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Effect Of Application Nano Powder To Dried Sawdust Extract To Soil On Distribution Of The Size Of Soil Aggregates And Their Hydraulic Conductivity

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Abstract

A laboratory experiment was performed in the College of Agriculture's laboratories, University of Anbar is to study the effect of sawdust's extract and cycles of wetting and drying. Irritated soil samples were collected from the fields of the College mentioned and their aggregates were distributed in an order which is above than 9.5, 4, 2, 1, 0.5, 0.25, and below than 0.25 mm. The diameter and the height of the cylinders were 100 mm consecutively, they were filled by soil which weighs 800 g with the same size distribution of the original soil samples. Approximately, 5% of the organic matter exists in the soil was injected in Sawdust's extract depending on the dry weight without any addition The addition of (Non-ESD), Nano-Powdered Extract Drye r(np ESD), and sawdust's extract as a solution without treatment (SESD), Then the containers were applied to five cycles of wetting and drying (DW) and incubated at a temperature of 22°C. The size distribution of the soil after incubation was estimated in the same order as the size distribution of the original sample, and the hydraulic conductivity to the size-distributed soil aggregates was estimated as well.

According to the results obtained, the np ESD addition was the best to increase the soil aggregations above than 9.5 mm and the ratios were higher in comparison with the rest of the ranges size, while SESD was the best to form clusters less than 9.5 mm, and that the np ESD addition increased the hydraulic conductivity of the aggregates larger than 9.5 mm, The DW cycles highly affected the weight ratios of the soil aggregations greater than 9.5 mm and those with a size range of 9.5-4 mm fluctuating.

Keyword; extract sawdust, nanoparticles, aggregate size distribution, hydraulic conductivity.

Introduction

Arunrat et al. (2020) confirmed that the total carbon content in the soil was higher in corn and rice farms by 58.71 Mg/ha, and lower in strawberry farms. The carbon content is positively correlated with clay content and bulk density. The tillage causes a combination of aeration factors, and soil aggregation and their effect crop residues and fertilization in the root area, which leads to increase aeration and break soil agglomerations. It exposes organic matter to microbial representation which in turn accelerates the decomposition of organic soil matter.

Liu et al. (2014) observed that the percentage of carbon in large soil aggregates with a size of 1-0.5 mm is higher in forest and pasture soils in comparison to the rest of the studied size distributions, while the percentage of carbon was lower for the same soils in the size of 0.5-0.25 mm. Furthermore, the carbon's fixation in the micro aggregates forming the macro aggregates was more stable than carbon in macro ones.

Ciric et al. (2012) explained that Arenosols sandy soils had lower aggregate due to high sand content and scarcity of active bonds, while Fluvisols soils had higher clay content so they had better aggregates than Arenosols. The strongest soil structure was found in the soils of Chernozems and Gleysols, and those soils had a strong ratio of multiple bonds and Solonetz had very large aggregates (clods) because it contained a high percentage of sodium and clay content.

Zhou et al. 2020 concluded that the crop's rotation includes soybean and corn. Soybean increases the sizes of water-fixed soil aggregates, the reason for increasing macro aggregates sizes is attributed to plowing led to an acceleration of the rate of regeneration of the total soil aggregates. It did not allow micro aggregates to form within the total aggregates. The reduction of tillage led to higher aggregate stability.

Tao et al. (2018) found that the soil organic carbon concentration in macro aggregates which is larger than 2 mm with a size of 2-0.5 mm is distinctly increased under no-tillage system. This indicates that the no-tillage system provides favorable conditions for carbon accumulation in macro aggregates and that the 13C isotope of C in straw residues was observed within aggregates larger than 2 mm and this isotope was lower in the no-tillage system than in the conventional tillage system.

Bronick and Lal.'s review for soil structure and type of management 2005, it was shown that the negative charge on clay particles is parallelly increased with the increase of the degree of soil interaction, which leads to controlling the dispersal of clay and increasing its coagulation.

Park et al. (2007) indicated a noticeable decrease in aggregates' stability after exposing the aggregates to two and three DW cycles, especially, when carbon from glucose materials is added to the soil. The soil's aggregates remained stable until the fifth wetting and DW cycle. Dörner et al.)2010) studied the effect of the kinetics of alternation of DW cycles, convection, and no-load cycles on soil structure and showed that aggregates' formation due to water stress is less than aggregation due to mechanical stress. Xu et al. (2017) observed that the 10-5 mm and 5–2 mm diameters of soil aggregates are decreased from 33.3% to 0.25% and 22.14% to 22.9% in the DW0 cycle to the DW10 cycle consecutively. The opposite occurred in the aggregates whereby, the weight ratio of the aggregates is noticeably increased from 1-2 mm and 0.5-0.25 mm and was less than 0.25 mm from the DW_0 cycle to the DW_{10} cycle.

Yang et al. (2020) indicated that the lithological discontinuity is a more important factor than the precipitation factor in the size distribution of soil aggregates, which is inferred from coarse aggregates in rocky soils and fine aggregates in soils of acidic igneous rocks, and that the stability of soil organic carbon is determined by the quality of mineralized organic carbon and the rates of precipitation decline. In rocky soils, the destruction of aggregates has a limited effect by affecting the mineralization of organic carbon, which indicates that the retention of organic matter in aggregates plays a secondary role in the stability of organic matter.

Hu et al. (2018) showed that the size distribution of soil aggregates is increased by weight percentage of soil aggregates which is less than 0.25, whereby, it is increased by the increasing of DW cycles to 15 cycles. particularly, when soil aggregates are exposed to 7–5, of 3–5, 3–2, and 1-2 mm for wet sieving.

Mashhour (2014) explained the addition of some substances such as humic, vegetable residues, calcium sulfate, and iron sulfate with clay and, with DW cycles again and again. It was found that the process of formation and aggregates stability mainly depends on the presence of clay and organic matter. The successive cycles of DW increased the formation and aggregates stability due to the effect of expansion and contraction as a result of soil moisture. The best treatments were the treatment of humic acid + 10% clay with DW cycles, which gave the best contribution ratios of 9.2% compared to no addition.

Karahan and Erşahin (2016) found that Ks can be predicted from the morphological characteristics of the soil. The properties are measured by multiple regression analysis and the soil type, viscosity, pore amount, and root size which made the prediction coefficient (R2) of ks equal to 0.95. The increasing hydraulic conductivity by one unit increases the main weighted diameter at slow hydration by 2482 units, and the negative effect of the water conductivity in the assemblies with a diameter of 4-2 mm and those larger than 9.5 mm did not have a significant effect on the water conductivity, also Impact of DW cycles on the saturated hydraulic conductivity (ks) of aggregates larger than 9.5 mm was important in this properties, as it increased by 13, 8, 13, 19, 18 and 18% for the second, fourth, sixth, seventh, eighth and last of the DW cycles, Straight. found a significant effect of sawdust extract levels on the saturated hydraulic conductivity within ranges of 9.5 - 4 mm. There has been a significant increase in bonus add-on 5, 10, and 15% levels with 8.4, 32.9, and 74.2%, respectively. (Al-Mohammadi and Al-Nuaymy (2019) Fand (2021)).

Therefore, this study aims to know the effect of the Nano powder of the dried organic matter extract on the volume distribution of soil aggregates and the conductivity of soil aggregates with sizes larger than 2 mm.

Materials and methods

Sawdust's extract was collected from one of the carpentry factories in Anbar Governorate (C:N 1:400). 50 kg of sawdust are ground using a high-speed grinder to increase their fineness and reduce their decomposition time. The mulch was left for aerobic decomposition after being stacked on a piece of polyethylene. 2% of Nitrogen was added to the dry weight of the soil and urea fertilizer . (46%N) was used for that, while triple superphosphate fertilizer (20% P) was used as phosphorous at 0.5% as a source of phosphorus (Sarhid (2016). The sawdust was mixed with fertilizers in the heap and then moisten the mixture by spraying it with water spray. The pile is stirred continuously to homogenize the moisture. These procedures are repeatedly done every 3 or 4 days, and the collected juice was returned to the heap again until the texture of the sawdust material changed to a disintegrated substance of dark color. The temperature of the heap was measured with a soil thermometer, its temperature at the beginning of the reaction was 65 ° C, then it is gone down to 45 °C.

The decomposition process took 75 days. After that, the decomposed sawdust was re-brushed on the polyethylene piece and left to be aired for three days. Then the lysate was soaked in 0.1N KOH solution for 24 hours. Then, the solution is separated from the decomposing material by centrifuging by placing the soaked in a perforated bag inside a washing machine dryer, then turning on the dryer and cutting off the solution leaving the drain tube of the dryer.

