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MOVEMENT OF WATER AND SALT ACCUMULATION IN SOIL AS EFFECTED BY EMULSIFIED AND UN-EMULSIFIED CRUDE OIL

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Abstract

A study was conducted to evaluation of a proposed and modified method for the direct addition of oil derivatives to the soil surface as improvers after emulsification with irrigation water under conditions similar to the field conditions of moisture system and degrees of tillage and smoothing and its effect on the infiltration and Infiltration rate and the capillary movement of water to the top and its relation to the moisture and salt distribution in the clay soil sector. The study factors were the smoothing soil index (PWD) of the soil masses after tillage and softening) with two parameters, high P1 and low P2 with MWD 17.026 and 10.511 mm, respectively. (C0), 0.5% w / w non-emulsifiable (C1) and 0.5% w / w crude oil treatment. The second factor is the crude oil applied method (C) (C2) Emulsion with irrigation water by adding an emulsifying agent Anionic surfactant: Sodium Dodocyl sulphate coconut fatty acid. The third factor is the primary wetting factor (W). Initial moistening factor the water volume used in adding to treatments C0, C1 and C2 to the soil, with two treatments, W1 field capacity and W2 saturation ratio. The results showed that the control treatment (C0) achieved the highest infiltration rate at the beginning of the measurement period for the first 10 minutes, which followed by the C1 treatment that decreases significantly from it and that the lowest infiltration rate is shown when treatment C2. As time progressed until the end of the measurement period, C1 and C2 treatment showed an increase in the Infiltration rate compared to control treatment (C0) and the highest values were found at C2 treatment. The results showed that the highest values of sorptivity (S) and the lowest values of the transmissibility equation (A) calculated from the Philip equation (1957b) at the C0 control treatment, the decrease in S values was obtained and increase in the A values in the C1 crude oil treatment and the highest increase in A values was observed in the emulsified crude oil treatment (C2), there was an increase in S values by increasing the level of wetting from W1 to W2 and increasing in S and A values by decreasing the smoothing degree from P1 to P2. The results of the movement of water upward showed that the speed of vertical wetting of all treatments decreased significantly with time and away from the default groundwater level. The control treatment (C0) showed the highest speed and lowest time to reach the soil surface compared to C1 and C2 treatment and the lowest speed and the longest time to reach the soil surface was found in C2 treatment. The differences between the primary wetting treatments were W1 and W2. The results for the values of the calculated constants ($\varkappa$, λ) 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 was obtained in the ë values with deceased in the smoothing index from P1 to P2, while the increase in the λ values was slight with an increase in the primary wetting level from W1 to W2. The results showed that the moisture content in soil columns because of the vertical upward movement of water decreased significantly by moving vertically from the default groundwater surface. The control treatment (C0) was significantly excelled on than C1 and C2 treatment in moisture content. The lowest values were found at C2 treatment with significant differences between the treatments. The differences between the treatment increased by increasing the height of the vertical height and increasing the smoothing degree from P2 to P1. Soil salinity showed the highest values in the layer directly above the default groundwater and decreased the values by increasing the height of the soil surface. There was a significant decrease in salinity at C1 and C2 treatment compared to control treatment (C0) and the lowest values showed a significant difference at C2. The significant differences increased between these equations By increasing the vertical distance to the top, the highest accumulation of salinity at C0 was obtained in the surface layer and the lowest at C2.

Key word: infiltration, crude oil, emulsified, salt accumulation.

Introduction

Soil conditioners 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. These

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materials cover the surfaces of minutes and soil aggregates 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, which affects the water traits such as Water Infiltration and the hydraulic conductivity (Hartmann *et al*., 1983; Al-Hadithi, 1995). Al-Khafaji *et al*., (1985) and Hur and Kerenm (1997) found that adding Petroleum Derivatives makes Soil Aggregates more stable against water action, which helped keep the water flow sections open during water flow, which increases infiltration rate, accumulative infiltration, Base infiltration and Saturated Hydraulic Conductivity, Al-Obeid, (1997) found that adding Fuel oil at a concentration of 1% Spray on the surface of clay soil or 5 cm depth, which it increased infiltration and infiltration rate with ratio 76%, compared with the control treatment. Gabriels *et al*., (1975), Shuhab, (1977) and Toogood, (1977). The mixing of fuel oil with the soil led to a slow movement of water due to the low soil susceptibility to Wetting of the presence of hydrophobic substances and increase the level of addiction is a reason to determine the entry of water and water movement and reduce the infiltration rate because of large distances in the soil filled with Petroleum. 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 the speed of wetting (Al-Dubaki, 1983). Al-Doori, (2002) found a decrease in capillary water elevation with ratio73.64% when adding fuel oil with ratio 1, 2 and 4% compared to the control treatment. The addition of Bitumen with the ratio of 0.5% reduced the capillary height with ratio of 70% during the measurement 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 pointed to the negative effects of oil derivatives when added or accumulate 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 of 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 mixing method for 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, these methods are still limited in small areas. oil derivatives are characterized as liquids has no ability to form a stable and homogenous mix with water that can be directly added to the surface of the soil to achieve higher homogeneity in the improved distribution of soil sector, it can improve physical and water properties and reduce the harmful effects of oil derivatives on plants and organisms soil. Duck, (1966) explained that water and oil are immiscible liquids and that a stable and homogeneous emulsion is formed due to the high surface tension of the water and capillary pressure of the water that generates tension between the oil droplets to form larger droplets after fusion or coagulation, 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 their molecules, made up of hydrophobic groups and hydrophilic groups, dissolves hydrophobic groups in the oil droplet surface and hydrophilic groups moves out into the water phase to dissolve. The strength of this membrane prevents the oil droplets from preventing coalescence with each other as a result of the repulsion between droplets because of the similarity in the charge, Depending on the type of emulsifying agent the surfactants were anionic, cation or amfotere. In the present study, the efficiency of adding oil After emulsification with water will be evaluated as a proposed method for the direct addition of the soil surface under two levels degree of soil smoothing and Primary moisture level (I) the movement of water from the top down (ii) the movement of water from the bottom up in the soil sector and its impact on the distribution of moisture content and salinity distribution and their accumulation in the soil sector.

