BIOPROTA

Key Issues in Biosphere Aspects of Assessment of the Long-term Impact of Contaminant Releases Associated with Radioactive Waste Management

Report of the 'PROBIOTA'

International Forum on the Application of Guidance and Methodologies for Assessing Radiation Impacts on Non-Human Biota from Radioactive Waste Disposal Facilities

Lappeenranta, Finland
31 January – 1 February 2007

Hosted by POSIVA

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Preface

The report is presented as working material for information. The content may not be taken to represent the official position of the organisations involved. All material is made available at the users' risk.

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1. INTRODUCTION

1.1 Background

In recent years a number of assessment methodologies have been, or are currently being, developed to enable the impact of radioactive substances on the environment to be assessed through the calculation of dose to non-human biota (NHB). However such methodologies, and associated application guidance, have generally been developed in consideration of routine operational discharges from industrial sites where data on environmental discharges and/or environmental concentrations may be available or can be predicted with reasonable levels of certainty. In the case of releases from radioactive waste disposal facilities, long-term prospective assessments are required that may involve a greater degree of uncertainty and be subject to a variety of different possibilities for evolution of the biosphere. No international consensus on the application of latest guidance and methodologies for assessing impacts on NHB from long term releases of radionuclides from waste disposal facilities has been developed.

This forum was therefore set up within the BIOPROTA programme in order to provide an opportunity for open discussion on the issues associated with the inclusion of non-human biota assessments in the application of current guidance and methodologies used in post-closure Performance Assessments (PA) for waste disposal facilities.

1.2 Objectives

The specific objectives of the Forum were:

- To provide an open forum for the exchange information on the suitability and adequacy the current guidance and methods when applied to long-term assessments;
- To share experience in the practical application of the guidance;
- To share experience of other approaches which have been developed and tested;
- To provide feedback to developers and users on methodology implementation issues; and.
- To identify common research requirements to address key data gaps and uncertainties.

1.3 Participation

There were 15 participants from six countries, representing a range of operators and technical support organisations. Points of contact are list in Appendix A. In addition, a number of other organisations who were unable to attend have expressed direct interest in the outcome through the BIOPROTA Forum.

1.4 Report Structure

Section 2 provides summaries of the presentations made [1] and the following discussion. Conclusions and recommendations are given in Section 3. With permission of the authors, the presentations are being made available on the BIOPROTA website, www.bioprota.com

1.5 Acknowledgements

The forum was hosted by POSIVA. Special thanks go to Ari Ikonen and POSIVA for organising and providing the venue and hospitality during the forum.

1 Some presentations provided detail of approaches used for assessing impact to human populations in addition to non-human biota. Where this is the case, summaries in this report highlight the NHB aspects given the primary focus of the workshop. For further information on all aspects, presentation materials are available on the BIOPROTA website.

2. PRESENTATIONS

2.1 Kathryn Higley: Summary of on-going work of ICRP Committee 5

Kathryn summarised progress by ICRP Committee 5 in the development and application of an assessment methodology for protection of the environment from ionising radiation. It is intended that the method will be applicable for normal, existing and emergency situations. Committee 5 was established in 2005 with a 4 year work programme. Intermediate reports of committee task groups are in preparation, The final report of the Committee is due in 2009.

To date, an initial list of Reference Animals and Plants (RAPs) has been agreed, with the objective of making the best use of biological and dosimetric data. It is intended that supporting databases on radiation effects, dosimetry, transfers and background data will be produced for these organisms.

The Committee acknowledge a lack of data on transfer and radiation effects for a number of the RAPs. For example, in a survey of effects literature, acute effects data were only available for around 54% of the RAPs although data for related organisms were available for an additional 35% of the RAPs. The aim is to collate data for all life stages of interest. However, data are often lacking for all but the adult lifestage of many organisms. Due to these and other data gaps, the Committee are investigating the use and applicability of scaling functions that may enable some of the data gaps to be addressed. For example, allometric scaling has been shown to be applicable in extrapolating properties from one species or taxa to another and is widely applicable to for example home range, lifespan and CRs. Allometric scaling has been used in the United States as part of the BDAC methodology to estimate CR for various biota. Committee 5 is applying the method to morbidity effects data for RAPs. There is greater confidence in the simplified dosimetric quantities.

