The Effect Of The Time Period Among Washes, The Wash Water Quality And The Percentage Of Addition On The Bulk Density Values And Weighted Mean Diameter Of Salt-Affected Soil

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Abstract: Irrigated soils suffer in arid and semi-arid regions of the world, from the problem of the accumulation of salts for not using sufficient washing water in quantity and quality to remove the added salts from the soil body, wrong irrigation practices and poor quality and quantity of irrigation water, there is no effective drainage system that contributes to increasing soil salinity. This field experiment was conducted to study the effect of the time period between washings, wash water quality, addition percentage on the values of bulk density and weighted drop rate of soil affected by salinity. As 3 breaks were specified between washes (5 and 10 15 days), two types of washing water (4 and 8 dS m^{-1}), and two percentages for addition (25 and 50%). Soil field operations were conducted in order to apply all study treatments. The bulk density and weighted mean diameter were estimated for depths 0-25, 25-50, 50-75 and 75-100 cm after the end of soil washing. The results showed that the time period exceeded 10 days, the quality of water was 4 dS m^{-1} and the percentage of addition was 50% on reducing soil bulk density values, compared to other levels, the bulk density values increased with increasing soil depth and they were 1.43, 1.52, 1.57 and 1.63 mg m^{-3}, for depths 0-25, 25-50, 50-75 and 75-100 cm respectively. As for the weighted average diameter values, the largest values appeared at the 15-day time period, the water quality of 8 dS m^{-1} and the rate of addition of 50%, compared to other levels. As the values decreased, the soil depth increased by 0.31, 0.22, 0.20 and 0.14 mm, for depths 0-25, 25-50, 50-75 and 75-100 cm, respectively.
Keywords: soil affected by salinity, washing, bulk density, weighted average diameter.

The research part of first author dissertation

Introduction

Many lands in the world suffer in general, and irrigated lands in arid and semi-arid regions in particular of the problem of the accumulation of salts in it for 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, which results from its evaporation in the summer, especially the accumulation of salts in the root zone and the 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, the presence of high concentrations of salts in the root zone (Corwin et al., 2007; Kahlon et al., 2013).

Soil washing process during the reclamation process affects soil properties, many researchers the superiority of the intermittent washing method by sinks, with continuous washing to dissolve the salts present in the surface layer, its transfer 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.*, 2006). In addition, the increased washing times increased the speed of washing salts from the soil (Zeng et al., 2013). Al-Qaisi (2000) also noted that washing soils affected by salt with salt water, resulted in a very low soil bulk density and weighted drop rate at the final stages of washing.

Al-Nabulsi (2001) studied the effect of water quality and frequency of washing on the physical properties of soil, found that the salt water caused a decrease in water tip and soil permeability. The bulk density values increased when using high salinity water for washing, decreases with depth as it reached 1.59, 1.54 and 1.52 mg. m^{-3} for depths 0-10, 20-10 and 30-20 cm. The total soil porosity decreased in the surface layer 0-10 cm compared to the other layers. Tedeschi and Dell (2005) also found a clear decrease in soil aggregation stability with an increase in soil salinity and wash water used for reclamation. A very large inverse relationship appeared between soil stability and percentage of sodium exchanged (ESP), whether samples were taken in the fall or spring. Rainfall in autumn and spring has led to a drastic decrease in soil salinity, which failed to affect ESP responsible for soil agglomeration dispersion, building soil not being formed for agricultural purposes.

In a study by Huang et al. (2010), to demonstrate the effect of washing with different water types with electrical conductivity, on the physical and chemical properties of alluvial mixture soil taken from the study site, in the Minqin Basin in northwest China

They found a decrease in the total porosity from 13.17% to 7.23% and the stability factor of soil aggregates at a rate of 4.75-2 mm. At a depth of 0-20 cm from the soil surface, by increasing the electrical conductivity of the wash water added during washing.

Estimating the amount of water needed to wash unplanted soils, reducing salinity of the soil affected by salt to an appropriate level and improving plant growth conditions, this study was proposed with the aim of demonstrating the effect of the difference in the time period between washes and the quality and percentage of the addition of wastewater, on the values of bulk density and weighted mean diameter 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 the wash water, and the percentage of addition on some of its chemical and physical properties during the washing process for clay textured soils affected by salinity. 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. Soil bulk density and weighted drop rate were measured and the depths above were calculated at the end of the washing experiment.
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.

