考慮膠體加速放射性核種衰變鏈多成員核種遷移的數值模式發展

報告者：黃昶輔
指導教授：陳瑞昇
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摘要

相較於其他能源，核能提供了乾淨能源，但也必須承擔核電廠運轉過程所產生的高階廢棄物的處置問題。高階廢棄物深層地質處置為台灣未來須面對的嚴肅課題。然而，在興建高階廢棄物處置設施過程中可能會造成地底下的介質出現裂隙。這些裂隙會是放射性核種透過地下水外釋到生物圈主要的通道。在裂隙中地下水常存在膠體，放射性核種可進一步吸附於可移動的膠體而加速其傳輸。因此了解膠體對放射性核種在裂隙-母岩系統的遷移行為對於高階廢棄物場址各階段的安全評估都相當重要。本研究發展出一個數值模式來模擬膠體與放射性核種衰變鏈的多成員核種在裂隙-母岩系統中的傳輸。本模式採用的是使用有限差分法獲得的數值解，並撰寫成 FORTRAN 程式執行數值模式的計算。最後，將會透過模式的參數進行敏感性分析來了解重要的參數影響。該模型考慮了膠體濃度的時間與空間變化，將可增加高階廢棄物深層地質處置場安全評估的信賴度。

關鍵字: 放射性核種衰變鏈、膠體、裂隙、數值模式、有限差分法

Development of Numerical Model for Colloid-Facilitated Transport of Multiple Members of a Radionuclide Decay Chain

Presenter：Chang-Fu Huang
Advisor：Prof. Jui-Sheng Chen
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Abstract

Compared with other energy resources, nuclear energy provides clean energy, but it should deal with the disposal of high-level waste (HLW) generated during the operation of nuclear power plants. The deep geological disposal of HLW is a serious issue that Taiwan will face in the future. However, fractures may appear in the media in subsurface during the construction of HLW disposal facilities. These fractures will be the main pathway for the release of radionuclides to the biosphere through groundwater, and colloids often exist in the groundwater in the fractures. Mobile colloids can sorb radionuclides and facilitate their transport. Therefore, understanding the transport behavior of colloid for radionuclides in the fracture-matrix system is very important for the safety evaluation of HLW sites at all stages. In this study, a numerical model was developed to simulate the transport of multiple members of a radionuclide decay chain and colloids in the fracture-matrix system. The numerical solution of the model was obtained using the finite difference method, and a FORTRAN computer code has been programmed for our proposed numerical solutions. Finally, a sensitivity analysis of the model parameters is carried out to understand the important parameter effects. This model considers the temporal and spatial variation of colloid concentration, which will increase the reliability of the safety assessment of HLW deep geological disposal sites.

Keywords: Radionuclide decay chain, Colloid, Fracture, Numerical model, finite difference method