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Enhancement of Physical Properties of Clay Soils by Adding Sand

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Abstract: Five ratios of fine sand were mixed including 10, 20, 30, 40, and 50 % sand to soil containing 60% clay, aim at monitoring the changes in hydrological properties of soil by adding sand. The study concluded that percentage of particles of clay, silt, and sand changed from mixing sand with soil in different proportions produced different curves for particle size distribution. Therefore, other textural classes can be obtained from by adding sand to clay soil with 10, 20, 30, 40% sand to the clay soil. The clay loam when mixed 50% sand with soil the change in soil particles ratios and sizes will change soil texture, which are an important physical characteristic with direct impact on other soil characteristics, based on results that percentage of sand soil particle additives increase, The soil bulk density increases and the lowest total porosity was in treatment 50% sand add to clay soil that was followed mixing in ratio of 40,30,20,10 and 0 percent. The results indicates a significant increase in soil air porosity with increase sand ratio as indicated by soil water holding which is reduced by increasing the tension on soil and also the negative relation between soil water-holding with added sand ratio to soil at all levels of tension compared to the non-treated soils of sand. There were close relations between sand ratio and saturated water conductivity, more pronounced increase in the of saturated water conductivity with increase added sand ratio to soil.

Keywords: Sand, Soil mixture, Particles size, Soil physical properties

Clay soils have greater strength when dry and are susceptible to waterlogging due to limited water movement and the greater strength of clay can narrow the range of water content suitable for tillage and seedling emergence (Patrick et al 2004). The clay soils be compacted when wet achieve the lowest possible hydraulic conductivity (Benson and Gurdal 2013). This depend on a large part of the mineralogical nature of clay particles that make up the soil response to change the moisture content due to clays swell and shrink as the wet and dry conditions respectively due to makes agriculture operation difficult (Jakarta et al 2004). Clay soil rich in fine clay particles tends to stay wetter for longer as the fine particles hold more water and move tightly than does sand or loam (Jon and Jackie 2015). The clay soils pack tightly and make difficult for water and nutrient to move and can block the growth of plant roots. However, to improve the balance the soil structure, the best way to do that by mixing in other materials such as mixing sand into heavy clay soils to alleviate these restrictions. The aim of study greatly affects clay soil with different percentage of sand particles to monitoring the changes in hydrological properties of soil.

MATERIAL AND METHODS

The soils samples were collected at depth of (0- 30 cm) from located at Basrah University, Agriculture Research Station (Northern Basrah). The soil had silt content of 25% and clay 65% and sand content 10%. The sand was added to nature soil from the depth of 0- 30 cm were collected from field located at Basra Desert (Western Basrah). Five ratios by weight of sand: soil was prepared (10, 20, 30, 40, and 50%). The diameter of particle was 0.02-0.2mm. Soil and sand mixed manually and oven dry and carefully packaged into plastic sinks of 10 cm diameter and 70 cm height and put into fine gravel filter at the base of each column. The core sample was collected from the plastic containers to determine soil bulk density and calculated from mass of soil/ volume as a core and particle density was determined using volumetric cylinder (Danielson and Sutherland 1986). According to ASTM (D2487-11) the particle size distribution of fine particles soil can be determining by the method of sedimentation (Bouyoucous 1951). The particle size distribution of coarse particles soil determines by the method of sieving, both the particle size distribution of fine and coarse particles soil are presented as a curve on a semi – logarithm plot, the x- axis represent particle size in mm, whereas the y-axis represents the percentage of passing. Water retention curves were sketch by the relation between soil water content (ϴ) and water tension (h) using Pressure plate apparatus method (Danielson and Sutherland 1986). The tension ranging from 10-1500 KPa determine with pressure cell, at any pressure placed on pores media it empties or loads water from a certain volume of pores. Air Porosity can be calculated from total Porosity, bulk and particle densities. The ratio of the bulk density, rb, to the particle density, rp, describes the fraction of the total volume occupied by solids. Total porosity, f, is therefore: f = 1 - (rb/rp) …….(1),then Air Porosity ,fa is given by : fa= f-ϴv ………(2) which ϴv refer to soil water volumetric is given by: ϴv= ϴw× rb ………(3) Which ϴw refer to soil water content at field capacity(30Kpa).

