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METHODOLOGY FOR BIOSPHERE ANALYSIS IN HIGH LEVEL WASTE DISPOSAL. APLICATION TO THE MEDITERRANEAN SYSTEM

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Abstract

For several years CIEMAT has been developing for ENRESA a conceptual approach and tools to support the modelling of the migration and accumulation of radionuclides within the biosphere once those radionuclides are released or reach one or more parts of the biosphere (atmosphere, water bodies or soils). The model development also includes evaluation of radiological impacts arising from the resulting distribution of radionuclides in the biosphere. At the time when the methodology was proposed, the level of development of the different aspects proposed within it was quite heterogeneous and, while aspects of radionuclide transport modelling were already well developed in theoretical and practical terms, other aspects, like the procedure for conceptual model development and the description of biosphere systems representatives of the long term needed further developments. The developments have been performed in parallel to international projects, within which there were and are an active participation, mainly, the BIOphere Models Validation Study (BIOMOVS II) international Project, within which it was developed the so called Reference Biosphere Methodology and, the International Atomic Energy Agency (IAEA) Programme on BIOsphere Modelling and ASSessment methods (BIOMASS), that is under development at present. The methodology been made takes account of these international developments. The purpose of the work summarised herein is the application of the methodology to the 1997 performance assessment (PA) exercise made by ENRESA, using from it the general and particular information about the assessment context, the source term, and the geo-biosphere interface data.

1. INTRODUCTION

For several years CIEMAT has been developing for ENRESA a methodology to deal with the biosphere in long-term performance assessments for high level radioactive waste [1]. A basic idea within the Methodology is that the modelling of the biosphere and the final model/s to produce results are strongly influenced by: (a) external decisions: national and international regulations, expert judgements in the whole process, lack of knowledge; and (b) internal decisions: the final biosphere systems to consider as relevant for the consequences in the future, mathematical approaches and data requirements. The Methodology must be flexible enough to allow for these factors and the changes produced as a consequence of evolution in safety criteria, regulations and knowledge. Another basic idea under the Methodology is the approach used to consider the biosphere in the long-term. The biosphere will be represented by means of one or more so called Reference System/s. The first try to develop Reference Systems within this Project produced the document MICE in 1996 [2] and the ideas considered there combined paleoclimatic studies with present locations for climatic analogues states to produce the description of the possible future systems in a specific region of interest. At present, the BIOMASS IAEA Programme [3] in collaboration with several national organisations is working to complete and augment the Reference Biosphere Methodology (developed originally during the BIOMOVS II international Project [4]) and to produce some "practical" examples of Reference Systems.

2. APPLICATION OF THE METHODOLOGY TO A MEDITERRANEAN SYSTEM

An application of the "reference biosphere methodology" has been performed with support from QuantiSci consulting company and published in 1998 [5]. The method proposed and the results obtained in the trial application are the basis for the summary presented in this paper. The consecutive actions for the application consists of eight steps with sub-steps as follows:

Step1: To establish the Assessment Context

Step2: Description of the Biosphere System: The Mediterranean system description defined during the project [2] is used as the representative situation for the biosphere system. Source term and geo-biosphere interface information is obtained from [6].

Step3: Generation of the FEP List

Step3.1: The International Biosphere List of Features, Events and Processes [4] already existing has been used as a starting point.

Step3.2: Each FEP from that List has been considered either for inclusion, within this biosphere application, or omitted, with reasons why. Screening of FEPs for the application is based on the selected Assessment Context and on the Description of the Biosphere system (steps 1 and 2 respectively).

Step4: Generation of Conceptual Models

Step5: Mathematical Description

Step6: Treatment of Data

Step7: Implementation of the Model in the Code

Step8: Interpretation and Presentation of Results

3. RESULTS AND CONCLUSIONS

Figure 1 shows an example of results (deterministic ones) obtained in the test case used [5]. Some of the main conclusions obtained are summarised as follows:

- The methodology tested within this application and the corresponding steps applied, show a coherent and clear procedure that facilitates proceeding from the initial premises of the assessment up to the final model to be used, clarifying and recording the logic or reasoning under any decision taken.
- The biosphere system used to test the methodology and the capabilities, do not correspond to any site specific description. The description of the system has been built up with information about the geo-biosphere interface given in the ENRESA-1997 [6] document, the generic Mediterranean system description [2] and some changes made ad hoc for coherency between the interface and the rest of the system. The biosphere system then has to be considered as generic and not site-specific.

