Nuclide Release Pathways in and Around a Trench Repository for Radioactive Waste – 16014

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ABSTRACT

An effective model for a safety assessment of a conceptual trench repository system, in which low-and intermediate level radioactive waste (LILW) is disposed of has been developed. The repository system is assumed to be located in the surface area of a mountain hill near the seashore. An easy-to-use computer program based on this model, developed as a GoldSim [1] template, has been extended based on the previous one in consideration of the rather possible complex pathways in and around the trench for its performance assessment, which is able to evaluate a nuclide release from the repository and farther transport into the geosphere and biosphere under various normal, disruptive natural, and manmade events, and scenarios that can occur after a failure of waste drums with associated uncertainty. To demonstrate the nuclide release and transport behavior through these various possible pathways in the near- and far-fields of the repository system under certain scenarios, some illustrative evaluations and a simple sensitivity investigation with C-14 for the concrete barriers of the trench were made.

INTRODUCTION

LILW in drums are currently being disposed of in concrete silos in Gyeongju, Korea. And low-level radioactive waste (LLW) excluding intermediate-level radioactive waste is also scheduled to be disposed of in concrete trenches at the same site in the next stage.

As was done in a previous study [2], 200-liter storage drum packages for LILW, not just LLW for versatility, which amounts to a total of 125,000 packages, are assumed to be disposed of in a trench with multiple concrete barriers, grouted with concrete, and then backfilled outside. An impervious and multilayered trench top cover for preventing water infiltration and some erosion as well as nuclide release are is considered to be placed on the rooftop.

Through this study, many possible release and transport pathways from the trench into the biosphere are identified, modeled, and evaluated. All nuclides released with groundwater flow from the trenches are transported along with various unsaturated and saturated pathways including a surface pathway, a vadose zone, weathered rock layer, and an aquifer pathway to the biosphere.

In the previous study, five normal and some disruptive scenarios for nuclide release and transport around the repository system with rather limited pathways in and around the trench repository were evaluated and illustrated based on a rather deterministic safety assessment in which a conservative base case having not much barrier credits since closure of the repository, under which nuclides are released by groundwater that normally flows along their own preferential pathways after release from the trench repository, and several other possible cases were evaluated.

Through the current study conducted to show further usability of the model which has been extended, some more illustrative evaluations with C-14 to investigate the simple sensitivity of concrete barrier failure time under the scenario of the changing credit time of the trench top cover were made in a probabilistic way and demonstrated.

MODELING AND ILLUSTRATION

Impervious materials and multilayered covers for preventing rain water infiltration and some erosion, as well as nuclide release, are considered to be placed on the roof, over which bentonite and top soil are placed. In GoldSim modeling, a trench and its surroundings are discretized into several compartments ready for overflow, run-off, and downward infiltration, as well as diffusive and advective transport of nuclides in and among them. Based on the model for deterministically evaluating possible scenarios associated with nuclide release and transport, which is well described in the previous work [2] and as was also similarly done for different types of repositories in some of previous works [3-9], an extended model with more possible pathways in and around the trench repository has been developed.
For modeling with the commercial GoldSim development tool, the entire system of the trench is assumed to consist of multiple concrete boxes and a surrounding backfill, as shown in Fig. 1. A far-field area is composed of a vadose zone, weathered rock medium, aquifer with saturated flowing groundwater, and a biosphere system next to geosphere-biosphere interfaces, over which nuclides are transferred from the far-field of the repository into the human environment. Such transport processes as advection and dispersion, as well as sorption, and decay chain during transport are considered.
River and ocean water bottoms are possible considerations for the main surface water bodies through which nuclides are transferred into the biosphere where pumping wells for potable water and irrigation can normally also exist.

