International Union of Radioecology

RADIOLOGICAL PROTECTION OF THE ENVIRONMENT

IUR Web Based Questionnaire Results

Research, Facilities and Scientific Priorities

IUR Report 5 : 2006

IUR Web Based Questionnaire Results for Environmental Protection

Research, Facilities and Scientific Priorities

Executive Summary

The IUR Taskgroup on Protection of the Environment from Ionising Radiation

Following the publication of the Task Group's report "Protection of the Environment: Current Status and Future Work", the main emphasis of this task group changed to one that focuses on the identification and prioritisation of the research requirements in the field of protection of the environment from ionising radiation. There is a pressing need to identify and help to address, through innovative research, knowledge gaps that affect our ability to make scientifically defensible decisions and risk assessments regarding the biological impact of ionising radiation released in to the environment. There is a need to identify all the key issues and to address those that are of highest priority in allowing the development of suitable assessment tools and to provide the science that underpins the acceptance of these tools in society. Therefore, this task group has the following primary objectives:

- To identify knowledge gaps and to prioritise research requirements to address them; and
- To identify researchers and facilities where the research may be conducted to address these knowledge gaps.

Furthermore, our secondary objective is to improve communication, particularly at an international level, on issues related to the protection of the environment from ionising radiation via setting up a virtual network for discussion. It is hoped that this will help to harmonise the approaches being developed and eventually to provide a forum for testing and validating assessment tools.

To help establish these objectives, an interactive website containing a research expertise questionnaire was set up which IUR members and other interested parties were invited to complete.

This report represents the findings of this questionnaire. In total, forty-one respondents provided the information that is summarized in the report below. Researchers were asked their opinions of environmental ionizing radiation research deficiencies and priority areas for future R&D programmes. These knowledge gaps where split into five areas:

- the need for frameworks or approaches for the protection of the environment (1 statement, 4 opinions);
- transfer of radionuclides in the environment;
- effects of ionizing radiation on biota;
- dosimetry, and
- gaps in the assessment frameworks to demonstrate protection of the environment from ionizing radiation.

The need for frameworks or approaches for the protection of the environment
For this category the majority of respondents felt that the ICRP 60 statement should be questioned and that the statement is not proven. Therefore, by inference frameworks and approaches to demonstrate protection are required (as suggested by the final statement).

Two separate methods were used to prioritise the statements within the latter four categories. The most imperative knowledge gaps from each of these areas were identified by each method and are as follows:

Transfer of radionuclides in the environment
Method 1.

1. We need to better understand the processes that determine how radionuclides transfer through an ecosystem
2. We need to better understand and estimate uncertainties in the transfer factors
3. We need to better understand the role chemical speciation plays in determining how radionuclides transfer through ecosystems
4. We need to determine transfer factors for particular radionuclides and biota

Method 2.

1. We need to better understand the processes that determine how radionuclides transfer through an ecosystem
2. We need to better understand and estimate uncertainties in the transfer factors
3. We need to better understand the role chemical speciation plays in determining how radionuclides transfer through ecosystems
4. We need to consider dynamic modeling techniques to predict radionuclide transfer through an ecosystem under short term, transient releases

Effects of Ionising Radiation on Biota

Method 1.

1. We need to understand the interaction between ionising radiation and other non-radioactive chemical stressors, non-ionising radiation and environmental stressors
2. We need to understand more about how radiation induces biological damage (e.g. genomic instability, bystander effect)
3. We need to undertake radiation exposure studies on different biota groups (e.g. amphibians, fish, reptiles)
4. We need to understand whether localized exposure (e.g. to organs) is important in terms of demonstrating protection from exposure to ionising radiation
5. We need to establish no observed effect levels for different radiation types for reproductive endpoints in groups of biota

Method 2.

1. We need to understand the interaction between ionising radiation and other non-radioactive chemical stressors, non-ionising radiation and environmental stressors
2. We need to determine the difference between effect and harm
3. We need to understand the indirect ecological effects of exposure to ionising radiation in an ecosystem (e.g. we need to understand how a predator population may respond to an impacted prey population and vice versa)
4. We need to understand more about how radiation induces biological damage (e.g. genomic instability, bystander effect)
5. We need to undertake radiation exposure studies on different biota groups (e.g. amphibians, fish, reptiles)

Dosimetry

Method 1.

1. We need radionuclide retention models for different biota (will this affect the dose to the organism or perhaps their organs)
2. We need to undertake quality assurance on the dosimetry approaches that have been proposed or are in use
3. We need to evaluate the uncertainties associated with the different dose per unit concentration factors that have been proposed or are in use
4. We need to conduct experiments to determine the relative biological effectiveness (RBE) of different radiation types on different biota

Method 2.

1. We need to undertake quality assurance on the dosimetry approaches that have been proposed or are in use
2. We need to evaluate the uncertainties associated with the different dose per unit concentration factors that have been proposed or are in use
3. We need radionuclide retention models for different biota (will this affect the dose to the organism or perhaps their organs)
4. We need to conduct experiments to determine the relative biological effectiveness (RBE) of different radiation types on different biota

Gaps in the Assessment Frameworks to Demonstrate Protection of the Environment from Ionising Radiation

Method 1.

1. We need to provide better estimates of uncertainty in the assessment
2. We need information on spatial and temporal averaging of radionuclide distributions
3. We need to better understand how the variation in background/natural radiation rates may influence any assessment
4. We need to validate the assessment tool and the overall approach
5. We need to consider alternatives to doses e.g. ambient concentrations, body burden etc…

Method 2.

1. We need to provide better estimates of uncertainty in the assessment
2. We need to validate the assessment tool and the overall approach
3. We need more basic ecological data to allow us to measure/predict changes that are already occurring
4. We need to assess the limitations of extrapolation tools
5. We need information on spatial and temporal averaging of radionuclide distributions

The report also describes the research interests, capabilities and facilities of forty-one laboratory and research groups. These organizations are:

1. Bangladesh Atomic Energy Commission, Bangladesh
2. Belgian Nuclear Research Centre, Belgium
3. Canadian Nuclear Safety Commission, Canada
4. Center for Ecological -Noosphere Studies of the National Academy of Sciences of Armenia, Republic of Armenia
5. Centre for Ecology and Hydrology, UK
6. Centro de Estudios Ambientales de Cienfuegos, Cuba
7. CIEMAT (Research Centre for Energy, Environment and Technology), Spain
8. Democritus University of Thrace, Greece
9. ECOMAtters Inc., Canada
10. Environment Agency, UK
11. Enviros Consulting Ltd., Scotland
12. Fisheries and Oceans Canada, Canada
13. Food Standards Agency, UK
14. Georgian Institute of Agroradiology and Ecology, Georgia
15. Health Protection Agency, UK
16. IAEA - Marine Environment Laboratory, Monaco
17. Institute for Environmental Sciences, Japan
18. Institute of Biology, Komi Scientific Center, Ural Division of RAS, Russia
19. Institute of Industrial Ecology, Russia
20. Institute of Nuclear Energy Research , Taiwan
21. Institute of Radioprotection and Nuclear Safety, France
22. Instituto de Radioproteção e Dosimetria-Comissão Nacional de Energia Nuclear (IRD-CNEN), Brazil
23. iThemba Laboratory for Accelerator Based Sciences, South Africa
24. Loughborough University, UK
25. McMaster University, Canada
26. National Institute of Radiological Sciences Japan, Japan
27. Newcastle University, UK
28. Norwegian Radiation Protection Authority, Norway
29. Norwegian University of Life Sciences, Norway
30. Riso National Laboratory, Denmark
31. SENES Oak Ridge, Inc., Center for Risk Analysis, USA
32. SKB (Swedish Nuclear Fuel and Waste Mngmt Co), Sweden

33. SPA "TYPHOON", Russia
34. The Centre for Environment, Fisheries & Aquaculture Science (CEFAS), UK
35. The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Poland
36. UMR5805 EPOC, France
37. Università Cattolica del Sacro Cuore, Faculty of Agricultural Sciences, Italy
38. University of Bern, Switzerland
39. University of Georgia, USA
40. University of Novi Sad, Faculty of Sciences, Serbia and Montenegro
41. Westlakes Scientific Consulting Ltd., UK

Contents

Introduction

The IUR Taskgroup on Protection of the Environment from Ionising Radiation

Following the publication of the Taskgroup's report "Protection of the Environment: Current Status and Future Work" (IUR, 2002)[1] the main emphasis of this task group changed to one that focuses on the identification and prioritisation of the research requirements in the field of protection of the environment from ionising radiation. The international organizations (UNSCEAR, EU, IAEA, ICRP, OECD/NEA) are currently coordinating their efforts in this field and following the Stockholm conference in 2003[2] the IUR has taken on the role of identifying and filling data gaps and uncertainties whilst the others have taken on the following:

- UNSCEAR – Review of the current publications and production of available data on the exposure (dose) and effects of radiation on biota
- ICRP – Formulation of the framework for the protection of the environment on the basis of best available knowledge and technologies as reviewed by UNSCEAR
- IAEA – Implication of the framework of environmental protection as recommended by the ICRP and the setting of standards

The IUR has recognized a pressing need to identify and help to address, through innovative research, knowledge gaps that affect our ability to make scientifically defensible decisions and risk assessments regarding the biological impact of ionising radiation released in to the environment. There is a need to identify all the key issues and to address those that are of highest priority in allowing the development of suitable assessment tools and to provide the science that underpins the acceptance of these tools in society. Therefore, this task group has the following primary objectives:

- To identify knowledge gaps and to prioritise research requirements to address them; and
- To identify researchers and facilities where the research may be conducted to address these knowledge gaps.

Furthermore, our secondary objective is to improve communication, particularly at an international level, on issues related to the protection of the environment from ionising radiation via setting up a virtual network for discussion. It is hoped that this will help to harmonise the approaches being developed and eventually to provide a forum for testing and validating assessment tools.

To help establish these objectives, an interactive website containing a research expertise questionnaire was set up which IUR members and other interested parties were invited to complete.

It must be noted that the results of this questionnaire reflect a snapshot of the current situation. Environmental protection is not a static issue and is changing constantly.

Time Frame

The process to generate the questionnaire and prepare this report was conducted on the following timescale:

- Initial discussions on the requirements for the interactive website (June - August 2004).

[1] IUR (2002) Protection of the Environment: Current Status and Future Work. International Union of Radioecology Report 3. 23pp. Task Group Chairs: Strand P. and Oughton D. Report contributors: Brechignac F., Brown J., Copplestone D., Domotor S., Howard B., Hunter G., Mobbs H., Oughton D., Pentreath J., Robinson C., Woodhead D., Zhu Y.

[2] The International Conference on the Protection of the Environment from the Effects of Ionizing Radiation Stockholm October 2003

- A core group discussed and prepared the questions to appear on the website. An invitation was made to identify interested parties and IUR members who would participate in the review of the information received (September 2004).
- Interactive website and data collection started (December 2004) for both the available facilities and researchers within the IUR membership and information on knowledge gaps.
- Nine to ten month live website period for IUR members and other interested parties to provide ideas and list knowledge gaps (December 2004 to September 2005).
- Review of information received and summary prepared for discussion at task group meeting (April 2005 to September 2005).
- Dissemination of final summary report (January 2006).

Report Structure

This report represents the findings of the questionnaire. The report is split into two sections. The first section is concerned with environmental ionising radiation knowledge gaps and provides priorities for future R&D programmes. The second section lists the research interests and facilities of all the questionnaire respondents.

Report Contributors

The Environmental Ionising Radiation Taskgroup members have prepared this report.

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The Taskgroup members would like to thank the input of David Wilson in data collation and evaluation and report writing.

Knowledge Gaps and Issues – statement summaries to derive future R&D needs and priority areas.

Having identified the need for an assessment framework to be developed for the protection of the environment from ionising radiation, the Taskgroup felt that it was necessary to review the knowledge gaps and uncertainties that are associated with the application of any assessment framework. Given that it is relatively easy to come up with an extensive list of potential issues that need to be addressed, it was felt that there needs to be some order to the research to address the areas of most concern first. Consequently, IUR members and other interested parties were asked, via a web-based questionnaire, for their opinions on a series of statements relating to knowledge gaps within environmental ionising radiation research. The statements were split into five categories:

- the need for frameworks or approaches for the protection of the environment (1 statement, 4 opinions);
- transfer of radionuclides in the environment (9 statements);
- effects of ionising radiation on biota (17 statements);
- dosimetry (8 statements), and
- gaps in the assessment frameworks to demonstrate protection of the environment from ionising radiation (19 statements).

Respondents were asked their opinion on the following ICRP 60 statement:
'If human is adequately protected, then other non-human species (organisms) are likely protected sufficiently? (ICRP 60,1990).' The opinions were captured by asking the respondents to agree or disagree with four given opinions. The responses are provided in the relevant section below.

The remaining statements required respondents to rate each statement on a scale of 1-5, based on whether the respondent strongly agreed (1), agreed (2), neither agreed nor disagreed (3), disagreed (4) or strongly disagreed (5) with the statement. The statements were generated by agreement with the IUR protection of the environment from ionising radiation Taskgroup members.

The summary of the statements and responses for each category are found in Figs 1-4. Forty-one responses were received in total, although not every respondent answered each question. The number of respondents to each individual question can be found in the Appendix 1.

In order to assist with the direction of future research programmes, the statements were ranked in order of priority within each category, using two separate methods. The first method used the choices of top three priorities made by the respondents at the end of each category, the second used the answers to each individual statement.

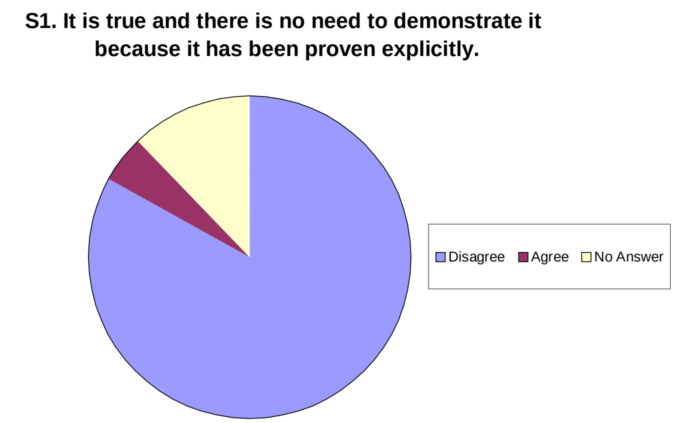
Method 1. At the end of each category, respondents were asked to list their top three priorities from the preceding category. The number of times a particular statement was listed as 1st, 2nd and 3rd priority was added up, and this was turned into a ranking score by multiplying each value by x3 (for number of 1sts), x2 (for number of 2nds), and x1 (for number of 3rds).

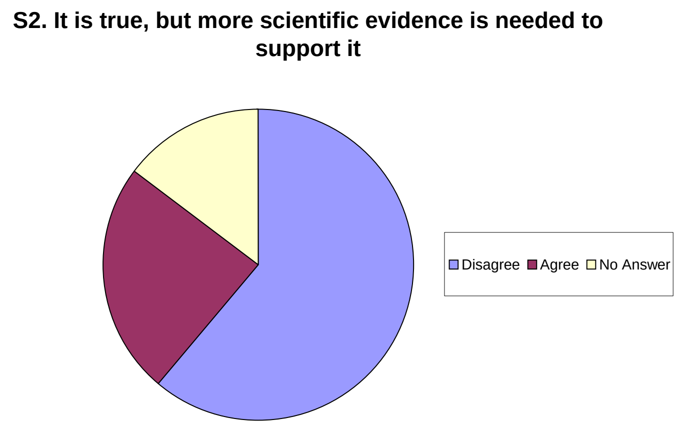
Method 2. The second method to create a priority list for each category was similar to the one used in the Taskgroup for Multipollution context report (*in press*). Priority rankings for each statement within a category were calculated by attaching a score to each rating, and adding these scores up. The scores were: strongly agree = 2; agree = 1; neither agree nor disagree =0; disagree = -1; and strongly disagree = -2. As the number of respondents was different for each statement, the total score for each statement was divided by the number of respondents for that statement. Therefore, the total score for each statement could range between -2 (all strongly disagrees) to 2 (all strongly agrees).

Comparisons of the score generated by method 1 should not be made to prioritise between statements between categories, however scores generated by method 2 could be used for this purpose.

Full details of the breakdown of response to each statement are given in Appendix 1.

The Need for Frameworks or Approaches in the Protection of the Environment





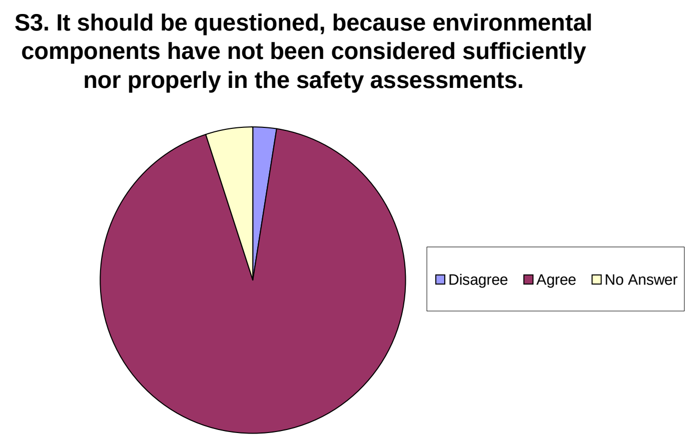


Fig 1. Summary of responses to the need of frameworks in the protection of the environment.

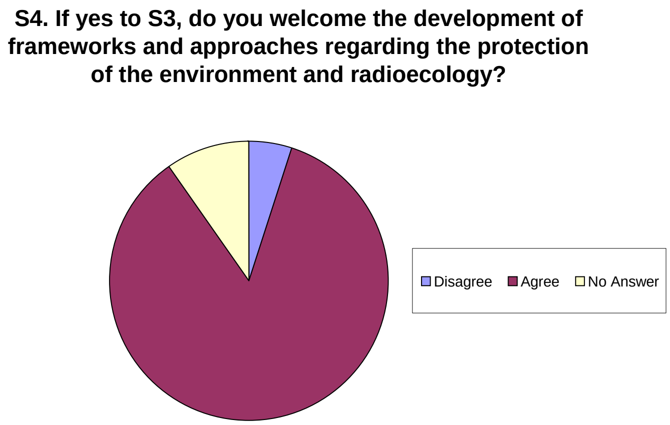


Fig 1 cont.

The majority of respondents (Figure 1) felt that the ICRP statement should be questioned and that the statement is not proven. Therefore, by inference frameworks and approaches to demonstrate protection are required (as suggested by the final statement).

Transfer of Radionuclides in the Environment

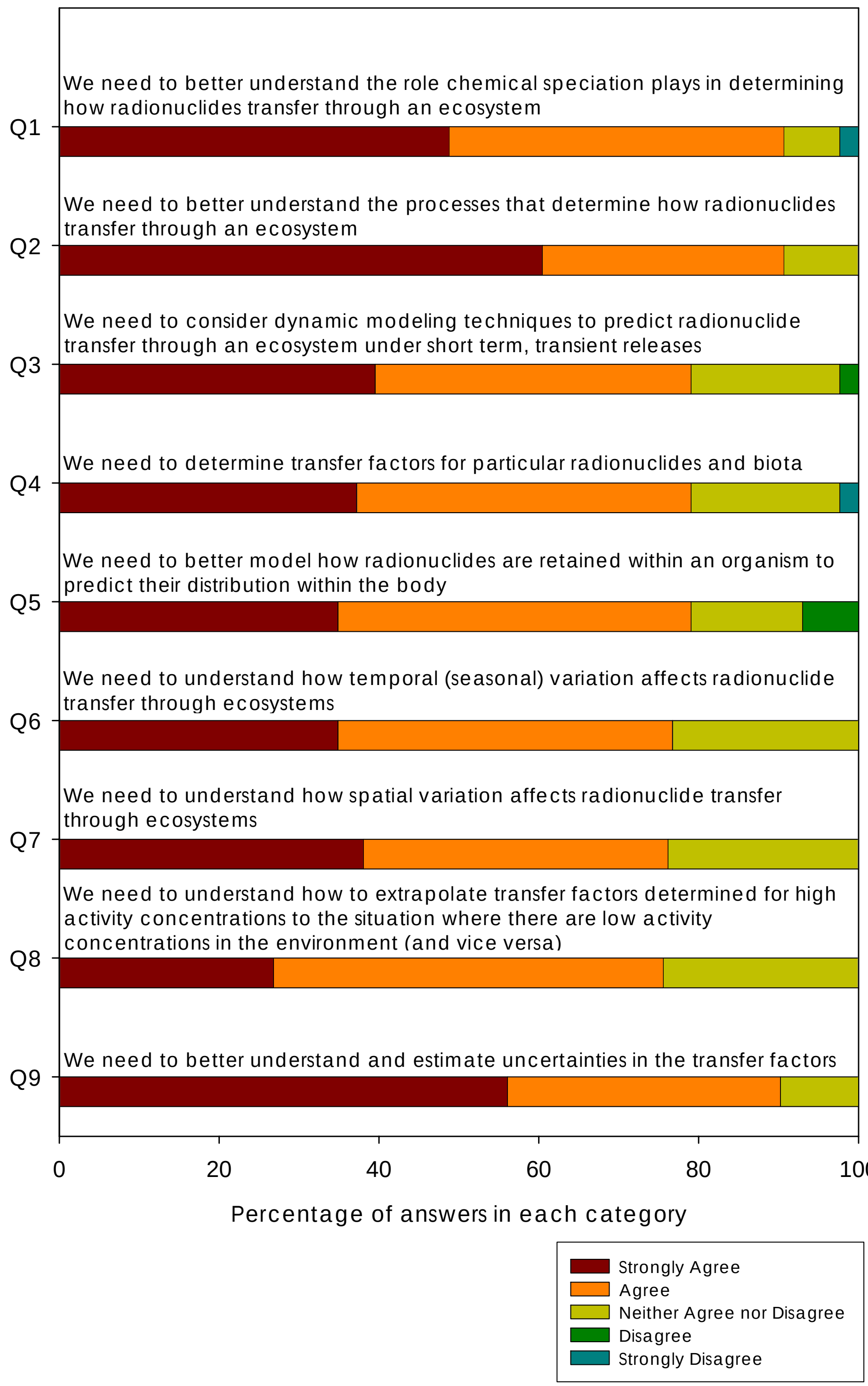


Fig 2. Summary of responses to proposed research knowledge gaps within transfer of radionuclides in the environment category.