The committee is continuing with the RAPs approach but there is some concern about the continuing data gaps in chronic effects data at environmentally relevant concentrations. The committee is also considering the applicability of other approaches including toxicological approaches.

Discussion

Ulrik Kautsky began discussions by raising concern over the limited choice of RAPs, stating that it can be difficult for stakeholders to understand why particular organisms have or have not been selected, and suggested that greater emphasis be placed on the use of a wider range of reference organisms and application of the allometric approach. In response Kathryn that a selection of organisms was initially required for the activities of Committee 5, but it is hoped that the number of organisms included by the Committee will be extended to ensure the final approach will be more applicable to a variety of scenarios.

There was discussion of the advantages of allometric scaling methods for addressing data gaps in NHB assessment methodologies. Ulrik noted that in calculating doses to NHB it is the dimensions of the organism that are of ultimate importance in determining dose and therefore the allometric approach is appropriate to NHB assessments. The question was raised as to whether the data is available to allow an allometric approach to be applied to reproduction as well as morbidity endpoints for NHB assessments. Committee 5 has not yet had the opportunity to investigate the applicability to other effects endpoints, but it is intended that this will be progressed further.

2.2 Brenda Howard: Methodology development in EC projects ERICA and PROTECT

Brenda summarised the tiered approach to NHB assessment as set out in the ERICA Tool and related documentation. A number of changes to the initial project plan were required during the ERICA project, some in response to an internal evaluation of FASSET output (the previous related EU project) and others to take account of particularly challenging goals such as extrapolation from individual dose rates and effects to populations and ecosystems. . The number of ecosystems being considered was reduced from the 7 included in FASSET to 3 (marine, freshwater and terrestrial). The ERICA integrated approach considers more reference organisms than the RAPs specified by the ICRP and includes data for 31 radionuclides.

The ERICA consortium has developed a tiered assessment tool, a prototype of which is available on the ERICA website (www.erica-project.org). Considerable effort has been made to address data gaps relating to the transfer of radionuclides into biota (CR). However, it has been necessary to apply some approaches that are more doubtful than others as a result of the lack of data for some organism-radionuclide combinations. Transparency in the derivation of each factor has been ensured through the provision of detail on origin or derivation of each CR value.

The final ERICA tool is due for release in February 2007 and will be presented at an open event on the ERICA integrated approach to the assessment and management of environmental risks from ionising radiation in Paris on 14-15 February 2007.

Brenda also described the scope and objectives of the EC Coordinated Action PROTECT. The project is divided into three work packages (WP). WP1 is intended to look at the protection of the environment in general and involves consultation with industry and regulators on national regulatory approaches for chemicals and radionuclides. The aim is to identify similarities and differences in approaches and endpoints. The practicability of existing (and developing) approaches will then be evaluated in WP2, which will build on the work and membership of the Biota Working Group already established as part of the IAEA EMRAS programme. The next meeting is due to take place in June 07. This WP is expected to include a training component. Finally, WP3 aims to provide input into discussions on appropriate derivation numerical benchmark values for application within the EU (possible influence on the revision of the BSS) in consultation with the IAEA and ICRP. The implications of different criteria on existing practices would also be considered in consultation with industry, regulators and NGOs.

The first review (from WP1) is due to be released in November 2007. An evaluation of existing and developing approaches is due to be released in July 2008. Recommendations for criteria development will be available in draft form in January 2008 for comment and will be finalised in September 2008. A major IAEA International Conference is expected to take place in 2009/10.

