The effect of the time period among washes, the quality of the wash water, and the percentage of addition on the efficiency of washing salts in soil affected by salinity

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Abstract: Irrigated soils suffer in arid and semi-arid regions of the world, the problem of the accumulation of salts, not using sufficient washing water to remove the added salts with irrigation water. Also, the wrong irrigation practices and the poor quality and quantity of irrigation water, as well as the lack of an effective drainage system, contributes to increasing soil salinity. This field experiment was conducted, to study the effect of the time period among washes, the quality of wash water, and the percentage of addition on the efficiency of washing salts and reducing the electrical conductivity of soil affected by salinity. 3 breaks were specified between washes (5, 10 and 15 days), and two types of washing water (4 and 8 dS m^{-1}), and two percentages for addition (25 and 50%). Soil field operations were carried out, to perform the washing process with the washing system installed, the electrical conductivity of the soil filtrate was estimated by standard methods known, for depths 0-25, 25-50, 50-75 and 75-100 cm, during eight stages of washing. The results showed a decrease in the electrical conductivity values of the soil filtrate, according to the sequence of soil washing phases until the eighth washing limits, and the largest decrease in electrical conductivity values was during the first washing, compared with the subsequent washing stages, especially in the surface depths of the soil, as evidenced by the results, the high electrical conductivity values were at the depths of 50-75 cm and 75-100 cm, especially for the initial washing treatments, with the time period exceeding 5 days, the water quality is 4 dS m^{-1} and the addition rate is 50%, which gave the best washing efficiency at 0-25 cm depth, with a decrease of 77.69% after the first wash, and (16.51, 24.50, 9.16, 15.64, 10.54, 4.91 and 3.20%) after the second, third, fourth, fifth, sixth, seventh and eighth washings, compared to the first phase of washing, respectively.
Keywords: soil affected by salinity, rest period between washes, type of wash water, percentage of addition.

The research part of first author dissertation

Introduction:
Many lands in the world generally suffer, and irrigated lands in arid and semi-arid regions in particular, the problem of the accumulation of salts, not using sufficient washing water to remove the added salts with irrigation water, in addition to disturbing the water balance, leads to the movement of ground water through the soil pores towards its surface, results from its evaporation in the summer, especially the accumulation of salts in the root zone and soil surface (Ismail, 2000). Soil salinity contributes to a decrease in the growth and productivity

of plants grown under these conditions, a number of researchers pointed to the decline in the growth and productivity of crops, in the presence of high concentrations of salts in the root zone (Corwin *et al*., 2007; Kahlon *et al.*, 2013).

The reclamation process is the ultimate solution to the salinization problem, it is one of the most basic factors for the success of the saline soil reclamation process, to determine the optimal amount of washing water, or called the washing codification, which represents the volume of water needed to reduce the concentration of salts, to the extent that does not interfere with the effective depth of the plant's root zone. The excess salts in the soil are usually washed away in a pond method, depends on the basis of transporting salts down, under the conditions of saturated water flow, as the land to be reclaimed, after being well leveled, is divided into square or rectangular basins separated by earth seals, then it is immersed in water for a period of approximately 100 days to ensure the dissolution of the salts, provided that during this period the soil is dried (in the case of intermittent washing), because the permeability of the soil decreases as the washing process progresses, as the drying process leads to improved soil composition, increased its permeability rate and reduced the growth rate of microorganisms, presence on the soil surface reduces the rate of water tip, this process allows soil samples to be taken, to find out the extent of the decrease in its salinity rate (Ismail, 2000).

Ramos *et al.* (2012) indicates that the use of washing is standardized, has contributed to increasing humidity and washing salts in the soil. Khoshgoftarmaesh and Vakil (2003) found that two washes were used before planting a barley crop, reduced electrical conductivity from 67.1 dS m^{-1} before implantation to 7.1 dS m^{-1} after planting. Al-Busaidi *et al.* (2012) explained that the quantity and quality of the added water affected the distribution of salts in the soil, increased washing helped remove salts in the soil, the results showed that the norm of washing 25% of the added water in washing salts outperformed compared to the treatments (15 and 20%).