Materials and Methods

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

Using the methods of analysis described in Black *et al*., (1965) and Page *et al*., (1982), the study included three factors in factorial experiment with three replicates: Factor 1: Soil Pulverization Index (P) (P1) Two treatments included the treatment of a high Soil Pulverization Index (P1), which was reached after two perpendicular plows were by using the Moldboard Plow and then smoothing

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

The value	Soil properties		
1.22	Bulk density (Mgm-3)		
2.66	Particle density (Mgm-3)		
54.10	Porosity (%)		
0.42	MWD (mm)		
54.90	Sand (gkg-1)		
337.70	Clay (gkg-1)		
607.40	Silt (gkg-1)		
clay	Texture class		
0.33	Field capacity (gm gm-1)		
0.50	Saturation percent (gm gm-1)		
7.41	pH		
3.61	Organic matter (gm kg-1)		
326.78	Total carbonate (gm kg-1)		
2.30	Ece (dSm-1)		
10.01	Mmole L^{-1}	Ca^{2+}	Soluble ions
7.02		Mg^{2+}	
25.22		Na^{+}	
2.38		K^{+}	
23.22		SO_4^{2-}	
46.34		Cl^{-}	
0.00		CO_3^{2-}	
2.47		HCO_3^{-}	
1.80	Ec_w (dSm^{-1})	Irrigation water	
7.00	PH_w		
10.00	Ec_w (dSm^{-1})	Derange water	

once using disc harrows and treatment of a low soil Pulverization Index (P2) it was done after two perpendicular plows and the smoothing process twice. The smoothing index was a weighted average diameter of the soil block (17.062 and 10.511 mm) for P1 and P2 respectively. According to the method mentioned in Hillel, (1980), using sieves with different diameters to pass through the soil and accumulate the weights of the soil models collected above each sieve and as shown in table 2. Three treatment included the control treatment without crude oil (C0) and the treatment of un-emulsified crude oil (C1) mixed with water with ratio of 0.5% (w / w). For dry soil weight and treatment of crude oil emulsion with water and 0.5% (w/w) for dry soil weight mixed and emulsified using artificial emulsifying agent (Anionic surfactant) Sodium Dodocyl Sulphate Coconut Fatty Acid (SDS) concentration of emulsifying agent in the mix up to μMole 7 According to Hermann *et al.*, (2001), the characteristics of crude oil used are shown in table 3. Factor 3: Primary wetting factor (W) with two treatment, field capacity (W1) and saturation ratio (W2) and refers to the volume of water added directly to the C0 comparison treatment or in the preparation of the mixture in C1 and the emulsion in C2 and calculated from the results of table 1, (PW = 0.33) and the saturation ratio (PW = 0.50), water was added only in C0. In C1 and C2 treatment, an electrical mixer was used to distribute crude oil to small droplets before adding to the surface of the soil. In C2, the mixing was performed in the first two stages before and after the addition of the emulsifying agent to obtain a homogeneous and stable emulsion of oil / (O / w) emulsion, Crude oil droplets are scattered in the dominant aqueous solution continuous phase.

The first experiment included estimating the movement of water from the bottom to top by the capillary action and conducted in experimental units represented by soil columns put with transparent plastic cylinders, open to the sides of diameter 15 cm and Length 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 roads on the sides of the cylinder to reach a 50 cm long soil column with a density of 1.20 Mgm-3 filled with 18 soil columns from the surface layer of field soil of the high smoothing index P1 and 18 other soil columns from the soil of the field with the low smoothing index P2. The enhanced oil treatments (C0, C1, C2) were then applied using water sizes according to the treatments (W1, W2) and all the columns were then dried in air to complete the coalescence process, which is the process of losing the water surrounding the crude oil droplets to form with each other a continuous membrane of crude oil on the surfaces of soil particles (Martin, 1981). All the columns were then placed in the groundwater basin of the electrical conductivity ECw = 10 dSm-1 to a depth of 10 cm. Measure the movement of water from bottom to top by the capillary action (cm) during

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

Sieves ranges	M i : average of sieves range (mm)	Wi: weight of residual soil (kg) on the sieves		Xi : average of percentage ratio=(wi×mi/∑wi)	
		P1*	P2**	P1	P2
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
50-0	(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

*P1 high pulverization index treatment; ** P2 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^o		0.8562
Water content (v/v %)		Nil
Sulphuric content (w/w %)		1.90
Carbon content (w/w %)		4.48
Wax content (w/w %)		3.10
The pouring point (C^o)		-15.00
Viscosity (cSt)	At 21.1 C^o	10.96
	At 37.8^{o}C	6.43
Initial boiling point (C$^{o)}$		40.00
Total distillation ratio (v/v %)		48.50

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. To describe the vertical movement of water from the bottom to up:

$$Z = \lambda t^{1/2} - \varkappa t$$

Where:

Z: cumulative vertical height upward (cm)

t : cumulative time (min.)

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

And 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 accumulation in the soil columns, kept all soil columns for an equal period until the arrival of the wetting front to the soil surface of all soil columns after 9284 from the beginning of the measurement 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 Pw content was estimated and the soil salinity was measured by the electrical conductivity of the soil. 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 Pw content was estimated and the soil salinity was measured by the electrical conductivity of Soil paste extract ECe. The Mean Weight Diameter (MWD) was estimated by means of wet sieving and bulk densities in cylinder form (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 coefficients were used in the Previous experiment to estimate the movement of the water towards the top. The field in the study area was divided into two parts, the first with a high smoothing index P1 and the second with a low smoothing index P2, each divided into plots with an area of 2 × 2 m, it was applied to its method factor of adding the crude oil treatment factor according to the amount of water used in W1 (Field capacity) and W2 treatment (saturation degree). The soil was then air-dried to complete the coalescence process, then the accumulative infiltration and the infiltration rate with time by using method the double range accumulative infiltration device and the method described by Boersma, (1965). The relationship between the accumulative infiltration and time was expressed by Philip (1957b).

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

Where:

I : Cumulative infiltration (cm)

S: Sorptivity constant (cm min^{½})

A: transmissibility constant (cm min^{½})

t: times (min.)

The infiltration rate was estimated from the calculation of the details for the infiltration equation and after the drying of the equation soil, the MWD of the aggregates soil and soil bulk density were estimated in the methods described in Black *et al*., (1965)

Results and Discussion

Vertical water movement down ward

The results of fig. 1, shows that the effect of the experimental parameters on accumulative infiltration values (cm), with a different time period. Where it is clear there are differences in calculated accumulative infiltration values during the measurement period of 240 minutes. The treatment of crude oil C1 and C2 were excelled by gave a high value compared with the control treatment C0,The highest values were found in the treatment of emulsified crude oil C2 with gave a values amount of 40.30-34.75 cm with an average of 37.15 cm, followed by treatment of crude oil C1 with gave a values amount of 33.89-28.86 cm with an average of 29.69 cm, compared with the control treatment which gave 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 aggregates soil, which increases the stability of aggregates and conserving them from deteriorating by the effect of rapid water immersion, maintaining 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 of small oil droplets less than 2 micrometers which have the ability to influence 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, (Dheyab, 2017). Making porous passages in all their diameter more stable and regular in C2 than in C1. That the decrease in the accumulative infiltration in the control treatment C0 was due to the poor soil structure, which resulted in the destruction of the aggregates soil and the increase in bulk density of As a result of the movement of the fine particle inside the pores, which reduced 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 smoothing degree of P1 were gave a high-value amounted to 35.04 to 23.33 with an average of 29.43 cm. The values of the