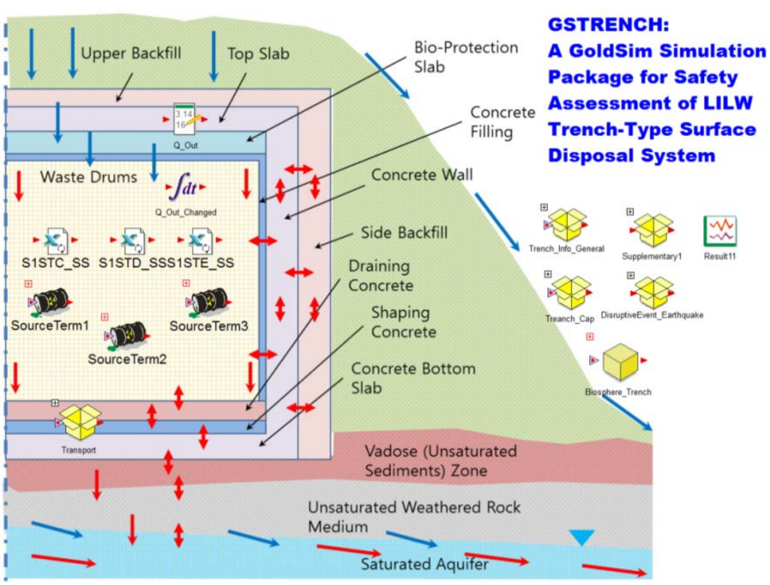

Fig. 1. Nuclide Release and Transport Modeling Scheme.

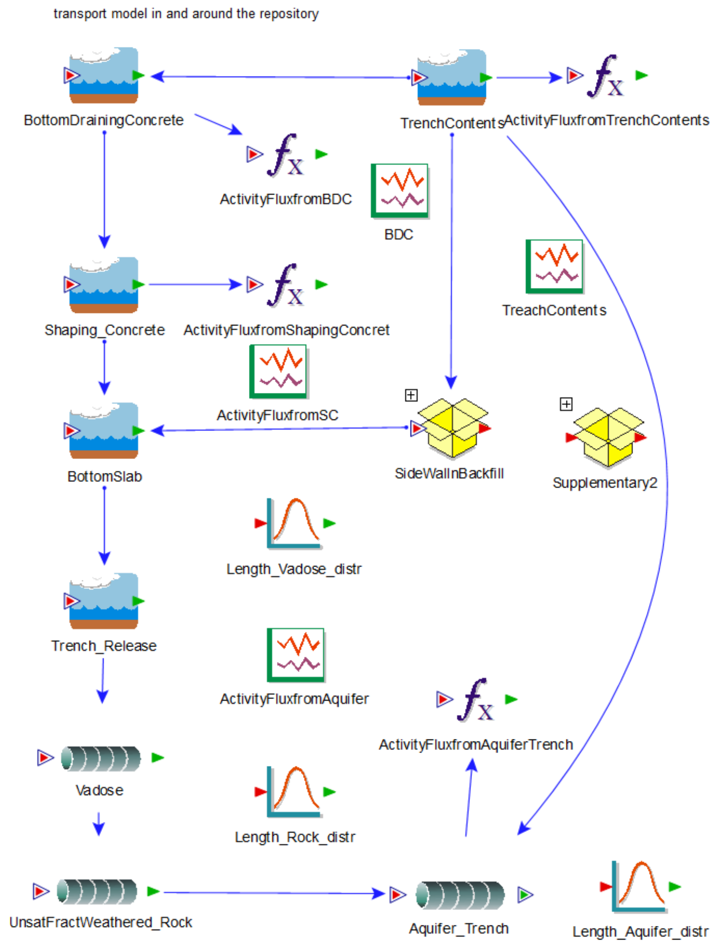

Fig. 2. Transport Modeling in and around the Repository System.

Exposure dose rates of the farming exposure group due to nuclide release under the base case (a normal scenario) are re-plotted from the previous work in Fig. 3 for H-3, C-14, Tc-99, and I-129, even though they were arbitrarily chosen for illustration purposes. Unlike the other two nuclides, which are shown to coincide with the curves from the base case scenario, C-14 and I-129, which have non-zero values of the sorption coefficient in the fresh concrete, showed some changes when compared to the base case “Sc1”, which means the concrete barriers with sorption capability could be more or less important for certain nuclides. The exposure dose rate to the farming exposure group due to C-14 alone under the scenario “Sc3”, a sudden degradation of all concrete barriers 1,000 years after closure, instead of a total immediate failure at closure or any gradual degradation, while keeping the trench cap totally failed, is shown in Fig. 4.

