Simplified Transport Modelling of a Disposal System and Doses Using Probabilistic Methods

Pekka Kupiainen/SYP 2016
Disposal system for SNF and LILW in Olkiluoto

- Spent nuclear fuel (SNF) repository based on KBS-3V concept
- Low and intermediate level waste (LILW) repository
- Construction license application accepted in 2015
- Simplified concepts for solute transport
  - Formulated in POSIVA 2012-20 report by Antti Poteri et al. (and his Ph. D.) (available online)
  - Master’s thesis in 2014 (by undersigned) (available online)
  - “Extension work” in 2015 to be published as Posiva Report (POSIVA 2016-01)

Figure provided by Posiva
Simplified transport for 1 and 2 compartments

- Diffusion and advection transport solutes in the disposal system (sorption retards)
- Branching
- Source terms, analytical solution, (radioactive decay)
- Modelling chain includes several models/tools → combination into one
Simplified transport model (SIPRO)

- One setup for disposal system with well-mixed compartments
- Geosphere-biosphere interface: the release rates through the bedrock divided in two branches without dilution
- Dose rates to the most exposed individual
- Limitations
  - Explicit time-dependence not modelled (growing canister defect, biosphere evolution)
  - One dose calculation end point
  - Lake+well configuration
- Comparison against TURVA-2012 results for model applicability
Results – release rates to biosphere from the SNF repository

- Dashed lines in TURVA-2012 safety case (by Posiva)
- Approximately similar; with highly sorbing nuclides, SIPRO overestimates
Results – Dose rates from the SNF repository

• Data for SIPRO objects are built from the two scenarios (BSA-RC, VS(A)-SOUTH)
• Roughly similar in spite of different modelling (dose assessment, time-evolution)
Analysis of uncertainties in SIPRO

- Parameters/input data are not all deterministic!
- 1) Assign distributions to distributed parameters
- 2) Run model x number of times by sampling parameters (incl. correlations)
- 3) Produce confidence levels for output release rates/dose rates
- (+ perform sensitivity analysis)
Results – probabilistic simulation (both SNF+LILW combined)

- **Left:** release rates for two nuclides
  - Dashed lines are simulated, histogram shows variability at the last time point
- **Right:** dose rates from all dose paths – reference case deterministic
Sensitivity analysis

- Uncertainty of the model output: which parameters contribute most? → variance-based sensitivity analysis (sensitivity indices)
- For release rates: parameters related to canister performance, bedrock and flow through the LILW hall → “bottlenecks” of the transport
- For dose rates: lake properties dominate over the other uncertainties
  - Fish ingestion dominates the total dose rate (C-14/I-129)
Conclusions and future

• Simple model to combine several models implemented in several tools in one
  – Based on Reference case / Base scenarios of the two repositories
• Most important release barriers easily identified → efficient sensitivity analysis of parameters
  – Limited interpretations: static configuration of compartments and user-assigned distributions!
• Model can be modified to other scenarios/repositories
  – Diffusion/advection transport

• Future:
  – Different studies to assess effects of different data due to changes in the disposal system (limited conceptual model!)
  – Development of sensitivity analysis