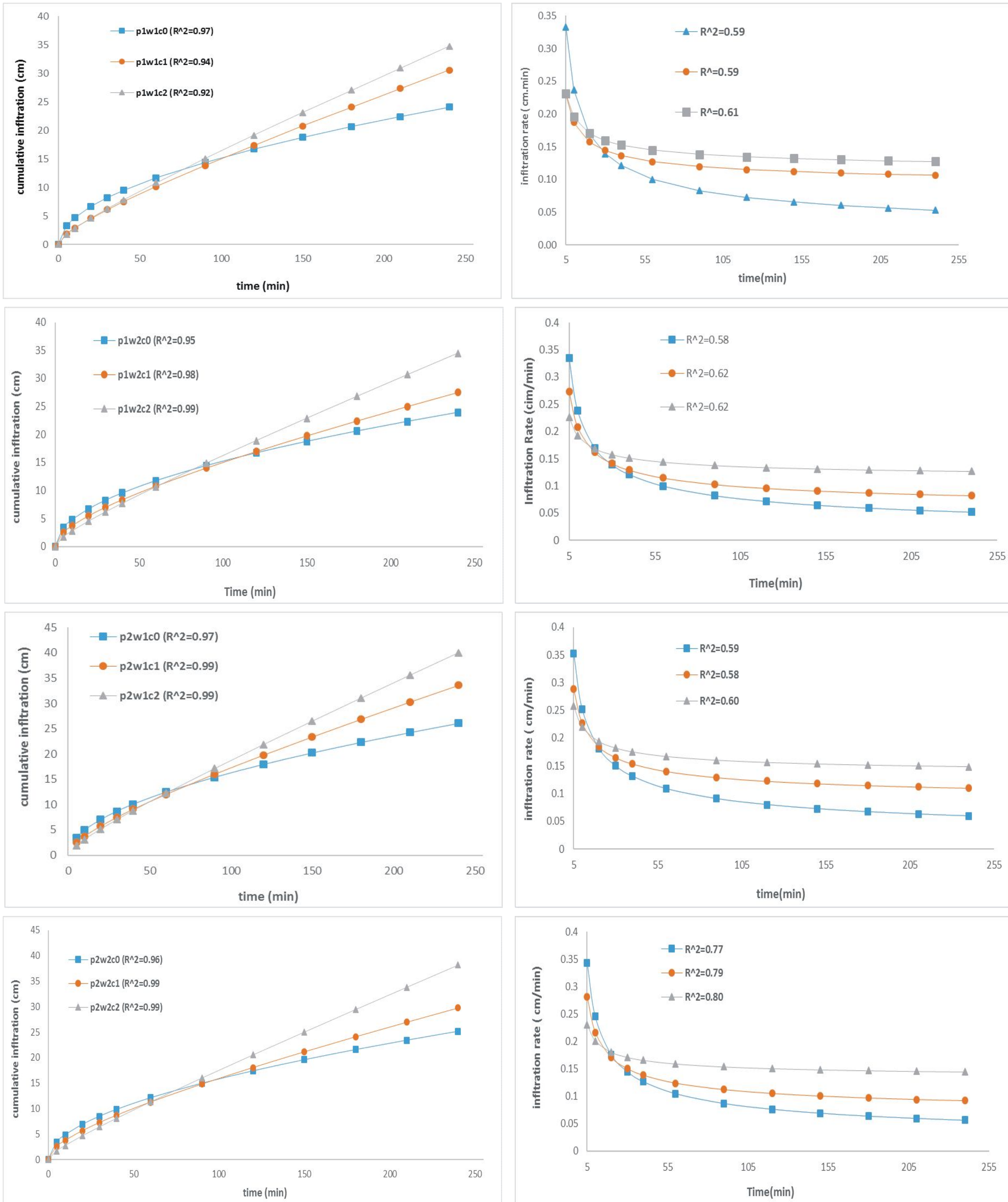

Fig. 1: Effect of the experimental treatments on Cumulative infiltration and infiltration rate.

low tolerance of P2, which 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 masses in the P1 treatment is more breakable to particle and small blocks at rapid immersion (Kuht and Reintam, 2004; Games *et al*., 2004), leading blockages in some pore channels. The primary wetting treatment of the limits of field capacity W1 showed an accumulative infiltration of 40 to 30.16 at an average of 31.77 cm. The increase of The primary wetting level to the W2 the limits of saturation degree to a reduction of accumulative infiltration of 35.26-23.33 with an average of 30.25 cm. which is due to a faster acceleration of the Wetting Front in the soil columns, increasing aggregates soil percentage, Which is deteriorate by rapid immersion. Fig. 1, shows that the differences in the accumulative infiltration values for the improvers differ by change with the smoothing degree, where the differences between the treatment of C1 and C2, Compared with the control treatment of C0 at treatment P1 which amounted to 6.24 and 11.13 cm, respectively. This is due to that emulsions of crude oil droplets C2 have the ability to diffusion and penetrating more homogenous in soil depths and pores when smoothing treatment P2, making their pores more regularly and stability, Compared within the high smoothing treatment P1. The differences between the smoothing degree and the primary wetting factor (W) affected the accumulative infiltration values. The differences between the accumulative infiltration values of W1 and W2 treatment at high smoothing degree P1 which gave 0.99 cm and increases at P2 treatment which gave 2.99 cm. The aggregates soil and pore channels are stable at the low smoothing degree by using of dampness using wetting level (P2) of the W1 field capacity limits. While the triple-interaction treatment between the three experimental factors, the smoothing index factor, the method adding of oil improvers factor and primary wetting factor, the results showed that the accumulative infiltration values for the treatment between these factors recorded values and the following:

The P2W1C2 constant 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.

The results in fig. 1 show the relationship between the infiltration rate and calculated time from the Philip differentiation Philip equation (1957b) for the interaction treatment between the experimental factors, the smoothing degree of soil (P) and the method adding of oil improvers (C) and the primary wetting factor (W). There is an increase in the infiltration rate at the beginning of the measurement period and for all equations due to the matric potential and the gravity of earth which are dominant at the beginning of the measurement, Then the values gradually decrease with time accessing to the nearest value for stability 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 the infiltration. This phase is called the base Infiltration (Hassan, 2007; Hassan, 2018). The results showed that there were significantly excelled differences in the infiltration rate between oil improvers treatment. At the beginning of the first 20-minute measurement period, the C0 Compared treatment showed the highest values compared with C1 and C2 treatment. C2 treatment recorded the highest values due to the effect of hydrophobic petroleum material. values due to the effect of hydrophobic petroleum material,As a result of surface formation of hydrophobic surface on the surface of particles, aggregates and pores soil it works on Increase the contact angle between the water and these surfaces, causing reduced soil uptake of water and 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 of emulsified crude oil treatment C2 due to the properties of crude oil emulsion in the Diffusion and penetrating of the largest depths and in the different pores and Cavities of soil, which increased the hydrophobic surfaces compared to the treatment (C1) Dheyab, (2017).