Further information on PROTECT can be found on the project website (www.ceh.ac.uk/protect). The first project meeting will be held in Chester, UK in March 2007.

Discussion

In discussion, Brenda mentioned that there was agreement amongst a key group of the ERICA consortium to work together to maintain the ERICA Tool after the end of the project

It was recognised that the application of the ERICA Tool and documentation for different purposes, including the assessment of long-term releases over long timescales, will clearly be valuable input to the PROTECT programme. It was

suggested that this forum and the work of the PROTECT project should be agenda items at the BIOPROTA meeting in Prague (23 – 25 May). Brenda agreed that it may be a good time to provide an update of the progress within PROTECT, with a particular emphasis on issues of concern within the PA context.

It was noted that some of the ecological studies carried out in support of safety cases for waste repositories could inform PROTECT technical recommendations, especially regarding the longer term migration and accumulation of radionuclides in catchment areas and other biosphere systems.

2.3 Bjorn Cederwall: Radioprotection and the status of the species: Typological v population thinking

Bjorn raised questions about the objectives of current approaches for NHB assessments. He argued that, given an objective to protect the environment and, in particular to preserve biodiversity and maintain a sustainable environment, the primary endpoint should be mutation in the germline. This is the only one of the identified endpoints that can directly affect biodiversity through the transmission of genetic effects to the next generation given that the underlying gene pool is an important factor in determining variability within species. All other endpoints (e.g. reproduction and morbidity) are only applicable to the current generation and are not therefore directly applicable to 'populations'.

Overall, Bjorn considered that the extension of concepts developed for human individual protection (i.e. the reference organism approach) is inadequate to take account of the dynamic evolution of species. This was acknowledged to be particularly important when assessments that relate to evolutionary timescales.

It was also argued that there should be greater care in semantics used to describe ecosystem organisation levels and that it should be recognised that only species were defined mechanistically; other groupings were human constructs. There would be value in greater involvement of interdisciplinary groups to address contradictions in emerging methodologies.

Discussion

Brenda Howard began discussions by acknowledging that the establishment of appropriate environmental protection endpoints is difficult. It is important to recognise the difficulties associated with addressing population dynamics and to acknowledge the need to do so in the future. Further consideration of population dynamics would benefit from the involvement of ecologists and there were doubts about whether funding would be forthcoming for such work.

In further discussion, the importance of recognising and acknowledging the defects and uncertainties implicit in the use of the emerging methodologies was highlighted. It is important to consider the sensitivity of results to variations in the relevant parameters to determine which are the most significant and to focus future efforts in the most appropriate way. It was noted that many of the uncertainties were common to assessments of radioactive and non-active pollutants.

It was also noted in discussions that it is important to keep in mind the objectives of the assessment. Such objectives are often set by regulators and may or may not require the consideration of biodiversity, for radioactive materials. Requirements for the analysis of effects may therefore vary nationally.

Finally, it was noted that there is a need to be able to justify the level of approach taken, for example by keeping in mind the types of approaches used to assess impacts from non-radioactive contaminants within the environment.

2.4 Karen Smith: Nirex Experience - Application of the ERICA Prototype Tool to a generic UK waste repository

Karen presented work-in-progress to assess the potential impacts of a UK geological repository at a generic UK site using the ERICA assessment tool. The assessment follows on from an assessment conducted by Westlakes Scientific Consulting, prior to the development of the FASSET/ERICA methodology. An evaluation of the applicability of the prototype tool to a generic assessment has been conducted and particular data gaps and uncertainties within tier 2 methodology identified. On the basis of the initial review of the prototype, it was concluded that the tool provided a suitable means of assessing NHB doses from a generic UK repository; the range of radionuclides and the default reference organisms were, on the whole, applicable to the generic UK case. Nonetheless a number of uncertainties/data gaps were identified:

- For the terrestrial environment, no carnivorous mammal was included within the prototype tool. This could be a potentially important gap. It was acknowledged that the tool allows additional reference organism geometries to be specified, but CR values would need to be identified separately. Brenda Howard explained that carnivorous mammals had been excluded because it had been demonstrated that the difference in concentration ratios between carnivorous mammals and herbivorous mammals was not significant.

