

Background

The long-term safety of radioactive waste repositories is usually demonstrated by means of a safety assessment which normally includes modelling of radionuclide release from a multi-barrier surface or deep repository to the geosphere and biosphere. The present quantitative evaluation performed emphasizes on contrasting disposal options under consideration in Slovenia and concerns siting, disposal concept (deep versus surface), and waste packaging. The assessment has identified a number of conditions that would lead to acceptable waste disposal solutions, while at the same time results also revealed options that would result in exceeding the radiological criteria. Results presented are the output of a collective effort of a Quintessa-led Consortium with SCK•CEN and Belgatom, in the framework of a recent PHARE project.

Objectives

The key objective of this work was to identify the preferred disposal concept and packaging option from a number of alternatives being considered by the Slovenian radioactive waste management agency (ARAO) for low and intermediate level short-lived waste (LILW-SL). The emphasis of the assessment was the consideration of several waste treatment and packaging options in an attempt to identify the minimum required containment characteristics which would result in safe disposal and the cost-benefit of additional safety measures. Waste streams for which alternative treatment and packaging solutions were developed and evaluated include decommissioning waste and NPP operational wastes containing drums with unconditioned ion exchange resins in overpacked tube type containers (TTCs). For the former the disposal options under consideration were either direct disposal of loose pieces grouted into a vault or use of high integrity containers. For the latter three options were foreseen. The first is overpacking of resin containing TTCs grouted into high integrity containers, the second option is complete treatment with hydration, neutralisation, and cementation of the dry resins into drums grouted into high integrity containers and the third is direct disposal of TTCs into high integrity containers without additional treatment.

Principal results

Performance assessment models were developed for each combination of siting option, repository design and waste packaging option. The near-field release modelling was undertaken using the AMBER code. Detailed unsaturated water flow modelling was undertaken in 2D for surface and in 3D for tunnel concept using the HYDRUS code (Figure 1), where the level of temporal engineered barrier degradation is accounted for in each packaging option in a stepwise manner as described below.

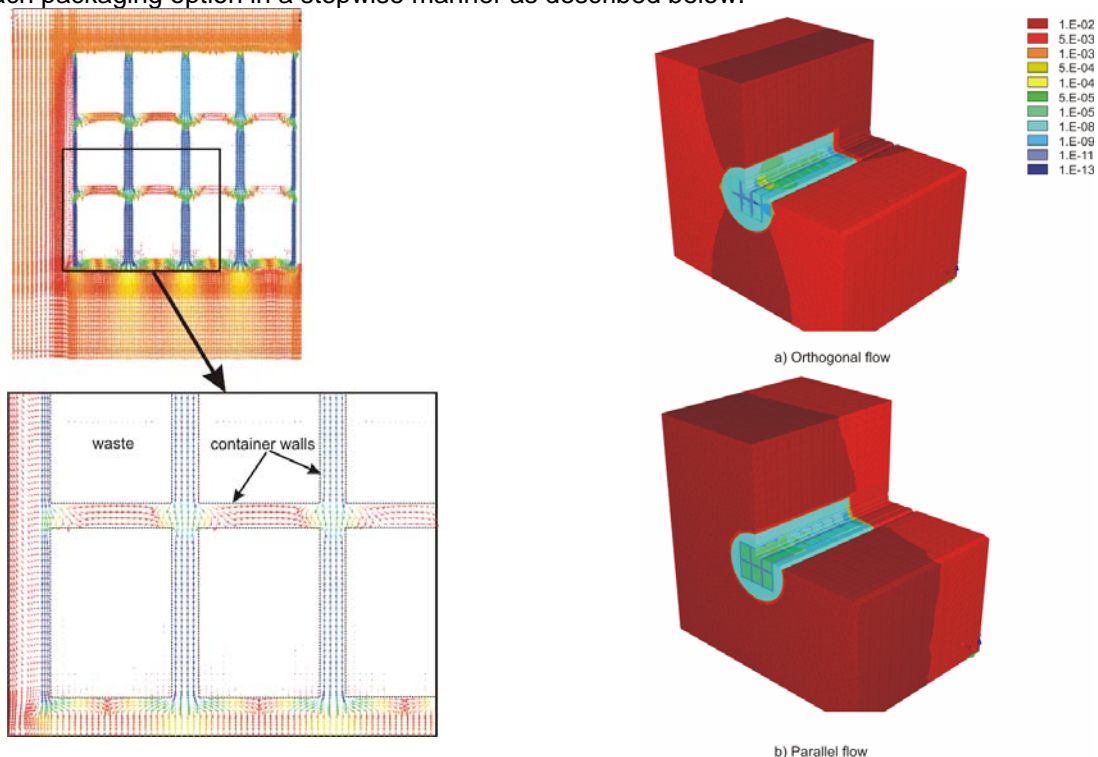


Figure 1: Water flow fields: 2D unsaturated water flow model for surface repository (left), 3D saturated water flow model for geologic repository (tunnel concept) (right)