Many researchers have noted the superiority of the intermittent flushing method, by analogy with continuous washing to dissolve the salts present in the surface layer, and transmission with the movement of water to the depth and from it to places of puncture (Ismail, 2000). They also indicated that increasing the washing times in the intermittent washing method, showed greater efficiency in using less water (Ramos *et al.* 2012; Skaggs *et al*., 2004). In addition to that, increase the washing times, it increased the speed of washing salts from the soil (Zeng *et al*., 2013). Chu *et al.* (2016) indicated that increased water intake and washing times increased, it has contributed to reducing the salinity of the studied soil, especially in unsaturated soil conditions. Hoseini and Delbari (2015) show that water with electrical conductivity was 0.53 dS m^{-1} (a volume humidity of 0.25 to 5), can reduce the salt concentration in the soil by 85%, the soil does not need to add any reforms. Hussein *et al*. (2010) show that washing requirements increase, it has contributed to the increase in the decrease in soil salinity of the surface and subsurface layer, where the rate of soil salinity was 6.0 and 7.0 dS m^{-1} at the level of 40% addition to the surface and subsurface layer, respectively, significantly exceeded the level of additive 20%, which amounted to 8.3 and 7.7 dS m^{-1}, respectively.

To estimate the amount of water needed to wash unplanted soils, and reduce the salinity of the soil affected by salt to the appropriate level, improving plant growth conditions, so this study has been proposed, to demonstrate the effect of the difference in the time period between washes and the quality and percentage of wastewater addition, on the efficiency of washing salts in the soil under study.

Materials and methods:

The reclamation experiment was conducted in the fields of the Agricultural Research Station of the Faculty of Agriculture, Basrah University for the year 2018, to study the effect of the time period among washes, the quality of wash water, and the percentage of addition, on some of its chemical and physical properties, during washing process of clayey soil affected by salt. Soil samples were collected from depths 0-25, 25-50, 50-75 and 75-100 cm antenna, then it was sifted through a sieve of 2 mm holes, and the electrical conductivity of the saturated soil paste was measured for every depth. The physical and chemical properties of the soil were also estimated for the composite sample and shown in Table (1), according to standard methods adopted in Richards (1954) and Page et al. (1982), Jackson (1958), and Black (1965).

The study included the use of 3 time intervals between washes (5, 10 and 15 days), and two types of washing water (4 and 8 dS m^{-1}), and two percentages of addition (25 and 50% more than the field capacity of the soil). The land was plowed and the ground animal wastes sifted from a 4 mm sieve were added to the soil at a rate of 2% by weight

The land was divided into rows 3×3 m, shoulders covered with polyethylene, a height of 70 cm, a distance of 3 m between each of the two rows, with two plastic pipe-lined piezometers drilled in the middle of each row. The first was used to measure the change of ground water level during the washing stages, which reaches its depth below the ground water level. As for the second piezometer, it was lined with a plastic tube perforated on the sides and closed from the bottom with a plastic cover and a depth of 1 m, to identify the salinity of the water expelled from the washed soil.

The washing and irrigation system was installed (Figure 1), included a main pipe for feeding water and branch pipes for distributing water to the panels, with a valve installed for each panel. The field soil was divided into three equal parts (a rest period between washes is five days, a rest period was ten days, and a rest period was fifteen days). Each section is divided into 12 experimental units (2 washing water quality ×2 addition percentage ×3 refinement) for each section in the form of rows. The soil filtrate electrical conductivity was measured (1: 1), at depths 0-25, 25-50, 50-75 and 75-100 cm after each wash and for eight stages of washing, the water unit percentage was also calculated from the following equation:

$$Water\ unit\ ratio = \frac{\text{The amount of washing water}}{\text{Ecf} - \text{Eci}}$$

ECi= the electrical conductivity of the soil before the beginning of washing for any of the washing stages (dS m^{-1}).

ECf = the electrical conductivity of the soil after the end of each subsequent washing stage (dS m^{-1}).

The amount of washing water = the amount of water used for one wash (m^{-2} liter).

The experiment was designed as a splinter experiment, the data were analyzed statistically by using the SPSS statistical program to analyze the variance between the factors using the F test and the value of the least significant difference (R.L.S.D) under the 0.05 probability level for comparison between the averages of the studied treatments.