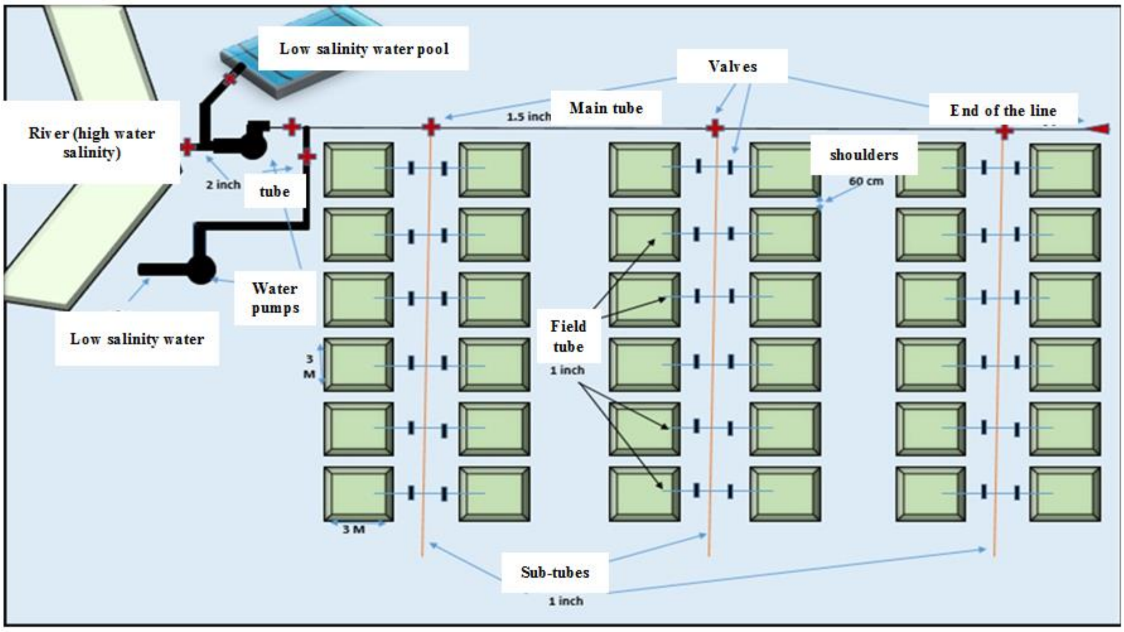

Figure (1) Scheme of the field experiment and the washing system used in the washing experiment.

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

Figure 2 and Table 2 show that there is a significant effect of the time interval between washes after the end of washing on the soil bulk density values (pb), as the treatment of the 10-day period exceeded significantly on the rest of the time interval coefficients reduce the values of pb, which gave the lowest value of 1.51 mg. m^{-3}, while there was no significant difference between the 15-day and 5-day period transactions, which amounted to 1.54 and 1.56 mg. g^{-3}, respectively. The reason is that a 10-day period may be the best in not deteriorating soil aggregates, due to the convenience of drying and moistening periods during this period of time in maintaining the soil structure, in addition to the fact that large quantities of washing water degrade soil aggregates and reduce the overall porosity of the soil, the alternation of drying and moisturizing. It may cause mud to swell and expand, which improves soil porosity and thus reduces soil bulk density. Al-Zubaidi (1992) indicated a preference not to use high washing standards when washing saline soils in order to avoid negative effects on soil properties as a result of washing.

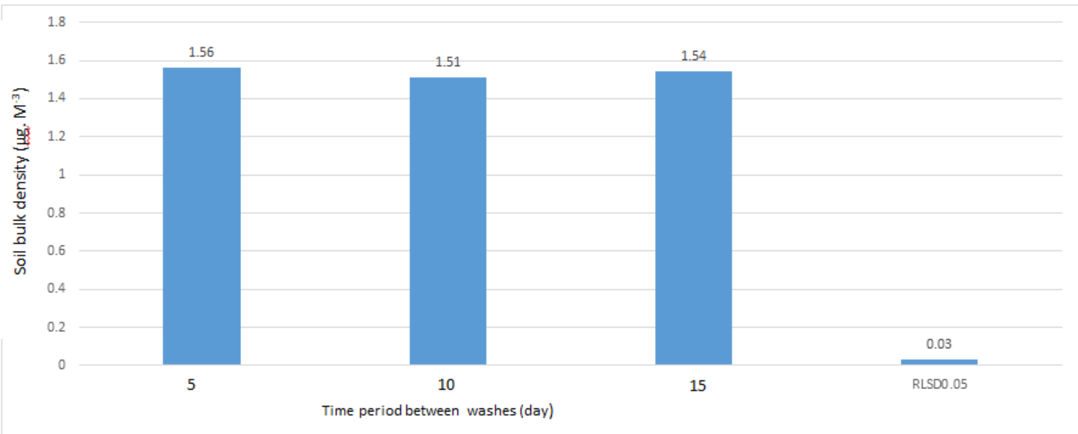

Figure (2) The effect of the time period between washes after the end of the washing process on the soil bulk density values.

Table (2) Analysis of variance for tabular F-values for the values of physical properties of soil after the end of soil washing.

source	**d.f.**	**Soil bulk density**	**Weighted average diameter of soil**
T	2	4.594 *	34.531 *
Q	1	17.220 *	122.485 *
S	1	10.112 *	39.442 *

d	3	48.804 *	99.863 *
T*Q	2	7.566 *	9.750 *
T*S	2	4.665 *	0.651 n.s.
Q*S	1	0.033 n.s.	10.387 *
T*Q*S	2	3.354 *	0.475 n.s.
T*S*d	6	1.843 n.s.	1.167 n.s.
T*Q*d	6	0.608 n.s.	2.096 n.s.
Q*S*d	3	0.237 n.s.	8.057 *
T*S*Q*d	6	0.321 n.s.	2.355 n.s.

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

Fig. 3 and Table 2 show the significant effect of wash water quality after the end of the washing process on the pb values of the soil. The water quality was 4 dSiMs-1 significantly higher than the water quality 8 dm^{-1} in reducing the b values by 1.52 and 1.56 mg m^{-3}, respectively, due to the negative impact of the high salinity of the wash water on the degradation of soil aggregates and the decrease of soil water tip, in addition to the effect of monovalent single cations such as sodium, negatively on the physical and hydraulic properties of the soil, causes the swelling of the inner layers of clay soil, the separation of small particles of clay from the building units of the soil, agreed with Al-Nabulsi (2001) who showed that the values of b increased when high salinity water was used for washing.