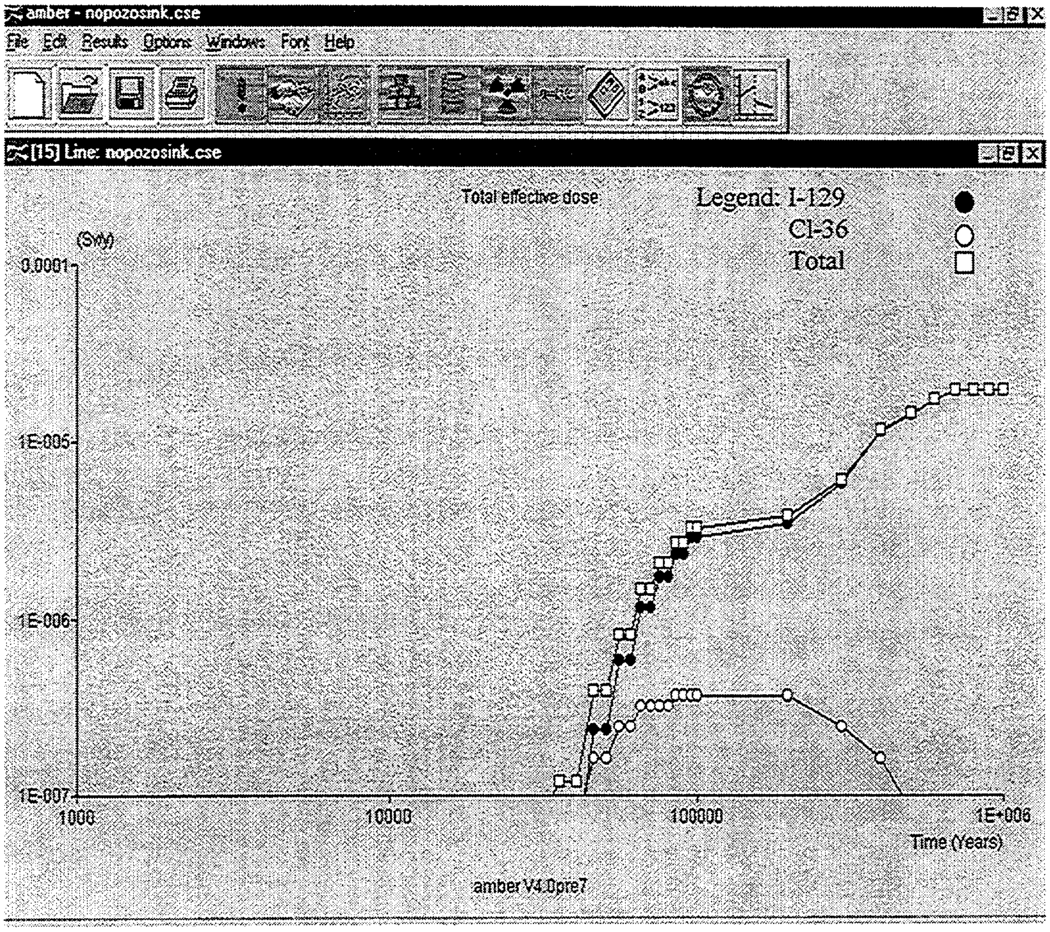

FIG. 1. Total effective dose (Sv/y) and Cl-36 and I-129 contributions to the total dose for the deterministic case.

- The model developed here for the transport of radionuclides and for calculating the associated annual individual doses is reasonably complete. That is, all relevant transport and exposure pathways have been considered. However, this completeness only applies to the particular assessment context considered. Different FEPs treatment, and hence, different conceptual modelling assumptions would arise for alternative assessment contexts. Especially important to consider could be the changes that would be necessary for alternative geosphere-biosphere interfaces and for different assessment endpoints. The necessity to consider these alternatives should become clearer as the ENRESA project develops and as international recommendations and regulatory requirements are further clarified.
- The assumptions for the critical group definition are conservative especially since all water requirements are obtained from the contaminated well and the human consumption products considered are obtained from the contaminated agricultural area. Those assumptions would not be realistic if an average present Spanish person was selected for the assessment, and in that case the doses would be lower.

- The dilution of the contaminated groundwater pathways into the surface aquifer represents the major reduction of the concentration of contamination becoming to the biosphere (order 10^4 in reduction). Although this factor has not been treated as an uncertain one, the results from an uncertainty analysis had been very interesting. What it is recommended for next iteration. The modelling of that type of interface and other type of possible interfaces should be considered in great detail for further applications as well.
- Probabilistic results imply a "parameters uncertainty" of one order of magnitude taking into account that only nine parameters has been considered uncertain and that some of them are not really relevant for final total doses. Distribution coefficients for soil are the most important parameters from those sampled, which variability ranges can be analysed in detail to reduce the uncertainty margin to what is really relevant.
- Doses from deterministic calculations goes up to 0,02 mSv/y while doses from probabilistic goes up to 0,3 mSv/y for the mean of the peak values, and that implies that certain combinations of parameter values result in a worse situation. Note that the set of parameters sampled in this case is not big and then the small margin of uncertainty (one order of magnitude) is explained. A more complete uncertainty analysis could become in a more significant uncertainty.
- As long as parameter values always have an uncertainty due to the lack of knowledge or due to the variability, to use a probabilistic approach has several advantages, apart from the one mentioned above. For example: to be able to determine the most relevant parameters and the less relevant, that can be omitted in the next iteration as uncertain parameters; to be able to determine the ranges of values where the answer of the model is more sensitive and then restrict the ranges to be studied to those really important. To do this correctly it is necessary to start varying every parameter considered.

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