.00 | 56.00 | 57.21 | -2.23 | 7.66 | 21.90 | 15.76 | 15.76 | 17.81 | -0.82 | 19.45 |
| | $Sq_3$ | 69.00 | 53.64 | 43.03 | 55.22 | 32.57 | 367.99 | 80.00 | 70.14 | 73.50 | 74.55 | 5.92 | 20.32 | 25.86 | 20.95 | 18.30 | 21.70 | -0.08 | 1.82 |
| | $Sq_4$ | 69.94 | 63.04 | 52.64 | 61.87 | 37.56 | 424.35 | 109.62 | 76.00 | 80.00 | 88.54 | 12.49 | 42.90 | 30.90 | 25.86 | 25.50 | 27.42 | 1.01 | 24.04 |
| Mean | $Sq_1$ | 20.32 | 15.78 | 14.00 | 16.70 | 3.67 | 41.52 | 24.71 | 19.99 | 21.54 | 22.08 | -18.74 | 64.36 | 11.20 | 8.34 | 8.18 | 9.24 | -2.44 | 58.20 |
| | $Sq_2$ | 26.11 | 18.15 | 16.26 | 20.17 | 6.28 | 70.95 | 36.84 | 25.45 | 27.60 | 29.96 | -15.04 | 51.64 | 13.70 | 10.19 | 10.00 | 11.30 | -2.05 | 48.89 |
| | $Sq_3$ | 31.80 | 23.73 | 19.79 | 25.11 | 9.98 | 112.75 | 45.70 | 32.20 | 35.78 | 37.89 | -11.31 | 38.84 | 16.30 | 11.77 | 11.53 | 13.20 | -1.69 | 40.30 |
| | $Sq_4$ | 34.77 | 28.88 | 24.99 | 29.55 | 13.31 | 150.39 | 58.30 | 35.85 | 40.74 | 44.96 | -7.99 | 27.43 | 18.81 | 13.65 | 13.77 | 15.41 | -1.27 | 30.30 |

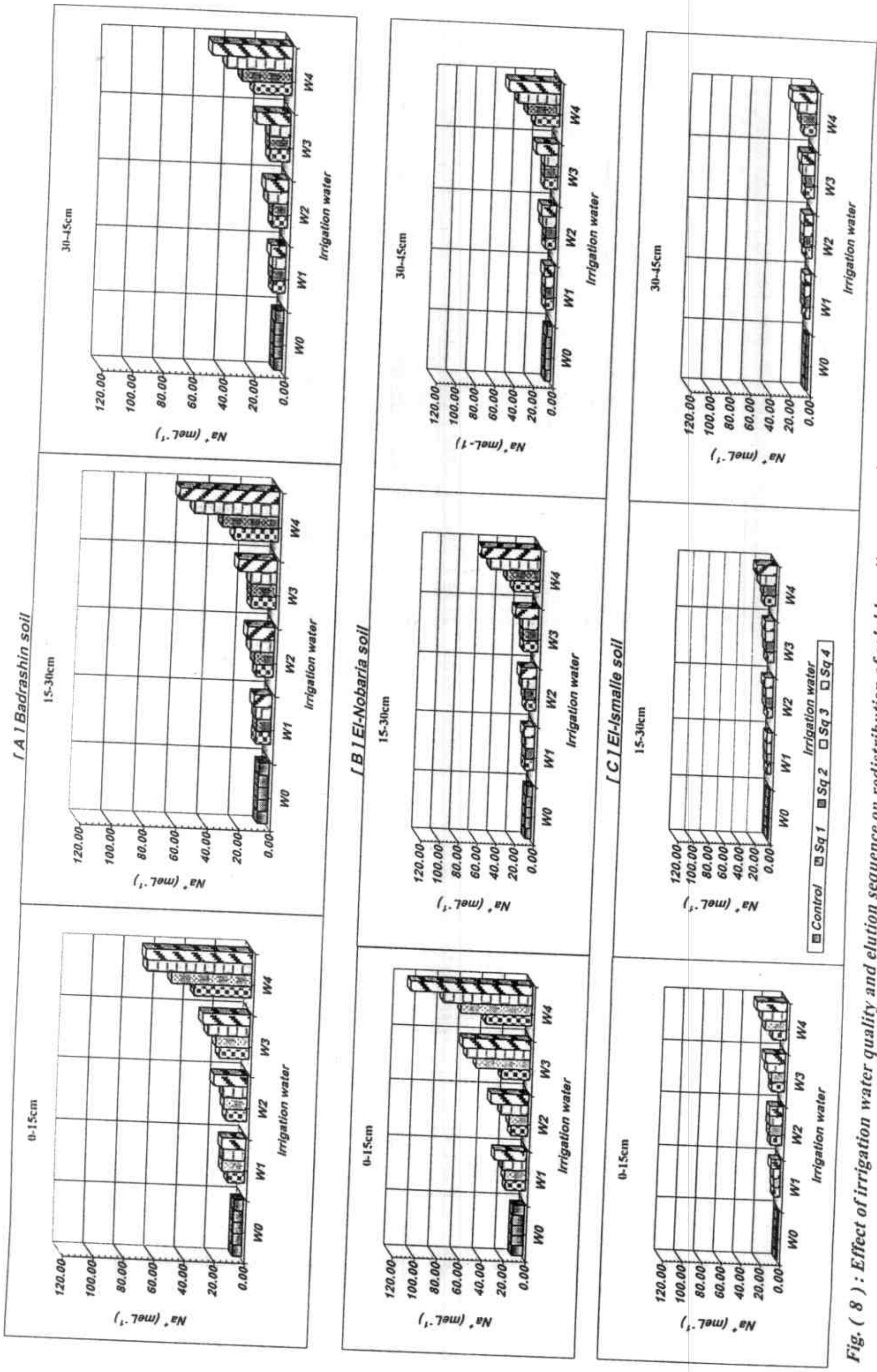


*Fig. ( 8 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble sodium (meL⁻¹) in saturation paste extract of soils columns.*

both the sandy clay loam and sandy soils due to all the elution sequences that consist of the alternative application of the ($W_0$) with $W_1$ , $W_2$ , $W_3$ or $W_4$ expect for $Sq_3$ and $Sq_4$ when the alternatively applied water was $W_4$ in case of the sandy clay loam where soluble $Na^+$ tended to accumulate.

The elution sequences $Sq_1$ , $Sq_2$ , $Sq_3$ and $Sq_4$ resulted increase in soluble $Na^+$ content of the clayey soil when the water alternatively applied with the tap water was $W_2$ , $W_3$ or $W_4$ expect for $Sq_1$ in case of application of $W_2$. On the other hand, all the elution sequences except for $Sq_4$ that consisted of alternative application of the tap water with ($W_1$) resulted in reduction in the clay soil content of soluble $Na^+$.

***D: Soluble Potassium ($K^+$):***

Results presented in Table (12) and Fig. (9) reveal that using tap water ($W_0$) for intermittent leaching of the investigated soils resulted in decrease in soluble $K^+$ content of these soils. The relative change (RC) was highest in the sandy clay loam soil (56.34 %) followed by the sandy one (27.62%) and finally the clayey soil (13.16%).

Using the tested water qualities alternatively with the tap water in different sequences caused soluble $K^+$ to increase in the clayey soil. The relative increase in soluble $K^+$ content was lowest when El Bostan drain water ($W_1$) was applied alternatively with the tap water ($W_0$). When the used water was that of Seedy Ghazy drain the soil content of soluble $K^+$ was more obvious. When water of El Hedaya irrigation canal ($W_3$) was used instead of Seedy Ghazy drain water the clay soil content of soluble $K^+$ increased and the increase become most pronounced when Haris drain water was used. Also, the effect of the elution sequences on accumulation of soluble $K^+$ in the clayey soil followed the order: $Sq_1 > Sq_2 > Sq_3 > Sq_4$.

Table ( 12 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble potassium ($meL^{-1}$) in saturation paste extract of soils columns.

| Locations | | [A] Badrashin soil | | | | | | [B] El-Nobaria soil | | | | | | [C] El-Ismailia soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation water | Treatments | Depth (cm) | | | | | | | | | | | | | | | | | |
| | | 0-15 | 15-30 | 30-45 | Average | △ $K^+$ | %RC | 0-15 | 15-30 | 30-45 | Average | △ $K^+$ | %RC | 0-15 | 15-30 | 30-45 | Average | △ $K^+$ | %RC |
| $W_0$ | Control | 0.28 | 0.25 | 0.13 | 0.22 | -0.03 | 13.16 | 1.50 | 1.29 | 1.53 | 1.44 | -0.87 | 56.34 | 0.30 | 0.25 | 0.25 | 0.27 | -0.02 | 27.62 |
| $W_1$ | $Sq_1$ | 0.36 | 0.30 | 0.30 | 0.32 | 0.05 | 26.32 | 1.54 | 1.53 | 1.53 | 1.53 | -0.83 | 53.51 | 0.33 | 0.33 | 0.30 | 0.32 | -0.01 | 13.14 |
| | $Sq_2$ | 0.46 | 0.33 | 0.33 | 0.37 | 0.09 | 47.37 | 1.75 | 1.65 | 1.60 | 1.67 | -0.77 | 49.46 | 0.37 | 0.34 | 0.29 | 0.33 | -0.01 | 9.52 |
| | $Sq_3$ | 0.50 | 0.39 | 0.39 | 0.43 | 0.13 | 68.42 | 1.93 | 1.86 | 1.60 | 1.80 | -0.71 | 45.52 | 0.41 | 0.30 | 0.30 | 0.34 | -0.01 | 8.62 |
| | $Sq_4$ | 0.56 | 0.46 | 0.46 | 0.49 | 0.18 | 94.74 | 1.87 | 1.82 | 1.71 | 1.80 | -0.70 | 45.42 | 0.48 | 0.36 | 0.35 | 0.40 | 0.01 | 7.67 |
| $W_2$ | $Sq_1$ | 0.40 | 0.39 | 0.36 | 0.38 | 0.10 | 51.32 | 2.00 | 1.73 | 1.65 | 1.79 | -0.71 | 45.62 | 0.57 | 0.41 | 0.33 | 0.44 | 0.01 | 18.52 |
| | $Sq_2$ | 0.41 | 0.41 | 0.41 | 0.41 | 0.12 | 61.84 | 2.00 | 1.80 | 1.78 | 1.86 | -0.68 | 43.60 | 0.55 | 0.50 | 0.43 | 0.49 | 0.02 | 33.90 |
| | $Sq_3$ | 0.48 | 0.41 | 0.39 | 0.43 | 0.13 | 68.42 | 2.18 | 2.05 | 1.78 | 2.00 | -0.61 | 39.25 | 0.57 | 0.46 | 0.44 | 0.49 | 0.02 | 33.00 |
| | $Sq_4$ | 0.56 | 0.43 | 0.43 | 0.47 | 0.17 | 86.84 | 2.65 | 2.46 | 2.33 | 2.48 | -0.38 | 24.80 | 0.69 | 0.57 | 0.39 | 0.55 | 0.03 | 49.29 |
| $W_3$ | $Sq_1$ | 0.46 | 0.46 | 0.46 | 0.46 | 0.16 | 81.58 | 1.70 | 1.68 | 1.68 | 1.69 | -0.76 | 48.86 | 0.50 | 0.50 | 0.44 | 0.48 | 0.02 | 30.29 |
| | $Sq_2$ | 0.56 | 0.54 | 0.44 | 0.51 | 0.20 | 102.63 | 2.23 | 2.23 | 2.08 | 2.18 | -0.53 | 33.90 | 0.57 | 0.48 | 0.48 | 0.51 | 0.03 | 38.43 |
| | $Sq_3$ | 0.60 | 0.56 | 0.41 | 0.52 | 0.20 | 106.58 | 2.60 | 2.18 | 1.89 | 2.22 | -0.51 | 32.58 | 0.62 | 0.48 | 0.48 | 0.53 | 0.03 | 42.95 |
| | $Sq_4$ | 0.62 | 0.56 | 0.48 | 0.55 | 0.23 | 118.42 | 2.75 | 2.33 | 1.93 | 2.34 | -0.45 | 29.15 | 0.88 | 0.57 | 0.50 | 0.65 | 0.05 | 76.43 |
| $W_4$ | $Sq_1$ | 0.65 | 0.60 | 0.54 | 0.60 | 0.26 | 135.53 | 2.45 | 2.23 | 2.23 | 2.30 | -0.47 | 30.16 | 0.75 | 0.57 | 0.46 | 0.59 | 0.04 | 61.05 |
| | $Sq_2$ | 0.71 | 0.66 | 0.57 | 0.65 | 0.30 | 155.26 | 3.00 | 3.00 | 3.00 | 3.00 | -0.14 | 9.03 | 0.70 | 0.56 | 0.54 | 0.60 | 0.04 | 62.86 |
| | $Sq_3$ | 0.79 | 0.79 | 0.79 | 0.79 | 0.40 | 211.84 | 3.72 | 2.85 | 2.70 | 3.09 | -0.10 | 6.30 | 0.75 | 0.69 | 0.57 | 0.67 | 0.06 | 81.86 |
| | $Sq_4$ | 0.81 | 0.79 | 0.79 | 0.80 | 0.41 | 214.47 | 3.78 | 3.00 | 3.00 | 3.26 | -0.02 | 1.15 | 0.88 | 0.69 | 0.69 | 0.75 | 0.07 | 104.5 |
| Mean | $Sq_1$ | 0.47 | 0.44 | 0.42 | 0.44 | 0.14 | 73.68 | 1.92 | 1.79 | 1.77 | 1.83 | -0.69 | 44.53 | 0.54 | 0.45 | 0.38 | 0.46 | 0.02 | 24.18 |
| | $Sq_2$ | 0.54 | 0.49 | 0.44 | 0.49 | 0.17 | 91.78 | 2.25 | 2.17 | 2.12 | 2.18 | -0.53 | 34.00 | 0.55 | 0.47 | 0.44 | 0.48 | 0.02 | 31.42 |
| | $Sq_3$ | 0.59 | 0.54 | 0.50 | 0.54 | 0.22 | 113.82 | 2.61 | 2.24 | 1.99 | 2.28 | -0.48 | 30.92 | 0.59 | 0.48 | 0.45 | 0.51 | 0.03 | 37.30 |
| | $Sq_4$ | 0.64 | 0.56 | 0.54 | 0.58 | 0.24 | 128.62 | 2.76 | 2.40 | 2.24 | 2.47 | -0.39 | 25.13 | 0.73 | 0.55 | 0.48 | 0.59 | 0.04 | 59.46 |