- The level of conservatism associated with default occupancy factors was raised as an issue, with the particular example of the 'wading bird' which was assumed to have an occupancy factor of 1 within the water column. It was suggested that such discrepancies between the default habit data and actual ecology of species represented by the reference organisms could reduce the confidence of stakeholders in the overall methodology. In response, Brenda noted that the ERICA tool does make some conservative assumptions and the help file will be modified to explain where this occurs. We will try to ensure that as many identified errors will be addressed prior to the release of the final assessment tool as possible.

- The applicability of the methods used to address data gaps in the concentration ratios was also identified. Questions related to the relative merit of different methods and identification of alternative means of deriving data were raised.

Discussion

Simon Norris also raised the issue of undertaking assessments against a background of climate and landscape changes was also identified as a factor that particularly distinguishes PA from most other forms of assessment.

It was suggested that it would be useful to identify key radionuclides and organisms of concern and the method of CR derivation to focus further work.

Ulrik Kautsky argued that uncertainties could be reduced by abandoning the use of CRs and moving to a method based on proportions of organic carbon (an indicator of calorific intake) and scaling factors based on relative fresh weight. An SKB report on this subject is available: Pools and fluxes of organic matter in a boreal landscape: implications for a safety assessment of a repository for nuclear waste Kumblad, Linda; Söderbäck, Björn; Löfgren, Anders; Lindborg, Tobias; Wijnbladh, Erik; Kautsky, Ulrik 2006.

2.5 Mark Willans: NHB and the 2002 LLWR (Drigg) Post-closure Assessment

Mark summarised an assessment carried a few years ago as part of the Post-closure Safety Assessment conducted for the LLW facility at Drigg, UK. At the time of the assessment the methodology employed within England and Wales (Environment Agency R&D 128) was considered unsuitable for the assessment due to data gaps associated with the radionuclides of concern. Therefore the method of Amiro was employed. Nonetheless, data gaps were still encountered, particularly relating to the availability of concentration ratios.

Weighted doses to terrestrial and aquatic biota were calculated to be within the order of 10^{-3} µGy/h. On the basis of the assessment C-14 and Np-237 were identified as the radionuclides contributing most to NHB dose in both freshwater and marine environments and C-14 and Tc-99 were the dominant radionuclides for the terrestrial environment (based on peak radionuclide concentrations irrespective of period of release). A further iteration of the assessment is planned following the release of a revised version of R&D 128, which incorporates additional radionuclides.

Discussion

The question was raised as to whether it would be beneficial to apply the ERICA assessment tool in place of R&D 128 during the re-assessment. Mark was keen to look into the possibility of this, particularly since R&D 128 was always intended as an interim methodology prior to the release of the FASSET/ERICA assessment tool.

2.6 Angela Becker: German perspective on PA and NHB assessment

Angela set out the basis for the range of safety indicators that is under discussion in GRS to determine the possible impacts of a waste repository on the environment and humans. In Germany investigations are underway to identify a suitable host rock for a waste repository that will remain stable for a period of 1 million years. It is felt that the evolution of the environment, especially under consideration of climate change, cannot be assessed for such a long time, while human activities and individual habits are always unpredictable.

