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# Effect Of Irrigated Soils Compaction In Some Physical And Water Properties Of Soil In Central And Southern Iraq

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**Abstract**

A field study was carried out to reveal the effect of compaction of irrigated soils resulting from the movement of heavy machinery adopted in soil and crop management processes in central and southern Iraq on some physical, water and engineering properties of soil. The effect of compaction of heavy and light soils in the fields of cereal crops "wheat and rice" was studied. The study was conducted on eight sites in four stations of different textures, two sites in each station. The four sites are Al-Fajr district, Dhi Qar governorate (mixed texture soil), sand dunes station located on the FAO project between Dhi Qar and Al-Qadisiyah (mixed sandy soil), rice research station in Al-Mashkhab area / Najaf governorate (clay mixed soil), and Al-Qadisiyah region. Hor Salib (Alluvial clay soil). Samples were taken, ten replicates for each site, from the soil with a depth of 30-50 cm and some physical properties of the soil were measured, namely texture, bulk and real density, total porosity, soil resistance to penetration, accumulative water tip, tip rate and water conductivity. It was noted that there is a positive relationship between the apparent soil density and the total porosity affected by the compaction factor. The bulk density of the soil subjected to C1 compaction increased compared to the neighboring soil less susceptible to C0 compaction and sandy soil. The results showed a lower porosity in compacted soils compared to non-compact soils. And there was a clear effect of compaction operations on the values of soil resistance to penetration, tip rate and aggregate tip of C1 compacted soil and soils less exposed to C0 compaction operations in the studied sites. In general, the effect increased in clay soils, while there was no significant effect of compaction processes in sandy soils.

**Keywords**: soil compaction, bulk density, total porosity, soil penetration resistance

## INTRODUCTION

Soil compaction is the reorganization and rearrangement of soil particles by expelling air from the soil pores. This happens by using mechanical means that produce compressive loads, and this leads to a decrease in soil porosity and an increase in the apparent density of the soil (Term Detail, 2018). Heavy soils (clay) are more prone to compaction than others due to the small size of soil particles and their ability to hold water. Soil compaction differs from soil compaction, in that the latter is the gradual expulsion of water from saturated soil using constant stress, accompanied by a decrease in volume. Under the influence of the external load, the pressures arising at some points can exceed the internal bonds between the soil particles, and slippages arise in some of them, and here the soil connection in one area may be disrupted, thus breaking the resistance of the soil in that area. Soil compaction is an important factor affecting the rate of water loss in soil and is one of the factors responsible for the deterioration of the physical quality of soil. Soil compaction is mainly caused by the weight of machinery and equipment, which reduces the overall porosity and increases the bulk density of the soil and thus reduces the rate of water sinking compared to non-compact soils (Hamza and Anderson, 2005). Uncompressed soil contains 4 to 5 times more water than machine compacted soil. The effect of machinery on the soil is greater on the rate of water infiltration into the soil than plowing the soil, in addition to the pressure of the soil resulting from agricultural machinery, it may also result from livestock grazing.

The internal resistance, opposition or reluctance to remove solid particles in ideal loose bodies lies solely in the friction arising at the points of contact or contact of the particles. In natural cohesive soils such as viscous clays, the movement of the particles in it is resisted by the internal structural bonds and the viscosity of the hydrocolloid covers is only for the minutes, and not from the friction arising at the points of contact or contact of the particles. The mechanical behavior of soil is affected by the density, composition or arrangement of the particles, as well as the quantity and distribution of fluids present (such as water and air), in addition to other factors such as the electrical charge of the particles, the chemical composition of the pore water, and the chemical bonds between the particles. Compaction is one of the factors affecting soil construction, as it is the result of external forces and pressures above the soil surface. This comes from the movement and traffic of livestock and machinery, as the compaction increases in terms of value and extension through the soil layer when adequate moisture is available, and the amount of those forces and pressures increase with time. Which results in a soil with a high bulk density offset by low porosity and high penetration resistance, in addition to the deterioration of the soil structure and its physical properties related to the compaction factor. The aim of this study was to evaluate the effect of soil compaction resulting from the movement of heavy machinery used for wheat and rice crop management on some physical and water properties of soil.

**MATRIALS AND METHODS**

The study was conducted on eight sites in four stations of different textures, two sites in each station. The four selected sites were: Al-Fajr district in the province of Dhi Qar (loamy texture

soil), sand dunes station located on Al-Fao project between Dhi Qar and Al-Qadisiyah (loamy-sandy soil), the rice research station in Al-Mashkhab area, province of Najaf (clay-loam soil), and Al-Qadisiyah region. Hor Salib marsh (Alluvial clay soil). The research started by taking soil samples for the study sites at different depths (10-50 cm), and the initial records of the physical and chemical properties of the soil (Table1 and 2) were taken using standard methods in estimating the volume distribution of soil particles (Blake et al. 1965). The sampler core method was used to estimate the density The apparent value of the soil, and the water tip was measured using a double ringe infiltrometer according to the method (1956 Haise), which was referred to (1960 by Parr and Bertrand,). The penetrometer was used to detect the soil's resistance to penetration and compaction.