The majority of responses (Figure 2) to all statements within this category were positive (either strongly agree or agree). At least 76% of respondents agreed with all statements. Only four of the statements received any negative responses, with statement 5 being the most disagreed with at only 7%, corresponding to 3 out of 41 respondents. A number of comments given by respondents were received to qualify these responses:

- Despite statement 1(understanding how chemical speciation affects transfer), statement 2 (the processes that determine transfer), and statement 4 (determine transfer factors for particular radionuclides and biota) all receiving strong agreement from respondents (91%, 91% and 79% of all respondents either agreed or strongly agreed with these statements respectively), they all received a common criticism however which is that the gaps in the understanding of radionuclide transfer isn't as high a priority when compared to the gaps in understanding concentration factors when undertaking assessments.
- It should be pointed out that statements 1 and 2 also received supporting comments. For statement 1, understanding the role that chemical speciation played is especially important for complex radionuclides, such as Pu and Am. It was also noted that 'radioecological sensitivity should be surveyed with environmental stochasticities'. For statement 2, better understanding of radionuclide transfer would result from reconciling modeling with experimental results. Also the subject would be made simpler by just concentrating on finding the key process involved in radionuclide transfer.
- Further caveats were added for statement 4. Firstly, that the real issue is variability, where there are many measurements. Secondly, one respondent agreed with the statement if phrased for site specific problems, but thought the task too vast to do in a generic way. Despite this, a number of situations were suggested were transfer factors were important: various nuclides passed in bird guano; divalent metal ions and molluscs; and for neptunium. Finally, encouragement was received to include as many radionuclides and biota as possible.
- It was thought that statement 3 (using dynamic models to predict transfer under short term, transient releases) 'may become an important part of the assessment process'. Also that researchers 'must transcend the common transfer approach'. However it was suggested a blanket approach to this subject was not necessarily appropriate, as 'it depends on the nuclides and their decay factors'.
- The comments received for statement 5 (modeling radionuclide retention within an organism) were mixed. On the one hand, it was thought not to be very important as 'we are working on doses to whole organisms'. On the other hand, it was suggested that 'biokinetic modeling is the way forward'. A method of achieving this was suggested by looking at 'the coefficient of accumulation in plant tissue'. Also, it was stated that essentially what was required was 'biophysical and biochemical data'.
- Statements 6 and 7 dealt with seasonal and spatial variation. One respondent felt that seasonal variation would be difficult to model but there were already plenty of good models available for spatial variation. However, despite receiving further support for the need to understand spatial variation, another respondent felt it was a very difficult task. There was also a warning about making things too complex: simplification is also needed. Finally in response to these two statements, a respondent listed 'plutonium, americium, hot particles (erosion, corrosion and metal-passivation with bases)' as being of particular interest/difficulty within this context.
- Although agreeing with statement 8 (extrapolating transfer factors between high and low activity concentrations), one respondent urged that 'we need to understand the uncertainties potentially included in the "extrapolation"'. One situation where extrapolation was deemed important was 'radioactive fallout from the sixties (erosion of soil and migration depending of orography)'.
- Many comments were received suggesting that statement 9 (understand and estimate uncertainties in the transfer factors) was very important. It was stated that 'variability is too great and is the main cause of uncertainty in assessments', and it was suggested that the uncertainties in models and predictions should also be included in this statement.

Finally, it was suggested that: 'We need to reconcile field data with modeling data in self-consistent models for key radionuclides and species, generating interpretation of functional models in terms of biological processes. The challenge is to broaden from key nuclides and species to a general representation of the ecosystem and its interrelationships (integrated dynamic ecological modeling) capable of short and long-term endpoint determinations. Only in this way can we improve assessment of environmental impact / doses to biota from its currently simplistic form to one that is more realistic.'

In order to assist with the direction of future research programmes, the findings show that the top four knowledge gaps within the area of radionuclide transfer in the environment are:

Method 1. (Method 2 positions in brackets after the statement)

Rank	Statement No.	Score	Statement
1	2	49	We need to better understand the process that determine how radionuclides transfer through an ecosystem (1)
2	9	33	We need to better understand and estimate uncertainties in the transfer factors (2)
3	1	30	We need to better understand the role chemical speciation plays in determining how radionuclides transfer through ecosystems (3)
4	4	24	We need to determine transfer factors for particular radionuclides and biota (6)

(Full list: 2, 9, 1, 4, 3, 5, 6, 7, 8)

Method 2. (Method 1 positions in brackets after the statement)

Rank	Statement No.	Score	Statement
1	2	1.51	We need to better understand the process that determine how radionuclides transfer through an ecosystem (1)
2	9	1.46	We need to better understand and estimate uncertainties in the transfer factors (2)
3	1	1.35	We need to better understand the role chemical speciation plays in determining how radionuclides transfer through ecosystems (3)
4	3	1.16	We need to consider dynamic modeling techniques to predict radionuclide transfer through an ecosystem under short term, transient releases (5)

(Full list: 2, 9, 1, 3, 7, 4, 6, 5, 8)

In addition to these deficiencies, a number of radionuclide transfer knowledge gaps were proposed for consideration:

- Need to have more bioindicators.
- Make use of free-living species.
- Look at the value of using birds.
- Use year round non-destructive monitoring.
- The radiation effect on processes within plant organism.
- The radiation effect on abnormalities in plant.
- We need to settle the matter of radiation weighting factors in biota.
- There is already much radioecological data - what we need is to interpret and model the results using an integrated ecosystem approach.
- Natural sources of irradiation, including occupational exposure, drinking water, influence of chemical form in foodstuffs, organism response to natural radiation fields.
- Effects of mixed contaminants that include radiation.

Effects of Ionising Radiation on Biota

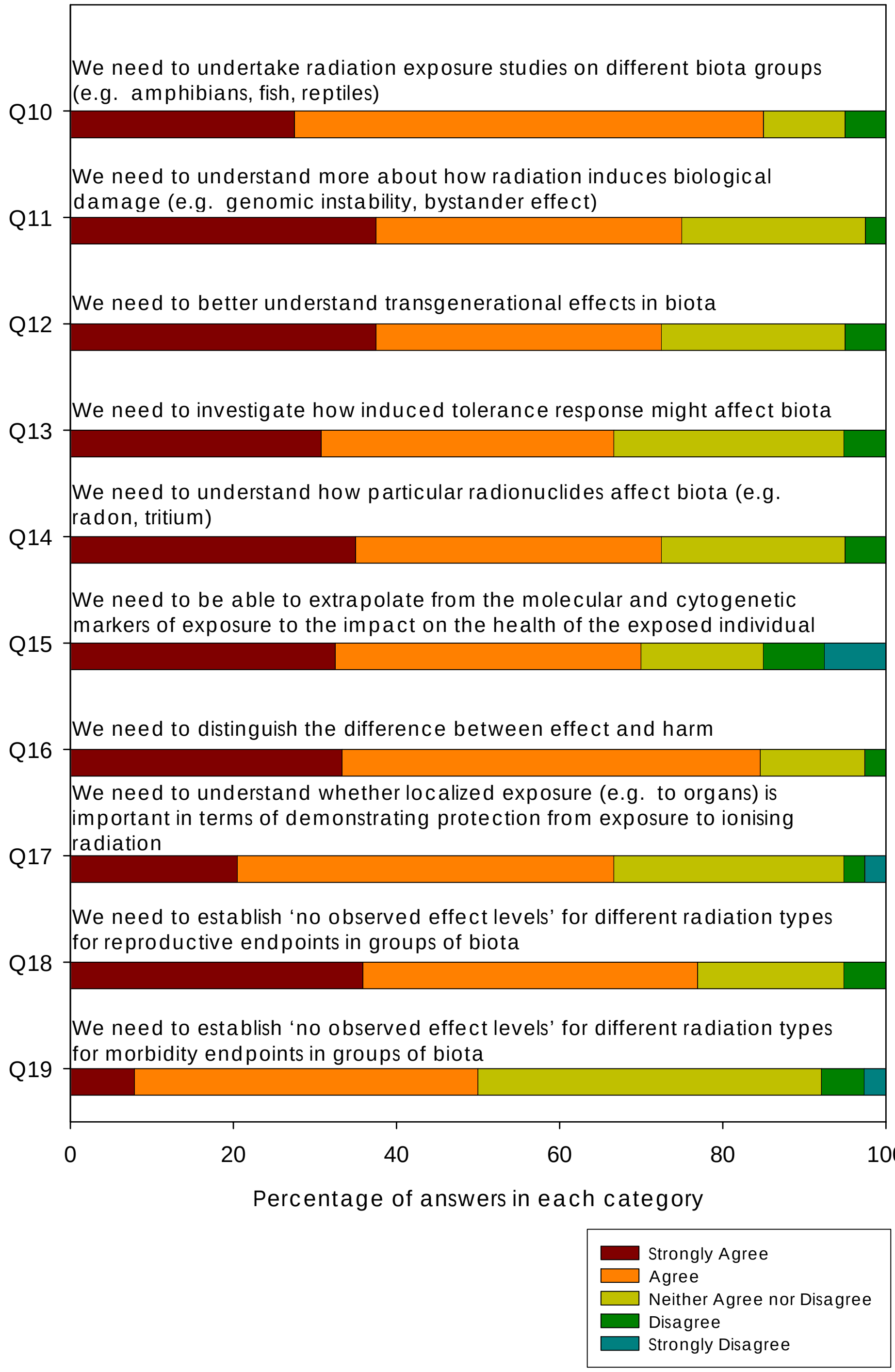


Fig 3. Summary of responses to proposed research knowledge gaps within effects of ionising radiation on biota.

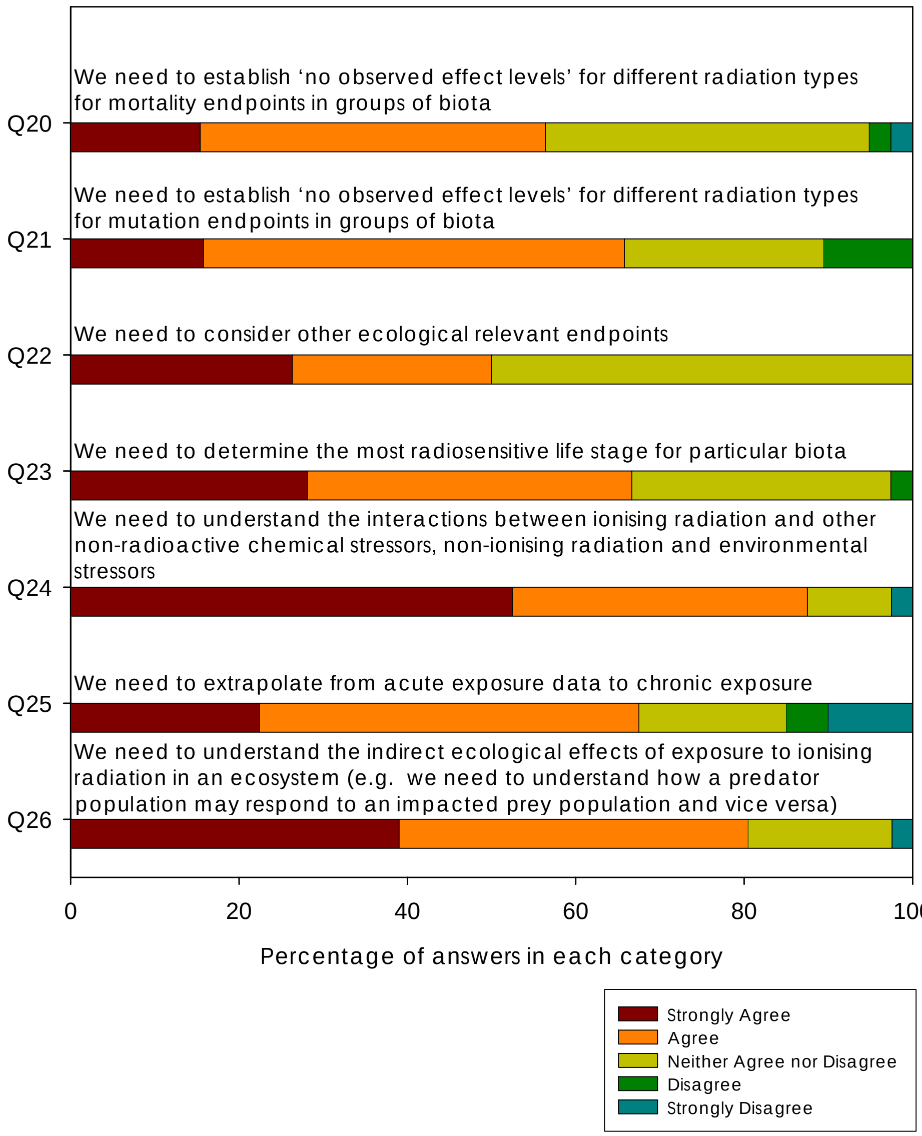


Fig 3. Cont.....

The resp ire were more varied than the section on radionuclide transfer. There were still many positive responses as before, e.g. statements 24 (87.5% of responses either agree or strongly agree), 10 & 16 (85%) and 26 (80%), but almost every statement had some negative responses (either disagree or strongly disagree); only statement 22 had no negative response at all. Furthermore, in some cases the negative responses formed a relatively large proportion of the total, e.g. statements 21 (11% of responses either disagree or strongly disagree), and 15 & 25 (15%). Finally, some of the statements only generated a response of indifference (neither agree nor disagree), e.g. statements 20 (38% of the responses neither agree nor disagree), 19 (42%) and 22 (50%). A number of comments were received to qualify these responses.

- In response to statement 10 (we should undertake radiation exposure studies on different biota groups, one respondent suggested that 'within the FASSET project a number of wildlife groups were identified where there was insufficient information to understand the effects of ionising radiation. Not all groups will need work but, for example, amphibians and reptiles should be considered as a priority'. Another group of biota proposed for further consideration was plants.

- Comments on statement 11 (understand more about how radiation induces biological damage suggests that as there are already some biological effects present in some wildlife groups not fully understood, which should be prioritized ahead of understanding the mechanisms behind them. However, if those mechanisms could be generalized across all biota groups, then this would significantly broaden our understanding of radiation effects.
- Whilst agreeing with statement 12 (understand transgenerational effects), especially in the laboratory, one respondent suggested that 'in the field it is expected that the level of effects will be in equilibrium with the level of exposure and therefore transgenerational effects may already be at equilibrium and captured in the effects data available.
- It was suggested for statement 13 (investigate how induced tolerance response affect biota), that the negative effects of ionising radiation on the environment should receive priority.
- As for statement 4 in the previous section, one response to statement 14 (understand how particular radionuclides affect biota), agreed only when the statement was phrased within a site-specific problem context, but not one expressed generically. Another general response stated that 'there are so many radionuclide/biota combinations so whilst it would be nice to be able to do combination studies there is much work be done on understanding the effects of radiation in total first. There may be specific examples e.g. tritium in flounder in Cardiff Bay that have become particular issues and thus these should be investigated automatically'. There were also a number of suggested samples to consider: e.g. polonium in marine biota, caesium, strontium, plutonium; alpha emitters in almost any ecosystem; polonium, radium and uranium; tritium, carbon-14, caesium, argon, xenon, krypton, strontium; and nuclides related to nuclear facilities (fuel processing plant etc).
- Responding to statement 15 (extrapolating from molecular and cytogenetic markers of exposure to the impact on the health of the exposed individual), one respondent warned that 'to enable biomarkers to be used as an early warning system we need to understand what the biological consequence of the results of biomarker studies are'. Another respondent disagreed with the statement suggesting that it should be altered to read 'on the health of the exposed population'.
- One respondent agreed with statement 16 (difference between effect and harm), stating that harm is what should be considered during assessments.
- Expanding on statement 17 (whether localized exposure is important in demonstrating protection from ionising radiation), one respondent suggested that 'radionuclide concentrations in organs of biota are not normally measured due to cost. What would be nice would be to take one species, for example, to see if there are any differences in effects between whole organism radiation exposure and organ specific radiation exposure'. However, another respondent suggested that the focus should be placed upon reproductive organs.
- There was a common response in disagreement with statements 18, 19, 20 and 21 (dealing with no observed effect levels for different radiation types for reproductive, morbidity, mortality and mutation endpoints respectively). The respondents suggested that for all four statements, full dose-effect responses would be better employed than no observed effect levels. However there were supporting responses for all four of these statements as well e.g. for statement 18, which was considered an important key knowledge gap (as identified by the FASSET D4 document, e.g. amphibians, reptiles). Other biota groups suggested were; model species, plants, and reference organisms (ICRP, FASSET). For statements 19, 20, and 21, it was suggested that the work required could be combined with the experiments needed for reproductive endpoints, anticipating that the mortality endpoint experiments will not be critical for exposure studies, and that the relationship between the mutation and reproduction endpoints would be particular useful as an early warning indicator. Another response supporting statements 19, 20 and 21 suggested that there was a need to establish no observed effect levels for humans for medical and biological research as well.

- Despite the large number of respondents neither agreeing nor disagreeing with statement 22 (considering other ecological relevant endpoints), there were a large number of suggestions for consideration: e.g. for validation purposes we should look for biodiversity, structural and functional indices; no observed effect level for edificator species; population growth rates, element cycling (e.g. N); abundance, plant cenosis; resource allocation; ecosystem stability: e.g. determination of NOEL on functioning (e.g. numbers (biomass) in the different groups, their activity measured in O2 uptake) in small defined ecosystems (e.g. microcosms, mesocosms); transgenic biota / mutagenic effects control; and, combined effects with environmental agents and disturbances.
- In support of statement 23 (most radiosensitive life stage for particular biota), one respondent suggested that 'some experiments to establish if there are highly sensitive life stages in different wildlife groups would be useful - it might allow us to generate extrapolations to ensure risks are minimised when undertaking assessments. Which species is open for debate and is likely to focus on species that can be used experimentally. As with statements 19, 20, and 21, it was also suggested that there was a need to establish no observed effect levels for humans for medical and biological research. However, one respondent disagreed with the statement, suggesting that although it may be of interest any results would be misleading.
- Two comments supported statement 24 (interactions between ionising radiation and non-radioactive stressors). They suggested that the gradients in effects are also important, and that this statement becomes important as the framework approach develops.
- One respondent posed 'is this possible?' in response to statement 25 (extrapolate from acute to chronic exposure). In support of the statement, other respondents suggested this was 'important since most of our data are for acute exposure', and that 'this might allow us to utilize more of the existing effects data in the literature. However, balancing this, it was suggested that it 'would be better to know what the actual consequences of chronic exposure are'.
- The final statement in this section, statement 26 (understand the indirect ecological effects of exposure to ionising radiation in an ecosystem) was supported by a couple of respondents, stating that this was important as experience shows that surprises usually come from indirect effects, and that this could be best achieved through the use of population models.

