Transport Modeling of Desorbed ^{137}Cs from Contaminated Artificial Lake

Jaehyun Lee

Geologic Fluid Dynamics & Geologic Fluids Lab.

Despite many safety measures in nuclear power plants, some unexpected situations can occur and cause severe radiation accidents. A considerable amount of radionuclides can be released during such accidents, and Cesium-137 (^{137}Cs), one of the most fatal radionuclides, can contaminate surrounding water resources. Adsorbents can be used to remove dissolved ^{137}Cs from the surface water reservoir, but ^{137}Cs can be desorbed from the settled adsorbents over time and contaminate adjacent aquifers. Therefore, it is important to understand how the desorbed ^{137}Cs behaves in subsurface aquifers.

In this study, the 2D cross-sectional aquifer model using TOUGH2-EOS7R was conducted to simulate the ^{137}Cs transport caused by the seepage of groundwater beneath the artificial lakes. The ^{137}Cs plume primarily migrates through advection and dispersion in the aquifer and affected by the adsorption process, radioactive decay, and hydrogeologic properties of the aquifer. Therefore, for a systematic investigation of ^{137}Cs transport, various scenarios were considered with a reported range of distribution coefficient (K_d), local temperature conditions, and heterogeneous aquifer properties. The characteristics of ^{137}Cs plume were used to evaluate the influence of each parameter during the model period. Then, the health risk of chronic exposure for human was calculated with the amount of discharged ^{137}Cs.

Transport modeling of the base-case (homogeneous K and constant K_d of 10 ml/g) shows that approximately 0.065 % of the initially released amount of ^{137}Cs arrived downstream, and the maximum radioactive dose appeared at 220 years. The results indicate that the K_d is the most critical parameter to control the migration rate and average concentration of ^{137}Cs plume. In addition, the coupled heterogeneity of K and K_d notably enhanced the complexity of ^{137}Cs transport but slightly increased the overall retardation. These findings will provide a preliminary reference for the risk assessments of cleanup methods using adsorbents, but the validation process of several hypothetical assumptions are necessary for specific applications.