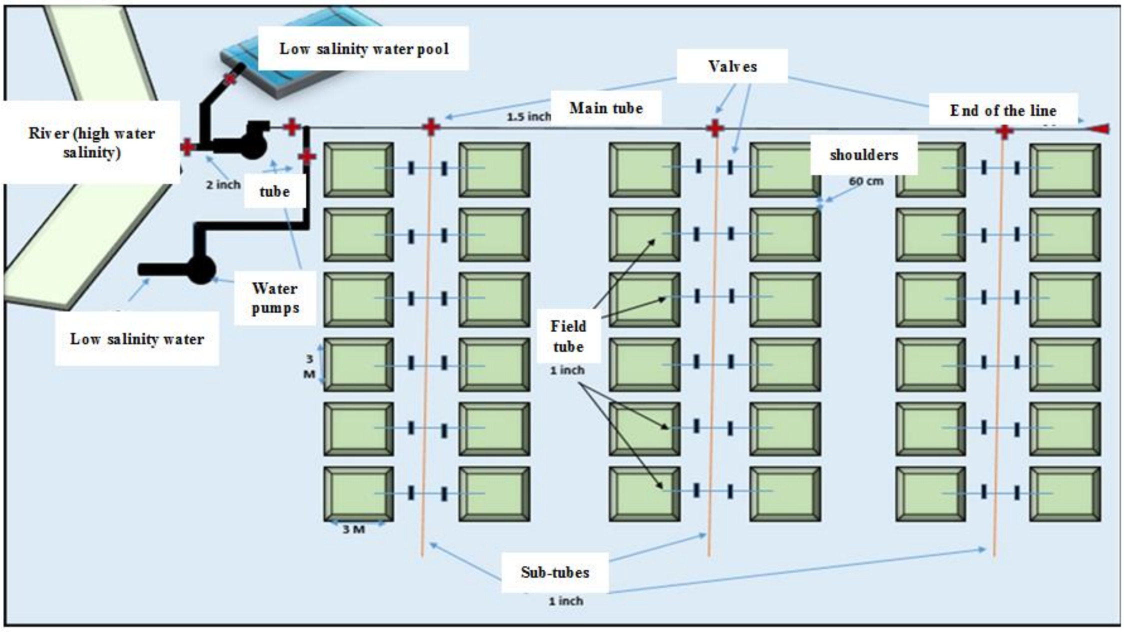

Figure (1) Scheme of the field experiment and the washing system used in the washing experiment.

Table 1: Chemical, Physical and Biological Properties of Soil Samples before planting.

Parameters		Unit	Amount
Sand		g. Kg^{-1} soil	119.10
Silt			248.70
clay			632.20
texture		Clay	
Weighted average diameter		Mm	0.202
Bluk density		µg. *m-3*	1.26
Particle *Density*			2.67
Total Carbonates		g. Kg^{-1}	310.0
Organic mater			9.10
porosity		%	52.80
Field capacity			30.29
Water saturated conductivity		cm. h^{-1}	1.20
E.C.(1:1)	**Depth 0-25cm**	ds.m^{-1}	105.50
	Depth 25-50cm		76.70
	Depth 50-75 cm		39.10
	Depth 75-100cm		30.70
pH		------	7.33
Dissolved ions	**Ca^{++}**	mmol. L^{-1}	80.00
	Mg^{++}		810.00
	Na^{+}		892.52
	K^{+}		32.17
	Cl^{-}		2600.00
	SO_4^{-2}		2.70
	HCO_3^{-1}		200.00
	CO_3^{-2}		0.00
Irrigation water properties	**Unit**	Low salinity water	High salinity water
E.C.	**ds.m^{-1}**	3.00-4.00	7.00-8.00
pH	**-----**	7.22	7.84
SAR	**----**	3.59	11.66

Results and discussion

Table (2) show that the results of the statistical analysis of F-test, significant effect of all the main factors represented by the factors (time between washes T, quality of wash water S, percentage of added wash water Q and depth of soil d), on the electrical conductivity values of the soil filtrate, for all the eight washing stages, except for the added washing water percentage factor (Q). It was not significant in the fourth, sixth, seventh and eighth washing, as for the bilateral, triple and quadruple interactions between these factors, the statistical differences between them varied.

