A Study on Invasion Behavior of Buffer Material into a Neighboring Rock Fracture Considered Density Distribution Change in Buffer Material Based on Particle Diffusion Model

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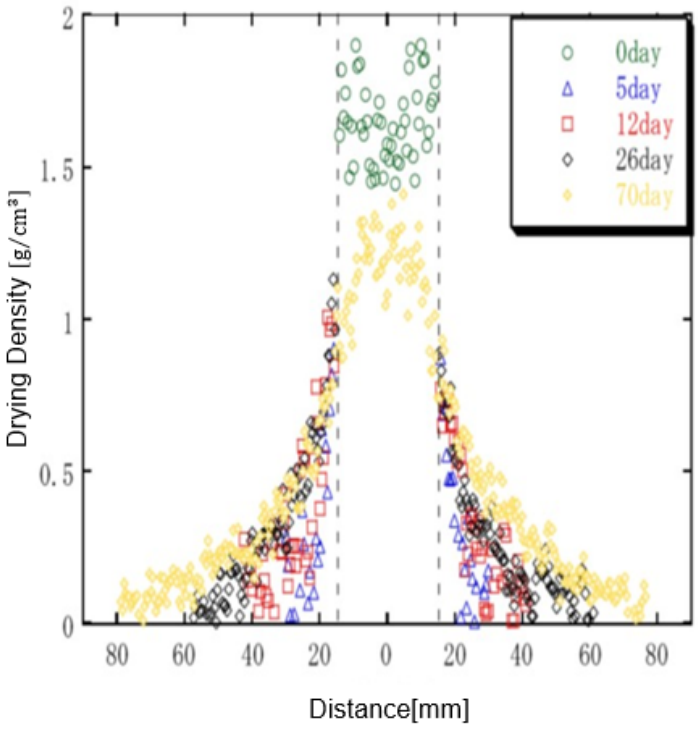
In Japan, a high-level radioactive waste generated by reprocessing spent fuel from nuclear power plants is to be buried by geological disposal. Geological disposal is a disposal method which radioactive wastes are buried at depths 300 m or more below the ground surface. A multi-barrier system combined natural barriers (rock mass) and engineered barriers is adopted to confine radioactive materials from the living environment and to prevent leakage of radioactive materials for a very long period. Vitrified waste is encapsulated by a thick metal container called overpack, and the surrounding is installed with a buffer material (compacted bentonite). Since the buffer material is directly contacted with the rock mass, if there is a fracture in the surrounding rock mass, invasion of the buffer material to fracture is possible to cause density loss. The invasion behavior of the buffer material into the fracture is one of the most important factors to evaluate the stability of buffer material after disposal. In previous studies, invasion experiments of the buffer material were conducted to simulated fractures reproduced with acrylic discs, and a relational expression was derived in which the invasion distance (radially) to the fracture was proportional to the square root of time, but it was found that the invasion distance (radius) tended to converge in the long-term. In earlier studies, some extrusion analyses of the buffer material into a rock fracture were conducted, but they cannot explain the actual measurement results.
In this study, the invasion radius of bentonite (buffer material) into the fracture and the density distributions in the bentonite and the fracture were analyzed, and the convergence of the invasion phenomenon was discussed. The analysis was based on the radial diffusion equation in the cylindrical coordinate system, considering the experimental system. The diffusion coefficient of bentonite particle in the fracture was derived from the invasion experimental data, and solid phase (bentonite) diffusion coefficient in the buffer material was derived based on the particle diffusion model. The analysis results including the long-term behavior were generally in good agreement with the actual measurement results in the precipitation groundwater system (distilled water system).