RESULTS AND DISCUSSION

With different rates of sand added to soil, atheroma's significantly increased in sand with increase of sand ratio (Fig. 2, Equation 50. The addition of sand led to a significant decrease in clay +silt percentage (Fig. 3). Because the percentage of particles of clay, silt, and sand has changed from mixing sand with soil in different proportions produced different curves for particle size distribution. The value of the number multiplied by particle diameter, represents the slope of the line equation, which decreases by increasing the ratio of sand in the mixture and thus decreases the ratio of fine particle (0.05 -0.004 mm silt and less than 0.002 mm clay) and conversely increase the percentage of coarse particle (greater than 0.05 mm sand) (Linear equations 6-11, Table 1). Therefore, other textural classes can be obtained from adding different ratios of sand to clay soil by predicting the percent of sand from equation 4 and the percent of the clay with silt in equation 5 and applying the values of these equations in the Marshall's triangle. According to the values of the percentages of sand in the equation 4 and percentages of clay and silt in equation 5, the textural classes of the sand mixture with the clay soil were clayey when mixing 10,20, 30,40% sand to the clay soil and clay loam when mixed 50% sand with soil texture is the component of the soil matrix and therefore any change in soil particles ratios and sizes will change soil texture, which are an important physical characteristic with direct impact on other soil characteristics. The variety of particle soil ratios, sizes, and texture can be adopted (Figs. 1 to 3). These results explain changes in the physical properties of the soil. Based on results on figure 4 and equation 12 in Table 1, it was concluded that percentage of sand soil particle additives increase, so are soil bulk density values positive linear increases. AL-Bayati et al (2012) observed positive linear relationship between the soil content of sand and its bulk density. In this respect, EL-Mosselly (2013) reached a negative linear relationship between the ratio of clay and the bulk density of the particle soil, so increase in bulk density can be explained with an increase in the percentage of sand added to the soils. The addition of sand to the clay soil reduced the percentage of spaces in soil and therefore decreased the total size of the soil, thus reducing the bulk density. In figure 5 and equation 13 in a Table 1, the lowest total porosity values in treatment S5 (50% sand add to clay soil) that was followed by t

Table 1. Liner equations describing the properties of soil

Equation No.	Equations
4	% sand= 6.63 ×mixture rate +5.80
5	% clay with silt= -7.86× mixture rate+96.6
6	Percent fine(S0)=151.89×particle diameter+58.16
7	Percent fine(S1)=145.43×particle diameter+46.37
8	Percent fine(S2)=145.31×particle diameter+38.17
9	Percent fine(S3)=135.60×particle diameter+30.84
10	Percent fine(S4)=130.70×particle diameter+22.18
11	Percent fine(S5)=125.05×particle diameter+13.72
12	Bulk density = 0.0347×mixture ratio + 1.2327
13	Total porosity = -1.3049+×mixture ratio 53.462
14	Air porosity = 1.5766×mixture ratio + 5.5687
15	%Water content (S0) = -0.0235×suction value + 50.739
16	%Water content (S1) = -0.0234×suction value + 45.351
17	%Water content (S2) = -0.0222×suction value + 40.843
18	%Water content (S3) = -0.0217×suction value + 38.098
19	%Water content (S4) = -0.0205×suction value + 34.108
20	%Water content (S5) = -0.0197×suction value + 30.412
21	Hydraulic conductivity = 0.0327×mixture ratio - 0.0471