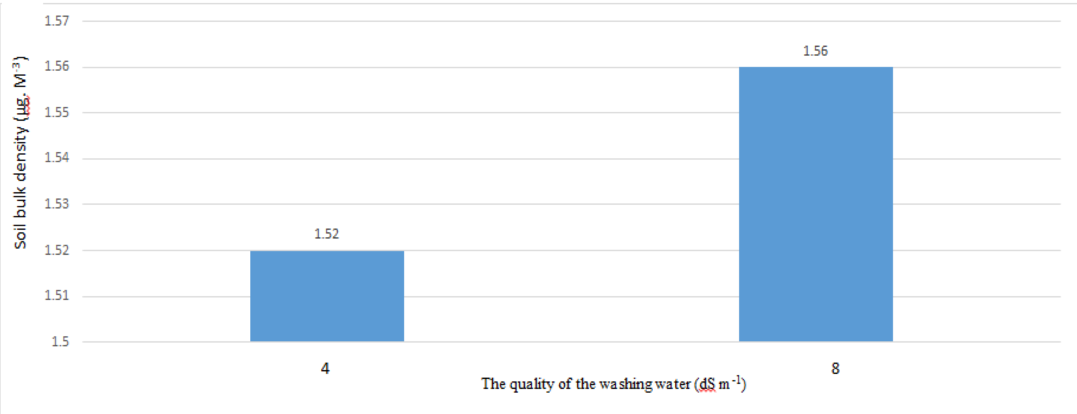

Figure (3) The effect of washing water quality after the end of the washing process on the soil bulk density values.

Figure 4 and Table 2 show the significant effect of the percentage factor of wash water added after the end of the washing process on the values of pb for soil, as it was evident from the results, the percentage of addition exceeded 50% significantly (1.51 µg m^{-3}) in reducing the value of b compared to the percentage of addition of 25% (1.57 µg m^{-3}). The reason may be that the effect of large quantities of washing water leads to better washing of salts from the soil body and a decrease in sodium ions, thus preserving the soil structure and preventing crack formation due to drought (Kamel and Bakry, 2009).

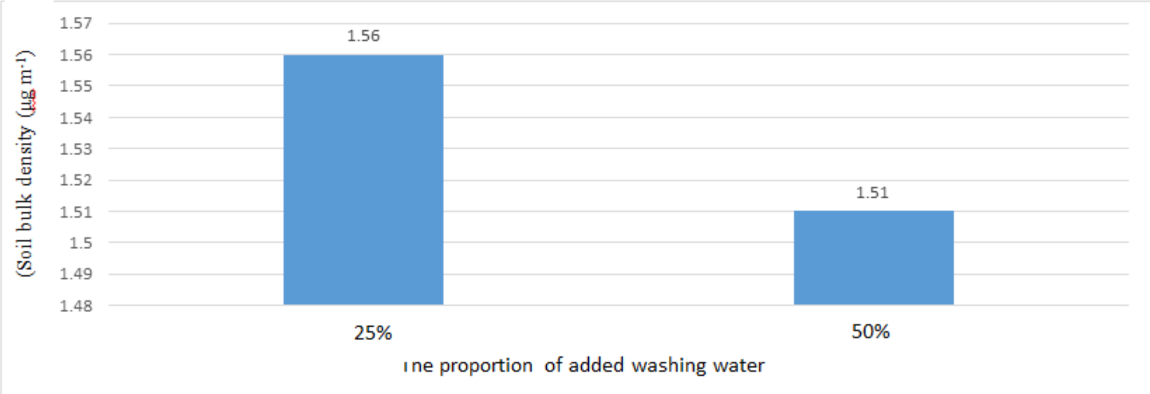

Figure (4) The effect of the percentage of wash water added after the end of the washing process on the soil bulk density values.

Figure 5 and Table 2 show the change of pb values according to the depth of the soil after the end of the washing process, there were significant differences in the values of pb between depths, the lowest value (1.43 mg. m^{-3}) was recorded at 0-25 cm depth, they differed significantly compared to the rest of the depths, which were the values of 1.52, 1.57 and 1.63 mcg m-3 for the depths of 25-50, 50-75 and 75-100 cm, respectively. The results also show that pb increases with depth. The reason for increasing the values of b with depth is the decrease in organic matter at lower depths, compared with upper depth (0-25 cm) (Table 1), as well as the effect of the weight of the upper layers, which increases with the depth increase, in addition to increasing soil salinity at the lower depths. Al-Hadithi *et al*. (2008) indicated that adding organic matter at a level of 2% to gypsum soil reduced the b of the soil from 1.50, 1.60 and 1.63 mcgm-3 to 1.44, 1.50 and 1.60 mg m^{-3} for depths 0-10 cm and 10-25 cm and 25-40 cm respectively, which is attributed to the role that organic matter plays in improving soil construction and increasing its porosity.