The weight of the dry matter was calculated after drying in an oven at a temperature of 40° C in the sawdust extract through drying 100 ml of the solution and weighing the remainder 35 ^{o}C, an amount of extract will be added to the soil, it was calculated depending on the equivalent of the extract amount which is 5% of the organic matter in the dry soil as an equivalent amount of the dry matter in the extract to the decomposed matter, which was added to the soil as a

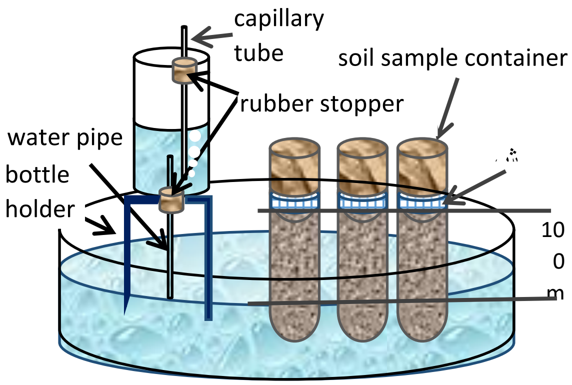


Figure 1. Method of wetting samples to reach saturation using a Maclaurin bottle used in the WD cycles

solution of sawdust extract (SESD), as well as dried sawdust extract powder is added in the same way to calculate the amount of extract ,As the dried portion was taken from the extract and ground into nanoscale particles at the laboratories of the Ministry of Science and Technology in the Republic of Iraq and with a QM ISp04 planetary ball mill device, then the amount of powder required to be weighed is an equivalent to 5% of the organic matter which was dissolved with water according to the amount added from the solution to reach the field capacity and the properties of the suspension are differed from the original solution of the extract in terms of viscosity and color, whereby it is marked by light golden color with a little viscosity (np ESD). In other hand, the treatment in which sawdust extract non-ESD) was not added, but sufficient amount of water was added to the soil to reach the field capacity, All the solutions are transferred to the cylinder by dropping them from a bottle that has been calibrated to a height above the soil surface at heights that give a discharge of about 200 ml h^{-1}.

Table 1 aggregate size distribution as a percentage based on the weight

Greater than 9.5 mm	**9.5 -4 mm**	**4-2 mm**	**2-1 mm**	**1 - 0.5 mm**	**0.5-0.25 mm**	**Less than 0.25**
13.8	14.57	8.61	9.82	8.64	14.40	30.18

A distributed soil sample was collected from the fields of College of Agriculture, Anbar University, the quantity was dispersed and aired, A size distribution of the sample was passed through a set of sieves with holes 9.5, 4, 2, 1, 0.5 and 0.25 mm so that the extents of soil aggregates were ordered respectively< 9.5, 9.5 - 4, 4-2, 1-2, 1 0.5, 0.5 -0.25 and >0.25 mm and the values of the size distribution is clearly shown in Table 1, Then cylinders that their height and diameter is 100 mm were filled by placing a filter paper with a piece of gauze and tied with a tape at the lower end of the cylinder. Then the soil was added to the container after weighing 800 g of soil after re-collecting it from the soil distributed by size to the original soil sample in the same proportions of its size distribution after carefully mixing it on a piece of polyethylene.

Soil samples were wetted by capillary property by placing soil cylinders on top of soft sand's column which heightened 100 mm, then the water column is fixed which is designed for water height using a Maclaurin bottle shown in Figure 1. The wetting process continues until saturation is reached which takes 16 hours, after that the containers are left to drop their water, and until soil moisture is reached, which is sufficient for the soil to reach the field capacity by adding the amount of the extract solution. This is the first DW cycle. Then all the cylinders were incubated at 22°C for 3 days, then the samples were taken out of the incubator and placed horizontally on the ground, and left for 3 days to be dried. The wetting is re-saturated again for 16 hours for the cylinders which will go on for the subsequent cycles which are 5 DW cycles. Besides, the containers which will be analyzed will be cut from both sides using a pretty hot knife without touching the soil in. The size distribution is repeated with the same set of sieves to screen the original sample after extracting the soil from the cut container, then place the soil on top of the sieves' set and perform the sieving process, finally, the remaining samples are weighed.

Hydraulic conductivity

Hydraulic conductivity was measured according to the method of Park et al. (2005). As the settling soil aggregates were taken on the sieve 9.5 mm and also settled among the sieves 9.5 and 4, As well as assemblies with a diameter confined to sieves 4 to 2 mm and as follows:

Measuring the length and width of one of the assemblies for the size range for which the hydraulic conductivity is measured (greater than 9.5, 9.5-4, or 4-2 mm). Then the selected assembly is coated with wax to become a capsule. A thin blade is used to cut the two sides of the capsule to remove the waxy cover and let water passing through. Then funnels and tubes are fixed and at the same places of the cut in which they help for aggregating the soil while the tubes, the first is for water's entrance and the second is for its exit Then a pressure difference of 50 cm is fixed for both sides of the capsule by two columns of water between the two sides of the measuring capsule, in which the height of the water varies by 50 cm, as in Figure 2.

The measurement lasts for 60 minutes. The volume of water left the capsule cannot be calculated precisely because of the lack of micro cylinders or micropipettes to collect water. Thus, it was replaced by weighing a quantity of cotton and cramming it at the end of the water outlet tube, then weighing the quantity of cotton after the expiry of the necessary hydraulic conductivity estimation time, and the difference between the two weights obtained represents the amount of water passing through the capsule. Then ks is calculated from equation 1 (Park et al. (2005)):$\mathrm{Ks} = \frac{4\mathrm{vL}}{\Delta \mathrm{H} \pi \mathrm{d}^2} \dots\dots\dots\dots\dots\dots\dots 1$

Ks are the saturated by hydraulic conductivity of the capsule, v is the volume of water passing through the soil aggregate (cm3 sec-1), L is the length of the capsule (cm), ΔH is the hydraulic head (50 cm), and d is the diameter of the capsule (cm).

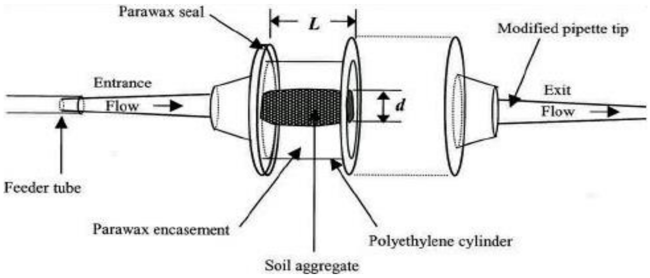


Figure 2 Diagram of the Hydrodynamic Conductivity Meter (Park et al. (2005)) (Dimensions of the diagram are not real)

The soil properties given in Table 2 were estimated from the soil passing through a 2 mm sieve. The soil texture was determined from the American soil triangle by estimating its separations employing the volumetric pipette method according to the method presented by Gee and Bauder (1986). The electrical conductivity of the soil was estimated using an EC-Meter, and the degree of soil interaction was done as well with a pH-Meter mentioned in Richards, (1954). Gypsum was estimated according to what was mentioned in (Brady and Well 1999). Lime was estimated by a gravimetric method according to (U. S. Salinity Laboratory Staff, 1954.), and the organic matter was estimated depending on what had been mentioned in (Allison, 1965.)

Table 2. Some physical and chemical properties of soil

Separates ofsoil			Class of texture	Ec dS.m^{-1}	pH	Gypsum	lime	O.M. in soil aggregates	
clay	silt	sand						>9.5 mm	-4 9.5 mm
gm.kg^{-1}						gm.kg^{-1}			
18.35	51.15	28.51	silty loam	6.78	7.66	2.55	15.78	19.69	9.37

Results and discussion

Size distribution of soil aggregates

Soil aggregates larger than 9.5 mm

Figure 3 shows the effect of the type of wood extract added to the soil under the influence of wetting and drying cycles. Figure 3 states the types of SESD which have significant decreases in the weighted percentage of soil aggregates (POWSAS above than 9.5 mm by 6.7% in comparison with non-ESD and ESD np which is not highly different than np Ez SD in comparison with POWSAS greater than 9.5 mm before adding ESD shown in Table 2, in which its percentage is 13.8%, compared to non-ESD , np ESD and SESD . It is observed that POWSAS greater than 9.5 mm obviously increased by 496, 496 and 456% respectively . This validates the fact that The addition of water to irritated soil will increase the rate of soil aggregates at high rates. While the reason underlies the low performance of the added extract as SESD, is water solution which is more saturated with the extract materials. Therefore, the water as a solvent for the materials in the soil will work less, and crushing the dried extract powder and re-dissolving it with the same amount of water in the same proportion of the dry matter of the extract is not enough to saturate the water with the extract materials. At the same time, it is observed in Figure 3b that there is no significant effect of DW cycles in POWSAS greater than 9.5 mm, but by comparing the value of POWSAS which is greater than 9.5 mm DW_1 with its value before the addition of ESD, it is found that it leads in this cycle by 468%. Tracking the performance of the additions for each cycle separately in figure 3c, reveals that there was no significant effect of the additions in any of the DW cycles, Tracking the effect of DW cycles with the type of addition also shows that there is no significant effect of DW cycles for the non-ESD and SESD types of addition, While the DW cycles had a significant effect on the type of addition np ESD, Whereby, the POWSAS that is greater than 9.5 mm increased obviously 11.3, 10.5, 12.14, and 10.8% for the cycles from DW2 to DW5, respectively, in comparison to DW1 cycle. The reason for the superiority of the addition type of np ESD may be due to the fineness of the ESD particles, and this may give preference to the growth of a type of organism whose secretions can work to re-form large soil aggregates, Especially, the performance of the add-on type np ESD was better after the DW_2 cycle, As the ability of clay to adsorb organic matter varies with the type and age of the organic matter (Arunrat et al. 2020), expansion and contraction also helps to form large aggregates (Ciric et al. 2012). At the same time, it is noticed that there are no significant differences for the additives within the DW cycles separately, that the negative charge on the clay particles increases with the increase in the degree of soil interaction, which leads to controlling the dispersal of the clay and increasing its coagulation (Bronick and Lal. 2005).