In order to assist with the direction of future research programmes, the findings show that the top five knowledge gaps within the area of the effects of ionising radiation on biota are:

Method 1. (Method 2 positions in brackets after the statement)

Rank	Statement No.	Score	Statement
1	24	31	We need to understand the interaction between ionising radiation and other non-radioactive chemical stressors, non-ionising radiation and environmental stressors. (1)
2	11	23	We need to understand more about how radiation induces biological damage (e.g. genomic instability, bystander effect) (4)
3	10	18	We need to undertake radiation exposure studies on different biota groups (e.g. amphibians, fish, reptiles) (5)
4	14	17	We need to understand whether localized exposure (e.g. to organs) is important in terms of demonstrating protection from exposure to ionising radiation (8)
5	18	13	We need to establish no observed effect levels for different radiation types for reproductive endpoints in groups of biota (7)

(Full listing: 24, 11, 10, 14, 18, 23, 15, 16, 12, 25, 19, 26, 13, 17, 20, 22, 21)

Method 2. (Method 1 positions in brackets after the statement)

Rank	Statement No.	Score	Statement
1	24	1.35	We need to understand the interaction between ionising radiation and other non-radioactive chemical stressors, non-ionising radiation and environmental stressors (1)
2	16	1.154	We need to determine the difference between effect and harm (8)
3	26	1.146	We need to understand the indirect ecological effects of exposure to ionising radiation in an ecosystem (e.g. we need to understand how a predator population may respond to an impacted prey population and vice versa) (12)
4	11	1.10	We need to understand more about how radiation induces biological damage (e.g. genomic instability, bystander effect) (2)
5	10	1.08	We need to undertake radiation exposure studies on different biota groups (e.g. amphibians, fish, reptiles) (3)

(Full listing: 24, 16, 26, 11, 10, 12, 18, 14, 13, 23, 15, 17, 22, 21, 25, 20, 19)
In addition to these prioritised knowledge gaps, a number of radionuclide transfer knowledge gaps were proposed for consideration:

- Of critical importance will be to link analytical knowledge (lower levels of organisation, biomarkers, individual dose-effect response curves) to integrated knowledge (ecosystem functioning impairment, long-term shifts, biodiversity erosion) that are both necessary to conduct adequate risk assessment.
- Need to understand, at a broad level, the impacts at all trophic levels of an ecosystem.
- We need to understand how individual level impacts (i.e. biomarkers) relate to population impacts.

Dosimetry

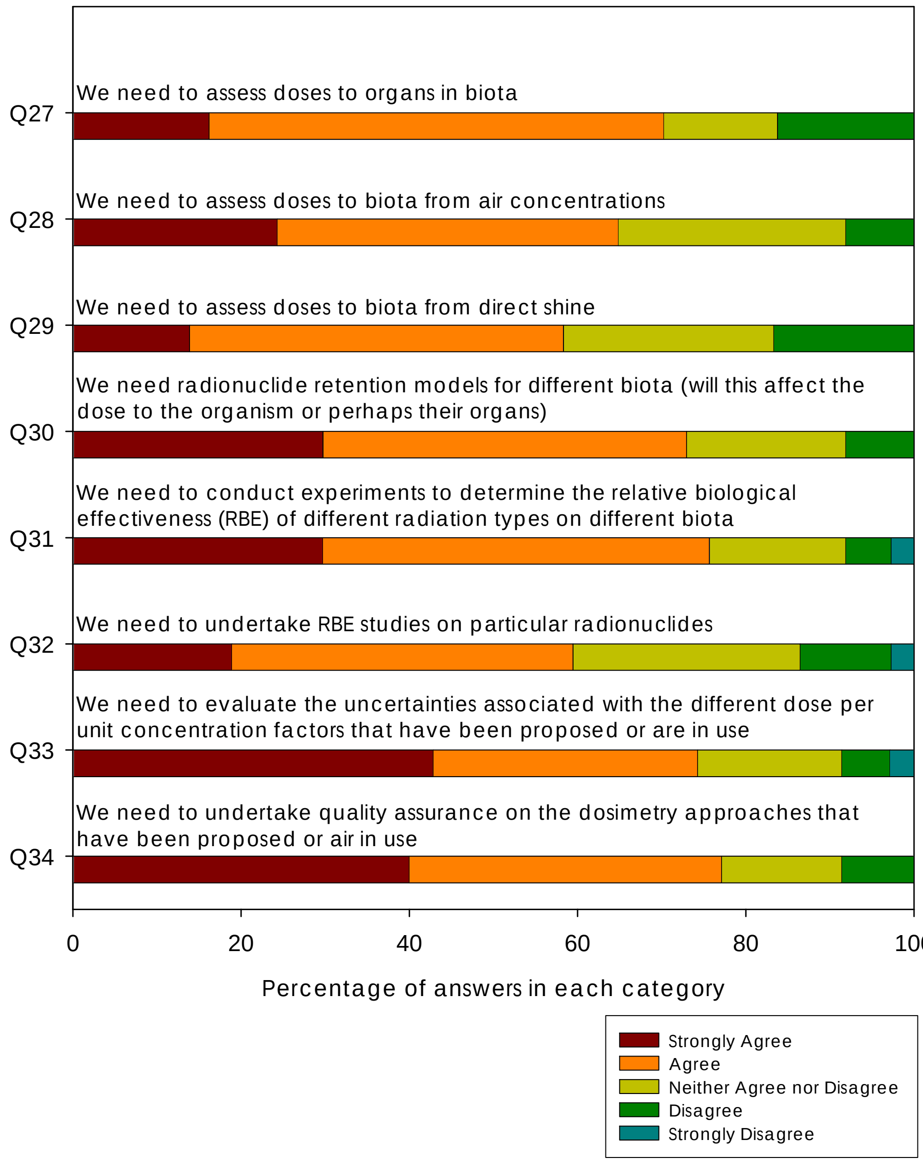


Fig 4. Summary of responses to proposed research knowledge gaps within dosimetry

Every statement within the dosimetry category (Figure 4) received some negative (disagree or strongly disagree) comments; for a number of statements (27, 29, and 32), these formed a substantial percentage of respondents (16%, 17%, & 14% respectively). Positive (agree or strongly agree) still comprised the largest proportion of responses to each statement, but this was not as large a proportion as received for the previous category. The percentage of positive responses ranged from 58% (statement 29) to (statement 34). A number of comments were received to qualify these responses.

- One respondent felt that statement 27 (assess doses to organs in biota) was necessary 'only to check that there aren't any surprises when undertaking safety assessments'.

- In supporting statement 30 (need for radiation retention models for different biota), one respondent felt that researchers should try to adapt already existing models.
- Whilst feeling that statement 31 (conducting experiments to determine RBE of different radiation types on different biota) was not a critical issue, one respondent felt 'it would be worth establishing whether there are any species that are more sensitive that we would expect. Other work is reported in the literature'.
- A number of radionuclides were suggested in response to statement 32 (undertake RBE studies on particular radionuclides): tritium was by far the favourite. The full list of responses is as follows: tritium; caesium-137; uranium-238; radon-222; polonium-210; and carbon-14.
- One respondent felt that statement 33 (evaluate uncertainties associated with different dose per unit concentration factors) was essential. Also supporting the statement, another respondent felt that a 'sensitivity analysis and consideration of the DCCs in use in different assessments would be useful'.
- It was suggested that statement 34 (undertake quality assurance on dosimetry approaches) could be achieved by 'using field based monitoring e.g. putting TLD's on animals etc. to verify that the models work within acceptable bounds'.
- Statements 28 & 29 (assess doses to biota from air concentrations and direct shine respectively) did not receive any qualifying comments.

In order to assist with the direction of future research programmes, the findings show that the top four knowledge gaps within the area of dosimetry:

Method 1. (Method 2 positions in brackets after the statement)

Rank	Statement No.	Score	Statement
1	30	36	We need radionuclide retention models for different biota (will this affect the dose to the organism or perhaps their organs) (3)
2	34	27	We need to undertake quality assurance on the dosimetry approaches that have been proposed or are in use (1)
3	33	26	We need to evaluate the uncertainties associated with the different dose per unit concentration factors that have been proposed or are in use (2)
4	31	23	We need to conduct experiments to determine the relative biological effectiveness (RBE) of different radiation types on different biota (4)

(Full listing: 30, 34, 33, 31, 27, 28, 32, 29)

An additional comment was received concerning the statements on dosimetry. 'Dose to biota models assume simple geometries (e.g. ellipsoidal or cylindrical) and uniform or simple non-uniform distributions. we need to understand the error committed when making these assumptions to organ doses (e.g. Tc in the hepatopancreas and the green gland of the lobster). We also need to understand the uncertainties of applying DCFs to biota to calculate exposure to very small organisms, e.g. phytoplankton, where it is possible that due to the small mass, the amount of radionuclide deposited per organism is so small that the assumption of a continuous dose over relatively short periods of time loses meaning'.

Method 2. (Method 1 positions in brackets after the statement)

Rank	Statement No.	Score	Statement
1	34	1.09	We need to undertake quality assurance on the dosimetry approaches that have been proposed or are in use (2)
2	33	1.06	We need to evaluate the uncertainties associated with the

			different dose per unit concentration factors that have been proposed or are in use (3)
3	30	0.95	We need radionuclide retention models for different biota (will this affect the dose to the organism or perhaps their organs) (1)
4	31	0.95	We need to conduct experiments to determine the relative biological effectiveness (RBE) of different radiation types on different biota (4)

(Full listing: 34, 33, 30, 31, 28, 27, 32, 29)

Gaps in the Assessment Frameworks to demonstrate protection of the environment from ionising radiation

The responses (Figure 5) to the Assessment Framework gaps statements were mainly positive (either agree or strongly agree), with statements 43 and 53 both receiving 89% positive responses. However, two statements clearly stand out: statement 44, where approximately a third of responses were positive, a third negative (either disagree or strongly disagree), and a third were indifferent (neither agree nor disagree); and statement 50 where positive responses comprised less than 20%, and both negative and indifferent responses were about 40%. Respondents showed were also indifferent to statements 35 and 51 (37%). A number of comments were received to qualify these responses.

- Statement 35 (alternatives to doses e.g. ambient concentrations, body burdens) only received qualified support to simplify the early stages of an assessment. Latter stages should continue to use dose units. Another respondent accepted that this would be easier for implementation, but 'we should first have the link between concentration and harm'.
- One respondent strongly agreed with statement 36 (adequacy of the reference organism approach). Further support suggested that 'reference geometries that can be mixed -and - matched with dose per unit intake would be a more flexible approach enabling a variety of organisms to be assessed'. Also 'relationships between representative, index species and the reference organism should be discussed'.
- In support of statement 37 (variation in background/natural radiation rates influencing assessment) one respondent stated that signal and noise (background radiation) should be identified. Another respondent supported the statement 'for comparative purposes to help deriving the screening levels and also for thinking about the acceptability of a practice in a local area'.
- One respondent suggested that for statement 38 (spatial and temporal averaging of radionuclide distributions), there already existed reasonable models to handle spatial and temporal averaging, but that guidance on the interpretation of these models is needed.
- Supporting statement 39 (consider additional ecosystems in an assessment framework), it was stated that 'where ecosystems contain significantly different transfer pathways or the concentration ratios (CRs) are known to be significantly different the CRs will be needed to modify the default values but guidance on where this is important is needed'.
- Strong support was received for statement 40 (understand short term releases/transient radionuclides), as it would enable us to handle accident scenarios, but another respondent asked if this would not be an effect of acute exposure?
- Whilst strongly supporting statement 41 (basic ecological data allowing measurement/prediction of changes), on respondent warned 'there is too much to do here but it needs to be done. Suggest using a model or case study approach to validate the overall assessments to enable us to predict change'.
- One respondent felt that both statements 42 (communicating framework approaches and results) and 46 (validating the assessment tool and overall approach) were crucial in gaining acceptability.

- In agreeing with statement 43 (better estimates of uncertainty in the assessment), it was stated that methods for considering uncertainty need to be considered and guidance provided.

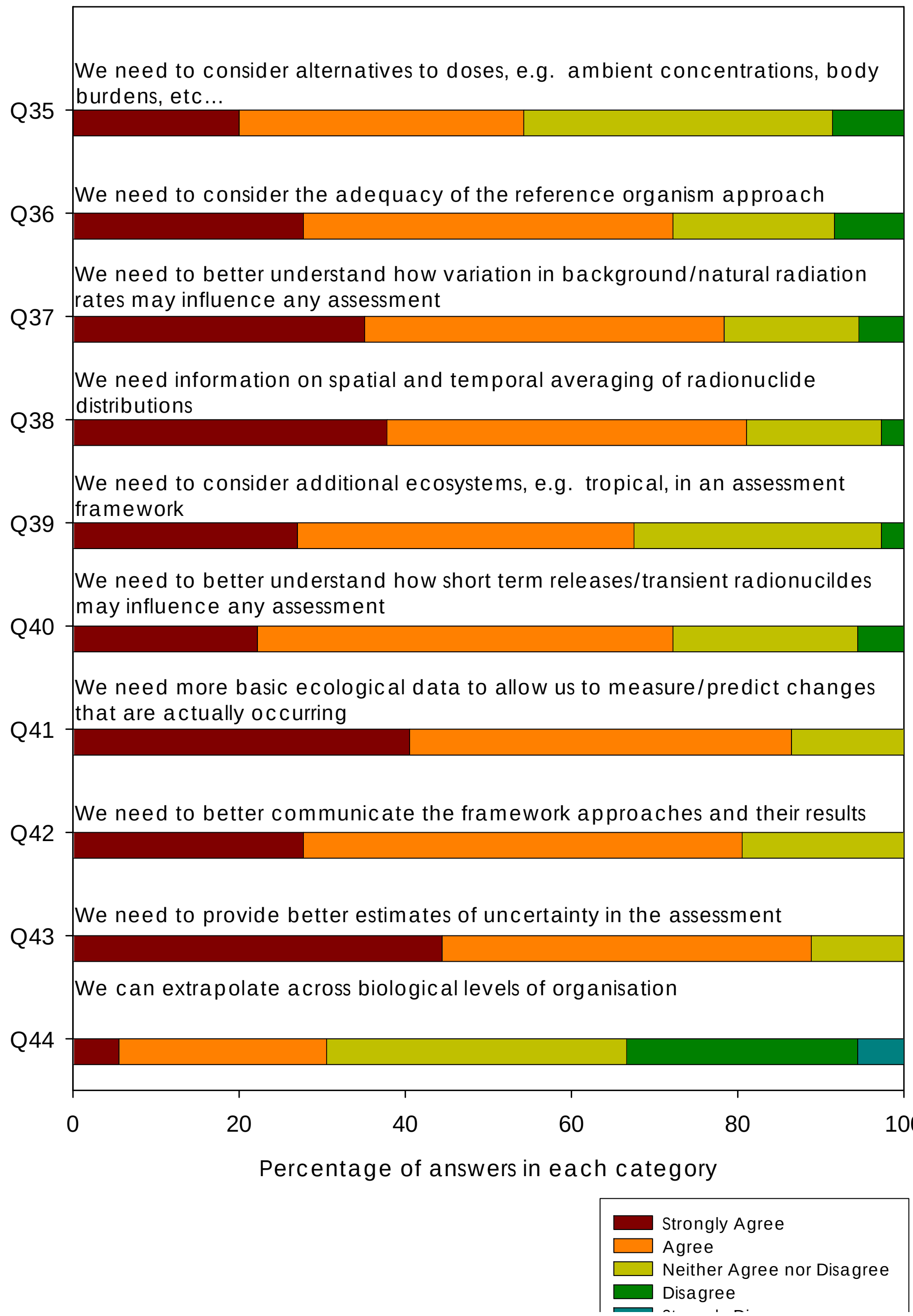


Fig 5. Summary of responses to proposed research knowledge gaps within gaps in the Assessment Frameworks to demonstrate protection of the environment from ionising radiation

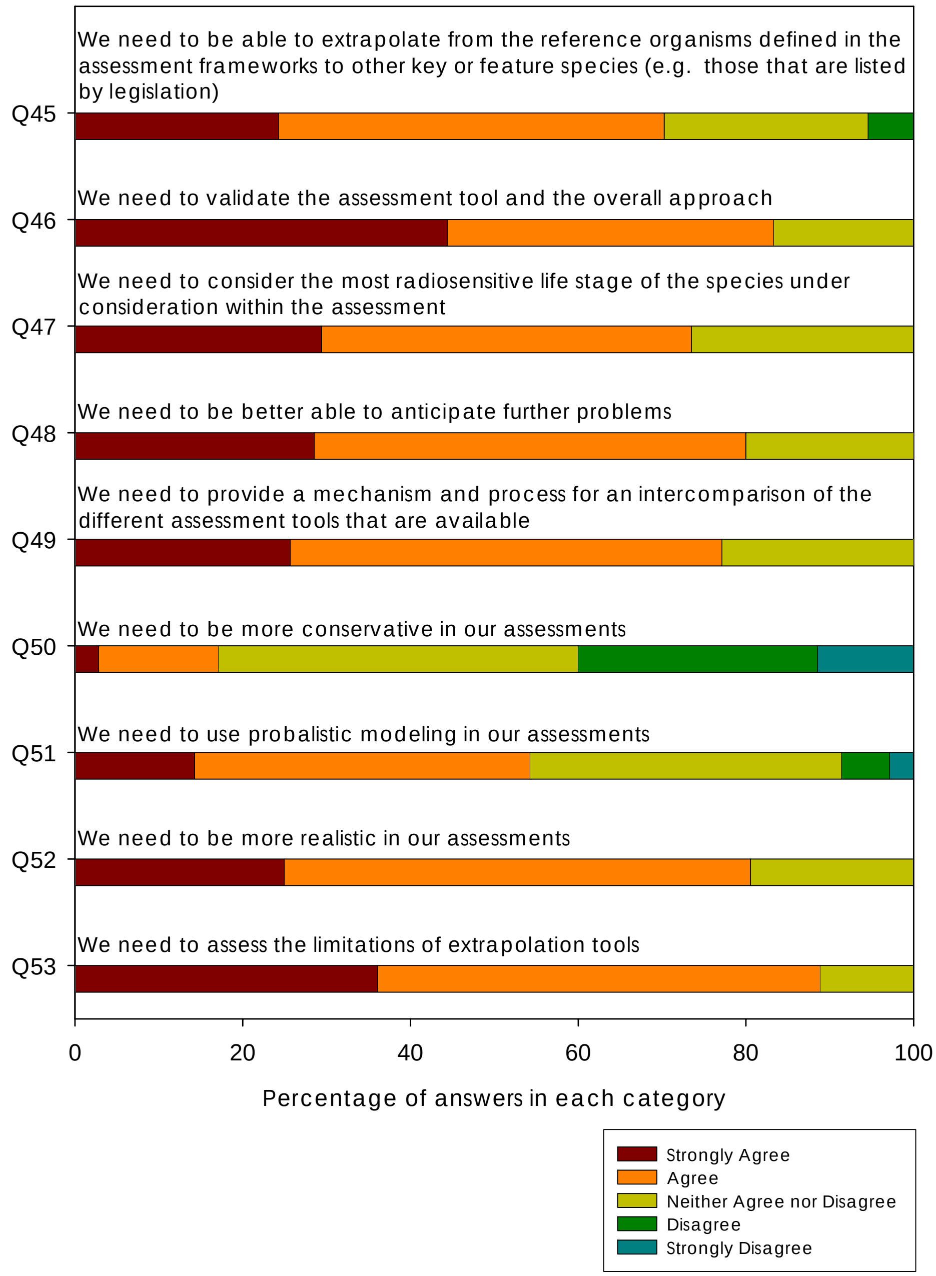


Fig 5. Cont….

- There was not much support for statement 44 (extrapolating across biological levels of organization). Warnings were received that this could only be considered ‘in some concrete cases’ and that when it is done, ‘it should be appropriate and justified’.
- It was suggested that statement 45 (extrapolate form reference organisms to other key or feature species) should be addressed ‘ideally’, and that ‘this might make it easier for people to understand this’.

- One suggestion for statement 47 (considering the most radiosensitive life stage) was that it could be assessed by considering model species and then taking into account any issues in the assessment'.
- In providing support for statement 48 (anticipating future problems), one respondent predicted that these are 'likely to be mixtures'.
- Two respondents strongly supported the need for statement 49 (mechanisms and processes for an intercomparison of different assessment tools) and both stated that the IAEA EMRAS programme is working on this.
- Statements 50 and 52 deal with being more conservative and realistic respectively in assessments. One respondent suggested that 'realistic is much better than conservative estimation of risk'. Another suggests that 'there is a balance between realism and conservatism' which is taken into account by the tiered approach. Finally, a third respondent did not commit to either realistic or conservative approaches, but stated that it depended on the purpose of the assessment.
- It was thought that the use of probabilistic modeling in our assessments (statement 51) 'in many cases would be useful', especially 'to aid our appreciation of the level of risk'.
- Finally a qualification was given for statement 53 (assess the limitations of extrapolation tools): 'extrapolation tools should be used where we have confidence in them - this means understanding their limits and advantages'.

