Movement of water and salt accumulation in the soil as effected by emulsified and un emulsified crude oil

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ABSTRACT

A study was conducted to evaluate a proposed and modified method for the direct addition of oil derivatives to the soil surface as improvers after emulsion with irrigation water under conditions similar to the field conditions from moisturizing system, degrees of tillage and Pulverizing, its effect on the infiltration and Infiltration rate and the capillary movement of water upward, its relation to the moisture and salt distribution in the clay soil sector. The study factors were as follows: The first factor: soil pulverization index (represents the mean weight diameter (MWD) for soil blocks after plowing and Pulverizing) in two treatments, High pulverization index (P1) and low pulverization index (P2) with mean weight diameter amounted to (17.026, 10.511 mm), respectively. The second factor: the method of adding crude oil improvers (C) which included three treatments: The control treatment without adding (C0), non-emulsified crude oil treatment 0.5% w/w (C1), the emulsified crude oil treatment 0.5% w/w mixed with irrigation water by adding an industrial emulsifying agent (Anionic surfactant: Sodium Dodecyl sulphate coconut fatty acid) (C2). The third factor: primary moisturizing factor (W): represents the volume of used water in the added treatments (C0, C1, C2) to the soil in two treatments, the field capacity (W1) and the saturation ratio (W2). The results showed that the control treatment (C0) achieved the highest infiltration rate at the beginning of the measuring period for the first 10 min, which followed by the C1 treatment that decreases significantly from it, The lowest infiltration rate was shown at the C2 treatment, and with time progression to the end of the measuring period, the two treatment (C1, C2) showed an excelling in the infiltration rate compared to the C0 treatment and the highest values were found at the C2 treatment. The results showed that the highest values of sorptivity (S) and the lowest values of the transmissibility (A) that calculated from the (Philip, 1957b) equation at the control treatment (C0), the decrease in S values and increase in the A values were obtained in the crude oil treatment (C1). The highest decrease in S values and the highest increase in A values have appeared at the treatment of the emulsified crude oil (C2), an increase in S values has obtained by increasing the moisturizing level from W1 to W2, and an increase in S and A values with decreasing pulverization degree from P1 to P2. The results of the water movement upward showed that the progressing speed of the vertical moisturizing side for all treatments decrease significantly with time and away from the level of default groundwater. The control treatment (C0) showed the highest progressing speed and lowest time to reach the soil surface compared to the two treatments (C1, C2) and the lowest speed and the longest time to reach the soil surface was found in the C2 treatment. The decrease of the water movement speed upward has obtained with increasing the degree of pulverization from P2 to P2, while the differences were slightly between the primary moisturizing treatments W1 and W2. The results of the constants values ($\varkappa$, λ) that calculated from (Philip, 1957c) equation showed that the highest values for these constants were found in the control treatment (C0), with higher differences compared to the two treatments (C1, C2) and the highest reduction was found in the C2 treatment. An increase has obtained in the λ values with the decrease in the pulverization index from P1 to P2, while the increase in the λ values was slight with an increase in the primary moisturizing level from W1 to W2. The results showed that the moisture content in soil columns because of the vertical water movement upward decreased significantly by moving vertically away from the surface of default groundwater. The control treatment (C0) was significantly excelled on the two treatments (C1, C2) in moisture content and the lowest values were found at the C2 treatment with significant differences between the treatments. The differences between the treatment have increased by increasing the vertical height upward and increasing the pulverization degree from P2 to P1. Soil salinity showed the highest values at the layer directly above the default groundwater and the values decrease with increasing the height of the soil surface. A significant decrease in salinity has obtained at the two treatments (C1, C2) compared to the control treatment (C0) and the lowest values showed a significant difference at the C2 treatment. The significant differences between these equations increased with the upward vertical distance, the highest salinity accumulation occurred at the C0 treatment in the surface layer and the lowest at the C2 treatment.

Keyword: infiltration, crude oil, emulsified, salt accumulation.

1. INTRODUCTION

Soil improvers have been used from various sources, mainly Petroleum Derivatives, to improve physical and water properties such as water Infiltration, reduce surface evaporation and increase water retention capacity. where these materials cover the surfaces of soil particles and aggregations in whole or in part with hydrophobic complexes that increase the contact angle between water and these surfaces, which affects the forces causing the capillary water movement that effects on the water traits such as Water Infiltration and the electrical conductivity (Hartmann et al., 1983; Al-Hadithi, 1995). Al-Khafaji et al., (1985) and Hur and Keren, (1997) found that adding Petroleum Derivatives makes Soil aggregates more stable against water action, which helped to keep the water flow sections open during the flow, which increases the infiltration rate, base infiltration, cumulative infiltration, and the saturated hydraulic conductivity. Al-Obeid, (1997) found that adding Fuel oil at a concentration of 1% by spraying on the surface of clay loam soil or to a depth of 5 cm led to increasing the infiltration and infiltration rate with a ratio of 76%, compared to the control treatment. Gabriels et al., (1975), Shuhab, (1977) and Toogood, (1977) found that the mixing of fuel oil with the soil led to a slow water movement due to reducing the soil wettability because of the presence of hydrophobic substances. The increase of the adding level caused a limiting in the entry of water, the water movement and reducing the infiltration rate because of large distances in the soil filled with oil materials. On the other hand, the addition of Petroleum Derivatives led to the reduction of capillary water height due to the formation of hydrophobic surfaces on the soil particles and Aggregates, which reduces its moisturizing speed (Al-Dubaki, 1983). Al-Doori, (2002) found a decrease in the height of capillary water with a percentage of (73.64%) when adding fuel oil with a ratio of (1, 2, 4%) compared to the control treatment. The addition of Bitumen with the ratio of (0.5%) led to reducing the height of capillary water with a percentage of (70%) during the measuring period (Al-Hadi, 2014). Petroleum Derivatives containing compounds with high molecular weights such as crude oil, fuel oil, and bitumen are characterized by high viscosity, very slow permeability and very high soil absorption (Ivshina et al., 1998). On the other hand, many studies have indicated to the negative effects for the oil derivatives when adding or accumulating them at high concentrations in the soil surface or in microsites in reducing the number of microorganisms, enzyme activity, and plant growth (Talyer, 1976; Voets et al.,1977; Al-Ansari et al., 1998). Abdul-kareem, (2002) suggested that the level of permitted hydrocarbon compounds and does not cause damage to organisms and plants should not exceed (0.5% w/w). In order to reduce the harmful effects for the oil derivatives, In the previous studies, different methods have been used, including spraying the outer surfaces of the soil blocks with a fine spraying without soaking them (Hillel, 1980) or using the method of mixing these materials with soil after mixing them with water (Nedawi, 1998; Abdul-kareem, 2002; Al-Hadi and Al-Atab, 2005) or using a dilute mixture by using organic solvents (Al-Maleky, 2005; Al-Saraji, 2006). However, the applications of these methods are still limited in small areas. Oil derivatives are characterized by its a liquids has no ability to form a stable and homogenous mixture with water that can be directly added to the surface of the soil to achieve the highest homogeneity in the distribution of improver in the soil sector, which can improve the physical and water properties and reducing the adverse effects of oil derivatives on soil microorganisms and plant. Duck, (1966) explained that water and oil are immiscible liquids and that a stable and homogeneous emulsion is formed due to the raise the surface tension of the water and the presence of capillary pressure for the water that generates tension between the oil droplets to form larger droplets after fusion or coagulation, and the emulsion becomes non-homogeneous. Martin, (1981) noted that water and oil can be mixed and have a stable emulsion by adding emulsifying agents, reducing the surface tension between the two liquid. The composition of its molecules consisting of hydrophobic groups and hydrophilic groups dissolves hydrophobic groups in the surface of oil droplet and the hydrophilic groups moves out toward the water phase to dissolve in it. An interfacial film is formed between the two liquids and the strength of this film prevents oil droplets from the coalescence process together due to repulsion between droplets due to the similarity in the charge depending on the type of emulsifying surfactants was anionic or cationic or amphoteric. The stability and homogeneity of the oil/water (o / w) emulsion is increased by the reduction of the volume of the oil droplets by about 2 μm, This depends on the appropriate concentration for the emulsifying agent to prevent the coagulation of the oil droplets and to maintain the highest homogeneity for the emulsion (Hermann et al., 2001). In the present study, the efficiency of adding oil After its emulsification with water will be evaluated as a proposed method for the direct addition of the soil surface under two levels of pulverization degree for soil and Primary moisturizing in (I) the water movement of from the top to the down (ii) the water movement from the bottom to the top in the soil sector and its impact on the distribution of moisture content and salinity distribution and their accumulation in the soil sector.

2. MATERIALS AND METHODS

This study was conducted in the field of the College of Agriculture, University of Basra, on the Garmat Ali location on newly reclaimed sedimentary clay soil (Clayey, mixed calcareous hyperthermic typic torrifluverts class) (Al-Atab, 2008). A sample was taken from field soil to a depth of (0-30 cm) for conducting the physical and chemical analysis as shown in Table (1).

