

MODELING CONCEPTS TO ADDRESS RISK OF BRINE INFILTRATION INTO SHALLOW GROUNDWATER RESOURCES

Lena Walter, University of Stuttgart, +4971168564674, lena.walter@iws.uni-stuttgart.de

1. Lena Walter, Department of Hydromechanics and Modeling of Hydrosystems, Universität Stuttgart, Germany
2. Holger Class, Department of Hydromechanics and Modeling of Hydrosystems, Universität Stuttgart, Germany
3. Bernd Flemisch, Department of Hydromechanics and Modeling of Hydrosystems, Universität Stuttgart, Germany
4. Sergey Oladyshkin, Department of Hydromechanics and Modeling of Hydrosystems, Universität Stuttgart, Germany

Carbon Capture and Storage is currently debated as a possible technology that could allow a significant reduction of CO₂ emissions into the atmosphere – given that the technology can be applied world-wide in hundreds to thousands of large-scale storage projects. A challenging and important task during CO₂ injection into saline aquifers is to assess the risks, which could occur. Reliable risk estimation and minimization is in fact the crucial task to get enough acceptance of the CCS technology by the societies. Potential risks are, for example, CO₂ leakage, geomechanical failures, and brine displacement with subsequent infiltration into shallower drinking water aquifers. Assessing these risks requires consideration of uncertainties. Walker et al. (2003) categorized uncertainties into different levels, e.g. statistical uncertainty and scenario uncertainty (and others). In this work, a consistent approach to assess the risk at the different levels of uncertainties is developed. Uncertainties associated with geology are addressed at the levels of scenario uncertainty and statistical uncertainty, and they are combined with analytical approximations to develop an operational strategy for water production wells.

For this work, there is a special focus on the risk of groundwater pollution with salt due to displaced brine which migrated into shallower aquifers containing drinking water resources. Risk is defined as damage multiplied with probability, where the damage needs to be an output parameter of the model (or derived from such a parameter). The damage can be calculated for all scenarios to identify those with the highest relevance. Probabilities of hazardous events to occur are then calculated at the level of statistical uncertainty with the integrative probabilistic collocation method (IPCM). The idea is to replace the full numerical model by a simple response surface that can represent an approximation of a selected model output (e.g. brine discharge through a fault) dependent on the space of selected uncertain and design parameters. Once the response surface is determined, the probabilities can be obtained by running Monte Carlo simulations on this reduced model. The challenge remains in the computation of the coefficients of the polynomials for building the response surface.

The complexity of the applied numerical models limits the options for the definition of damage in terms of model output parameters. For example, a non-compositional two-phase model can account for brine discharge into a shallow drinking water aquifer but not for salt load or effectively obtained salt concentration in the subject of protection. This would require a two-phase (brine/CO₂) three-component (water, CO₂, salt) approach or a spatial coupling of models with different complexity. CO₂ plume development and brine migration occur on different spatial scales. While CO₂ (hopefully) is only in the deep geologic target reservoir, the migration of brine and the transport of salt occur over larger (more regional) scales. In order to reduce computational costs, a spatially coupled model can take benefit thereof. Two phases and two components (CO₂ and brine with constant salinity) are considered near to the CO₂ injection area; a single phase (brine) containing the

components water and salt is modeled in the regions where brine migration is expected to occur. The sub-models need to be coupled by interface/boundary conditions.