Soil aggregates size 9.5-4 mm

Figure 4 shows the effect of ESD and DW cycles in POWSAS 9.5-4 mm. It is clear from Figure 4a that the type of SESD addition in this size range was the opposite of its effect on the larger size content, such as 9.5 mm, POWSAS increased by 9.5-4 mm significantly, with an increase of 26.9 and 31.6% in both non-ESD and np ESD types, respectively. The reason for this may be due to the nature of the regularity of soil particles and the distribution of the pores (Fig. 14 and 15). It is also noted that the water conductivity increases at the same type of addition (Fig. 10). This indicates that the soil pores in this size range and at the same type of addition have become more conductive and less twisting and perhaps larger, and this also reflects an increase in ventilation and thus a change in the nature of the chemical reactions of carnivores, reactions, and biological activity. Referring to the same figure and comparing it with the volume distribution of soil aggregates before adding the extract, it is noticed that the addition of the extract reduced POWSAS 9.5-4 mm by 46.7%, 48.6, and 32.33% for non ESD, np ESD, and SESD additives, respectively. The reason for the decrease is since soil aggregates in this volumetric range have entered the construction of soil aggregates larger than 9.5 mm after the addition of Liu et al. (2014).

Figure 4b indicates that there was no significant effect of DW cycles compared to the first cycle, although most cycles had decreased POWSAS 9.5-4 mm, the decrease in POWSAS 9.5-4 mm was not significant except in DW_3 and DW_5 cycles and by 27.6 and 19.2% for the above two cycles, respectively, compared to the DW_2cycle. The reason for the decline may be explained by the geometrical rearrangement of this size range of aggregates and their re-formation. When comparing POWSAS 9.5-4 mm before adding the extract with the first cycle after adding the extract, it was noticed that POWSAS 9.5-4 mm decreased by 42.4% This decrease is attributed to the fact that the water in the three additions works to dissolve and re-react the components in the soil and salts, thus forming new bonds that work to connect the clusters of this range with the soil aggregations of the same range or a group of aggregates of smaller ranges to form soil aggregates with a greater range than this size range.

Figure 4c shows the effect of the two factors overlapped in POWSAS 9.5-4 mm. There was no significant change in POWSAS 9.5-4 mm at the non-ESD type of DW cycles from DW2 to DW5, respectively in comparison to the DW1 cycle particularly when the effect of DW cycles at each addition type was traced. On the other hand, it is noted that POWSAS 9.5-4 mm decreased significantly by 36.6, 30.7 and 32.4% for the DW3, DW4, and DW5 cycles, respectively, compared to the DW2 cycle.

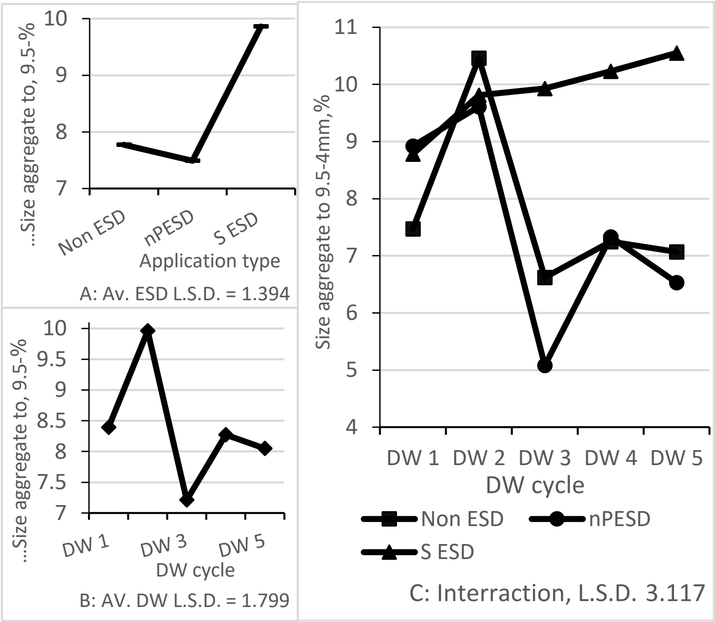


Fig. 4 Effect of application type of ESD and DW on percentage of weight soil aggregate size 9.5-4mm

While for the np ESD additive type, it was observed that POWSAS 9.5-4 mm became less at DW3 cycle clearly by 43.4 and 47.1% compared to DW1 and DW2 cycles. Furthermore, there were no crucial differences for DW cycles at SESD supplementation type. When the types of addition for one cycle are compared together. The same figure accentuates that there are no critical differences for the additions of the courses DW1, DW2, and DW4 separately, while in the DW3 one, it was found that the addition and SESD type increase POWSAS 9.5-4 mm significantly by 33.3 and 48.8% in to the non-ESD and np ESD types, respectively, which did not differ among themselves. The results in the DW5 cycle follows another direction compared to the third one, as POWSAS increased 9.5-4 mm significantly by 49.2 and 61.6% compared to the non-ESD and np ESD additions, respectively, and the rest of the differences were not crucial. The reason may be attributed to the large existence of organic carbon molecules in the addition type SESD, which makes them nucleate to form the assembly Tao et al. (2018), while it was in the additive type np ESD that it was pulverized with small Nano sized sizes and was rapidly represented inside the bodies of microorganisms, while it was non numerically sufficient in non ESD, Also, carbon sequestration in the soil causes a decrease in the stability of organic carbon in soil aggregates (Yang et al. 2020). In the np ESD additive, it is expected that the small size of carbon particles will make them more retaining, thus less effective in mineralization and representation of organic carbon.

As shown in Figure 3c, by comparing POWSAS 9.5-4 mm before addition with their values at cycle DW1 after addition, it is clear that POWSAS 9.5-4 mm decreased by 48.7, 38.8, and 39.7% for non-ESD, np ESD, and SESD additives, respectively, this decrease may be ascribed to the union of aggregates of this size range with each other or with smaller ranges to form soil clusters greater than 9.5 mm. **Soil aggregates with a size of 4-2 mm**

Figure 5 shows the effect of ESD and DW cycles in POWSAS 4-2 mm, and Figure 5a accentuated that the type of addition SESD in this size range trended the same direction in the size range 9.5-4 mm, POWSAS 4-2 mm . This significantly reflects the increase which is 33.8% in comparison to the two types of non ESD and np ESD, respectively. At the same time, there is a distinction between the value of POWSAS

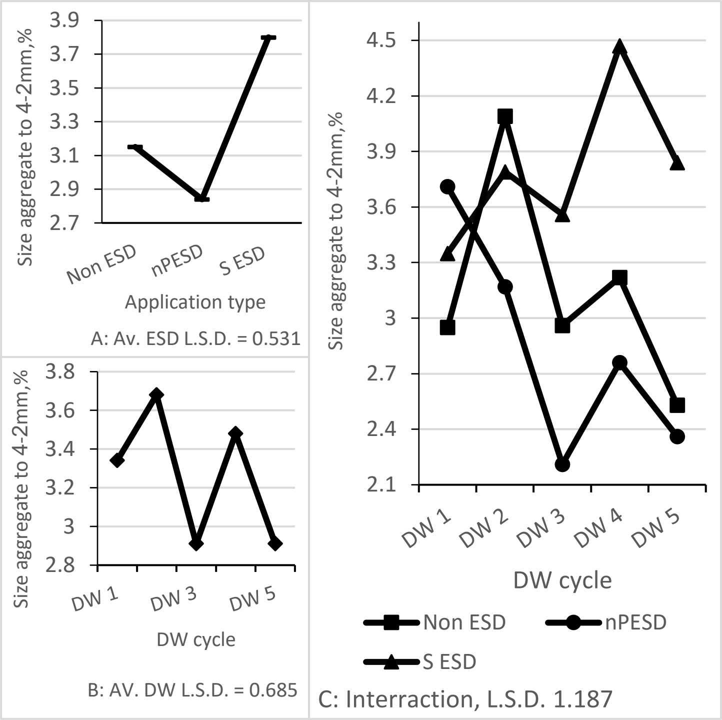


Fig. 5 Effect of application type of ESD and DW on percentage of weight soil aggregate size 4-2 mm

pre and post the addition in which it is about 4-2 mm after adding the extract in comparison to its pre-addition value, with decreases of 63.4, 67, and 55.9% for non-ESD, np ESD, and SESD additives, respectively. Figure 5b shows a significant decrease in POWSAS 4-2 mm by 20.9% at DW3 and DW5 cycles compared to DW2. While POWSAS 4-2 mm is increased by 19.5 and 18.2% at DW4 and DW5 compared to DW3 and DW4 consecutively. POWSAS 4-2 mm was at the first cycle before the addition, it was noticed that the ratio of its decrease is 61.2%.