The oil improvers treatment showed a change in the infiltration rate after 20 minutes from the beginning of the measurement period. The treatment C1 and C2 were significantly excelled, Compared with the control treatment C0. The highest values were recorded in the emulsified crude oil treatment C2 at the end of the measurement period (240 minutes). Base-infiltration values in the C0 amount to (0.059-0.052) average 0.055 cm^{-1} and in treatment C1amount to (0.107-0.082) with an average of 0.098 and in treatment C2 (0.148-0.127) with an average of 0.137 cm^{-1}. The decrease in the Base-infiltration of the C0 treatment is due to the low stability of the soil aggregate and the increase in soil bulk density due to the deteriorate of these aggregate during the progress of the wetting side and rapid immersion and Converted it into soft particles that reduced the diameter and regularity of pore channels in the soil sector (Dikinya *et al*., 2006). The increase in the accumulative infiltration

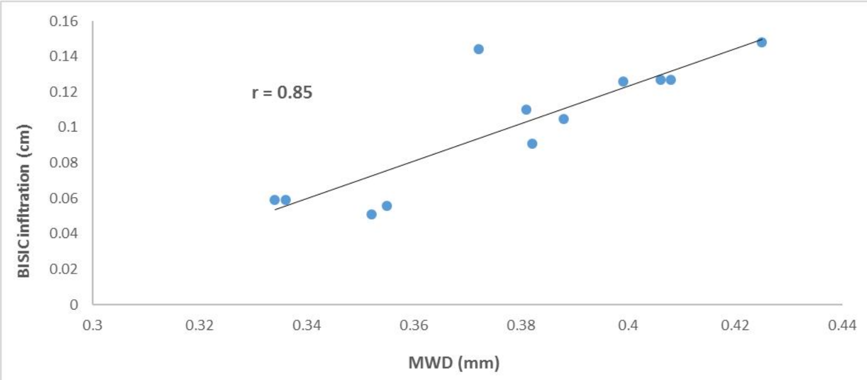

Fig. 2: Correlation between basic infiltration and MWD for the studying treatments.

rate in equations C1 and C2 is due to the effect of the addition of oil materials in the packaging of the oil materials compounds in the packaging of soil aggregates and transport areas, which made it more stable against the deteriorate during the progress of the wetting front and rapid immersion, This effect is more effective when using emulsified crude oil treatment C2, Compared with the crude oil C1 treatment in the diffusion and penetrating of the depths and the larger area of the soil aggregates and transport areas, which maintained the regularity of the water flow in the soil sector (Hassan, 2016).

The results of fig. 2, show that there is a significant positive correlation between r = 0.85** between the base-infiltration and MWD for soil treatments and that there is a significant high negative correlation between the base-infiltration and soil bulk density (Pb) r = - 0.97 ** fig. 3). These results confirm the effect of soil aggregates, their stability and soil bulk density in the infiltration values of the study parameters. The results of fig. 1, show that the smoothing degree treatment P2 showed an increase in the infiltration rate, compared with the high-the smoothing treatment P1 in the early measurement period or the advanced measurement periods. The base-infiltration values were at the end of the measurement (240 minutes) between 0.148-0.059.With an average of 0.148 cm^{-1} for P2 treatment and between 0.127-0.051 with an average of 0.091 cm^{-1} for P1 treatment. This is due to the dominance of small soil masses in P2 treatment with higher surface capacity, more water absorption and more stability against the deteriorate compared to large block soil. That the large block soil is the More Capability to deteriorate and crash into small blocks and particles when immersion rapid. The results of fig. 1, showed that the primary wetting treatment W1 an increase in the infiltration rate in the early or late time period, compared to the W2 wetting treatment. The base-infiltration values have ranged at the time 240 minutes between 0.148-0.053 with an average of 0.092 cm for W2 treatment 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 wetting in the rapid progress of the wetting front and immersion and the effect of the destruction of soil aggregates and blocks soil. When comparing with. The base-infiltration values for the experimental treatment of the interaction between the factors of the study, they take the following order:

P2W1C3 (0.148 $cm.min^{-1}$) > P2W2C2 (0.144) > P1W1C2 (0.127) > P1W2C2 (0.126) > P2W1C2 (0.110) > P1W1C1 (0.106) > P2W2C1 (0.091) > P1W2C1 (0.082) > P2W1C0 (0.059) > P1W2C0 (0.056) > P1W1C0 (0.053) > P1W2C0 (0.051).

The results in table 4, shows Values of treatment constants (Philip, 1957b), Which expresses soil Sorptivity and which depends on the matric potential structure of the soil and (A) constants, which expresses the Transmissibility, which was calculated from the equations of the field data (experimental) Philip, (1957b): I = St1/2 At The values of the constant S were high in the C0 comparison treatment, which ranged from 1.540 to 1.460 with an average of 1.493 min.½. This is due to the high matric potential of clay soil, which increases the speed of wetting and absorption of water, especially in the early periods of the measurement time. The values of the constants in crude oil treatment (C1) ranged between 1.000-0.640 with an average of 0.890 cm min.½. (Al-Doori, 2002; Shabib, 2016). This is due to the effects of hydrophobic surfaces because of its packaging with oil

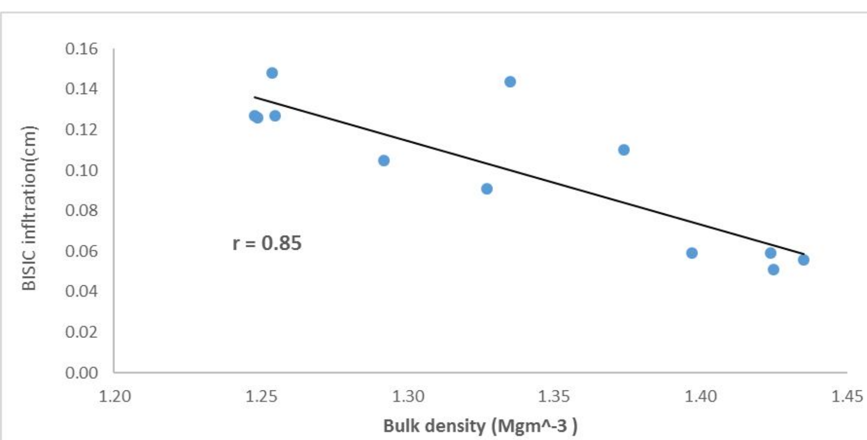

Fig. 3: Correlation between basic infiltration and bulk density for the studying treatments.

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

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

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 enhanced oil treatments C2 was recorded the highest in S constant values, compared to C0 and C1 treatment. The values ranged between 0.570-0.450 at an average of 0.520 c cm min.½. This is due to the ability of the crude oil emulsion to diffusion and penetrating in high homogeneity in soil depths and for all particles, soil aggregates and pores, which Increase the percentage of hydrophobic surfaces. The results show that the low smoothing treatment (P2) was an increase in the values of constant (S), compared to P1 treatment. The values ranged between 1.530-0.450 with an average of 0.945 cm min.½ and between 1.480-0.520 with an average of 0.940 cm min.½ 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 smoothing degree. The primary wetting W2 treatment showed an increase in the values of constant S, compared to W1 treatment and the average values amounted to 0.990, 0.945 cm min.½, respectively. This may be due to the effect of increasing the primary wetting level in 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.