Therefore, the view should concentrate rather more on the impermeability of the isolation rock zone than on possible hazard to the environment to find a deep geological formation without any need for further maintenance and control. For the assessment of the impermeability, possible indicators are being considered such as:

- A total of less than 1 % of the radionuclides disposed of should penetrate into the border area of the isolating rock zone and the host rock during a period of 1 million years
- The additional concentration of natural radionuclides within pore water in the host rock should never exceed the actual conditions (about 1 µg/ l U, 0.1 µg/l Th)
- The additional power density, i.e. the total decay energy until only stable elements exist, should never exceed 1 MeV/l
- Radio-toxicity in pore water should result in a (theoretical) dose lower than 0.1 mSv/year to man (from the EC Drinking Water Directive)
- Non-human biota should never be exposed to a radiation risk higher than ICRP comm. 5 is actually discussing: no detectable changes in DNA, no increase in morbidity or reduction in lifespan or reproductive capacity

- Limits for the concentration of natural radionuclides in accessible groundwater shall be defined in a manner that the natural concentrations do not rise significantly

- The risk to humans by radionuclide concentrations in accessible groundwater should be assessed using a standardized biosphere model. This remains necessary because of the artificial radionuclides in the repository.

The discussion of these criteria has just begun. It is not yet clear whether some criteria are contradictory or redundant.

With regard specifically to non-human biota it is anticipated that doses to NHB will not have to be assessed as part of a repository PA, it will rather be sufficient to do this exercise once, because the acceptable dose to NHB is higher by some orders of magnitude than the acceptable dose to humans. Whether this also holds for the groundwater wood louse, the preferred reference animal which lives in an extreme habitat, remains to be clarified.

2.7 Carol Robinson and Ari Ikonen: POSIVA site-specific assessment of a geological repository for spent nuclear

Carol summarised a test case conducted for the proposed waste repository at Olkiluoto in Finland that aimed to identify a suitable methodology for the assessment of impacts of releases from the repository on NHB. The assessment was conducted according to regulatory requirements stipulated by STUK that the period of the assessment should be up to several thousand years (interpreted as 10,000), assuming a similar climate to present. In assessing impacts it was required that there be no decline in biodiversity or populations based on the assumption of similar species being present as at present. In addition, no impacts should be evident on individuals of rare or domestic animals.

The assessment was based on the ERICA and EPIC methodologies, using assessment data from the latter where available as this was deemed most appropriate to the climatic conditions at the repository site and was based on a dissolving canister scenario. One main difference in the overall assessment was the inclusion of migratory occupancy factors to take account of the movement of biota from one ecosystem to another. However, doses calculated were very low (within the order of 10^{-30} to 10^{-32} µGy/h) and therefore it was questioned whether taking account of migration was required since this served to reduce the overall dose received compared with the assumption of 100% occupancy within the maximally exposed ecosystem. The radionuclide giving rise to the highest dose rates was generally Pu-239. However, in a wetland ecosystem Cl-36 was found to be the dominant radionuclide.

Following the summary of the NHB test case, Ari added some remarks about the assessment in terms of the overall safety case. In particular it was noted that there is a need for simplistic bounding calculations for PA, but there should also be detailed process level descriptions to ensure the assessment is transparent, traceable and scientifically reasonable. A knowledge quality assessment is therefore required to build confidence in an assessment. This should include uncertainty and sensitivity analyses plus pedigree analysis to evaluate the relative importance of different parameters and assumptions, thus enabling efforts to be focused on the most important and/or sensitive issues. As such, consideration is being given within Posiva to the application of the pedigree matrix presented by van der Sluijs at an ERICA end user group meeting.

Finally, Ari noted that Posiva is producing a biosphere assessment database that will enable the source of all data used within the Olkiluoto safety case to be readily

accessed. The overall strategy for the handling of parameters and data within the safety case is documented in Posiva working report 2006-109, available via the Posiva website (www.posiva.fi).

Discussion

A number of points of discussion were raised. These included the source of input data for transfer values within the biosphere assessment database. Ari confirmed that data for CRs are taken from current data sources such as ERICA/EPIC and then put into software database. However, if critical CR values are identified, some assessments may be undertaken to derive site specific values and these would be included within the database. Additional research may be undertaken if something critical presents itself. The ERICA tool itself has not been applied since it is intended that the assessment will be incorporated within the Pandora suite of programmes being developed for the Posiva safety case.

