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Nuclide Release Behavior from a Repository for a Pyro-process HLW and SF due to Variation of the MWCF Properties

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1. Introduction

An assessment program for an optional evaluation of a repository both for disposal of such high-level wastes (HLWs) from various steps of pyro-processes of PWR spent nuclear fuel (SF) and for direct disposal of PWR and CANDU SFs has been developed by utilizing general purpose GoldSim developing tool[1], by which nuclide transports in the near- and far-field of a repository as well as a transport through a biosphere under various natural and manmade disruptive events affecting a nuclide release could be modeled and evaluated. KAERI has been in charge of modeling and developing assessment tools by which the above mentioned repository system could be assessed in accordance with various features, events, and processes (FEPs) that could happen in and around the repository system. To cope with such various natural and manmade disruptive FEPs as well as normal release scenarios, all the possible cases in view of the Korean circumstances should be modeled and have been evaluated even though we have not yet have any repository.[2-6]

A possible case, among many others, with the variation of such physical properties as the fracture width and the rock matrix diffusion depth, associated with the natural fractures in the geological rock media, along which nuclide could be transported preferentially with the flow of groundwater is considered in the current study. Due to whatever the reason, such as e,g., the earthquake or human intrusion, it is assumed that the physical properties of the major water conducting fault (MWCF) is changed resulting in the size of fracture width and the matrix diffusion depth. For such case another illustration is made for probabilistic evaluation of a hypothetical Korean HLW repository, as similarly done in the previous studies.

2. Methodology and Illustrations

Once nuclides spread out to the buffer material surrounding a canister as well as the backfill region in the tunnel after a leakage from a damaged HLW or SF canister through tiny holes, farther transporting into the MWCF of the far-field area of the repository via the internal fractures having flowing groundwater could happen. The nuclides will then eventually reach the human environment by passing over the geosphere-biosphere interface (GBI) resulting in a possible exposure to human bodies.

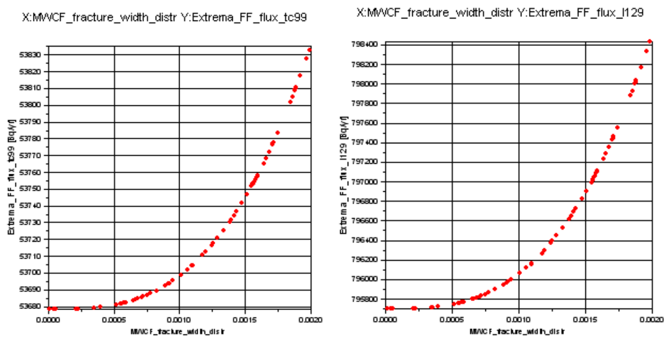
In such a case the fracture in the MWCF could behave as a very preferential and even critical pathway for nuclide transport. The MWCF zone through which all the nuclides released from the internal single fracture to the GBI are assumed to be a bundle of planar fractures through which transport upwards into the biosphere takes place as similarly done as the case of an internal fracture existing between the near-field zone of the repository which frequently is modeled as a single planar fracture.

To observe the influence of the fracture width and the depth to which is the nuclide could diffuse in the rock matrix on the nuclide release flux from the MWCF, both parameter values for the fracture width and the matrix diffusion depth in the MWCF are assumed to vary uniformly and statistically. The arbitrary chosen values are between $2\times10^{-5}\times0.01$ m and $2\times10^{-5}\times100$ m for the range of the fracture width and between 0.01×0.1 m and 0.01×100 m for the matrix diffusion depth. Other data are available from the previous studies.

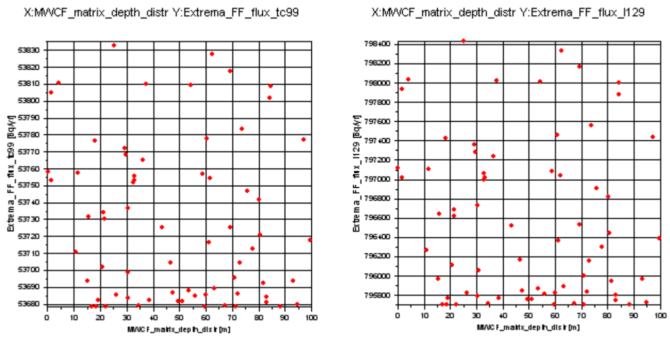
The nuclide transport in the MWCF used to be assumed to be advection-dominated with dispersion and the matrix diffusion into the rock matrix which facilitates in the application of pipe pathways in current GoldSim modeling approach, for ^{99}Tc and ^{129}I, both of which are arbitrary chosen for the illustrative purpose, having long half-lives (2.12×10^5 yr for ^{99}Tc and 1.57×10^7 yr for ^{129}I). However, despite of quite different sorption behaviors (retardation factor = 2.7×10^3 for Technetium and 1.04 for iodine), the sensitivities of the width of the fracture to the release fluxes shows a similar behavior as seen in Fig.1.

Simple results from the illustration could be drawn: The sensitivity of the size of the fracture width in the MWCF to both of ^{99}Tc and ^{129}I release fluxes is highly noticeable as naturally expected. This is simply because the velocity in the fracture increases as the volumetric flow rate of groundwater increases volumetrically due to increase of the aperture size. However, on the contrary, the sensitivity of the matrix diffusion depth in the MWCF to nuclide release flux does not seem that sensitive since the diffusion into the pore of rock matrix and sorption there simply retard the transport for a while.

The nuclide flux in the MWCF also decreases with an increase of the fracture width from the special case (results are not shown here) that volumetric flow rate of groundwater remains constant. This is naturally due to the decrease of the flow velocity as the size of fracture width increases.



(1a) (1b)



(2a) (2b)

Fig.1. Sensitivity of (1) the fracture width and (2) the matrix diffusion depth on the nuclide release fluxes of (a) ^{99}Tc and (b) ^{129}I from the MWCF.

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