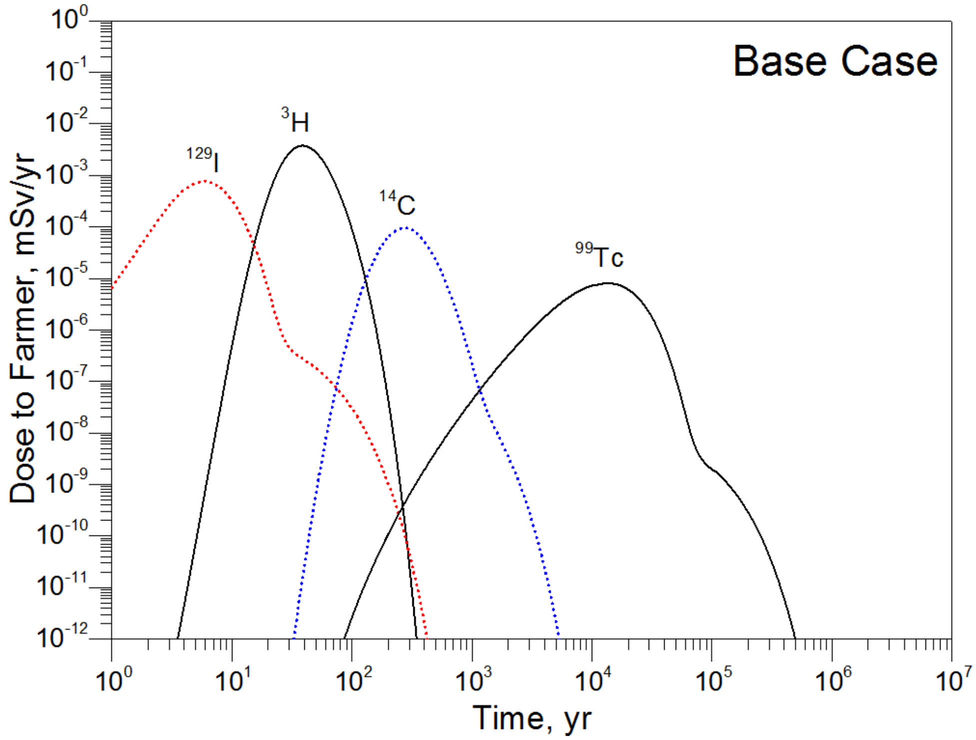

Fig. 3. Exposure dose rates due to four nuclides selected for farming exposure group under the base case scenario.

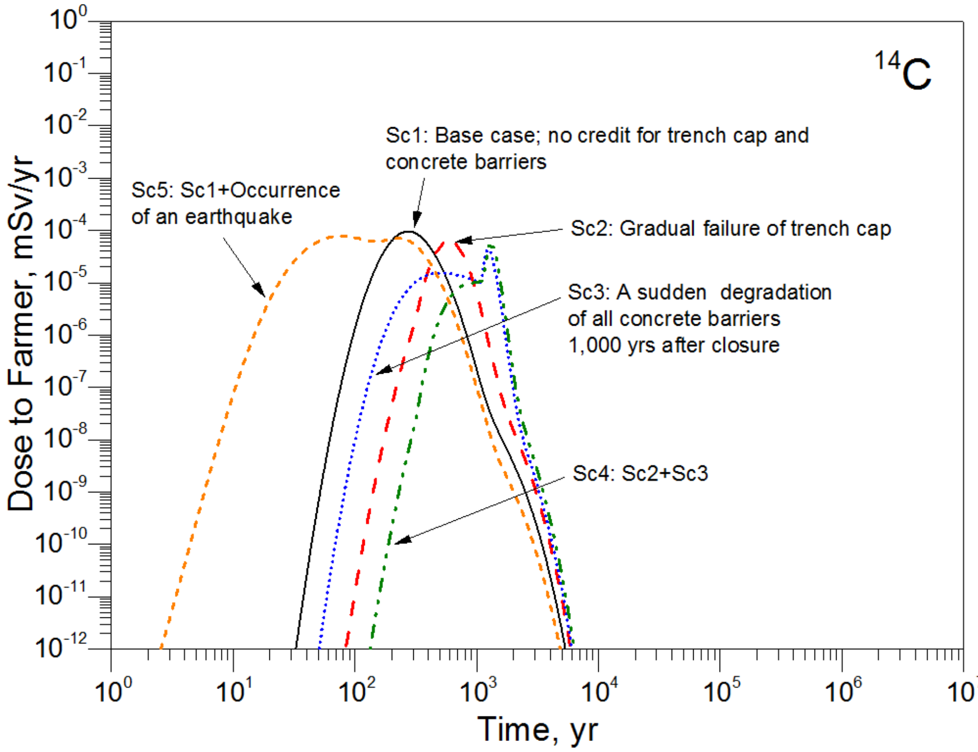

Fig. 4. Exposure dose rates due to C -14 for farming exposure group.