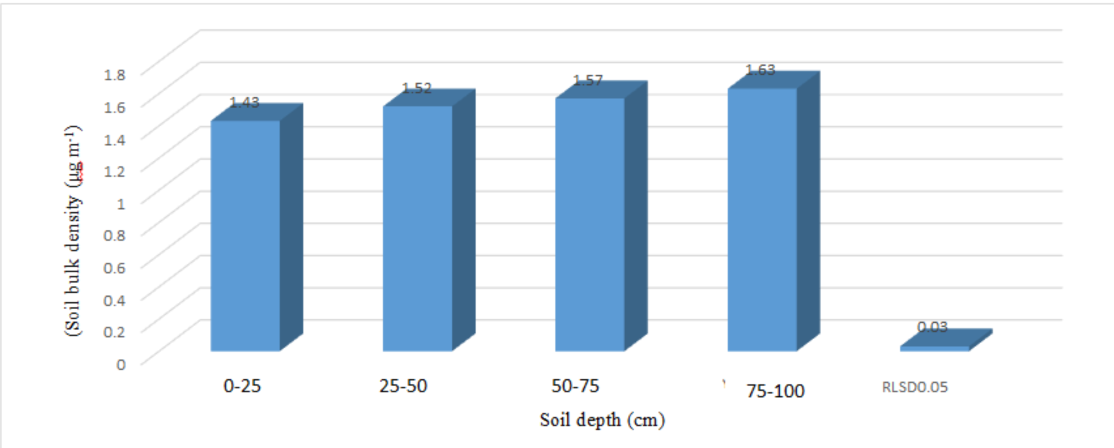

Figure (5) The effect of soil depth after the end of the washing process on the soil bulk density values.

Figure 6 and the statistical analysis of F-test (Table 2) show the significant effect of the bilateral interference between the time periods between washes and the wash water quality after the end of the washing process on the pb values of the soil, the 15-day period of washing water quality of 4 dS m^{-1}

significantly decreased the values of b over the rest of the parameters, gave the lowest value (1.50 mg. m^{-3}), while it did not differ significantly with the 10-day period coefficients, which amounted to 1.51 and 1.52 mg / m-3 for the quality of wash water 8 and 4 dSM-1, respectively. As for the largest value of pb, it was recorded for the 15-day period with a water quality of 8 dS m^{-1} (1.59 mg. m^{-3}), which did not differ significantly, in turn, with the same treatment of washing water, with a 5-day period between washes. The reason for the increase in the value of pb was when treating the 15-day and 5-day period with a water quality of 8 dS m^{-1}, to the effect of washed salts on the formation of pseudomonas and the poor physical properties of the soil, because the permeability of the soil decreases as the washing process progresses with an increase in the electrical conductivity of the added wash water (Al-Nabulsi, 2001). Kamel and Bakry (2009) reported that the percentages of salts removed from the second and third layers (10-20 and 20-30 cm), less than the surface layer (0-10 cm) at the beginning of washing due to the salt movement from top to bottom, which was attributed to the poor physical properties of the study soil at the end of the washing experiment.

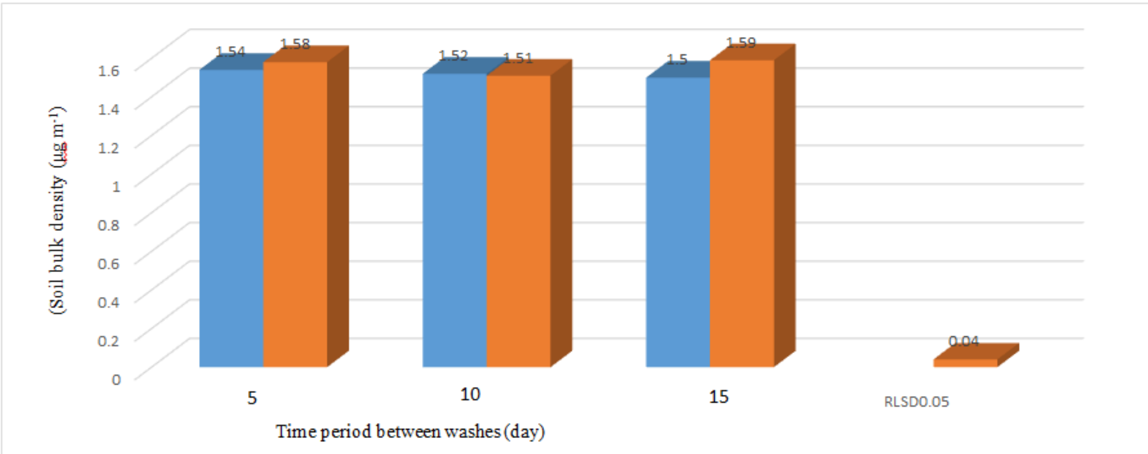

Figure (6) The effect of the bilateral interaction of the time period between the washes and the quality of the wash water added after the end of the washing process on the soil bulk density values.

Figures 7 and Table 2 show that there is a significant effect of the bilateral interaction between the time period between washings and the percentage of wash water added after the end of the washing process on the values of b for soil. As the lowest value was 1.49 mcg / m-3 for the 15-day period at an additional 50%, which did not differ significantly with the transactions of the 10-day period at the addition rates of 25 and 50%, they did not differ from the treatment of the 5-day period at the 50% addition rate, as it amounted to 1.51, 1.52 and 1.53 mg m^{-3}, respectively, while the largest value was 1.60 mcg / m-3 for the 15-day period at an addition of 25%. The excess of the 15-day period with the 50% addition rate may be due to the increase in soil moisture storage in this time period, compared to the 25% addition rate, contributed to preserving the soil building from degradation, agreed with Zeng *et al*. (2013).