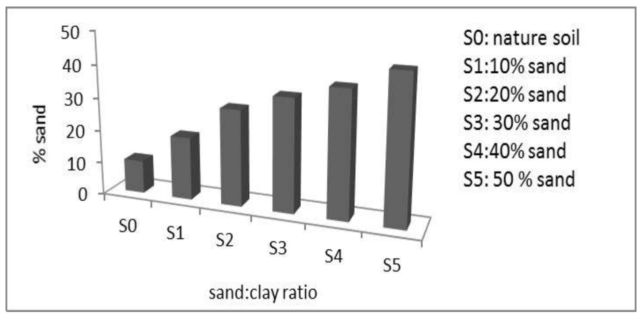

Fig. 1. Sand percentage for different sand: Soil ratios

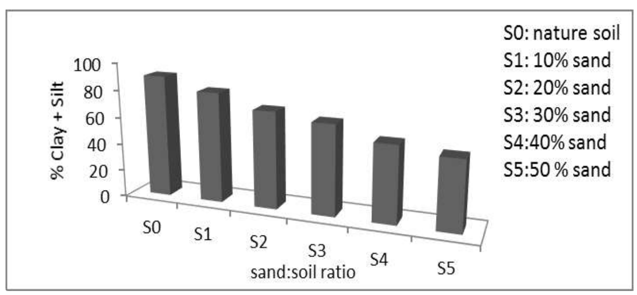

Fig. 2. Clay plus silt percentage for different sand: soil ratios

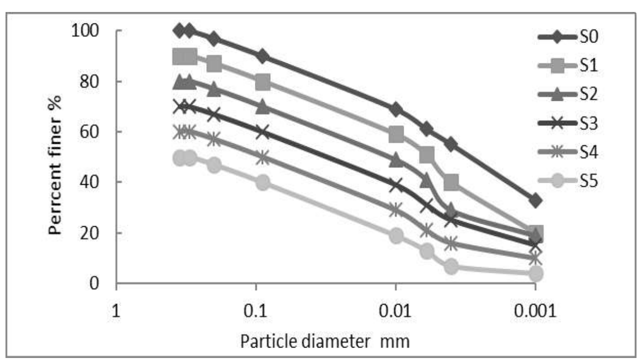

Fig. 3. Particles size distribution for different sand: soil ratios

S4,S3,S2,S1 and S0 due to the inverse relationship between the bulk density and the total soil porosity according to equation 1 for the calculation of the total porosity.

There was significant increase in soil air porosity values with increase sand ratio which added to soil (Fig. 6 and equation 14 in a Table 1). The additive sand to clay soil increased the bulk density, the pore- size distribution was altered and the numbers of macrospores increased because of the change in the volume of pores and the size of soil solids within the unit of total soil volume. Mekkiyay and Al-Khazragie (2015) explained that adding sand at different rates to silty clay soil has increased the percentage of pore particles compared to the soil that is not treated with sand. Thus with increase in the percentage of fines particle in sand matrix with silty clay, most of fine particle initially occupy the space among the sand particle, thereby reduction in pore space among particles.

The soil water holding is reduced by increasing the tension on soil samples and also the linear equations 15-20 show the negative relation between soil water-holding with added sand ratio to soil and at all levels of tension compared to the non-treated soils of sand. These S1, S2, S3, S4 and S5 retained considerably less than amount of water compared to S0 (soil without sand). This indicate ability of soil to lose water with increased content of sand due to the soil ability to release more water than samples with less sand at the same water tension as soil. Thus addition sand mixed with soil decreased the total plant available water.

Bruand et al (2005) observed that adding clay to a sandy soil has increased soil moisture content at high-tension, and estimated that clay particles filled the voids between sand particles and thus increased the fine particles ratio in the soil, increasing water soil retention compared to clay non mixed with sand. Equation 21 in Table 1 indicates that there were close relations between sand ratio and saturated water conductivity. In figure 8, a more pronounced increase in the values of saturated water conductivity with increase added sand ratio to soil clay soil remarkably decrease soil water content in turn increase soil air content at 30 Kpa (Moisture at field capacity) decrease with increase sand additive ratio. Mojid et al (2009) also observed reduced value of field capacity with increase sand percent in mixture because of the change in the volume of pores and the size of soil solids within the unit of total soil volume may increase intra aggregates space as sand mixed with clay made bonds between sand-clay –sand or clay –sand-clay. Thereby increase of macro pores due to added sand ratios increase can be explained by the change of phase composition of the soil matrix due to sand addition increase the air phase compared to soil non-mixed with sand. The same trend was observed by Jaikiral et al (2004) and concluded that increased hydraulic conductivity due to the mixing of sand in