Given such low dose rates, a discussion regarding a suitable means of reporting impacts took place. It was suggested that it may be appropriate to express radioactive decay in terms of the number of atoms disintegrating per organism or population. However, it was noted that this approach cause concern to some and therefore a combined approach may be appropriate.

The consideration of releases within the context of weathering of rocks was also discussed and the need to consider this as a source of exposure to natural radionuclides was also identified.

Finally, Deborah Oughton welcomed Posiva's work on pedigree analysis following on from ERICA consortium and EUG considerations. She also indicated that she would be interested in hearing more of Posiva's experience in application. Ari indicated that the database was in the process of being set up and had not yet been populated.

2.8 Ulrik Kautsky: SRCan (Safety Report of Canister) and dose to the environment

Ulrik presented the assessment of dose to the environment from a HLW repository at 500 m depth. Entrance points to the biosphere have been modelled. These generally occur in low lying areas such as mires, peat bogs and lakes. Modelling of activity concentrations within each of these biosphere objects provided the basis for both human and NHB assessments, the latter were conducted using the ERICA assessment tool. The assessment began using Tier 1 of the assessment tool and was based on time independent maximum releases occurring over a period of 1 million years and by calculating the risk quotient (RQ). This was a conservative approach and a RQ greater than 1 was calculated for all ecosystems (primarily resulting from Ra-226 and Po-210) and further assessment at tiers 2/3 was therefore required.

Ulrik raised a number of issues with the application of the tool related to a lack of transparency in how the Predicted No Effect Dose Rate (PNEDR) of 10 µGy/h was derived. He also questioned as to how it would be possible to explain 'a failure' at Tier 1, but 'pass' at Tier 3 to stakeholders, particularly for a prospective assessment, such as required for a waste repository that has not yet been constructed. It was argued that the tiered approach increased the difficulty of assessment, particularly since the very conservative nature of Tier 1 implied maximum doses that were not applicable to the system under investigation. The general applicability of reference organisms is therefore questionable.

Discussion

Members of the ERICA consortium (Deborah Oughton and Brenda Howard) began discussions by clarifying the method used to derive the 10 µGy/h PNEDR used within Tiers 1 and 2 of the assessment tool. The PNEDR was derived on the basis of chronic effects data (24 data points) over 18 species across all ecosystems. The PNEDR was based on 5% of species receiving 10% effects to which a safety factor (of around 5) was subsequently applied. The use of such safety factors is similar to the approach applied for non-radioactive substances. As a result of discussions on the suitability of combining effects data across all ecosystems to derive the PNEDR, it was explained that an analysis of the data held within the FRED database had been carried out and the distribution of chronic effects was not found to differ between ecosystems. However, in the case of acute data, differences in the distribution of effects were noted between freshwater and marine ecosystems.

The issue of radiosensitivity was raised by Bjorn. He noted that this can be measured via multiple endpoints and that there was therefore uncertainty as to whether the most sensitive organism had been used as the basis for deriving species sensitivity distributions (SDD). Deborah explained that the SDD was based on all available data and was therefore not based on data for the most sensitive species alone.

With regard to communications with stakeholders, of tier-specific results, it was acknowledged that the distinction between tiers 1 and 2 may be difficult to explain although the point about the deliberately highly conservative nature of Tier 1 could be stressed. It was also stated that there is no requirement to begin an assessment at Tier 1. It would be reasonable to start at a higher tier for example if site specific data are available or specific reference organisms are required.

Ulrik was concerned about why the SKB NHB assessment should have failed at Tier 1, while the assessment conducted for the Posiva waste repository implied doses of the order of 10^{-30}. However, following discussions it became apparent that one of the principal differences related to the source term. In the Posiva assessment, the source term was based on disintegration of a single canister whereas SKB assumed multiple disintegrations occurring with time. Without a standardised source term, further analysis of differences would be difficult.