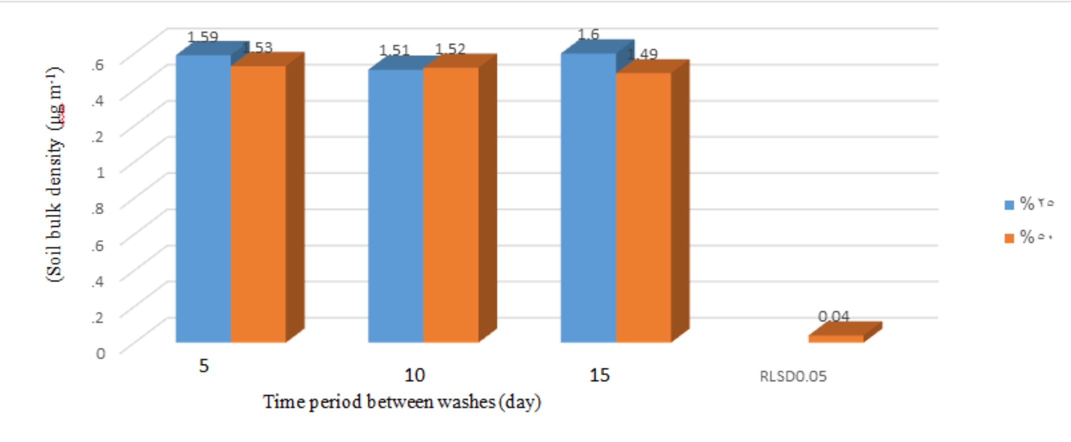

Figure (7) The effect of the bilateral interaction between the time period between washings and the percentage of wash water added after the end of the washing process on the soil bulk density values.

Table 2 shows that there are no significant differences for the effect of the bilateral interference between the wash water quality and the addition ratios after the end of the washing process on the b values of the soil.

Fig. 8 and Table 2 show that there is a significant effect of triple interaction among the time period between washes, the quality of the wash water, and the addition percentage after the end of the washing process on the values of pb for the soil. The lowest value was 1.45 mg. m^{-3} for the 15-day period, with a water quality of 4 dS m^{-1} and an addition rate of 50%. Which did not differ significantly from the two treatments of the 10-day time period for each of the water quality 4 dSM-1, the percentage of addition of 50%, and the water quality of 8 dS m^{-1} with an addition rate of 25% of 1.50 and 1.48 mg M-3, respectively, significantly outperformed the rest of the treatments, as for the highest value of pb, it was for the time period 15 days, the quality of washing water was 8 dS m^{-1}, and the rate of addition of 25% was 1.65 mg. m^{-3}, agreed with Emdad *et al.* (2006) regarding an increase in the values of the bulk density of the surface and subsurface layer of the soil by increasing the salinity of the irrigation water, as there was an increase in the values of bulk density of the surface and subsurface layer of the soil, with an increase in soil salinity from 2-6 dS m^{-1}, the increase was by (4 and 6%) respectively.

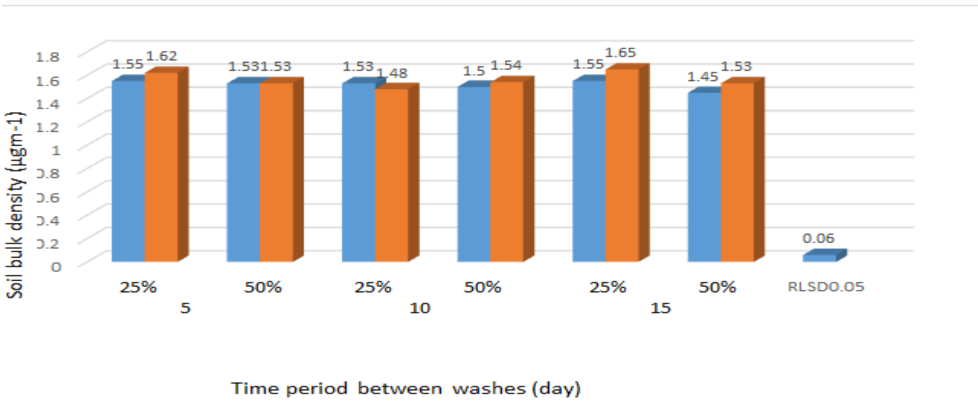

Figure (8) The effect of the triple interaction among the time period between washes and the quality and percentage of wash water added after the end of the washing process on the soil bulk density values.

Table 2 shows the a significant effect of the triple interaction among wash water quality, addition rate, and soil depth, time period between washings, wash water quality, and soil depth and time period between washings, washing water addition percentage and soil depth) as well as the quadruple interaction among experiment factors. with depth in b values after the end of the washing process.

The results in Fig. 9 and Table 2 show that there is a significant effect of the time interval between washings after the end of the washing process (after the eighth wash) on the weighted mean soil diameter values. As the 15-day treatment (0.26 mm) significantly outperformed the rest of the time periods, while the rest of the transactions showed significant differences between them and were by 0.21 and 0.18 mm for the 10-day and 5-day transactions, respectively. The reason for the decrease in MWD values in the shorter time periods may be due to the increased washing of salts, the lack of salinity as well as the lack of influence of single ions such as the sodium ion, which causes the dispersion of soil particles due to its radial radius (Al-Sadoun, 2006 and Daniel, 2008).