Table (2) Analysis of variance for the tabular F values for the electrical conductivity of soil (E.C) during the phases of the washing process.

source	d.f.	E.C. 1	E.C. 2	E.C. 3	E.C. 4	E.C. 5	E.C. 6	E.C. 7	E.C. 8
T	2	133.256 *	33.337 *	20.180 *	9.289*	11.556 *	31.293 *	5.218*	4.395*
Q	1	28.927*	15.269 *	34.196 *	1.344 n.s.	9.945*	4.243 n.s.	0.013 n.s.	1.200 n.s.
S	1	74.253*	31.659 *	45.238 *	19.104 *	76.545 *	26.419 *	15.234 *	65.269 *
d	3	64.824*	44.335 *	51.718 *	40.690 *	80.619 *	35.870 *	20.592 *	40.582 *
T*Q	2	12.905*	10.279 *	16.677 *	0.639 n.s.	0.837 n.s.	4.063*	2.988 n.s.	4.129*
T*S	2	13.984*	5.485*	9.593*	11.756 *	15.459 *	0.187 n.s.	1.320 n.s.	5.965*
Q*S	1	18.837*	0.236 n.s.	0.047 n.s.	0.726 n.s.	9.729*	5.314*	42.956 *	55.224 *
T*Q*S	2	14.136*	7.006*	20.768 *	6.144*	8.241*	22.785 *	3.610*	19.500 *
T*S*d	6	1.340 n.s.	0.192 n.s.	0.206 n.s.	0.739 n.s.	3.961*	1.120 n.s.	0.445 n.s.	0.176 n.s.
T*Q*d	6	0.589 n.s.	0.195 n.s.	0.327 n.s.	0.165 n.s.	0.730 n.s.	0.748 n.s.	0.909 n.s.	0.698 n.s.
Q*S*d	3	0.244 n.s.	0.040 n.s.	0.733 n.s.	0.581 n.s.	1.046 n.s.	0.130 n.s.	1.327 n.s.	3.415*
T*S*Q*d	40	2.270*	0.943 n.s.	1.917*	1.079 n.s.	2.204*	0.952 n.s.	1.438 n.s.	3.484*

T = time between washes, Q = percentage of wash water added, S = quality of wash water
d = depth of soil, * = significant at the level 0.05, n.s. = Not significant

The results are illustrated in Figures 2 and 3, the effect of the factors of the time period between washes, the quality of the water and the percentage of its addition at depths 0-25 and 25-50 cm on the soil electrical conductivity (EC) values, respectively, these values decrease as a result of the washing operations, as the soil electrical conductivity values continued to decrease, respectively. The stages of soil washing up to the limits of the eighth washing, except for treatment T15S8Q25 (Figure 3A). The EC value has increased. At a depth of 25-50 cm, after the first washing, from 76.7 to 106.7 dS m^{-1}, due to the accumulation of salts at this depth in the first stage of washing because the added washing water is not sufficient to push it to further depths (Tagar *et al.*, 2010).

The decrease in EC values, it was more than possible during the first wash compared to the subsequent washing stages, for example, the EC value decreased. At depth 0-25 cm for treatment T5S4Q50 from 105.5 to 23.56 dS m^{-1} after the first washing (Figure B2), a decrease of 77.69%, while the EC values were. After the second, third, fourth, fifth, sixth, seventh and eighth washings (19.67, 14.85, 13.49, 11.38, 10.18, 9.68 and 9.37) dS m^{-1}, with a decrease of

(16.51, 24.50, 9.16, 15.64, 10.54, 4.91 and 3.20)%, compared to the previous wash, respectively.

As for the depth of 25-50 cm, the EC values decreased. For T5S4Q50 treatment of 76.7 dSM-1 prior to washing, to 26.14 dS m^{-1} after the first washing (Figure B3), with a decrease of 65.92%, whereas EC values were. After the second, third, fourth, fifth, sixth, seventh, and eighth washings 20.07, 14.48, 11.28, 10.09, 9.93, 9.65, and 9.08 dS m^{-1}, with decreased rates of (23.22, 27.85, 22.10, 10.55, 1.59, 2.82 and 5.91%) compared to the previous wash, respectively, this is a significant drop in EC values. After the first stage of washing compared to the subsequent stages of washing, due to the ECe being the rate, before washing it was very high (112 dS m^{-1}). Thus, the first washing led to the removal of the largest amount of salts from the soil body, as well as the high concentration of highly soluble salts at the beginning of washing, it concentrates in the large pores that the wash water passes through, cracks were formed through wetting and drying in the first stage of washing, contributed to encouraging downward movement of water (Dennis *et al.*, 2007).

