Effect of wetting and drying on structural regeneration of puddled soil

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Abstract

The effect of repeated wetting and drying and the degrees of drying on structure regeneration of puddled soil were studied on two soils, e.g., a grey clay and a sandy loam soil. Degrees of drying were arranged by sun drying at different periods, e.g., 2-4 days, 5-8 days and 9-12 days drying, which were corresponding to pF 2.1-2.5, 3.1-3.8 and 4.6-6.0 respectively. Five wetting/drying cycles were conducted during this experiment. Measurements on the effect of different degrees of puddling showed that the two soils responded quite similar towards partially drying. An increased in the degree of drying resulted in faster improvement of soil structure.. Drying the puddled soil to its air dry water content is very effective in the process of structural regeneration. But this study also showed that the regeneration of puddled soil is possible by partial drying.

Key Words

Puddled soil, wetting/drying, dispersion, structural regeneration

Introduction

During the rice growing season, wetting and drying cycles influence the reaggregation of soils (Bakti *et al.* 1998) which is beneficial for growing upland crops after rice harvest. Greenland (1981) reported that in wetland rice, continuous flooding and rice cropping cause a breakdown of water stable aggregates resulting in the deflocculation of the soil. When puddled soils are drained soil aggregates reform. This is beneficial for the improvement of aeration and the preservation of soil structure (van de Goor 1974). In studying the aggregation of allophane soils, Kubota (1972) found that drying after flooding resulted in aggregation of silt and clay particles, and that drying was the main factor responsible in these soils. Whereas, White (1966) found that cracks in some soils, which develop during drying, will produce the initial faces of soil aggregates and when soil drying is rapid it is not uniform, leading to unequal stresses and strains resulting in aggregate formation. According to van de Graaff (1978), during rapid drying the stresses developed produce smaller ped than those developed during slow drying, leading to smaller aggregates. Sanchez (1973) suggested that puddled soil must be dried slowly to increase structural aggregation. The objective of this study was to investigate the effect of degree of drying or partial drying on structure regeneration of puddled soil.

Materials and methods

Two contrasting soils were used in this experiment: a grey clay from Griffith, NSW (GC_G) and a sandy loam from the Lockyer Valley near Brisbane, Queensland (LO_G). The effect of puddling intensity was examined by using air-dried equivalent of 1600 g oven dried soil (< 2mm) which was puddled at total energies applied of 0, 50, 100, 150 and 200 Joules. The amount of dispersible silt+clay (<20 μm) and clay (<2 μm) were determined by sedimentation using the pipette method. Saturated hydraulic conductivity (K_{sat}) of the puddled soil was measured using a falling head method. After the saturated hydraulic conductivity measurements the soil was drained and dried for 12-14 days of sun drying. Once the soil dried to approximately their air dry water content, the soil was carefully flooded again. The soil was stored in a constant temperature of 20 ^oC for 48 hr to allow equilibrium before saturated hydraulic conductivity measurement was taken. Samples for the amount of dispersible clay and silt+clay determination were taken from a spare cylinder. After the saturated hydraulic conductivity measurement, the soil was drained again, and 5 wetting/drying cycles was conducted in this experiment. The effect of degrees of drying were investigated where the soil was arranged by sun drying at different periods, e.g., 2-4 days, 5-8 days and 9-12 days drying, which corresponded to pF 2.1-2.5, 3.1-3.8 and 4.6-6.0 respectively. These soil were subjected to a single level of puddling with an applied energy of 50 Joules. Five wetting/drying cycles were conducted for this experiment.

Results

Puddling of soil results in disaggregation and dispersion of soil materials. Results showed that the amount of dispersed clay or silt+clay increased with increasing puddling energy applied (P< 0.05) (Figure 1). Figure 2 showed that there was a significant reduction (P<0.05) in the saturated hydraulic conductivity, K_{sat}, after

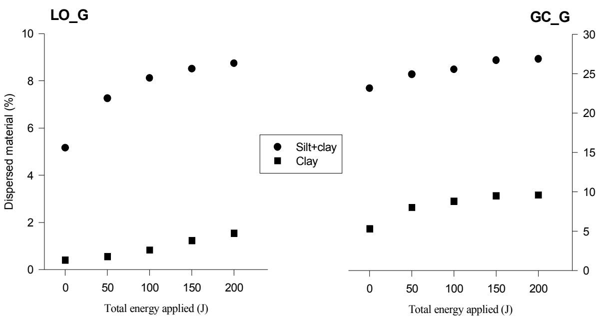

Figure 1. Effect of puddling on soil dispersion for LO_G and GC_G soil.

