Distribution of Soil Water Repellency along Different Particle Sizes of Coastal Sand Dunes in Sri Lanka

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Abstract

Water repellent soils do not wet spontaneously when a drop of water placed on the soil surfaces. Although water repellency has been reported for all major soil types in the world, occurrence of water repellency in Sri Lankan soils has not been reported so far. The objective of this study is to examine the presence of water-repellent condition of a sand dune in Dry zone of Sri Lanka under Casuarina equisetifolia land cover and the distribution of water repellent conditions along the difference particle sizes. Water repellency was determined using water drop penetration time (WDPT) and contact angle. The uppermost or the surface soil layer (0-5 cm depth) showed the highest water repellency as measured by WDPT and the contact angle in all the particle sizes. Water repellency decreased with increasing depth of the soil. Both WDPT and the contact angle increased as the particle size decreased. The WDPT for soils in the 0-5 cm layer increased only from 22 to 1705 s with decreasing particle size from 0.15 mm < 0.04 mm. Samples were non-repellent (WDPT< 1 s) for particle sizes >0.09 mm in the 5-10 layer and particle sizes >0.04 mm in the 10-15 cm layer. Soils changed from non-repellent to severely repellent with decreasing particle size from 0.09 to < 0.04 mm in the 5-10 cm layer, and from non-repellent to slightly repellent with decreasing particle size from 0.04 to < 0.04 mm in the 10-15 cm layer. Smaller particle sizes seemed to contribute more to the occurrence of soil water repellency.

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

Introduction

Soil water repellency is a phenomenon that soils do not wet spontaneously when a drop of water placed on the soil surfaces. It has significant effects on reduction on infiltration rates, increased surface runoff, erosion, and the hydrologic balance of soils (Feng et al. 2001). The level of soil water repellency depends on the content and the composition of the prevailing organic matter including its hydrophobicity and hydrophilicity. Mineral soil particles are usually wettable. Soils become water repellent as a result of the organic coatings on mineral particles or due the presence of particulate organic matter.

Over the past decades, soil water repellency or the resistance of soil to wetting has been encountered in a long list of countries on all inhabited continents (DeBano 2000; Doerr et al. 2000). Although water repellency has been reported for all major soil types in the world, occurrence of water repellency in Sri Lankan soils has not been reported so far. Sri Lankan soils are mostly found to be readily wettable (Leelamanie and Samarawickrama 2011).

Sandy soils along the coastlines of many countries in land covers such as Eucalyptus globulus Labill. and Pinus pinaster. It has been investigated in particular detail and reported for the occurrence of water repellency. Casuarina equisetifolia is one of the common land covers that can be seen in Sri Lankan sand dunes. In our previous study, we found that dried leaves of Casuarina equisetifolia to show strong water repellent conditions.
(Leelamanie and Samarawickrama 2011).

The objective of this study is to examine the presence of water repellent condition of a sand dune in dry zone of Sri Lanka under Casuarina equisetifolia land cover and the distribution of water repellent conditions along the difference particle sizes.

Materials and Methods

The study area was a sand dune in Dry zone (6°06'53.98" N, 81°05'32.20" E) of Sri Lanka under thick cover of Casuarina equisetifolia. The soil type is sandy Regosols. The floor was covered with thick layer of Casuarina leaf litter to 3-7.5cm thickness.

A soil pit was cut to identify the soil horizons. Bulk soil samples were taken from 0-5cm, 5-10cm and 10-15cm depths separately. Each bulk soil sample was air dried and passed through 2mm sieve to remove larger particles. Bulk soil samples were further separated in to six size fractions by sieving them through a set of sieves as 0.36mm, 0.16mm, 0.14mm, 0.09mm, 0.04mm and less than 0.04mm. All the size classes were tested with three replications.

Determination of water repellency

Persistency and the degree of water repellency were measured in each size fraction in each depth by using WDPT test and Sessile Drop Method (SDM), respectively (Leelamanie et al. 2008).

For the 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. The persistency of water repellency can be categorized into several classes as WDPT ≤ 1 s non-repellent, 1-60s slightly repellent, 60-600s strongly repellent, 600-3600s severely repellent, and > 3600 s extremely repellent.