The results also indicate the highest decrease in EC values, after washing operations, T5S4Q25 (Fig. 2A) was obtained at a depth of 0-25 cm, as well as treatment T5S4Q50 (Fig. 2B) at the same depth and Form 3B at depth 25-50 cm, the reason was that these two treatments have close periods of time (5 days) and a low quality of washing water (4 dS m^{-1}). Pierong *et al*. (2019) indicated a positive correlation between the efficiency of washing salts and increasing the amount of wash water, the study indicated that the highest salt washing efficiency was recorded for the treatment of a 6-day rest period, while the lowest efficiency was recorded for the 30-day treatment.

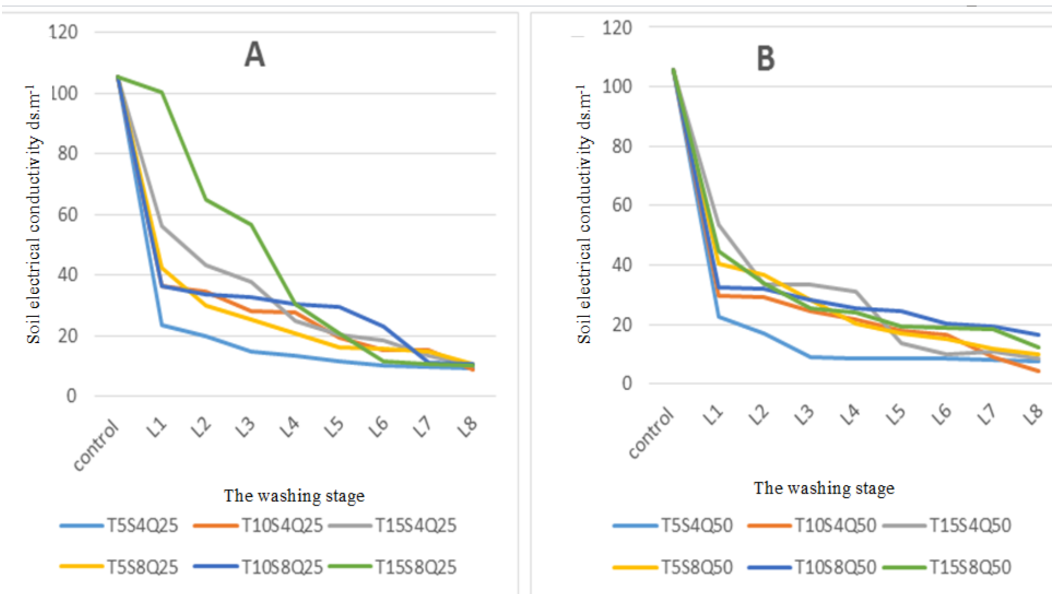

Figure (2) The effect of the time period between washes, the quality of the wash water, the percentage of water addition of 25% (A) and 50% (B) for depth 0-25 cm on the soil electrical conductivity values after the different washing stages.

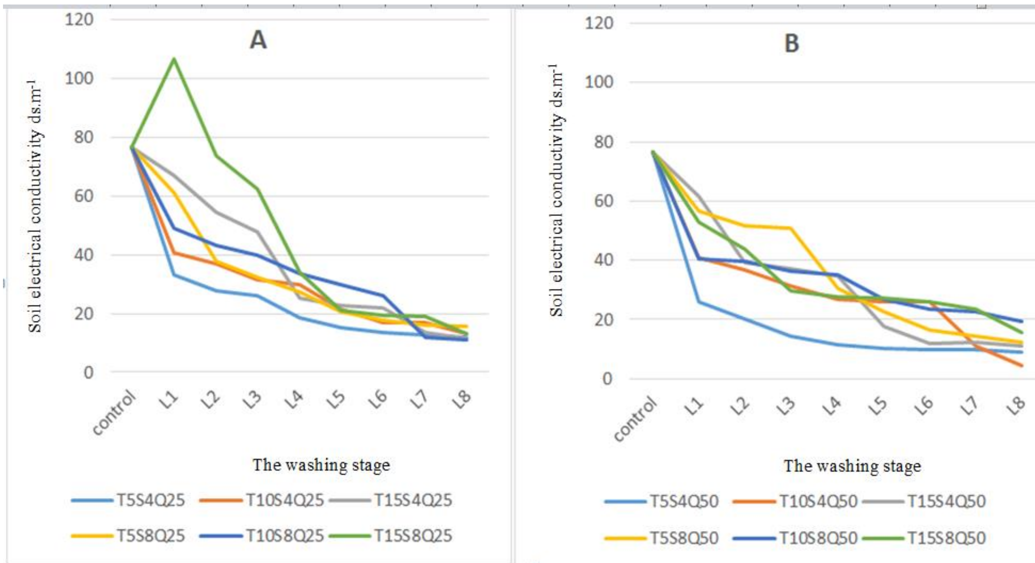

Figure (3) The effect of the time period between washes, the quality of the wash water, the percentage of water addition of 25% (A) and 50% (B) for depth 25-50 cm on the soil electrical conductivity values after the different washing stages.