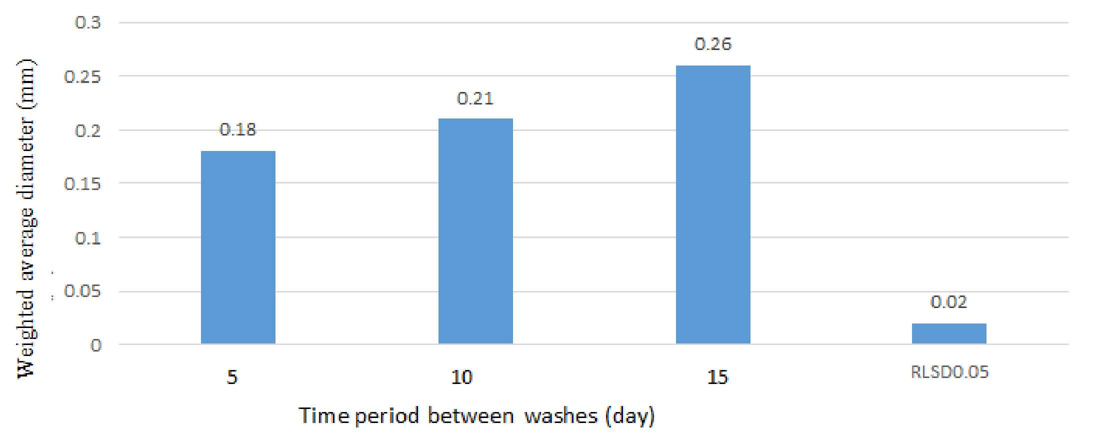

Figure (9) The effect of the time period between washes after the end of washing on the weighted mean soil diameter values.

Figure 10 and Table 2 illustrate the significant effect of the wash water quality factor after the end of the washing process on the weighted average soil diameter (MWD) values, the quality of washing water 8 dS m^{-1} was superior in giving the largest value (0.24 mm), differs significantly compared with the quality of washing water 4 dS m^{-1}, which amounted to 0.19 mm, with an increase of 20.83%, this can be attributed to the formation of false structures by salts in the soil, which deteriorates as the salts were removed and washed out of the soil bed during washing (Al-Halfi, 2016).

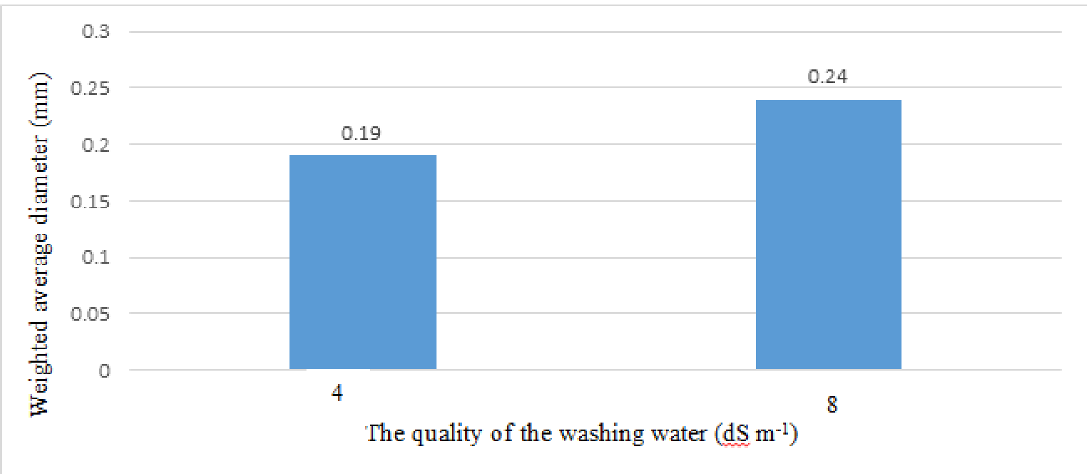

Figure (10) The effect of the wash water quality after the end of washing on the weighted average diameter values of the soil.

Figure 11 and Table 2 show that there was a significant effect of the ratio of wash water addition after the end of the wash currency on the MWD values of the soil, the largest value was 0.25 mm for the 50% addition rate, which was significantly superior to the 25% (0.18 mm) addition rate, with an increase of 28%. The addition of more than 50% may be due to the increase in soil moisture content, thus increasing the growth of microorganisms, contributes to increasing the decomposition of the organic matter added to the studied soil before the washing process, increases the formation of clusters and preserves the soil building from degradation (Al-Mousawi, 2007).

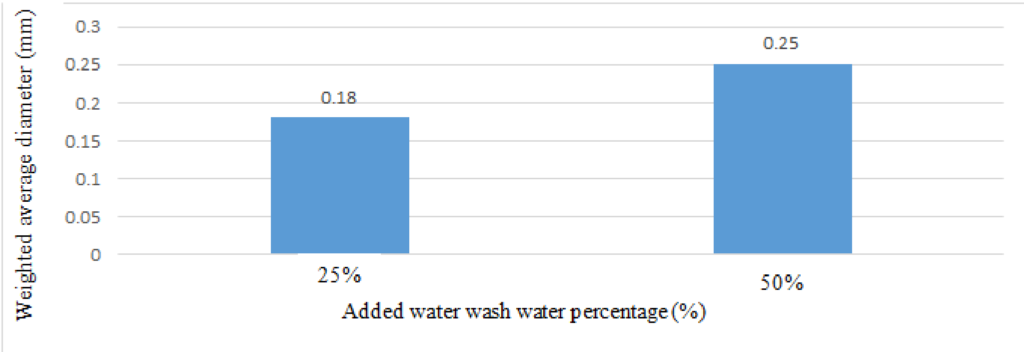

Figure (11) The effect of the percentage of wash water added after the end of washing on the weighted average diameter values of the soil.