Table 1: Some physical and chemical traits of soil for a depth of (0- 30 cm).

Soil properties			The value
Bulk density ($mg.m^{-3}$)			1.22
Particle density ($mg.m^{-3}$)			2.66
Porosity (%)			54.10
MWD (mm)			0.42
Sand ($g.kg^{-1}$)			54.90
Clay ($g.kg^{-1}$)			337.70
Silt ($g.kg^{-1}$)			607.40
Texture class			clay
Field capacity ($gm.gm^{-1}$)			0.33
Saturation percent ($gm.gm^{-1}$)			0.50
PH			7.41
Organic matter ($gm.kg^{-1}$)			3.61
Total carbonate ($gm.kg^{-1}$)			326.78
Ece ($dS.m^{-1}$)			2.30
Soluble ions	Ca^{2+}	μmole L^{-1}	10.01
	Mg^{2+}		7.02
	Na^{+}		25.22
	K^{+}		2.38
	SO_4^{2-}		23.22
	Cl^{-}		46.34
	CO_3^{2-}		0.00
	HCO^{3-}		2.47
Irrigation water	Ec_w ($dS.m^{-1}$)		1.80
	PH_w		7.00
Derange water	Ec_w ($dS.m^{-1}$)		10.00

Using the analysis methods described in (Black et al., 1965; Page et al., 1982),The study included three factors in factorial experiment with three replicates: The first factor: soil pulverization index (P),which included two treatments, high Soil Pulverization Index (P1) treatment, which was reached by conducting two perpendicular plowings using the Moldboard Plow and then smoothed once using disc harrows, low soil Pulverization Index (P2) treatment which conducted by doing two perpendicular plowings and twice smoothing process. The Pulverizing index amounted as a mean weight diameter for the soil block (17.062, 10.511 mm), respectively for the two treatments (P1, P2) according to the method mentioned by (Hillel, 1980), using sieves with different diameters through which the soil is passed, the weights of the assembled models above each sieve are calculated as shown in Table (2). The second factor: the method of adding crude oil improvers (C) which included three treatments: The control treatment without adding (C0), non-emulsified crude oil treatment 0.5% w/w (C1), the emulsified crude oil treatment 0.5% w/w mixed with irrigation water by adding an industrial emulsifying agent (Anionic surfactant: Sodium Dodecyl sulphate coconut fatty acid) (C2), with the concentration of the emulsifying agent in the mixture amounted to (7 µmole) according to (Hermann et al., 2001), the characteristics of the used crude oil are shown in Table (3). The third factor: Initial moisturizing factor (W): in two treatments, the field capacity (W1) and the saturation ratio (W2) that represents the volume of water directly added to the control treatment (C0) or the prepared mixture in the C2 treatment and the emulsion in the C3 treatment that calculated from the results of Table (1), the moisture content at field capacity (PW = 0.33) and saturation ratio (PW = 0.50), and the water added only in the C0 treatment. In the two treatments (C1, C2), an electrical mixer was used to distribute crude oil into small droplets before adding it to the soil surface. In the treatment of C2, The mixing was conducted in two stages, the first one before and after adding the emulsifying agent to obtain a homogeneous and stable emulsion of oil-in-water (o / w) emulsion, where Crude oil droplets are scattered in the continuous water phase.

Table 2: Rating method of MWD soil clods as indexes for soil pulverization factor.

Sieves ranges	**Mi: the average of sieves range (mm)**	Wi: the weight of residual soil (kg) on the sieves		Xi: the average of percentage ratio=(wi*mi/∑wi)	
		P_1^*	**P_2^{**}**	**P_1**	**P_2**
120 -90	(120+90)/2 =105	0	0	0	0
90 -70	(90+70)/2=80	1.17	0	0.967	0
70 – 50	(70+50)/2=60	3.16	1.59	1.94	0.97
50 -30	(50+30)/2=40	17.47	6.77	7.22	2.75
30 – 10	(30+10)/2=20	20.58	16.51	2.55	3.36
10 -2	(10+2)/2=6	40.08	52.50	2.48	3.20
< 2	2/2=1	15.28	20.84	0.15	0.21
∑wi		97.74	98.22		
MWD=∑Xi				17.02 mm	10.51 mm

*p_1 high pulverization index treatment

** p_2 low pulverization index treatment

Table 3: Some characteristics of crude oil from southern Rumiala field/Basra Iraq.

The characteristics		**The value**
Specific weight at 21.1C^0		0.8562
Water content (v/v %)		Nil
Sulphric content (w/w %)		1.90
Carbon content (w/w %)		4.48
Wax content (w/w %)		3.10
The pouring point (C^0)		-15.00
Viscosity (cSt)	At 21.1 C^0	10.96
	At 37.8 C^0	6.43
Initial boiling point (C$^{0)}$		40.00
Total distillation ratio (v/v %)		48.50

The first experiment included estimating the water movement from the bottom to top by the capillary action and it conducted in experimental units represented by soil columns placed in the transparent plastic cylinders, open from both sides with a diameter of 15 cm and length of 60 cm. After placing a glass wool barrier at the lower end to prevent soil erosion, The soil was gradually added to the cylinders with the strike on the sides of the cylinder to reach a soil column with a 50 cm long and density of (1.20 mg.m-3). An 18 soil columns were filled from the surface layer for the field soil with high pulverization index (P1) and 18 other soil columns from field soil with low pulverization index (P2). The improved oil treatments (C0, C1, C2) were then applied using water volumes according to the treatments (W1, W2). All columns were then air-dried to complete the Coalescence process, namely the loss of water surrounding the crude oil droplets to form a continuous membrane of crude oil on the surface of soil clusters and particles (Martin, 1981). All the columns were then placed in the groundwater basin with the electrical conductivity (EC_w = 10 $dS.m^{-1}$) to a depth of 10 cm. The water movement from bottom to top was measured by the capillary action (cm) during different time periods Until the arrival of water to the Surface of soil columns at a height of 40 cm from the level of the default groundwater. The equation of (Philip, 1957c) was used to describe the vertical water movement upward as following:

$$\mathbf{Z} = \boldsymbol{\lambda}\, t^{1/2} - \aleph\, t$$

Where:

Z: cumulative vertical height upward (cm)

t: cumulative time (min.)

λ: capillary conductivity constant (cm $min^{1/2}$)، $\varkappa$

For the purpose of estimating the moisture distribution due to the movement of water from the bottom to up and the movement of salts and accumulating it in the soil columns, all soil columns kept for an equal period until the arrival of the moisturizing pattern to the soil surface for all soil columns after 9284 min from the beginning of the measuring period. The soil columns were then cut into 4 sections starting from the surface of the default groundwater of (0-10, 10-20, 20-30, 30-40 cm), in which the moisture content (Pw) and soil salinity were estimated by measuring the electrical conductivity in the saturated soil paste extract (EC_e). The Mean Weight Diameter (MWD) was estimated by wet sieving method and bulk density by pycnometer (Back et al., 1965). The second experiment included estimating the accumulative infiltration and the infiltration rate in a field experiment, in which the same factors and treatments were used as in the previous experiment of estimating the water movement upward. The field in the study area was divided into two parts, the first with a high Pulverizing index (P1) and the second with a low Pulverizing index (P2), each divided into plots with an area of (2 × 2 m^2), The treatments of the method of adding crude oil factor were applied to them, depending on the amount of water used in the W1 treatment (field capacity) and the W2 treatment (degree of saturation). The soil was then air-dried to complete the coalescence process, the accumulative infiltration and the infiltration rate were then estimated with time by using the method of infiltration device with double range according to the method described by (Boersma, 1965). The relationship between the accumulative infiltration water and time was expressed according to the equation of (Philip, 1957b).

$$I = St^{1/2} + At$$

Where:

I: Cumulative infiltration (cm)

S: Sorptivity constant (cm min½)

A: transmissibility constant (cm min½)

t: times (min.)

The infiltration rate was estimated through calculating the details for the infiltration equation; and after drying the soil of the treatments in air, the MWD of the soil aggregates and soil bulk density were estimated by the methods described in (Black et al., 1965).

