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A GoldSim Based Biosphere Assessment Model for a HLW Repository

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1. Introduction

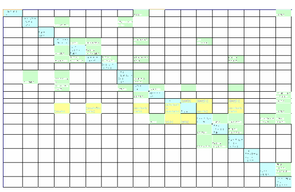
To demonstrate the performance of a repository, the dose exposure to a human being due to nuclide releases from a repository should be evaluated and the results compared to the dose limit presented by the regulatory bodies. To evaluate a dose rate to an individual due to a long-term release of nuclides from a HLW repository, biosphere assessment models and their implemented codes such as ACBIO1 and ACBIO2 have been developed with the aid of AMBER [1] during the last few years [2-5]. BIOMASS methodology [6] has been adopted for a HLW repository currently being considered in Korea, which has a similar concept to the Swedish KBS-3 HLW repository [7]. Recently, not just only for verifying the purpose for biosphere assessment models but also for varying the possible alternatives to assess the consequences in a biosphere due to a HLW repository, another version of the assessment modesl has been newly developed in the frame of development programs for a total system performance assessment modeling tool by utilizing GoldSim [8]. Through a current study, GoldSim approach for a biosphere modeling is introduced. Unlike AMBER by which a compartment scheme can be rather simply constructed with an appropriate transition rate between compartments, GoldSim was designed to facilitate the object-oriented modules by which specific models can be addressed in an additional manner, like solving jig saw puzzles. According to the HLW repository, which has been envisaged since the beginning of the previous 10 year long term R&D studies performed in KAERI, Korea reference HLW Repository System (KRS) has been considered to be located in or at least near a coastal area in view of the general and current sociogeographical situation in Korea and to be constructed in crystalline rock at a depth of around 500m [9]. In such a case, such fresh water bodies as 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 the principal geosphere-biosphere interfaces (GBIs), into which a nuclide released from the geosphere could take place and ready to spread out to the biosphere as conceived in previous studies.

2. Methodology and Illustrations

Although, through every step of a whole biosphere modeling, the nuclides transport from various geological media to the biosphere might somehow need to be accounted for in detail and in a coupled manner, to a large extent, a biosphere modeling can be done independently with its linear behavior, without knowing even what happens in the geosphere, making an access possible to it in a separate manner, as is currently being done in many other countries. For such cases AMBER looks very appropriate to model it independently, exclusive of a consideration of a geological transport before GBI. However, by supporting a functionality in a modeling of continuous dynamic systems as well as applying it to such a simulation as discrete events and time-delayed effects, GoldSim seems better and could be applied easily for a final assessment of a biosphere since it efficiently integrates the results of complex nuclide transport models through engineered barriers and geological fractured rock media surrounding a HLW repository for a consecutive farther transport and transfer modeling through a biosphere. A linear compartment model to describe the interaction among various biosphere components including features, events, and processes (FEPs) as shown in Fig. 1(a) for a nuclide transfer under the assumption of an instant mixing in each compartment or cell volume could be modeled by AMBER or GoldSim as depicted in Figs 1(b) and 2(a), respectively. Unlike in AMBER in which the resulting transfers between two compartments due to various processes are described by simple transition rates expressed as an inverse of the turnover time for the AMBER scheme, in GoldSim the inflow and outflow between two cells is expressed by mass or volumetric flow rates. For both of these, once the concentration in each compartment or cell is calculated, then the nuclide concentration in a foodstuff in food chain pathways is calculated by assuming an instant equilibrium between plants and animals as well as their environment as shown in Fig. 2(b). As always, three exposure groups including farming, freshwater fishing and marine fishing are defined to account for the classification of an exclusive intake of local products with relevant assumptions. Nuclide uptake in aquatic biota is calculated by using concentration ratios for aquatic organisms or bioaccumulation factors and a uptake in terrestrial vegetation is calculated by using soil to plant concentration factors, root-uptake factors and external to internal surface translocation factors. Specific transfer coefficients are also used when a nuclide transfer to animal products is calculated. External doses are calculated with relevant dose conversion factors as well. Dose exposure rates shown in Figs. 3(a) and 3(b) are the results from test calculations by ACBIO2 and GoldSim model, respectively with slightly different compartment schemes and input data for an illustrative purpose.

3. Concluding Remarks

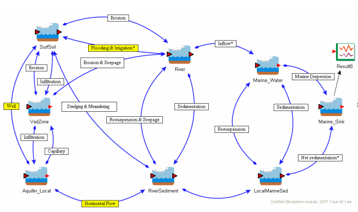
A biosphere assessment model developed in assistant with GoldSim has been introduced by which a dose exposure rate due to a long-term nuclide release from KRS could be evaluated. Although currently it is not clear if the KRS will be located in or near a coastal area or mountain area far from the coast, by taking the current situation in Korea into consideration, such a biosphere model should be prepared and then continuously modified as progress in developing the KRS is being made. Such AMBER template cases as ACBIO1 and ACBIO2 will also be compared with the newly developed GoldSim biosphere model for verifying the purpose as well as for seeking more appropriate models for possible scenarios associated with the KRS.



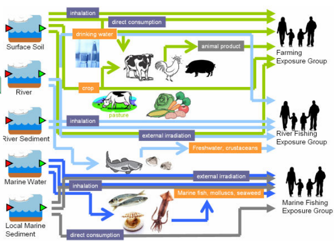
(a)

(b)

Fig.1. (a) RES Matrix constructed with FEPs and (b) compartment modeling scheme in ACBIO2

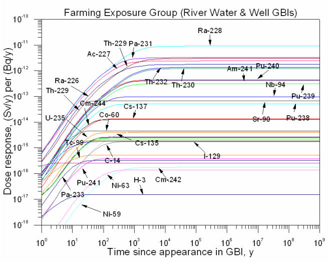


(a)

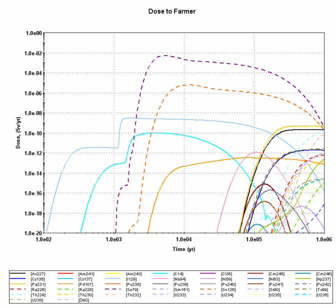


(b)

Fig. 2. (a) Compartment modeling scheme in GoldSim and (b) biosphere exposure pathways used both for ACBIO2 and GoldSim



(a)



(b)

Fig. 3. (a) Dose rate in response of 1Bq/y by ACBIO2 and (b) dose rate by GoldSim model for an imaginary input data for a HLW repository

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