Table 2. Particle size (%) and soil texture

Treatment	S0	S1	S2	S3	S4	S5
% sand	10	19	29	34	38	44
% silt	30	26	23	21	20	16
% clay	60	55	48	45	42	40
Texture	Clay	Clay	Clay	Clay	Clay	Clay loam

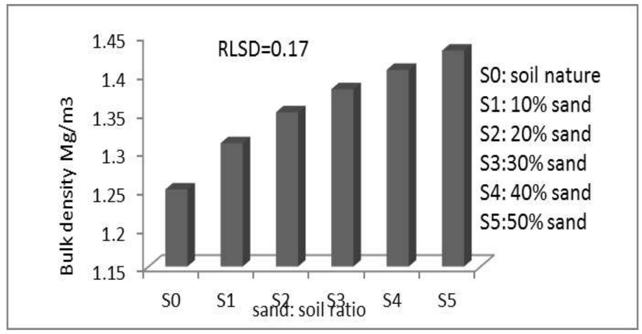

Fig. 4. Soil bulk density for different sand: soil ratios

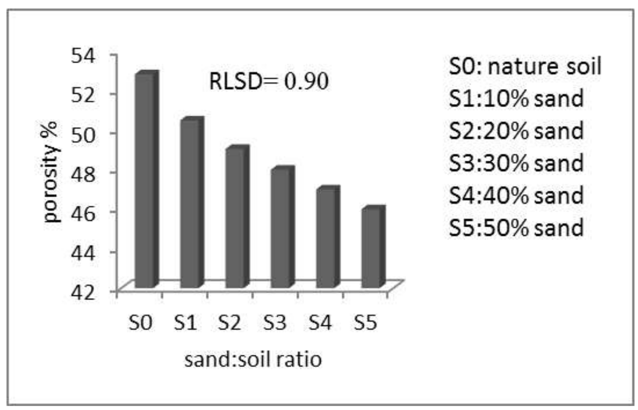

Fig. 5. Soil total porosity for different sand: soil ratios

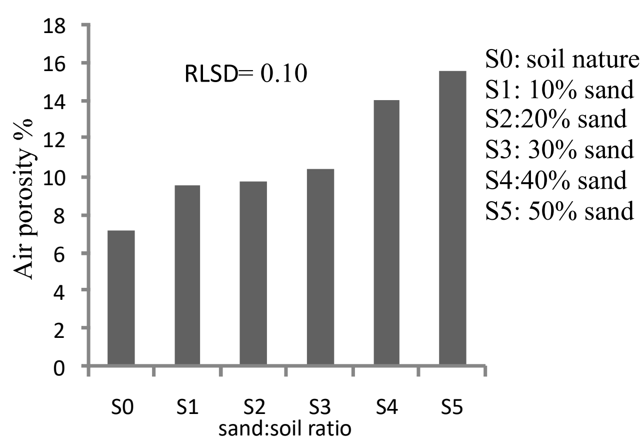

Fig. 6. Soil air porosity for different sand: soil ratio

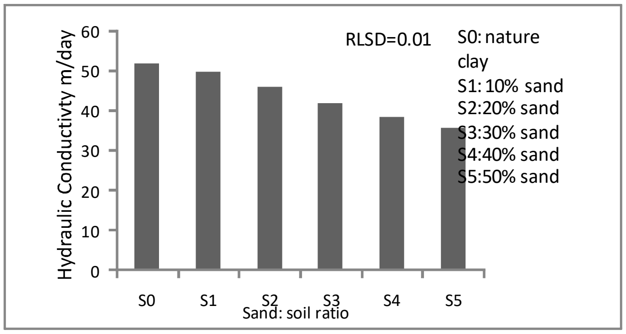

Fig. 8. Soil hydraulic conductivity for different sand: soil ratios

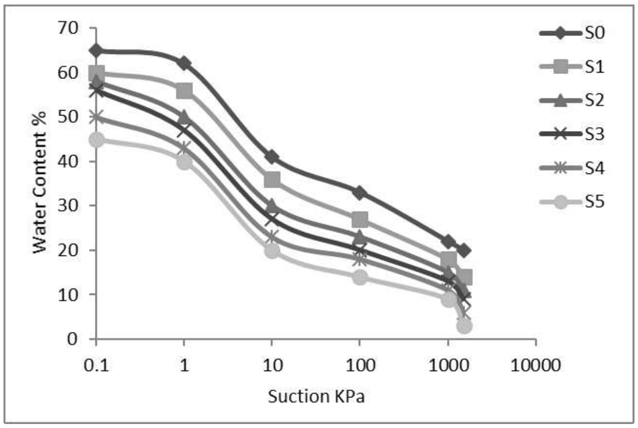

Fig. 7. Water characteristics curves for different sand: soil ratios

the top of soil (0-10 cm depth) can increase penetration of water in soil profile leading to greater volume of soil water stored in the profile. Mojid et al (2009) reported that clay in soil reduced the hydraulic properties by limiting percolation losses while maintaining adequate infiltration and water retention.

CONCLUSIONS

Adding fine sand to the clay soil altered the porous media of the soil, as the volume of the pores and the size of the soil solids within the unit of total soil size changes, thereby increasing the percentage of spaces between particles, increasing the content of the air soil content and decreasing the content of the water soil. With increasing the ratio of sand mixed with the clay soil is a good indicator of the enhancement of the porous media and water environment of soils that have high clay content, which allows the use of sand covering large areas of the Basra desert to improve the properties of clayey soil and increase its ability to deliver water conductivity. This help in controlling soil waterlogging, as well as the possibility of leaching the accumulated salts to improve the media of porous soil. During the increase