It is also revealed in Figure 5c that there is no significant difference between the DW cycles for the non-ESD and SESD types of addition when

the two factors overlapped , while a significant decrease was observed in DW4 and DW5 cycles by 40.4 and 36.4% compared to DW1 cycle np ESD additive type. It is noted that there are no cruial differences in the two cycles DW1 and DW2 while there was a prominent increase for POWSAS 2-4 mm in the DW4 and DW5 sessions, by 61.1 and 62% for SESD, compared to np ESD.

While the value of POWSAS 4-2 mm increased by 51.8 and 62.6% for the SESD additive type compared to the non ESD and np ESD additive types, respectively, at the DW_5 cycle. By comparing the first cycle of the values of POWSAS 4-2 mm before addition with their values after adding the extract, it was noticed that the values decreased by 65.7, 56.9, and 61.1% for the non-ESD, np ESD, and SESD type of addition, respectively. The trend of results within this size range is similar to its trend in the size range 9.5-4 mm, and therefore the reasons and factors that affected the size range 9.5-4 mm have affected this range.

Soil aggregates with a size of 1-2 mm

Figure 6 shows the effect of ESD and DW cycles in POWSAS 1-2 mm, and it is clear from Figure 6a, as in the previous two periods of this size range, that POWSAS 1-2 mm increased significantly by 22.2 and 44.9 for the SESD type compared to the non-ESD and np ESD types on the arrangement, the values of POWSAS 1-2 mm decreased by 70.9, 75.1 and 70.4% after addition compared to their value after adding sawdust extract. The reason for the increase may be due to the difference in the size of the extract particles, which will affect the adhesion and cohesion forces, and to the greater representation of carbon in the organisms for the type of addition np ESD.

It is noted from Figure 6b that there were no fundamental differences for the DW cycles except for the DW3 cycle, in which the values of POWSAS 1-2 mm decreased significantly by 27.9 and 27% compared to the DW1 and DW2 cycles, consecutively, and the values of POWSAS 1-2 mm became less by 67.9% after Addition of ESD when it is compared to its value before adding ESD. The reason for the decrease in DW3 cycle is ascribed to the contraction and expansion properties of soil aggregates, binder particles and their dynamics (Ciric et al. 2012 and Mashhour 2014).

The consequence of the two interactive factors is obviously observed in Figure 6c particularly at the non-ESD type of addition, the values of POWSAS are not permanent thus, they are decreased 1-2 mm and became 32.9 and 31% in the DW3 and DW5 cycles compared to the DW2 one. POWSAS values decreased as well by 1-2 mm for np ESD additive type with percentages of 58.1, 34.8, and 45.3% for DW3, DW4, and DW5 ones consecutively, in comparison to the DW1 one. There were no significant differences in the DW cycles for the type of SESD addition. At the same time, when observing the difference between the types of addition for the DW cycles separately, we find that POWSAS 1-2 mm when adding np ESD decreased significantly by 59.4% compared to non ESD in the DW3 cycle. While the addition type SESD POWSAS values increased significantly by 110, 62.3, and 85.2% in cycles DW3, DW4, and DW5 respectively, While the SESD type of addition significantly increased by 42.4% compared to non-ESD. When comparing the values of POWSAS 1-2 mm before addition with their values after addition, we find that POWSAS 1-2 mm decreased at DW1 cycle by 73.6, 65.2, and 65.2% for the non-ESD, np ESD, and SESD additives, respectively. The reasons for the increase and decrease in POWSAS 1-2 mm are due to the difference in the quantity and size of the sawdust extract particles, which will lead to the difference in the forces of adhesion and cohesion, as well as to the forces of expansion and contraction, which will restore the regularity of the soil aggregates to form the larger soil aggregates.

Soil aggregates with a size of 1-0.5 mm

Figure 7 presents the effect of ESD and DW cycles in POWSAS 1-0.5 mm, and in general, it is noted that the results are in the same direction in Figs 4, 5, and 6.It can be seen from Figure 7a that the values of POWSAS 1-0.5 mm significantly decreased for np ESD addition by 9.9%, while the addition of SESD had a significant increase of POWSAS 1-0.5 mm values by 21% compared to non-ESD addition, On the other hand, the values of POWSAS 1-0.5 mm decreased by 81.1, 82.9 and 77.1% for non ESD, np ESD, and SESD additives, respectively, compared to their values before addition.

The results of Figure 7c appear more dynamic than the previous size ranges. It is noted that for the type of non-ESD addition, the values of POWSAS 1-0.5 mm increased by 30.1 and 17.1% for the DW_2 and DW_4 cycles, respectively, compared to DW_1. While it decreased significantly by 31.3 and 26.4% for the DW3 and DW5 cycles, respectively, compared to DW2, while it is increased noticeably in the DW4 one by 31% in comparison with DW3, which is plainly decreased in the DW5 cycle when a comparison is set with DW4. Tracing the POWSAS and how its percentages are primly decreased, the range of its decrease as follow 1-0.5 mm 37.6, 62.2, 46.4 and 58.2% for cycles from DW2 to DW5, particularly, when it is taken with DW1 cycle . These percentages are yielded 39.2, 14.1, and 33% for the cycles from DW3 to DW5 due to the clear decrease in the values in comparison to DW2. While the value of POWSAS increased 1-0.5 mm in the DW4 cycle compared to DW3. It is clear from the same figure. The addition of SESD is underlined the plain decrease of POWSAS 1-0.5 mm by 21.8% in the DW3 cycle compared to DW1, it is also underlined the increase in the DW5 cycle compared to DW4 by 25.2%

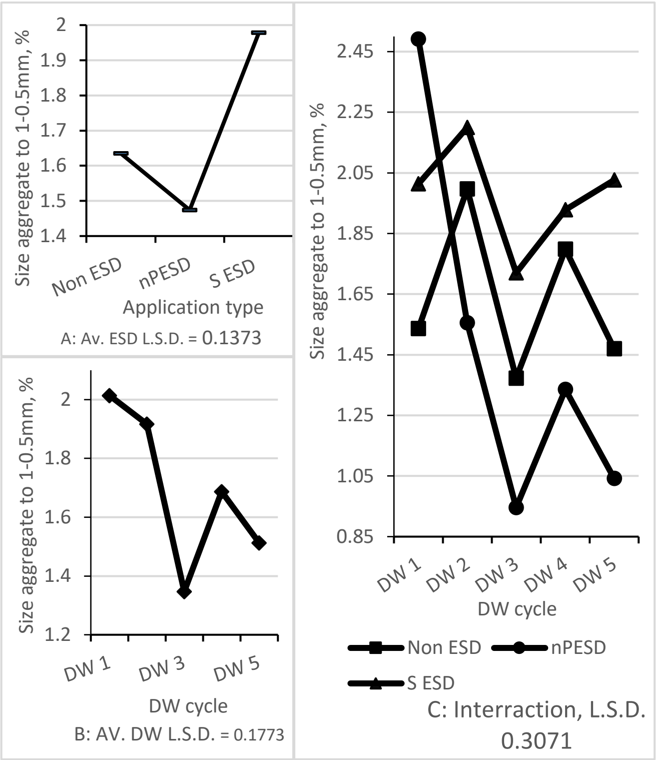
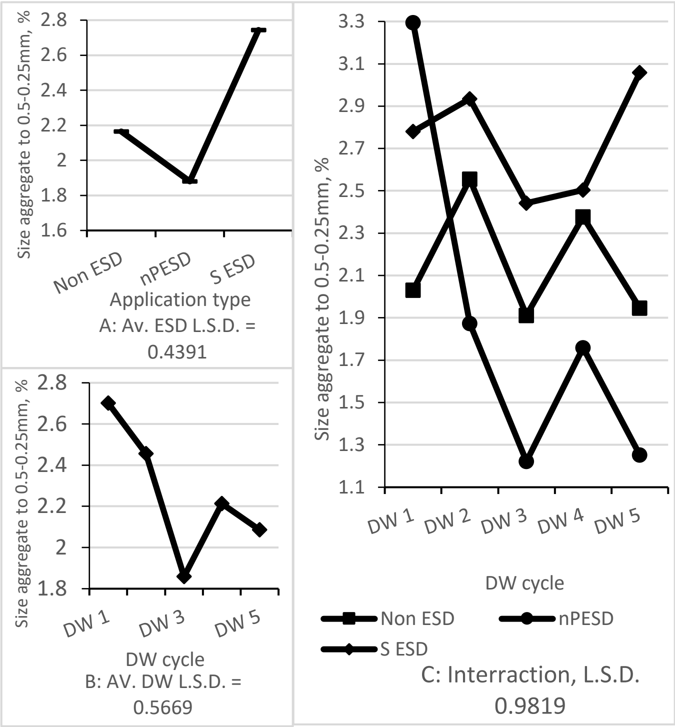


Fig.7 Effect of application type of ESD and DW on percentage of weight soil aggregate size 1-0.5 mm

Figure 7b gave a clear image of the addition type's effect of each cycle separately, it turns out that in the DW1 cycle, the two types of addition np ESD and SESD increased POWSAS 1-2 mm significantly by 62.2 and 31.1% in comprison to non-ESD addition, it is increased as well by 81.8% when the addition type SESD compared to np ESD. The value of POWSAS is increased 1-2 mm when adding non-ESD and SESD in DW2 cycle whereby, the percentages are 22.1 and 41% compared to the addition type np ESD in the DW3 cycle. Furthermore, it was noticed that the two types of addition np ESD and SESD increased POWSAS 1-2 mm significantly by 31.1 and 25.3% compared to the non-ESD addition, While it decreased significantly in the np ESD addition type and the DW4 cycle by 46.2 and 44.3% compared to the non-ESD and SESD additive types, respectively, while in the DW5 cycle, it was noticed that POWSAS 1-2 mm decreased significantly for the np ESD addition type by 29.1% compared to the addition type. non-ESD, At the same time, the value of POWSAS 2-1 also increased for the addition of SESD by 37.8 and 94.5% compared to non-ESD and np ESD, when comparing the values of POWSAS 1-2 mm before addition and after addition for the first cycle, it was noticed that they decreased by 82.2, 71.2 and 76.7% for non ESD, np ESD and SESD types, respectively. The same reasons for the increase and decrease that affected the volumetric range 1-2 mm can be generalized to the size range 1-0.5 mm.