The results in fig. 4, there is a significant negative correlation between the MWD values of the soil aggregates of the study treatment with the constant S values (r = -0.95**). These results confirm that the constant S values increase in the treatment leading to the reduction of MWD the soil. The treatment P2 showed an increase in the values of constant A compared to the equation P1. The values ranged between 0.013-0.008 with an average of 0.690 cm min.½ and between 0.011-0.004 with an average of 0.061cm min.½ respectively. This is due to the increase in the high soil block in the P1 treatment, Which it is prone to collapse and crash into particles and smooth blocks fill pore channels and reduce the area sections of transmitting water (Kuht and Reintam, 2004; Games *et al*., 2004). The primary wetting W2 treatment showed a little increase in the S constant values Compared with the W1 teratment and the mean values amounted to 0.990, 0.945 cm min.½, respectively. This may be due to the effect of increasing the wetting level in W2 treatment of saturation limits in increasing the breaking of soil blocks and aggregates into small particles, which increased the surface area of soil particles effective for water absorption. W1 and W2 treatment did not show differences in A constant values, Both recorded an average 0.060 cm min.½.

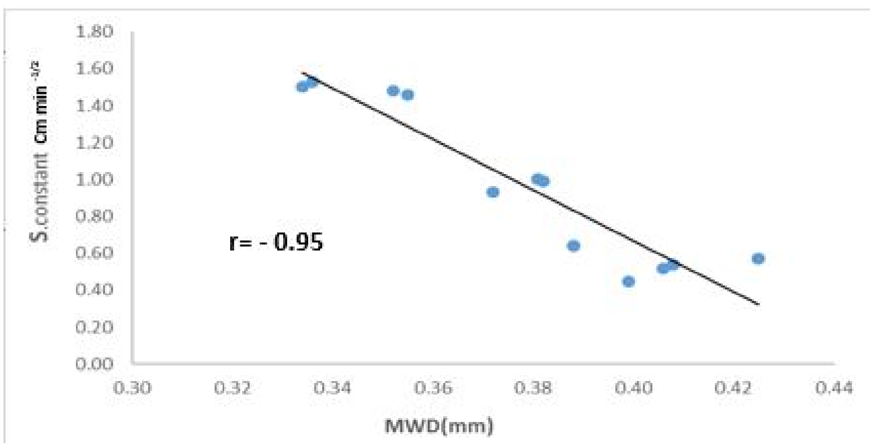

Fig. 4: Correlation between S-constant and MWD for the studying treatments.

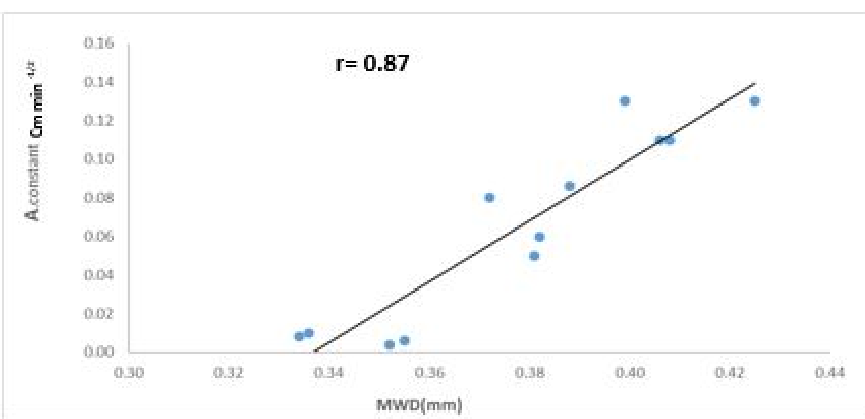

Fig. 5: Correlation between A-constant and MWD for the studying treatments.

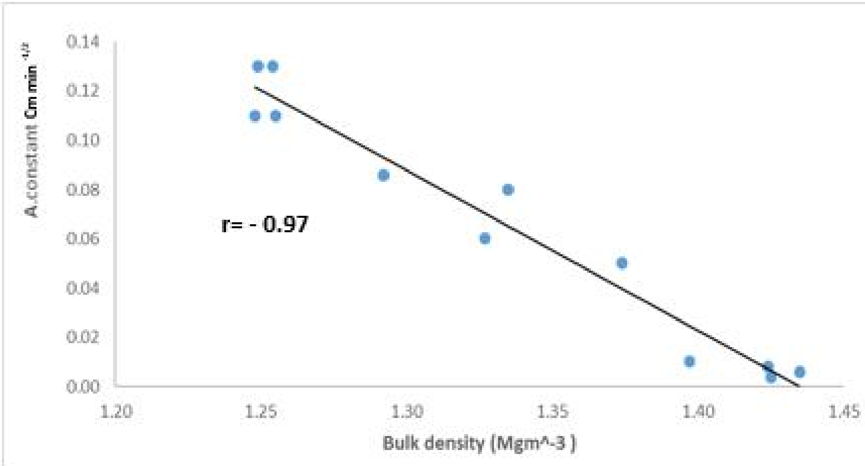

Fig. 6: Correlation between A-constant and bulk density for the studying treatments.

The results of table 4, shows that the lowest values of constant A were found in the control treatment (C0) between 0.010-0.004 cm min.½ with an average of 0.007 cm min.½. It is increased the A values in the C1 treatment, ranging from between 0.086-0.050 with an average of 0.069 cm min.½. The highest values of constant A obtained at treatment (C2) ranged from 0.130 to 0.110 at an average of 0.120 cm min.½. This is due to that the mobility 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 increasing the total area of the pore channels sector that transmitting water. The positive effect increased with the addition of crude oil emulsified C2 for the high permeability and diffusion of crude oil emulsions in the depth of soil and pores, which increased the stability of soil aggregates, pore channels and the regularity of their diameter. The results of fig. 6, show that there is a significant negative correlation between the values of constant A and the bulk density values for the estimated study coefficients r = -0.97**.

