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A Dose Assessment Model for KRS HLW Repository

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1. Introduction

The objective of this study is to develop a dose assessment model ACBIO2, by which dose to human due to long-term nuclide release from high-level radioactive waste (HLW) repository system can be evaluated. A conceptual Korea HLW Repository System (KRS) for direct disposal of spent fuel is to be introduced by the end of 2007. A preliminary reference repository concept considering generic site characteristics was envisaged in 2003 [1]. During last few years through a series of safety assessment studies, nuclide release behavior from the near- and far-field of repository system has been investigated [2-4]. Recently, to demonstrate how much a reference repository is safe, a generic biosphere models have been developed [5-7]. Even though still not site-specific, modified biosphere model becomes necessary accounting for various FEPs and scenarios associated with nuclide transport and transfer in both geosphere and biosphere associated with KRS. KRS might be located in or at least near a coastal area in view of general sociogeographical situation and will be constructed in crystalline rock in the depth of about 500m. In such case such fresh water bodies as water running rivers, well and/or still lakes and varying near seawater as well as sediments beneath fresh and marine water bodies are expected to be principal geosphere-biosphere interfaces (GBIs), into which nuclide released from the geosphere could be taken place and ready for spread out to the biosphere.

2. Methodology

The long-term behaviors of nuclides in the varying ecosystems, which are controlled by slow processes whereas the turnover time of human food chain is too short, are very difficult to model together. Furthermore, the nature of the future biosphere and human behavior and even exposed population are very uncertain at the time of nuclide release. A possible solution to overcome such problem could be the application of an approach based on general human habits and biosphere conditions, i.e., *reference biosphere concept* which has been developed as part of IAEA international joint research project BIOMASS [8] and which was initially explored by BIOMOVS II Reference Biosphere Working Group in the BIOMOVS II study [9].

2.1 BIOMASS Methodology

The BIOMASS methodology proposes a complete procedure to develop the biosphere model providing a systematic methodology based on key steps by which conceptual and mathematical modeling can be made: first of all, defining assessment context such as goal of assessment, description of the repository, GBIs as source terms, various assumptions, and many other things is needed for overall requirements for the biosphere assessment. Once completed, such biosphere components as climate, geographical/topographical information, human activities, surface water bodies and biota are characterized to describe the biosphere. Interaction matrix showing nuclide transfer pathways with selected features, events and processes (FEPs) associated with the nuclide behavior in the biosphere system can then be constructed as shown in Fig. 1. Then possible interactions that could occur among the LDEs in RES matrix are allocated to off-diagonal elements (ODEs), each of which is related to a FEP or a process of the mathematical model.

2.2 Modeling methodology

A linear compartment model for nuclide transfer among various biosphere component systems under the assumption of rapid mixing in each compartment volume is applied. The resulting transfers between two compartments due to various processes are then described by simple transfer coefficient expressed as inverse of turnover time. Such turnover of nuclides in each compartment can be calculated by solving first-order differential equations to get nuclide concentration in it, which is ready to give rise to doses to human through various biosphere pathways. The nuclide concentration in foodstuff in food chain pathways is then calculated assuming instant equilibrium between plants and animals as well as their environment. Adopting BIOMASS methodology, biosphere modeling has been made through this study by utilizing AMBER [10] as described above (Fig. 1). Three exposure groups including farming, freshwater fishing and marine fishing are defined accounting for the classification of exclusive intake of local products with relevant assumptions. Nuclide uptake in aquatic biota is calculated using concentration ratios for aquatic organisms or bioaccumulation factors and uptake in terrestrial vegetation is calculated using soil to plant concentration factors, root-uptake factors and external to internal surface translocation factors. Specific transfer coefficients are also used when nuclide transfer to animal products is calculated. External doses are calculated with relevant dose conversion factors as well. Uncertainties associated with model as well as due to other uncertainties involved in parameter values can be estimated by assigning appropriate statistical distribution and ranges. Dose exposure shown in Fig. 2a is a result from test calculation when using the same input data as used in the previous studies [5-7,11-12] where neither separate consideration of the deeper sediment nor suspended matter in aquatic compartments are made unlike current study, which shows, even though exposure rates for two other exposure groups almost remain the same, but a little higher dose rate especially for marine fishing group. Calculated dose exposure rates for each nuclide for marine fishing group are also shown in Fig. 2b.

3. Conclusion

A biosphere assessment methodology and the model have been prepared by which dose exposure rate due to long-term release of nuclides from KRS could be evaluated. Even though currently it is not clear KRS will be located in or near a coastal area or mountain area far from the coast, taking current situation in Korea into consideration, such biosphere model should be prepared and then continuously modified as progress for developing KRS is being made. To this end ACBIO 2.0, an AMBER template case has been developed and tested. Several possible scenarios have also been identified to adopt varying cases for biosphere assessment for KRS.

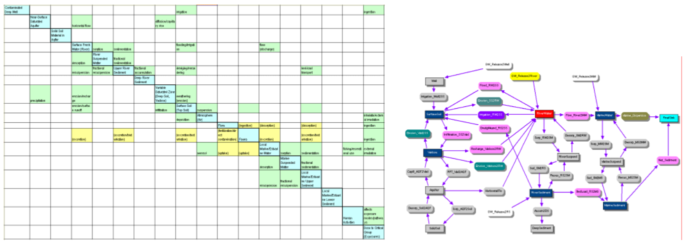

Fig. 1. RES and its implementation to compartments in AMBER.

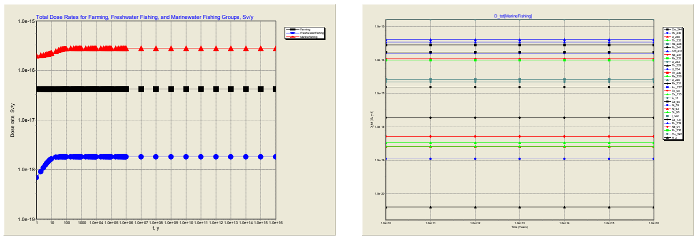

Fig. 2. a. (*left*) Total individual dose rate for each exposure group; b. (*right*) Individual dose rate for each nuclide for marine fishing group.

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