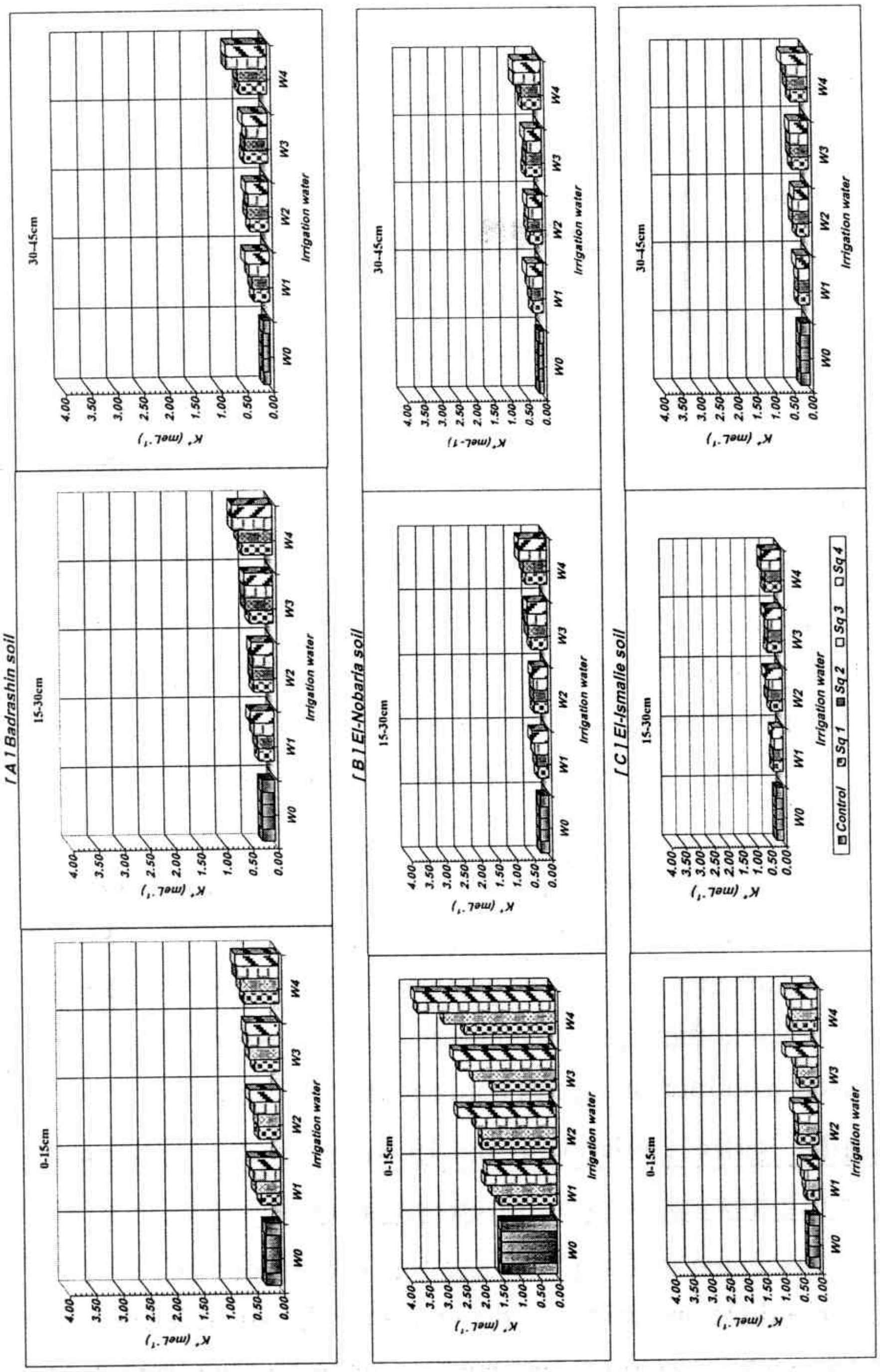


Fig. ( 9 ) : Effect of irrigation water quality and elution sequence on redistribution of soluble potassium ($meL^{-1}$) in saturation paste extract of soils columns.

Unlike the effect of the different used elution sequences and water qualities on soluble $K^+$ in the clayey soil, intermittent leaching of the sandy clay loam was associated with decrease in soil content of soluble $K^+$ regardless of quality of the used water. However, the used elution sequences can be arranged according to their efficiencies in this concern as follows: $Sq_1 > Sq_2 > Sq_3 > Sq_4$. Intermittent leaching of the sandy soil using the different water qualities except for ($W_1$) in the different elution sequences resulted in accumulation of soluble $K^+$ followed the order $Sq_4 > Sq_3 > Sq_2 > Sq_1$. When El Bostan drain water ($W_1$) was used in the different sequences with the tap water ($W_0$), all the elution sequences resulted in reduction in soil content of soluble $K^+$ expect for $Sq_4$.

As a general conclusion of this part of study it could be depthwise distribution of ***Ca, Mg, Na*** and ***K*** reveals that these cations were found to be generally highest in the surface layer of all the investigated soils, however, concentrations of those elements differed with depth depending on quality of the water, type of the soil, and type of the cation itself.

Also it could be concluded that the soluble cations in the different segments of the studied soils in the following order Na > Ca > Mg > K . This cations concentration order agrees well with that of ***Somaya et al, (1993)***, who added that the concentration of most cations and anions in soils increased with increasing salt concentration in irrigation water.

## 4.2. Soluble salts redistribution in soils under intermittent leaching using normal and magnetized waters:

Data presented in Table (13) and Fig. (10) reveal values of EC in ($dSm^{-1}$) in the different depths of the studies soils due to leaching them with saline and magnetized saline waters. It could be seen from the table that using El Bostan drain water ($W_1$) resulted in decreases in EC values of all the investigated soils, however the rate of change (RC) was highest in the sandy clay loam soil and lowest in the clayey one and came in between in the sandy soil. Magnetizing this type of water ($W_1$) caused rate of change to be more obvious in all the investigated soils where it increased from 14.49, 70.00 and 65.91 % to 21.74, 79.24 and 74.47 % in the clayey, sandy clay loam and the sandy soils, respectively.

Using Seedy Ghazy drain water ($W_2$) for intermittent leaching of the soils was of positive effect on removal of soluble salts from both the sandy clay loam and sandy soils whereas on contrary it caused soluble salts to accumulate in the clayey soil. However rate of change in EC value was slightly higher in the sandy clay loam soil than the sandy one. The accumulation of soluble salts in the clayey soil might be attributed to its high retentively of water and consequently soluble salts. Similar results were attained by ***Alawi et al, (1980)*** who found that irrigation of clay soil with saline waters led to a marked accumulation of total soluble salts. ***Abd-Allah (1988)*** and ***Mostafa et al, (1992)*** went almost to similar results.

Magnetizing Seedy Ghazy drain water caused its removal effect on soluble salts of the sandy clay loam and sandy soils to increase where rate of change in EC values of these soils increased from 62.52 and 60.61 % to 74.70 and 71.59 %, respectively. Moreover, the magnetization of ($W_2$) water and its usage in intermittent leaching resulted in reduction in EC value of the clayey soil i.e. it resulted in removal of soluble salts instead of increasing it upon utilization of the same type of water ($W_2$) but without being magnetized. Such a finding reveals that application of magnetic technology in treating saline water may improve its effect on leaching soluble salts of the salt affected soils. However, it could be said that the effect seemed to be more pronounced in the light textured soils than heavy textured ones.

The effect of using water of El Hedaya irrigation canal ($W_3$) for intermittent leaching of the investigated soils seemed somewhat like that of Seedy Ghazy drain water ($W_2$) i.e. it caused reduction in EC value of both the sandy clay loam and sandy soils whereas the reverse was true in the clayey soil. Using such a water ($W_3$) after being magnetized increased rate of reduction in EC value (RC) of the sandy clay loam and sandy soils from (39.09 and 51.89 %) to (62.64 and 63.64 %), respectively. The magnetization of ($W_3$) water and using it in intermittent leaching although did not cause removal of soluble salts of the clayey soil, yet it led to less accumulation of soluble salts within layers of this soil where the average rate of accumulation of soluble salts expressed as EC value was reduced from (36.96 %) to only (10.29%). Once again, the aforementioned results impose the beneficial effect of magnetization of water on its efficiency in leaching soluble salts out of soils.

Haris drain water ($W_4$) seemed to be of the least effect on leaching soluble salts out of the sandy soil (rate of change was 13.64 %). This type of water ($W_4$) on the other hand caused soluble salts to accumulate in both the sandy clay loam and clayey soils. The high soluble salt content of this type of water besides the relatively higher retentively of water by the sandy clay loam soil and the high water retentively by the clayey soil account for such a finding under condition of intermittent leaching of these soils.

Magnetizing Haris drain water ($W_4$) seemed to reduce rate of accumulation of soluble salts in the clayey soil from 234.06 to 142.75. Moreover, it caused reduction in soluble salt content of the sandy clay loam averaged (33.70 %) and increased reductively of EC value in the sandy soil from 13.64 to 37.88 %.

Depthwise distribution of EC values indicates that these value were highest generally, in the surface layer (0-15 cm) and tended to be lower in the layer below though a very slight difference could be observed between EC values of the subsurface layer (15-30 cm) and the deepest one. This pattern of soluble salt distribution characterized all the investigated soils under leaching with the different used water qualities whether they were unmagnetized or after they have been magnetized.

The results obtained herein agree with that of ***Hilal and Hilal (2000)*** who found that sandy loam soil pots irrigated with highly saline water continued to retains salts with much greater rate as compared to pots irrigated magnetized saline water. They added that moisture loss by evaporation was lower with magnetized water. According to ***Tkatchenko (1997)***, magnetic field causes the hydration of salt ions and others impurities to slide down and cause better salt solubility, Kinetic changes of salt crystallization and accelerated coagulation.

**4.2.1.Soluble anions:**

4: ***Soluble bicarbonate ($HCO_3^-$):***

It seems from data presented in Table (14) and Fig. (11) that using El Bostan drain water ($W_1$) for intermittent leaching of the clayey and sandy loam clay soils generally reduced their contents of soluble $HCO_3^-$, however, rate of change seemed higher in the clayey soil than the sandy clay loam one. The effect of ($W_1$) water on the $HCO_3^-$ content of the sandy soil seemed contradictory to that achieved in the other two ones i.e. it caused soluble $HCO_3^-$ content to in increase at a rate of 74.25 %.

Magnetization of El Bostan drain water improved its effect on leaching soluble $HCO_3^-$ out of both the clayey and sandy clay loam soil, where the rates of change in these soils increased from 17.57 and 13.51 % to 20.28 and 25.57 %, respectively. This means that the magnetized water was of more noticeable effect on leaching $HCO_3^-$ out of the clayey loam soil than the clayey one.

***Tkatchenko (1997)*** and ***Hilal and Hilal (2000)*** reported similar results where they concluded that magnetized water was of pronounced higher ability on removing $HCO_3^-$ than normal water.

The effect of ($W_1$) water on accumulation of soluble $HCO_3^-$ in the sandy soil was reduced due to magnetizing this water where rate of accumulation of soluble $HCO_3^-$ was reduced from 74.25 to 23.93%.

Usage of Seedy Ghazy drain water ($W_2$) for intermittent leaching of the studied soils resulted in general decrease in $HCO_3^-$ content of the sandy clay loam only with a rate of change about 6.22%. On other hand, such a water caused $HCO_3^-$ ions to accumulate in both the clayey and sandy soils, yet rate of accumulation was higher in the sandy soil than in the clayey one.

Magnetizing Seedy Ghazy drain water ($W_2$) although adversed its effect on soluble $HCO_3^-$ content of the clayey soil i.e. decreased its content of $HCO_3^-$ by about 15.68%, yet it only reduced accumulation of soluble $HCO_3^-$ content of the sandy soil from 75.11 to 47.38 %. The reducing effect of the magnetized water on soluble $HCO_3^-$ content of the sandy clay loam soil increased from an average of 6.22 to 23.84 %.

The effect of intermittent leaching of the studied soils using water of El Hedaya irrigation canal ($W_3$) seemed to be similar to that of Seedy Ghazy drain water but values of rate of change in soils content of soluble $HCO_3^-$ varied from those previously attained. Also, magnetizing this water resulted decrease in soluble $HCO_3^-$ contents of both the clayey and the sandy clay loam soils but only reduced magnitude of accumulation of soluble $HCO_3^-$ in the sandy soil.

Haris drain water ($W_4$) was of reducible effect on $HCO_3^-$ content of the clayey soil only, however, magnetizing this water caused it to reduce soluble $HCO_3^-$ content of the sandy clay loam and also to reduce rate of accumulation of soluble $HCO_3^-$ in the sandy soil from 59.02 to 48.75 %.

The aforementioned finding might be attributed to that, the high salinity level of soil solution inhibits the dissolution of nonsoluble carbonate composition soil ***(Mostafa et al, 1992).***

Distribution of soluble $HCO_3^-$ showed patterns differed from a soil to another.

In the clayey soil, the $HCO_3^-$ content was generally highest in the subsurface layer. This was true upon usage of all the investigated water qualities except for that of Haris drain were intermittent leaching of the clayey soil using this water caused $HCO_3^-$ content to be highest in the subsurface layer and tended to decrease depthwise. This occurred whether the used waters were magnetized or not.

In the sandy clay loam $HCO_3^-$ was highest in the surface layer followed by the deepest one. This occurred generally, regardless of quality of the used water. Magnetization of the water used for leaching seemed to be of no effect on changing pattern of $HCO_3^-$ distribution within the different depths of the sandy clay loam soil.

Pattern of distribution of $HCO_3^-$ within the different depths of the sandy soil leached with the non-magnetized water qualities differed completely from that attained upon leaching this soil with the types of waters after being magnetized. The non-magnetized waters resulted in a pattern characterized by presence of $HCO_3^-$ in highest concentration in the surface layer (0-15 cm) whereas the magnetized waters resulted in a $HCO_3^-$ depthwise distribution pattern characterized by presence of $HCO_3^-$ in a highest concentration in the deepest layer (30-45 cm). This phenomenon might be due to the dipole magnetic unit used for magnetizing the used waters achieves its maximum magnetic effect for

*Table (14) : Soluble bicarbonate (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water .*

| Soil type | Depth (cm) | Irrigation water W1 | W2 | W3 | W4 | L .S .D at 0.05 level | |
|---|---|---|---|---|---|---|---|
| Clayey | | Magnetized irrigation water | | | | | |
| | 0-15 | 2.08 | 2.43 | 2.51 | 2.08 | Treat. : | *N.S |
| | 15-30 | 2.60 | 2.78 | 2.78 | 1.82 | Depth : | *N.S |
| | 30-45 | 2.08 | 1.94 | 2.22 | 2.08 | Water : | 0.19 |
| | Average | 2.25 | 2.38 | 2.50 | 1.99 | Treat.*Depth : | *N.S |
| | $\triangle HCO_3^-$ | -0.43 | -0.33 | -0.24 | -0.63 | Treat.*Water : | 0.27 |
| | %RC** | 20.28 | 15.68 | 11.44 | 29.48 | Depth*Water : | 0.33 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.47 |
| | 0-15 | 2.41 | 3.05 | 3.05 | 2.22 | | |
| | 15-30 | 2.50 | 3.24 | 3.98 | 1.94 | | |
| | 30-45 | 2.08 | 2.69 | 2.87 | 2.20 | | |
| | Average | 2.33 | 2.99 | 3.30 | 2.12 | | |
| | $\triangle HCO_3^-$ | -0.37 | 0.13 | 0.36 | -0.53 | | |
| | %RC** | 17.57 | 5.90 | 16.75 | 25.00 | | |
| Sandy clay loam (calcareous) | | Magnetized irrigation water | | | | | |
| | 0-15 | 3.68 | 3.61 | 3.89 | 4.16 | Treat. : | 0.10 |
| | 15-30 | 3.12 | 3.33 | 3.38 | 3.61 | Depth : | 0.12 |
| | 30-45 | 3.51 | 3.61 | 3.61 | 4.16 | Water : | 0.16 |
| | Average | 3.44 | 3.52 | 3.63 | 3.98 | Treat.*Depth : | *N.S |
| | $\triangle HCO_3^-$ | -0.55 | -0.52 | -0.47 | -0.30 | Treat.*Water : | 0.22 |
| | %RC** | 25.57 | 23.83 | 21.45 | 13.87 | Depth*Water : | 0.27 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.39 |
| | 0-15 | 4.44 | 4.68 | 4.59 | 5.25 | | |
| | 15-30 | 3.38 | 3.89 | 3.89 | 4.16 | | |
| | 30-45 | 4.16 | 4.42 | 4.68 | 4.44 | | |
| | Average | 3.99 | 4.33 | 4.39 | 4.62 | | |
| | $\triangle HCO_3^-$ | -0.29 | -0.13 | -0.11 | 0.00 | | |
| | %RC** | 13.51 | 6.22 | 4.99 | 0.00 | | |
| Sandy | | Magnetized irrigation water | | | | | |
| | 0-15 | 2.12 | 2.50 | 2.86 | 2.78 | Treat. : | 0.13 |
| | 15-30 | 2.52 | 2.78 | 2.95 | 2.86 | Depth : | *N.S |
| | 30-45 | 2.60 | 3.33 | 3.33 | 3.05 | Water : | 0.21 |
| | Average | 2.41 | 2.87 | 3.05 | 2.90 | Treat.*Depth : | 0.23 |
| | $\triangle HCO_3^-$ | 0.09 | 0.18 | 0.21 | 0.18 | Treat.*Water : | 0.30 |
| | %RC** | 23.93 | 47.38 | 56.45 | 48.75 | Depth*Water : | 0.37 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.52 |
| | 0-15 | 4.35 | 3.61 | 4.68 | 3.38 | | |
| | 15-30 | 3.05 | 3.33 | 4.42 | 3.05 | | |
| | 30-45 | 2.78 | 3.29 | 3.90 | 2.86 | | |
| | Average | 3.39 | 3.41 | 4.33 | 3.10 | | |
| | $\triangle HCO_3^-$ | 0.27 | 0.28 | 0.45 | 0.22 | | |
| | %RC** | 74.25 | 75.11 | 122.52 | 59.02 | | |