To show the variation of MWD values according to soil depth, the results in Fig. 12 and Table 2 show a significant effect of this factor at the end of the washing process, when comparing the depths, it is noticed that the highest MWD values were at the depth 0-25 cm, with significant differences with the rest of the depths, reaching 0.31 mm. The results also showed that there were significant differences between the rest of the depths, which gave the values 0.22, 0.20 and 0.18 mm for the depths of 25-50, 50-75 and 75-100 cm, respectively. The lowest values were at depth 75-100 cm of washed soil aggregate, the MWD values decrease with increasing soil depth, this decrease of MWD values with soil depth is due to the decrease in the percentage of organic matter in the lower depths as well as the high salinity in these depths as a result of washing it from the higher depths, agreed with Hassan (2013) and Al-Hadi and Odeh (2014) who note that MWD values decrease with increasing depth.

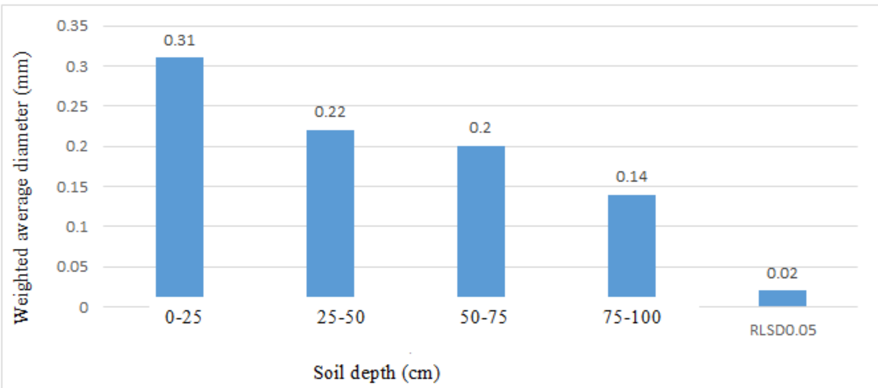

Figure (12) The effect of soil depth after the end of washing on the weighted mean soil diameter values.

Table 2 shows that there was no significant effect of the bilateral interaction between the time period between washes and the wash water quality after the end of the washing process on the soil MWD, to demonstrate the effect of the bilateral interaction between the time period between washings and the percentage of wash water added at the end of the washing process on the soil MWD, it appears from Figures 13 and Table 2 that there is significant interaction, the 15-day period exceeds the percentage of adding 50% significantly to the rest of the transactions, which gave the largest value by 0.31 mm, while the lowest value was 0.16 mm, was recorded at the time period of 10 days and 5 days at the rate of addition of 25%. The results that the transactions of the addition percentage were 50% significantly higher than the transactions 25% for each period under study, due to the effect of large quantities of washing water, which increases soil moisture and with long droughts, and in turn preserves the building of the soil, compared to the small amount of washing water and with close periods of drought. The 15-day period exceeding the time period is due to the suitability of this period in reducing soil salinity and dissolved ion concentrations, compared to the 5-day and 10-day time periods. As a result of the movement of water, dissolving salts, and its dispersal between the large and small pores of the soil, and thus moving them away from their sites (Jamali *et al.*, 2012).

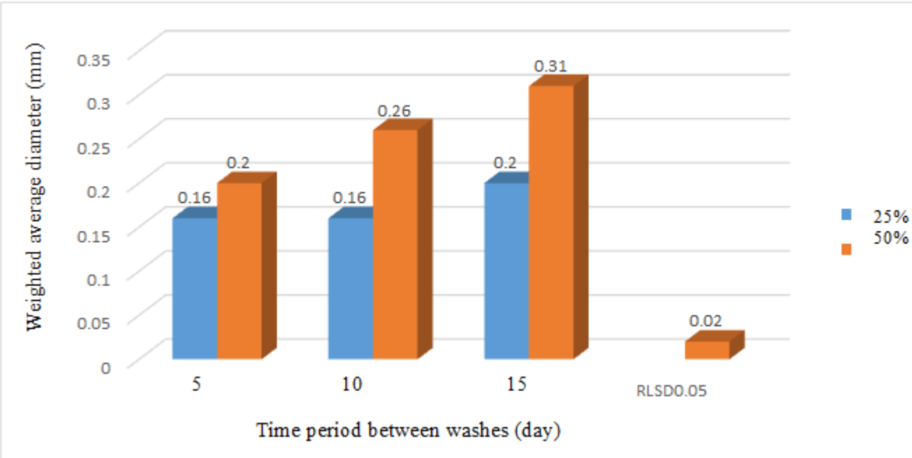

Figure (13) The effect of the bilateral interaction of the time period between washes and the percentage of wash water added after the end of washing on the weighted soil diameter ratio.

