Contribution ID: **56** Type: **Oral Presentation**

Linearized Water and Air Flow in Porous Media

Tuesday, 1 June 2021 10:15 (15 minutes)

The hydraulic and air conductivity and the water retention of porous media are non-linear functions of the water (or air) content or capillary pressure (Van Genuchten, 1980; Vereecken et al., 1989, 1990; Assouline and Or, 2013), which results in non-linear water and air, single- and two-phase flow equations that usually preclude analytical and necessitate numerical solutions. If assuming exponential dependence of the hydraulic (Gardner, 1958) or air (Philip, 1998) conductivity on the capillary pressure, the steady flow equations can be linearized when described in terms of the matric flux potential (the integral of the conductivity over the capillary pressure). If assuming also linear dependence of the hydraulic (or air) conductivity on the water (or air) content, the unsteady flow equations are also linear. The two major advantages of linear flow equations are that they facilitate analytical solutions to a variety of flow problems and that the action of multiple water (or air) sources can be described by linearly superposing the solutions describing their decoupled actions.
In the lecture, we will describe briefly a few applications of linear water (or air) flow equations for describing steady and unsteady, forced, water (or air) injection into porous media at different geometries and boundary conditions, relevant for several agricultural and environmental circumstances. These include: 1. Coupled point (or line) source irrigation and localized root water uptake (Communar and Friedman, 2010), which serves the major principle of; 2. The freeware DIDAS program for Drip Irrigation Design and Scheduling (https://app.agri.gov.il/didas, Friedman et al., 2016); 3. Evaluating the role of water availability in determining the yield/plant population density relationship (Friedman, 2016); 4. A proposed method for determining the soil hydraulic properties based on periodic point source irrigation (Communar and Friedman, 2014); 5. Simultaneous water uptake from an on-surface water source and from a shallow water table (in also laterally confined lysimeters) (Friedman and Gamliel, 2019); 6. Single-phase, air flow bounds (Ben-Noah and Friedman, 2019) to two-phase, air-water flow in periodic air injection (Ben-Noah et al., 2020).
Overall, the solutions to the simplified, linear water and air flow equations, described reasonably well measured distributions of water and air contents (pressures) and fluxes in a wide range of water (and air) contents, making them constructive, practical tools for the design and assessment of irrigation and subsurface air injection operations.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

Assouline, S. and Or, D. (2013). Conceptual and parametric representation of soil hydraulic properties: A review. Vadose Zone J., 12:1-20.
Ben-Noah, I. and Friedman, S.P. (2019). Bounds to air-flow patterns during cyclic air injection into partially saturated soils inferred from extremum states. Vadose Zone J. 17, doi:10.2136/vzj2018.01.0023.
Ben-Noah, I., Nitsan, I. and Friedman, S.P. (2020). Forced gas injection and water infiltration into sand–a two-phase flow barrel and column experiment. Soil Sci. Soc. Am. J. doi:10.1002/saj2.20042.
Communar, G. and Friedman, S.P. (2010). Relative water uptake rate as a criterion for trickle irrigation system design: 1. Coupled source-sink steady water flow model. Soil Sci. Soc. Am. J. 74:1493-1508.

Communar, G. and Friedman, S.P. (2014) Determination of soil hydraulic parameters with cyclic irrigation tests. Vadose Zone J. doi: 10.2136/vzj2013.09.168.
Friedman S.P. (2016). Evaluating the role of water availability in determining the yield/plant population density relationship. Soil Sci. Soc. Am. J. 80:563-578.
Friedman, S.P., and Gamliel, A. (2019). Steady water flow with interacting point source–point sink–water table in a cylindrical soil domain. Vadose Zone J. 18:180204, doi:10.2136/vzj2018.11.0204.
Gardner, W.R. (1958). Some steady-state solutions of the unsaturated moisture flow equation with application to evaporation from a water table. Soil Sci. 85:228-232.
Philip, J.R. (1998). Full and boundary-layer solutions of the steady air sparging problem. J. Contam. Hydrol. 33:337-345.
Van Genuchten, M.T. (1980). A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Sci. Soc. Am. J. 44:892-898.
Vereecken, H., Maes, J., Feyen, J. and Darius, P. (1989). Estimating the soil moisture retention characteristic from texture, bulk density, and carbon content. Soil Sci. 148:389-403.
Vereecken, H., Maes, J. and Feyen, J. (1990). Estimating unsaturated hydraulic conductivity from easily measured soil properties. Soil Sci. 149:1-12.

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Session Classification: MS25

Track Classification: (MS25) Subsurface Water Flow and Contaminant Transport Processes –Special Session in Honor of Harry Vereecken