In order to assist with the direction of future research programmes, the findings show that the top five knowledge gaps within the area of dosimetry:

Method 1. (Method 2 positions in brackets after the statement)

Rank	Statement No.	Score	Statement
1	43	21	We need to provide better estimates of uncertainty in the assessment (1)
2	38	18	We need information on spatial and temporal averaging of radionuclide distributions (5)
3	37	16	We need to better understand how the variation in background/natural radiation rates may influence any assessment (8)
4	46	14	We need to validate the assessment tool and the overall approach (2)
5	35	12	We need to consider alternatives to doses e.g. ambient concentrations, body burden etc…(16)

(Full listing: 43, 38, 37, 46, 35, 36, 52, 39, 41, 53, 40, 42, 45, 47, 48, 49, 44, 51, 50)

Method 2. (Method 1 positions in brackets after the statement)

Rank	Statement No.	Score	Statement
1	43	1.33	We need to provide better estimates of uncertainty in the assessment (1)
2	46	1.28	We need to validate the assessment tool and the overall approach (4)
3	41	1.27	We need more basic ecological data to allow us to measure/ predict changes that are already occurring (9)
4	53	1.25	We need to assess the limitations of extrapolation tools (10)
5	38	1.16	We need information on spatial and temporal averaging of radionuclide distributions (5)

(Full listing: 43, 46, 41, 53, 38, 48, 42, 37, 52, 47, 49, 39, 36, 45, 40, 35, 51, 44, 50)

Further comments was received concerning the statements on Assessment Frameworks gaps:

- A two step strategy is proposed: 1- Reference organism approach based methodology to fill a conceptual gap (complying with existing legislation, being able to provide some demonstration level) and acknowledging its limitations (various more or less secure extrapolations); 2- Feed more integrated scientific developments (ecosystem approach) prone to yield an alternative/complementing methodology that would better address the real ecological context.
- Some of the assessment methodologies may be so overly conservative that they could generate concern to the public and are certainly forcing industry and regulators to investigate further where there may not actually be an issue. The use of reference organisms is a too - defined approach that is not transferable between different organisms. A more flexible approach is required.

A number of comments were made on the questionnaire process:

- Questionnaires are very well set. I feel that besides "filling gaps", the "strengthening one's strengths" philosophy should be followed.

Research Interests, Capabilities and Facilities

To facilitate joint working and collaboration amongst environmental ionising radiation researchers, respondents were asked a series of questions about their research interests, capabilities and facilities. Questions were split into two separate areas: the transfer, and the effects of radionuclides. The questions asked where as follow:

Transfer of Radionuclides

The first four questions dealt with ICRP statement 60, 1990: "if human is adequately protected, then other non-human species (organisms) are likely protected sufficiently"

- It is true and there is no need to demonstrate it because it has been proven explicitly
- It is true, but more scientific evidence is needed to support it
- It should be questioned, because environmental components have not been considered sufficiently nor properly in the safety assessments
- If yes, do you welcome the guidance to introduce the outlines of the protection of the environment regarding the radioecology?

Other questions were on:

- Do you conduct studies on transfer processes in the environment?
- Provide details of main experience/strengths, ecosystem studied, and type of biome.
- Do you conduct field studies of radionuclide transfer to biota?
- Provide details of main experience/strengths
- Briefly describe your organisation's facilities providing details of radionuclide isotopes analysed and accreditation status

Effects of Radionuclides

- Do you conduct studies on radiation effects on organisms? (Provide details of main experience/strengths, organism types, type of ecosystem)
- Do you have laboratory facilities for experimental work on terrestrial or aquatic organisms, which allow irradiation or feeding of contaminated foods? (Provide details on facilities, species of interest, and whether any licences to conduct work are in place)
- Have you conducted or would you consider conducting RBE studies? (Provide details)
- Have you conducted radiation effects studies at contaminated field sites? (Provide details)
- Can you make in-house dosimetry measurements? (Provide details)
- Can you undertake experiments where you can manipulate radionuclides within model ecosystems? (Provide details)
- Do you study biomarkers? (Provide details)
- Do you study or have links with other researchers who have, other relevant biological or ecological disciplines? (Provide details)

In total, there were forty-one respondents. A summary of responses concerning the transfer and effects of radionuclides are in Tables 1 and 2 respectively. Full details of all responses can be found in Appendix 2. The organisations that took part in this questionnaire are as follows:

1. Bangladesh Atomic Energy Commission, Bangladesh
2. Belgian Nuclear Research Centre, Belgium
3. Canadian Nuclear Safety Commission, Canada
4. Center for Ecological -Noosphere Studies of the National Academy of Sciences of Armenia, Republic of Armenia
5. Centre for Ecology and Hydrology, UK
6. Centro de Estudios Ambientales de Cienfuegos, Cuba
7. CIEMAT (Research Centre for Energy, Environment and Technology), Spain
8. Democritus University of Thrace, Greece
9. ECOMAtters Inc., Canada
10. Environment Agency, UK
11. Enviros Consulting Ltd., Scotland
12. Fisheries and Oceans Canada, Canada
13. Food Standards Agency, UK

14. Georgian Institute of Agroradiology and Ecology, Georgia
15. Health Protection Agency, UK
16. IAEA - Marine Environment Laboratory, Monaco
17. Institute for Environmental Sciences, Japan
18. Institute of Biology, Komi Scientific Center, Ural Division of RAS, Russia
19. Institute of Industrial Ecology, Russia
20. Institute of Nuclear Energy Research , Taiwan
21. Institute of Radioprotection and Nuclear Safety, France
22. Instituto de Radioproteção e Dosimetria-Comissão Nacional de Energia Nuclear (IRD-CNEN), Brazil
23. iThemba Laboratory for Accelerator Based Sciences, South Africa
24. Loughborough University, UK
25. McMaster University, Canada
26. National Institute of Radiological Sciences Japan, Japan
27. Newcastle University, UK
28. Norwegian Radiation Protection Authority, Norway
29. Norwegian University of Life Sciences, Norway
30. Riso National Laboratory, Denmark
31. SENES Oak Ridge, Inc., Center for Risk Analysis, USA
32. SKB (Swedish Nuclear Fuel and Waste Mngmt Co), Sweden
33. SPA "TYPHOON", Russia
34. The Centre for Environment, Fisheries & Aquaculture Science (CEFAS), UK
35. The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Poland
36. UMR5805 EPOC, France
37. Università Cattolica del Sacro Cuore, Faculty of Agricultural Sciences, Italy
38. University of Bern, Switzerland
39. University of Georgia, USA
40. University of Novi Sad, Faculty of Sciences, Serbia and Montenegro
41. Westlakes Scientific Consulting Ltd., UK

Table 1

Organisation	Conduct Studies on Transfer Processes in the Environment?	Ecosystem Studied			Biomes Studied			Conduct Field Studies of Radionuclide Transfer to Biota?
		Terrestrial	**Marine**	**Freshwater**	**Temperate**	**Tropical**	**Other**	
1. Bangladesh Atomic Energy Commission	✓	✓		✓		T, F		
2. Belgian Nuclear Research Centre	✓	✓			T			✓
3. Canadian Nuclear Safety Commission								
4. Center for Ecological, NASc., Armenia	✓	✓		✓			✓	✓
5. CEH	✓	✓		✓	T, F			✓
6. Centro de Estudios Ambientales de Cienfuegos	✓		✓			M		✓
7. CIEMAT	✓	✓			T			
8. Democritus University of Thrace								
9. ECOMAtters Inc.	✓	✓		✓	T, F,			✓
10. Environment Agency	✓	✓	✓	✓	T, M, F			✓
11. Enviros Consulting Ltd.	✓	✓	✓	✓	T, M, F		✓	✓
12. Fisheries and Oceans Canada	✓		✓		M		✓	
13. Food Standards Agency	✓	✓	✓	✓	T, M, F			
14. Georgian Inst. of Agroradiology and Ecology		✓		✓	T, F			✓
15. Health Protection Agency	✓	✓		✓	T, F			
16. IAEA - Marine Environment Laboratory	✓		✓		M	M	✓	

Table 1 (Cont.)

Organisation		Ecosystem Studied	Biomes Studied	

		Terrestrial	Marine	Freshwater	Temperate	Tropical	Other	
17. Institute for Environmental Sciences	✓	✓			T			
18. Inst. of Biology, Komi Scientific Center								
19. Institute of Industrial Ecology	✓	✓		✓	T, F			
20. Institute of Nuclear Energy Research	✓	✓				T		
21. IRSN	✓	✓	✓	✓	T, M, F	T, M		
22. IRD-CNEN	✓	✓		✓		T, F		✓
23. iThemba Lab. for Accelerator Based Sciences	✓	✓		✓	T, F			✓
24. Loughborough University	✓	✓			T			
25. McMaster University								
26. National Inst. of Radiological Sciences Japan				✓			✓	
27. Newcastle University	✓	✓			T			✓
28. Norwegian Radiation Protection Authority	✓	✓	✓		T, M			✓
29. Norwegian University of Life Sciences	✓	✓	✓		T, M			✓
30. Riso National Laboratory	✓	✓	✓	✓	T, M, F			✓

Table 1 (Cont.)

O r g a n i s a t i o n	P r	Ecosystem Studied			Biomes Studied			a d i o

		Terrestrial	Marine	Freshwater	Temperate	Tropical	Other	
31. SENES Oak Ridge, Inc., Center for Risk Analysis								
32. SKB	✓	✓	✓	✓	T, M, F		✓	
33. SPA "TYPHOON"	✓		✓	✓	M, F		✓	
34. CEFAS	✓		✓		M		✓	✓
35. The Henryk Niewodniczanski Inst. Nuc. Physics	✓	✓	✓		T		✓	
36. UMR5805 EPOC	✓		✓	✓	M, F	M	✓	
37. Università Cattolica del Sacro Cuore	✓	✓			T			
38. University of Bern	✓	✓	✓	✓	T, M, F	T, M, F		
39. University of Georgia	✓	✓		✓	T, F			✓
40. University of Novi Sad, Faculty of Sciences	✓	✓		✓	T, F			✓
41. Westlakes Scientific Consulting Ltd.	✓	✓	✓	✓	T, M, F			✓

Table 2a

Organisation	Conduct studies on radiation effects on organisms?	Facilities for experiments which allow irradiation of feeding of contaminated foods?	Conduct (or consider conducting) RBE studies?	Conduct radiation effect studies at contaminated field sites?	Make in-house dosimetry measurements?	Undertake experiments manipulating radionuclides within model ecosystems?	Study Biomarkers
1. Bangladesh Atomic Energy Commission							
2. Belgian Nuclear Research Centre	✓	✓			✓	✓	✓
3. Canadian Nuclear Safety Commission							
4. Center for Ecological, NASc., Armenia							
5. CEH							
6. Centro de Estudios Ambientales de Cienfuegos		✓					
7. CIEMAT	✓	✓	✓		✓		✓
8. Democritus University of Thrace							✓
9. ECOMAtters Inc.				✓			
10. Environment Agency	✓	✓	✓	✓			✓
11. Enviros Consulting Ltd.	✓			✓			
12. Fisheries and Oceans Canada		✓				✓	
13. Food Standards Agency							
14. Georgian Inst. of Agroradiology and Ecology	✓	✓					✓
15. Health Protection Agency							
16. IAEA - Marine Environment Laboratory		✓				✓	
17. Institute for Environmental Sciences							

Table 2a (Cont.)

Organisation	Conduct studies on radiation effects on organisms?	Facilities for experiments which allow irradiation of feeding of contaminated foods?	Conduct (or consider conducting) RBE studies?	Conduct radiation effect studies at contaminated field sites?	Make in-house dosimetry measurements?	Undertake experiments manipulating radionuclides within model ecosystems?	Study Biomarkers
18. Inst. of Biology, Komi Scientific Center	✓	✓		✓	✓	✓	✓
19. Institute of Industrial Ecology							
20. Institute of Nuclear Energy Research							
21. IRSN	✓	✓	✓		✓	✓	✓
22. IRD-CNEN							
23. iThemba Lab. for Accelerator Based Sciences			✓		✓		
24. Loughborough University							
25. McMaster University	✓	✓	✓		✓	✓	✓
26. National Inst. of Radiological Sciences Japan	✓	✓	✓			✓	✓
27. Newcastle University	✓						✓
28. Norwegian Radiation Protection Authority	✓	✓	✓	✓	✓		✓
29. Norwegian University of Life Sciences	✓	✓	✓		✓	✓	✓
30. Riso National Laboratory							
31. SENES Oak Ridge, Inc., Center for Risk Analysis							
32. SKB				✓			
33. SPA "TYPHOON"	✓					✓	

Table 2a (Cont.)

Organisation	Conduct studies on radiation effects on organisms?	Facilities for experiments which allow irradiation of feeding of contaminated foods?	Conduct (or consider conducting) RBE studies?	Conduct radiation effect studies at contaminated field sites?	Make in-house dosimetry measurements?	Undertake experiments manipulating radionuclides within model ecosystems?	Study Biomarkers
34. CEFAS		✓			✓		
35. The Henryk Niewodniczanski Inst. Nuc. Physics							
36. UMR5805 EPOC							
37. Università Cattolica del Sacro Cuore							
38. University of Bern							
39. University of Georgia	✓	✓	✓		✓		✓
40. University of Novi Sad, Faculty of Sciences	✓			✓	✓		
41. Westlakes Scientific Consulting Ltd.	✓	✓			✓		✓

Table 2b

Organisation	Organism Type											Biome		
	Amphibians	Bacteria	Birds	Crustaceans	Fish	Insects	Invertebrates	Mammals	Molluscs	Plants	Soil Fauna	Temperate	Tropical	Other
1. Bangladesh Atomic Energy Commission					F					T F			T F	
2. Belgian Nuclear Research Centre								T		T		T		
3. Canadian Nuclear Safety Commission														
4. Center for Ecological, NASc., Armenia														
5. CEH														
6. Centro de Estudios Ambientales de Cienfuegos				M	M				M	M			M	
7. CIEMAT								T						
8. Democritus University of Thrace														
9. ECOMAtters Inc.										T		T		
10. Environment Agency	T F			T M	M		T M F		M	M	T	T M F		
11. Enviros Consulting Ltd.							T	T				T		
12. Fisheries and Oceans Canada														
13. Food Standards Agency														
14. Georgian Inst. of Agroradiology and Ecology										T F		T F		
15. Health Protection Agency														
16. IAEA - Marine Environment Laboratory														
17. Institute for Environmental Sciences														

Table 2b (Cont.)

Organisation	Amphibians	Bacteria	Birds	Crustaceans	Fish	Insects	Invertebrates	Mammals	Molluscs	Plants	Soil Fauna	Temperate	Tropical	Other
	Organism Type											Biome		
18. Inst. of Biology, Komi Scientific Center										T F		T		✓
19. Institute of Industrial Ecology														
20. Institute of Nuclear Energy Research														
21. IRSN		T F		T M F	M	M F	M F	T	T M F	T M F	T	T M F	T M	
22. IRD-CNEN														
23. iThemba Lab. for Accelerator Based Sciences														
24. Loughborough University														
25. McMaster University				M	M F			T				M F		✓
26. National Inst. of Radiological Sciences Japan		F												✓
27. Newcastle University			T									T		
28. Norwegian Radiation Protection Authority											T	T		
29. Norwegian University of Life Sciences		T M F		M F	M F	T	T M F	T M F		T M F	T	T M F		
30. Riso National Laboratory														
31. SENES Oak Ridge, Inc., Center for Risk Analysis														
32. SKB														
33. SPA "TYPHOON"	F	F	T	F	M F	T	T	T	F	T	T	T M F		✓

Table 2b (Cont.)
Organisation Organism Type Biome

	Amphibians	Bacteria	Birds	Crustaceans	Fish	Insects	Invertebrates	Mammals	Molluscs	Plants	Soil Fauna	Temperate	Tropical	Other
34. CEFAS														
35. The Henryk Niewodniczanski Inst. Nuc. Physics														
36. UMR5805 EPOC														
37. Università Cattolica del Sacro Cuore														
38. University of Bern														
39. University of Georgia	F				F									
40. University of Novi Sad, Faculty of Sciences					F					T		T F		
41. Westlakes Scientific Consulting Ltd.				M			T		M			T F		

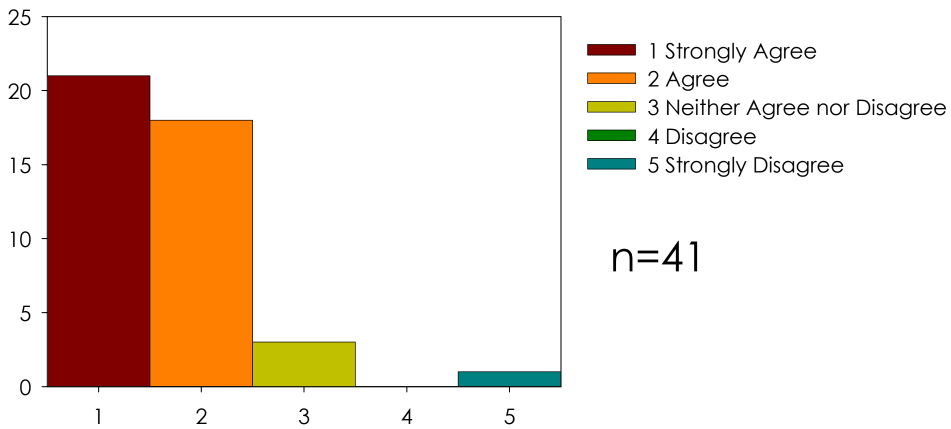
Appendix 1

Knowledge Gaps and Issues in Environmental Protection Research

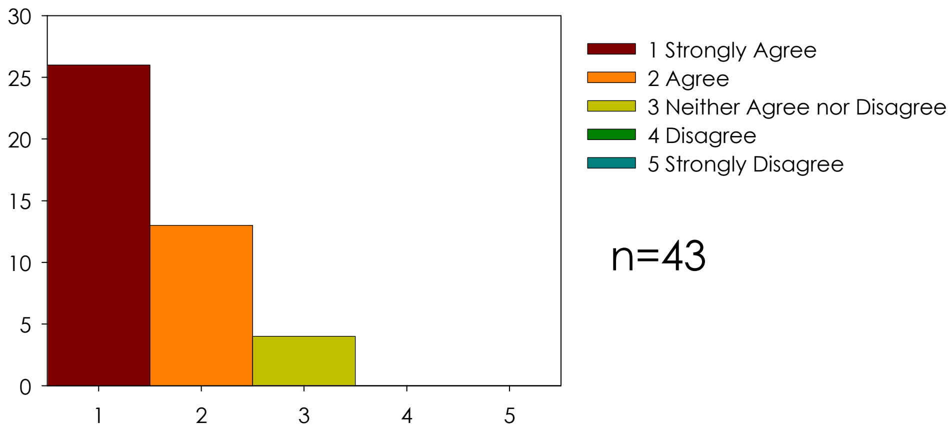
Full Breakdown of Responses

Transfer of Radionuclides in the Environment

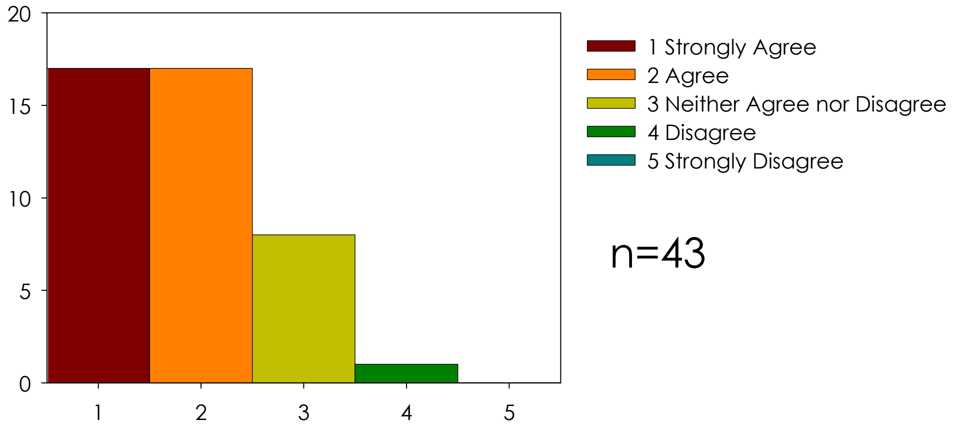
Q.1 We need to better understand the role chemical speciation plays in determining how radionuclides transfer through an ecosystem



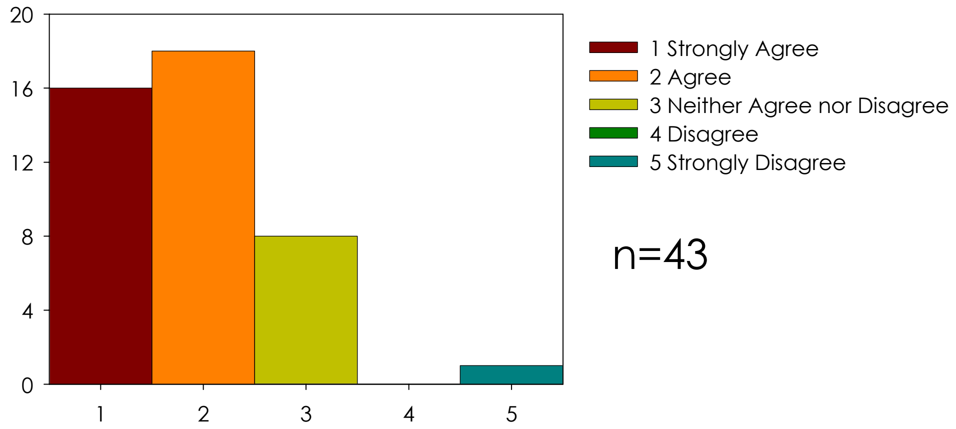
Q.2 We need to better understand the processes that determine how radionuclides transfer through an ecosystem



