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Effect of biofilm on soil hydraulic properties: laboratory studies using xanthan as surrogate

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Many soil bacteria produce extracellular polymeric substances (EPS) in which they are embedded while residing in the porous matrix. EPS are often attached as a biofilm to both the bacteria cell and the soil particles. As a consequence, their influence on water flow through variably saturated porous media often cannot be neglected. While the influence of attached microbial biomass and EPS on saturated water flow has been studied extensively, its investigation for unsaturated flow in soils has found significantly less attention.
The objective of this study was the quantification of the effect of biofilms on the unsaturated soil hydraulic properties. We determined the soil water retention and unsaturated hydraulic conductivity functions of biofilm-affected soils by using xanthan as an EPS surrogate. Evaporation experiments were conducted on two sandy soil materials. The amount of added xanthan was varied in 6 stages from zero to 0.25 %. Additional measurements of soil water retention using the dewpoint method closed the remaining gap from the evaporation method to air-dryness. The experimental data were evaluated by the simplified evaporation method of Schindler.
The results show that the unsaturated hydraulic conductivity is reduced markedly by added xanthan and the shape of the soil water retention curve is alterated significantly for all stages of xanthan addition. The reduction in hydraulic conductivity is high enough to fully suppress stage-one evaporation for xanthan-sand mixtures. The water-holding capacity of the xanthan and the alteration of the effective pore size distribution explain these results.