3. RESULTS AND DISCUSSION

Vertical water movement downward

Figure (1) shows that the effect of the experimental treatments on accumulative infiltration values (cm), with a different time period. where it is clear there are differences in the calculated accumulative infiltration values during the measuring period which amounted to (240 min). The treatments (C1, C2) showed an excelling compared to the control treatment (Co), The highest values found in the treatment of emulsified crude oil (C2), which their values ranged between (40.30-34.75 cm), with an average amounted to (37.15 cm), followed by crude oil treatment (C1) with range (33.89-28.86 cm), with an average of (29.69 cm), While the control treatment recorded a range of (26.51-23.30 cm), with an average of (24.82 cm), the effect of crude oil in increasing the infiltration is due to the formation of hydrophobic surfaces around soil aggregates, which increases the stability of aggregates and conserving them from deteriorating by the effect of rapid water immersion, which maintains the regularity of large and medium pore channels (Al-Doori, 2002; Shabib, 2016). The high superiority of the accumulative infiltration in the treatment of emulsified crude oil (C2) is due to the emulsifying properties from small oil droplets less than (2 μm) which have the ability to penetrate and spread in the pores of the soil and their voids in different diameters and depths compared to non-emulsified crude oil in the soil sector, which improved soil structure, reduced bulk density, and increased the stability of soil aggregates (Dheyab, 2017), making porous channels in all their diameters more stable and regular in the C2 treatment compared to the C1 treatment. The decrease in the accumulative infiltration in the control treatment (C0) is due to the poor soil structure, which led to the destruction of the soil aggregates and increasing bulk density as a result of the movement of the fine particle inside the pores, which led to reduce its diameters that transmitting water (Meek et al., 1992). The results showed that the values of the accumulative infiltration values in the treatment of high Pulverizing degree (P1) ranged between (35.04 to 23.33), with an average of (29.43 cm). The values at the treatment of low pulverization index (P2) increased between (40.30-25.26 cm), with an average of (32.55 cm). which it is due to the presence of large soil block in the P1 treatment is more breakable to particle and small blocks at rapid immersion (Kuht and Reintam, 2004; Games et al., 2004), which leads to blockages in some porous channels. The primary moisturizing treatment for the limits of field capacity W1 showed an accumulative infiltration ranged between (40 - 30.16), with an average of (31.77 cm). The increase of The primary moisturizing level to the limits of saturation degree (W2) led to a reduction of accumulative infiltration ranged between (35.26-23.33), with an average of 30.25 cm. This decrease is due to the increase in the water level to the saturation limits, which led to the rapid progress of the moisturizing pattern in the soil columns, which increased the percentage of soil aggregates that are destroyed by rapid immersion. Figure (1) shows that the differences in the accumulative infiltration values for the improvers differentiated with change the Pulverizing degree, where the differences between the treatments (C1, C2) compared to the control treatment (C0) at the P1 treatment which amounted to (6.24, 11.13 cm), respectively. This is due to that the droplets of emulsified crude oil (C2) have the ability to spread and penetrating more homogenous in soil depths and its pores at the Pulverizing treatment (P2), making their pores more regularly and stability compared to the high Pulverizing treatment (P1). The interaction between the degree of Pulverizing and the primary moisturizing level (W) has affected on the accumulative infiltration values. The differences between the accumulative infiltration values of the treatments

(W1, W2) at the treatment of high Pulverizing degree (P1) which gave 0.99 cm and increases at the P2 treatment which gave 2.99 cm. This is due to soil aggregates and porous channels that are stable at low Pulverizing degree using the moisturizing level (P2) for the limits of field capacity W1. The triple-interaction treatment between the three experimental factors (the Pulverizing index factor, the method adding of oil improvers factor, and the level of primary moisturizing factor) showed that the accumulative infiltration values for factorial treatment between these factors recorded the following values: The P2W1C2 at average 40.00 cm <P2W2C2 at average of 38.52 cm <P1W1C2 at average 35.05 cm <P1W2C2 at average 43.75 cm <P2W1C1 at average 33.89 cm <P2W2C1 at average 30.83 cm <P1W1C1 at average 30.71 cm <P1W2C1 at average 28.86 cm P2W1C0 at average 26.51 cm P2W2C0 at average 25.26 cm <P1W1C0 at average of 24.16 cm <P1W2C0 at average 23.33 cm.Figure (1) shows the relationship between the infiltration rate and the calculated time from the differential equation of (Philip, 1957b) for the interaction treatment between the factors of experiment (the degree of soil Pulverizing (P), the method of adding oil improvers (C), and the primary moisturizing factor (W). There is an increase in the infiltration rate at the beginning of the measuring period and for all equations due to the matric potential and the gravity of earth which are dominant at the beginning of the measurement. The values gradually decrease with time accessing to the nearest value for constant where the soil is almost saturated, The structural hydraulic force decreases when the hydraulic pressure difference is equal in all points and the gravity forces dominate on the infiltration process, This stage is called the base Infiltration (Hassan, 2007; Hassan, 2018). The results showed that there were significant differences in the infiltration rate between oil improvers treatment. At the beginning of the first 20-minute measuring period, the control treatment (C0) showed the highest values compared to the treatment (C1, C2). The C2 treatment recorded the highest values, This is due to the effect of hydrophobic petroleum materials as a result of the formation of a hydrophobic surface on the surfaces of soil particles and aggregates that increase the contact angle between the water and these surfaces, thus reducing the soil's water absorption and a decrease in the total quantity at the beginning of the measurement (Gabriels, 1974; Shabib, 2016). The effect of hydrophobic petroleum material, Its effect has increased further in reducing the infiltration rate in the treatment of emulsified crude oil (C2) due to the properties of crude oil emulsion in the Spread and penetrating for the largest depths and in the different pores and Cavities of soil , which increased the hydrophobic surfaces compared to the C1 treatment (Dheyab, 2017).

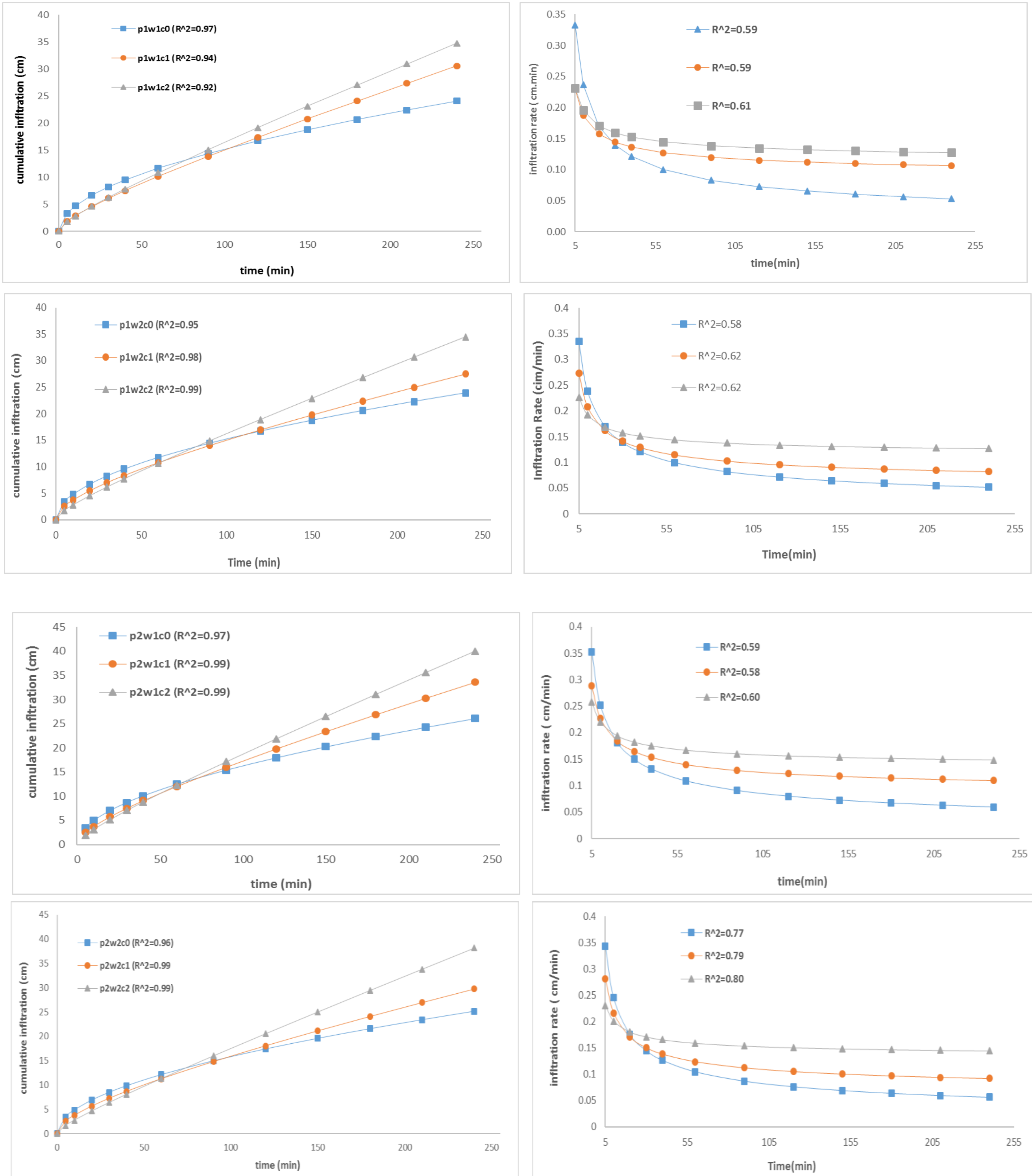

Figure 1: Effect of the experimental treatments on Cumulative infiltration and infiltration rate.