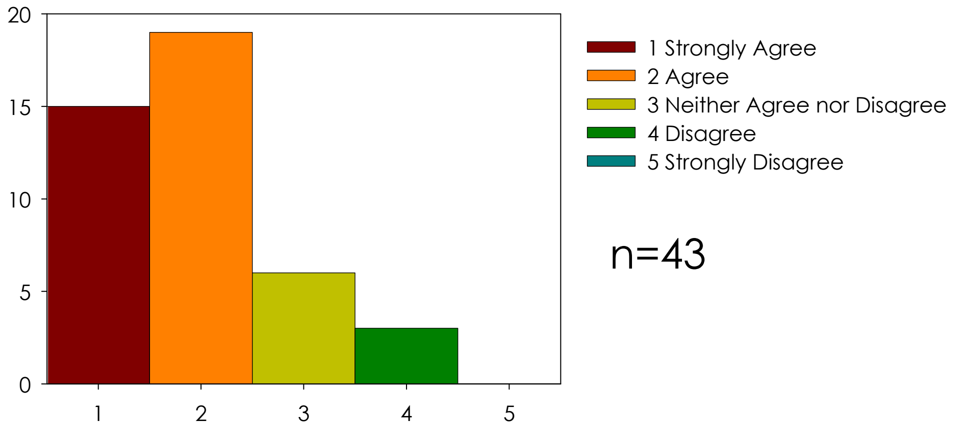
Q.3 We need to consider dynamic modeling techniques to predict radionuclide transfer through an ecosystem under short term, transient releases



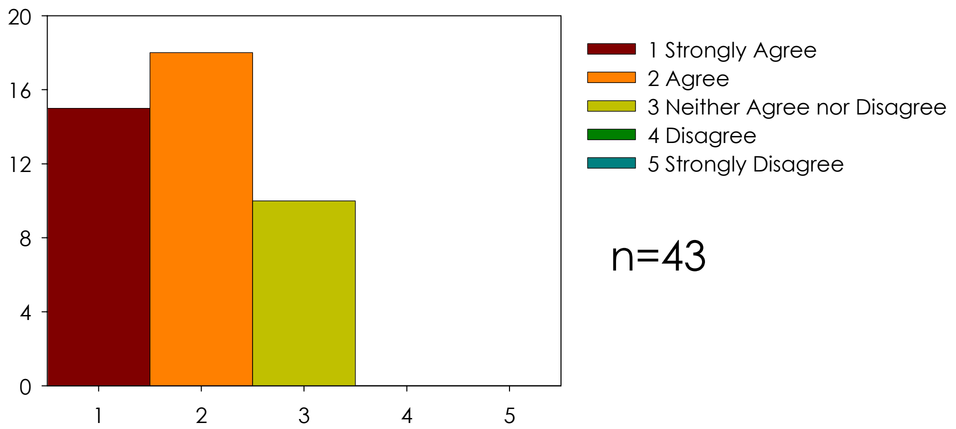
Q.4 We need to determine transfer factors for particular radionuclides and biota



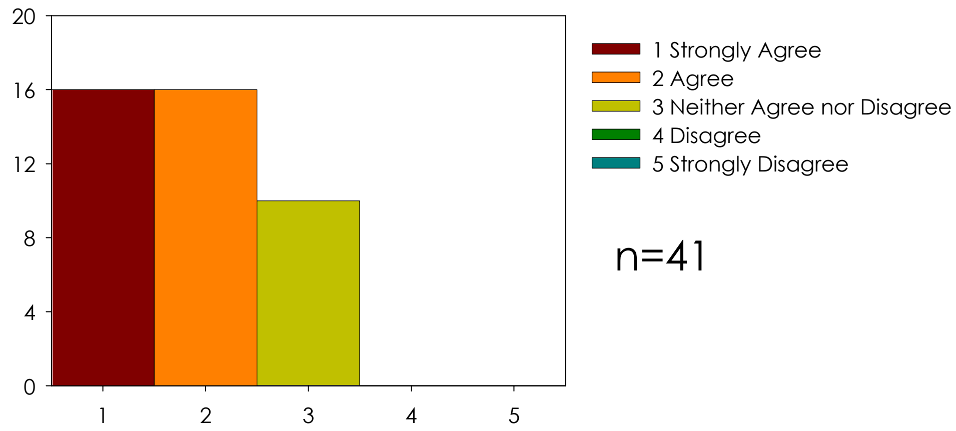
Q.5 We need to better model how radionuclides are retained within an organism to predict their distribution within the body



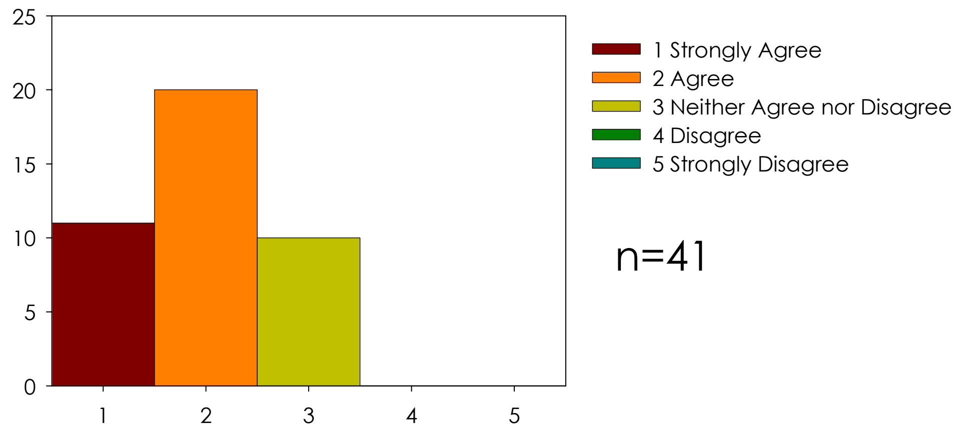
Q.6 We need to understand how temporal (seasonal) variation affects radionuclide transfer through ecosystems



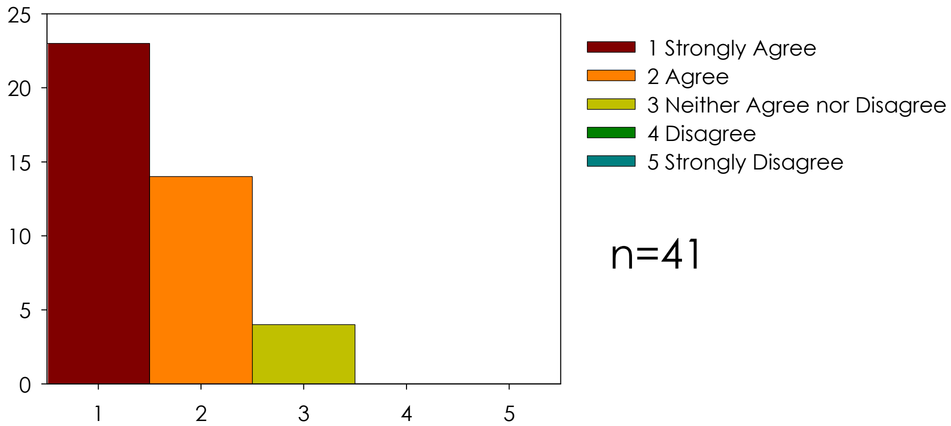
Q.7 We need to understand how spatial variation affects radionuclide transfer through ecosystems



Q.8 We need to understand how to extrapolate transfer factors determined for high activity concentrations to the situation where there are low activity concentrations in the environment (and vice versa)

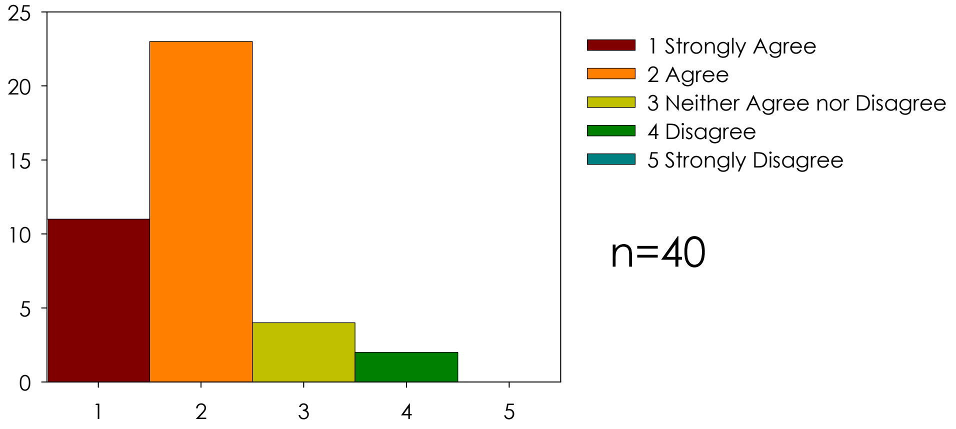


Q.9 We need to better understand and estimate uncertainties in the transfer factors

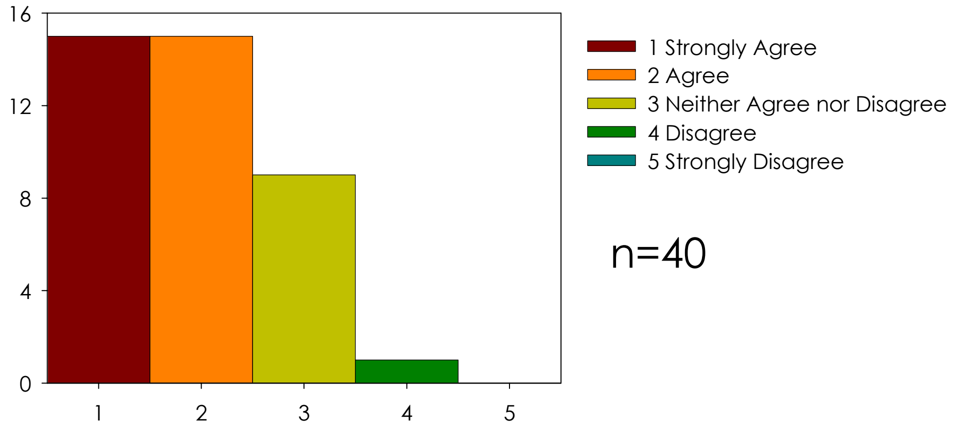


Effects of Ionising Radiation on Biota

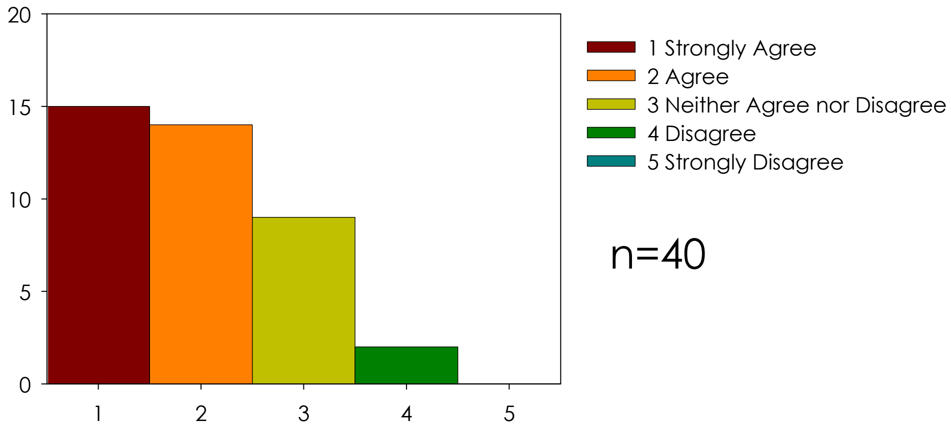
Q.10 We need to undertake radiation exposure studies on different biota groups (e.g. amphibians, fish, and reptiles)



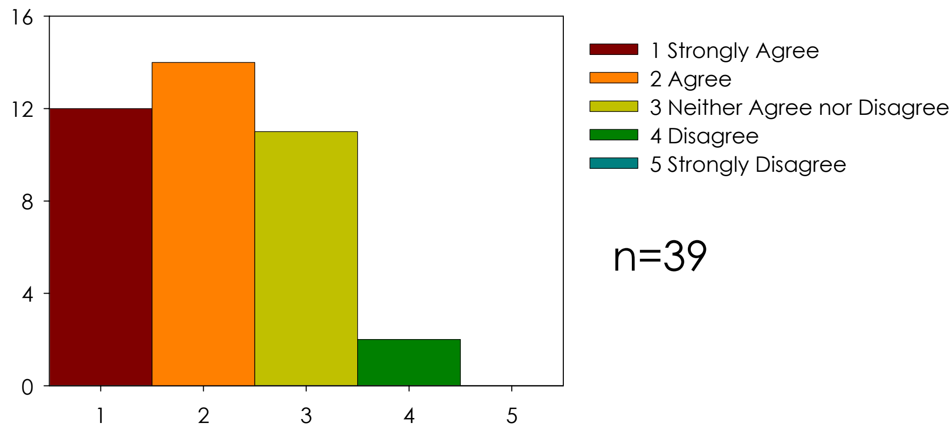
Q.11 We need to understand more about how radiation induces biological damage (e.g. genomic instability, bystander effect)



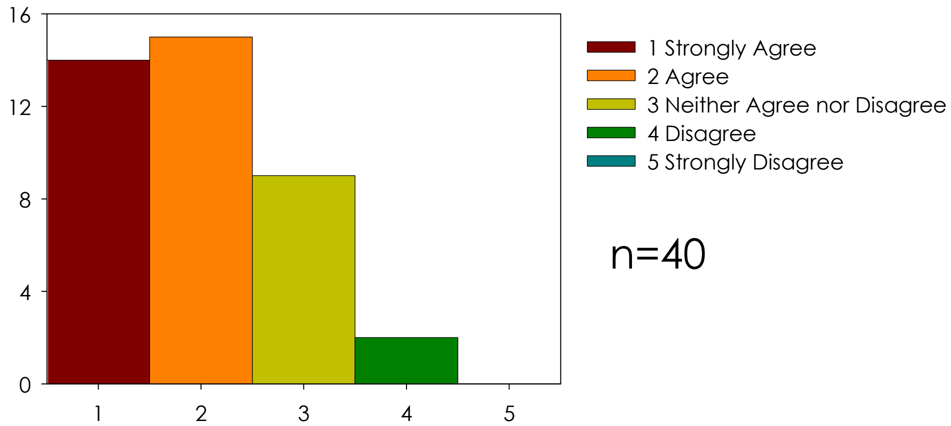
Q.12 We need to understand transgenerational effects in biota



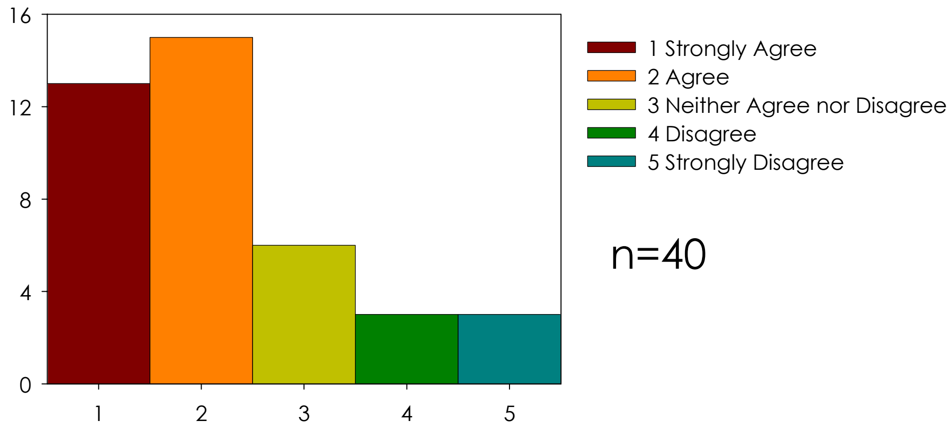
Q.13 We need to investigate how induced tolerance response might affect biota



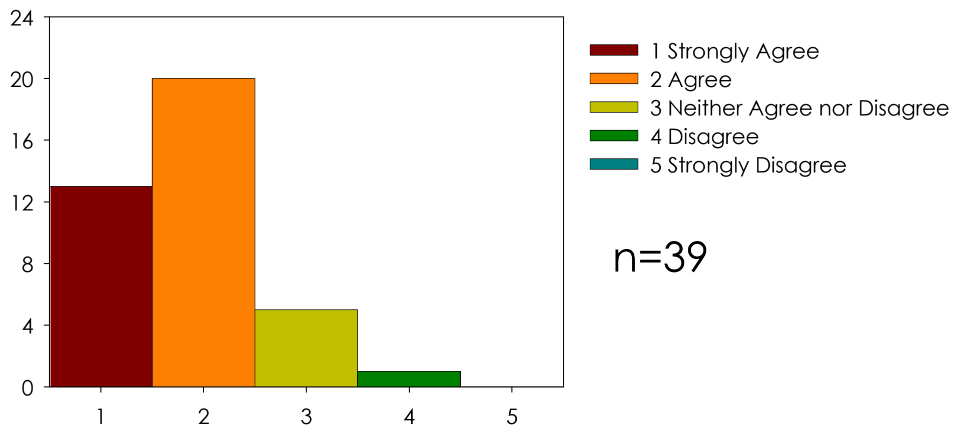
Q.14 We need to understand how particular radionuclides affect biota (e.g. radon, tritium)



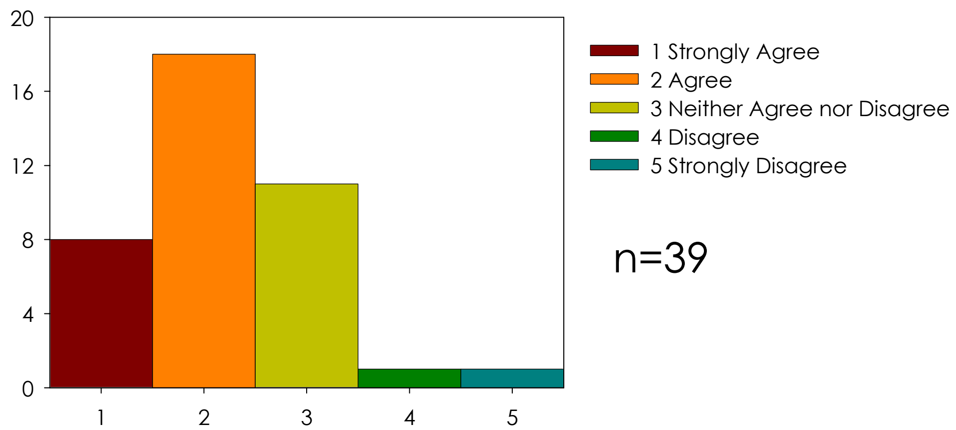
Q.15 We need to be able to extrapolate from the molecular and cytogenetic markers of exposure to the impact on the health of the exposed individual



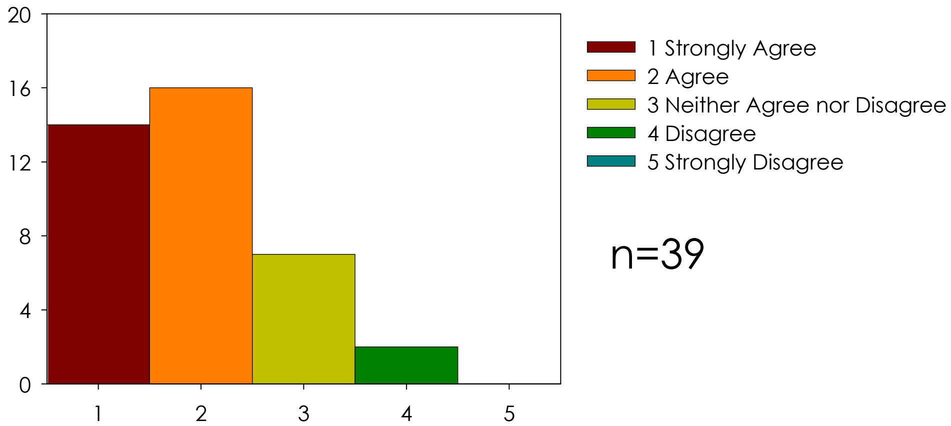
Q.16 We need to determine the difference between effect and harm