Soil aggregates with a size of 0.5-0.25 mm



A: Av. ESD L.S.D. = 0.4391

B: AV. DW L.S.D. = 0.5669

C: Interraction, L.S.D. 0.9819

Fig.8Effect of application type of ESD and DW on percentage of weight soil aggregate size 0.5-0.25 mm

Figure 8 shows the effect of ESD and DW cycles in POWSAS 0.5-0.25 mm, from Figure 8a it is observed that the SESD type of addition increased significantly in the POWSAS 0.5-0.25 mm at a rate of 26.8 and 46% compared to the two types of addition ESD and SESD, respectively. While those values were reduced by 85, 86.9, and 80.9% for the three non-ESD, np-ESD, and SESD additives, respectively, after adding the extract compared to their values before addition.

It is clear from Figure 8b that POWSAS 0.5-0.25 mm decreased by 31.2 and 22.7% in DW_3 and DW_5 cycles respectively compared to DW_1, and it also became less in the DW3 session by 24.3% compared to DW2. A comparison is set between the results of the pre and post addition first cycle. A decrease of 81.1% values is observed.

Figure 8c shows the effect of the interaction of the two factors and it turns out that there was no significant difference for DW cycles in the two additions of non-ESD and SESD, while there was a significant decrease in POWSAS 0.5-0.25 mm by 43.1, 62.9, 46.6, and 62% for the cycles from DW2 to DW5, respectively, compared to the DW1 cycle.

When the results for the types of additions for the DW cycles are followed separately, it is noted that the addition of np ESD in the DW1 cycle significantly increased the value of POWSAS 0.5-0.25 mm by 62% in comparison to non-ESD, and in the two cycles DW2 and DW3 this value increased plainly by 36.2 and 99.8%. In addition, SESD is compared to np ESD, while in the DW5 cycle, POWSAS increased 0.5-0.25 mm noticeably, by 57.2 and 144% for the SESD type of addition compared to the two additions ESD and np ESD, no significant difference was observed for the types of addition in the DW4 cycle, at the same time their values decreased by 85.9, 77.1 and 81% after adding the extract compared to their value before adding the extract.

The results were in the same direction for the soil aggregates within the size ranges from 0.5 to 9.5 mm. It was shown (Amezketa, 1999) that the soil aggregates were divided into two main groups, which are macro aggregates larger than 250 microns, and micro aggregates smaller than 250 microns. Thus, It is observed that the mechanisms and mechanics of the coupling are similar for all segmented bezels within the range from 0.5 to 9.5 mm.

Soil aggregates smaller than 0.25 mm

Figure 9 labels the effect of ESD and DW cycles in POWSAS smaller than 0.25 mm as Figure 9a clarifies that the type of SESD addition in which the value of POWSAS less than 0.25 mm increased parallely with a percentage of 39.6 and 46% when it is compared to the two additions ESD np and SESD, respectively. While those values decreased by 90.6, 84.8, and 87.1% for the non ESD, np ESD, and SESD additives after adding the extract comparatively with their value before the addition.

Figure 9b indicates a significant decrease in POWSAS 0.25 mm by 35.7, 29.4, 32.3, and 33.3% for the humidification cycles from DW2 to DW5, respectively, compared to the DW1 cycle, while a tangible decrease in the value is obtained when the results are pinpointing before and after the results in the first cycle"87.5%."

It was noticed from Figure 9c that there were no significant changes for the results of the smaller POWSAS 0.25 mm when the factor of DW cycles and the two types of addition Non-ESD and SESD interaction, while the smaller POWSAS 0.25 mm and the smallest POWSAS 0.25 mm decreased significantly with percentages of 60.8, 58.6, 54.7 and 66% for the wetted cycles Figure 9 labels the effect of ESD and DW cycles in POWSAS smaller than 0.25 mm as Figure 9a clarifies that the type of SESD addition in which the value of POWSAS less than 0.25 mm increased parallel with a percentage of 39.6 and 46% when it is compared to the two additions ESD np and SESD, respectively. While those values decreased by 90.6, 84.8, and 87.1% for the non ESD, np ESD, and SESD additives after adding the extract comparatively with their value before the addition.

Figure 9b indicates a significant decrease in POWSAS 0.25 mm by 35.7, 29.4, 32.3, and 33.3% for the humidification cycles from DW2 to DW5, respectively, compared to the DW1 cycle, while a tangible decrease in the value is obtained when the results are pinpointing before and after the results in the first cycle"87.5%."

It was noticed from Figure 9c that there were no significant changes for the results of the smaller POWSAS 0.25 mm when the factor of DW cycles and the two types of addition Non-ESD and SESD interaction, while the smaller POWSAS 0.25 mm and the smallest POWSAS 0.25 mm decreased significantly with percentages of 60.8, 58.6, 54.7 and 66% for the wetted cycles from DW$_2$ to DW$_5$ on Ranking compared to the DW$_1$ cycle, from the same figure, it is noted that the types of addition in cycles DW$_1$ and DW$_4$ did not differ significantly between them, it was found that the type of addition of SESD increased the smallest POWSAS 0.25 mm and the smallest POWSAS 0.25 mm significantly by 81.7, 84.2 and 143% for the cycles DW$_2$, DW$_{3,}$ and DW$_5$ respectively compared to the type of The addition of np ESD, at the same time, showed a significant increase of the same addition by 70.7% compared to the non-ESD.

A similar trend of the ranges of soil aggregates from the ranges 9.5-4 mm and to soil aggregates smaller than 0.25 in that their ratios are generally low after the addition compared to before the addition and compared to their ratios in the size range greater than 9.5 mm in which the value of POWSAS increased, this indicates that the ranges smaller than 9.5 mm has been reorganized its aggregate structure to be part of the structure of soil aggregates larger than 9.5 mm.

Hydraulic conductivity of soil aggregates greater than 9.5 mm

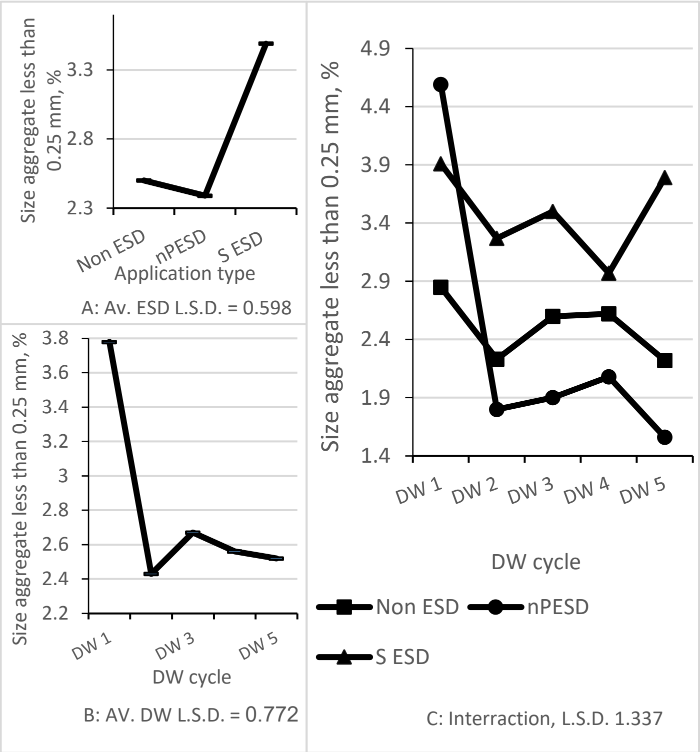


Fig.9Effect of application type of ESD and DW on percentage of weight soil aggregate size less than 0.25 mm

A similar trend of the ranges of soil aggregates from the ranges 9.5-4 mm and soil aggregates smaller than 0.25 which are generally low after the addition when a comparison is set between before and after the addition and between their ratios in the size range greater than 9.5 mm whereby, the value of POWSAS is increased. This indicates that the ranges smaller than 9.5 mm has been reorganized its aggregate structure to be part of the structure of soil aggregates larger than 9.5 mm. Hydraulic conductivity of soil aggregates is greater than 9.5 mm. Figure 10 obviously states the effect of ESD and DW cycles on the saturated hydraulic conductivity ks for soil aggregates larger than 9.5 mm. It is clear from Figure 10a that the ks of the np ESD type is increased significantly by 10.2% compared to the non-ESD type, on the contrary, the ks value of the SESD application is decreased by 22.4 and 29.6% compared to the two types of ESD non and ESD np, respectively. The reason for the increase in soil structure is ascribed to the noticeable improvement in soil structure, which is reflected in Figure 3, as well as the improvement in the main weighted diameter and soil porosity (data included in the first part of the study) on the first hand, and on the other hand, it may be due to the type of excretions of living organisms, which may be hydrophobic in the state of the addition type SESD, which will vary from one type of addition to another attributing to the different organisms that grow on it (Rahman et al. (2018) and, Amezketa (1999)).