** N.S.= not significant.*
***RC= rate of change.*

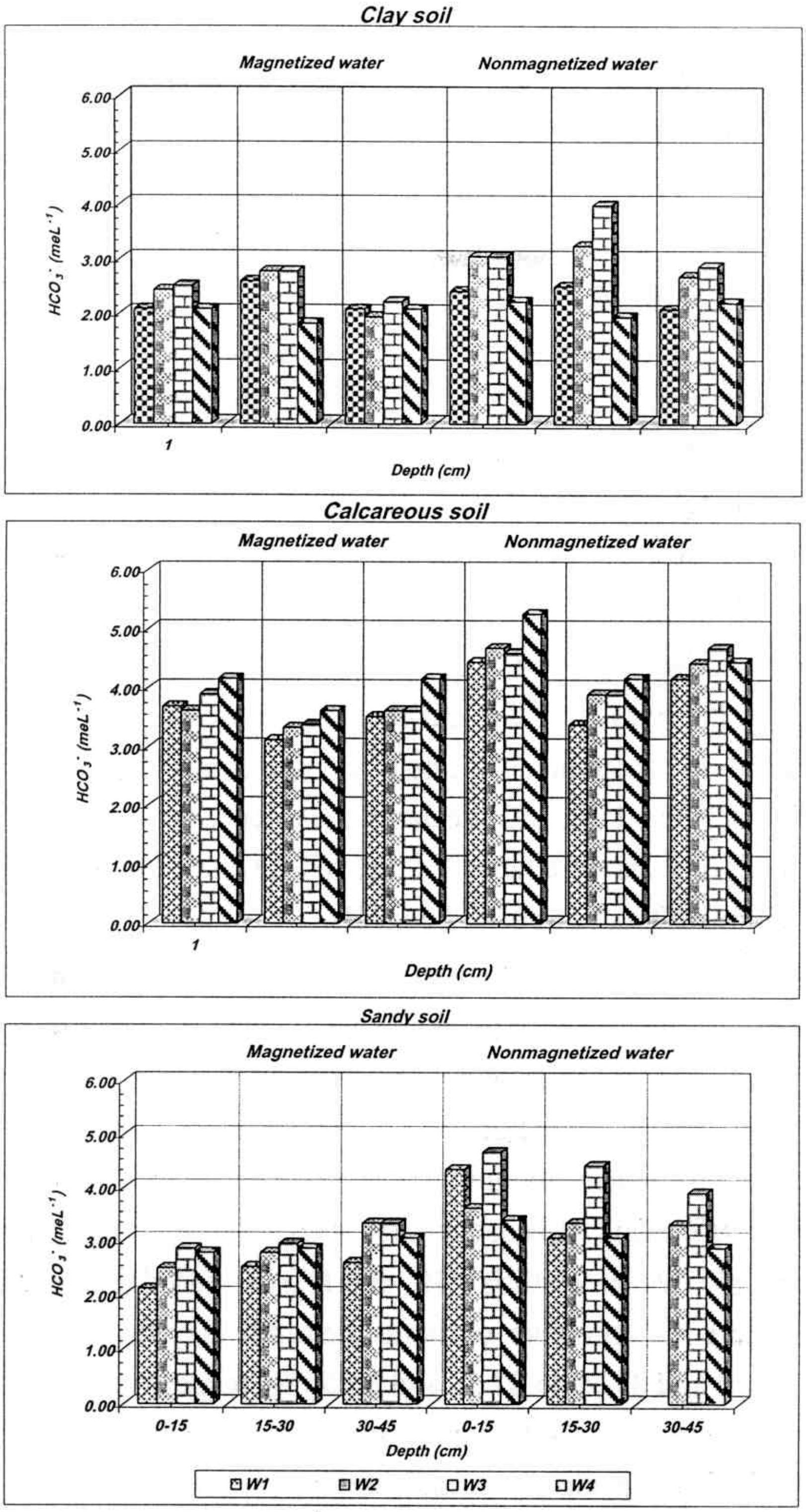


***Fig. (11) : Soluble bicarbonate (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water.***

hydro carbonate *$HCO_3^-$* water *(Tkatchenko, 1997)*. Thus, *$HCO_3^-$* became more easily to be moved down and hence, tended to accumulate downwards upon using the magnetized waters for leaching the investigated soil.

***B: Soluble chloride ($Cl^-$):***

Usage of El Bostan drain water ($W_1$) or Seedy Ghazy drain water ($W_2$) for intermittent leaching of the studied soils whether without magnetization or after being magnetized generally reduced soils content of $Cl^-$ ions. ***Tkatchenko (1997)*** found that magnetized water removed 50% to 80% of soil $Cl^-$ compared to a removal of only 30% by normal water.

One exception was observed when the non-magnetized Seedy Ghazy drain water was used for leaching the clayey soil where soluble $Cl^-$ ions tended to accumulate at rate of change of about 18.86 %. The data in Table (15) and Fig. (12) declared the effect of magnetization of water on increasing its efficiency of the used waters ($W_1$ and $W_2$) on removal of soluble $Cl^-$ out of all studied soils.

Intermittent leaching of both the sandy clay loam and sandy soils using water of either El Hedaya irrigation canal ($W_3$) or Haris drain ($W_4$) resulted in reduction in soils content of soluble $Cl^-$. On the other hand, such waters led to accumulation of soluble $Cl^-$ in the clayey soil with rate of change far higher upon utilization of ($W_4$) than ($W_3$). The higher $Cl^-$ content of ($W_4$) than ($W_3$) accounts for such a finding. Magnetization of the previously water qualities ($W_3$ and $W_4$) increased their reducing effect on soluble $Cl^-$ contents of both the sandy clay loam and sandy soils from 75.70 and 83.99 to 87.51 and 84.57 %, respectively in case of ($W_3$) corresponding to reduction percentage from 8.12 and 16.80 to 61.40 and 44.76 %, respectively in case of ($W_4$).

*Table (15) : Soluble chloride (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water.*

| Soil type | Depth (cm) | Irrigation water $W_1$ | $W_2$ | $W_3$ | $W_4$ | L.S.D at 0.05 level | |
|---|---|---|---|---|---|---|---|
| Clayey | | Magnetized irrigation water | | | | | |
| | 0-15 | 3.76 | 6.93 | 8.15 | 41.88 | Treat. : | 1.65 |
| | 15-30 | 2.82 | 4.70 | 6.27 | 25.07 | Depth : | 2.02 |
| | 30-45 | 3.45 | 5.64 | 6.89 | 31.02 | Water : | 2.61 |
| | Average | 3.34 | 5.76 | 7.10 | 32.66 | Treat.*Depth : | 2.86 |
| | $\Delta Cl^-$. | -3.07 | -1.26 | -0.25 | 18.91 | Treat.*Water : | 3.69 |
| | %RC** | 55.06 | 22.63 | 4.53 | 338.93 | Depth*Water : | 4.52 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 6.39 |
| | 0-15 | 7.92 | 11.51 | 14.73 | 71.60 | | |
| | 15-30 | 3.10 | 7.51 | 8.68 | 38.06 | | |
| | 30-45 | 3.68 | 7.51 | 7.13 | 42.61 | | |
| | Average | 4.90 | 8.84 | 10.18 | 50.76 | | |
| | $\Delta Cl^-$. | -1.91 | 1.05 | 2.06 | 32.49 | | |
| | %RC** | 34.14 | 18.86 | 36.83 | 582.21 | | |
| Sandy clay loam (calcareous) | | Magnetized irrigation water | | | | | |
| | 0-15 | 4.07 | 8.15 | 14.10 | 41.36 | Treat. : | 0.90 |
| | 15-30 | 3.29 | 5.95 | 6.27 | 20.37 | Depth : | 1.10 |
| | 30-45 | 3.76 | 8.20 | 7.52 | 24.44 | Water : | 1.42 |
| | Average | 3.71 | 7.43 | 9.30 | 28.72 | Treat.*Depth : | 1.56 |
| | $\Delta Cl^-$. | -33.23 | -31.48 | -30.60 | -21.47 | Treat.*Water : | 2.01 |
| | %RC** | 95.02 | 90.01 | 87.51 | 61.40 | Depth*Water : | 2.47 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 3.49 |
| | 0-15 | 13.43 | 21.64 | 30.06 | 108.79 | | |
| | 15-30 | 4.57 | 6.14 | 11.11 | 40.25 | | |
| | 30-45 | 6.71 | 9.50 | 13.07 | 56.05 | | |
| | Average | 8.24 | 12.43 | 18.08 | 68.36 | | |
| | $\Delta Cl^-$. | -31.10 | -29.13 | -26.47 | -2.84 | | |
| | %RC** | 88.93 | 83.30 | 75.70 | 8.12 | | |
| Sandy | | Magnetized irrigation water | | | | | |
| | 0-15 | 2.82 | 3.45 | 5.17 | 15.67 | Treat. : | 0.38 |
| | 15-30 | 2.19 | 2.19 | 2.82 | 10.97 | Depth : | 0.47 |
| | 30-45 | 1.88 | 1.88 | 2.34 | 10.34 | Water : | 0.60 |
| | Average | 2.30 | 2.51 | 3.44 | 12.33 | Treat.*Depth : | 0.66 |
| | $\Delta Cl^-$. | -3.80 | -3.76 | -3.59 | -1.90 | Treat.*Water : | 0.85 |
| | %RC** | 89.71 | 88.77 | 84.57 | 44.76 | Depth*Water : | 1.04 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 1.48 |
| | 0-15 | 3.51 | 4.21 | 4.70 | 24.88 | | |
| | 15-30 | 2.29 | 2.94 | 3.01 | 14.70 | | |
| | 30-45 | 3.10 | 2.94 | 3.01 | 16.12 | | |
| | Average | 2.97 | 3.36 | 3.57 | 18.57 | | |
| | $\Delta Cl^-$. | -3.68 | -3.60 | -3.56 | -0.71 | | |
| | %RC** | 86.71 | 84.93 | 83.99 | 16.80 | | |

** N.S.= not significant.*
***RC= rate of change.*

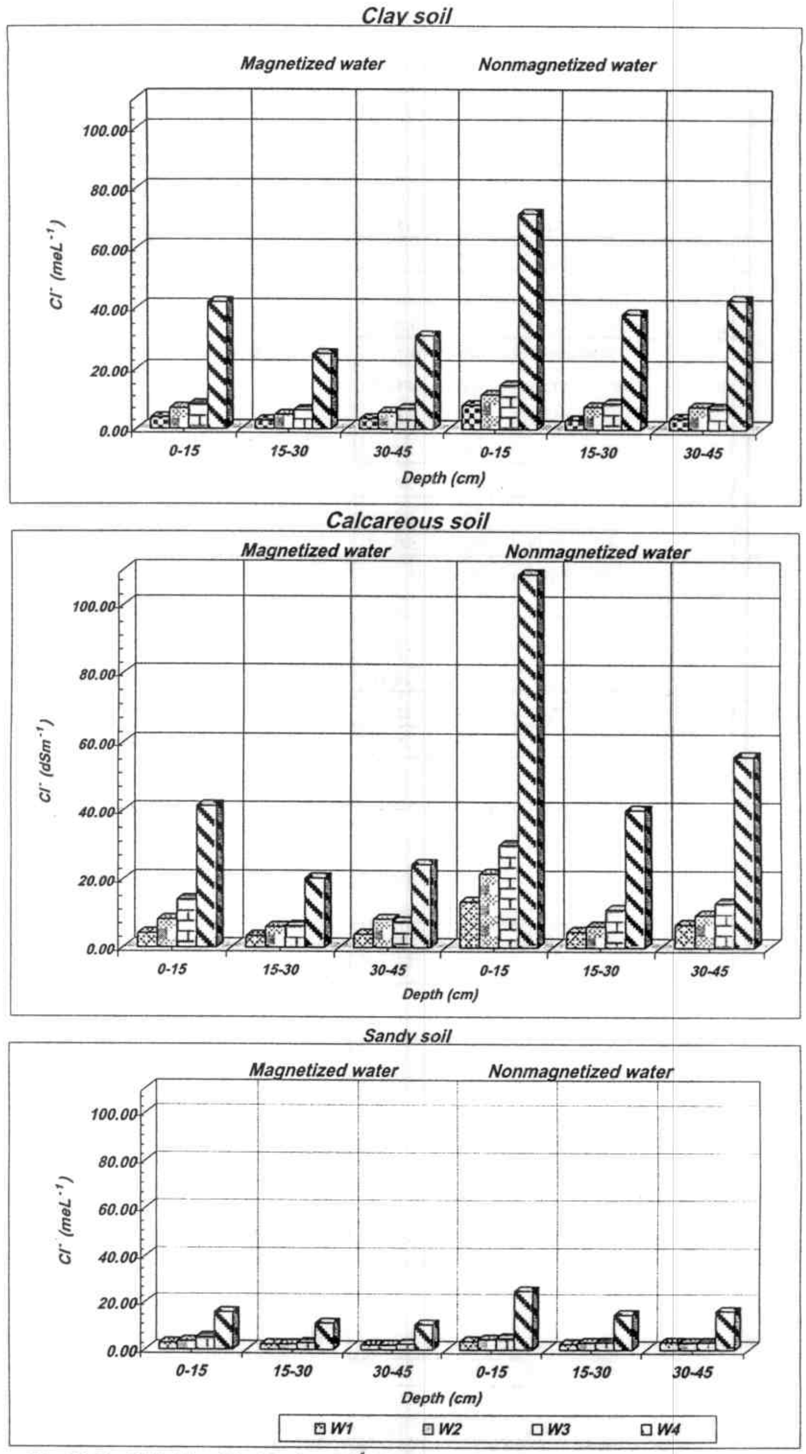


***Fig. (12) : Soluble chloride (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water .***

Concentration was highest in the surface layers (0-15 cm) of all the investigated soils, lowest in the subsurface layer (15-30 cm) and came in between in the deepest one (30-45 cm). No certain effect for magnetizing the water or the type of the used water could be observed on redistribution of the soluble **$Cl^-$** within the different soil depths.

***C: Soluble sulphate ($SO_4^{2-}$):***

Data in Table (16) and Fig. (13) illustrate that except for the clayey soils, intermittent leaching of the soils with the non-magnetized as well as the magnetized saline water ($W_1$ and $W_2$) resulted in partial removal of soils contents of soluble $SO_4^{2-}$. The magnitudes of removal and consequently the rate of reduction in soluble $SO_4^{2-}$ content were higher in case of the magnetized waters than in the case of the non-magnetized ones. ***Hilal and Hilal (2000)*** went almost to similar results and indicated that magnetized water has doubled the leaching of $SO_4^{2-}$.

Regarding the clayey soil, its leaching with El Bostan drain water ($W_1$) whether before magnetization or after being magnetized resulted in reduction in its soluble $SO_4^{2-}$ content yet rate of reduction increased upon utilization of the magnetized water from 0.30 to 9.85 %. Leaching of this clay soil with the non-magnetized water of Seedy Ghazy drain water ($W_2$) caused its content of soluble $SO_4^{2-}$ to increase by 27.21 %. However, magnetization of such water caused its original soluble $SO_4^-$ content to increase to 11.22 % only.