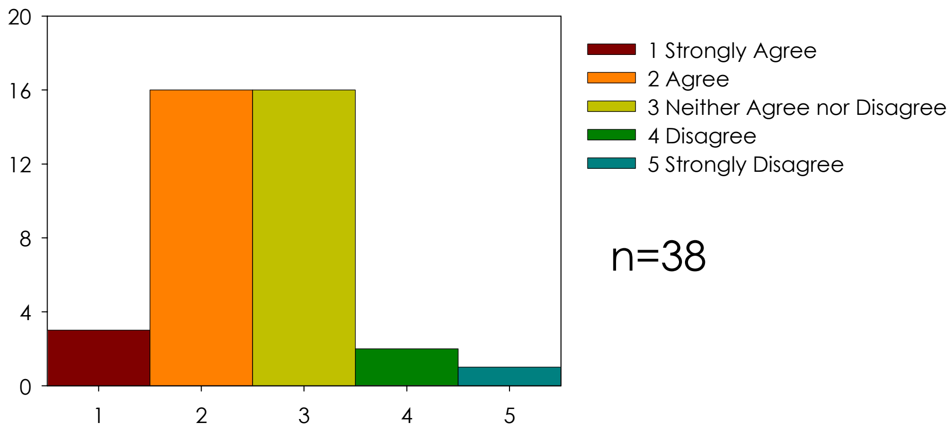
Q.17 We need to understand whether localized exposure (e.g. to organs) is important in terms of demonstrating protection from exposure to ionizing radiation



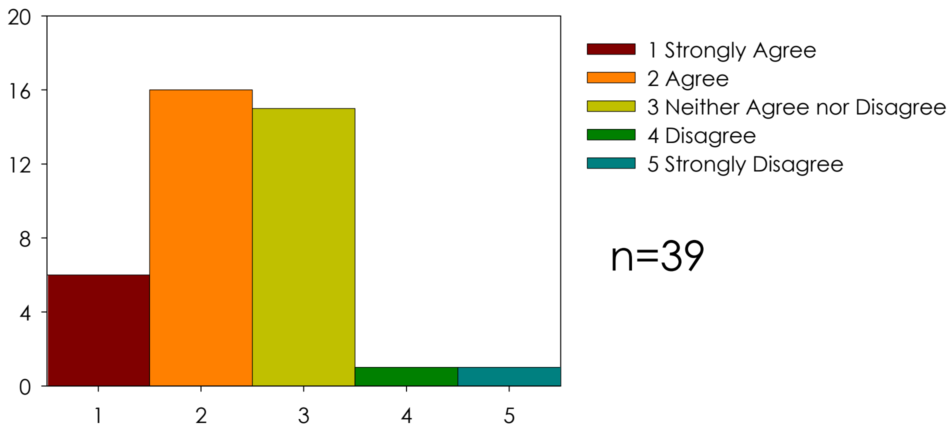
Q.18 We need to establish no observed effect levels for different radiation types for reproductive endpoints in groups of biota



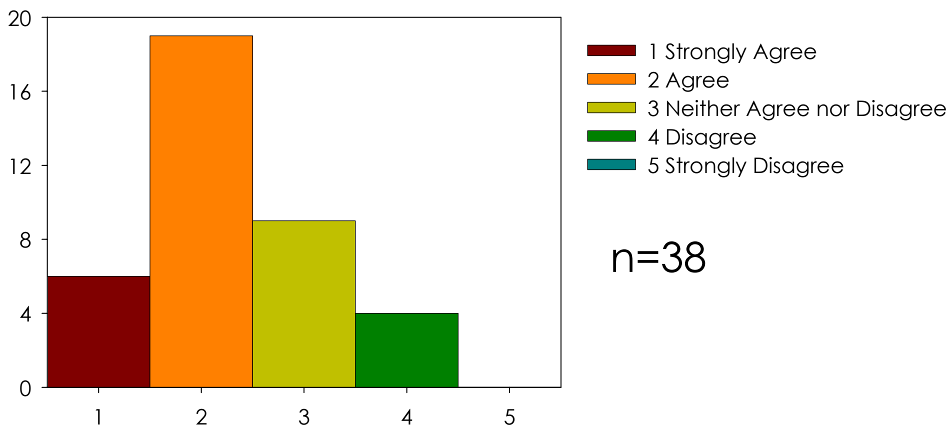
Q.19 We need to establish no observed effect levels for different radiation types for morbidity endpoints in groups of biota



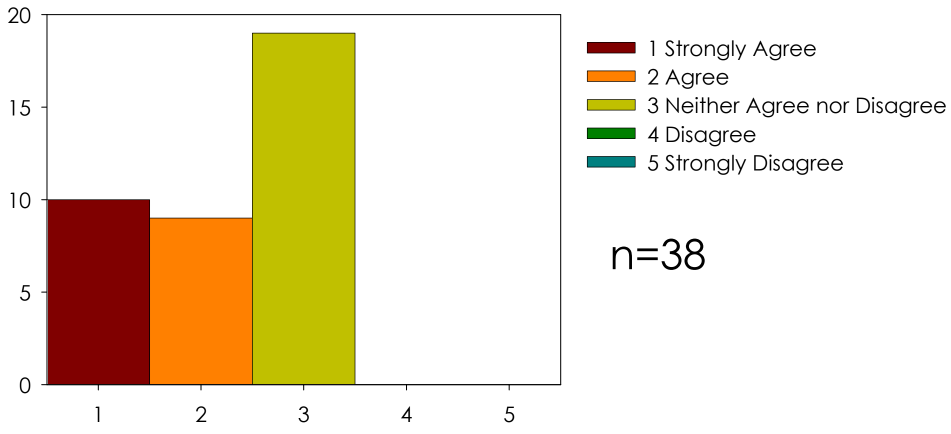
Q.20 We need to establish no observed effect levels for different radiation types for mortality endpoints in groups of biota



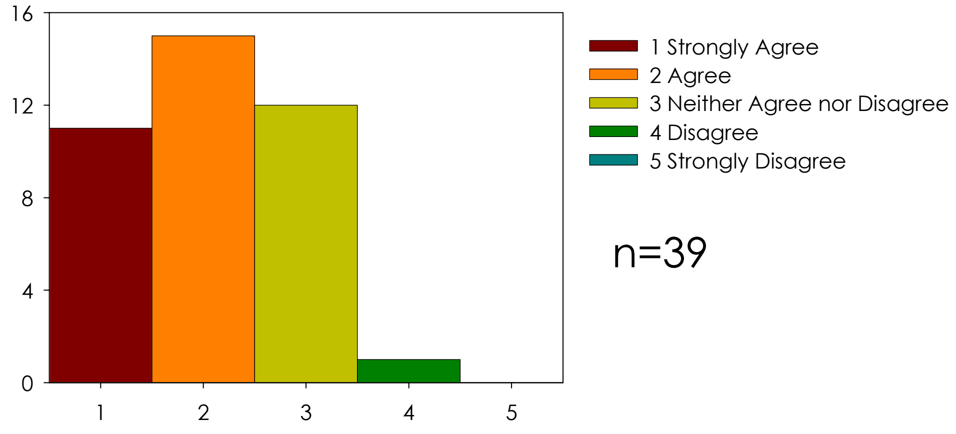
Q.21 We need to establish no observed effect levels for different radiation types for mutation endpoints in groups of biota



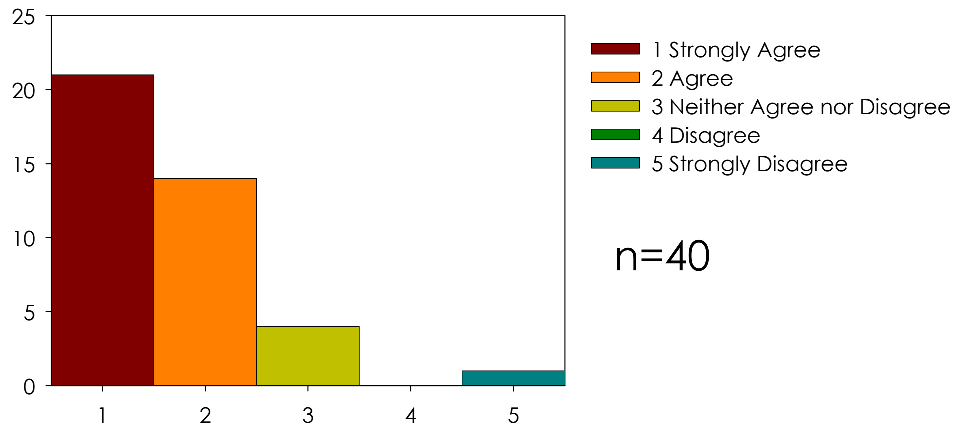
Q.22 We need to consider other ecological relevant endpoints



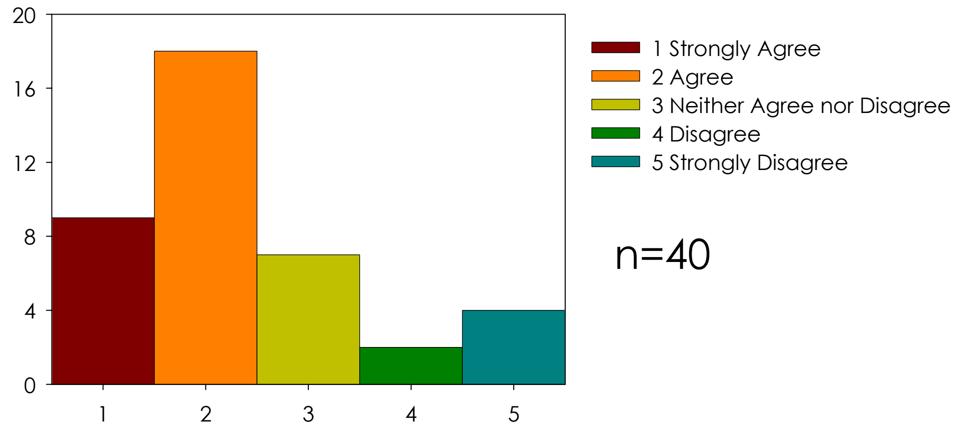
Q.23 We need to determine the most radiosensitive life stage for particular biota



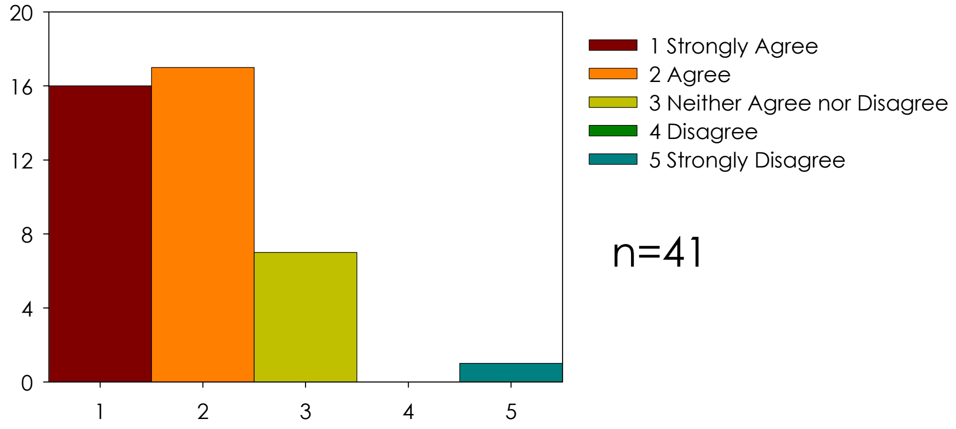
Q.24 We need to understand the interaction between ionizing radiation and other non-radioactive chemical stressors, non-ionising radiation and environmental stressors



Q.25 We need to extrapolate from acute exposure data to chronic exposure



Q.26 We need to understand the indirect ecological effects of exposure to ionizing radiation in an ecosystem (e.g. we need to understand how a predator population may respond to an impacted prey population and vice versa)



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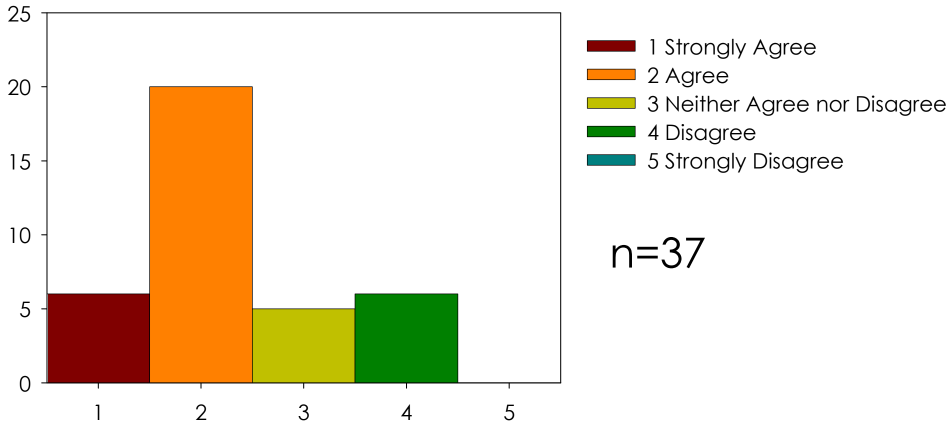
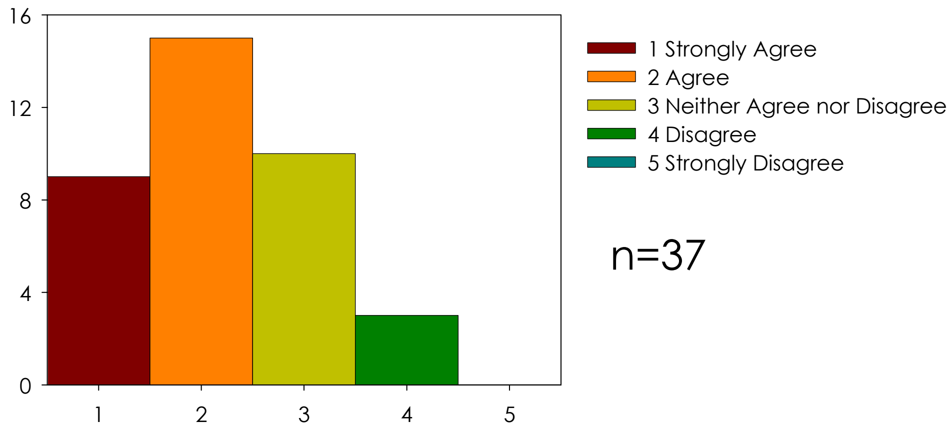
Dosimetry

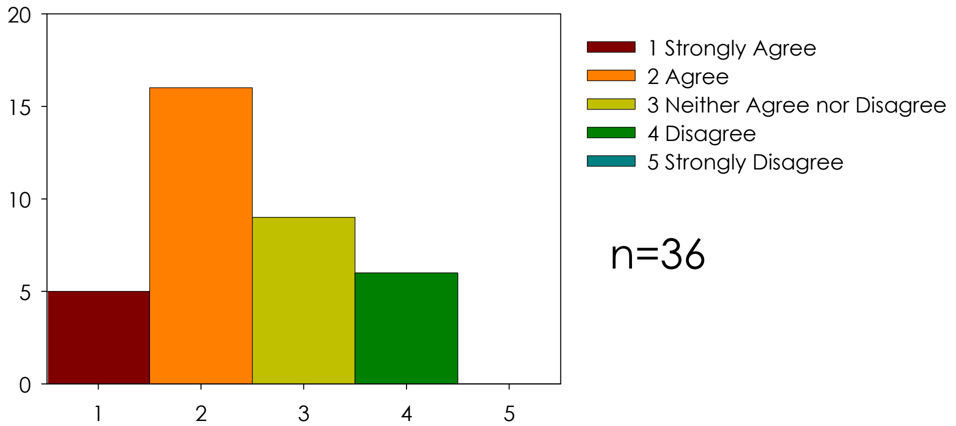
Q.27 We need to assess doses to organs in biota



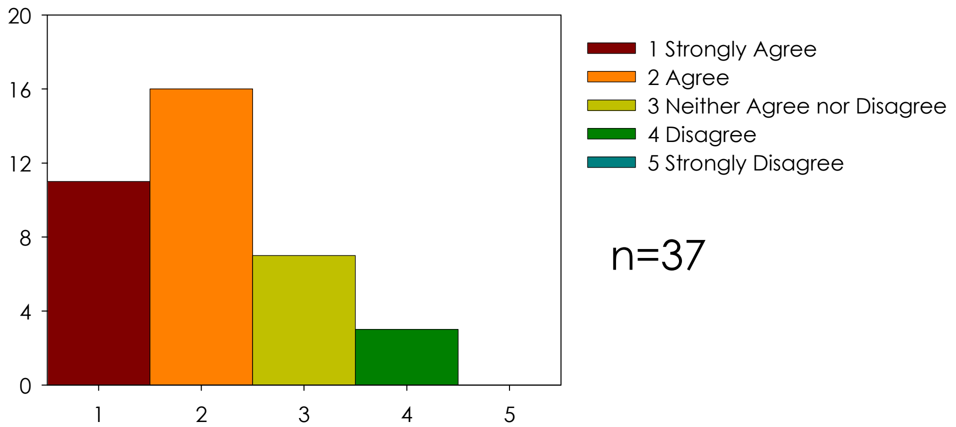
Q.28 We need to assess doses to biota from air concentrations



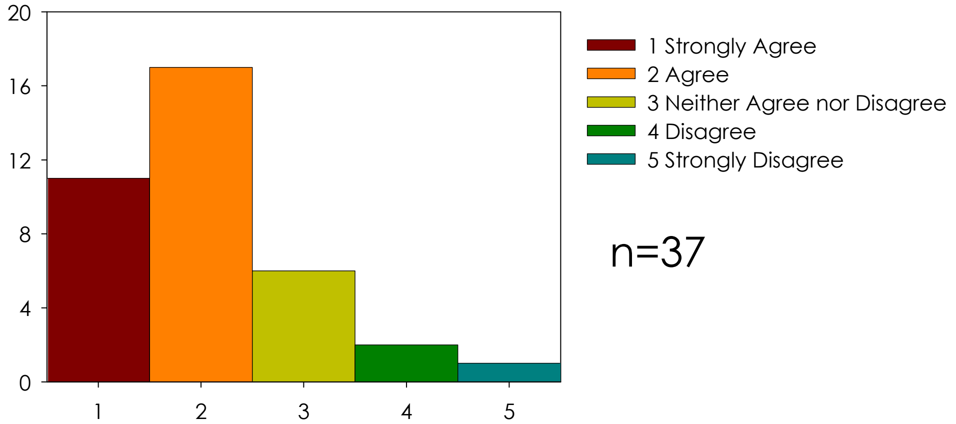
Q.29 We need to assess doses to biota from direct shine



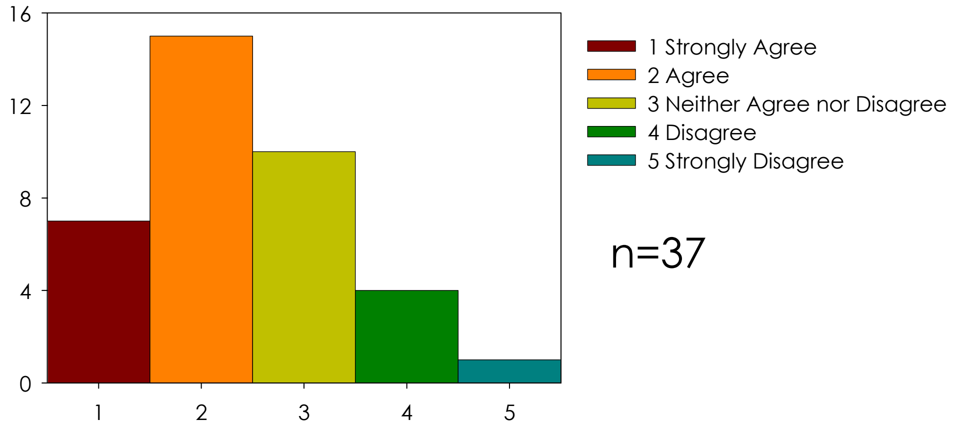
Q.30 We need radionuclide retention models for different biota (will this affect the dose to the organism or perhaps their organs)