Figure 10b shows that there was a significant increase in ks by 16.6, 30.4, and 26.1% for DW3, DW4, and DW5 cycles compared to DW1, at the same time, ks is increased significantly by 12.6, 26, and 21.8% for cycles DW3, DW4 and DW5 respectively compared to DW2 one. The reason for the increase may be due to the reorganization after the second cycle and the modifications that are occurred to the network of pores, which in turn will change the shape of micro-cracks and capillary tubes (Tang et al. 2011) and Figures 13, 14 and 15 show this as well. It is noticed from Figure 10c and from the interaction of the two factors that ks increased significantly when adding non ESD by 27.9, 47.1, 57, and 37.2% for cycles from DW_2 to DW_5, respectively, compared to cycle DW_1, while ks increased significantly by 22.7% in cycle DW_4 compared to in the DW_2 cycle, while the ks increased significantly for the addition of np ESD in the DW_4 and DW_5 cycles, respectively, compared to DW_1, while there was a significant increase in ks when SESD was added by 23.3, 25.2% for two cycles DW_2 and DW_5, respectively, compared to DW_1, at the same time, ks increased significantly for the same type of addition by 39.7, 58.1 and 63.8% for cycles DW_3, DW_4 and DW_5, respectively, compared to DW_2. On the one hand, it is noted that the type of addition ESD np increased ks significantly by 35.9 and 37.8% compared to the two additions of non-ESD and SESD in the DW_1 cycle,In the second cycle, the increase of ks was significant by 41.3 and 47.5% for the non-ESD and ESD np addition type sequentially and compared with the SESD addition, and the increase was significant by 28.7 and 23.6% for the same two additions compared to the addition of SESD in the DW_3 cycle, at the same time, ks increased significantly and in the DW_4 cycle by 24.4 and 25.9% for the two types of non-ESD and ESD np addition, respectively, and compared with the addition of SESD, while in the DW_5 cycle, ks increased significantly by 17.6 and 23.9% for the two types of ESD np addition, compared to non-ESD and SESD sequentially.

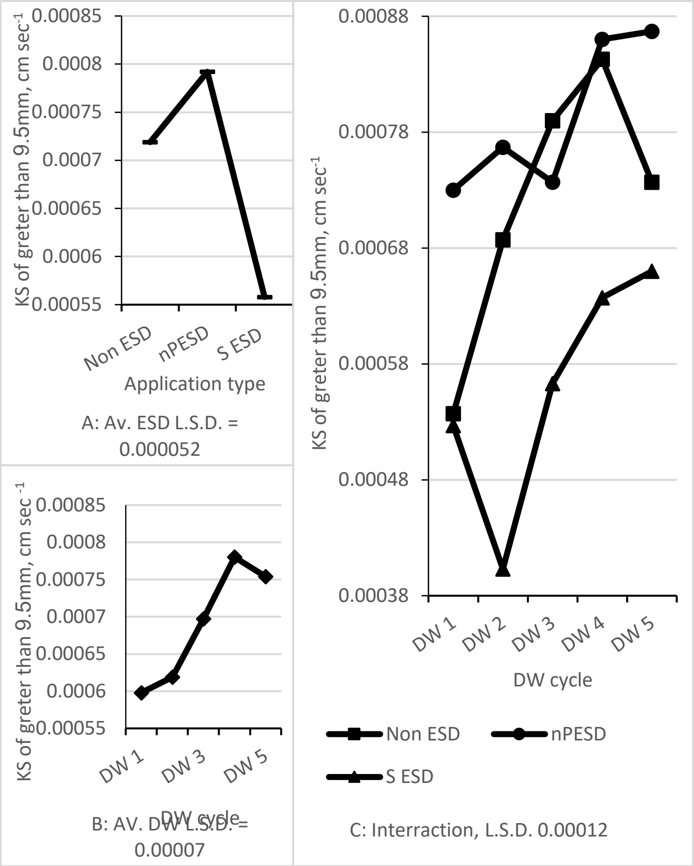


Fig.10 Effect of application type of ESD and DW on ks for aggregate size greater than 9.5 mm

The change in soil structure with DW cycles Figures 3 to 8 will lead to an increase in the size and continuity of soil pores and make them more numerous than those small pores and that the water flow is faster in soils with granular structure Karahan and Karahan (2016). Ouyang et al. (2013) also obtained a change in ks with the change in the type of soil conditioner added, and that ks increases with the increase of large soil aggregates.

Hydraulic conductivity of soil aggregates 9.5-4 mm

It is observed from Figure 11 the effect of ESD and DW cycles on the saturated water conductivity ks for soil aggregates with a size of 9.5-4 mm. In this volumetric range, the effect of the type of addition may differ, and the reason may be due to the type of developing organisms that differed from one type of addition to another.

Figure 11b shows a significant increase in Ks by 492, 626, 629, and 730% for cycles from DW_2 to DW_5 compared to $_{DW1}$ within the size of soil aggregates 9.5-4 mm, and increased by 22.5, 23.1, and 40.2% for cycles DW_3, DW_4 and DW_5respectively compared with DW2, Ks increased by 14.4 and 13.9% for the DW5 cycle compared to the DW4 and DW5 cycles, respectively. The reason for this increase in Ks may be ascribed to rearrangement of the soil pore sizes and making them less torsional, which made the water flow faster within the length of the soil pool.

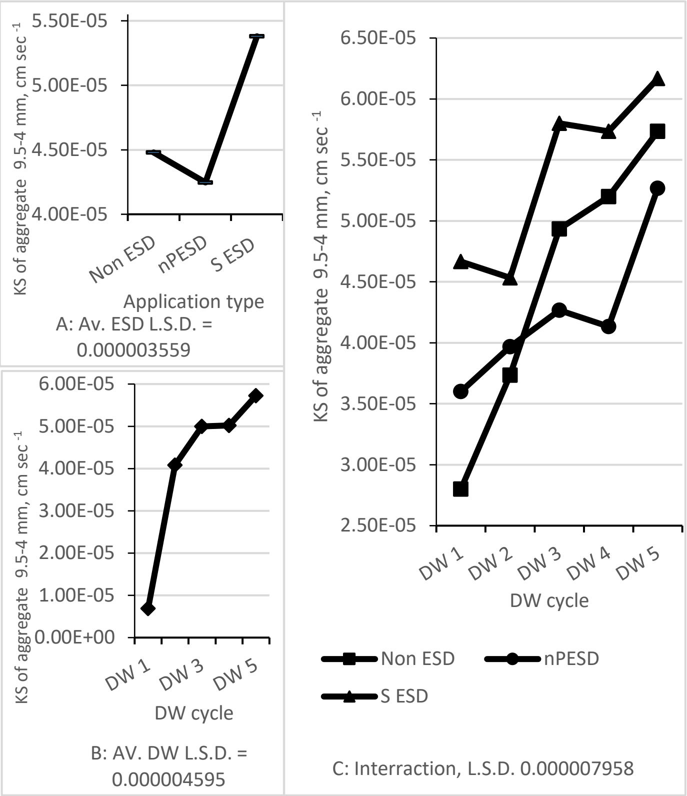
Figure 11c shows that the interaction of the two factors that Ks increased when non-ESD was added by 33.2, 76.1, 85, and 104% for the cycles from DW2 to DW5 compared to DW1, while it is increased by 31.4, 34.6, and 53.6% for the cycles DW3, DW4, and DW5, respectively, compared to DW5 and DW2. The difference was not clear when adding ESD np only at DW5 cycle, which is increased by 46.4, 32.8, 36.8, and 27.6 compared to cycles from DW1 to DW4, consecutively.

As for the addition of SESD, it was noticed that Ks increased significantly by 24.2, 22.7, and 32% for the DW3, DW4, and DW5 cycles, respectively, compared to the DW1 cycle, while it is increased by 28, 26.5, and 36.2% for the DW3, DW4 and DW5 cycles in comparison to the DW2 cycle. On the other hand, it is noticed that in the DW1 cycle, Ks became more significantly for the two additions ESD np and SESD by 28.6 and 42.9% compared to the addition of non ESD, In the DW2 cycle, a significant increase of SESD type was evident by 21.5% compared to the non-ESD application, while the ks increased for the SESD application by 17.6 and 35.9% compared to the two types of non-ESD and ESD np supplementation, respectively, while it is increased in the DW4 cycle by 28.6%.