The intermittent leaching of the investigated soils by usage of water of either El Hedaya irrigation canal ($W_3$), or Haris drain ($W_4$) exerted effect on soluble $SO_4^{2-}$ content of the investigated soils similar to those shown upon utilization of Seedy Ghazy drain water ($W_2$) expect for the sandy clay loam soil when it was leached with El Hedaya drain water ($W_3$) after being magnetized where such a water caused the original soluble $SO_4^{2-}$ content to increase by 3.71%. However it showed

*Table (16) : Soluble sulphate (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water.*

| Soil type | Depth (cm) | Irrigation water $W_1$ | $W_2$ | $W_3$ | $W_4$ | L.S.D at 0.05 level | |
|---|---|---|---|---|---|---|---|
| *Clayey* | | Magnetized irrigation water | | | | | |
| | 0-15 | 13.76 | 17.54 | 19.72 | 29.01 | *Treat. :* | 0.98 |
| | 15-30 | 11.50 | 13.39 | 15.00 | 27.87 | *Depth :* | 1.20 |
| | 30-45 | 10.98 | 13.78 | 13.96 | 19.14 | *Water :* | 1.55 |
| | Average | 12.08 | 14.90 | 16.23 | 25.34 | *Treat.*Depth :* | 1.70 |
| | $\Delta$ $SO_4^{2-}$ | -0.99 | 1.13 | 2.12 | 8.96 | *Treat.*Water :* | 2.19 |
| | %RC** | 9.85 | 11.22 | 21.09 | 89.10 | *Depth*Water :* | 2.68 |
| | | Nonmagnetized irrigation water | | | | *Treat.*Depth*Water :* | 3.80 |
| | 0-15 | 15.65 | 22.37 | 24.51 | 45.46 | | |
| | 15-30 | 12.07 | 16.63 | 17.40 | 42.74 | | |
| | 30-45 | 12.36 | 12.14 | 15.76 | 25.51 | | |
| | Average | 13.36 | 17.05 | 19.22 | 37.90 | | |
| | $\Delta$ $SO_4^{2-}$ | -0.03 | 2.74 | 4.37 | 18.38 | | |
| | %RC** | 0.30 | 27.21 | 43.46 | 182.86 | | |
| *Sandy clay loam (calcareous)* | | Magnetized irrigation water | | | | | |
| | 0-15 | 19.13 | 22.06 | 32.53 | 61.58 | *Treat. :* | 1.51 |
| | 15-30 | 14.97 | 16.31 | 30.81 | 45.12 | *Depth :* | 1.85 |
| | 30-45 | 14.66 | 17.28 | 29.95 | 43.77 | *Water :* | 2.38 |
| | Average | 16.25 | 18.55 | 31.10 | 50.16 | *Treat.*Depth :* | 2.61 |
| | $\Delta$ $SO_4^{2-}$ | -15.09 | -14.01 | -8.11 | 0.84 | *Treat.*Water :* | 3.37 |
| | %RC** | 66.39 | 61.64 | 35.70 | 3.71 | *Depth*Water :* | 4.13 |
| | | Nonmagnetized irrigation water | | | | *Treat.*Depth*Water :* | 5.84 |
| | 0-15 | 33.57 | 41.45 | 71.91 | 78.92 | | |
| | 15-30 | 17.28 | 24.70 | 44.18 | 71.15 | | |
| | 30-45 | 17.84 | 21.93 | 50.15 | 54.76 | | |
| | Average | 22.90 | 29.36 | 55.41 | 68.28 | | |
| | $\Delta$ $SO_4^{2-}$ | -11.97 | -8.93 | 3.31 | 9.36 | | |
| | %RC** | 52.66 | 39.29 | 14.58 | 41.18 | | |
| *Sandy* | | Magnetized irrigation water | | | | | |
| | 0-15 | 8.82 | 10.89 | 16.37 | 22.06 | *Treat. :* | 0.46 |
| | 15-30 | 5.88 | 7.04 | 8.95 | 13.72 | *Depth :* | 0.56 |
| | 30-45 | 5.90 | 6.84 | 7.31 | 7.16 | *Water :* | 0.72 |
| | Average | 6.87 | 8.26 | 10.88 | 14.31 | *Treat.*Depth :* | 0.79 |
| | $\Delta$ $SO_4^{2-}$ | -2.56 | -2.29 | -1.79 | -1.14 | *Treat.*Water :* | 1.02 |
| | %RC** | 66.20 | 59.36 | 46.46 | 29.55 | *Depth*Water :* | 1.25 |
| | | Nonmagnetized irrigation water | | | | *Treat.*Depth*Water :* | 1.77 |
| | 0-15 | 12.90 | 17.48 | 20.70 | 27.73 | | |
| | 15-30 | 7.84 | 10.47 | 11.20 | 17.84 | | |
| | 30-45 | 7.48 | 8.48 | 11.17 | 13.10 | | |
| | Average | 9.41 | 12.14 | 14.36 | 19.56 | | |
| | $\Delta$ $SO_4^{2-}$ | -2.07 | -1.55 | -1.13 | -0.14 | | |
| | %RC** | 53.70 | 40.23 | 29.33 | 3.74 | | |

***RC= rate of change.*

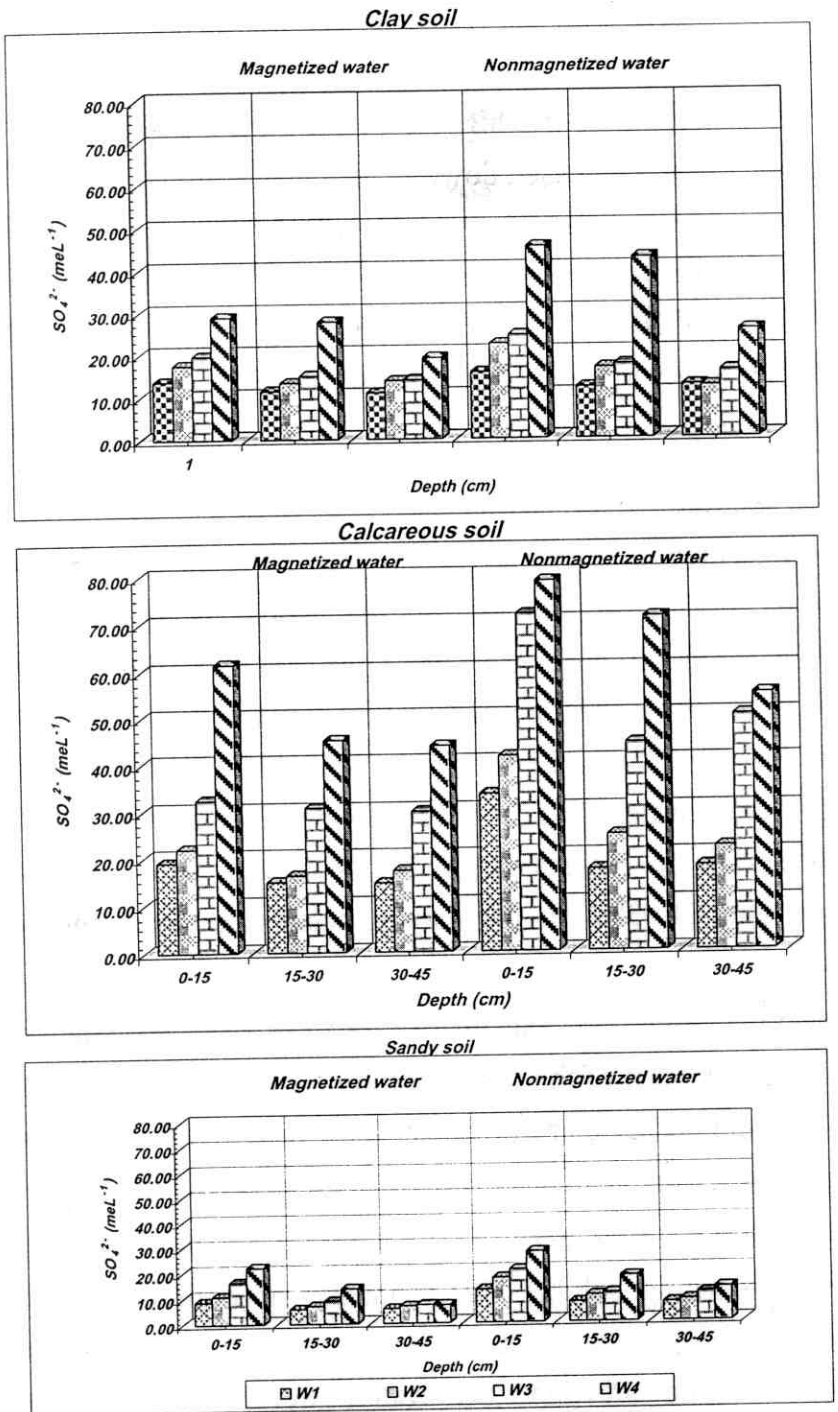


***Fig. (13) : Soluble sulphate (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water.***

by indicated that magnitudes and rates of change varied depending on type of the investigated soil.

$SO_4^{2-}$ ions landed to be highest in the surface layer of all the investigated soils and decreased downwards. Neither the magnetization of the used waters not their quality could portray any change on $SO_4^{2-}$ depthwise distribution pattern. However, accumulation of $SO_4^{2-}$ ions in the surface layer might be due the formation of relatively in soluble sulphate salts not easily to be leached downwards.

### <u>4.2.2. Soluble cations:</u>

#### *A: Soluble calcium ($Ca^{2+}$):*

Data presented in Table (17) and Fig. (14) shows that soluble calcium $Ca^{2+}$ content of all the studied soils decreased due to intermittent leaching of these soils using the saline water of El Bostan drain ($W_1$) or Seedy Ghazy drain ($W_2$) whether before magnetization of these waters or after these waters have been magnetized. Magnetization of El Bostan drain water ($W_1$) caused reduction in soluble $Ca^{2+}$ content of the studied soils to increase from (13.64, 75.32 and 70.94 %) to (24.95, 83.06 and 81.93%) in the clayey, sandy clay loam and sandy soils, respectively.

Magnetized water of Seedy Ghazy ($W_2$) drain reduced the original soluble contents of the clayey, sandy clay loam and sandy soils by (0.16, 64.32 and 68.76 %), respectively upon usage of this water after being magnetized for intermittent leaching of the studied soils.

The effect of intermittent leaching using water of El Hedaya canal ($W_3$) on reducing soluble $Ca^{2+}$ contents of both the sandy clay loam seemed identical to that achieved due to usage of Haris drain water ($W_4$). This was true whether the waters were used before being magnetized or after have been magnetized.

*Table (17) : Soluble calcium (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water .*

| Soil type | Depth (cm) | Irrigation water W1 | W2 | W3 | W4 | L.S.D at 0.05 level | |
|---|---|---|---|---|---|---|---|
| Clayey | | Magnetized irrigation water | | | | | |
| | 0-15 | 5.27 | 5.61 | 6.18 | 13.26 | Treat. : | 0.46 |
| | 15-30 | 4.59 | 5.15 | 5.44 | 10.30 | Depth : | 0.56 |
| | 30-45 | 4.34 | 5.15 | 5.44 | 9.50 | Water : | 0.73 |
| | Average | 4.73 | 5.30 | 5.69 | 11.02 | Treat.*Depth : | *N.S |
| | △ $Ca^{2+}$ | -1.18 | -0.75 | -0.47 | 3.54 | Treat.*Water : | 1.03 |
| | %RC** | 24.95 | 15.91 | 9.83 | 74.74 | Depth*Water : | 1.26 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 1.79 |
| | 0-15 | 6.55 | 7.72 | 9.79 | 21.36 | | |
| | 15-30 | 5.15 | 5.67 | 8.59 | 19.04 | | |
| | 30-45 | 4.64 | 5.50 | 6.36 | 14.79 | | |
| | Average | 5.45 | 6.30 | 8.25 | 18.40 | | |
| | △ $Ca^{2+}$ | -0.65 | -0.01 | 1.46 | 9.07 | | |
| | %RC** | 13.64 | 0.16 | 30.76 | 191.70 | | |
| Sandy clay loam (calcareous) | | Magnetized irrigation water | | | | | |
| | 0-15 | 6.29 | 7.21 | 11.40 | 22.12 | Treat. : | 0.59 |
| | 15-30 | 5.95 | 6.70 | 10.37 | 19.55 | Depth : | 0.72 |
| | 30-45 | 5.10 | 5.84 | 9.69 | 17.17 | Water : | 0.93 |
| | Average | 5.78 | 6.58 | 10.49 | 19.61 | Treat.*Depth : | 1.02 |
| | △ $Ca^{2+}$ | -13.32 | -12.95 | -11.11 | -6.82 | Treat.*Water : | 1.32 |
| | %RC** | 83.06 | 80.71 | 69.27 | 42.53 | Depth*Water : | 1.62 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 2.28 |
| | 0-15 | 11.34 | 18.50 | 25.24 | 31.42 | | |
| | 15-30 | 7.07 | 10.30 | 20.09 | 28.84 | | |
| | 30-45 | 6.86 | 7.73 | 16.48 | 23.46 | | |
| | Average | 8.42 | 12.18 | 20.60 | 27.91 | | |
| | △ $Ca^{2+}$ | -12.08 | -10.32 | -6.36 | -2.92 | | |
| | %RC** | 75.32 | 64.32 | 39.63 | 18.23 | | |
| Sandy | | Magnetized irrigation water | | | | | |
| | 0-15 | 3.61 | 3.74 | 5.49 | 7.40 | Treat. : | 0.24 |
| | 15-30 | 2.89 | 3.32 | 3.74 | 4.12 | Depth : | 0.30 |
| | 30-45 | 2.58 | 2.58 | 2.81 | 2.91 | Water : | 0.38 |
| | Average | 3.03 | 3.21 | 4.01 | 4.81 | Treat.*Depth : | *N.S |
| | △ $Ca^{2+}$ | -2.51 | -2.48 | -2.33 | -2.18 | Treat.*Water : | *N.S |
| | %RC** | 81.39 | 80.24 | 75.32 | 70.42 | Depth*Water : | 0.67 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.94 |
| | 0-15 | 5.76 | 6.53 | 8.33 | 9.18 | | |
| | 15-30 | 4.30 | 4.59 | 4.64 | 6.53 | | |
| | 30-45 | 4.12 | 4.12 | 4.09 | 5.76 | | |
| | Average | 4.73 | 5.08 | 5.69 | 7.16 | | |
| | △ $Ca^{2+}$ | -2.19 | -2.12 | -2.01 | -1.73 | | |
| | %RC** | 70.94 | 68.76 | 65.03 | 55.99 | | |

* N.S.= not significant.
**RC= rate of change.

