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Modelling of multiphase flow in evaporation tests in concrete columns

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In order to characterize better the thermo-hydraulic properties and processes in concrete from a Radioactive Waste Disposal Facility at El Cabril (Spain), evaporation tests in columns have been analysed by means of numerical models. The tests consisted of letting water evaporate from the top of the column while monitoring water loss by weighing the column, and monitoring temperature and relative humidity by means of sensors placed within the column. Both non-isothermal (by heating the column with a lamp) and isothermal tests (without heating) were performed.

The conceptual model considers unsaturated liquid flow and transport of vapour and heat. Some models also take into account the salinity in order to study its effect on vapour pressure and evaporation. A retention curve has been obtained from relative humidity and gravimetric water content measured after dismantling the columns. The models have been calibrated by fitting permeability and a tortuosity factor for vapour diffusion to the measured water loss, relative humidity and (in the case of the non-isothermal test) temperature.

Results show that vapour diffusion is dominant above an evaporation front, and liquid advection is the dominant water transport process underneath this front. The salinity slightly reduces the evaporation with a factor of at most 5%. The tortuosity factor estimated from the isothermal test is lower than that of the non-isothermal test. This can be explained by the evaporation and condensation together with the heat transport that take place at pore scale under non-isothermal conditions, which are not taken into account by the model.