As for the change of EC values. In depths 50-75 cm and 75-100 cm, a result of washing operations and for all study parameters, as shown in Figures 4 and 5 respectively, The results show higher EC values. At a depth of 50-75 cm (Figure 4) after the first washing stage, salinity begins to decrease. This increase is more pronounced by using factor Q25 (Fig. 4A), except for the two factors T5S4Q50 and T5S4Q25 (Fig. 4B and 4A) respectively. EC values decreased. Depending on after the eight stages of washing. The reason may be attributed to lower EC values. To the difference in concentration between the salinity present in the soil pools and the water flowing into the total pores, it decreases when the electrical conductivity of the water used in washing increases, which affects the desalination process (Tagar et al., 2007).

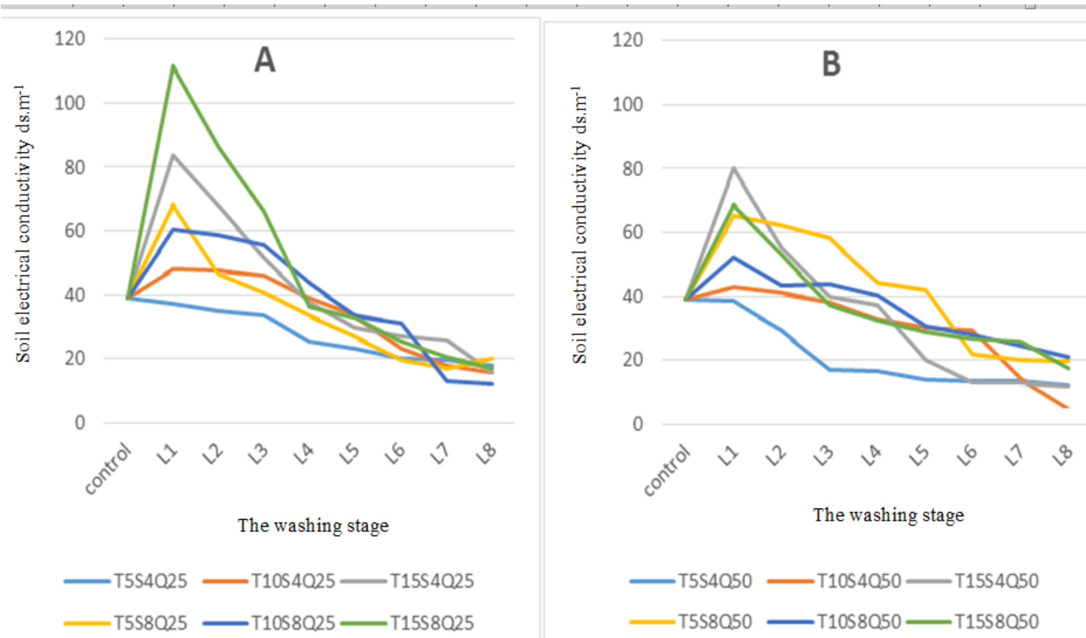

Figure (4) The effect of the time period between washes, the quality of the wash water, the percentage of water addition of 25% (A) and 50% (B) for the depth 50-75 cm, on the soil electrical conductivity values after the different washing stages.

As for soil depth 75-100 cm, the results show (Fig. 5) the high EC values, more than at depth 50-75 cm, especially after the first stage of washing, the reason for this height is at depths of 50-75 cm and 75-100 cm, due to allowing large quantities of water to flow into the surface layer of soil through large pores, while the movement in small pores of soil particles is much less, leads to its concentration in the depths far from the soil surface, consequently, the removal of salts within aggregates is slower at depths further from the surface (AL-Sibai *et al.*, 1997).