The oil improvers treatment showed a change in the infiltration rate after 20 min from the beginning of the measuring period., where the infiltration rate in the control treatment (C0) decreased. A significant excelling was obtained in the treatments (C1, C2) compared to the control treatment (Co). The highest values were recorded in the treatment of emulsified crude oil (C2) at the end of the measuring period (240 min). Base-infiltration values in the C0 treatment ranged between (0.059-0.052), with an average (0.055 $cm.min^{-1}$), in the C1 treatment amounted to (0.107-0.082), with an average of (0.098), and in the C2 treatment (0.148-0.127), with an average of (0.137 $cm.min^{-1}$). The decrease in the Base-infiltration of the C0 treatment is due to a decrease in the stability of the soil aggregates and the increase in the bulk density of the soil due to the deteriorate of these aggregate during the progress of the moisturizing pattern and rapid immersion and converting it into fine particles that reducing the diameter and regularity of pore channels in the soil sector (Dikinya et al., 2006). The increase in the accumulative infiltration rate in the treatments (C1, C2) is due to the effect of adding oil materials in the covering the oil materials compounds to soil aggregates and pores channels, which made it more stable against the deteriorate during the progress of the moisturizing pattern and rapid immersion, This effect is more effective when using the treatment of emulsified crude oil (C2) compared to the crude oil treatment (C1) in the spread and penetrating for the depths and the larger area from the soil aggregates and pores channels, which maintained the regularity of the water flow in the soil sector (Hassan, 2016). Figure (2) shows that there is a highly significant positive correlation r = 0.85 ** between the base-infiltration and MWD for soil treatments, there is a significant high negative correlation between the base-infiltration and soil bulk density (Pb) (r = - 0.97 **) as shown in Figure (3). These results confirm the effect of soil aggregates, their stability and soil bulk density in the infiltration values for the study treatments. The results of Figure (1) show that the Pulverizing degree treatment (P2) showed an increase in the infiltration rate compared to the high Pulverizing treatment (P1) in the early measuring period or the advanced measuring periods. The base-infiltration values at the end of the measurement (240 min) ranged between (0.148-0.059), with an average of (0.148 $cm.min^{-1}$) for the P2 treatment and between (0.127-0.051), with an average of (0.091 $cm.min^{-1}$) for the P1 treatment. This is due to the dominance of small soil blocks in the P2 treatment with higher surface capacity, more water absorption, and more stability against the deteriorate compared to large soil blocks. Kuht and Rantam, (2004) and Games et al., (2004) indicated that the large soil blocks are more Capability to deteriorate and crash into small blocks and particles when immersion rapid. The results of Figure (1) showed that the primary moisturizing treatment (W1) an increase in the infiltration rate in the early or late time period, compared to the moisturizing treatment (W2). The base-infiltration values have at the time 240 minutes ranged between (0.148-

0.053), with an average of (0.092 $cm.min^{-1}$) for the W2 treatment and between (0.144-0.051), with an average of (0.092 $cm.min^{-1}$). This is due to the effect of increasing the level of primary moisturizing level in the progress speed of the moisturizing pattern and immersion, and their effect on the destruction of soil aggregates and soil blocks. When comparing the base-infiltration values for the factorial treatments of interaction between the study factors, which took the following order: $P_2W_1C_3$ (0.148 cm min^{-1}) > $P_2W_2C_2$ (0.144) > $P_1W_1C_2$(0.127) > $P_1W_2C_2$ (0.126) > $P_2W_1C_2$ (0.110) > $P_1W_1C_1$ (0.106) $P_2W_2C_1$ (0.091) > $P_1W_2C_1$ (0.082) > $P_2W_1C_0$ (0.059) > $P_1W_2C_0$ (0.056) > $P_1W_1C_0$ (0.053) > $P_1W_2C_0$ (0.051).

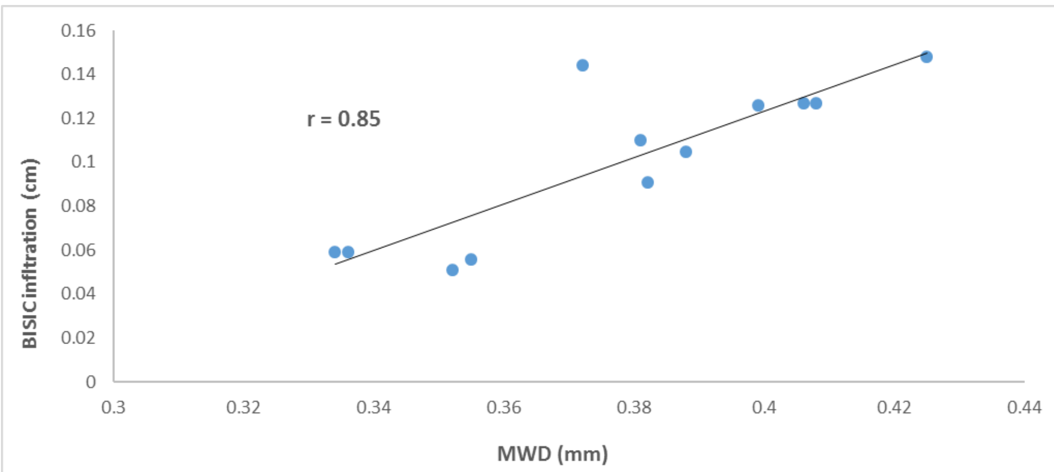

Figure 2: correlation between basic infiltration and MWD for the studying treatments.

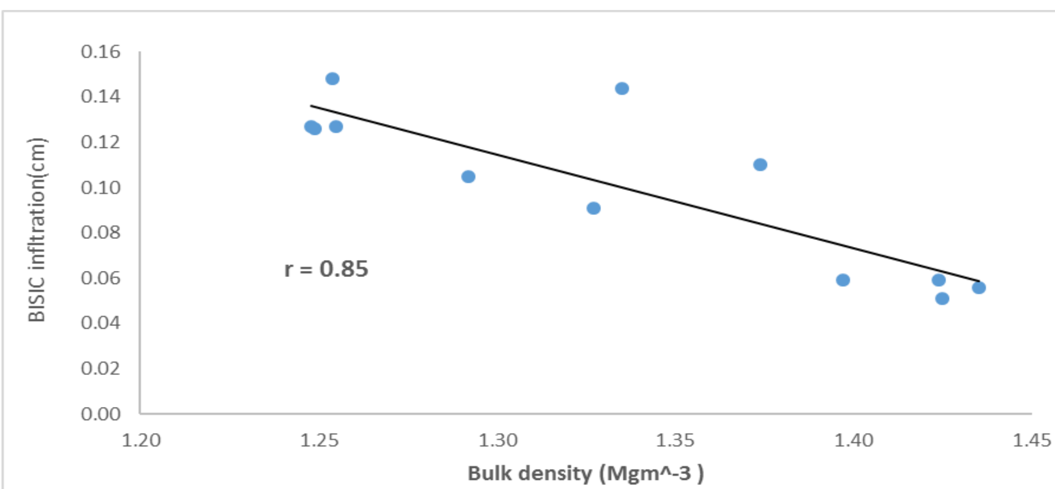

Figure3: correlation between basic infiltration and bulk density for the studying treatments.

Table (4) shows the values of the constants for (Philip 1957b) equation, Which expresses on soil Sorptivity and which depends on the matric potential for the soil, and (A) constants, which expresses on the Transmissibility, which was calculated from the equations of the field data (experimental) with (Philip,1957b) equation: $I = St^{1/2} + At$. The values of the S constant were high in the control treatment

C0, which ranged from 1.540 to 1.460, with an average of (1.493 cm.min$^{1/2}$). This is due to the high matric potential of clay soil, which increases the speed of its moisturizing and absorption of water, especially in the early periods of the measuring time. The values of the S constant in the treatment of crude oil (C1) decreased which ranged between (1.000-0.640), with an average of (0.890 cm.min½), This is due to the effects of hydrophobic surfaces because of its covering with oil materials, which affected the contact angle between these surfaces and water, thus reducing their absorption of water (Toogood, 1977; Al-Doori, 2002; Shabib, 2016). The treatment of emulsified Crude oil (C2) recorded the highest decrease in the values of the S constant, compared to the treatments (C0, C1), which their values ranged between (0.570-0.450), with an average of (0.520 c cm min^{½}). This is due to the ability of the emulsified crude oil to spreading and penetrating in high homogeneity in the soil depths and for all particles, soil aggregates, and pores, which Increased the percentage of hydrophobic surfaces (Dheyab, 2017). The results show that the low Pulverizing treatment (P2) was an increase in the values of constant (S), compared to the P1 treatment, where their values ranged between (1.530-0.450), with an average of (0.945 cm min½), and between (1.480-0.520), with an average of (0.940 cm min½), which is due to the increase in total surface area in the P2 treatment compared to the P1 treatment because of the difference in the Pulverizing degree. The primary moisturizing treatment W2 showed an increase in the values of constant S, compared to the W1 treatment and the average values for it amounted to (0.990, 0.945 cm min½), respectively. This may be due to the effect of increasing the primary moisturizing level in the W2 treatment to saturation limits in increasing the breakdown of soil blocks and aggregates to particles and small aggregates, which increased the surface area of the effective water absorption.