Fig. 14 and Table 2 show the significant effect of the bilateral interaction between the wash water quality and the addition percentage after the end of the washing process on the MWD values of the soil, whereas, the quality of the water, 8 dS m^{-1}, with an addition of 50%, gave the largest value with a rate of 0.29 mm, which showed significant differences with the rest of the treatments, which also differed between them, the lowest value was 0.17 mm for the quality of 4 dS m^{-1} water with an addition rate of 25%, may be due to the effect of high water quantities and high electrical conductivity washing water quality on increasing the activity of soil microorganisms, increasing the decomposition of the organic matter mixed with the soil prior to the washing experiment, which contributes to improving the formation of soil aggregates and maintaining the soil structure (Huang *et al.*, 2010).

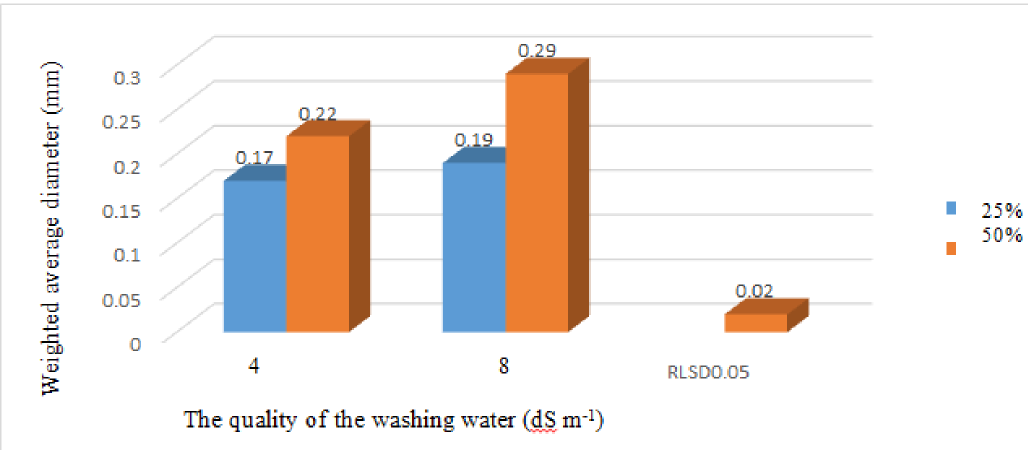

Figure (14) The effect of the bilateral interaction of the quality and percentage of wash water added after the end of washing on the weighted average soil diameter.

Table 2 shows that there were no significant differences due to the triple interaction between the time period between washes, the quality of wash water, and the percentage of addition after the end of the washing process on MWD soil.

The results shown in Fig. 15 and Table 2 show that there is a significant effect as a result of the triple interference between the washing water quality, the percentage of addition and the soil depth after the end of the washing process on the soil MWD, as the quality of washing water 8 dS m^{-1} with an addition rate of 50% at a depth of 0-25 cm was significantly superior to the rest of the treatments, which gave the largest value (0.47 mm), while the lowest value (0.11 mm) was for the quality of 4 dS m^{-1} water with an addition of 25% at the depth of 75-100 cm. The MWD values for the additive ratio are 50% compared to the 25% addition ratio factors, the quality of the washing water exceeding 8 dS m^{-1} at a depth of 0-25 cm is due to the negative effect of the sodium ion movement as a result of washing to the lower depths of the soil bed, the deterioration of its physical properties, especially the MWD of the soil, in addition to the decrease in the soil organic matter content with the depth before washing.

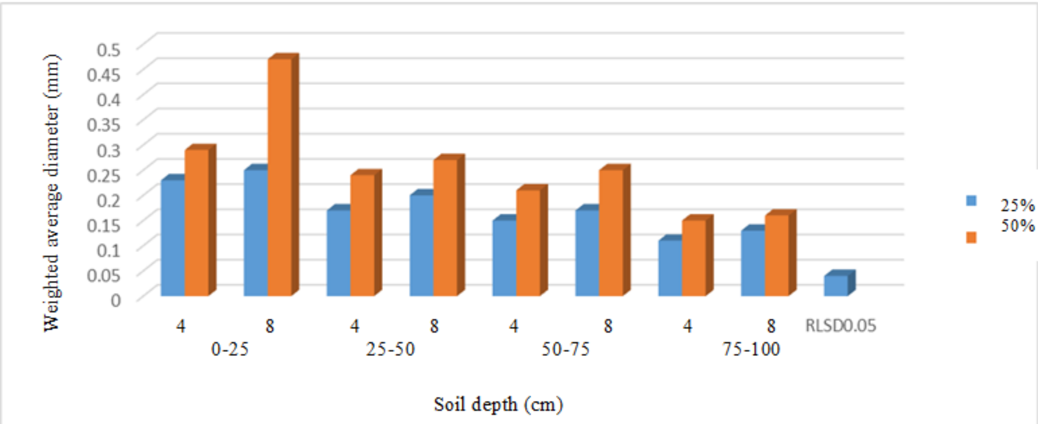

Figure (15) The effect of the bilateral interaction of the quality and percentage of wash water added after the end of washing on the weighted average soil diameter after the end of the washing process on MWD soil.

Table 2 shows that there is no significant effect after the end of the washing process in the MWD values of the soil due to the triple interaction between (time period between washings, wash water quality and soil depth) and (time between washings, percentage of added wash water and soil depth). Also, there was no significant effect of the interdisciplinary interactions between the factors of the time period between washes, the quality of the wash water, the percentage of addition and the depth of the soil.

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