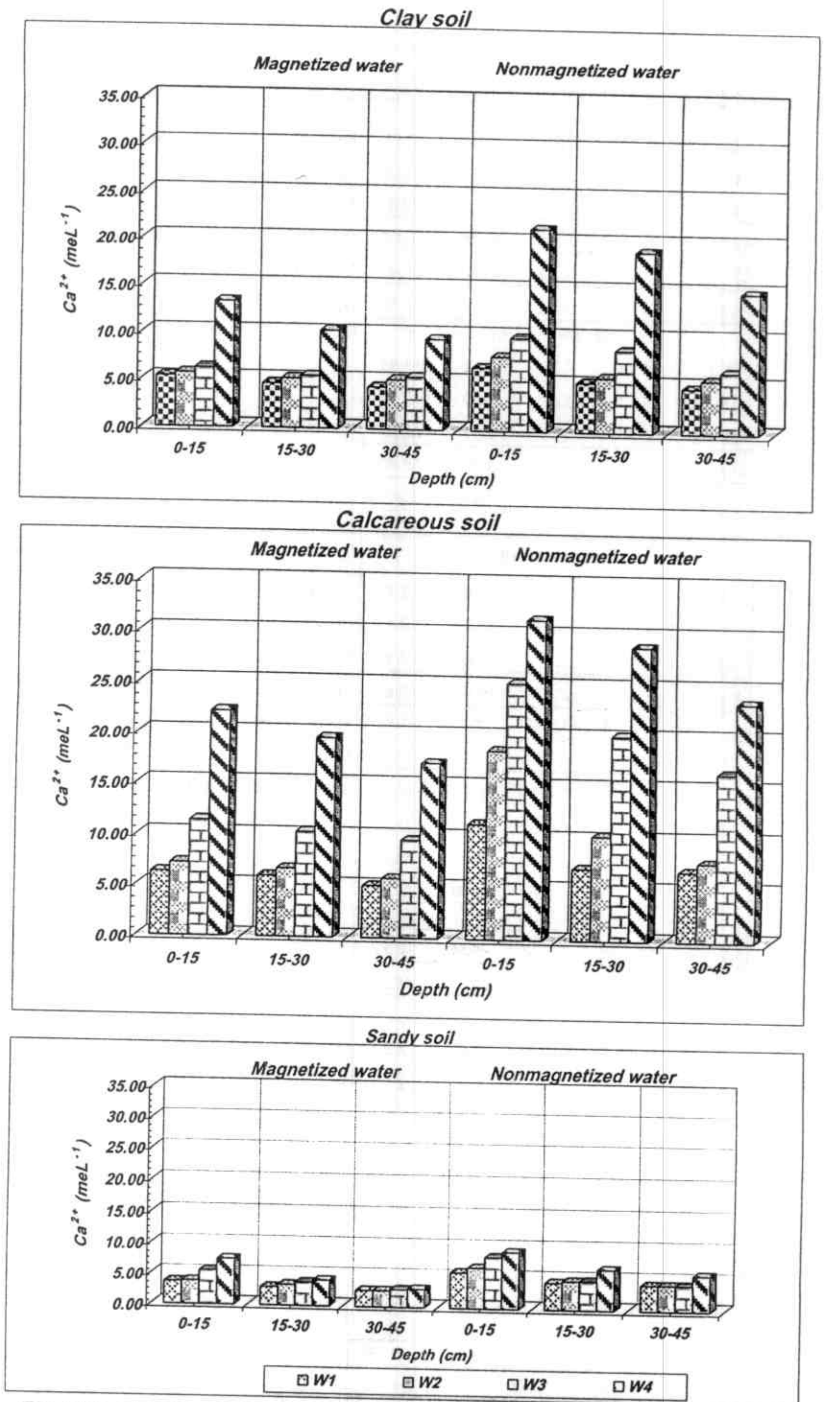


***Fig. (14) : Soluble calcium (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water .***

Application of non-magnetized water ($W_3$ and $W_4$) to the clayey soil resulted in increases in its original content of the soluble $Ca^{2+}$ estimated by (30.76 and 191.70 %), respectively. Intermittent leaching of El Hedaya canal water ($W_3$) after has being magnetized to the clayey soil, on the other hand, decreased its original content of soluble $Ca^{2+}$ be about 9.83 %. Magnetizing Haris drain water ($W_4$) reduced accumulation of soluble $Ca^{2+}$ in the clayey soil from (191.70 to 74.74 %). This means that magnetization of Haris drain water though was of a reducing effect on accumulation of soluble $Ca^{2+}$ in the clayey soil, yet it did not succeed in lowering its content of soluble $Ca^{2+}$ below its original level. The high retentively of the clayey soil for water and consequently soluble $Ca^{2+}$ may account for such a finding. Also, the higher cation exchange capacity of the clayey soil than the other investigated soils may give reason for the higher retentively of the clayey soil for $Ca^{2+}$ due to its presence as a counter in for the negative charge present on the clay particles.

Depthwise distribution pattern of $Ca^{2+}$ cations seemed to be identical with that of $SO_4^{2-}$ anions i.e. these ions where found in highest concentration in the surface layers and tended to decrease depthwise. Magnitudes of $Ca^{2+}$ concentrations though were reduced in the different soil depths due magnetization of water, yet pattern of depthwise distribution of $Ca^{2+}$ remained unaffected by this process.

### *B: Soluble magnesium ($Mg^{2+}$):*

Table (18) and Fig. (15) shows that usage of either of El Bostan drain water ($W_1$), Seedy Ghazy drain water ($W_2$) or El Hedaya canal water ($W_3$) resulted in reduction in original soil content of the soluble $Mg^{2+}$. This was true for all soils whether upon usage of the non-magnetized waters or the magnetized ones. However, percentage of reduction seemed dependent not only on type of the leached soil and

*Table (18) : Soluble magnesium (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water.*

| Soil type | Depth (cm) | Irrigation water | | | | L.S.D at 0.05 level | |
|---|---|---|---|---|---|---|---|
| | | $W_1$ | $W_2$ | $W_3$ | $W_4$ | | |
| *Clayey* | | Magnetized irrigation water | | | | | |
| | 0-15 | 3.17 | 3.49 | 3.64 | 9.63 | Treat. : | 0.06 |
| | 15-30 | 2.55 | 2.99 | 3.22 | 5.83 | Depth : | 0.08 |
| | 30-45 | 2.82 | 3.33 | 3.33 | 8.81 | Water : | 0.14 |
| | Average | 2.85 | 3.27 | 3.40 | 8.09 | Treat.*Depth : | 0.17 |
| | △ $Mg^{2+}$ | -1.26 | -0.94 | -0.84 | 2.68 | Treat.*Water : | 0.28 |
| | %RC** | 37.02 | 27.65 | 24.85 | 78.98 | Depth*Water : | 0.41 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.83 |
| | 0-15 | 3.85 | 4.32 | 4.75 | 18.83 | | |
| | 15-30 | 2.38 | 3.33 | 3.39 | 7.45 | | |
| | 30-45 | 3.34 | 3.50 | 4.55 | 11.54 | | |
| | Average | 3.19 | 3.72 | 4.23 | 12.61 | | |
| | △ $Mg^{2+}$ | -1.00 | -0.60 | -0.22 | 6.07 | | |
| | %RC** | 29.42 | 17.77 | 6.42 | 178.91 | | |
| *Sandy clay loam (calcareous)* | | Magnetized irrigation water | | | | | |
| | 0-15 | 5.66 | 5.76 | 7.29 | 18.69 | Treat. : | 0.08 |
| | 15-30 | 3.33 | 4.61 | 6.47 | 11.64 | Depth : | 0.12 |
| | 30-45 | 3.91 | 5.50 | 6.56 | 13.60 | Water : | 0.20 |
| | Average | 4.30 | 5.29 | 6.77 | 14.64 | Treat.*Depth : | 0.24 |
| | △ $Mg^{2+}$ | -11.14 | -10.67 | -9.98 | -6.28 | Treat.*Water : | 0.39 |
| | %RC** | 84.64 | 81.11 | 75.81 | 47.70 | Depth*Water : | 0.59 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 1.18 |
| | 0-15 | 7.67 | 10.82 | 13.87 | 43.08 | | |
| | 15-30 | 3.80 | 5.28 | 9.46 | 17.15 | | |
| | 30-45 | 4.45 | 5.50 | 10.92 | 18.37 | | |
| | Average | 5.31 | 7.20 | 11.42 | 26.20 | | |
| | △ $Mg^{2+}$ | -10.67 | -9.78 | -7.79 | -0.85 | | |
| | %RC** | 81.05 | 74.29 | 59.23 | 6.43 | | |
| *Sandy* | | Magnetized irrigation water | | | | | |
| | 0-15 | 2.56 | 3.39 | 4.98 | 5.27 | Treat. : | *N.S |
| | 15-30 | 1.74 | 1.91 | 2.06 | 2.90 | Depth : | 0.03 |
| | 30-45 | 1.91 | 2.37 | 2.43 | 3.70 | Water : | 0.05 |
| | Average | 2.07 | 2.56 | 3.16 | 3.96 | Treat.*Depth : | 0.06 |
| | △ $Mg^{2+}$ | -0.74 | -0.64 | -0.53 | -0.38 | Treat.*Water : | 0.10 |
| | %RC** | 65.19 | 57.01 | 46.92 | 33.47 | Depth*Water : | 0.16 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.31 |
| | 0-15 | 3.53 | 4.98 | 5.27 | 7.65 | | |
| | 15-30 | 1.91 | 2.43 | 2.74 | 3.88 | | |
| | 30-45 | 2.74 | 2.90 | 3.88 | 4.98 | | |
| | Average | 2.73 | 3.44 | 3.96 | 5.50 | | |
| | △ $Mg^{2+}$ | -0.61 | -0.48 | -0.38 | -0.08 | | |
| | %RC** | 54.15 | 42.22 | 33.36 | 7.47 | | |

** N.S.= not significant.*
***RC= rate of change.*

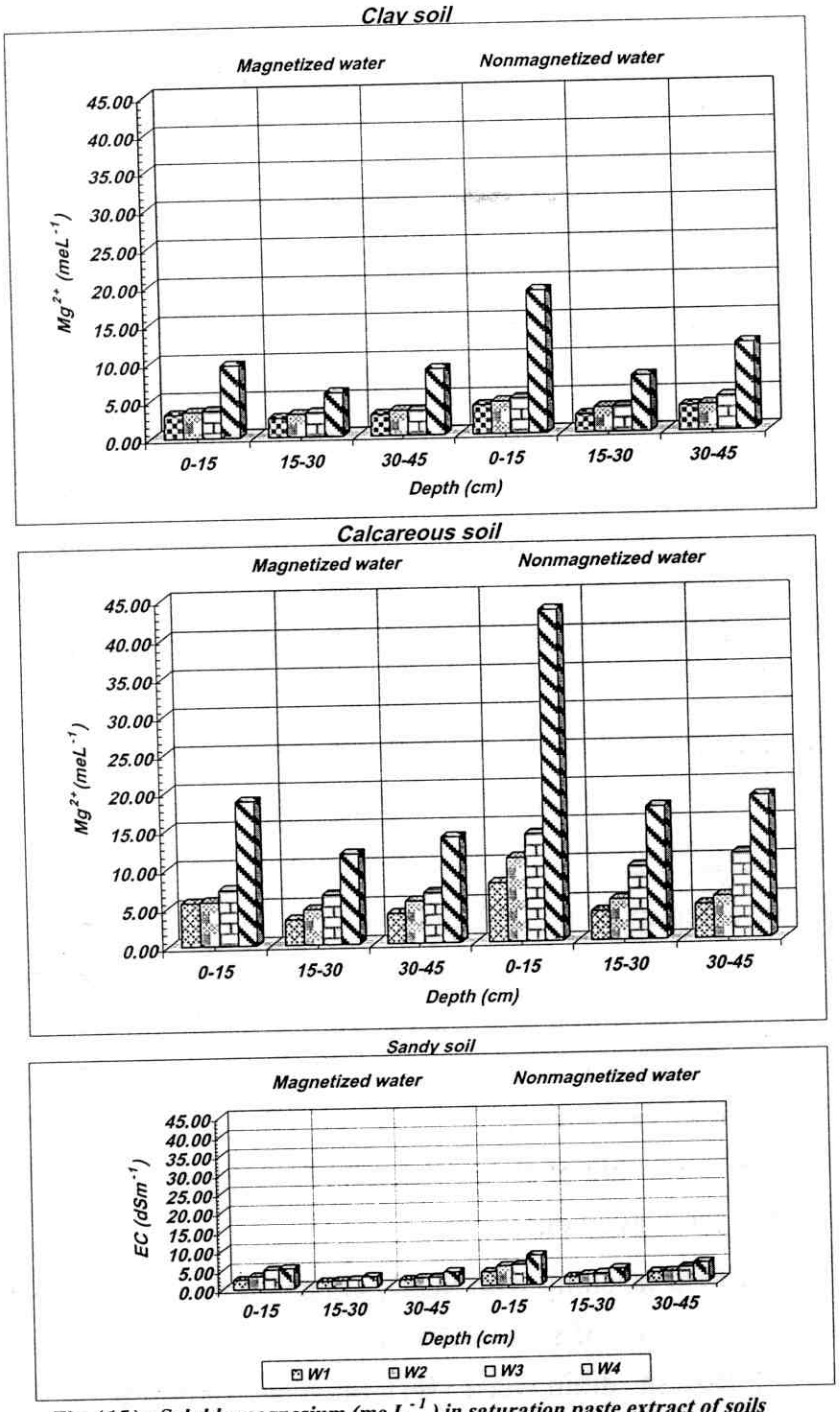


***Fig. (15) : Soluble magnesium (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water.***

type of the water used for leaching but also on the magnetization process of the used waters where such a process could succeed in enormousing effect of the used water for leaching soluble $Mg^{2+}$ out of the studied soils.

Intermittent leaching with Haris drain water ($W_4$) caused contradictory results on soluble $Mg^{2+}$ contents in the investigated soils. Such water resulted in accumulation of soluble $Mg^{2+}$ in the clayey soil, yet rate of increase in $Mg^{2+}$ in this soil was reduced upon magnetizing the used water. Unlike what happened in the clayey soil, intermittent leaching of both the sandy clay loam and sandy soil with Haris drain water whether this water was magnetized or not could reduce their contents of soluble $Mg^{2+}$. The rate of reduction seemed higher in case of using the magnetized water than in case of using the non-magnetized one.

Depthwise distribution pattern of a $Mg^{2+}$ ion coincided with that of $Ca^{2+}$ ones i.e. $Mg^{2+}$ concentration tended to decrease downwards.

***C: Soluble sodium ($Na^+$):***

Data presented in Table (19) and Fig. (16) reveal that the original soluble $Na^+$ content of all the investigated soils was reduced due to intermittent leaching of these soils using El Bostan drain water ($W_1$) whether in its non-magnetized form or the magnetized one. However, values of reduction rate seemed to be higher upon usage of the magnetized water. Also, rate of change seemed more obvious in the light textured soils than the clayey one.

The intermittent leaching with Seedy Ghazy drain water ($W_2$) was of an effect on reduction of soluble $Na^+$ similar to that achieved due to utilization of El Bostan drain water ($W_1$). Such an effect was observed on both the sandy loam and sandy soils whether the used water was magnetized or not. On the other hand, usage of such a water ($W_2$) in leaching the clayey soil resulted in an increase in its content of soluble $Na^+$, however, the accumulation percentage of soluble $Na^+$ was reduced when the magnetized water was used in leaching instead of the non-magnetized one.

Water of El Hedaya canal ($W_3$) was of an effect on redistribution of soluble $Na^+$ in all the investigated soils identical to that attained due to Seedy Ghazy drain water. This finding was true whether upon utilization of the non-magnetized water or the magnetized one. However, magnitudes of change and rate of change in soluble $Na^+$ content seemed dependent on type of soil and state of water from the standpoint of magnetization.

Pattern of distribution of soluble $Na^+$ in the different investigated soils due to their intermittent leaching using Haris drain water ($W_4$) differed widely from those attained due to usage of the aforementioned types of water ($W_1$, $W_2$ or $W_3$). Soluble $Na^+$ tended to accumulate in the clayey soil due to application of Haris drain water. Rate of increase in soluble $Na^+$ seemed to be reduced when the applied water was in the magnetized form. The magnetized water of Haris drain caused soluble $Na^+$ content of the sandy clay loam and sandy soils to be reduced although usage of this water before being magnetized was of an adverse effect on these soils content of soluble $Na^+$. The results obtained herein assure the desired rate of magnetization of water in reducing soils content of soluble $Na^+$. Thus, the magnetization technique may be suggested as an easy way for reducing soil sodicity and consequently the improvement of its physical, chemical and nutritional status.