For SDM soil was sprinkled on a double sided adhesive tape adhered to a smooth glass slide. After the soil was pressed to the tape with 100g weight for 10 seconds the slide was tapped gently to remove the surplus soil. The procedure was repeated twice to ensure the dense arrangement of particles on the adhesive tape. Then the slide was place on the stage of the digital microscopic camera. A 10 μL drop of de-ionized water was placed on the sample surface using a micro pipette and a digital microphotograph of the horizontal view of the water drop was taken within 1s. The contact angle of each sample was manually measured with a protractor using the microphotograph.

Results and Discussion

The tested sandy soils of the sand dune under Casuarina equisetifolia land cover was found to show extreme water repellency on the surface showing WDPT > 3600 s.

The uppermost or the surface soil layer (0-5cm depth) showed the highest water repellency as measured by WDPT and the contact angle in all the particle sizes. Water repellency decreased with increasing depth of the soil. Both WDPT and the contact angle increased as the particle size decrease. The WDPT of different particle sizes in different soil depths is presented in Fig. 1.

The WDPT of sandy soil samples in the 0-5cm layer increased only from 22s to 32s with decreasing particle size from 0.36mm to 0.15mm, remaining as slightly water repellent. The WDPT increased from 32s (slight water repellency) to 1705 s (severe water repellency) with decreasing particle size from 0.15 mm < 0.04 mm. Sandy soil samples were non-repellent (WDPT< 1 s) for particle sizes larger than 0.09 mm in the 5-10 layer and particle sizes larger than 0.04 mm in the 10-15 cm layer.

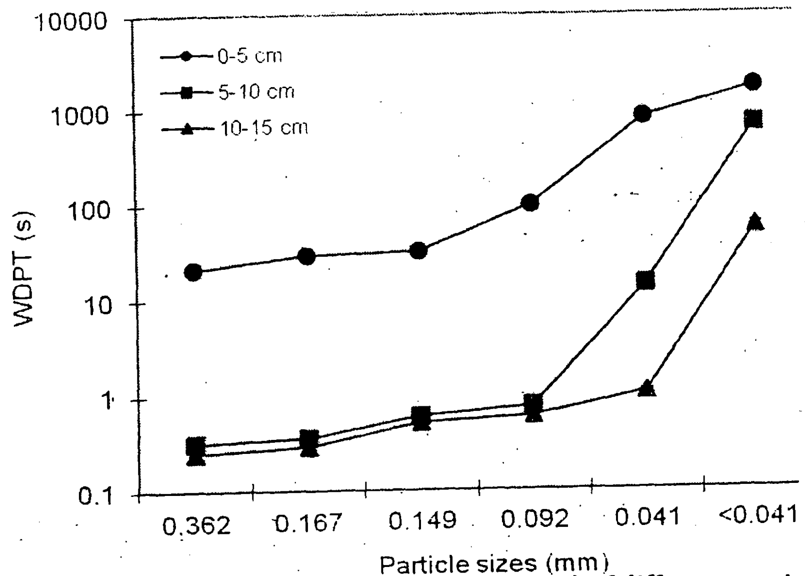

Figure 1: Water drop penetration time (WDPT) of different particle sizes in different soil depths

With decreasing particle size from 0.09 to < 0.04 mm in the 5-10 layer, soils changed from non-repellent to severely repellent. In the 10-15 layer, soils changed from non-repellent to slightly repellent with decreasing particle size from 0.04 to < 0.04 mm.

As the particle size decreases from 0.36 mm to < 0.04 mm contact angle increased from 87° to 115° in the 0-5 cm layer, 58° to 100° in the 5-10 cm layer, and 87° to 115° 10-15 cm layer.

The relation between contact angle and WDPT showed that the WDPT is highly sensitive to the contact angle changes around 90°, which is comparative to the previously reported experimental findings (Leelamanie et al. 2008)

Conclusions

The uppermost or the surface soil layer (0-5 cm depth) showed the highest water repellency as measured by WDPT and the contact angle in all the particle sizes. Water repellency decreased with increasing depth of the soil. Both WDPT and the contact angle increased as the particle size decrease. Smaller particle sizes seemed to contribute more to the occurrence of soil water repellency in the dune sand in dry zone of Sri Lanka under Casuarina equisetifolia. This means that the water repellency is more strongly caused not by the organic coatings but by the fine organic matter particles.

References

Doerr SH, Shakesby RA, Walsh RPD 2000 Soil water repellency: its causes, characteristics and hydro-geomorphological significance. Earth-Sci. Reviews, 51: 33-65.