Modeling U Transport in Unsaturated Zone at Peña Blanca, Mexico

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We present a quantitative model to describe transport of radionuclides underground. Applicable to unsaturated (vadose) as well as saturated (phreatic) layers, the model provides constraints on the in-situ migratory behavior of radioisotopes in dissolved and colloidal pools of a groundwater system. It shows, for examples, that uranium in water percolating through the vadose zone will have its concentration and ratio $^{234}\text{U}/^{238}\text{U}$ linearly correlated under the ideal condition of a constant removal of the two U isotopes from vadose-zone solids. The intercept and slope of the linearity serve to constrain removal rates of the two uranium isotopes from solids to the solution through dissolution and alpha recoil. The model also allows estimation of the fluid transit time in the vadose zone. At Peña Blanca, the uneven distribution of rainfall between winter (wet) and summer (dry) results in a conspicuous seasonal variability in uranium removal rate, hence dissolved uranium signals, within the unsaturated zone. Our data indicate a much higher uranium dissolution rate during the dry season than during the wet season, possibly reflecting a condition of increased oxygenation in the zone during the dry period.