Table 4: constant of Philip's equation 1957b $Y = St^{\frac{1}{2}} + At$

NO.	Treatment	Constant(A)	Constant(B)
1	P1W1C0	0.006	1.46
2	P1W1C1	0.086	0.64
3	P1W1C2	0.11	0.54
4	P1W2C0	0.004	1.48
5	P1W2C1	0.05	1.00
6	P1W2C2	0.11	0.52
7	P2W1C0	0.01	1.53
8	P2W1C1	0.08	0.93
9	P2W1C2	0.13	0.57
10	P2W2C0	0.008	1.50
11	P2W2C1	0.06	0.99
12	P2W2C2	0.13	0.45

Figure (4) shows that there is a significant negative correlation between the MWD values for the soil aggregates of the study treatment with the values of the S constant (r = - 0.95 **). These results confirm that the values of the S constant increased in the treatments that leading to the reduction of MWD for the soil aggregates. The P2 treatment showed an increase in the values of A constant compared to the P1 treatment, where their values ranged between (0.013-0.008), with an average of (0.690 cm.min½), and between (0.011-0.004), with an average of (0.061cm min½), respectively. This is due to the increase in the percentage of large soil block in the P1 treatment, Which are more prone to collapse and crash into fine particles and blocks fill pore channels and reduce the area sections of transmitting water (Kuht and Reintam, 2004; Games et al., 2004). The primary moisturizing W2 treatment showed a little increase in the values of the S constant compared to the W1 treatment and the values of their average amounted to (0.990, 0.945 cm.min½), respectively. This may be due to the effect of increasing the moisturizing level in the W2 treatment for the saturation limits in increasing the breaking soil blocks and aggregates into small particles, which increased the surface area of the effective soil particles for water absorption. The two treatments (W1, W2) did not show differences in the values of the A constant, where both recorded an average amounted to (0.060 cm min½).

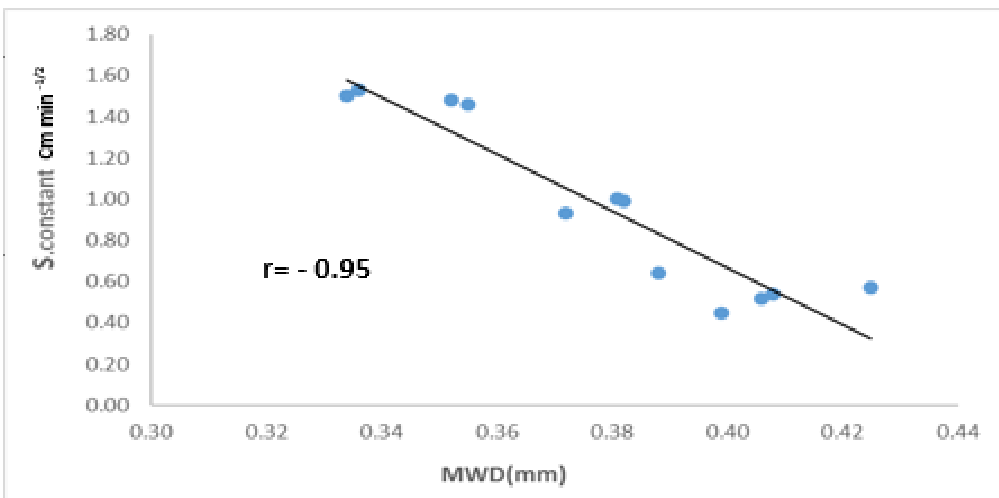

Figure 4: correlation between S constant and MWD for the studying treatments.

The results of Table (4) shows that the lowest values of the A constant were found in the control treatment (C0) with a range between (0.010-0.004), with an average of (0.007 cm min½). The A values in the C1 treatment increased, where their values ranged between (0.086-0.050), with an average of (0.069 cm.min½). The highest values for the A constant obtained at the C2 treatment ranged from 0.130 to 0.110, with an average of (0.120 cm.min½), This is due to that the transmissibility constant is dependent on saturated hydraulic conductivity, which is affected by the stability of the soil aggregates and total pores, which was improved by the addition of the petroleum improvers, which increases the total area of the pore channels sector that transmitting water. The positive effect increased when adding the emulsified crude oil (C2) for the high penetrating and spreading in the depth of soil and pores, which increased the stability of soil aggregates, pore channels and the regularity of their diameters. Figure (5) illustrates the relationship between the values of the A constant and the MWD values for the estimated soil aggregates is that there is a highly significant positive correlation r = 0.87 ** between the values of the A constant and the values of the mean weight diameter. From the results of Figure (6), there is a significant negative correlation between the values of the A constant and the values of bulk density for the estimated study treatments r = - 0.97 **.

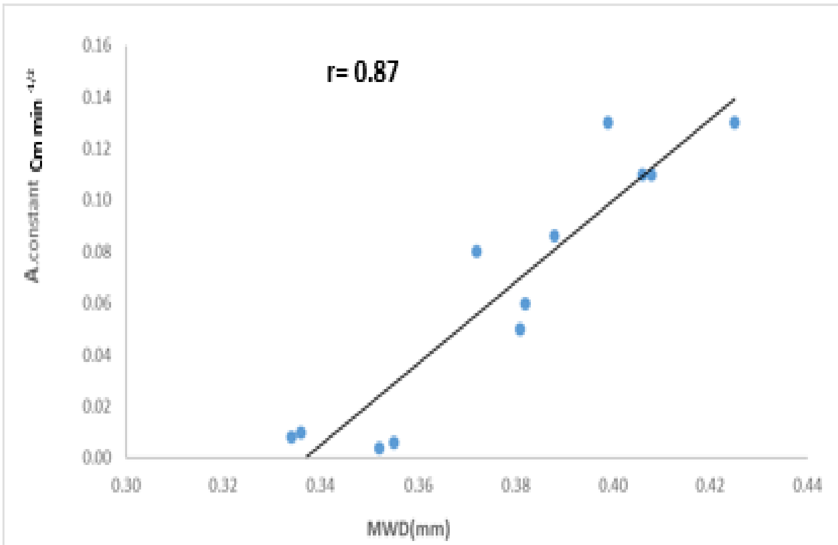

Figure 5: correlation between A constant and MWD for the studying treatments.

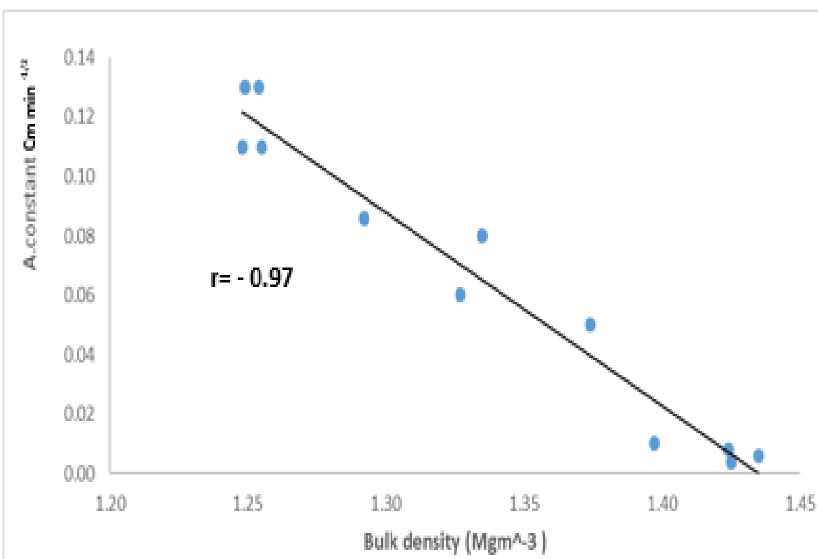

Figure 6: correlation between A constant and bulk density for the studying treatments.