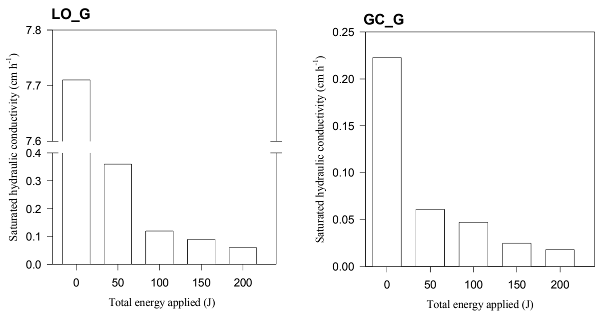

Figure 2. Effect of puddling on saturated hydraulic conductivity (K_{sat}) for LO_G and GC_G soil.

puddling. K_{sat} decreased rapidly when the soil was puddled with only 50 - 100 Joule energy input. When the soil is puddled with greater energy (100 to 200 Joule) however, the additional reduction in K_{sat} was small. A large reduction in K_{sat} of the puddled soil was due to the disaggregation induced by puddling. The greater the soil dispersion, the lower is the saturated hydraulic conductivity (Figure 3). Wetting/drying cycles are known to improve soil structure. Results clearly showed reduction in the amount of silt+clay (<20 μm) and clay (<2 μm) dispersed during wetting/drying cycles in clay (GC_G) and sandy loam (LO_G) soil respectively. Figure 5 and 6 shows the silt + clay data for the two soils.

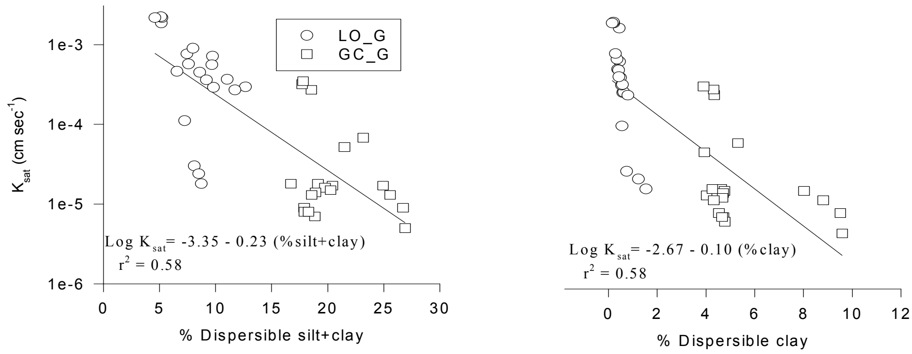

Figure 3. The relationship between puddled soil hydraulic conductivity and the amount of dispersed silt+clay and clay for LO_G and GC_G soil.

Repeated wetting/drying cycles to air dry water contents increased K_{sat} of the puddled soil significantly in the fine textured soil but had little effect on the sandy soil (Figure 4). However, in fine textured soil (GC_G) the recovery of K_{sat} was not significant except for the soil puddled with energies less than 100 Joules. This improvement was partly the consequences of rapid wetting. Rapid wetting causes partial slaking by inducing micro-cracks and these micro-cracks has the effect of making the soil easily crumbled. The Combined effect of wetting-drying and degree of drying on the % dispersed silt+clay is shown in Figure 5 and 6 for the surface 3.5 cm of soil. It is clear that the degree of drying has a strong effect on the structural regeneration shown by the decrease in dispersed silt +clay. The greater the drying and the greater the frequency of drying,, the greater is the reduction is dispersed material. In the two soil the amount of <20 µm and <2 µm dispersed soil was significantly reduced until the fifth cycle.