For addition ESD np compared to non ESD, at the same time, the increase of SESD was about 42.9 and 29.7% after the addition compared to the two types of addition, non ESD and np ESD, respectively. The increase in cycle DW5 was for the type of addition SESD also at a rate of 17.1% compared to np ESD. The reason for the direct increase with the wetting and drying cycles is due to the noticeable improvement in the apparent soil density and soil porosity (data respectively compared with DW2, Ks increased by 14.4 and 13.9% for the DW5 cycle compared to the DW4 and DW5 cycles, respectively. The reason for this increase in Ks may be ascribed to the rearrangement of the soil pore sizes and making them less torsional, which made the water flow faster within the length of the soil pool.

Figure 11c shows that the interaction of the two factors that Ks increased when non-ESD was added by 33.2, 76.1, 85, and 104% for the cycles from DW2 to DW5 compared to DW1, while it is increased by 31.4, 34.6, and 53.6% for the cycles DW3, DW4, and DW5, respectively, compared to DW5 and DW2. The difference was not clear when adding ESD np only at DW5 cycle, which is increased by 46.4, 32.8, 36.8, and 27.6 compared to cycles from DW1 to DW4, consecutively.

As for the addition of SESD, it was noticed that Ks increased significantly by 24.2, 22.7, and 32% for the DW3, DW4, and DW5 cycles, respectively, compared to the DW1 cycle, while



A: Av. ESD L.S.D. = 0.000003559

B: AV. DW L.S.D. = 0.000004595

C: Interraction, L.S.D. 0.000007958

Fig.11 Effect of application type of ESD and DW on ks for aggregate 9.5 -4 mm

it is increased by 28, 26.5, and 36.2% for the DW3, DW4 and DW5 cycles in comparison to the DW2 cycle. On the other hand, it is noticed that in the DW1 cycle, Ks became more significantly for the two additions ESD np and SESD by 28.6 and 42.9% compared to the addition of non ESD, In the DW2 cycle, a significant increase of SESD type was evident by 21.5% compared to the non-ESD application, while the ks increased for the SESD application by 17.6 and 35.9% compared to the two types of non-ESD and ESD np supplementation, respectively, while it is increased in the DW4 cycle by 28.6%.

For addition ESD np compared to non ESD, at the same time, the increase of SESD was about 42.9 and 29.7% after the addition compared to the two types of addition, non ESD and np ESD, respectively. The increase in cycle DW5 was for the type of addition SESD also at a rate of 17.1% compared to np ESD. The reason for the direct increase with the wetting and drying cycles is due to the noticeable improvement in the apparent soil density and soil porosity (data presented in the first part of the study), as well as possibly to the rearrangement of soil pores may become more continuous and less torsional.

Hydraulic conductivity of soil aggregates of 4-2 mm

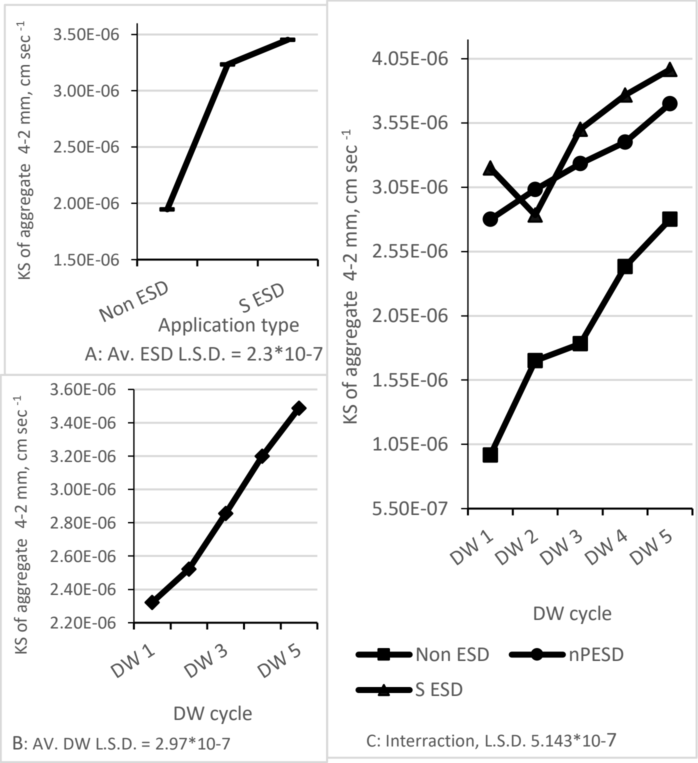
It is observed from Figure 12 the effect of ESD and DW cycles on the saturated hydraulic conductivity ks for soil aggregates with a size of 4-2 mm. As for the DW cycles, it was found that ks increased significantly by 23.3, 37.9, and 50.4% for the DW_3, DW_4, and DW_5 cycles, respectively, compared to the DW_1 cycle.

Figure 12c displays the interaction effect of the two factors. It is noted that the values of ks when adding non-ESD were significantly increased by 75.8, 89.3, 62.4, and 189.6% for cycles from DW_2 to DW_5 compared to DW_1, while the increase was significant by 42.9 and 64.7% for cycles DW_4 and DW_5. respectively, compared to the DW_2 cycle, with a rate of 32.8 and 53% for the same two cycles compared to DW_3.At the same time, there was a significant increase in ks when adding ESD np by 21.4 and 32% in the two cycles DW_4 and DW_5, respectively, compared to DW_1 cycle, while the increase was significant in the DW_5 cycle compared to DW_4 by 22%, while for the addition of SESD, it was a significant increase in ks in both cycles DW_4 and DW_5 respectively, by 17.8 and 203% compared to DW_1 cycle, while the increase was by 25, 34.6 and 24.6% for the cycles DW_3, $DW_{4,}$ and DW5, respectively, compared to the DW_2cycle.

On the other hand, it is noticed that in the first cycle, the addition of np ESD significantly increased ks by 189.6%, while it increased significantly by 231% for the addition of SESD compared to non-ESD, and it also increased significantly by 78.5, 66.5% for the two types of addition np ESD and SESD, respectively, in DW_2 cycle with a 76.5 and 91.3%, and in the same two cycles with a percentage of 39.9, 55.1% in the DW_4 cycle compared to non-ESD, while in the DW_5 cycle, the ks increased significantly for ESD np type by 32.1% compared to non ESD, while the SESD type increased by 246.6 and 15. 4 compared to the non-ESD and ESD np additives, respectively.

than the previous two sessions. As for the picture of np ESD addition, the structure appears mostly granular, not acute-angled, with some laminar structure, and the pores appear significantly and larger than the previous two cycles. For the same addition in the previous two sessions, the figure can explain the results in Figures 10, 11, and 12.

It is noted that the rates of increase in this size range of soil aggregates are higher than the rates of increase in soil aggregate in the two largest ranges and that the reason for this is due to the short length of the capsule and therefore the torsions will be less and the capillary tubes will be more continuous, while the reason for the increase of ks may be attributed to the higher rates in the later cycles in comparison to Its percentage in the advanced cycles in all the studied ranges is due to the rearrangement and continuity of the soil pores Figs 13, 14 and 15. Perhaps also due to the different cohesion and adhesion forces of soil particles according to the dynamics of these assemblies, as well as the soil solution will be less viscous in the later cycles due to the change in the secretions of living organisms on the one hand and the change in some chemical properties of the soil and dissolved ions.



A: Av. ESD L.S.D. = 2.3*10-7

B: AV. DW L.S.D. = 2.97*10-7

C: Interraction, L.S.D. 5.143*10-7

Fig.12 Effect of application type of ESD and DW on ks for aggregate 4 -2mm

Pictures of soil aggregates under SEM

"Figure 13" presents the electron microscope images with a resolution of 20 microns for the first cycles, and from the non-ESD addition image, it is noted from the image that the structure in it is lumpy and lamellar with sharp angles with multiple sizes of the particles in which the small sizes exceed with an important percentage of pores, while in the image of the addition np ESD it is noted that its structure predominant is lamellar and granular, with blunt angles, with the appearance of some threads, which may indicate developing hydatids as indicated in the picture. It is also noted and an important percentage of pores as well. As for the SESD image, a massive structure appears and one large block with some plates that appear as if they are coated with a gelatinous substance, and some fine cracks appear as indicated and with a percentage of weak pores. Figure 13 can explain Figure 10a.

Figure 14 shows the electron microscope images with a resolution of 20 microns for the third cycle, and from the non-ESD addition image, it is clear that the block structure is still prevalent in addition to the lamellar structure, but sometimes smooth and sharp corners at other times, while the image of the np ESD addition shows that the structure is mostly granular with Some of the lamellar structure is not acute-angled and the pores appear in the form of large gaps, in the image of SESD addition, the structure appears in most of it of acute-angled blocks and of one mass with some lamellar assemblies and one large gap as well, and Figure 14 can explain the results in Figure 11.

