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Restricted increases of water storage during rainfall events due to water repellency in a forest soil of a Japanese cypress plantation

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In Japan, water repellent soils are usually found in forests. Particularly in plantations of Hinoki cypress (*Chamaecyparis obtsusa*), severe water repellency frequently occurs and impedes water infiltration into soil matrix. This may influence the manner of water storage in forest soils at solum scale. The objective of this study is to clarify the effect of water repellency on the solum scale water storage in forest soils.

In a small headwater catchment widely planted with Hinoki cypress, Observations of flow paths using dye tracer, and soil water content measurement at depth of 10, 30, 50 cm using TDR were conducted. The amounts of soil water storage in depths of 0 to 60 cm (S: mm) and the increases of S at cumulative rainfall of 20 mm (ΔS_{20}) for observed rainfall events were calculated using measured water content data. Ideally, ΔS_{20} should be 20 mm if rainwater is completely stored in the soil within 60 cm, and ΔS_{20} should be 0 mm if never stored.

In dry summer, water repellent soil covered more than 70 percent of the catchment area except the bottomland and its vicinity. The soil below 15 cm was not water repellent, namely, was wettable. The flow patterns visualized by dye tracer were rather preferential in dry conditions, while more diffusive in moderate moisture conditions. Laboratory ethanol percentage tests revealed that soil samples exhibited strong water repellency at water content lower than 0.25 m^3m^{-3}.

The calculated ΔS_{20} values were very small when the soil became dry (antecedent water content of 10 cm depth was lower than 0.25 m^3m^{-3}). The small ΔS_{20} in dry conditions mean that only small proportions of rainwater was stored in the soil within 60 cm in spite of low saturations of the soil matrix. This tendency is not expected from the general flow theory of wettable soils but can be explained by considering water repellency.

In dry conditions, the matrix of the surface soil could not absorb rainwater because of water repellency. As shown by the dye tracer tests, the rainwater was only able to move to the subsoil at few locations, which were connected to vertical continuous macropores such as decayed root channels or interstructural voids. Therefore the matrix of wettable subsoil not neighboring the macropores was bypassed and could not absorb the rainwater. Consequently, a large part of subsoil did not participate in water storage. These phenomena led to the restricted increases of solum scale water storage of the soil during rainfall events. The process shown above can be regarded as an example of physical nonequilibrium in soil water storage.