Numerical Model for Leaching and Transporting Behavior of Radiocesium in MSW Landfill

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Abstract

On March 11, 2011, the Great East Japan Earthquake and subsequent tsunami occurred. They attacked Fukushima Daiichi Nuclear Power Station, resulting in loss of an electrical power for the cooling system of reactors and then the meltdown of nuclear fuel rods. The explosion of hydrogen gas in the electrical generation reactors caused the spread of the radioactive substances, mainly radiocesium, into the atmosphere. The radiocesium in the atmosphere fell down with rainfall so that it contaminated the soil surface, trees, branches and leaves, roads, concrete structures, farm products, sewage sludge, and so on. Because their waste and incineration ash included the radiocesium, their final disposal in landfill sites has to be carefully designed to prevent the radiocesium from leaking to the outside. COMSOL Multiphysics® was used to numerically investigate the effects of the landfilled waste on the radiocesium concentration leachate from the landfill site and to propose the landfill design such as (1) acceptant concentration of the radiocesium included in the landfilled waste (2) permeability and geometry of the soil sorption layer underlying the landfilled waste layer to adsorb the radiocesium leaching from the waste, (3) and permeability and geometry of the impermeable final cover on the landfilled waste layer to prevent the rainfall from infiltrating the waste and leaching the radiocesium, in order to minimize the concentration of the leachate.

Figure 1 illustrates the proposal for landfilling the waste contaminated with the radiocesium and Fig.2 shows the cross-sectional analysis domain. The leaching and transport behavior of the radiocesium in the domain was simulated using a Subsurface Flow Module considering the first-order degradation of the radiocesium, the soil adsorption/desorption nonequilibrium reaction expressed by the linear isotherm model, and the radiocesium leaching rate from the landfilled waste expressed by the solid inner diffusion model. The analysis domain consisted of the existing waste layer, the intermediate cover layer, the soil sorption layer, the radiocesium contaminated waste layer, and the impermeable final cover. Each layer had the physical and chemical properties as shown in Fig.3. The rainfall was set at 600 mm/yr. COMSOL can simulate the process that the radiocesium was leaching from the waste, then it was transported with the flow of the rainfall infiltration and was adsorbed to the soil sorption layer, and finally the leachate with the radiocesium was emitted to the drainage pipe. Figure 4 shows the radiocesium concentration of the leachate emitted from the landfill site. The simulation result was useful in public explanation for the effects of the soil sorption layer and the impermeable final cover on the decrease of the radiocesium emission and their importance. In addition, the parametric sweep

can be used for determining their permeability and geometry conditions.

Figures used in the abstract

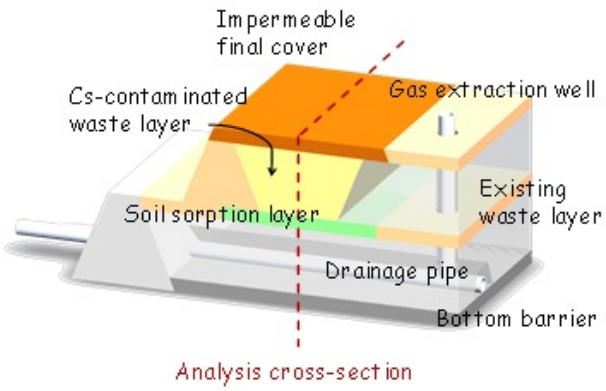

Figure 1: Proposal for landfilling waste contaminated with radiocesium.

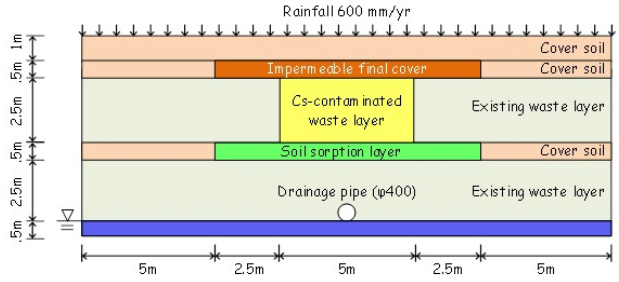

Figure 2: Cross-sectional analysis domain.

	Unit	Existing waste	Cs-cont. waste	Cover soil	Soil sorp. layer	Imperm. final cover
Permeability	m^2	10^{-12}				10^{-16}
Porosity	---	0.3				
Dry bulk density	kg/m^3	1200		1800		
VG parameter, α	1/m	3.01				
VG parameter, n	---	1.26				
Distribution coef.	mL/g	0			10	0
Cs leaching rate	Bq/kg/day	0	$82(t)^{-0.5}$	0		

Figure 3: Calculation parameters.

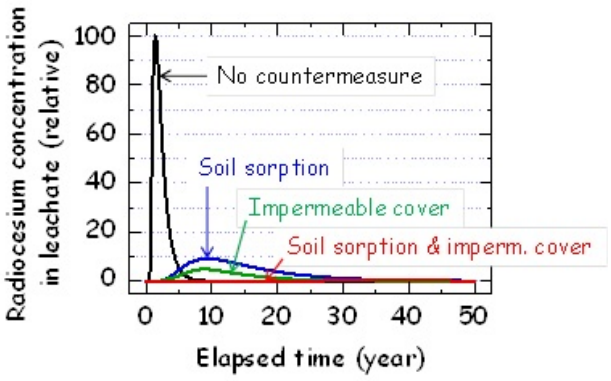

Figure 4: Estimated radiocesium concentration of leachate emitted from landfill site.