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A GoldSim Model for Colloid Facilitated Nuclide Transport

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1. Introduction

Recently several total system performance assessment (TSPA) programs, called 'template' programs, ready for the safety assessment of radioactive waste repository systems which are conceptually modeled as shown in Fig. 1 have been developed by utilizing GoldSim[1] and AMBER[2] at KAERI.[e.g. 3,4] It is generally believed that chelating agents (chelators) that could be disposed of together with radioactive wastes in the repository and natural colloids available in the geological media affect on nuclides by enhancing their transport in the geological media. A simple GoldSim module to evaluate such quantitative effects, by which colloid and chelator-facilitated nuclide release cases could be modeled and evaluated is introduced. Effects of the chelators alone are illustrated with the case associated with well pumping scenario in a hypothetical repository system.

2. Modeling

A pumping well is assumed to be accidentally drilled very near to the repository for drinking and irrigation after the closure of the repository. All groundwater flows out the repository that is located around 100m below the surface is assumed to be available for the pumping well, bottom of which reaches up the depth of the repository bottom. Two special species, arbitrarily named XColl and XChel, are added that are allowed to be transported through the geological repository system. Special media colloid and chelator are also assigned to be present as suspended particulate media in the water in the various geological media. Then nuclides could be sorbed to those suspended solid particles and transported with nuclides on them through any possible mass flux links involving the fluid. When nuclides enter a medium, they are instantaneously partitioned among such media as stable geological medium and suspended solid media, i.e., chelators and colloids present in the medium. 1,000 kg of chelators are assumed to be disposed of together with the radioactive wastes in the repository, but no natural colloids are assumed to be present in the geological media for simple illustration.

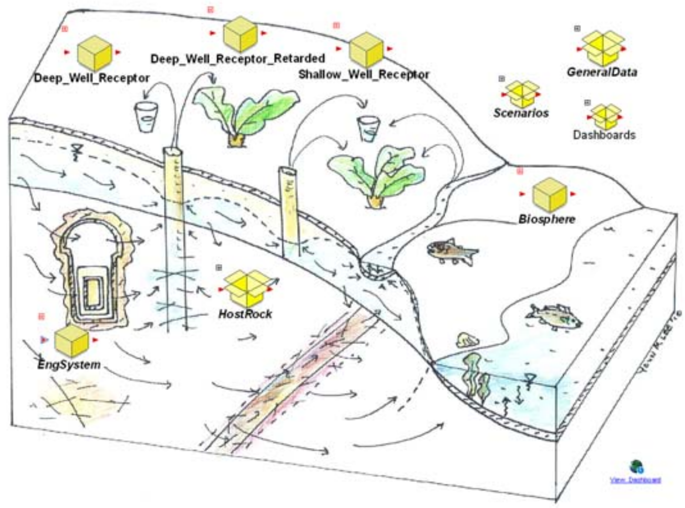

Fig. 1. Schematic Conceptual Modeling Domain for *GoldSim* Modeling

3. Illustration

It is observed in Fig. 2 that chelator (half-life: 10^3 years) in the waste package is quickly flushed out with some decay. As seen in Fig. 3, in the repository, the chelators from the waste package appear at 1,440 years immediately after repository credit time of 1,400 years and then get flushed out instantaneously again. The chelators are very much diluted when they are released from the repository as seen in Fig.4. Unlike Fig. 5 for the case of no chelators, a spike, due to the effect of the chelators, is clearly observed at the early time but still does not seem that much in Fig. 6 which shows the mass outflux of Pu-239 from the repository. Pu is assumed to have 100 m^3/kg of sorption capacity (Kd) to the chelator. Even when Kd of Pu increases to 1,000 m^3/kg, the effect of chelators remains to be negligible as shown in Fig. 7.