Noticing this result, in this study the degradation of concrete walls was more investigated by changing the full degradation times for all concrete barriers, still keeping a failure portion of the roof top of the trench through which the annual precipitation enters into the trench with its starting and ending times varies as a function of time as is assumed to behave as described in Fig. 5. The concrete degradation time is assumed to follow a triangular distribution with its peak value of 1,000 years between 0 and 10,000 years.

Although the degradation of concrete walls may be dependent on the material used for the barrier fabrication, its degradation characteristics and thickness, as well as the near-field geochemical circumstances and thermal-chemical-geohydrological environment, other than the variation of the physical values of both the waste packages and trench walls, such as their porosity and tortuosity, as well as the geochemical sorption coefficients, are excluded for illustration purposes for the time being.

In Fig. 6, two groups of realization of the exposure dose rates due to C-14 to the farming exposure group are compared with each other. The group of curves appeared earlier are for the case that no credit is given for the trench roof top cover at all, which might be considered to be the most conservative with a total failure of the top cover immediately after the closure of the repository. The one with the curves arriving a little later are in accordance with a gradual degradation, as a function of the failure portion.

The difference between these two cases are more easily identified in Fig. 7, where two groups of scatterplots, each of which represents the case of different degradations for varying degradation time of the concrete barrier degradation times versus the peak exposure dose rate to the farming exposure group due to C-14, which has a non-zero value of sorption coefficient in all concrete barriers.

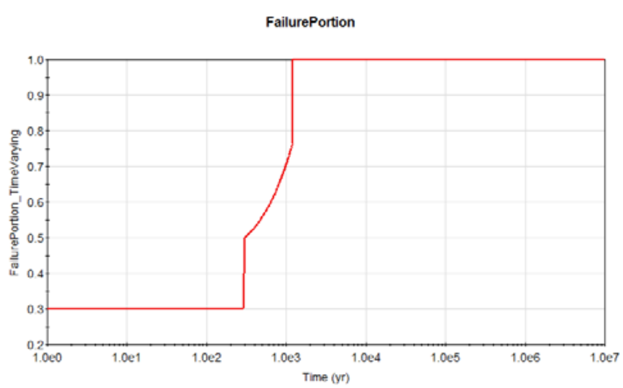

Fig. 5. Failure portion of the trench cap as a function of time.