The depthwithe distribution pattern of $Na^+$ in all the investigated soils revealed that $Na^+$ was accumulated in highest concentration in the surface layer of all the investigated soils and tended to decrease with depth. The upward movement of the saline solution in drying periods

*Table (19) : Soluble sodium (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water .*

| Soil type | Depth (cm) | Irrigation water | | | | L .S .D at 0.05 level | |
|---|---|---|---|---|---|---|---|
| | | $W_1$ | $W_2$ | $W_3$ | $W_4$ | | |
| Clayey | | Magnetized irrigation water | | | | | |
| | 0-15 | 12.66 | 17.37 | 20.10 | 49.51 | Treat. : | 1.58 |
| | 15-30 | 9.68 | 12.60 | 14.91 | 38.37 | Depth : | 1.93 |
| | 30-45 | 8.99 | 12.66 | 13.96 | 33.48 | Water : | 2.49 |
| | Average | 10.44 | 14.21 | 16.32 | 40.45 | Treat.*Depth : | 2.73 |
| | △ $Na^+$. | -1.02 | 1.81 | 3.39 | 21.49 | Treat.*Water : | 3.52 |
| | %RC** | 11.50 | 20.42 | 38.33 | 242.82 | Depth*Water : | 4.31 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 6.10 |
| | 0-15 | 13.85 | 23.81 | 27.32 | 77.58 | | |
| | 15-30 | 10.50 | 17.23 | 17.57 | 56.00 | | |
| | 30-45 | 10.07 | 12.32 | 14.37 | 43.04 | | |
| | Average | 11.47 | 17.79 | 19.75 | 58.87 | | |
| | △ $Na^+$. | -0.24 | 4.49 | 5.97 | 35.31 | | |
| | %RC** | 2.77 | 50.73 | 67.40 | 398.93 | | |
| Sandy clay loam (calcareous) | | Magnetized irrigation water | | | | | |
| | 0-15 | 13.65 | 18.90 | 29.61 | 63.35 | Treat. : | 1.15 |
| | 15-30 | 10.88 | 12.82 | 21.45 | 35.40 | Depth : | 1.40 |
| | 30-45 | 11.84 | 16.27 | 22.97 | 38.77 | Water : | 1.81 |
| | Average | 12.12 | 16.00 | 24.68 | 45.84 | Treat.*Depth : | 1.99 |
| | △ $Na^+$. | -23.42 | -21.60 | -17.52 | -7.58 | Treat.*Water : | 2.57 |
| | %RC** | 80.43 | 74.18 | 60.17 | 26.01 | Depth*Water : | 3.14 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 4.44 |
| | 0-15 | 30.86 | 35.14 | 64.89 | 114.68 | | |
| | 15-30 | 13.34 | 17.00 | 27.54 | 66.57 | | |
| | 30-45 | 15.86 | 20.82 | 38.17 | 70.14 | | |
| | Average | 20.02 | 24.32 | 43.53 | 83.80 | | |
| | △ $Na^+$. | -19.71 | -17.69 | -8.66 | 10.26 | | |
| | %RC** | 67.69 | 60.75 | 29.74 | 35.25 | | |
| Sandy | | Magnetized irrigation water | | | | | |
| | 0-15 | 7.19 | 9.20 | 13.36 | 26.97 | Treat. : | *N.S |
| | 15-30 | 5.62 | 7.08 | 8.50 | 17.00 | Depth : | 0.54 |
| | 30-45 | 5.57 | 6.71 | 7.38 | 13.44 | Water : | 0.69 |
| | Average | 6.13 | 7.66 | 9.75 | 19.14 | Treat.*Depth : | 0.76 |
| | △ $Na^+$. | -3.04 | -2.74 | -2.35 | -0.56 | Treat.*Water : | 0.98 |
| | %RC** | 72.28 | 65.33 | 55.91 | 13.43 | Depth*Water : | 1.20 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 1.70 |
| | 0-15 | 10.99 | 13.00 | 15.82 | 38.21 | | |
| | 15-30 | 6.61 | 9.27 | 10.79 | 24.53 | | |
| | 30-45 | 6.15 | 7.28 | 9.69 | 20.74 | | |
| | Average | 7.92 | 9.85 | 12.10 | 27.83 | | |
| | △ $Na^+$. | -2.70 | -2.33 | -1.90 | 1.09 | | |
| | %RC** | 64.19 | 55.44 | 45.26 | 25.88 | | |

** N.S.= not significant.*
***RC= rate of change.*

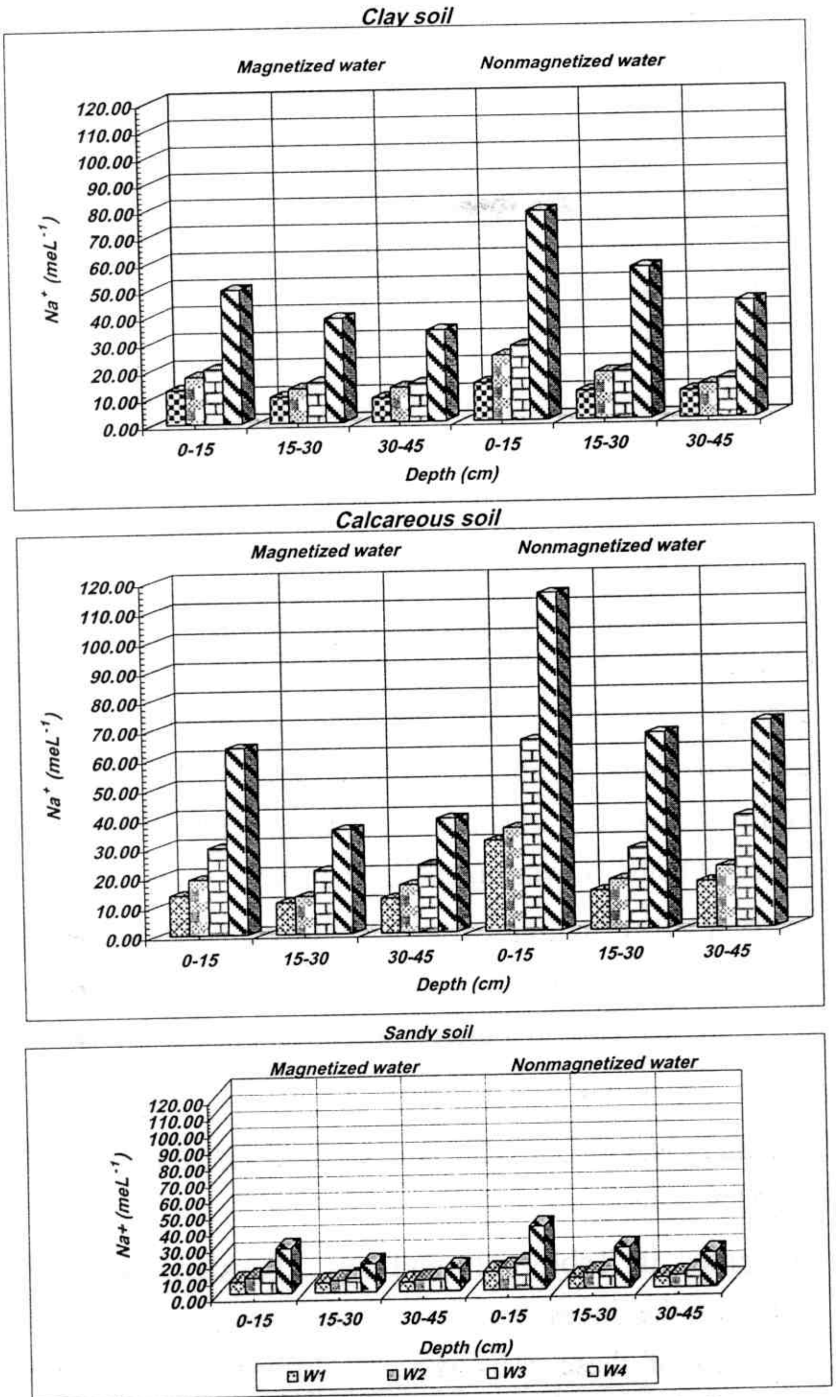


***Fig. (16) : Soluble sodium (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water .***

among the successive applications of the leaching water might account for such a phenomenon.

***D: Soluble potassium ($K^+$):***

Data presented in Table (20) and Fig. (17) show redistribution of soluble $K^+$ within the different depths of the investigated soils due to their leaching intermittently using the different types of waters in their magnetized form as well as their non-magnetized one.

All the used waters whether before magnetization or after being magnetized caused the original content of soluble $K^+$ in both the clayey and sandy soils to increase, yet rate of change in soil content was more less when the magnetized waters were used.

Unlike the previously mentioned effect of the used waters on increasing soluble $K^+$ content of the clayey and sandy soils, the usage of such waters resulted in reduction in the original content soluble $K^+$ in the sandy clay loam soil. The magnitudes of reduction and consequently rate of change in this soil content of soluble $K^+$ varied depending on type of the used water and whether it was magnetized or not.

Pattern of $K^+$ distribution with depth seemed similar, to a great extent, to that of $Na^+$ because they are of similar chemical properties. Thus, $K^+$ tended to decrease depthwise in respect of type of the water quality or the magnetization process.

### 4.2.3. Effect of intermittent leaching of the investigated soils on their SAR and ESP values:

Data presented in Table (21) and Fig. (18) show values of the SAR and ESP of the investigated soils that were attained due to intermittent leaching of these soils using the different sources of water under study.

*Table (20) : Soluble potassium (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water.*

| Soil type | Depth (cm) | Irrigation water | | | | L.S.D at 0.05 level | |
|---|---|---|---|---|---|---|---|
| | | $W_1$ | $W_2$ | $W_3$ | $W_4$ | | |
| Clayey | | Magnetized irrigation water | | | | | |
| | 0-15 | 0.39 | 0.43 | 0.46 | 0.71 | Treat. : | 0.02 |
| | 15-30 | 0.36 | 0.38 | 0.38 | 0.66 | Depth : | 0.02 |
| | 30-45 | 0.36 | 0.36 | 0.38 | 0.51 | Water : | 0.02 |
| | Average | 0.37 | 0.39 | 0.41 | 0.63 | Treat.*Depth : | *N.S |
| | △ $K^+$ | 0.09 | 0.10 | 0.12 | 0.28 | Treat.*Water : | 0.03 |
| | %RC** | 46.05 | 53.95 | 60.53 | 147.37 | Depth*Water : | 0.04 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.06 |
| | 0-15 | 0.48 | 0.44 | 0.63 | 0.85 | | |
| | 15-30 | 0.38 | 0.41 | 0.51 | 0.79 | | |
| | 30-45 | 0.38 | 0.41 | 0.48 | 0.69 | | |
| | Average | 0.41 | 0.42 | 0.54 | 0.78 | | |
| | △ $K^+$ | 0.12 | 0.13 | 0.22 | 0.39 | | |
| | %RC** | 63.16 | 65.79 | 113.16 | 206.58 | | |
| Sandy clay loam (calcareous) | | Magnetized irrigation water | | | | | |
| | 0-15 | 1.28 | 1.58 | 1.75 | 2.39 | Treat. : | 0.09 |
| | 15-30 | 1.22 | 1.27 | 1.66 | 2.14 | Depth : | 0.11 |
| | 30-45 | 1.08 | 1.11 | 1.58 | 2.05 | Water : | 0.14 |
| | Average | 1.19 | 1.32 | 1.66 | 2.19 | Treat.*Depth : | 0.15 |
| | △ $K^+$ | -0.99 | -0.93 | -0.77 | -0.52 | Treat.*Water : | 0.20 |
| | %RC** | 63.82 | 59.97 | 49.56 | 33.49 | Depth*Water : | 0.24 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.34 |
| | 0-15 | 1.57 | 2.31 | 2.56 | 3.78 | | |
| | 15-30 | 1.53 | 1.64 | 1.93 | 2.73 | | |
| | 30-45 | 1.54 | 1.80 | 2.33 | 3.00 | | |
| | Average | 1.55 | 1.92 | 2.27 | 3.17 | | |
| | △ $K^+$ | -0.82 | -0.65 | -0.48 | -0.06 | | |
| | %RC** | 53.10 | 41.88 | 31.07 | 3.88 | | |
| Sandy | | Magnetized irrigation water | | | | | |
| | 0-15 | 0.41 | 0.51 | 0.57 | 0.87 | Treat. : | *N.S |
| | 15-30 | 0.33 | 0.42 | 0.42 | 0.53 | Depth : | 0.02 |
| | 30-45 | 0.32 | 0.39 | 0.37 | 0.50 | Water : | 0.03 |
| | Average | 0.35 | 0.44 | 0.45 | 0.63 | Treat.*Depth : | *N.S |
| | △ $K^+$ | 0.00 | 0.01 | 0.02 | 0.05 | Treat.*Water : | 0.04 |
| | %RC** | 0.00 | 19.43 | 23.05 | 71.90 | Depth*Water : | 0.05 |
| | | Nonmagnetized irrigation water | | | | Treat.*Depth*Water : | 0.06 |
| | 0-15 | 0.48 | 0.59 | 0.66 | 0.95 | | |
| | 15-30 | 0.36 | 0.45 | 0.46 | 0.65 | | |
| | 30-45 | 0.35 | 0.42 | 0.42 | 0.60 | | |
| | Average | 0.40 | 0.49 | 0.51 | 0.73 | | |
| | △ $K^+$ | 0.01 | 0.02 | 0.03 | 0.07 | | |
| | %RC** | 7.67 | 32.10 | 39.33 | 99.05 | | |

** N.S.= not significant.*
***RC= rate of change.*

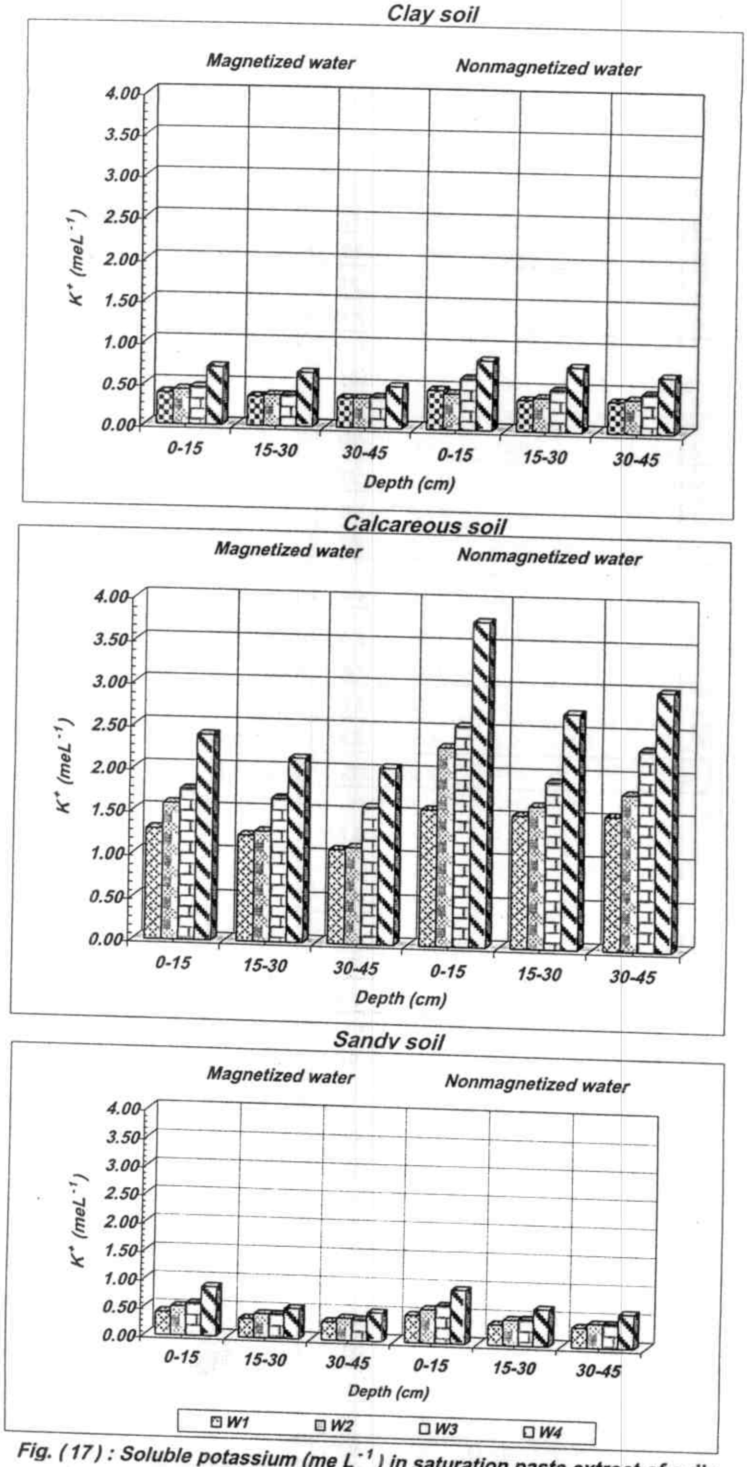


**Fig. (17) : Soluble potassium (me $L^{-1}$) in saturation paste extract of soils columns as affected with magnetization of irrigation water.**

It could be seen from data that usage of any type of the used waters resulted in marked increase in SAR values and consequently the ESP ones of the clayey soil. The increments in SAR or ESP seemed to be reduced when the waters were used after being magnetized. It is worthy to note that the hazardous effect of the used waters on increasing sodicity of the clayey soil followed the descending order: $W_4 > W_3 > W_2 > W_1$.