Vertical water movement up ward

The results in fig. 7, shows the relationship between the distance of the wetting front and the effect of water movement on the soil surface by capillarity overtime for the study treatment that was put according to the treatment of Philip, (1975c) with a nonlinear relationship. the results show that the speed of progress of the wetting front differ according to the measurement time and depth of the wetting front. All the treatment showed a state of convergence in the altitude and the rate of progress of the wetting process within the height of 0-10mm directly above the surface of the default groundwater and during the first 10 minutes of the measurement period. This is due to the near the source of water supply to this section and its moisture content is high up to the wetting degree and close to the field capacity Most of the soil Pores are filled with water and the water covers around the particles are thick, which increases the speed of filling the soil Pores, which increases the values of the unsaturated water conduction (Miyazaki *et al*., 1984; Nedawi, 2008; Al-Hadi, 2014). After the early period (10 minutes) and after the wetting front exceeded the vertical distance of 10 cm. There was a decrease in the average of the progress of the wetting

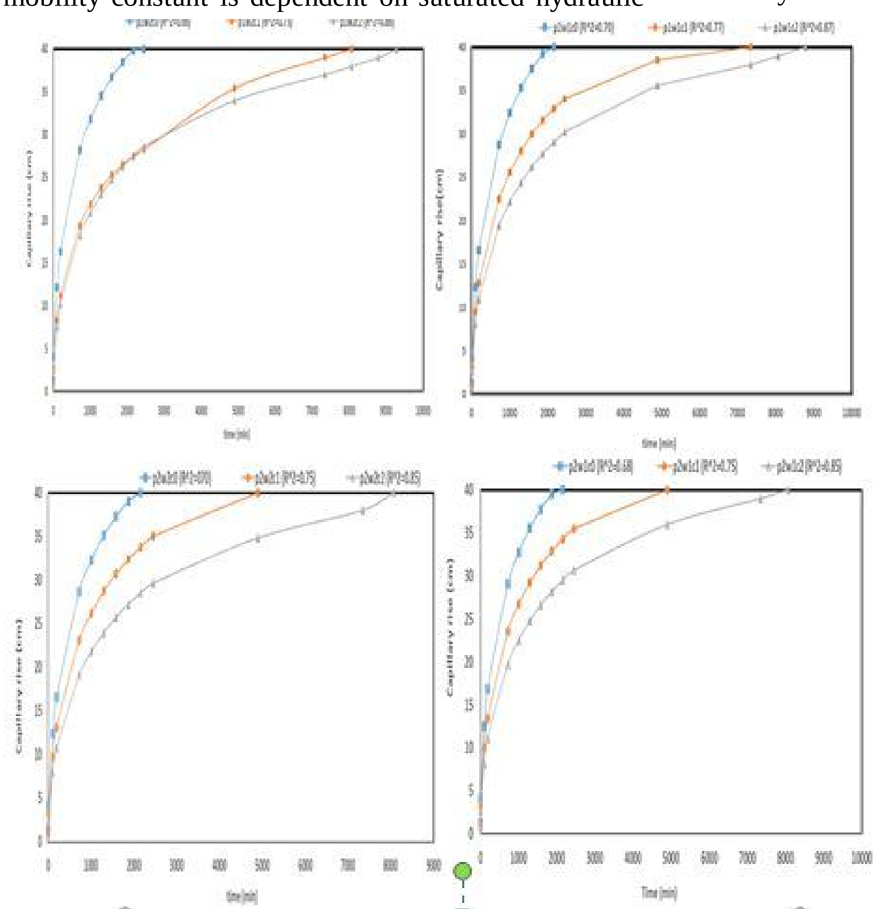

Fig. 7: Relationship between water movement upward with the time for study treatment.

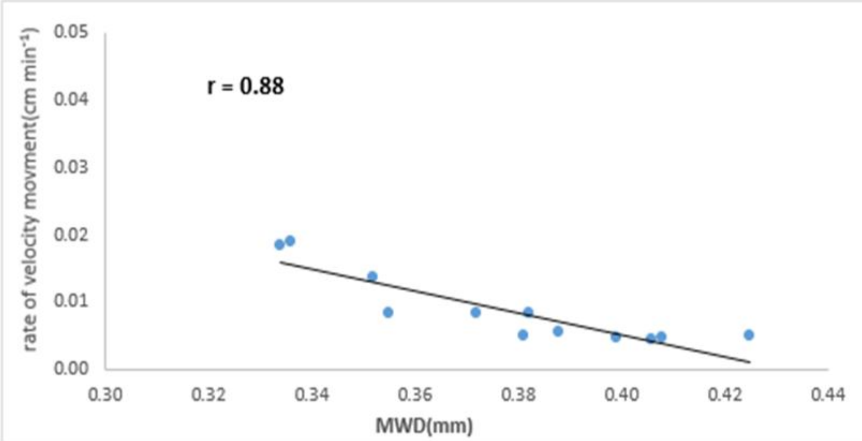

Fig. 8: Correlation between rate of capillary rise with the MWD for the studying treatments.

the dominance of large soil blocks in the treatment P1, which reducing the capillary water movement to top because the water goes longer in the case of large soil blocks and aggregates (Hamid, 1966). The results in fig. 8, showing the relationship between the average of speed of progress the wetting front from the calculated top (Fig. 7) show that there is a significant correlation between the progress of the wetting front and MWD of the study treatment r = -88. The results showed that the treatment of primary wetting W1 showed an increase in the speed

front to above for all treatment with increasing time and the decline continued until the access of the wetting front to the soil surface at a height of 40 cm. The experimental treatment difference in the average of progress to the above and in the time required to reach the soil surface, The control treatment (C0) showed the highest speed to progress above and the lowest time of access to soil surface between 4896-2016 with an average of 2988 minutes. There was a decrease in the speed of progress to above in the treatment of C1 and an increase in the access time of the wetting front to the soil surface ranged between 8064-4896 with an average of 6912 minutes. This is due to that oil material reduce the speed of wetting of aggregates, which reduces capillary height in the soil (Hillel, 1980). The soil is high wettability and the addition of oil materials Transformation soil surfaces, particles, aggregates and pores into hydrophobic, which increases the angle of contact with the water, Thus reducing the capillary water movement to top. The treatment of C2 emulsified oil showed a decrease in the speed of the wetting front compared to the treatment of C0 and C1 with a significant increase in the time required to reach the soil surface ranged from 9284-8064 with an average of 8729 minutes, This is due to the properties of crude oil emulsion made from oil droplets of less than 2 micrometers to Permeability and diffusion to more deeper into the soil, which increases the total area of soil aggregates, their particles and pores, hydrophobic compared to the treatment of C1 (Dheyab, 2017; Shabib, 2016). Fig. 7, shows that the treatment (P1)was high smoothing index showed a decrease in speed of progress the wetting front and the increase in the time required to reach the soil surface ranged from 8784-2160 at an average of 5616 minutes compared to the treatment of the low high smoothing index P2 and time period ranging from 9284-2448 with an average of 6470 minutes, This difference in the smoothing degree between these two treatments to

of the rise of the wetting front and the time required to reach the soil surface, including 8784-2160 with an average of 6024 minutes compared to the treatment of wetting degree to the saturation W2, Which the speed of the rise to top decreased from it with a time ranged between (9284-2448) at an average of 6395 minutes. This is due to increasing the level of wetting from field capacity in W1 to saturation degree in W2 has increased the speed of the progress of wetting and rapid immersion in breaking soil aggregates into smaller aggregates (Dheyab, 2017). This effect has increased the homogeneity of the soil pores of the pore channel of the capillary to up, increasing the speed of vertical water movement to top (Al-Hadi, 2014; Kheorenrumine *et al*., 1998).