Table1. Some physical properties of soil in the studied sites

| Station | Soil particle (g/kg) sand silt clay | | | Texture | Bulk Density $Mg.m^{-3}$ | Actual Density $Mg.m^{-3}$ | total porosity (%) |
|---|---|---|---|---|---|---|---|
| | Sand | Silt | clay | | Depth (30cm) | | |
| Al-Fajer district | 347.2 | 429.8 | 223 | Loam | 1.40 | 2.65 | 46.90 |
| | | | | | 1.34 | | 49.20 |
| Sand dunes/Faw | 747.10 | 110.40 | 142.50 | Sandy-loam | 1.82 | 2.64 | 30.86 |
| | | | | | 1.82 | | 30.90 |
| Michkhab rice research | 311 | 407.29 | 281.71 | Clay-loam | 1.47 | 2.65 | 44.52 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| station | | | | | 1.45 | | 45.28 |
| Qadisiyah-Slaib marsh | 27.0 | 444.8 | 528.2 | Silt-clay | 1.47 | 2.65 | 44.30 |

Table 2. Some of chemical properties of soil in the studied sites

| Trait | Station | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Al-Fajer district | | sand dunes/Faw | | Michkhab rice research station | | Qadisiyah-Slaib marsh | |
| | C1 | C0 | C1 | C0 | C1 | C0 | C1 | C0 |
| pH | 7.8 | 7.6 | 7.5 | 7.5 | 7.4 | 7.4 | 7.5 | 7.4 |
| EC $mS.m^{-1}$ | 8.4 | 7.6 | 3.5 | 4.0 | 4.5 | 4.2 | 5.3 | 4.7 |
| % OM | 1.19 | 1.11 | 0.96 | 0.93 | 1.19 | 1.15 | 1.18 | 1.22 |
| Available N $Mg.Kg^{-1}$ | 39.2 | 44.1 | 27.44 | 23.52 | 36.26 | 46.06 | 35.28 | 36.26 |
| Available P $Mg.Kg^{-1}$ | 51.85 | 56.56 | 3.647 | 2.290 | 50.82 | 44.85 | 43.36 | 55.41 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Available K $Mg.Kg^{-1}$ | 1018 | 1048 | 55.66 | 58.05 | 965 | 1003 | 795 | 682 |

**RESULTS AND DISCUSSION**

The results show that there are highly significant differences between the average values of bulk density under the influence of the compaction factor on the studied sites exposed to compaction compared to the neighboring sites less exposed to the effect of the compaction process (Table 3). Except for the site of the mixed sand dunes station, the two sites for each station differed significantly in the value of the average bulk density of the soil subjected to compaction due to agricultural machinery than it is in the uncompounded soil.

This difference between the compacted and uncompacted sites in the values of the bulk density indicates the role of compaction operations as a result of the exposure of the soil of site C1 to pressure due to the passage of agricultural machinery and the recurrence of its passage through time. For heavy machinery and equipment, which leads to soil compaction and compaction, as the compaction of the sub-surface soil, as evidenced by the increase in the bulk density of the soil due to the use of heavy machinery and the recurrence of its passage, and this is consistent with (Sidhu et al., 2014). The effect of compaction in sandy soils was not observed, due to the nature of sandy soil that resists compaction as a result of the low moisture content, so the water behaves easily due to the presence of those pores, and does not remain in the soil for a long time and this reduces the effect of compaction on the soil, even if the level of compaction It increases by increasing the level of soil moisture, and this is consistent with (Mckenzie et al., 2009), and sandy soil among its characteristics is that it has a light texture, which leads to quick drainage and does not conserve water well. Sandy soil is characterized by good aeration and the ability of sandy soil to retain water is reduced. Unlike clay soil, the bulk density of the soil that can occur as a result of the compaction process depends on both the soil texture and its moisture content (Goldsmith, 2001). The nature of clay soils is that it has a high moisture content, as the values of the apparent soil density increase in the same compaction conditions when the moisture content is increased.