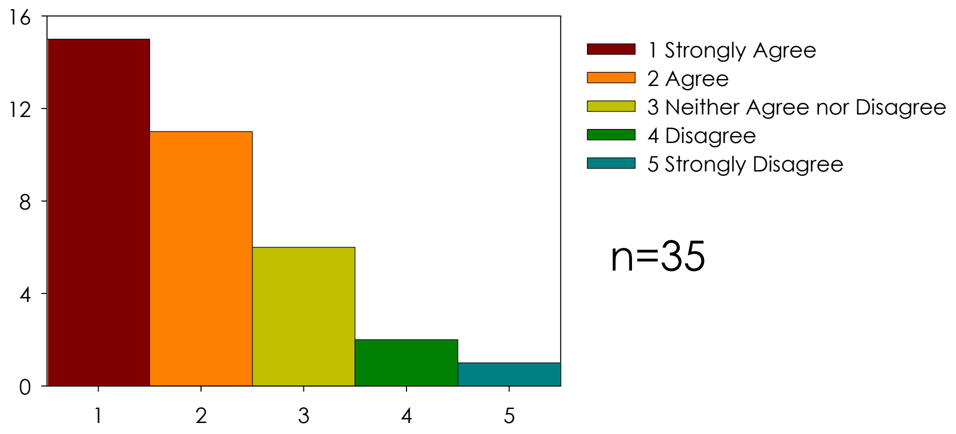
Q.31 We need to conduct experiments to determine the relative biological effectiveness (RBE) of different radiation types on different biota



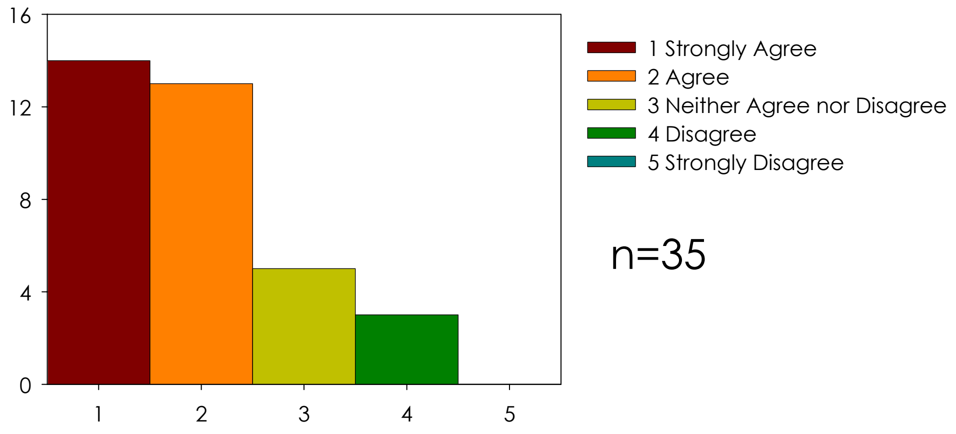
Q.32 We need to undertake RBE studies on particular radionuclides



Q.33 We need to evaluate the uncertainties associated with the different dose per unit concentration factors that have been proposed or are in use

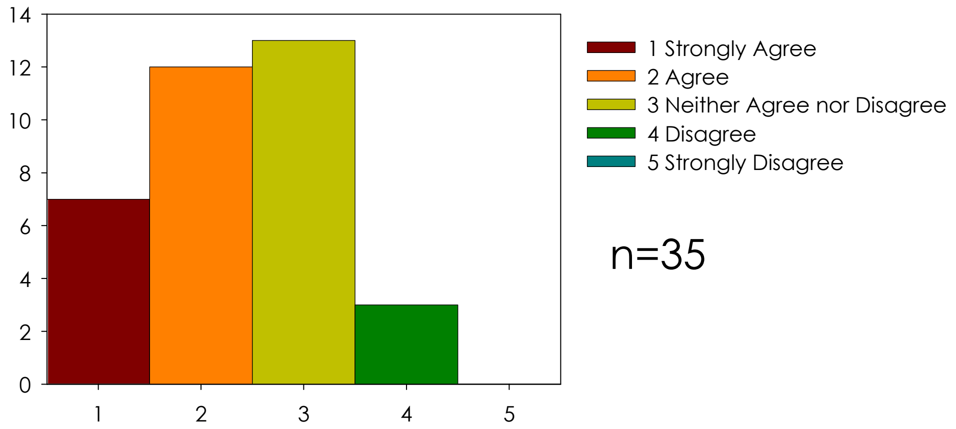


Q.34 We need to undertake quality assurance on the dosimetry approaches that have been proposed or are in use

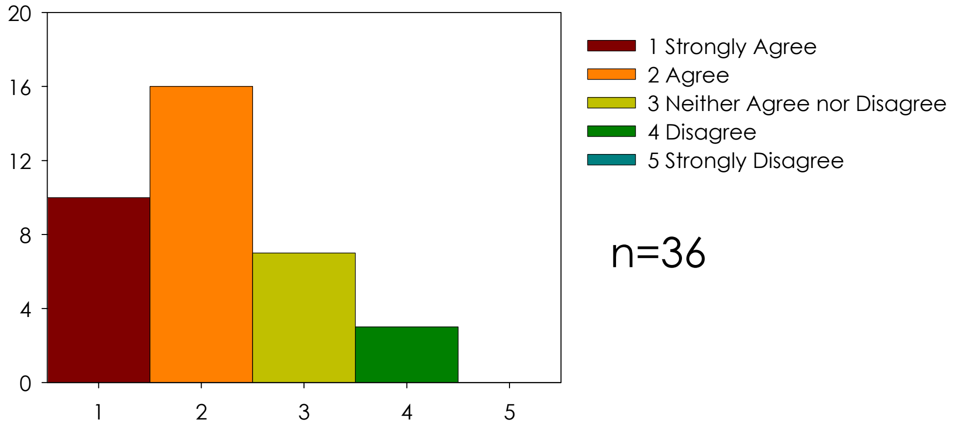


Gaps in the Assessment Frameworks to Demonstrate Protection of the Environment from Ionising Radiation

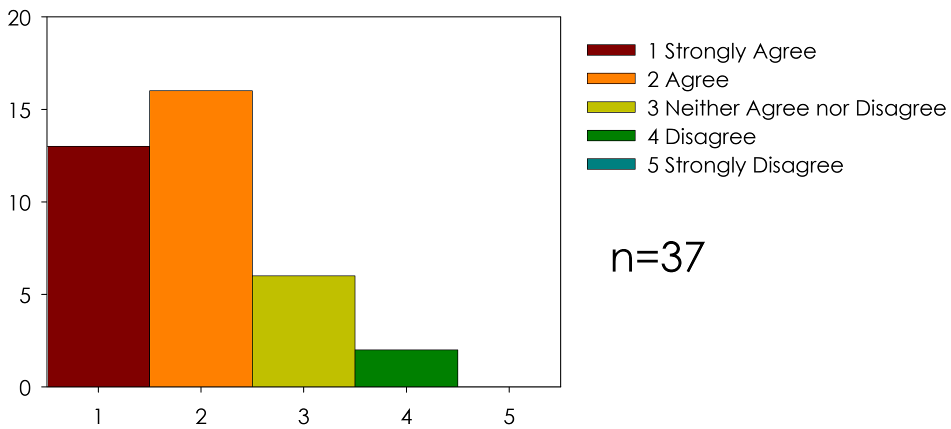
Q.35 We need to consider alternatives to doses for example ambient concentrations, body burdens etc



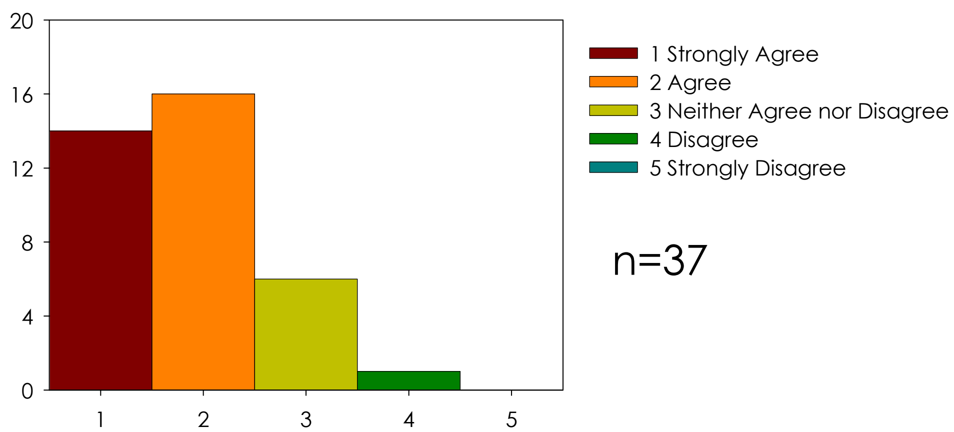
Q.36 We need to consider the adequacy of the reference organism approach



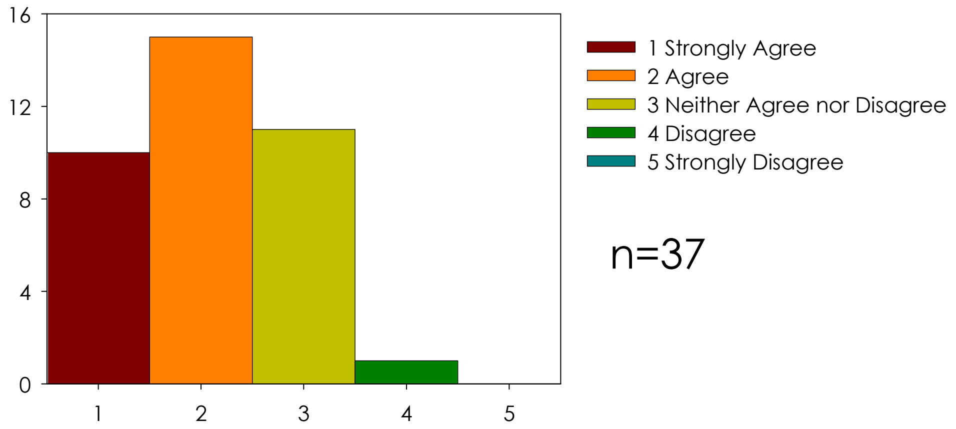
Q.37 We need to better understand how the variation in background/natural radiation rates may influence any assessment



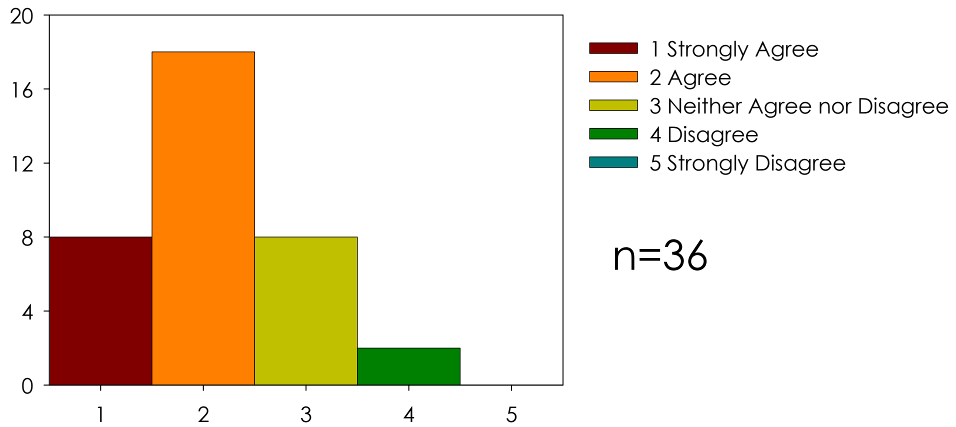
Q.38 We need information on spatial and temporal averaging of radionuclide distributions



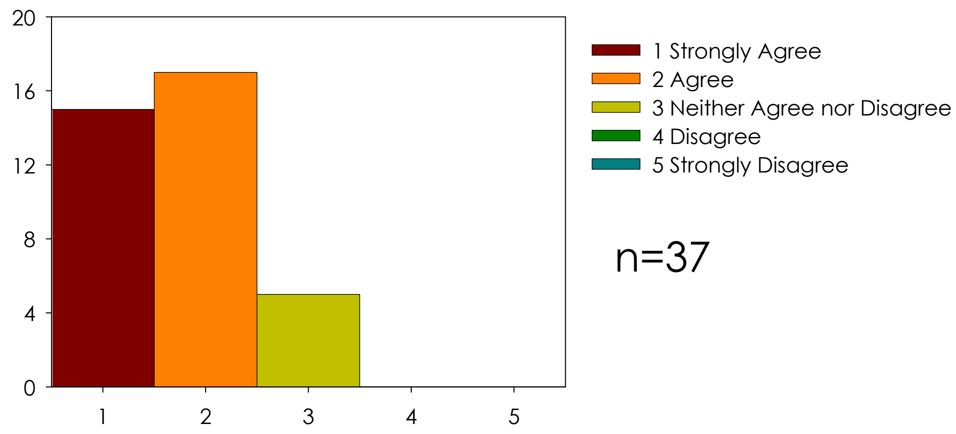
Q.39 We need to consider additional ecosystems, e.g. tropical, in an assessment framework



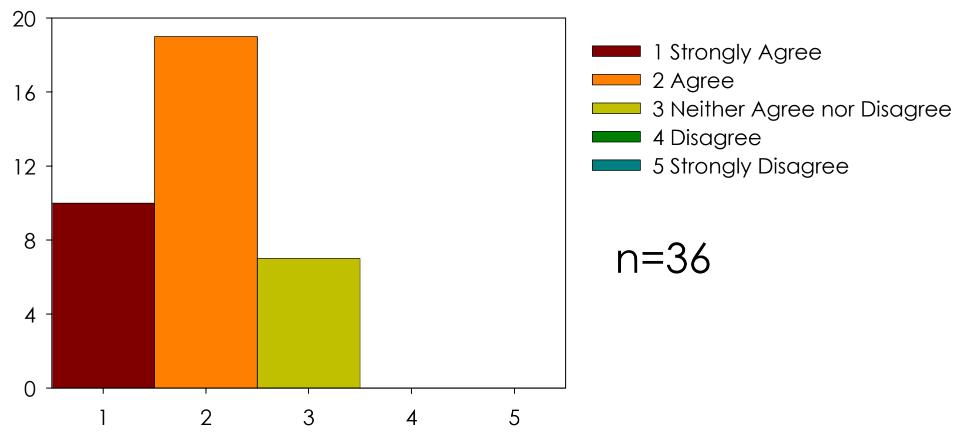
Q.40 We need to better understand how short term releases/transient radionuclides may influence any assessment



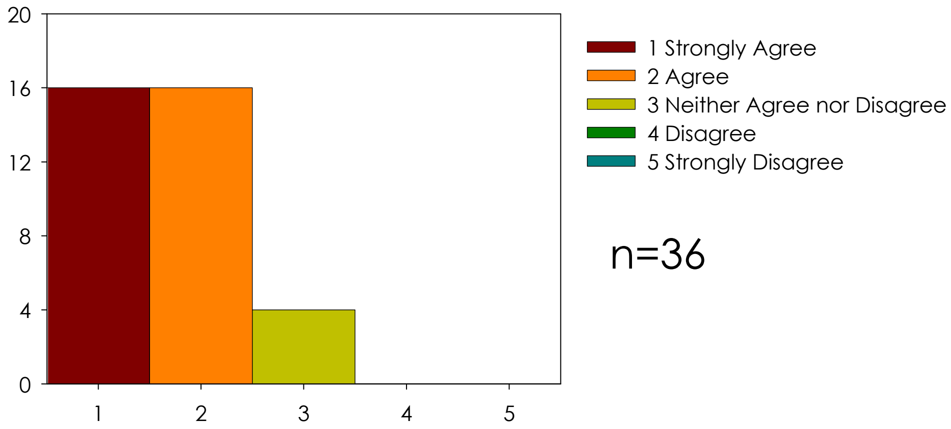
Q.41 We need more basic ecological data to allow us to measure/predict changes that are actually occurring



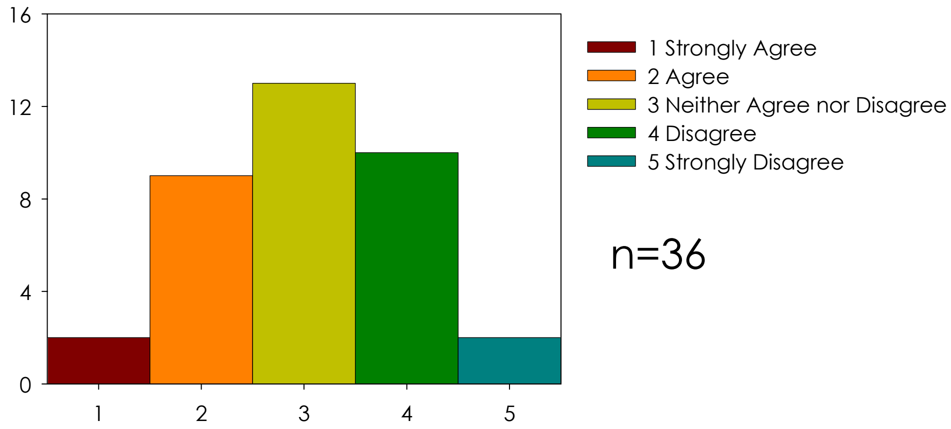
Q.42 We need to better communicate the framework approaches and their results



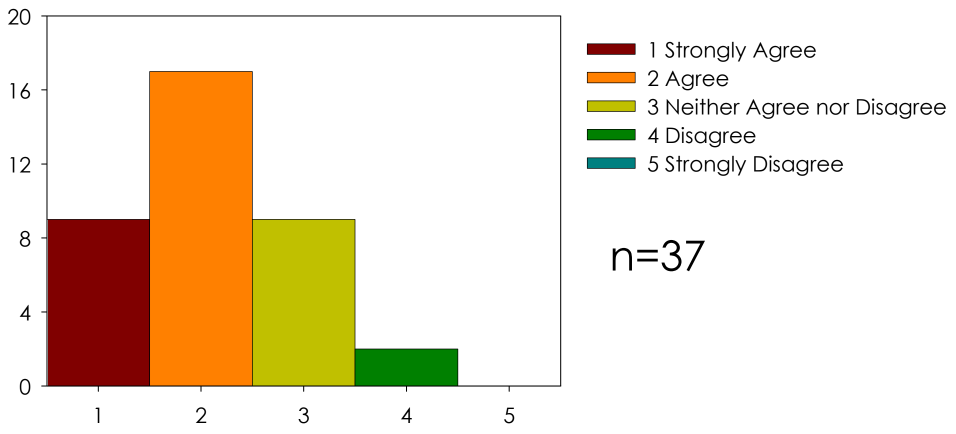
Q.43 We need to provide better estimates of uncertainty in the assessment



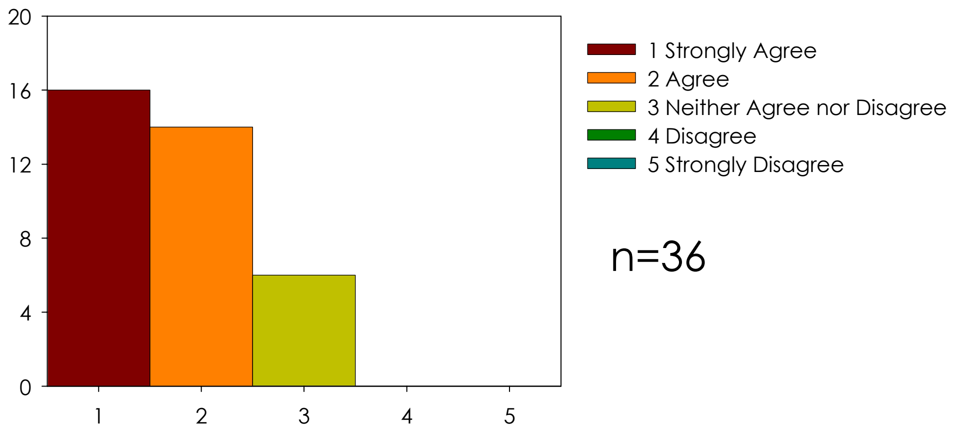
Q.44 We can extrapolate across biological levels of organisation



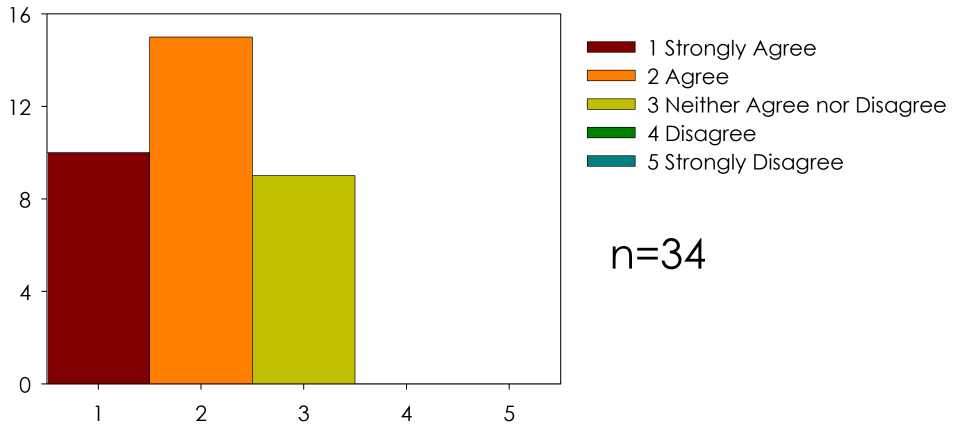
Q.45 We need to be able to extrapolate from the reference organisms defined in the assessment frameworks to other key or feature species (e.g. those that are listed in legislation)



