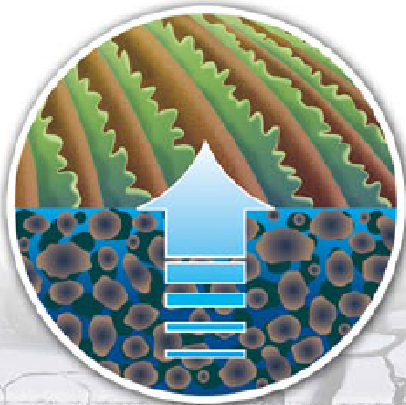
Abstracts



Toward Sustainable Groundwater in Agriculture

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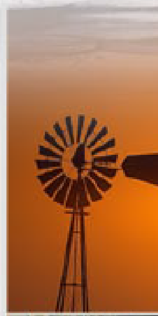

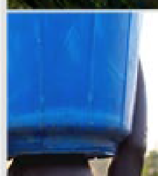

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Control of Topology of Water Fluxes in Arid Agriculture: Amalgamation of Subsurface Irrigation, Managed Aquifer Recharge and Engineered Soil Substrate

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Arid zone agriculture in Oman consumes more than 80% of national fresh water resources and relies on shallow unconfined aquifers with an emerging dependence on sewage treated water of quality different from groundwater. A superjacent coarse-textured vadose zone and top soil host plants' roots subject to harsh conditions of moisture deficit and heat stress that calls for improvements of the conjunctive water use efficiency. Mitigation of adverse ambient conditions impeding the plant growth and causing secondary salinization of topsoil is proposed by innovative agro-engineering techniques. We present the results of field-, farm- observations and experiments, as well as mathematical modeling of optimal control of descending, ascending and lateral water fluxes (viz., evapotranspiration, infiltration, seepage from/to subsurface emitters/drains, losses/gains from/to a deeper confined aquifer commingled via a leaky layer with the irrigated one, and water uptake by roots).We consider two main scenarios of moistening the root zone: by furrows and linear/point sources (subsurface emitters/ leaky pipes) over the soil substrate designed as a tessellation (double-porous medium with a cascade of silt-sand capillary barriers at the interfaces between blocks and fractures). In the first case, two flow regimes are studied: a) with intensive infiltration and phreatic surface mound commanding the periodic surface channels (typical for crop fields with drainage trenches in Holland) and aquitard transmitting groundwater upward from the subjacent aquifer, and b) with intensive evapotranspiration (typical in Oman) when surface water in furrows commands the phreatic surface trough caused by evapotranspiration and groundwater recharged through a leaky layer. The Emikh-Rybakova and Boussinesq-Cherepanov models and analytical solutions are used for quantification of managed aquifer recharge and recovery by controlling the furrow spacing, accretion to the water table and water level in the furrows. In the second scenario, the emitter depth-intensity and hydraulic properties (saturated hydraulic conductivity and capillarity) of the two porous elements and the tessellation geometry determine the tension-saturated perched flow. J.R.Philip, Kirkham-Brock, and Riesenkampf-Vedernikov models are used for predicting the following: a) how much water is "adsorbed" by blocks for further gradual interception by roots, b) how much is winding through the fractures to the next level of the substrate cascade, and c) how much is eventually percolated to the "natural" subsoil and recharges groundwater. Modeled flow nets, isochrones, isotachs, and lines of equal force acting on saturated soil REV (important for structural stability of the designed heterogeneity) are computed by computer algebra routines. Plant characteristics (biomass, number-size of leafs, roots' architecture) are found in field experiments for various tessellations and irrigation schedules. Both physical and mathematical models prove the efficiency of the proposed optimization of irrigation water fluxes.
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10.1002/2014WR016304.Kacimov A.R., Obnosov Yu.V. Tension-saturated and unsaturated flows from line sources in subsurface irrigation: Riesenkampf's and Philip's solutions revisited. Water Resources Research, 2016 (under review).