The results in table 5, show the value of the experimental constants to t Philip equation (1957c). It is clear that the values of the λ constant expressing the unsaturated water conductivity showed the highest values at the control treatment C0 ranged between 1.36-1.32 with an average of 1.34 cm min. This constant reduces in the treatment of crude oil (C1) between 1.07 - 0.96

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

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

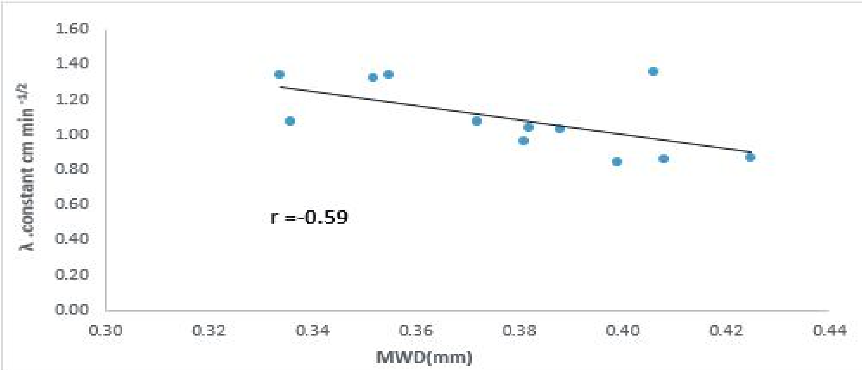

Fig. 9: Correlation between λ-constant with the MWD for the studying treatments.

with an average of 1.03 cm min.½. This constant reduces in the treatment of crude oil C2 between 0.87-0.80 with an average of 0.84 cm min.½. The low smoothing index treatment of P2 showed an increase in λ values compared to the P1 treatment. The values ranged from 1.36 to 0.84 with an average of 1.09, 1.34-0.80 With an average of 0.854 cm min.½, respectively. While the primary wetting treatment W1 showed an increase in the values of λ compared to the wetting treatment W2. which amounted to between 1.36 and 0.86 at an average of 1.088, 1.32-0.80, respectively. The difference in the values of λ between the C2, C1 treatment and C0 equations, which was increased in P2 treatment compared to P1 and W1 compared with W2, is due to the effect of the correlation between these equations on the MWD values of the soil aggregates and the soil bulk density value (Pb.).

The results in fig. 9, show that there is a significant high negative correlation between the MWD values in the treatment with the λ constant values of r = -0.59** and that there is a significantly high correlation between the soil bulk density value (Pb.) and P values for r = (Fig. 10). The results in fig. 9, show that there is a significant high negative correlation between MWD values in the treatments with λ constant values of r = -0.59** and that there is a significant positive correlation between the Pb values of the treatments with λ values and r = 0.62** (Fig. 10) These results confirm that the values of the λ constant expressing the unsaturated water conductivity are influenced by the MWD of the soil aggregates that determine the diameter and degree of pores of the regularity soil and it is affected by soil bulk density of the soil that determines the continuity of the pores of soil. 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 equations showed high differences among them. The highest mean of κ values was observed in the control treatment. The values in C1 and C2 treatment were significantly different, with 0.010, 0.007, 0.005 cm min.½ respectively, This is due to that the values of κ depended on the structural effort of the particles and soil aggregates, which is high in the control treatment (C0) and that the addition of the oil enhancers reduces the structural hydraulic of the particles and soil aggregates and pores that cause the formation of hydrophobic surfaces (Al-Doori, 2002; Unger, 2001) Which reduced the structural hydraulic, the results showed no significant effect of the smoothing factor or the primary wetting factor κ.

Moisture content distribution and salt accumulation in soil columns

• Moisture content distribution:

The results in fig. 11, show the effect of the study factors in the Pw moisture content values of the soil column sections from the height of 0 cm directly above the level of the default groundwater (the source of the supplied water) up to the top of the soil surface at height 40 cm which is 0-10, 10-20 and 20-30 and 30-40 cm, after reaching the vertical wetting front of the soil surface for all transactions at the time of 9284 minutes from the beginning of the experiment. The results showed that there were significant differences ($p < 0.05$) in moisture content between soil column sections (Table 6). The highest moisture content values found at 0-10 cm were very close to field capacity at Pw = 0.323. The average values of Pw 0.268, 0.233, 0.192 for heights 10-20, 20-30, 30-40 cm, respectively, This is due to a decrease in the mobility rate of Capillary Water upward Due to lower unsaturated water conductivity by increasing the vertical distance of the water movement through the macro capillary pores (Hillel, 2003).

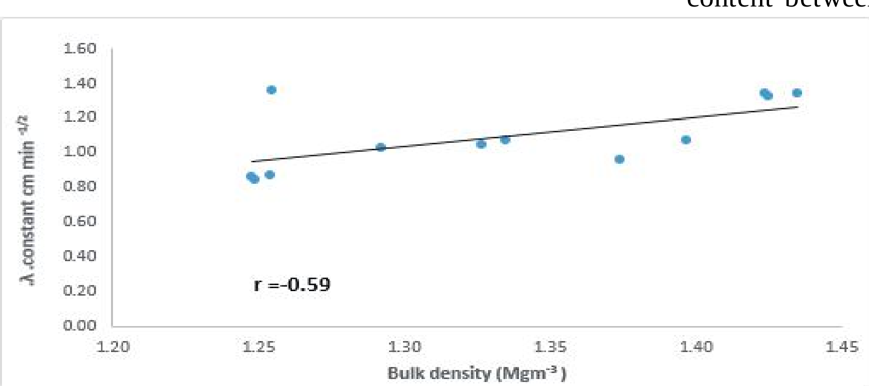

Fig. 10: Correlation between λ-constant with bulk density for the studying treatments.

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

S.O.V	MOSITURE 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		

The results (Fig. 11) The results show that there are no significant differences between the treatments of the Pw values at 0-10 cm. This is due to the near groundwater level. Most of the pores of the soil are filled with water and have thick water coverings. Jorenush and Sephakhah, (2003) noted that moisture content in soil columns is high enough to reach the wetting limits of depletion at the layer above the groundwater level and moisture content decreases by increasing elevation 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 oil emulsion improvers C2 showed the lowest values with an average of Pw = 0.242 with a significant decrease compared with the C0 control treatment with an average of 0.295 Pw. The treatment of C1 (Pw = 0.266) with equations C0 and C2, this is due to the difference in the ability of the oil emulsion improvers diffusion and permeability into depth in the soil to the formation of the hydrophobic surfaces, thus reducing the average of capillary and water mobility, where this effect extends to the depth of the emulsified crude oil (C2). And increased significant differences between the treatment C0, C1 and C2 at both heights 20-30 and 30-40 cm from the soil columns, although the moisture content for all treatments was significantly reduced, with Pw averages 0.282, 0.277, 0.197 respectively, at height (20-30 cm) 0.252, 0.187, 0.137, respectively, at the height (30-40 cm). This is due to the effect of the oil improvers added to C1 and C2 treatment increases the effect of reducing the capillary in the soil columns in the soil surface depths, due to the increase of the soil aggregates of the oil material at these depths (Dheyab, 2017) the highest. The low P2 treatment showed an increase in Pw values compared to P1 treatment. This is due to differences in the speed of progress of the wetting front, which increased with a lower smoothing degree from P1 to P2, which was caused by the lower diameter of the capillary tubes and the regularity of their diameter. The primary wetting treatment of W1 and W2 showed no significant differences between them (Table 6).

