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Simulation of solute transport from deep repository to near surface

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In The Czech Republic a selection of locality for deep repository of spent nuclear fuel is currently in progress. For the safety evaluation it is necessary to verify that the radionuclides penetrating the engineered barriers and a geosphere are not reaching a biosphere in high concentrations. Flow123D and GoldSim SW are used for the solute transport simulations in a geosphere. The advantage of Flow123D is that it allows simulating the transport on a 3D computational mesh. A simulation result is a time development of concentration/activity of the radionuclides. Information from the surface elements is used for effective dose computation.
The issue is that the computed concentration/activity is actually several meters below the surface (on a saturated zone boundary) and hence doesn't include dilution a sorption in unsaturated zone. This contribution tries to tackle this issue by comparison of results of two different models: Computation of effective dose from transport simulation with 1) only the saturated zone included 2) both saturated and unsaturated zone included.
Ad 1) Flow123D is used for the simulations. Results are underground water fluxes across element sides and concentration developments (in time) on mesh elements. From those it is possible to compute mass flux of individual isotopes on each element. We assume a conservative model of men using the contaminated water for drinking and for cultivation and breeding of products for direct consumption. The consumer basket based on the Czech statistical office data is common for both models. The model doesn't account for mixing with rain water in the unsaturated zone.
Ad 2) Flow123D is used for simulations in the saturated zone. Its outputs serve as inputs for ResRad SW used for simulations in the unsaturated zone. ResRad is primarily designed for simulations of different tasks hence it was necessary to modify it.
ResRad is predominantly used for simulation of solute transport from sources located near the surface. It assumes that the initial activity of isotopes is known and that no activity is added during the simulation period (zero mass source). Transport is simulated from the source through the unsaturated zone and it continues to the food chain. The result is an effective dose (time dependent) for a man living in the area.
From Flow123D, the concentration/activity value on a surface element [kg/m3] along with water flux through it [m3/y] are used to compute a mass flux [kg/y] entering the unsaturated zone which represents the intensity of released amount of substance. From this intensity it is possible to determine an effective dose interval for a man.
The result is a comparison of both models. In the unsaturated zone model, the following parameters are variated: unsaturated zone layers thickness, isotope sorption coefficients and the rain water infiltration amount.

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