The used waters were of different effects on both SAR and ESP values of the sandy clay loam soil whether upon application of these waters without magnetization or after being magnetized. El Bostan drain water ($W_1$) was of a reducing effect on values of SAR and ESP whether this water was magnetized or not. Seedy Ghazy drain water ($W_2$) as well as El Hedaya canal water ($W_3$) although resulted in pronounced reduction in values of SAR, yet values of ESP either remained unchanged or even increased. Haris drain water ($W_4$), however, resulted in increase in both values of SAR and ESP.

Magnetization of the used waters was of a marked effect on reducing both SAR and ESP values of the sandy clay loam soils, yet the reduction effect was more obvious in case of magnetizing El Bostan drain water ($W_1$) and Seedy Ghazy drain water ($W_2$) than the other used waters ($W_3$ and $W_4$).

All the used waters, except for Haris drain water ($W_4$), were of reducing effect on values both SAR and ESP of the sandy soils. The effect was more obvious upon magnetizing these waters. Magnetizing Haris drain water ($W_4$) although reduced both values of SAR and ESP as compared with the effect of its non-magnetized form, yet these values remained higher than the corresponding ones of the sandy soil before leaching it using such water.

*Table (21) : ESP and SAR of soils columns as affected with magnetization of irrigation water .*

| Soil type | Depth (cm) | Irrigation water | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $W_1$ | | $W_2$ | | $W_3$ | | $W_4$ | |
| | | ESP | SAR | ESP | SAR | ESP | SAR | ESP | SAR |
| Clayey | | Magnetized water | | | | | | | |
| | 0-15 | 8.70 | 6.16 | 11.23 | 8.14 | 12.48 | 9.07 | 17.41 | 14.63 |
| | 15-30 | 6.76 | 5.12 | 9.01 | 6.25 | 9.78 | 7.17 | 15.18 | 13.51 |
| | 30-45 | 7.01 | 4.75 | 8.42 | 6.15 | 9.18 | 6.67 | 12.79 | 11.07 |
| | Average | 7.49 | 5.35 | 9.55 | 6.85 | 10.48 | 7.63 | 15.13 | 13.07 |
| | | Unmagnetized water | | | | | | | |
| | 0-15 | 10.01 | 6.07 | 12.99 | 9.70 | 14.93 | 10.13 | 19.83 | 17.31 |
| | 15-30 | 8.20 | 5.41 | 10.51 | 8.12 | 10.42 | 7.18 | 18.73 | 15.39 |
| | 30-45 | 7.45 | 5.04 | 8.92 | 5.81 | 9.44 | 6.15 | 14.88 | 11.86 |
| | Average | 8.55 | 5.51 | 10.81 | 7.88 | 11.60 | 7.82 | 17.81 | 14.85 |
| Sandy clay loam (calcareous) | | Magnetized water | | | | | | | |
| | 0-15 | 8.67 | 5.58 | 10.33 | 7.42 | 13.33 | 9.69 | 16.03 | 14.02 |
| | 15-30 | 7.62 | 5.05 | 8.75 | 5.39 | 10.00 | 7.39 | 11.26 | 8.96 |
| | 30-45 | 7.85 | 5.58 | 9.17 | 6.83 | 10.88 | 8.06 | 11.49 | 9.88 |
| | Average | 8.05 | 5.40 | 9.42 | 6.55 | 11.41 | 8.38 | 12.92 | 10.95 |
| | | Unmagnetized water | | | | | | | |
| | 0-15 | 13.27 | 10.01 | 12.74 | 9.18 | 17.82 | 14.67 | 20.90 | 18.79 |
| | 15-30 | 9.17 | 5.72 | 10.30 | 6.09 | 11.85 | 7.16 | 16.30 | 13.88 |
| | 30-45 | 9.87 | 6.67 | 13.31 | 8.09 | 14.39 | 10.31 | 17.55 | 15.34 |
| | Average | 10.77 | 7.47 | 12.12 | 7.79 | 14.69 | 10.72 | 18.25 | 16.00 |
| Sandy | | Magnetized water | | | | | | | |
| | 0-15 | 5.97 | 4.09 | 6.72 | 4.87 | 7.33 | 5.84 | 12.05 | 10.72 |
| | 15-30 | 5.59 | 3.69 | 6.65 | 4.38 | 6.66 | 4.99 | 11.11 | 9.07 |
| | 30-45 | 4.94 | 3.72 | 6.44 | 4.27 | 6.54 | 4.56 | 11.91 | 7.39 |
| | Average | 5.50 | 3.83 | 6.60 | 4.51 | 6.84 | 5.13 | 11.69 | 9.06 |
| | | Unmagnetized water | | | | | | | |
| | 0-15 | 9.14 | 5.10 | 10.80 | 5.42 | 8.28 | 6.07 | 15.66 | 13.17 |
| | 15-30 | 7.16 | 3.75 | 9.31 | 4.95 | 9.40 | 5.62 | 12.62 | 10.75 |
| | 30-45 | 7.25 | 3.32 | 7.55 | 3.89 | 7.85 | 4.85 | 12.39 | 8.95 |
| | Average | 7.85 | 4.06 | 9.22 | 4.75 | 8.51 | 5.51 | 13.56 | 10.96 |

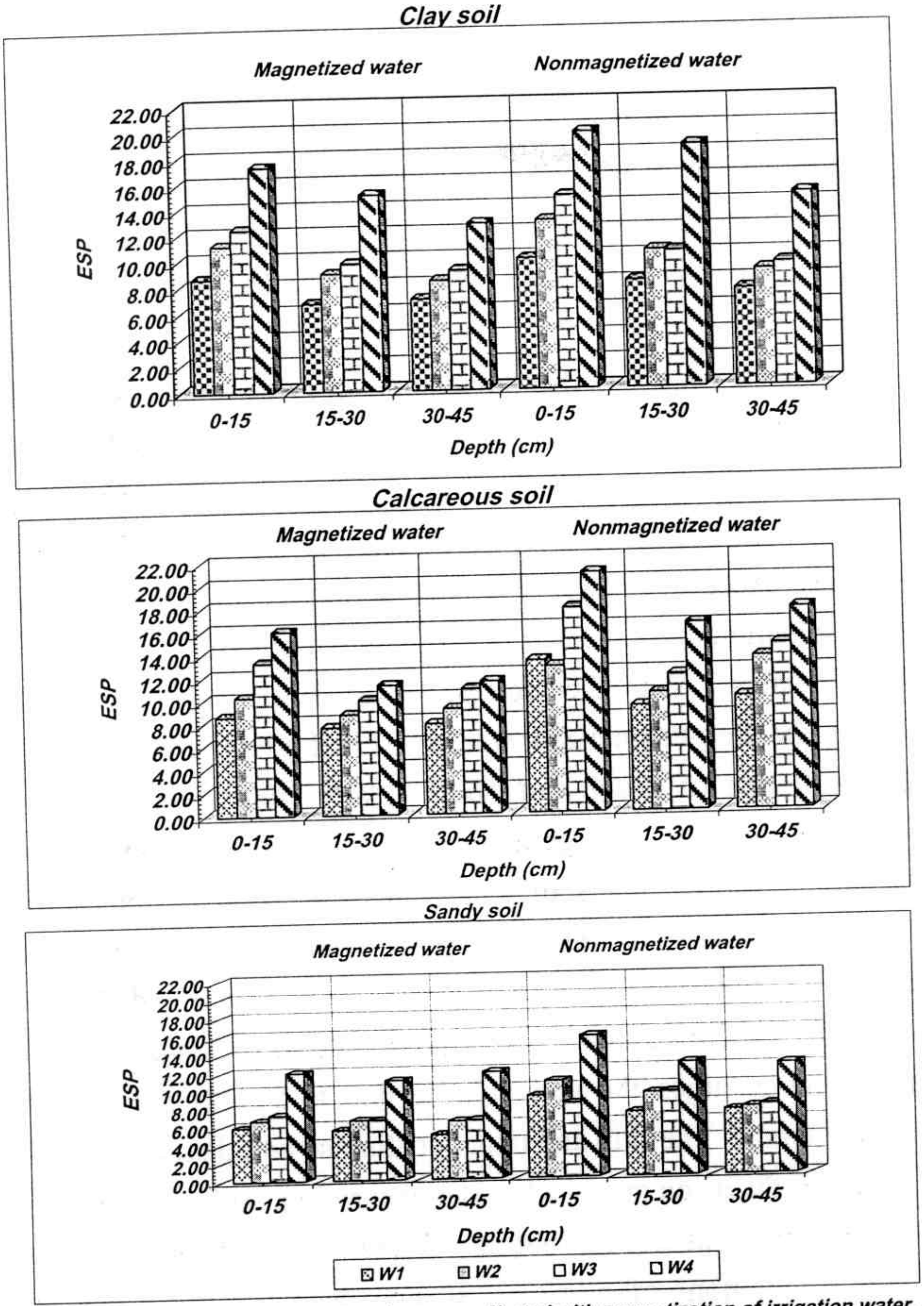


*Fig. (18) : ESP and SAR of soils columns as affected with magnetization of irrigation water.*

## 4.3. Effect of magnetization of different water qualities on germination percentage and rate of wheat seeds:

Data presented in Table (22) reveal the number of germinated seeds after 4,5,6 and 7 days of sowing in either the aforementioned water qualities i.e. $W_0$, $W_1$, $W_2$, $W_3$ or $W_4$ before magnetization and after being magnetized. Values of germination percentage (G%) as well as those of the germination rate (GR) were calculated and presented also in Table (22).

It is obvious from data that the count recorded for the germinated seeds after any period of the investigated ones was generally lower in case of usage of the non-magnetized waters than that recorded upon utilization of the magnetized one. This finding was true for all the tested water qualities. Accordingly value of germination percentage as well as these of germination rate seemed to be higher upon utilization of the magnetized waters than the corresponding ones achieved upon utilization of the non-magnetized waters. This finding stands in well agreement with that of ***Hilal and Hilal (2000)***. Magnetization of the irrigation might activate seed germination. ***Tkatchenko (1997)*** pointed that seeds carry various loads of energy depend upon proton pump situated at the level of cell membrane which when expanded quantitatively relieves the seeds from the state of repose and activate auxin, cytocynin and phusicocin. This accelerates breathing, enhances germination and enlarges the cell volume due to the influx of energy from the membrane. The skin and upper coating of all relaxing seeds of cereals retard $O_2$ diffusion and black water absorption. At the same time, inhibitors prevent seeds from sprouting. Magnetic field activates energy influx and stimulation of enzymes. It also decreases the effect of germination inhibitors due to increase in pH of the cell juice.

studied soils and irrigated with the investigated water qualities before or after being magnetized are presented in Table (24). It is obvious from these tables that *N* and *K* uptake values of the plants grown on the clayey soil were generally higher than the corresponding ones of the plants grown on the calcareous soil whereas the corresponding values of the plants grown on the sandy soil were the least. The uptake values of both *N* and *K* reflect the natural fertility status of the investigated soils according to which these soils are descendingly as follows: ***the clayey soil* > *the sandy clay loam (calcareous)* > *the sandy*** soil. Unlike *N* and *K*, values of ***P*** uptake were in the sandy clay loam soil lower than the sandy one. The calcareous nature of the sandy clay loam accounts for such a finding because phosphate may be absorbed on surface of $CaCo_3$ particles present in this soil besides soluble phosphate undergoes precipitation reactions with the soluble $Ca^{2+}$ of soil solution and hence is converted to forms unavailable for plant uptake. Such findings could be observed when the plants were irrigated with the used water qualities whether before being magnetized or after magnetization.

Values of *N*, ***P*** and ***K*** uptake recorded due to usage of the different water qualities were in the descending order: $W_1 > W_2 > W_3 > W_4$ regardless of magnetization process of these waters. However, it is of importance to indicate that the values attained due to irrigation with quality of water after being magnetized were generally higher the corresponding ones achieved due to irrigation with the same water before being non-magnetized.

### 4.4.2.Effect on N, P and K concentration:

Values of ***N, P*** and ***K*** percentage varied from a soil to another and also due to quality of the used irrigation water whether it was magnetized or not Table (25).

*Table ( 24 ):- Effect of magnetized irrigation water on N, P and K uptake ($mg\ pot^{-1}$) by wheat plants grown on the studied soils.*

| Soil type | Elements | Control | Irrigation water | | | |
|---|---|---|---|---|---|---|
| | | | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
| | | | Magnetized water | | | |
| Clayey | N | 38.20 | 33.02 | 28.73 | 25.97 | 16.70 |
| | P | 7.34 | 6.72 | 6.14 | 5.79 | 3.06 |
| | K | 58.19 | 49.63 | 39.34 | 35.12 | 24.37 |
| | | | Nonmagnetized water | | | |
| | N | 34.38 | 25.49 | 25.67 | 21.67 | 14.89 |
| | P | 6.66 | 5.10 | 5.28 | 4.05 | 2.53 |
| | K | 52.41 | 34.53 | 30.39 | 26.94 | 19.61 |
| | | | Magnetized water | | | |
| Calcareous | N | 25.14 | 22.15 | 19.62 | 16.88 | 11.63 |
| | P | 5.27 | 4.73 | 4.13 | 3.36 | 2.14 |
| | K | 42.47 | 36.34 | 30.33 | 25.02 | 15.15 |
| | | | Nonmagnetized water | | | |
| | N | 23.00 | 19.92 | 18.00 | 15.39 | 10.35 |
| | P | 4.97 | 4.38 | 3.95 | 3.28 | 1.88 |
| | K | 39.94 | 30.70 | 25.20 | 20.80 | 12.94 |
| | | | Magnetized water | | | |
| Sandy | N | 20.95 | 20.53 | 18.96 | 16.48 | 12.21 |
| | P | 5.07 | 4.88 | 4.77 | 4.22 | 2.56 |
| | K | 32.76 | 31.07 | 26.66 | 21.60 | 14.98 |
| | | | Nonmagnetized water | | | |
| | N | 19.09 | 18.67 | 16.98 | 13.20 | 6.88 |
| | P | 4.71 | 4.48 | 3.95 | 3.36 | 1.41 |
| | K | 30.67 | 26.58 | 21.12 | 16.84 | 8.33 |

*able ( 25 ):- Effect of magnetized irrigation water on N, P and K percent in wheat plants grown on the studied soils.*

| Soil type | Elements | Control | Irrigation water | | | |
|---|---|---|---|---|---|---|
| | | | $W_1$ | $W_2$ | $W_3$ | $W_4$ |
| Clayey | | | Magnetized water | | | |
| | N | 0.92 | 0.90 | 0.96 | 0.93 | 0.78 |
| | P | 0.17 | 0.18 | 0.21 | 0.21 | 0.14 |
| | K | 1.40 | 1.35 | 1.40 | 1.25 | 1.16 |
| | | | Nonmagnetized water | | | |
| | N | 0.88 | 0.97 | 1.05 | 0.98 | 0.80 |
| | P | 0.17 | 0.19 | 0.22 | 0.18 | 0.14 |
| | K | 1.35 | 1.30 | 1.24 | 1.22 | 1.06 |
| Calcareous | | | Magnetized water | | | |
| | N | 0.87 | 0.98 | 0.88 | 0.87 | 0.80 |
| | P | 0.18 | 0.18 | 0.19 | 0.17 | 0.15 |
| | K | 1.48 | 1.41 | 1.37 | 1.29 | 1.04 |
| | | | Nonmagnetized water | | | |
| | N | 0.80 | 0.68 | 0.93 | 0.90 | 0.82 |
| | P | 0.18 | 0.20 | 0.20 | 0.19 | 0.15 |
| | K | 1.40 | 1.38 | 1.30 | 1.22 | 1.04 |
| Sandy | | | Magnetized water | | | |
| | N | 0.81 | 0.84 | 0.86 | 0.80 | 0.76 |
| | P | 0.20 | 0.20 | 0.22 | 0.21 | 0.16 |
| | K | 1.27 | 1.27 | 1.21 | 1.06 | 0.94 |
| | | | Nonmagnetized water | | | |
| | N | 0.81 | 0.86 | 0.90 | 0.82 | 0.78 |
| | P | 0.20 | 0.21 | 0.21 | 0.21 | 0.16 |
| | K | 1.27 | 1.21 | 1.12 | 1.05 | 0.94 |

Regarding concentration of *N* in the wheat plants that were irrigated with either of the investigated waters, it could be noticed that it was generally lower when the used water was magnetized. The superiority of *N* concentration with the non-magnetized water over the magnetized ones could be attributed to the dilution effect since values of *N* uptake were, as mentioned before, higher with the magnetized waters than the non-magnetized ones.