The clear effect of compaction on the total porosity of the soil is also noted (Table 3). In general, the porosity values increased in Al-Fajr district with the highest rate, followed by Al-Mishkhab Research Station, Al-Qadisiyah site, and then the lowest values in the sand

Table3. Effect of compaction on some soil properties of four different location sites from middle and south Iraq

| Measurements | LOCATIONS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Al-Fajer | | sand dunes/Faw | | Mishkhab rice research station | | Qadisiyah-Slaib marsh | |
| | C1 | C0 | C1 | C0 | C1 | C0 | C1 | C0 |
| bulk density | 1.40 | 1.34 | 1.62 | 1.62 | 1.47 | 1.45 | 1.47 | 1.43 |
| total porosity | 46.90 | 49.20 | 30.86 | 30.90 | 44.18 | 44.90 | 44.30 | 44.95 |
| Penetration resistance | 29.45 | 27.30 | 21.00 | 20.80 | 29.05 | 27.65 | 34.45 | 32.77 |
| Soil infiltration | 0.24 | 0.25 | 0.35 | 0.35 | 0.17 | 0.18 | 0.12 | 0.13 |
| Cumulative infiltration | 15.85 | 16.42 | 20.66 | 20.77 | 12.26 | 12.99 | 6.68 | 7.50 |

*Values are means of four replications from each site, C1 and C0 are soil samples taken from compacted and non-compacted spoil, respectively.

dunes station. The reason for the high values of the total porosity of the soil is attributed to the role of compaction processes and the nature and characteristics of the soil for the mentioned sites, as it increased in heavy soils compared to light soils, as in Qadisiyah, which has clay soil, which has a high moisture content. Machines and livestock that cause a change in the size and distribution of pores in the soil. This is due to the nature of the soil, as the soil with horizontal pores is more susceptible to pressure than the soil with vertical pores, and this is consistent with (Schäffer et al., 2008). The use of machines or other pressures exerted on the surface of the soil leads to a sharp decrease in the size of the pores, not only in the surface layer, but exceeds it to reach the sub-soil layers (Brandhuber et.al., 2001)).

It also became clear that there is an effect of soil compaction on the resistance to penetration, through the presence of significant differences between the average values of soil resistance to penetration and according to the type of tissue for each of the study stations. The value of the soil penetration resistance for the first site in Al-Fajr district for rammed soil C1 differed from the neighboring area C0 for the same site, while it did not differ between the two sand dune sites. This may be attributed to the geometrical uniformity of the sand particles and the low moisture content of this soil as it enjoys good air conditions and water drainage despite its high apparent density and low soil total porosity values. Such as density, porosity, texture and soil structure. These results indicate that compaction has an effect on the penetration resistance characteristic and that the reason for this difference in the aforementioned characteristic is due to the role of machines in putting pressure on the soil, thus increasing its apparent density, decreasing the porosity, compaction and lining of the soil, which leads to an increase in the penetration resistance of the soil, which usually, is not detected. In sites with high bulk density, according to (Lipiec J et al., 2000).

The results showed that compaction processes affected the rate of soil infiltration. Where the highest percentage of water infiltration was recorded in sandy soil represented by the sand dunes station, while the lowest was in Al-Qadisiyah station with clay soil with a significant difference between the two sites for the same station. Soil infiltration values decreased in soils subjected to compaction C1 compared to newly cultivated soil C0, and the effect was higher in clay soils in Qadisiyah and Mashkhab, as well as in Al-Fajr soil with a mixed texture. This is attributed to the role of compaction processes and the resulting change in the physical properties of the soil. Soil compaction is an important factor affecting infiltration rate and is one of the factors responsible for the deterioration of soil physical quality.

Soil compaction reduces the porosity and increases the bulk density of the soil and thus reduces the infiltration rate compared to non-compacted or newly planted soil that has not been affected by soil service operations (Hamza and Anderson, 2005). The repeated use of machines in the plowing process, although it is important for soil aeration, affects the infiltration and leads to the demolition of agglomerations and building the soil, which leads to the creation of compact and hardened soil with few pores. Soil exposed to compaction has less pore area,

which leads to a reduction in infiltration rate. Working of heavy agricultural machinery over the soil has a greater effect on soil infiltration than plowing the soil itself (Yuxia et al., 2001).

It was noticed that there was no effect of compaction on the aggregation rate in the soils of the two sites of the sand dune station. This is due to the nature of sandy soil and its physical properties of low moisture content, porosity, high permeability and soil coarseness, which are not affected by compaction processes on the soil surface. While the compaction factor had a negative effect on the accumulation of water in the soil of the other studied stations. This is mostly due to the frequent use of machines in the process of plowing and leveling. Generally, in the depth region furthest from the plow blade, compressed soil layers are generated. These layers negatively affect many soil properties such as bulk density, total porosity, saturated water conductivity, in addition to the cumulative infiltration. This leads to a reduction in movement of water within the soil body, and in turn leads to a decrease in permeability and an increase in the accumulation of soil salinity in the root zone (Al-Hadi et al., 2011).

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