Assessment of Infiltration Rate of Water Repellent Dune Sand

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Abstract

A water-repellent or a hydrophobic soil does not wet up spontaneously when a drop of water is placed on the surface. The primary effect of water repellency is the reduction of infiltration rates. The purpose of this study was to determine the effect of water repellency on infiltration rate of dune sand in Dry zone of Sri Lanka under thick cover of *Casuarina equisetifolia*. Infiltration test was conducted in-situ and the water repellency measurements were conducted both in-situ and ex-situ. Water repellency was determined using the water drop penetration time (WDPT) test. Infiltration rate of the dune sand was determined using a double ring infiltrometer. The WDPT of the studied dune sand was > 1 h showing extreme water repellent condition. The water repellent condition in the dune sand was attributed to the water repellent leaf litter of *Casuarina equisetifolia*. The water repellent condition gradually decreased with the soil depth. The initial infiltration rate was 120 cm h^{-1} and started to increase with time after about 5 min elapsed time. The highest infiltration rate was 188 cm h^{-1}, which was achieved 12 min after the starting of the infiltration test. Then, the infiltration rate gradually decreased. The steady state infiltration rate was 164 cm h^{-1} and achieved within about 40 min from the beginning of the test. Water infiltration started within seconds irrespective of the extreme water repellent condition. This can be considered as governed by the ponding depth.

Key words: *Casuarina equisetifolia*, Infiltration, Water drop penetration time, Water repellency

Introduction

The rate of infiltration determines the time at which superficial water appears on the soil surface and the amount of runoff that will form over the soil surface during rainfall or irrigation event. If the rate of infiltration is limiting, the entire water balance in the root zone will be affected. A water-repellent or a hydrophobic soil does not wet up spontaneously when a drop of water is placed on the surface. It is common to see water pooling or runoff on the surface of dry water repellent soil rather than entering or infiltrating into the soil (Wallis and Horne 1992). Infiltration is the process of water entry into the soil. Water repellency can result in losses of plant available water, stresses for plant growth, and reduced agricultural crop production.

Water infiltration into the homogeneous wettable sand, without air-entrapment, is usually stable since the rate of infiltration is usually higher than the saturated hydraulic conductivity (Wang et al. 2000). Soil water repellency affect many hydrologic functions, primarily the infiltration rates in soils. Field observations have indicated that the rates of water infiltration into repellent soils are very irregular. However, the effects of water repellency on infiltration are not yet fully understood. No reported data is available on water repellent soils in Sri Lanka and their infiltration rates. The purpose of this study was to determine the effects of water repellency on infiltration rate of dune sand in Dry zone of Sri Lanka, which would be of prime importance for the understanding of water repellency effects on hydrological consequences.

Materials and Methods:

Study area

The study area was a sand dune (sandy regosols) in dry zone of Sri Lanka (6°06'53.98" N, 81°05'32.20" E) under the cover of *Casuarina equisetifolia*. The floor was covered with 3~7.5 cm thick layer of *Casuarina* leaf litter.

Infiltration test was conducted in situ and the water repellency measurements were conducted both in situ and ex situ (in the laboratory)

Determination of water repellency

Water repellency was determined using the water drop penetration time (WDPT) test. One drop of distilled water with 50 ± 1 µL of volume was placed on the soil surface and the time taken for the complete penetration of the water drop was measured using a stopwatch (King 1981; Leelamanie and Karube, 2007).

Determination of infiltration rate

Infiltration rate of the dune sand was determined using a double ring infiltrometer. Once the rings were properly installed, both the inner and outer rings were filled with water to a depth between 100 mm and 140 mm and allowed free infiltration. The initial level of water in the inner ring, outer ring, and effective time were recorded. During infiltration, inner ring water level was measured in every 90 s from a fixed point on the top of the ring down to the water level and promptly refilled to the starting level. Care was taken to keep the water level of the outer ring almost similar to that of the inner ring. A test was considered complete when water level reading of the inner ring within 90 s appeared to become constant responding to the steady state infiltration rate. The total time needed to determine the steady state infiltration rate was approximately 40 minutes.

Results and Discussion

Most Sri Lankan soils, in general, are highly wettable with WDPTs below 1 s. However, the WDPT of the studied dune sand was > 1 h showing extreme water repellent condition. Water poured on the sand surface started to flow over the surface without entering into the sand. The water repellent condition in the dune sand was attributed to the water repellent leaf litter of *Casuarina equisetifolia*. The water repellent condition gradually decreased with the soil depth showing that the accumulation of water repellent material decreased with the soil (sand) depth.

In general, water infiltrates faster (higher infiltration rate) into a dry soil, than into a wet soil. As a consequence, when water is applied on the surface of a normal wettable soil, the water infiltrates easily and rapidly at first, but the infiltration rate decreases as the soil becomes wet to achieve lower steady state infiltration than the initial infiltration rate. The infiltration rate into water repellent sand was found to show a different pattern. Infiltration rate into water repellent dune sand is presented in Fig. 1. In contrary to a wettable soil, the initial infiltration rate was 120 cm h^{-1} and started to increase with time after about 5 min. The highest infiltration rate was 188 cm h^{-1}, which was achieved 12 min after the starting of the infiltration test. Then the infiltration rate gradually decreased. The steady state infiltration rate was achieved within about 40 min from the beginning of the test. It was 164 cm h^{-1} and higher than the initial infiltration rate.

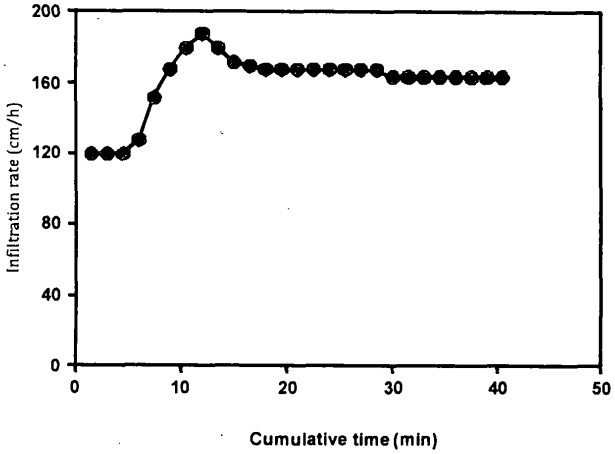

Figure 1: Infiltration rate of water repellent dune sand

Results revealed that water infiltration into dry sand started within seconds irrespective of the extreme water repellent condition which took more than one hour for a water drop to penetrate into the sand. This can be considered as governed by the ponding depth of the inner ring of the infiltrometer. However, further experiment is required to find the exact effects of ponding depth.

Conclusions

The WDPT of the studied dune sand was > 1 h showing extreme water repellent condition. The water repellent condition in the dune sand was attributed to the water repellent leaf litter of *Casuarina equisetifolia*. Gradually decreasing water repellency with the soil depth showed a decreased accumulation of water repellent material in lower layers.

In contrary to a wettable soil, the infiltration rate increased with time up to about 12 min. Then the infiltration rate gradually decreased. The steady state infiltration rate was achieved within about 40 min from the beginning of the test, which was higher than the initial infiltration rate.

Water infiltration into dry sand started did not correspond to the extreme water repellent condition, which was considered as governed by the ponding depth.

References

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