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MODELLING OF WITHDRAWAL OF A STRATIFIED FLUID FROM A POROUS MEDIUM

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The problem of withdrawal of fluid from a porous medium has many applications in reservoir engineering and aquifer sustainability. The extraction from layers of fluid of different density is of particular interest. When pumping begins in a phreatic aquifer, the interface between layers may draw down, leading to undesirable (nonpotable) water entering the outlet, or water entering an oil pipeline. We investigate the flow into a line sink or circular drain in a saturated porous medium containing a stratified fluid with either an interface between layers of different density or a free surface. Analytical techniques, spectral methods and full numerical calculations are used. The conditions under which the interface may draw down are studied by considering when steady, subcritical flows exist and then examining unsteady flows that lead to the drawdown of the interface. In two dimensions, the critical solutions that appear to be the limiting steady flow in any given situation have been computed with both hodograph methods and a spectral method, with good agreement. The spectral method is then modified to consider unsteady flows and in particular the approach to a steady state or the drawdown of the interface. Critical flow parameters have been obtained. In three dimensions, the axisymmetric flow into a circular well is considered by extending the spectral method. Again, steady and unsteady problems were solved to find the critical flow parameters. Results obtained were compared with full numerical simulations via the COMSOL^{TM} package, again with good agreement. In all situations, a strong relationship was found between the limiting steady flows and the drawdown of the interface. The understanding gained in this work is important to issues of water quality in stratified aquifers.

Some of the results of this research have been published in [1].

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