Benchmark of the Biosphere model for Wolsong LILW Disposal Center

Sung-Wook Hong and Joo-Wan Park
Korea Radioactive-waste Management Corporation, 848-2, Jung-dong, Giheung-gu, Yongin, Korea
heart@krmc.or.kr

1. Introduction

The implementation in Ecolego of the biosphere model was done using the descriptions provided in the Safety Analysis Report(SAR) of the Wolsong LILW Disposal Center(WLDC)[1]. The Ecolego model conceptualization is intended to confirm the Amber biosphere models referred from the SAR. A comparison of results from the Ecolego models and the Amber model was carried out by running the models with a constant unit release rate for a set of radionuclides, assuming a constant source for one million years. The analysis was conducted for releases to the sea.

2. Conceptual and Mathematical model implementation in Ecolego

The matrix representations in Ecolego of the conceptual models are for groundwater to Marine Water compartment and to Marine Sediment shown in Figures 1 and 2, respectively. The diagonal elements in the matrix correspond to the model compartments, sources and sinks. An additional diagonal element is included in each compartment corresponding to the total dose to the exposed group. The off-diagonal elements correspond to transfers between the compartments. The mathematical model consists of a system of ordinary differential equations that is used for estimation of the time dynamics of the radionuclide inventories in each compartment. The radionuclide concentrations in different environmental media and the doses to the exposed groups are calculated using algebraic equations which are represented in Ecolego with the help of the "Expression" block and/or post-processing functions[2]. All equations were implemented from the description provided in the SAR. The parameter values were taken when available from the SAR. The endpoint used for the benchmarking of comparison was the so-called Ecosystem Dose Factors(EDF), which are defined as the maximum value of the total dose to the exposed group, in Sv/yr, resulting from a continuous unit release of 1 Bq/yr during the whole simulation time to the Marine Water or Marine Sediment compartments, when calculating the EDFs for the sea. A simulation period of 10^6 years was taken in all cases. The radionuclides considered in the comparison were H-3, C-14, Co-60, Cs-137, I-129, Nb-94, Ni-59, Ni-63, Sr-90 and Tc-99. The following exposure pathways were included in the dose calculations:

- Ingestion of contaminated food (fish, crustacean, molluscs and marine plants)
- Inhalation of contaminated dust.
- Inhalation of contaminated aerosols.
- External exposure to contaminated sediments.
- External exposure via immersion in contaminated water.

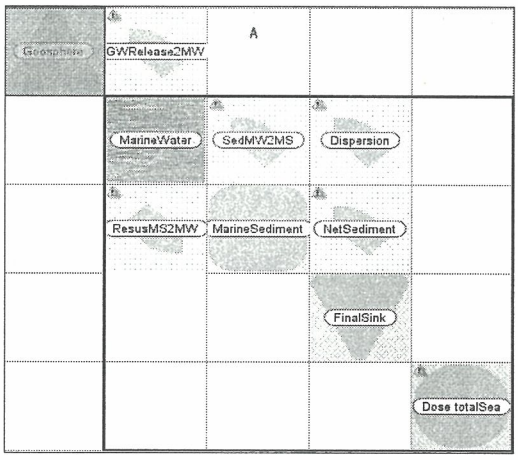

Fig. 1. Matrix representation in Ecolego of the Biosphere Model (Model A: Release to Marine Water Compartment)

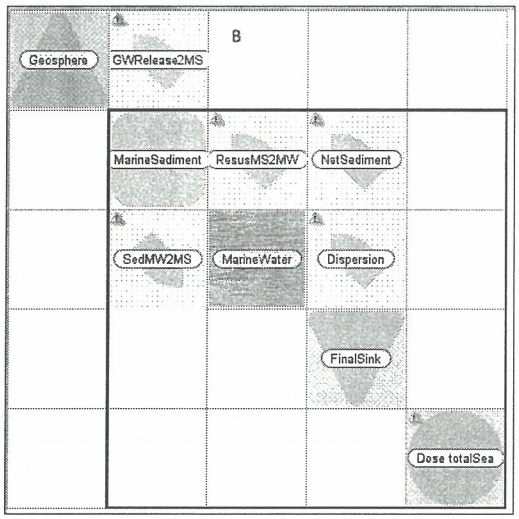

Fig. 2. Matrix representation in Ecolego of the Biosphere Model (Model B: Release to Marine Sediment)

3. Comparison of Ecosystem Dose Factors calculated with Amber and Ecolego

The EDF obtained with Ecolego for the sea is presented in Table 1, which also includes the values obtained with Amber. In table 1, Amber model corresponds to groundwater release to marine sediment[3]. It can be seen that the ratio of the EDFs and Amber model is within an order of magnitude for all ten radionuclides. For most radionuclides, values from the Ecolego show lower than those from the Amber model. As for the comparison between Ecolego Model A and B, reasonable agreement was achieved for most radionuclides except Nb-94 and Cs-137. The differences appear to be explained by differences in the conceptual models, i.e., different GBI(Geosphere Biosphere Interface) between Model A(release to Marine Water) and Model B(release to Marine Sediment).

Table 1. EDF values calculated with Ecolego and Amber

Radio nuclide	PEAK Values		
	ECOLEGO		AMBER
	Model A	Model B	SAR
H-3	2.86E-20	4.89E-21	1.27E-20
C-14	1.22E-16	1.20E-16	1.21E-16
Co-60	3.51E-15	7.18E-15	6.41E-15
Ni-59	5.80E-19	5.84E-19	6.37E-19
Ni-63	1.38E-18	9.08E-19	1.16E-18
Sr-90	1.09E-18	4.23E-17	4.55E-17
Nb-94	9.57E-18	4.71E-14	2.61E-14
Tc-99	2.29E-18	3.34E-18	3.44E-18
I-129	1.85E-16	2.45E-16	4.76E-16
Cs-137	1.30E-17	5.97E-15	4.62E-15

4. Conclusions

The model equations were implemented in Ecolego using the same model as in the SAR. Since the results obtained with Amber and Ecolego are in general consistent, it can be concluded that equations' implementation in both Amber and Ecolego corresponds well with the model description. The reasonable agreement obtained for the majority of the radionuclides indicates that the same parameter values are used and that the numerical methods implemented in these tools give consistent solutions. However, differences between some of the results suggest that there is a difference between the implemented models for this benchmark analysis.

5. References

[1] Korea Hydro & Nuclear Power Co.,Ltd., Safety Analysis Report for the Wolsong Low-and Intermediate-Level Radionuclide Waste Disposal Center, 2007.

[2] Facilia AB, Ecolego version 5, 2009.

[3] Quintessa Limited, Amber version 5.3, 2009.