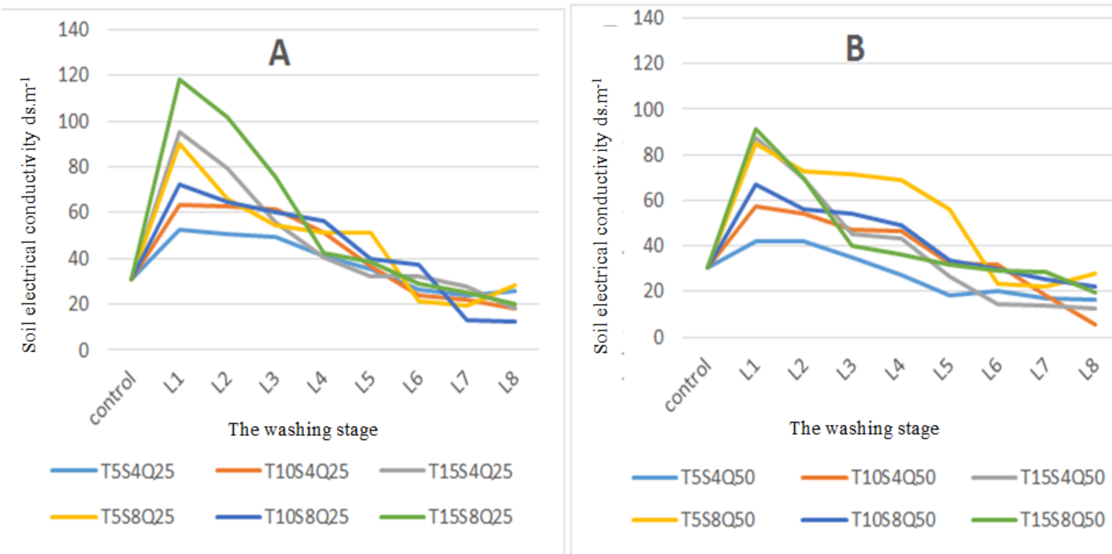

Figure (5) The effect of the time period between washes, the quality of the wash water, and the percentage of water addition of 25% (A) and 50% (B) for the depth of 75-100 cm on the electrical conductivity values of the soil after the different washing stages.

Table 3 shows the effect of experiment factors after the first stage of washing on the water unit percentage. The best percentage of water unit was recorded for the 5 day period between washes, by analogy with the transactions of the 10 and 15 day periods, it was also observed that the washing water quality of good quality (4 dS m^{-1}) gave the best water unit percentage (the lowest value), compare with the lower quality of wash water (8 dS m^{-1}), the water unit percentage values decreased with the decrease in the washing water addition percentage, so that the lowest values of the water unit percentage were recorded for the 25% addition percentage, compared to the 50% addition rate factors, was followed by the 10-day treatment period, exceeded it, especially when the wash water quality was 8 dSM -1 in both addition ratios. As for the effect of depth, it is noted from the results that there is an increase in the values of the unit water percentage with depth, indicates an increase in the accumulation of salts with depth due to the washing of salts from the surface layers to the depths with the movement of water. The negative numbers indicate the presence of saline accumulation and an increase in the salinity of the layer compared to the percentage of salts before washing. These results are consistent with the effect of the study factors on the soil electrical conductivity values after the eight stages of soil washing (Figures 2, 3, 4 and 5).

Table (3) The effect of the treatments on the water unit percentage after the first stage of washing (liter of dS^{-1} m^{-1}).

Time period between washes (day)	The quality of the washing water (dS m^{-1})	Wash water percentage (%)	Depth (cm)			
			0-25	25-50	50-75	75-100
5	4	25	6.34	11.93	284.03	-23.73
		50	7.53	12.34	989.95	- 54.23

	8	25	8.25	33.82	- 17.86	- 8.69
		50	9.58	31.34	- 23.96	- 11.55
10	4	25	7.53	14.45	- 70.91	-18.30
		50	8.24	17.47	- 70.08	- 19.00
	8	25	7.50	18.68	- 24.40	- 12.52
		50	8.51	17.25	- 32.35	- 17.32
15	4	25	10.48	54.14	- 11.64	- 8.08
		50	12.05	41.66	- 13.19	- 9.77
	8	25	—	- 17.33	- 7.16	- 5.94
		50	10.25	26.09	- 21.07	- 10.27

Table 4 shows the effect of experiment factors after the eighth stage of washing on the water unit percentage, the values of the water unit percentage increased in the eighth stage of washing compared to the first stage of washing, the patterns of the effects of the experimental factors coincided after the eighth stage of washing, with its effects after the first stage of washing in terms of high values of the water unit percentage for the treatments of the 5-day period, the quality of water 4 dSM-1 and the addition rate of 50%, as measured by the levels of other experiment factors. The higher values of the unit water percentage are due to the decrease in the change in the electrical conductivity of the soil between washes compared to the amount of wash water added. The positive values also indicate the efficiency of the added wash water in reducing the electrical conductivity of the soil depth under study, while the negative values indicate an increase in the electrical conductivity of the soil as a result of washing salts and their transfer from the soil surface to the lower depths of the soil.