Vertical water movement upward

Figure (7) shows the relationship between the progressing distance of the moisturizing pattern upward by the effect of the capillary ascent for the water to the soil surface over time for the study treatments, Which was placed according to (Philip, 1975c) equation, with a non-linear relationship, where the results showed that the speed of progress for the moisturizing pattern upward differs according to the measuring time and depth of the moisturizing pattern. All the treatment showed a state of convergence in the height and the average of the progressing speed for the moisturizing pattern within the height of (0-10 mm) directly above the surface of the default groundwater and during the first 10 min of the measuring period, This is due to the near the source of supplying water to this section and its moisture content is high, reach to the wetting degree and close to the field capacity. Most soil pores are filled with water, and the water covers around the particles are thick, increasing the speed of filling the soil pores, which increases the values of unsaturated hydraulic conductivity upward (Miyazaki et al., 1984; Nedawi, 2008; Al-Hadi, 2014). After the early period (10 min) and after the moisturizing pattern exceeded the vertical distance of (10 cm), A decrease occurred in the average of the progressing speed for the moisturizing pattern upward for all treatments with increasing time and The decline continued until the access of the moisturizing pattern to the soil surface at a height of 40 cm. The treatments of the experiment varied in the average of progressing speed upward and in the time required to reach the soil surface, The control treatment (C0) showed the highest progressing speed upward and the lowest time of access to soil surface between (4896-2016), with an average of (2988 min). While a decrease in the progressing speed upwards in the C1 treatment and an increase in the accessing time of the moisturizing pattern to the soil surface ranged between (8064-4896), with an average of (6912 min), This is due to that oil material reduce the speed of moisturizing of the soil aggregates, which reduces capillary height in the soil (Hillel, 1980). Al-Doori (2002), Unger, (2001) and Rao et al., (1998) indicated that the soil is high wettability, and the addition of oil materials transforms the surfaces of soil particles, their aggregates, and pores to hydrophobic, which increases the contact angle with the water, Thus reducing the capillary water movement upward. The C2 treatment of emulsified oil showed a decrease in the progressing speed of the moisturizing pattern compared to the treatments (C0, C1) with a significant increase in the time required to reach the soil surface ranged between (9284-8064), with an average of (8729 min), This is due to the properties of emulsified crude oil made of oil droplets (less than 2

μm) to penetrate and spread to high depth into the soil, which increases the total area of soil aggregates, their particles, and hydrophobic pores compared to the C1 treatment (Dheyab, 2017; Shabib, 2016). Figure (7) shows that the treatment of high Pulverizing index (P1) showed a decrease in the progressing speed of the moisturizing pattern and the increase in the time required to reach the soil surface ranged between (8784-2160), with an average of (5616 min) compared to the treatment of the low Pulverizing index (P2) and time period ranging between (9284-2448), With an average of (6470 min), This difference in the Pulverizing degree between these two treatments to the dominance of large soil blocks in the P1 treatment, which reduces the capillary water movement upward because the water traveled a long distance in the case of large soil blocks and aggregates (Hamid, 1966). The results in Figure (8) showing the relationship between the average of progressing speed for the calculated moisturizing pattern upward as shown in Figure (7). There is a highly significant negative correlation between the progressing speed of the moisturizing pattern upward and MWD for the study treatments r = - 88**. The results in Figure (7) show that the treatment of primary moisturizing (W1) showed an increase in the progressing speed of the moisturizing pattern and the time required to reach the soil surface ranged between (8784-2160), with an average of (6024 min) compared to the treatment of moisturizing degree to the degree of saturation (W2), which the progressing speed upward decreased with a time ranged between (9284-2448), with an average of (6395 min), This is due to increasing the level of moisturizing from field capacity (W1) to saturation degree (W2) has increased the progressing speed of the moisturizing pattern and rapid immersion in breaking soil aggregates into smaller aggregates (Dheyab, 2017). This effect has increased the homogeneity of the soil pores formed the porous channels for the capillary rising, which increased the speed of vertical water movement upward (Al-Hadi, 2014; Kheorenrumine et al., 1998).

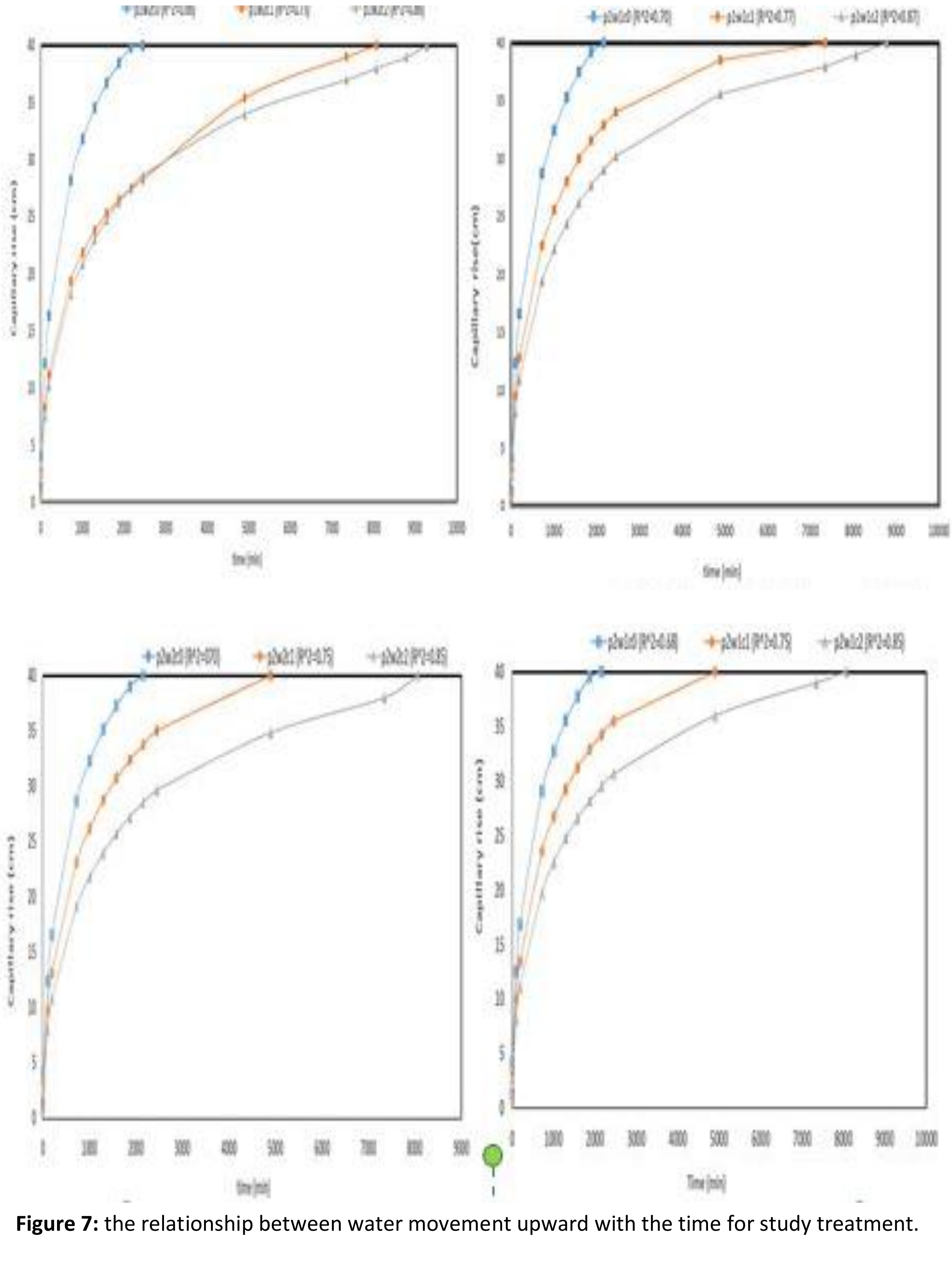

Figure 7: the relationship between water movement upward with the time for study treatment.

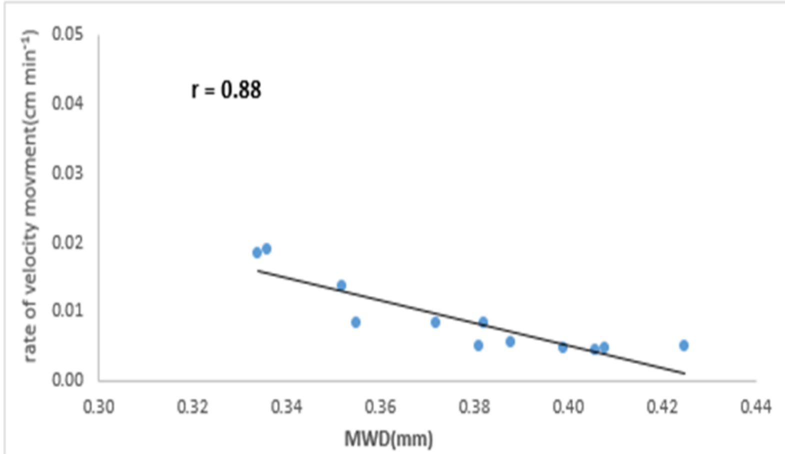

Figure 8: Correlation between the rate of capillary rise with the MWD for the studying treatments.

The results in Table (5) show the value of the experimental constants for (Philip, 1957c) equation, where it is clear that the values of the λ constant that express on the unsaturated hydraulic conductivity showed the highest values at the control treatment (C0) ranged between (1.36-1.32), with an average of (1.34 cm.min^{½}). This constant reduces in the treatment of crude oil (C1) between (1.07 - 0.96), with an average of (1.03 cm.min^{½}), This constant reduces in the treatment of emulsified crude oil (C2) between (0.87-0.80), with an average of (0.84 cm.min^{½}). The treatment of low Pulverizing index (P2) showed an increase in the λ values compared to the P1 treatment, where their values ranged between (1.36 -0.84), with an average of (1.09 cm.min^{½}), between (1.34-0.80), with an average of (0.854 cm.min^{½}), respectively. While the primary moisturizing treatment W1 showed an increase in the λ values compared to the moisturizing treatment (W2), which their values ranged between (1.36 - 0.86), with an average of (1.088), between (1.32-0.80), with an average (1.05), respectively. it is due to the effect of interaction between these treatments in the MWD values of soil aggregates and the values of bulk density (Pb).