2.9 Graham Smith: Conceptual data gaps and uncertainties

Graham identified some ideas about potentially important conceptual and data issues arising from his experience of undertaking repository PAs. The key questions identified included:-

- Can we demonstrate adequacy of reference organisms for species level protection?
- Are there any radionuclides which are critical to the overall safety case in respect of the need to demonstrate protection of the environment?
- If so, are these the same or different radionuclides identified as critical to human health protection?

Discussion

It was questioned that, if we need special ecologically orientated models for human dose assessment for key radionuclides, such as C-14 and Cl-36, why would we not need similar for NHB dose assessment. The issue of lack of concentration ratios for some species (particularly those not consumed by humans) and long-lived

radionuclides was raised once more as one of the key uncertainties in the estimation of NHB doses.

One of the key points arising from discussions was the need for industry input to the development of assessment methods to ensure they are suitable for the applications to which they will be applied. Regulatory input is also vital to ensure that the requirements for assessments are clear. Without such input there would be a lack of adequate direction.

The issue of effects data (or lack of) was also discussed, particularly in relation to the use of background radiation effects. Comparison of dose rates arising from anthropogenic radionuclides against those arising from background radiation has been suggested previously as a means of assessing impacts. However, information on effects arising from background radiation would be required to enable a useful interpretation of effects to be made.

Finally, the use of 'reference biospheres' that are often applied in PAs (e.g. well or drinking water scenarios) cannot be applied directly to NHB assessments since routes of exposure will differ greatly. The exposure of biota can occur via routes to which humans are not exposed such as immersion in soils or sediments.

2.10 Deborah Oughton: Use of uncertain data in decision making

Deborah began by describing some of the uncertainty associated with assessing impacts on NHB. Many of the uncertainties are common to all ecological assessments. There is generally a limited knowledge base for undertaking such assessments related to: the assessment of materials present in or released into the environment; and determination of relevant effects, which is often based on data derived without the aim of providing ecologically relevant endpoints. An added uncertainty with effects data is that there can be multi-causality; effects could be caused by a variety of stressors without a clear link between the presence of one substance and the effect observed.

Types of uncertainty can be categorised according to whether they arise as a result of randomness (variability) or from a lack of knowledge or data (uncertainty). Variability can be documented and expressed in statistical terms, but not reduced. Uncertainty can be reduced by experiment by increasing the knowledge base and can take a number of forms such as model, numerical and social (acceptance) uncertainties.

The application of uncertain data in a societal context was demonstrated by discussion of radiation weighting factors, and the continuing question about their applicability to NHB assessments. It was recognised that weighting factors are 'fudge factors' that enable risk to be assessed and result in a non-scientific weighted measure of impact (the sievert) from what is a scientific measure (the gray, which is measurable). Deborah commented on the level of controversy associated with discussions of RBE and the application of weighting factors may be due to the fact that the source of significant variability in the effects from alpha radiation is not fully understood, although this is a relatively minor contribution to overall uncertainty.

Social uncertainties can take various forms and can be linked to legislation (e.g. the use of the precautionary principle) or the perception of harm. In order to address social uncertainties, there has been a move over recent years to incorporate stakeholder opinion in decision making. This in itself can involve uncertainty and discussions related to the validity of inclusion (for example related to the possibility that minority opinions could take precedence in stakeholder processes. However, it is considered important that stakeholders are involved, but awareness of the issues involved and appropriate processes in this is required.

Discussion

A lively discussion ensued both during and following the presentation. One particular focus of discussions was on the uncertainty associated with the use of concentration ratios. It was noted that there would be natural variability in the uptake of radionuclides (and other contaminants) by NHB and this variability would also vary with site depending on the type and degree of contamination. Seasonality as a source of variability in concentration ratios was also raised. However, for long-lived radionuclides this is not considered to be a significant contribution to the overall uncertainty, but would be of greater importance for shorter-lived radionuclides and assessments. Some of the uncertainty associated with concentration ratios can be addressed through measurement (e.g ICPMS) or use of allometric scaling, but it is important to acknowledge that uncertainty remains due to inherent variability and that generic data be taken into account where appropriate.