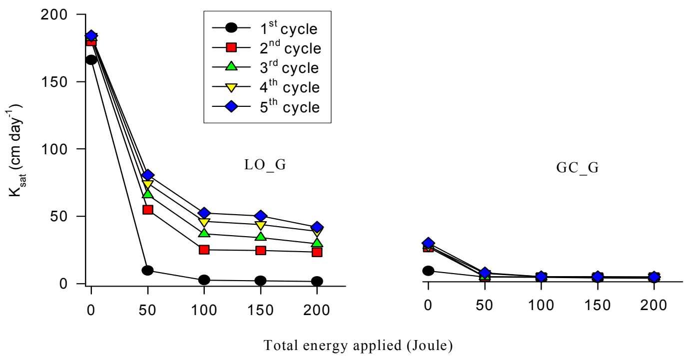

Figure 4. Changes in K_{sat} during wetting/drying cycles for LO_G and GC_G soil.

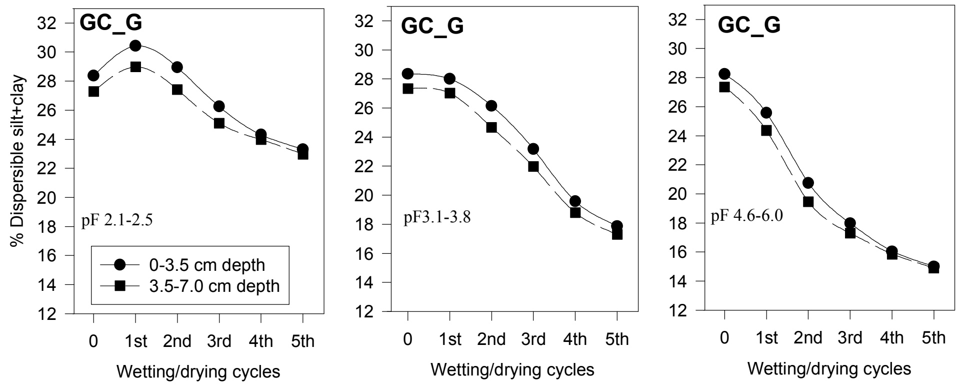

Figure 5. Effect of different degrees of drying on the amount of silt+clay (<20 µm) dispersed at 0-3.5 cm and 3.5-7.0 cm depth in GC_G soil.

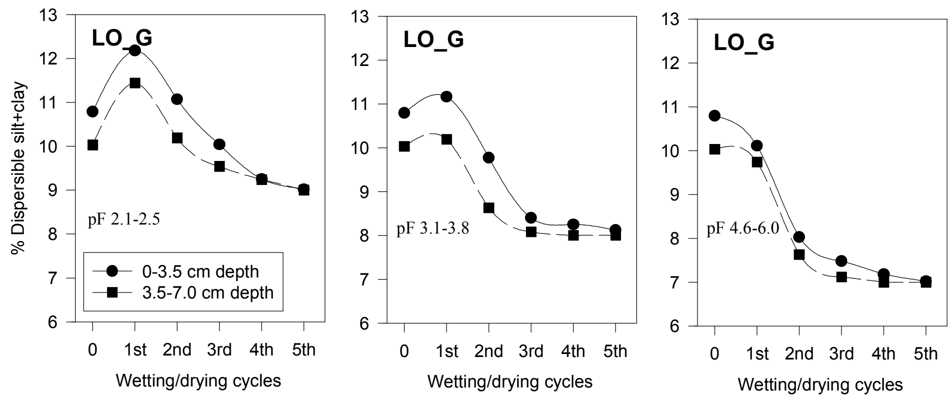

Figure 6. Effect of different degrees of drying on the amount of silt+clay (<20 µm) dispersed at 0-3.5 cm and 3.5-7.0 cm depth in LO_G soil.

Conclusion

Results of this study shows that soil puddling increased dispersion but dispersion decreased with wetting/drying cycles resulting in increased saturated hydraulic conductivity, K_{sat}, of the puddled soil. However, the improvement in K_{sat} for fine textured soil was small when intense puddling was applied (the soil was excessively puddle). This suggests that in clay soil where percolation rates are low, puddling, which is capital intensive and detrimental to soil structure, should be minimised. Drying the puddled soil to its air dry water content is very effective in the process of structural regeneration. This study also showed that partial drying will result in lower levels of structural regeneration of puddled soil and may possibly require greater frequency of drying to fully regenerate the soil.

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