Salt accumulation in soil columns

The results in fig. 12, showed the effect of the study factors on the soil salinity values of ECe dSm-1 in the soil columns by the effect of the vertical movement of the water above the source of the default groundwater (ECw = 10 dSm-1). It is clear that there are significant effects ($p < 0.05$) of the main study factors and some interaction, with a significant effect of the vertical distance at the surface of the default groundwater in salinity values (Table 6). The results in fig. 12 show that the ECe values are significantly reduced by increasing the vertical distance at the surface of the default groundwater. The average values of ECe were 8.43, 7.40, 6.50 dSm-1 for Heights 0-10, 10-20, 20-30 cm at surface. The salinity concentration at these heights difference depending on the heterogeneity of moisture content (Fig. 9), which is derived from the capillary movement above groundwater (ECw = 10 dSm-1). The results showed no significant differences in the EC values between the study treatments at the height of 0-10 cm. The values amounted to 8.42-8.42 were average 8.43 dSm-1, this is due to the similarity in the moisture content values of the study

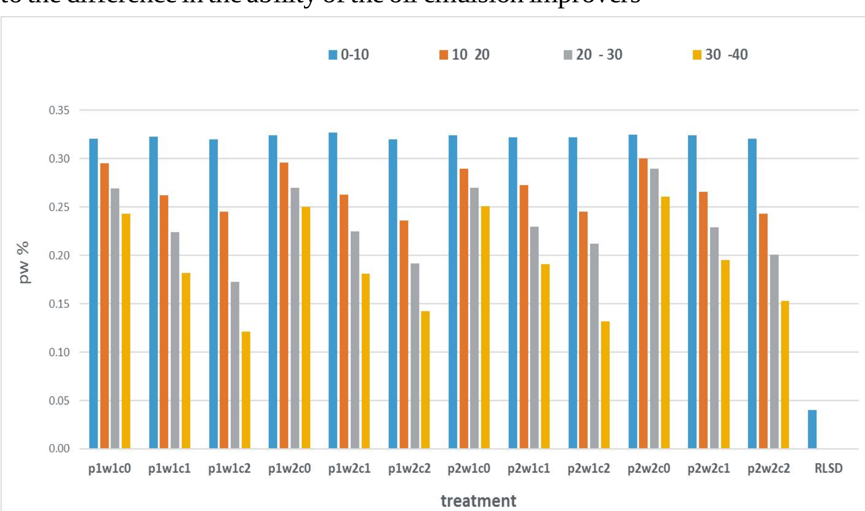

Fig. 11: Effect of the studying treatment on moisture content (pw) at soil colums.

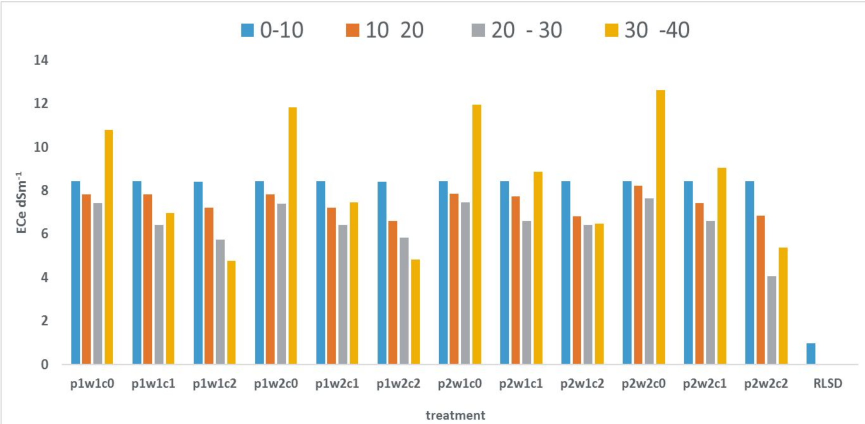

Fig. 12: Effect of the studying treatment on ECe dSm^{-1} at soil colums.

treatments for the proximity of this rise of the groundwater level (Fig. 9).

The treatment showed significant differences in the ECe values at 10-20 cm. The highest values were found in the control treatment C0 with an average of 7.93 dSm-1 followed by C1treatment with an average of 6.87 dSm-1 and the lowest mean of 6.46 dSm-1 at C2 and a significant difference compared with control treatment C0. due to differences in moisture content between C2 and C0, C1treatment. The significant differences in ECe values between the three C0, C1 and C2 treatment increased at 20-30 cm from the soil columns. Despite the overall reduces in the ECe average of all treatments, the average values were 7.47, 6.46, 5.50 dSm-1, respectively, These results agree with the Pw values of these equations, which averaged 0.282, 0.277, 0.197 respectively. The surface elevation of soil columns 30-40 cm showed an increase in average ECe values of 8.41 dSm-1 compared to heights 20-30 and 20-10 cm. This is due to the evaporation of the moving soil solutions to the top of the soil surface, leading 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 and 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 of the soil columns was 30-40 cm when the control treatment (C0) was treated with an average of 11.80 dSm-1 and a significant difference compared to C1 and C2 treatments at an average of 9.09 dSm-1. When C2 treatment is treated with an average of 5.35 dSm-1. This is due to the above-mentioned reasons for differences in the speed of Capillary movement and water mobility to the top and the volume of water flowing to the soil surface. The result shows that the lower smoothing treatment of P2 an increase in ECe values compared to the high P1 treatment. The differences between the two treatments increased with an increase from the groundwater level. The ECe averages were 7.48, 7.42 dSm-1 respectively at 10-20 cm and 6.53, 6.45 dSm-1 at height 20-30m and 9.06, 7.77 dSm-1 at surface height 30-40 cm, respectively. This is due to the difference in moisture content because of the difference in a capillary of water and water conductivity, which reduce with the increase of P2 to P1 relative to the relationship between capillary tubes with their regularity and continuity. The primary wetting treatment of W1 and W2 did not show significant differences in the electrical conductivity values between them.

Conclusion

That the emulsification of crude oil or its derivatives with irrigation water makes them optimizers with high efficiency in the diffusion and Permeability 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 movement of the capillary of the water to the top, which reduces the water lost surface evaporation and increase the ability of soils to conservation moisture, Soil salinization has been reduced by the accumulation of salts associated with the movement of capillary water originating from critical groundwater.

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