Table 5: constant of Philip's equation 1957b $z = \lambda t^{\frac{1}{2}} - xt$

NO.	Treatment	Constant(λ)	Constant(x)
1	P1W1C0	1.34	0.01
2	P1W1C1	1.03	0.01
3	P1W1C2	0.86	0.005
4	P1W2C0	1.32	0.01
5	P1W2C1	0.96	0.01
6	P1W2C2	0.80	0.005
7	P2W1C0	1.36	0.01
8	P2W1C1	1.07	0.007
9	P2W1C2	0.87	0.005
10	P2W2C0	1.34	0.01
11	P2W2C1	1.04	0.006
12	P2W2C2	0.84	0.004

Figure (9) shows that there is a highly significant negative correlation between the MWD values in the treatment with the values of the λ constant r = -0.59 **, there is a highly significant correlation between the value of soil bulk density (Pb.) for the treatments with the λ values r = 0.62** as shown in Figure (10). These results confirm that the values of the λ constant expressing the unsaturated hydraulic conductivity are influenced by the MWD of the soil aggregates that determine the diameter of soil pores channels, their regularity degree and It is affected by soil bulk density for the soil that determines the continuity of the soil pores channels. The results in Table (5) show that the values of constant κ, which expresses the matric potential of soil particles and their aggregates. The oil improvers treatments showed high differences among them. The highest average for the κ values was observed in the control treatment. The values in the treatments (C1, C2) were then significantly reduced, their averages amounted to (0.010, 0.007, 0.005 cm.min½), respectively, This is due to that the values of κ depended on the structural potential for the particles and soil aggregates, which is high in the control treatment (C0)and that the addition of the oil improvers reduces the structural potential for the particles and soil aggregates and their pores that cause the formation of hydrophobic surfaces (Al-Doori, 2002; Unger, 2001) Which reduced the structural potential, the results showed no significant effect of the Pulverizing factor or the primary moisturizing factor κ.

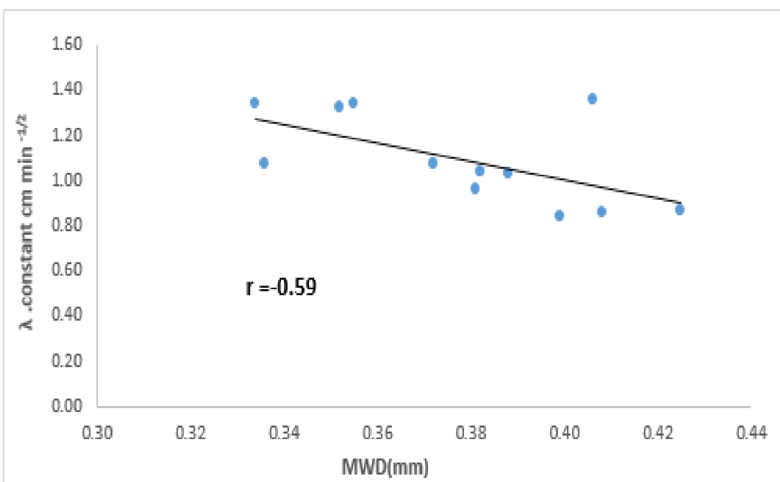

Figure 9: correlation between λ constant with the MWD for the studying treatments.

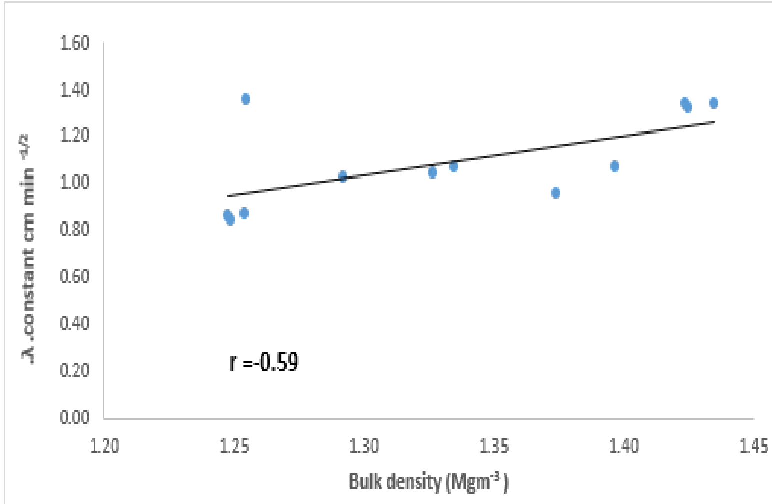

Figure 10: correlation between λ constant with bulk density for the studying treatments.

Moisture content distribution and salt accumulation in soil columns

Moisture content distribution

Figure (11) shows the effect of the study factors in the values of moisture content (Pw) for the soil column sections from the height of (0 cm), which located directly above the level of the default groundwater (the source of the supplied water) up to the top of the soil surface at height of (40 cm) which is (0-10, 10-20, 20-30, 30-40 cm), after reaching the vertical moisturizing pattern for the soil surface for all treatments at the time of (9284 min) from the beginning of the experiment. The results showed that there were significant differences ($p < 0.05$) in moisture content between soil column sections as shown in Table (6). The highest values of moisture content found at the height of (0-10 cm) were very close to field capacity, with the rate of (Pw = 0.323). The average values of moisture content (Pw) which amounted to (0.268, 0.233, 0.192) for heights (10-20, 20-30, 30-40 cm), respectively. This is due to obtaining a decrease in the rate of Capillary Water movement upward due to reduce the unsaturated hydraulic conductivity upward by increasing the vertical distance for dominance the water movement through the macro capillary pores (Hillel, 2003). Figure (11) shows that there are no significant differences between the study treatments in the Pw values at the height of (0-10 cm). This is due to the near groundwater level. Most of the medium and fine soil pores are filled with water and form a thick water covers. Jorenush and Sephakhah (2003) indicated that moisture content in soil columns is high enough to reach the limits of wetness at the layer above the groundwater level and the moisture content decreases by increasing the height at the groundwater level. There was a significant decrease in the Pw values at 10-20 cm compared to the height of 0-10 cm. The treatment of the emulsified oil improvers (C2) showed the lowest values with an average of (Pw = 0.242), with a significant decrease compared to the control treatment (C0) at an average of (0.295 Pw). The C1 treatment (Pw = 0.266) did not show a significant difference with the treatments (C0, C2), This is due to the difference in the ability of the oil emulsion improvers to spread and penetrate into soil depths in the formation of the hydrophobic surfaces, thus reducing the raise sped rate of capillary water movement, where this effect extends to this depth at the treatment of the emulsified crude oil (C2). A significant differences between the treatments (C0, C1, C2) increased at both heights (20-30, 30-40 cm) for the soil columns, although the high reduction in the moisture content for all treatments, which their averages of Pw amounted to (0.282, 0.277, 0.197), respectively, at height of (20-30 cm), and (0.252, 0.187, 0.137), respectively, at height of (30-40 cm). This is due to the effect of the oil improvers added to the treatments (C1, C2) which increases their effect in reducing the capillary raise for water in the soil columns at the soil surface depths, due to the increase in the concentrations of oil material at these depths (Dheyab, 2017), This impact reduced the speed of the capillary water movement upward. The low pulverization index (P2) treatment showed an increase in Pw values compared to the high pulverization index (P1) treatment. The differences between them increased with increase the vertical height at the level of the default groundwater and their average Pw values amounted to (0.269 and 0.266 at 10-20 cm), respectively; at the height (10-20 cm), respectively; and (0.239, 0.226) at height (20-30 cm), respectively. This is due to differences in the progressing speed of the moisturizing pattern, which increased with a lowing Pulverizing degree from P1 to P2, which was caused by the lower diameter of the capillary tubes and the regularity of their diameter. The primary moisturizing factors (W1, W2) did not show significant differences between them as shown in Table (6).