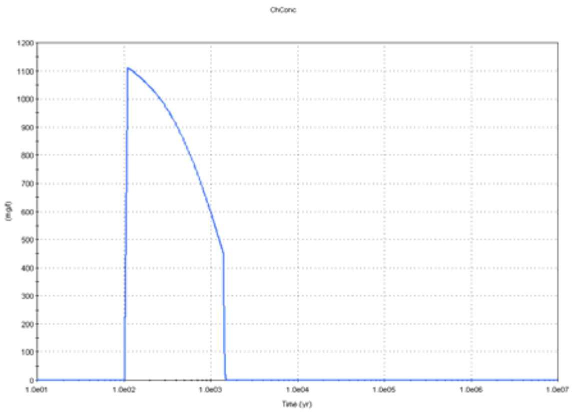

Fig. 2. Chelator concentration in the waste package

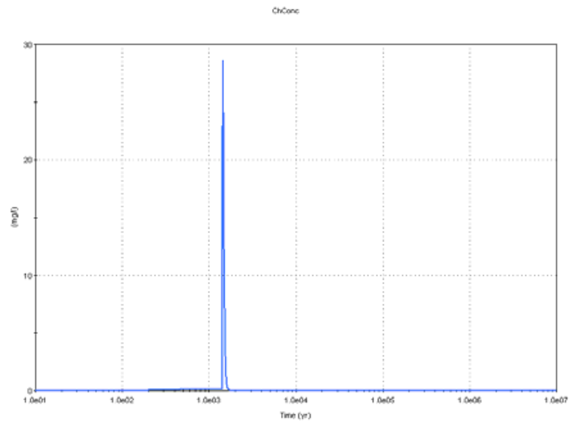

Fig. 3. Chelator concentration inside the repository

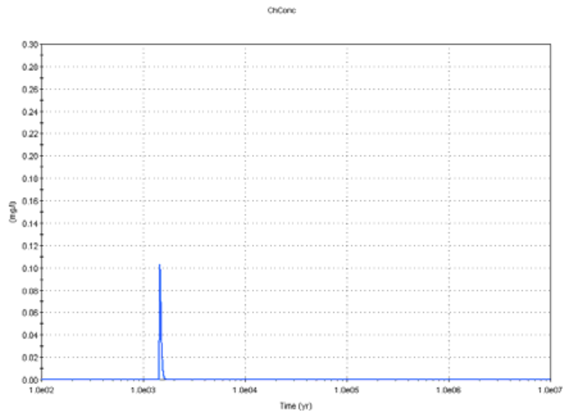

Fig. 4. Chelator concentration outside the repository

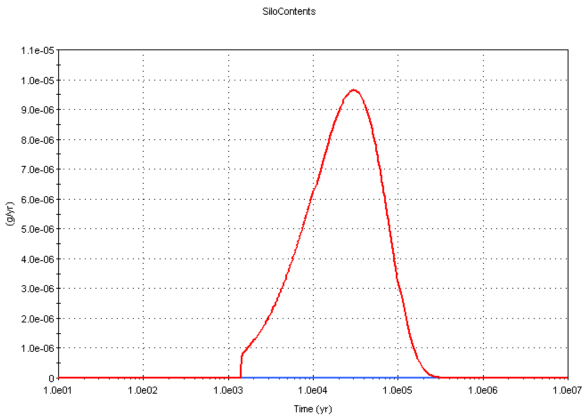

Fig. 5. Pu-239 mass flux from the repository (no chelators)

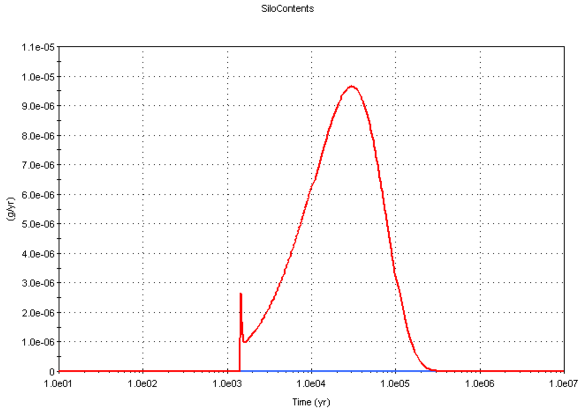

Fig. 6. Pu-239 mass flux from the repository (1,000kg of chelators in the waste package, Kd=100 m^3/kg)

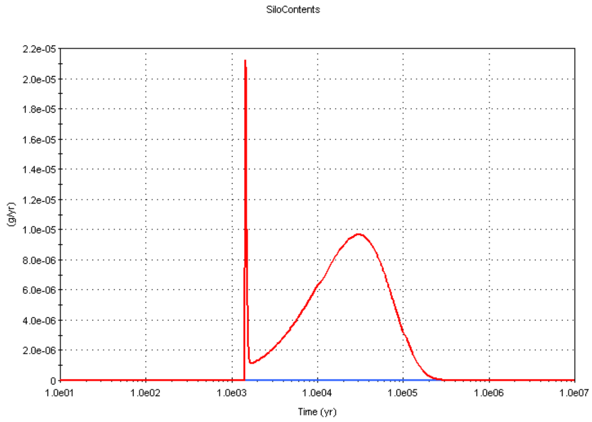

Fig. 7. Pu-239 mass flux from the repository (1,000kg of chelators in the waste package, Kd=1,000m^3/kg)

References

[1] GoldSim Contaminant Transport Module, User's Guide, Version 4, GoldSim Technology Group, 2006.

[2] AMBER 4.4 Reference Guide, Enviros, U.K., 2002.

[3] Y.M. Lee et al., "Nuclide Release from an HLW Repository: Development of a Compartment Model," *Annals of Nuclear Energy*, 34, 782-791, 2007.

[4] Y.M. Lee et al., "A GoldSim Model for the Safety Assessment of an HLW Repository," Progress in Nuclear Energy, 51, 746-759, 20