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Unsaturated hydraulic properties in a nearly saturated medium

Monday, 31 May 2021 19:50 (15 minutes)

In models and estimates of unsaturated hydraulic properties, the wet range between field saturation and the air-entry value is greatly oversimplified. Retention curves, for example, are often taken to be perfectly flat (unchanging water content) in this range, or are represented by an empirical formula that is unrelated to the active processes. Another example is diffusivity, which goes to infinity with a flat retention curve, making it both unrealistic and unusable. Though much neglected, the hydraulic properties of a nearly saturated medium are important in an increasing number of applications, for example:
• Macropore/matrix domain exchange, a major influence on preferential flow processes and control on rapid versus slow solute transport, which often occurs with the matrix domain at high water content.
• The precise timing of the transition from unsaturated to field-saturated conditions, as may be important to initiation of ponding, triggering of landslides, heightened vulnerability to erosion, and initiation of preferential flow.
• Subsurface initiation of preferential flow by seepage from nearly saturated matrix material into macropores.
• Hydraulic property measurement by tension infiltrometer, which frequently is done with the input condition at a very slight suction.
A new process-based model has been developed for the important case of a medium without macropores (i.e. having a distinct nonzero air-entry value) that is exposed to repeated wetting and drying cycles. On wetting, the medium does not exceed field saturation, with trapped air occupying some of the pore space. Water retention in the range between air-entry and field saturation is not dominated by capillarity but by trapped air expansion and contraction with change in matric pressure, and effects triggered by this process. Accordingly, the model represents this wet range by an augmented Boyles'law variation of trapped air volume with matric pressure, amplified by an empirical factor to account for associated liquid-bridge collapse or other mechanisms. Tests using high-quality measurements in this range showed good fits with Boyles'law amplified by a factor typically between 2 and 4.
This model can serve within a model of hydraulic conductivity, treated as saturated conductivity that varies with changes in effective porosity determined by the variable trapped air volume. Diffusivity can then be assigned a realistic value using the modeled retention and conductivity relations. Though few data are available for direct test of these dynamic properties, the model has value for exploring possible consequences of processes occurring under conditions close to field saturation.

Time Block Preference

Time Block C (18:00-21:00 CET)

References

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Student Poster Award

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