Figure 15 shows the electron microscope images with a resolution of 20 microns for the fifth cycle, and from the image of the non-ESD addition, it is clear that the dominant structure is lumpy and lamellar, but with smooth

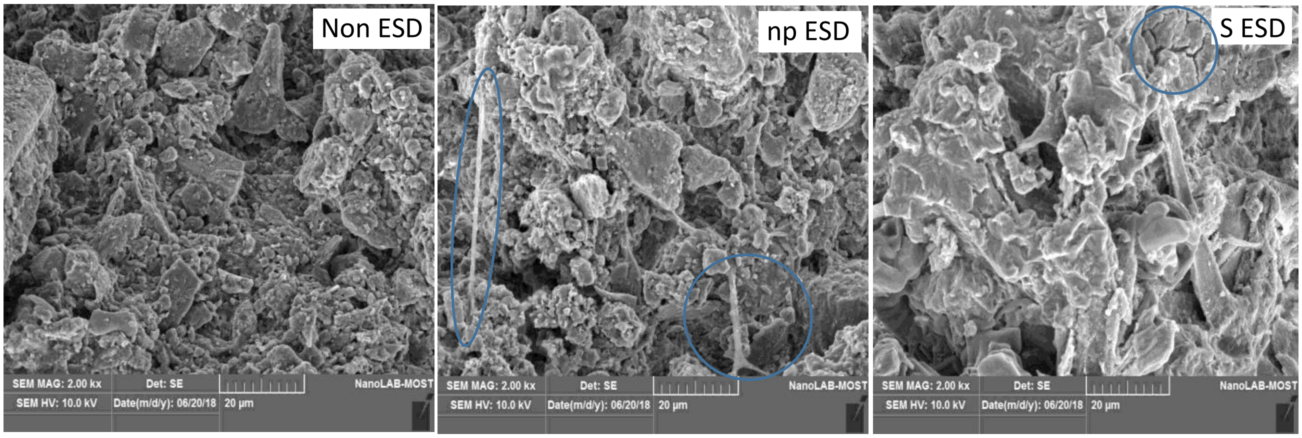


Fig.13 SEM image for Application type of ESD to soil samples throw first dry-wetting cyclewith 20 µm

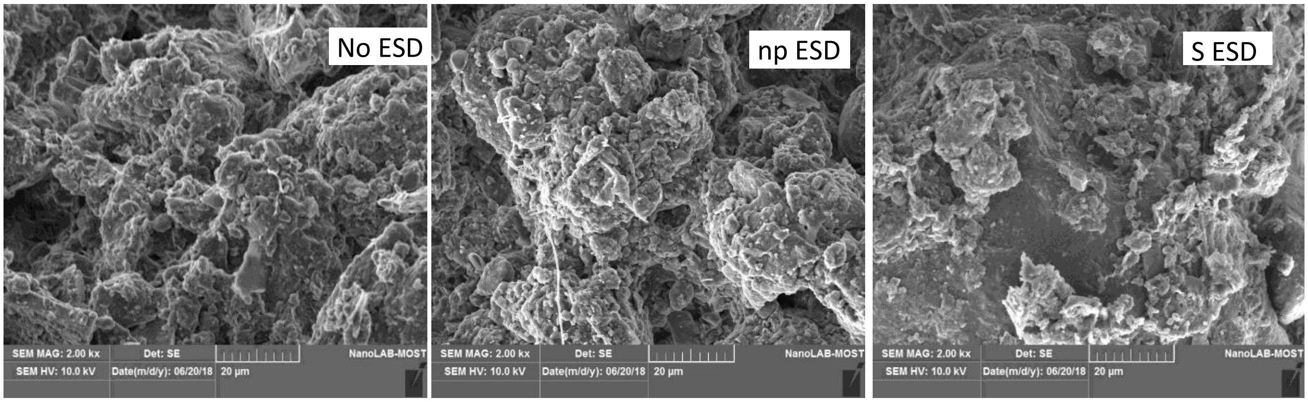


Fig.14SEM image for Application type of ESD to soil samples throw third dry-wetting cycle with 20 µm

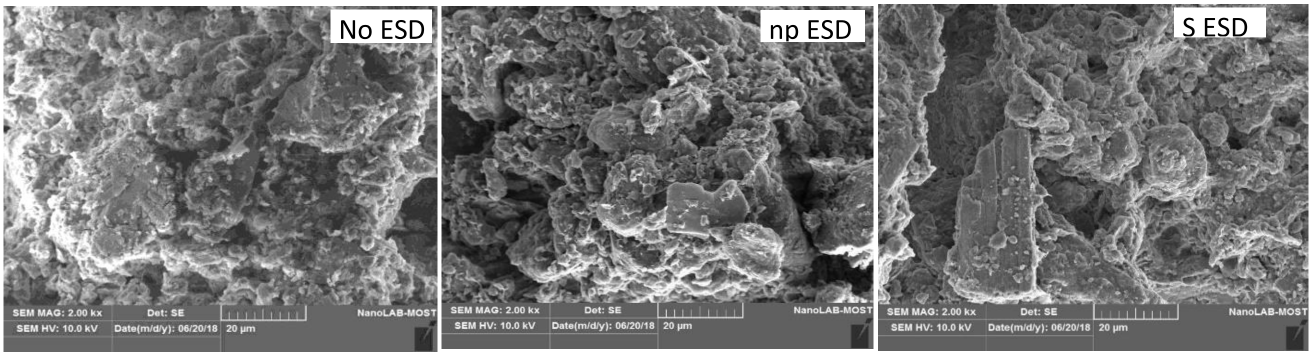


Fig.15 SEM image for Application type of ESD to soil samples throw fifth dry-wetting cycle with 20 µm

angles and fewer pores than the other two additions, but with larger pores than the previous two sessions. As for the picture of np ESD addition, the structure appears mostly granular, not acute-angled, with some laminar structure, and the pores appear significantly and larger than the previous two cycles. For the same addition in the previous two sessions, the figure can explain the results in Figures 10, 11, and 12.

It is noted that the rates of increase in this size range of soil aggregates are higher than the rates of increase in soil aggregate in the two largest ranges and that the reason for this is due to the short length of the capsule and therefore the torsions will be less and the capillary tubes will be more continuous, while the reason for the increase of ks may be attributed to the higher rates in the later cycles in comparison to its percentage in the advanced cycles in all the studied ranges is due to the rearrangement and continuity of the soil pores Figs 13, 14 and 15. Perhaps also due to the different cohesion and adhesion forces of soil particles according to the dynamics of these assemblies, as well as the soil solution will be less viscous in the later cycles due to the change in the secretions of living organisms on the one hand and the change in some chemical properties of the soil and dissolved ions.

Pictures of soil aggregates under SEM

"Figure 13" presents the electron microscope images with a resolution of 20 microns for the first cycles, and from the non-ESD addition image, it is noted from the image that the structure in it is lumpy and lamellar with sharp angles with multiple sizes of the particles in which the small sizes exceed with an important percentage of pores, while in the image of the addition np ESD it is noted that its structure predominant is lamellar and granular, with blunt angles, with the appearance of some threads, which may indicate developing hydatids as indicated in the picture. It is also noted and an important percentage of pores as well. As for the SESD image, a massive structure appears and one large block with some plates that appear as if they are coated with a gelatinous substance, and some fine cracks appear as indicated and with a percentage of weak pores. Figure 13 can explain Figure 10a.

Figure 14 shows the electron microscope images with a resolution of 20 microns for the third cycle, and from the non-ESD addition image, it is clear that the block structure is still prevalent in addition to the lamellar structure, but sometimes smooth and sharp corners at other times, while the image of the np ESD addition shows that the structure is mostly granular with Some of the lamellar structure is not acute-angled and the pores appear in the form of large gaps, in the image of SESD addition, the structure appears in most of it of acute-angled blocks and of one mass with some lamellar assemblies and one large gap as well, and Figure 14 can explain the results in Figure 11.

Figure 15 shows the electron microscope images with a resolution of 20 microns for the fifth cycle, and from the image of the non-ESD addition, it is clear that the dominant structure is lumpy and lamellar, but with smooth angles and fewer pores than the other two additions, but with larger pores

Conclusions

It is concluded that the type of addition np ESD was the best in the formation of soil aggregates larger than 9.5 mm, while the application of SESD was the best in the formation of aggregates less than 9.5 mm, and the type of addition np ESD increased the water conductivity of the aggregates larger than 9.5 mm. The addition of SESD increased the hydraulic conductivity in size ranges 9.5 - 4 mm and 4 - 2 mm. Wetting and drying cycles affected the weight ratios of soil aggregates larger than 9.5 mm and aggregates with a size range 9.5 - 4 mm oscillating, while in aggregates smaller than 4 mm, the percentage of soil aggregates decreased almost logarithmically. Furthermore, the third cycle is negatively affected the percentage of the weight of soil aggregates larger than 0.5 mm, while the wetting and drying cycles increased hydraulic conductivity of soil aggregates with ranges greater than 9.5 mm, 9.5 -4 mm and 4-2 mm.

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