Note worthy to indicate that value of *N* concentrations in the plants grown on the clayey soil seemed to be highest, whereas those of the sandy soil were lowest while those of the plants grown on the calcareous on came inbetween. Such a finding is probably attributed to the original content of *N* in the investigated soils which is in the descending order: ***the clayey soil > the calcareous soil > the sandy soil.***

Values of ***P*** concentration seemed lowest in the plants grown on the sandy clay loam (calcareous) soil whereas those of the plants grown on the sandy one seemed higher while those of the plants grown on the clayey soil were inbetween. This occurred whether the used waters were magnetized or not.

The low values of ***P*** concentration in the plants grown on the sandy clay loam soil is attributed mainly to the low uptake values of ***P*** in this soil due to its calcareous nature as mentioned before. On the other hand, the relatively low values of ***P*** concentration in the plants grown on the clayey soil can be attributed to the dilution effect. The higher value of ***P*** concentration in the plants grown on the sandy soil is a final product of its relatively high uptake of ***P*** values as well as the relatively low dry matter yield of plants grown thereon.

***K*** concentration values in wheat plants grown on the studied soils seemed higher when these plants were irrigated with the magnetized waters than the corresponding ***K*** concentration values attained when the plants were grown with the non-magnetized waters, such a finding is due to the higher uptake values of ***K*** by the plants irrigated with the magnetized water.

It is of importance to indicate that ***K*** concentration was also dependent on type of the water used for irrigation, therefore it was in the order: $W_0 > W_1 > W_2 > W_3 > W_4$.

Such a finding could be attributed to many factors, the most important one among them is the salinity of the used water which affect adversely the uptake of water, due to the high osmotic pressure of the soil solution, and consequently uptake of ***K***.

It could be concluded from the aforementioned discussion that magnetic the water used for leaching soil or irrigating the different plants can provide better soil-water–plant relationships and is thus worth further consideration.

## 4.5. Chemical analysis of the studied soils after removal of wheat plants:

Data presented in Table (26) reveal the changes that might take place in some chemical properties of the investigated soils due to cultivation of these soils and irrigating then with the studied water qualities.

### 4.5.1. The pH value:

*pH* values of the clayey soil tended to decrease slightly compared with the original one recorded before cultivation. This was true upon usage of all water qualities except for the tap water ($W_0$) where the value of soil ***pH*** exceeded very slightly the original one. These results agree with those of ***Dubey (1997)*** who reported that saline application reduced soil ***pH*** than saline water.

*pH* values of the other soils showed very slight but not stable change due to cultivation. No obvious effect could be noticed on soil ***pH*** due to magnetization of the different irrigation qualities. The slight ***pH*** decrease in the clayey soil is probably due to root exudates besides of some microbial activity, which result in $CO_2$ dissolves in water solution forming carbonic acid.

### 4.5.2.The EC value:

Expect for the tap water, irrigation with all the water qualities caused *EC* value of both the clayey and sandy soils to increase. Such an increase is expected due to the high content of the used waters of soluble salts. The increase in soil salinity seemed, therefore, to be parallel to the salinity of the irrigation water itself thus it was in the order: $W_1 > W_2 > W_3 > W_4$.

Cultivation of the sandy clay loam calcareous soil using the different water qualities for irrigation resulted in marked decreases in the original *EC* value of this soil which was already high ($11 dSm^{-1}$). This finding means that the used waters were able to leach a part of the soluble salts out of the sandy loam soil i.e. the salt balance was towards removal of salts out of the soil.

Regarding effect of the magnetized water as compared with that of the non-magnetized ones, on ***EC*** values of the investigated soils, data showed relatively lower values of *EC* upon irrigation with the former than upon usage of the later especially when the soluble salt content of water was highest ($W_4$).

### 4.5.3. *Ionic composition*:

#### *4.5.3.1. Soluble anions:*

- ***Soluble bicarbonate ($HCO_3^-$):***

Values of soluble $HCO_3^-$ of the cultivated soils, which were irrigated with the different water qualities, tended to be almost around their original contents in the studied soils. However, the magnetized waters seemed to cause relatively lower $HCO_3^-$ values as compared with the non-magnetized ones.

- ***Soluble chaloride ($Cl^-$):***

Soluble **$Cl^-$** contents of both the clayey and sandy soils tended generally exceed their original contents when these soils were cultivated and irrigated with the poor water qualities. The magnetized waters seemed to be of less effect on accumulation of soluble chloride in both the clayey and sandy soils than the non-magnetized ones.

Unlike what occurred in both the clayey and sandy soils, cultivation and irrigation of the sandy clay loam soil resulted in decrease in its content of soluble **$Cl^-$**. The decrease was more pronounced upon irrigation with the magnetized waters than the non-magnetized ones. This was true upon irrigation with all the water qualities except for that of Haris drain water ($W_4$) that caused soluble **Cl-** in this soil to exceeds its original content.

- ***Soluble sulphate content ($SO_4^{2-}$):***

The soluble sulphate content of both the clayey and sandy increased generally due to cultivation of these soils and irrigating them with all the investigated water qualities except for the control one i.e. Tap water ($W_0$). In the cultivated sandy clay loam soil, cultivation resulted in contradictory effects on soluble $SO_4^{2-}$ content dependent on the used water content of soluble $SO_4^{2-}$. Thus soluble $SO_4^{-2}$ was reduced upon irrigation with either $W_0$, $W_1$ *or* $W_2$ water. On the other hand, usage of $W_3$ or $W_4$ water was of an accumulative effect on the sandy clay loam soil content of soluble $SO_4^{2-}$. In all cases of the used waters, magnetization of these waters seemed to be of a reducing effect on soil content of soluble $SO_4^{2-}$ as compared with the non-magnetized waters.

Table (26 ) :- *Analysis of saturation paste extract in soils irrigated with magnetized water or non magnetized water after wheat removals .*

| Soil sample | irrigation water | SP | pH in soil paste | EC $dSm^{-1}$ | Soluble ions in saturation paste extract | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Anions me $L^{-1}$ | | | | Cations me $L^{-1}$ | | | |
| | | | | | $CO_3^{2-}$ | $HCO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ | $K^+$ |
| Clayly | | | | | *Non magnetized water* | | | | | | | |
| | $W_0$ | 80 | 7.90 | 2.50 | n.d. | 3.12 | 9.50 | 13.25 | 9.72 | 3.76 | 12.12 | 0.27 |
| | $W_1$ | 80 | 7.75 | 4.75 | n.d. | 3.12 | 19.00 | 26.46 | 15.12 | 8.28 | 24.72 | 0.46 |
| | $W_2$ | 80 | 7.70 | 5.50 | n.d. | 3.12 | 34.20 | 30.38 | 20.52 | 10.78 | 35.75 | 0.65 |
| | $W_3$ | 80 | 7.65 | 6.40 | n.d. | 3.64 | 41.80 | 38.85 | 27.00 | 14.60 | 42.25 | 0.44 |
| | $W_4$ | 80 | 7.55 | 8.70 | n.d. | 3.88 | 87.40 | 42.00 | 32.40 | 25.76 | 74.34 | 0.78 |
| | | | | | *Magnetized water* | | | | | | | |
| | $W_0$ | 80 | 7.90 | 1.75 | n.d. | 2.08 | 5.88 | 9.65 | 5.61 | 2.67 | 9.18 | 0.20 |
| | $W_1$ | 80 | 7.80 | 3.50 | n.d. | 2.60 | 13.30 | 20.81 | 12.96 | 3.68 | 19.74 | 0.30 |
| | $W_2$ | 80 | 7.75 | 5.30 | n.d. | 3.64 | 26.60 | 22.81 | 16.20 | 7.72 | 28.53 | 0.60 |
| | $W_3$ | 80 | 7.65 | 6.50 | n.d. | 3.12 | 34.20 | 35.48 | 21.60 | 11.68 | 39.16 | 0.36 |
| | $W_4$ | 80 | 7.60 | 8.70 | n.d. | 3.12 | 70.40 | 32.08 | 28.08 | 17.16 | 59.72 | 0.54 |
| Sandy clay loam (calcareous) | | | | | *Non magnetized water* | | | | | | | |
| | $W_0$ | 43 | 7.60 | 2.60 | n.d. | 4.44 | 5.88 | 17.04 | 7.73 | 4.28 | 14.25 | 1.13 |
| | $W_1$ | 45 | 7.65 | 7.60 | n.d. | 3.64 | 39.90 | 40.60 | 24.30 | 12.38 | 45.25 | 2.21 |
| | $W_2$ | 42 | 7.60 | 8.00 | n.d. | 4.16 | 41.80 | 43.89 | 24.84 | 13.64 | 49.14 | 2.23 |
| | $W_3$ | 43 | 7.65 | 9.00 | n.d. | 4.16 | 49.40 | 50.99 | 25.92 | 15.80 | 60.48 | 2.35 |
| | $W_4$ | 43 | 7.55 | 17.00 | n.d. | 4.16 | 124.10 | 70.11 | 35.64 | 28.73 | 129.73 | 4.27 |
| | | | | | *Magnetized water* | | | | | | | |
| | $W_0$ | 43 | 7.60 | 1.90 | n.d. | 3.64 | 3.92 | 12.41 | 5.15 | 3.37 | 10.41 | 1.04 |
| | $W_1$ | 45 | 7.55 | 6.70 | n.d. | 3.12 | 35.65 | 35.28 | 20.52 | 11.56 | 39.89 | 2.08 |
| | $W_2$ | 43 | 7.65 | 7.10 | n.d. | 3.12 | 38.00 | 40.12 | 21.60 | 12.10 | 45.43 | 2.11 |
| | $W_3$ | 43 | 7.65 | 7.90 | n.d. | 3.64 | 43.70 | 42.97 | 20.52 | 13.92 | 53.69 | 2.18 |
| | $W_4$ | 43 | 7.55 | 13.40 | n.d. | 3.64 | 102.60 | 50.96 | 30.60 | 23.13 | 100.06 | 3.41 |
| Sandy | | | | | *Non magnetized water* | | | | | | | |
| | $W_0$ | 20 | 7.70 | 1.40 | n.d. | 2.68 | 2.94 | 9.24 | 3.06 | 2.37 | 9.10 | 0.33 |
| | $W_1$ | 21 | 7.65 | 5.65 | n.d. | 3.12 | 26.60 | 33.88 | 22.68 | 8.56 | 31.23 | 1.13 |
| | $W_2$ | 20 | 7.60 | 6.60 | n.d. | 3.12 | 30.40 | 40.36 | 24.84 | 10.64 | 37.17 | 1.30 |
| | $W_3$ | 20 | 7.85 | 7.80 | n.d. | 3.64 | 43.73 | 44.28 | 27.00 | 11.04 | 52.25 | 1.36 |
| | $W_4$ | 21 | 7.60 | 12.00 | n.d. | 2.60 | 85.50 | 55.57 | 32.40 | 21.68 | 87.99 | 1.60 |
| | | | | | *Magnetized water* | | | | | | | |
| | $W_0$ | 20 | 7.70 | 1.00 | n.d. | 2.08 | 1.88 | 6.64 | 2.55 | 1.41 | 6.43 | 0.21 |
| | $W_1$ | 20 | 7.70 | 4.80 | n.d. | 2.08 | 19.95 | 30.95 | 18.36 | 7.64 | 26.00 | 0.98 |
| | $W_2$ | 20 | 7.75 | 5.70 | n.d. | 3.64 | 24.70 | 35.05 | 21.60 | 8.56 | 32.00 | 1.23 |
| | $W_3$ | 20 | 7.65 | 6.30 | n.d. | 3.64 | 32.30 | 35.93 | 21.60 | 9.60 | 39.42 | 1.25 |
| | $W_4$ | 20 | 7.60 | 10.15 | n.d. | 2.60 | 70.30 | 41.17 | 25.92 | 16.72 | 70.08 | 1.35 |

n.d. = not detected

#### *4.5.3.2.Soluble cations:*

- ***Soluble calcium ($Ca^{2+}$):***

Cultivation as well as irrigation with all water qualities except for the control water $W_0$, resulted in accumulation of soluble $Ca^{2+}$ in both the clayey and sandy soils. The increases in soluble $Ca^{2+}$ content seemed corresponding to the used water contents of soluble $Ca^{2+}$. Cultivation of the sandy clay loam soil, however, caused soluble $Ca^{2+}$ content of this soil to decrease generally. Such a finding might be due to precipitation of $Ca^{2+}$ in the form of $CaCO_3$, or even $Ca_3(PO_4)_2$ due to the calcareous nature of such a soil. In all cases magnetization of the used waters caused soluble $Ca^{2+}$ content of the investigated soils to be lower as compared with the corresponding ones achieved due to usage of the non-magnetized waters.

- ***Soluble magnesium ($Mg^{2+}$):***

Soils contents of soluble $Mg^{2+}$ as influenced by irrigation with cultivation and irrigation with the studied water qualities whether as they are or after being magnetized as shown in Table (26). It is obvious that the soluble $Mg^{2+}$ contents of both the clayey and sandy clay loam soils increased regardless of the magnetization process which caused effect of the used waters an accumulation soluble $Mg^{2+}$ obviously lower than that the non-magnetized waters.

Soluble $Mg^{2+}$ content of the sandy clay loam tended to decrease as compared with the original $Mg^{2+}$ content of this soil. The increase was corresponding to the investigated waters content of soluble $Mg^{2+}$ i.e. it was highest upon utilization of Haris drain water ($W_4$), lowest upon irrigation with El-Bostan drain water and came in between when the irrigation was conducted using $W_2$ or $W_3$. Once again the magnitudes of increase in values of soluble $Mg^{2+}$ were reduced when the magnetized waters substituted the non-magnetized one for irrigation.

- ***Soluble sodium ($Na^+$):***

Values of soluble $Na^+$ tended to increase obviously in both the clayey and sandy soils due to cultivating them with the wheat plants and irrigation with all the used water qualities except for the tap water where soluble $Na^+$ tended to decrease when it was used for irrigation. Yet the magnitude of decrease was marked when this water was magnetized.

In case of the sandy clay loam soil, soluble $Na^+$ content increased to values higher than its original one. The increase coincided with the $Na^+$ content of the $Na^+$ i.e. it followed the order: $W_4 > W_3 > W_2 > W_1$.

- ***Soluble potassium ($K^+$):***

Soluble $K^+$ content, as it was expected, increased in both the clayey and sandy soils due to their cultivation and irrigation with all qualities of the irrigation water except for the control or the tap water ($W_0$). However, cultivation of the sandy clay loam soils resulted in decrease in its soluble $K^+$ content. The increments of soluble $K^+$ in both the clayey and sandy soils seemed to be parallel to the corresponding $K^+$ content of the used waters. Magnetization of water, however, was of a slight effect on reducing accumulation of soluble $K^+$ due to irrigation with most of the used waters.