Table (4) The effect of the treatments on the water unit percentage after the eighth stage of washing (liter. dS^{-1} m^{-1}).

Time period between washes (day)	The quality of the washing water (dS m^{-1})	Wash water percentage (%)	Depth (cm)			
			0-25	25-50	50-75	75-100
5	4	25	- 25.87	641.70	267.93	- 252.32
		50	- 22.30	1094.16	582.87	1075.29
	8	25	- 29.72	2887.67	- 185.64	- 58.40
		50	- 14.09	318.20	1641.24	- 113.19
10	4	25	- 13.48	137.87	219.32	136.78
		50	- 6.83	96.54	67.06	48.27
	8	25	- 15.54	1060.78	999.58	675.04
		50	33.00	225.97	- 132.98	- 95.36
15	4	25	39.26	270.72	51.82	54.54
		50	57.75	402.37	442.32	421.40
	8	25	396.78	93.15	147.66	102.93
		50	57.16	82.93	72.52	68.38

Reviewing the water unit percentage values after the first and eighth stages of washing (Table 2 and 3), the following:
At the first stage, the effectiveness of the washing process was very high, especially at the first depth (0-25 cm), this was evident from the low values of the unit water percentage, and in contrast, there was a pool of salts at depths of 75-100 cm and 50-75 cm, due to the movement of the washing water downward, carrying the dissolved salts to the lower layers, hence higher values of unit water percentage. The results also indicated that the washing process was superior (in general) in the period of 5 days and 10 days for the first depth 0-25 cm (in which the values were somewhat close), compared to the 15-day period, when the

values of the water unit percentage were high, which indicates the slow effect of the salt washing process.

The 5-day period at 4 dS m^{-1} of water quality at first depth showed the best salinity reduction, by analogy with the 10-day period at the same transactions, whereas, the opposite occurred when the water quality was 8 dS m^{-1}.

At the fifth stage (Table 5) there appeared a decrease in the effectiveness of washing salts compared to the first stages, as the values of the water unit ratios increased at 0-25 cm depth, there was an improvement in the washing process for depths of 50-75 cm and 75-100 cm for all treatments. The effect of washing to remove salts was greater for the 15-day period compared to other periods. As for the sixth and seventh stages, there was a continuation of washing the salts in varying proportions that vary according to different treatments and according to the depths, this washing was increased with an increase in depth through a decrease in the water unit percentage values, it also showed the values of unit percentages of water. The washing process in the eighth stage was useless at the time periods of 5 days and 10 days, if these values were negative, which means that there is a rise (accumulation) in the amount of salts compared to the seventh stage at a depth of 0-25 cm, whereas, the washing and distribution of the salts with the depths continued to be better during the 15-day period for both washing water quality, from this we conclude that the eighth washing is no longer necessary and required for the 5 and 10 day periods.

Table (5) Table of the effect of the coefficients on the percentage of the unit of water after the fifth stage of washing (liter of dS^{-1} m^{-1}).

Time period between washes (day)	The quality of the washing water (dS m^{-1})	Wash water percentage (%)	Depth (cm)			
			0-25	25-50	50-75	75-100
5	4	25	55.41	164.49	221.18	86.63
		50	-331.74	524.09	225.97	76.24
	8	25	119.49	77.93	79.72	3057.53
		50	63.77	78.25	288.74	47.75
10	4	25	27.44	63.70	99.38	35.24
		50	54.33	1326.96	255.60	43.25
	8	25	28.70	135.71	51.46	31.26
		50	24.43	75.78	64.97	40.68
15	4	25	21.03	181.74	64.97	65.05
		50	35.28	37.08	36.41	37.23
	8	25	27.34	40.32	145.60	146.42
		50	40.06	1641.24	180.25	127.80

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