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Modelling the exposure of wildlife to radiation: key findings and activities of IAEA working groups.

Nicholas A. Beresford[1,6], Jordi Vives i Batlle[2], Karine Beaugelin-Seiller[3], Mathew P. Johansen[4], Richard Goulet[5], Michael D. Wood[6], Elizabeth Ruedig[7], Karolina Stark[8], Clare Bradshaw[8], Pål Andersson[9], David Copplestone[10], Hildegarde Vandenhove[2], Tamara L. Yankovich[11] and Sergey Fesenko[11]

[1]NERC Centre for Ecology & Hydrology, LancasterEnvironment Center, Library Av., Bailrigg, Lancaster, LA1 4AP, UK;[2]Belgian Nuclear Research Centre, Belgian Nuclear Research Centre, Boeretang 200, 2400 Mol, Belgium; [3] Institut de Radioprotection et de Sûreté Nucléaire (IRSN), PRP-ENV, SERIS, LM2E, Cadarache, France; [4]ANSTO Australian Nuclear Science and Technology Organisation, New Illawarra Rd, Menai, NSW, Australia; [5]Canadian Nuclear Safety Commission, Environmental Risk Assessment Division, 280 Slater, Ottawa, Canada, K1A0H3; [6]School of Environment & Life Sciences, University of Salford, Manchester, M4 4WT, UK; [7]Department of Environmental and Radiological Health Sciences, Colorado State University, Fort Collins, USA; [8]Department of Ecology, Environment and Plant Sciences, Stockholm University, SE-10691, Sweden; [9]Swedish Radiation Safety Authority, SE-171 16, Stockholm, Sweden; [10]Biological and Environmental Sciences, University of Stirling, Stirling, FK9 4LA, UK; [11]International Atomic Energy Agency, Vienna International Centre, 1400, Vienna, Austria.

INTRODUCTION

The International Atomic Energy Agency (IAEA) established the *Biota Working Group* (BWG) as part of its *Environmental Modelling for Radiation Safety* (EMRAS) programme in 2004 (http://www-ns.iaea.org/projects/emras/emras-biota-wg.htm). At that time both the IAEA and the International Commission on Radiological Protection (ICRP) were addressing environmental protection (i.e. protection of non-human biota or wildlife) within the on-going revisions to the Basic Safety Standards and Recommendations respectively. Furthermore, some countries (e.g. the USA, UK) were already conducting assessments in accordance with national guidelines. Consequently, a number of assessment frameworks/models had been or were being developed. The BWG was established recognising these developments and the need to improve Member State's capabilities with respect to protection of the environment from ionizing radiation. The work of the BWG was continued within the IAEA's EMRAS II programme by the Biota Modelling Group (http://www-ns.iaea.org/projects/emras/emras2/working-groups/working-group-four.asp).

The objective of both groups was: "*To improve Member State's capabilities for protection of the environment by comparing and validating models being used, or developed, for biota dose assessment (that may be used) as part of the regulatory process of licensing and compliance monitoring of authorised releases of radionuclides*". Here we summarise the main finding of these two working groups and outline the ongoing activities of their successor under the IAEAs *Modelling and Data for Radiological Impact Assessments* (MODARIA; http://www-ns.iaea.org/projects/modaria/default.asp?l=116) programme. Approaching 100 scientists from >20 IAEA member States have participated in the activities of the WGs using a range of assessment models/approaches. The complete list of refereed publications is listed at the end of this abstract.

MAIN FINDINGS

1. Through model-model and model-data intercomparisons we established that:

- Assuming unitary activity concentrations in environmental media and organisms, the approaches being used generally estimate comparable dose rates even though different assumptions are made in their parameterisation. Where differences in predicted outputs occur, these can generally be easily understood (e.g. different soil density assumption) or would have a minimal impact on an assessment (e.g. differences in the approach to estimating external dose rates from ^{3}H and ^{14}C due to their low contribution to dose). The assumed mass/size of an organism had little influence on the estimated dose rate except for very small organisms (e.g. fish eggs) and relatively high-energy (beta or gamma) radionuclide emissions.
- The estimation of organism activity concentration can be highly variable (often three or more orders of magnitude) between models, most especially for poorly-studied organisms.
- Predictions of simple concentration ratio (CR) based approaches and more complex food-chain models under equilibrium conditions were generally comparable. However, parameterisation of the diet for food-chain models could lead to potentially large uncertainty.
- Decisions on the how to include decay products can greatly influence an assessment outcome.

2. Homogenous distribution of radionuclides in the environment is generally assumed in assessment models. However, radionuclide activity concentrations in the environment vary vertically within soil and sediment profiles. After assessing the effect of heterogonous radionuclide distribution in sediment profiles we concluded that, in the case of initial screening tier assessments, conservatism is likely to be preserved by assuming a homogeneously contaminated volume and inputting the maximal activity concentration available for any layer.

3. The freely available assessment models/approaches consider a limited number of organisms-exposure scenarios. However, by understanding the main factors influencing the dose calculation and thinking ’outside the box’ it is possible for additional exposure scenarios to be modelled (e.g. scenarios have called for amongst other things: a tree dwelling reptile to be assessed – some participants achieved this by modelling it as a flying bird geometry; trees growing over waste trenches to be assessed – some participants achieved this by modelling the direct exposure to roots (by creating representative geometries) within the trenches as well as the exposure to the above-ground biomass).

ON-GOING ACTIVITIES

The work of the group continues within the framework of the IAEAs MODARIA programme, which was initiated in 2012 and will conclude November 2015. The work plan of the

MODARIA working group has largely been defined by the findings and recommendations of the previous EMRAS programmes. On-going activities of the working group include:

- The development of a database of biological half-life values for application in wildlife dose assessments (the database currently contains >1000 entries and the compilation will be made freely available).
- A comparison of dynamic models to predict radionuclide activity concentrations in, and dose rates to, marine organisms. This exercise used modelled seawater and sediment activity concentrations for the coastal environment near the Fukushima Dai-ichi nuclear complex supplied by the MODARIA aquatic modelling working group (http://www-ns.iaea.org/projects/modaria/default.asp?l=116#3).
- In the area of dosimetry, the group is comparing dose rates estimated assuming simple ellipsoid geometries (the standard approach in wildlife assessment) with those generated by realistic geometry simulations (i.e. voxel phantoms). Our aim is to determine if the simple assumptions made in models used for regulatory purposes are fit for purpose. The effect of soil moisture on external dose rate is also being evaluated.
- An evaluation to assess if current simplistic assessment approaches conservatively account for spatial heterogeneity (of radionuclide contamination, habitat etc.) in the environment.
- Guidance on conducting assessments based upon the experience of the group during the three IAEA programmes is being prepared.

Getting involved

The group welcomes the involvement of interested participants from IAEA Member States. To register on our emailing list see http://bit.ly/1zdu38Z. Current members cover a range of expertise, from model developers through to those wanting to learn about developments in this field, and we actively encourage participation by young scientists (including PhD. students).

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