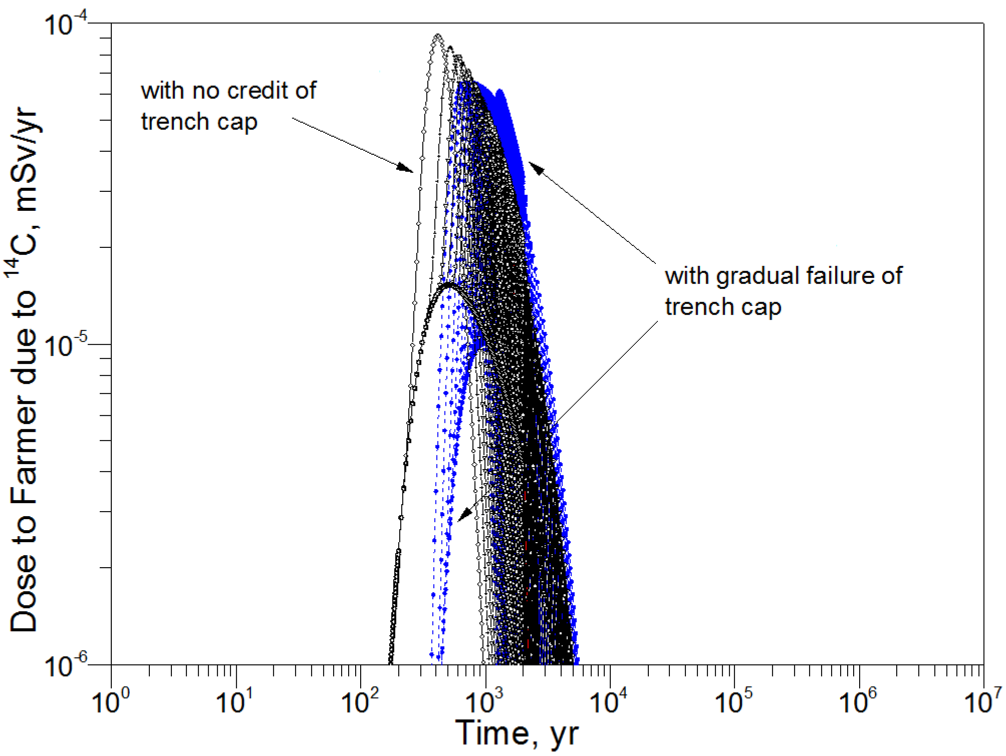

Fig. 6. Exposure dose rates to farming exposure group due to C-14 under varying concrete degradation times.

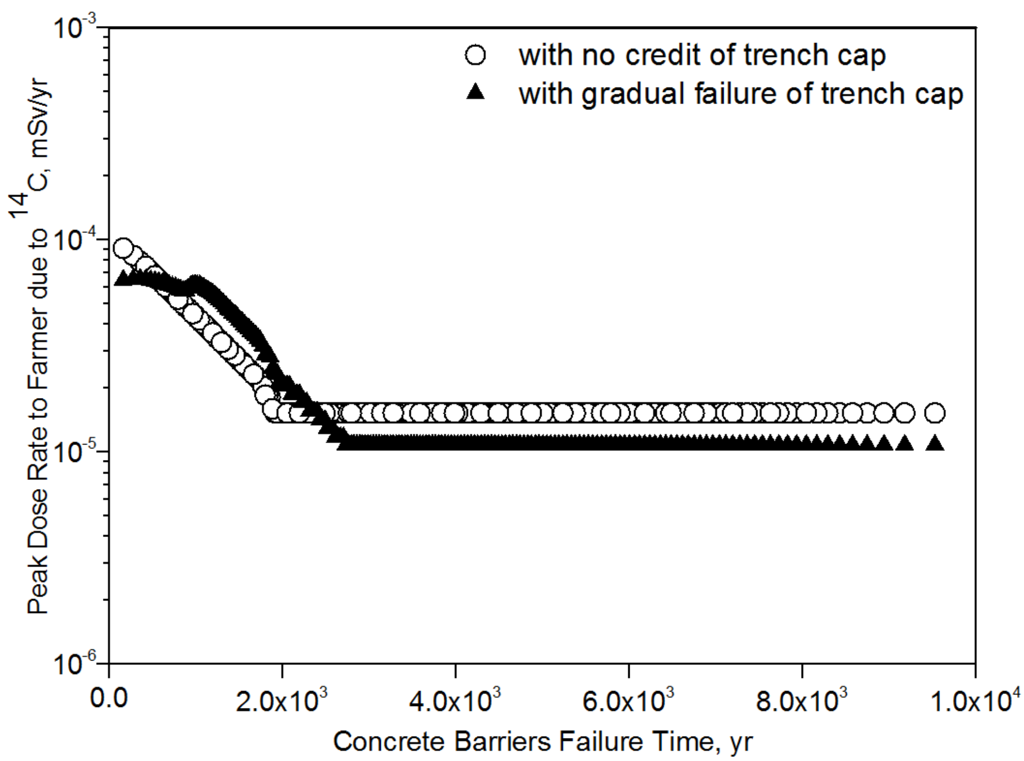

Fig. 7. Sensitivity of concrete barriers failure time to peak dose rate due to C-14.

CONCLUSION

An extended model considering more possible nuclide release and transport pathways in and around repository for a safety assessment of a conceptual LILW trench repository system has been developed. A computer program based on this extended model was developed as a template using GoldSim, which is ready for a system performance assessment of an LILW trench type repository and able to deterministically and probabilistically evaluate a nuclide release from a repository and farther transport into the geosphere and biosphere under various normal and disruptive events and scenarios that can occur after a failure of waste packages with associated uncertainty.

Through the current study, to demonstrate the nuclide release and transport behavior through these various possible pathways in the near- and far-fields of the repository system, some illustrative evaluation and a simple investigation for the sensitivity of the failure time of concrete barriers of the trench under the scenario of the changing credit time of trench top cover were made.

Although all parameter values associated with this evaluation still remain to be assumed, this kind of modeling approach and its results may be informative since such an evaluation is very important not only in view of addressing the safety assessment of the trench repository, but also for the design feedback of its performance.

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