A Source Term Modeling for Near Surface Disposal by MOSAIC

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The longevity of covers and vaults are much greater than that of metal drums, so drums are not generally given much credit for delaying releases from near-surface disposal systems. Once water enters the drums, leaching can commence. The rinse-release waste forms immediately release their inventory into solution, and the radionuclides are advected into the backfill, and thence to the boundary of the vault. The uniform-release waste forms release their inventory from the waste form into the backfill within a specified time period at a constant fractional release rate. Mass transfer of radionuclides from diffusion-release waste forms into the backfill also takes place, giving rise to a diffusion-release source term. In each case, the radionuclides entering the backfill are transported to the lower boundary of the vault by advection and diffusion. These processes, identified and subsequently modeled by Sullivan and coworkers[1], form the basis of the well-established DUST computer code. A near-field analysis module of MOSAIC(MOdular Safety Assessment code with Integrated Concrete analysis) code has been developed to provide similar leaching model capabilities to DUST, while enhancing it with additional capabilities.

In this paper, a diffusion-release source-term modeling by MOSAIC is discussed to compare its results with those from DUST. The problem that defined in IAEA's Vault Safety Case (VSC) is used for code comparison. Consistent with the design scenario description of VSC[2], the disposal facility is a set of 20 concrete vaults located above ground level. The waste disposal area contains two lines of 10 vaults. Each vault including four 200*l* drums contains 4,692 concrete cubes in array. Approximate dimensions of the disposal area are 170 by 210m giving a surface area of 35,700 m^2. 150,000 $m^3$of grouted waste is disposed in standard 200*l* drums and placed into concrete cubes, and grout filled in between the drums. The facility has a total of about 750,000 drums. Each vault has internal dimensions of 9m high by 20.5m wide by 83m long allowing concrete cubes to be stacked in an array 4 high x 17 wide x 69 long. It is assumed that the near-field barriers degrade with time. The drums are assumed to remain intact for 100 years and the concrete cubes are assumed to physically fail after 300 years of closure and chemically degrade over a 1,000 year period from site closure. The cap is assumed to be maintained during the 100-year active institutional control period, but then starts to degrade so that it allows 50 % of the total precipitation to pass up to 500 years, and no longer limits the rate of water infiltration after 500 years. The near field barrier is also assumed to be degraded chemically after 500 years, so that the distribution coefficient for degraded vault is used for the safety assessment thereafter. Before and after this degradation switching time (500yr), distribution coefficients listed in Table 1 are specified separately as the non-degraded and degraded value for radionuclides of interest. Table 2 lists the radionuclide inventory at facility closure and decay chains considered in this modeling. The release of these radionuclides from the engineered vault and their transport through the unsaturated zone are calculated by both MOSAIC and DUST. Figure 1 shows radionuclide release rates at the water table as a result of transport from vault through the engineered barrier system and the entire un- saturated zone. It seems the comparison between MOSAIC and DUST are very good for slightly sorbing Tc-99 and I-129, but MOSAIC predicted lower peak release rates for relatively stronger sorbing C-14 and U-238. this points to the problem of sorption (the two nuclides seem more sorbed in MOSAIC than in DUST) which, in turn, points to the transport regions outside the vault, because the release rates are really sensitive to sorption Kd. In DUST modeling, no degradation of the vault system from site closure until 500 years is not considered. But in MOSAIC modeling, time dependent sorption coefficients in the near field can be addressed. This enhanced feature can be used to model groundwater geochemistry changes due to alkaline plumes released from the dissolving cement waste matrix as well as the concrete vault structure.

The capability to treat waste forms that release contamination by all of the leaching mechanism provides MOSAIC all of the technical functionality included in the venerable DUST code. Moreover, certain additional functionality, such as proper treatment of time-dependent sorption, has been properly implemented in MOSAIC.

Table 1. Unsaturated Zone Distribution coefficients for Near-field (m^3/kg)

Element	Concrete		Red sand/ Calcrete		Brown sand/ Gritty clay		White Kaolinite clay		Weathered Granite	
	Non-degraded	degraded	Non-degraded	degraded	Non-degraded	degraded	Non-degraded	degraded	Non-degraded	degraded
C	2.0e+0	2.0e-1	5.0e-3	5.0e-3	5.0e-3	5.0e-3	1.0e-3	1.0e-3	5.0e-3	5.0e-3
Tc	1.0e-3	0.0e+0	1.0e-4	1.0e-4	1.0e-4	1.0e-4	1.0e-3	1.0e-3	1.0e-4	1.0e-4
I	1.0e-2	1.0e-3	1.0e-3	1.0e-3	1.0e-3	1.0e-3	1.0e-3	1.0e-3	1.0e-3	1.0e-3
U	2.0e+0	1.0e-1	2.5e-3	2.5e-3	6.8e-3	6.8e-3	1.4e-3	1.4e-3	3.0e-3	3.0e-3

Table 2. Radionuclide inventory at facility closure and decay chains

Nuclides	Inventory (Bq)	Decay Chain
C-14	1E+13	
Tc-99	1E+14	
I-129	3E+10	
U-238	5E+10	U-234Th-230Ra-226Ph-210Po-210

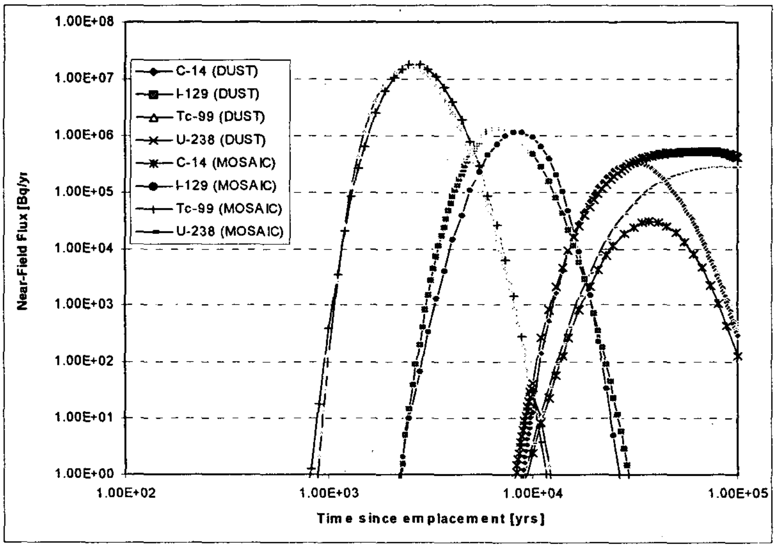

Fig. 1. Comparison of radionuclide fluxes at the outlet of unsaturated zone

References

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2. IAEA, Safety Assessment Methodologies for Near Surface Disposal Facilities, Results of a Coordinated Research Project, Volume 2: Test Cases, IAEA-ISAM, International Atomic Energy Agency, 2004.