Developments in the modelling approach for radiological safety assessment of ^{238}U-series radionuclides in waste disposal

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Human and environmental radiation exposures from sites or areas contaminated with radioactive substances need to be quantified as part of the risk assessment process and for developing long-term remediation strategies. In most radiological assessment models, simplistic, empirical ratios are used to simulate contaminant transfers between environmental compartments. These are favoured because they facilitate modelling. Their use, however, significantly increases the uncertainty of model predictions, because they do not account for the underlying processes that govern spatial and temporal variations in radionuclide concentrations. In relation to more explicit, process-based modelling, representation of the migration of radionuclides in the ^{238}U decay series in soils and their uptake by plants is of interest in various contexts, including the disposal of radioactive wastes and the remediation of former sites of uranium mining and milling.

The structures of models used to assess doses in the biosphere for long-term waste disposal assessments have not changed significantly in the last few years. Several aspects of the model representations of the biosphere are currently being debated in international forums, and these aspects would benefit from further investigation. The potential topics of interest include biogeochemical zonation of radionuclides in the sub-surface, caused by changes in the redox characteristics in response to a variable water table. It has been proposed that traditional model structures are not able to represent this aspect of the system adequately.

Major improvements are needed to make models more process-based and capable of simulating the kinetics of contaminant transfers. A major challenge is to identify where the greatest advantages can be gained in reducing model uncertainty and understanding variability, developing criteria to identify if further research is required for parameterizing dynamic-mechanistic models, and identifying the level of model complexity needed for specific exposure scenarios.

This paper reviews the processes that need to be represented in order to simulate the behavior of ^{238}U-series radionuclides in long-term assessment models for radioactive waste disposal, and proposes a model structure and associated mathematical model that can be used to investigate the potential impacts of seasonally variable conditions on the calculated radionuclide concentrations in soils and plants. This work looks also at the potential for the inclusion of spatio-temporal variability in models for long-term dose assessments.