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Steady Darcian Flow in Subsurface Irrigation of Topsoil Impeded by a Substratum: Kornev–Riesenkampf–Philip Legacies Revisited

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Abstract

Copyright © 2018 John Wiley & Sons, Ltd. Flows in homogeneous topsoils with a subjacent substratum or horizontal groundwater table generated by line-point emitters are studied and tracked back to the Kornev method of subsurface irrigation. Laplace's equation governs flow in a saturated or tension-saturated hat-shaped zone subtended by the substratum, provided pressure in a porous pipe or mole hole is positive. For low capillarity a free surface (phreatic line or capillary fringe) and a layer–substratum interface of a constant vertical component of velocity bound the flow domain. The free surface is found for various values of source strengths, emitter elevation above the substratum and the ratio of hydraulic conductivities of the topsoil and substratum. Subcritical and supercritical regimes are distinguished. In the limit of an impermeable substratum, the Riesenkampf solution for a line source is analysed. In soils of high capillarity, the J.R. Philip model of a point source and ‘exponential mirror principle’ give a series solution for a vertical array of alternating sources and sinks. Four topological situations emerge, depending on the layer thicknesses, topsoil potential, source depths strengths, saturated conductivity and sorptive number. The point source, groundwater table and soil surface are hydrologically intertwined, with formation of dividing surfaces (separatrices) and critical lines. Copyright © 2018 John Wiley & Sons, Ltd.

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Keywords

advective–dispersion equation, emitter, Kirchhoff potential, Laplace's equation, method of images, water productivity

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