Keywords: High-level Radioactive Waste, Geological Disposal, Rock Fracture, Diffusion Equation, Particle Diffusion Model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Distance[mm]
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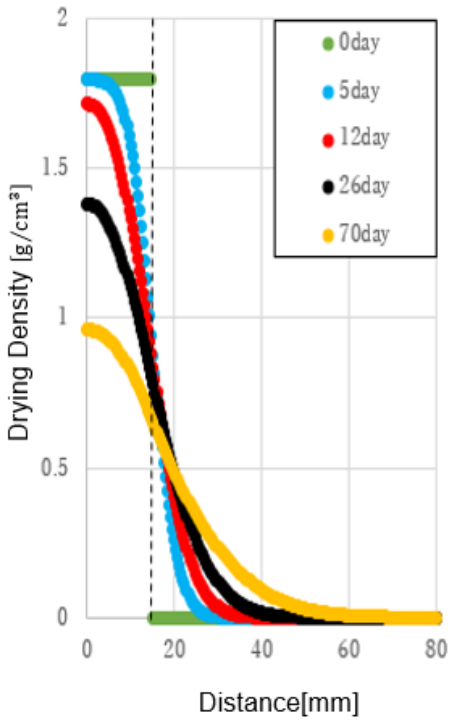
5day
12day
26day
70day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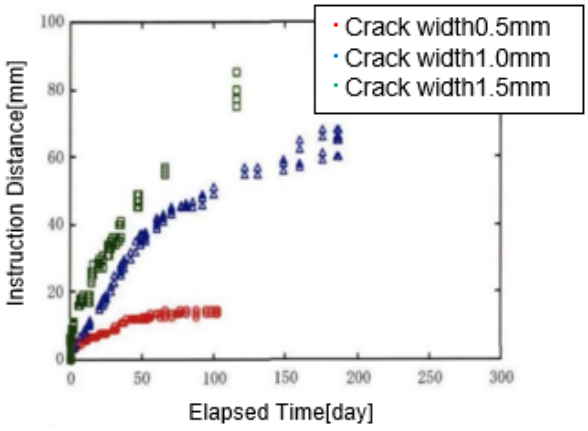
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Elapsed Time[day]
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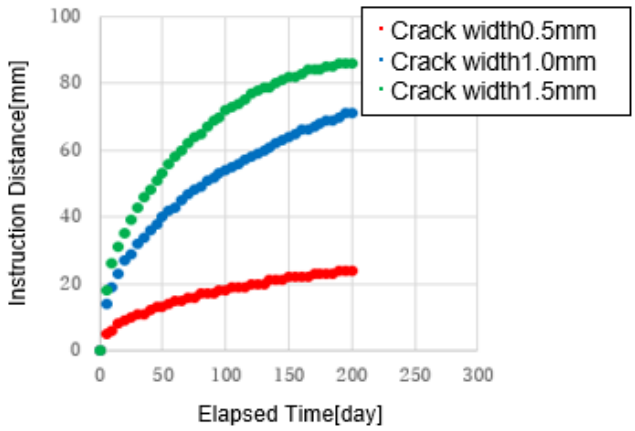
Crack width1.0mm
Crack width1.5mm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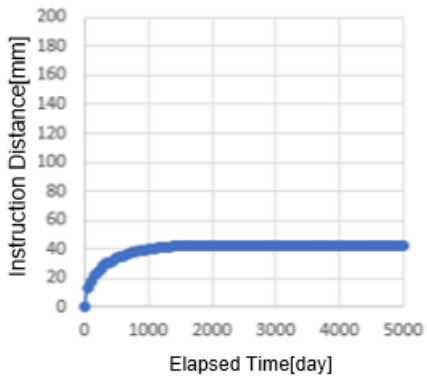
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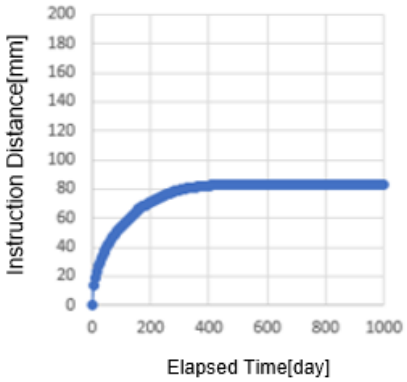
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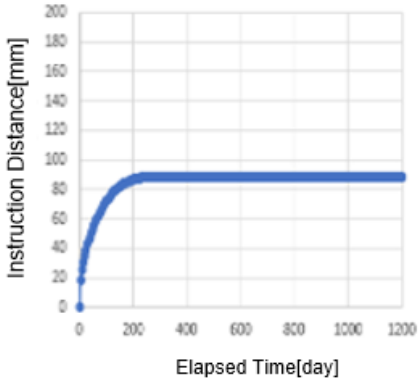
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