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Numerical model of fluid flow through heterogeneous rock for high level radioactive waste disposal

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Abstract

An international consensus has emerged that deep geological disposal on land is one of the most appropriate means for high level radioactive wastes (HLW). The fluid transport is slow and radioactive elements are dangerous, so it's impossible to experiment over thousands of years. Instead, numerical model in such natural barrier as fractured underground needs to be considered. Field observations reveal that the equation with fractional derivative is more appropriate for describing physical phenomena than the equation which is based on the Fick's law. Thus, non-Fickian diffusion into inhomogeneous underground appears to be important in the assessment of HLW disposal. A solute transport equation with fractional derivative has been suggested and discussed in literature. However, no attempts were made to apply this equation for modeling of HLW disposal with account for the radioactive decay. In this study, we suggest the use of a novel fractional advection-diffusion equation which accounts for the effect of radioactive disintegration and for interactions between major, macro pores and fractal micro pores. This model is fundamentally different from previous proposed model of HLW, particularly in utilizing fractional derivative. Breakthrough curves numerically obtained by the present model are presented for a variety of rock types with respect to some important nuclides. Results of the calculation showed that for longer distance our model tends to be more conservative than the conventional Fickian model, therefore our model can be said to be safer. © 2007 American Institute of Physics.

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Keywords

Fractional derivative, Heterogeneous media, High level radioactive waste disposal, Non-ficluan diffusion, Radioactive disintegration