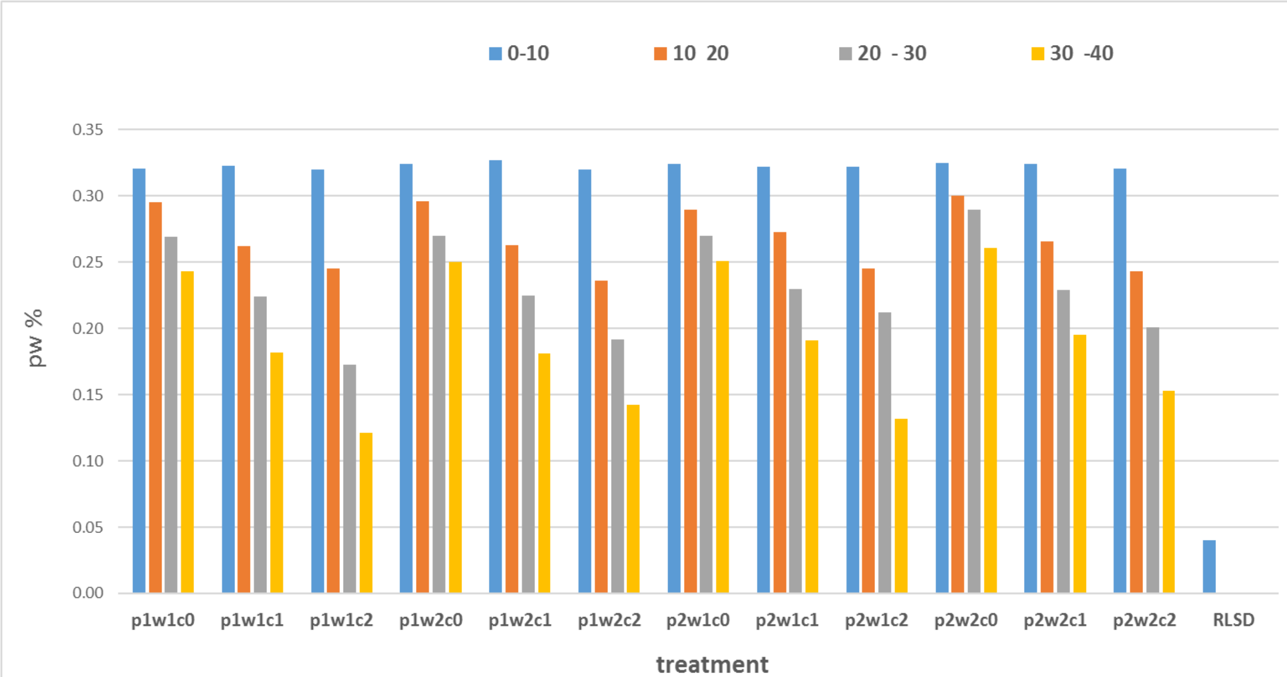

Figure 11: Effect of the studying treatment on moisture content (p_w) at soil columns

Table 6: variance analysis (F-value) of moisture content and salinity Through soil columns

S.O.V	MOISTURE CON. PW	EC
C	73.47**	870.63 **
P	4.000*	26.97 **
W	0.030ns	2.65 ns
D	36.88 **	2034.83 **
PW	0.43 ns	0.056 ns
PC	2.26 ns	3.895 *
PD	0.41 ns	2.642 ns
WC	2.57 *	2.939 ns
WD	0.003 ns	5.207 **
CD	24.110 **	4.108 **
PWC	0.001 ns	0.417 ns
PWD	1.315 ns	29.61 **
PCD	4.050 *	2.335 *
WCD	0.0006 ns	2.461 *
PWCD	16.02 **	2.569 *
	C: crude oil	P: Pulver index
	W: initial moist.	
	D: soil depth	

Salt accumulation in soil columns

Figure (12) shows the effect of the study factors on the values of soil salinity ECe (dS.m-1) in the soil columns by the effect of the vertical water movement upward which their source of the default groundwater (EC_w = 10 $dS.m^{-1}$). It is clear that there are significant effects ($p < 0.05$) for the main study factors and some interaction between them, with a significant effect for the vertical distance at the surface of the default groundwater in salinity values as shown in Table (6), where Figure (12) showed that the ECe values are significantly reduced by increasing the vertical distance at the surface of the default groundwater, where the average values for ECe amounted to (8.43, 7.40, 6.50 dS.m-1) for the heights (0-10, 10-20, 20-30 cm) at the surface of the groundwater. This is because of the concentration of salts at these heights vary depending on the heterogeneity of moisture content as shown in Figure (9), which their source the capillary movement upward from groundwater (ECw = 10 $dS.m^{-1}$). The results did not show significant differences in the EC values between the study treatments at the height of 0-10 cm, where their values amounted to (8.42-8.42), with an average (8.43 dS.m-1), this is due to the similarity in the moisture content values for the study treatments for the proximity of this height from the level of groundwater as shown in Figure (9). The treatment showed significant differences in the ECe values at the height of (10-20 cm). The highest values were found in the control treatment (C0), with an average of (7.93 $dS.m^{-1}$) followed by the C1 treatment with an average of (6.87 $dS.m^{-1}$). The lowest average amounted to (6.46 $dS.m^{-1}$) at the C2 treatment, with significant difference compared to the C0 treatment, This is due to differences in moisture content between the C2 treatment compared to the treatments (C0, C1). The significant differences in ECe values between the three treatment (C0, C1, C2) increased at the height of (20-30 cm) from the soil columns. Despite the overall reduces in the average of ECe for all treatments, where their average values amounted to (7.47, 6.46, 5.50 $dS.m^{-1}$), respectively. These results agree with the Pw values for these treatments, which their averages amounted to (0.282, 0.277, 0.197), respectively. The surface height from the soil columns (30-40 cm) showed an increase in average ECe values amounted to (8.41 $dS.m^{-1}$) compared to the heights (20-30, 20-10 cm), This is due to the evaporation of the soil movement solutions upward from the soil surface, which led to the accumulation of salts, and the concentration of the accumulated salts depends on the amount of water flowing to the surface of the soil, the concentration of dissolved salts and the period of influence (Jorenush and Sephakhah, 2003). The results showed that the highest significant increase in ECe values from the surface height from the soil columns (30-40 cm) appeared at the control treatment (C0), with an average of (11.80 $dS.m^{-1}$), with a significant difference compared to the treatments (C1, C2) at an average of (9.09 $dS.m^{-1}$). The lowest values were shown at the C2 treatment, with an average of (5.35 $dS.m^{-1}$). This is due to the above-mentioned reasons related to the difference in the speed of Capillary water movement upward and the volume of water flowing to the soil surface. The treatment of low Pulverizing (P2) showed an increase in ECe values compared to the high Pulverizing treatment (P1). The differences between the two treatments increased with an increase in the height from the level of groundwater. The averages of their ECe amounted to (7.48, 7.42 $dS.m^{-1}$), respectively at the height (10-20 cm), (6.53, 6.45 $dS.m^{-1}$) at the height (20-30 m) and (9.06, 7.77 $dS.m^{-1}$) at the surface height (30-40 cm), respectively. This is due to the difference in moisture content because of the difference in the speed of the capillary water movement and water pore channels, which reduce with the increase in the pulverization index from P2 to P1 to the relationship of this with diameters of capillary channels with their regularity and continuity. The primary moisturizing treatment (W1 and W2) did not show significant differences in the values of electrical conductivity between them.

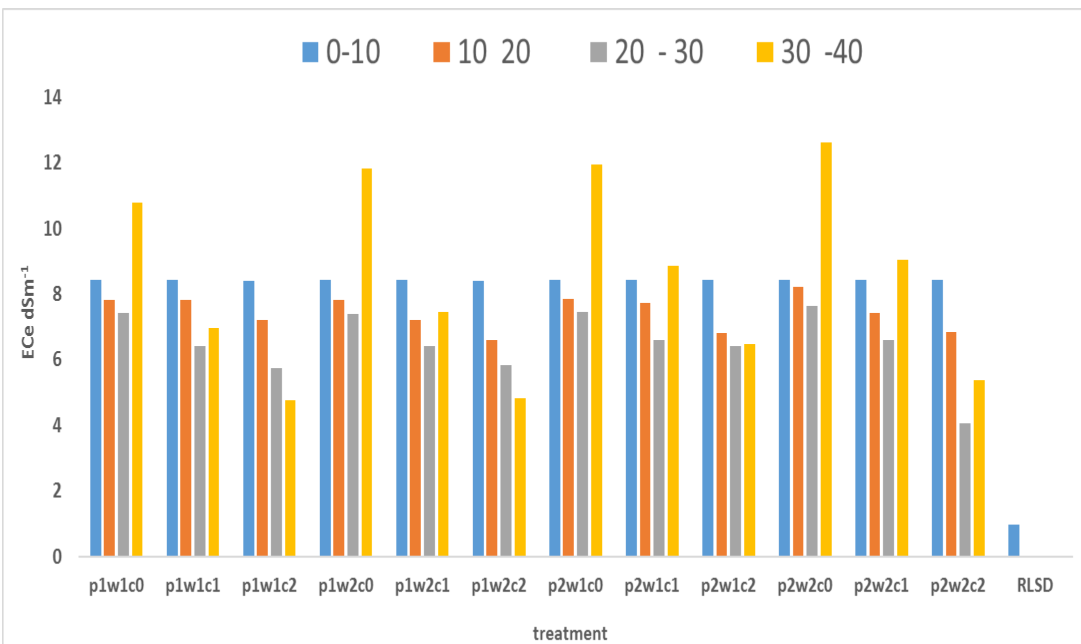

Figure 12: Effect of the studying treatment on ECe $dS.m^{-1}$ at soil columns

4. CONCLUSIONS

The emulsification of crude oil or its derivatives with irrigation water makes them improvers with high efficiency in spreading and penetrating in the depths and pores of the soil, which positively affected the improvement of the physical properties affecting the increase of the Infiltration in the soil and reduce the of the capillary water movement upward, which reduces the water lost by surface evaporation and increase the ability of soils to conservation moisture, The salinization process of soils was reduced by the accumulation of salts associated with the capillary water movement which their source from critical groundwater.

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