Kathryn noted with regard to concentration ratios that in the US there is a degree of certainty in those factors currently applied, but following discussions at the meeting it would appear that this is far from the case. The question as to how this could be fed back was therefore raised. One option proposed was to produce feedback as a combined radioecology group as opposed to individual waste management organisations. It was also proposed that the waste management community (both regulators and operators) could be presented with some of the conclusions from the workshop as a means of inviting input on additional requirements for addressing data gaps and uncertainties.

3. CONCLUSIONS AND RECOMMENDATIONS

It was concluded that a lot of useful information had been exchanged among participants with different backgrounds and technical contributions to make to waste disposal safety assessment. This included the opportunity for:

- methodology users to clarify some of the methodology components;
- discussion of time and spatial scale issues especially relevant to long term assessments supporting waste management decisions; and
- feedback to methodology developers on biosphere system descriptions relevant to long-term PA and next steps for research where data gaps exist.

The Forum was especially timely given the imminent completion of the ERICA project and the consultations around PROTECT and in the context of the current development of generic and site specific PAs for geological waste repositories.

From discussions it is clear that there is a large uncertainty associated with the use of concentration ratios for assessing impacts to NHB. This arises partly through a large number of data gaps and uncertainties, but also through inherent variability that will also be evident on a site specific basis.

There is a large degree of uncertainty as to how site evolution over the timescales required for waste repository PAs will affect ecosystems and the presence of biota. However, site evolution will be largely site specific so any consensus is likely to be difficult to reach. Uncertainty in assessments arises from many additional factors and therefore there may be merit in a comprehensive sensitivity analysis being conducted to ensure that resources can be used efficiently in addressing the key uncertainties associated with NHB assessments.

The point was also raised that NHB assessments for ionising radiation should not be considered in isolation. As noted in previous discussions, effects can arise from a variety of stressors, with the possibility of synergistic interactions. Chemotoxic and other impacts associated with waste repositories should therefore also be considered. The EC PROTECT project may be valuable in this respect by collating and comparing the available methods for assessing both chemical and radionuclide impacts.

The drivers for assessments can also result in some uncertainty with regulations tending to focus on present day knowledge and the applicability of this to future scenarios is not clear. For example, a regulatory requirement to preserve biodiversity does not take into account that the timescales relevant for PAs are equivalent to evolutionary timescales and therefore changes in populations and genetic diversity would be expected.

There was general agreement that there is a need to understand the overall objective of protection and to be clear about what the developed methods can achieve. The terminology used in communicating NHB assessments is vital to ensure that what we communicate what are capable of doing in relation to what we want to assess in a transparent fashion. This transparency is also essential to ensure that future priorities are correctly identified.

Finally, it was agreed that the forum provided a valuable opportunity for discussion and presentation of approaches to address the assessment of impacts on NHB and it was therefore agreed that there would be value in follow-on workshops on this topic, either as stand-alone meetings or as part of the annual BIOPROTA forum workshops.

As an initial way forward it was suggested that:

- BIOPROTA participants be invited to provide further feedback to the PROTECT project, with due care being taken not to duplicate the existing networks but also allowing for information exchange with waste management organisations within BIOPROTA. This will be managed through Brenda Howard, Deborah Oughton and Enviros.

- Representation from PROTECT be invited to the next annual BIORPOTA Forum in Prague, 23 – 25 May 2007 to allow an update of progress and continuing information exchange.

- Consideration be given to the usefulness of conducting a comprehensive sensitivity analysis to identify key uncertainties and to inform future work.

APPENDIX A: LIST OF PARTICIPANTS

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