For surface repository four degradation steps were foreseen; (0) all barriers functional, (1) soil cover degraded, (2) walls degraded and high integrity containers partly degraded and (4) fully degraded engineered barriers. In case of geologic repository three degradation steps are considered; (0) all barriers functional, (1) walls degraded and high integrity containers partly degraded and (3) fully degraded. All degradation levels were applied for each packaging option. In addition, sensitivity to tunnel orientation for tunnel concept and climate change and early cap failure scenario for surface concept has been addressed in the flow calculations. Results show complex water flow behaviour in case of unsaturated conditions for surface repository. For example, due to lower saturation of the unconditioned waste option, the hydraulic conductivity decreases below the level of that of conditioned waste. This results in lower water fluxes through unconditioned waste than through conditioned waste in the first two stages of degradation (Figure 2).

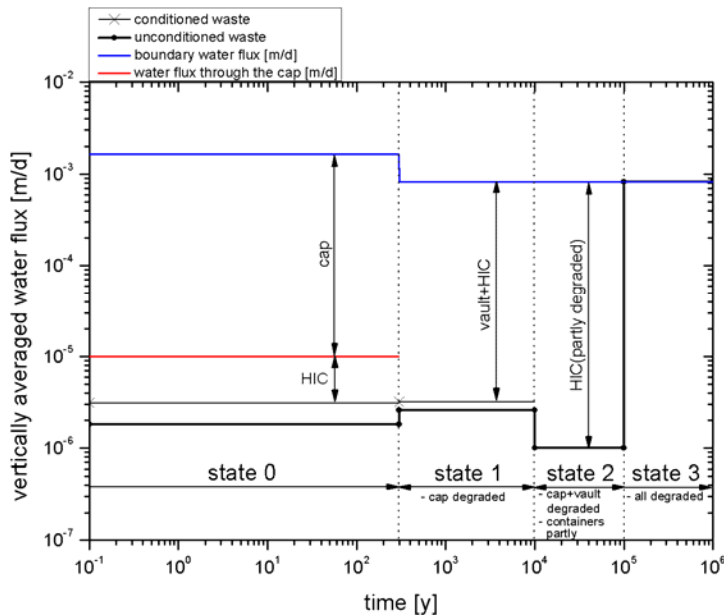


Figure 2: Stepwise function of water flux through surface repository near field owing to degradation of engineered barriers.

The preferred orientation of tunnels in terms of water flux was determined to be when the tunnels are oriented orthogonal to groundwater flow. This reduces water flux through the “conditioned waste” option, whereas no difference was observed for the “unconditioned waste” option. Water fluxes, averaged over high integrity containers at each degradation stage were then incorporated into the AMBER code (a compartment based model) for further radionuclide transport calculations appropriate to each packaging option. The calculation approach proved to be highly flexible, transparent and effective in terms of calculation time. Results demonstrated that all LILW-SL waste streams could be accepted at the preferred site for the surface repository concept, under the condition that all decommissioning waste would be grouted into high integrity containers. The use of high integrity containers was also recommended for all other waste streams. Results from detailed analysis further showed that in-drum-dried ion exchange resins in TTCs would be acceptable when grouted into high integrity containers, thereby avoiding the need for complicated processing and repackaging.

Future work

The future work is oriented towards obtaining more reliable hydraulic conductivity data for unsaturated conditions as this plays the major role in revealing the actual flow patterns. Further, the sensitivity analysis of parameters to flow conditions have to be examined thoroughly since the calculations showed that even small changes in some parameter values could lead to very different flow patterns.

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Main reference

Mallants, D., G. Volckaert, J. Perko, G. Towler, 2006. Assistance in Development of Conceptual Design for LILW Repository in Slovenia. Task 4 Report: Critical analysis of provisional waste acceptance criteria. Report QRS-1312A-TR4, October 2006.