in the percentage of spaces between particles to increase the same size of particles, these spaces are ways of running water through them or transporting salt with leach water without expensive field-drainage systems and only with collection drains to discharge excess water away from the cultivated area.

REFERENCES

Al-Bayati AHI, Al-Alwani AAM and Al-Taie FR 2012. Evaluation of some soil physical characteristics of Marshes soil south of Iraq. *Damascus University The Journal of Agricultural Science* **28**(1): 31-50.

ASTM 2011. *Classification of soils for Engineering Purposes, Annual Book of ASTM*- D2487-11, www.astm.org.

Danielson RE and Sutherland PL 1986. Porosity. *Methods of Soil Analysis*: *Part 1 Physical and Mineralogical Methods* **5**(2): 443-461.

Bouyoucous CA 1951. A re-calibration of the hydrometer for making mechanical analysis of soils. *Agronomy Journal* **43**: 434-438.

El-Mosselly E 2013. Physical properties of two soil type from Darya and Abe Jersh and the relations among component. Damascus University *The Journal of Agricultural Science* **29**(1): 17-28.

Jaikira IS Gill, Judy Tisdall Sukartono, Kusshartand IGM and Blairt A, Mckenzie M 2004. Physical properties of a clay loam soil mixed with sand. 3rd *Australian New Zealand Soils Conference*, 5-9 December 2004, University of Sydney, Australia.

Mojid MA, Mustafa SM and Wyseure GCL 2009. Growth, yield and water use efficiency in silt loam-amended loamy sand, *Journal of the Bangladesh Agricultural University* **7**(2): 403-410.

McCox EL 1998. Sand and organic amendment influence on soil physical properties related to turf establishment. *Agronomy Journal* **90**: 411-419.

Mekkiyah HM and Al-Khazragie A 2015. Behavior of clay soil mixed with fine sand during consolidation. *Journal of Applied Research* **1**(8): 437-443.

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