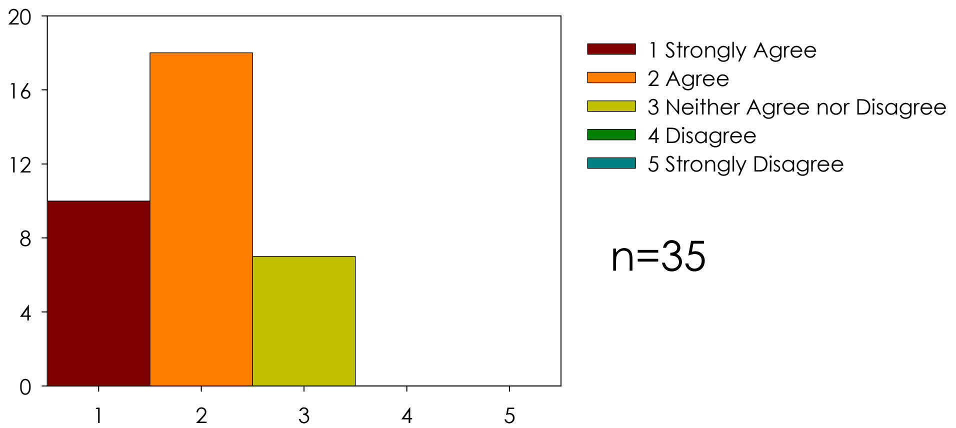
Q.46 We need validate the assessment tool and the overall approach



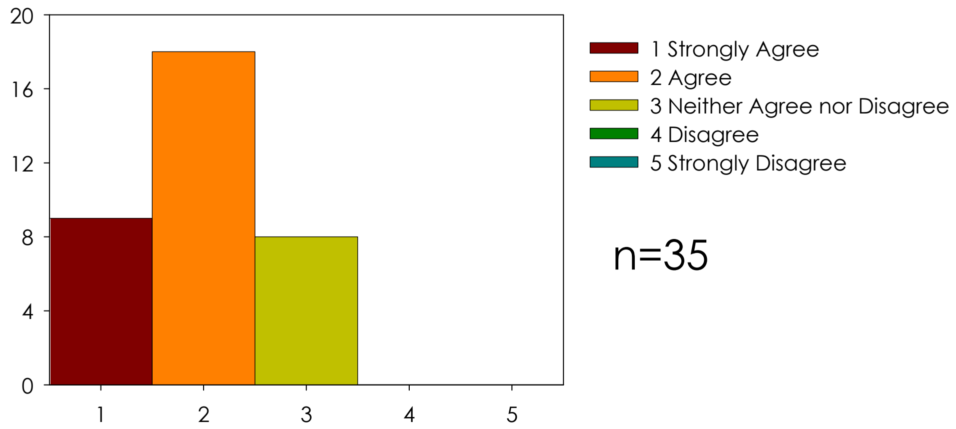
Q.47 We need to consider the most radiosensitive life stage of the species under consideration within the assessment



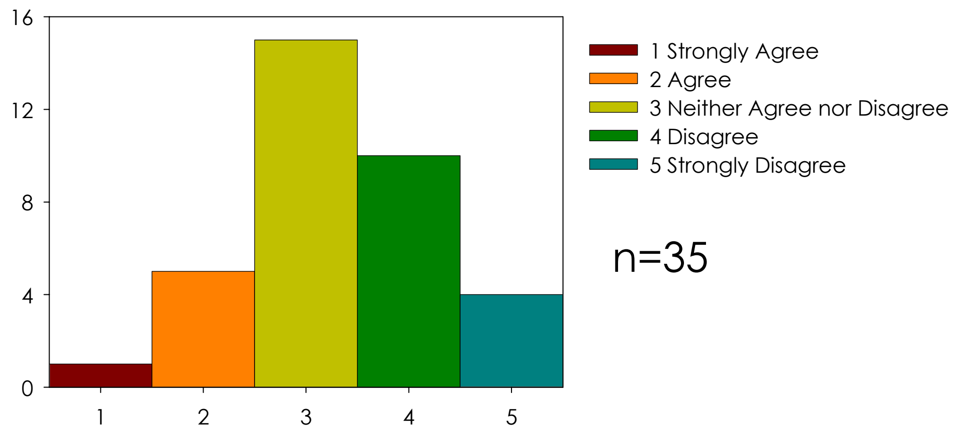
Q.48 We need to be better able to anticipate future problems



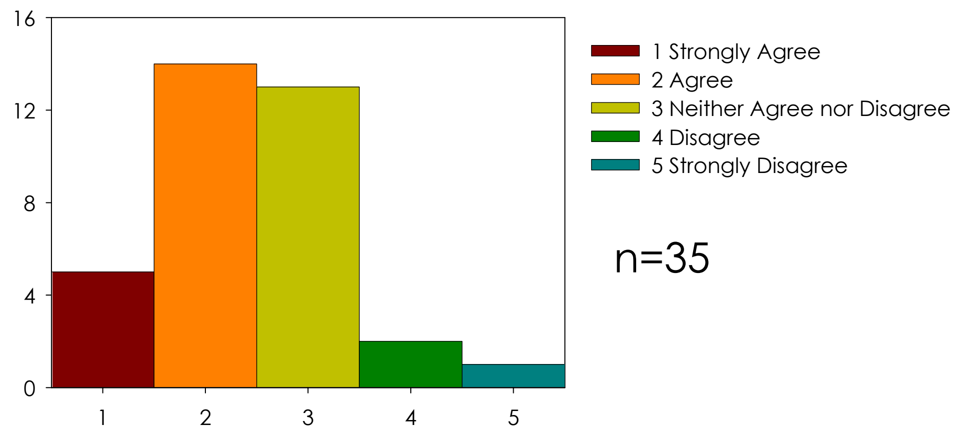
Q.49 We need to provide a mechanism and process for an intercomparison of the different assessment tools that are available



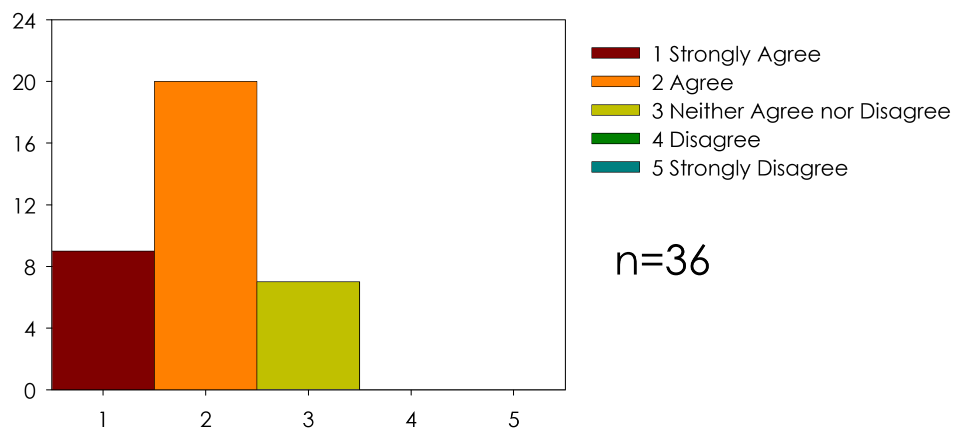
Q.50 We need to be more conservative in our assessments



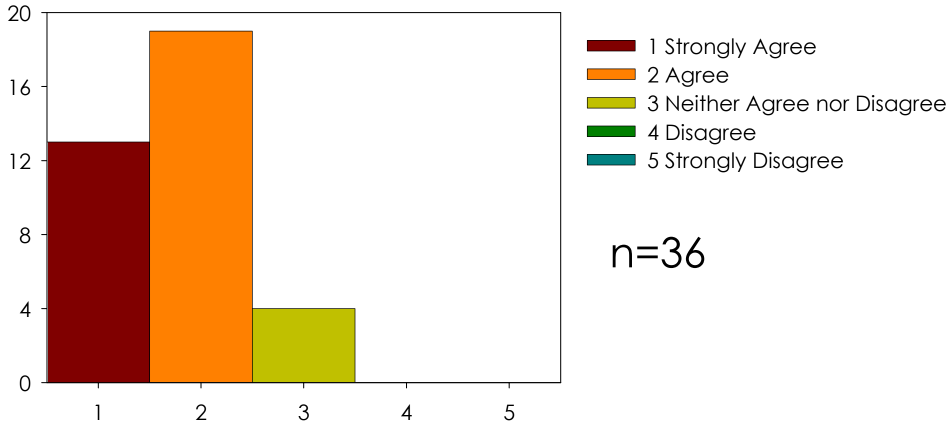
Q.51 We need to use probabilistic modelling in our assessments



Q.52 We need to be more realistic in our assessments



Q.53 We need to assess the limitations of extrapolation tools



Appendix 2

Research Interests, Capabilities, and Facilities

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List of Participating Organizations

1. Bangladesh Atomic Energy Commission, Bangladesh
2. Belgian Nuclear Research Centre, Belgium
3. Canadian Nuclear Safety Commission, Canada
4. Center for Ecological -Noosphere Studies of the National Academy of Sciences of Armenia, Republic of Armenia
5. Centre for Ecology and Hydrology, UK
6. Centro de Estudios Ambientales de Cienfuegos, Cuba
7. CIEMAT (Research Centre for Energy, Environment and Technology), Spain
8. Democritus University of Thrace, Greece
9. ECOMAtters Inc., Canada
10. Environment Agency, UK
11. Enviros Consulting Ltd., Scotland
12. Fisheries and Oceans Canada, Canada
13. Food Standards Agency, UK
14. Georgian Institute of Agroradiology and Ecology, Georgia
15. Health Protection Agency, UK
16. IAEA - Marine Environment Laboratory, Monaco
17. Institute for Environmental Sciences, Japan
18. Institute of Biology, Komi Scientific Center, Ural Division of RAS, Russia
19. Institute of Industrial Ecology, Russia
20. Institute of Nuclear Energy Research , Taiwan
21. Institute of Radioprotection and Nuclear Safety, France
22. Instituto de Radioproteção e Dosimetria-Comissão Nacional de Energia Nuclear (IRD-CNEN), Brazil
23. iThemba Laboratory for Accelerator Based Sciences, South Africa
24. Loughborough University, UK
25. McMaster University, Canada
26. National Institute of Radiological Sciences Japan, Japan
27. Newcastle University, UK
28. Norwegian Radiation Protection Authority, Norway
29. Norwegian University of Life Sciences, Norway
30. Riso National Laboratory, Denmark
31. SENES Oak Ridge, Inc., Center for Risk Analysis, USA
32. SKB (Swedish Nuclear Fuel and Waste Mngmt Co), Sweden
33. SPA "TYPHOON", Russia
34. The Centre for Environment, Fisheries & Aquaculture Science (CEFAS), UK
35. The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Poland
36. UMR5805 EPOC, France
37. Università Cattolica del Sacro Cuore, Faculty of Agricultural Sciences, Italy
38. University of Bern, Switzerland
39. University of Georgia, USA
40. University of Novi Sad, Faculty of Sciences, Serbia and Montenegro
41. Westlakes Scientific Consulting Ltd., UK

Bangladesh Atomic Energy Commission

Bangladesh Atomic Energy Commission
Nuclear Safety and Radiation Control Division
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
We are doing some experiment on transfer of radionuclides from soil to plant.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Tropical T; F

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
We have a good radioanalytical facilities. The following facilities are available:1. HPGe detector x2. Proportional beta counter x3. Alpha spectrometer x4. Liquid scintillation counter x5. Chemical laboratories x6. And other related facilities

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Organism types:
Terrestrial: Plants
Freshwater: Fish; Plants

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Tropical: T; F

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: No

Belgian Nuclear Research Centre

Belgian Nuclear Research Centre
Radiation Protection Research
Boeretang 200
Mol
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Transfer of radionuclides in the terrestrial soil-plant environment Transfer dynamics and fluxes Effect of environmental properties (soil, micro-organisms, rhizosphere effects, plant effects) on transfer. Effects studies. Countermeasures

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Radionuclide transfer and fluxes in contaminated areas. Chernobyl. Uranium waste heaps- NORM-industry contaminated land. Perennial vegetation (forests and grass land) - agricultural crops

Radioanalytical facilities, isotopes analysed and accreditation status:
At SCK-CEN infrastructure for virtually all radioanalytical measurement types and for virtually all radionuclides. Virtually all analysis techniques accredited

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
At the section of radioecology, we only perform some experiments on plants. Actually only on the effect of U uptake under hydroponics conditions on activity of stress enzymes, protein patters, metabolites, DNA damage (COMET). Effect of contaminants on DNA damage or gene expression are conducted with PCR.
In future radiation experiments and multiple stressors experiments.
At the section of Radiobiology, they have a longstanding and outstanding expertise in the study of the effects of radiation on mammals and they have at their disposal the most advanced infrastructure. Their major research subjects listed below. DNA micro-arrays to identify changes in gene expression profiles, induced by ionising radiation in different human hematopoietic cell types; Molecular, proteomic and hereditary changes induced in the mouse after irradiation of either

germ cells or early embryo; Physiological basis of radiosensitivity: implications for understanding how normal and cancerous cells respond to radiation; The Effect on Global Gene Expression in Murine Neural Tissue after Exposure to Ionizing Radiation

Organism types:
Terrestrial: Mammals (section of Radiobiology); Plants

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate T

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licenses are in place:
Gamma irradiation facilities for short-term exposure (e.g. continuously applied by radiobiology group). Greenhouses, growing chambres and phytotron to conduct uptake studies or hydroponics studies. Possibility to conduct long-term low dose irradiation by external source In principle, infrastructure to feed animals contaminated food, but animal-related research not the aim of our radioecology at this moment. Maybe in collaboration with the SCK-CEN Radiobiology section this could be materialised but again, potentially and only in case of external funding.

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No
Not in present but may be possible in future at NORM contaminted sites. Only for terrestrial environment; only plants and small fauna.
Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
Mostly done with TLD

Can undertake experiments where you can manipulate radionuclides within model ecosystems: Yes

Details of radionuclide manipulation experiments:
We perform many radionuclide manipulation experiments in laboratory, greenhouse etc and lysimeters. Radionulcide manipulation experiments in model ecosystems we have never done but I think as long as it concerns the terrestrial environment we could contribute

Study biomarkers: Yes

Details of biomarker studies:
Tests we perform at Radioecology Section stress enzymes stress induced change in metabolites protein patterns, gene expression (PCR in collaboration), comet test, metabolites. Future maybe micronucleus, micro array analysis.

Links with researchers with other relevant biological or ecological disciplines: Yes

Canadian Nuclear Safety Commission

Canadian Nuclear Safety Commission
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Radionuclide Transfer

Conduct studies on transfer processes in environment:	No
Conduct field studies on radionuclide transfer to biota:	No

Radionuclide Effects

Conduct studies on radiation effects on organisms:	No
Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods:	No
Conducted (considered conducting) RBE studies:	No
Conducted radiation effects studies at contaminated field sites:	No
Can make in-house dosimetry measurements:	No
Can undertake experiments where you can manipulate radionuclides within model ecosystems:	No
Study biomarkers:	No
Links with researchers with other relevant biological or ecological disciplines:	No

Center for Ecological-Noosphere Studies of the National Academy of Sciences of Armenia

Center for Ecological -Noosphere Studies of the National Academy of Sciences of Armenia
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Investigating transfer processes of naturally occurring and man-made radionuclides and particularly radioactive series of U and Th, 40-K, and 137-Cs, 90–Sr in atmospheric precipitation -soil - plant system, water and sediments.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Dry continental, Subtropical T; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Arranging and conducting field trips. Sampling, in-situ measurements. Investigations of radionuclides transfer in Armenia's mosses, arboreous species, herbs, fungi. For instance, we have identified some radioactive pollution indicating species to be adequately used in long -term radioecological monitoring.

Radioanalytical facilities, isotopes analysed and accreditation status:

1. Portable Multi-Channel Analyzer with NaI detector (Davidson, USA) -gamma measurements,
2. Portable Radiation Monitor E-600 (Eberline, USA) - gross alpha/beta, gamma measurements,
3. Gamma-spectrometer InSpector NaI with NaI(Tl) detector and Genie-2000 spectroscopy system (Canberra, USA) for all-spectrum gamma-emitting radionuclides and 40-K, 232-Th, 226–Ra, 137-Cs in particular,
4. Gamma-spectrometer InSpector with HpGe detector (Canberra, USA) for measuring the noted radionuclides,
5. 2 beta -radiometers RKB4 -1eM (Russia) for gross beta -radioactivity measurements.

At the moment accreditation of CENS Laboratory of Radioecology is in progress.

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Centre for Ecology and Hydrology

Centre for Ecology and Hydrology
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
See CV

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
FASSET and ERICA participation. See CV

Radioanalytical facilities, isotopes analysed and accreditation status:
UKAS accredited alpha, beta and gamma low level radioanalysis of a wide range of radionuclides

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

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Centro de Estudios Ambientales de Cienfuegos

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59350

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Radioecology: experimental design, fieldwork, environment monitoring, assessment of gamma, beta and alpha–particle emitting nuclides in environmental samples. Application of radiotracer and nuclear techniques in Marine Environmental Studies. Dating of Sediments and Sedimentology. Monitoring in Marine Environmental Implementation Quality Assurance and Quality Control Programmes. Developing of tools in the compression of the key process of controlling pollution and material transport in the coastal environment to formulate an integrated coastal zone management strategy

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Tropical M

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Evaluation of diffusion and transport processes in the marine environment using active and passive tracers(1999- 2003). Research carried out under Mr Carlo Papucci and Dr Roberta Delfanti supervision at the Marine Environment Research Centre , La Spezia, Italy. Oceanographic cruises (Nov 1999) on the Italian National Research Council vessel, URANIA. The cruises were aimed to determinate 137Cs in sample seawater at Ionian Sea. Northern Adriatic Campaign (Jul 2001). Framework of the EC-REMOTRANS. The campaign was aimed to study remobilization of radiologically important radionuclides from contaminated sediments in different European environments. Sedimentation Process in Cienfuegos Bay, Cuba. (Jan 2001 – Dec 2002). Project carried out under Mr Carlo Papucci and Dr Ornella Ferreti supervision at the Environmental Study Centre, Cuba and Marine Environment Research Centre, Italy. Marine radioactivity and non-radioactivity monitoring program in Cuba. (Jan 2002 up today) IAEA. Project supported by IAEA.Monitoring and Study of Marine Pollution (1999- today) . Included Monitoring Protocol to Assess As in the Marine Environment, to assess the level of arsenic spilled in Cienfuegos bay and to define the geogenic vs anthropogenic sources of the contaminant in sediment cores using radionuclear techniques. Project supported by IAEA.Oceanographic cruises (May-2004) on the Italian National Research Council vessel, URANIA. Estimates of carbon flux using 234Th/238U disequilibrium. Sedimentation Process in Batabano Golf, Cuba. (2003-Today)Application of Integrated Watershed and Coastal Areas Concepts in a Demonstrative Area at Cienfuegos Province, Cuba. Project supported by UNEP-GEF.Application of radiotracer techniques in the study

of bioindicators of marine pollution in tropical ecosystems. Project supported by IAEA. Strengthening the national monitoring and environmental emergency system of the Cuban marine ecosystem. CUB7-006. Project supported by IAEA

Radioanalytical facilities, isotopes analysed and accreditation status:
In recent years, CEAC's mission has been broadened up to cover the protection of the marine environment under different impacts (industrial discharges, urban outfalls, inputs from rivers, etc.).At the moment, our Center is involved in the following local, national, and international projects:1.-Use of Nuclear and Isotopic Applications to Address Specific Coastal Zone Management Problems in Cuba.2.-Improvement of the Radiation Monitoring System.3.-Monitoring Protocol to Assess As in the Marine Environment.4.-Application of radiotracer techniques in the study of bioindicators of marine pollution in tropical ecosystems.5.-Innovative tools for the improvement of Integrated Coastal Management in Cienfuegos, Cuba.6.-Application of Integrated Watershed and Coastal Area Management Concepts in a Demonstrative Area at Cienfuegos Province, Cuba. Facilities (localities, equipment) available •Mobile laboratory for sampling. •Global Positioning System (GPS). •Ship for marine sampling. •Microanalytical balances. •Vibratory Sieve Shakers. •pH/Conductivity/Temperature Meters. •Incubators. •Microscope Systems. •Kjendahl System. •Rotary Evaporator System. •Vacuum Filtration System. •Centrifuges •Multiparameter Water-Quality Meters (Salinity, Conductivity, Temperature).•Muffle. Furnaces. Freeze Dryer System.•Mortar grinder mill.•Desiccators. Heating Mantles. •Gamma Spectroscopy (with Ge and NaI Detectors) System. •Low Background Alfa-Beta System. •Atomic Absortion Spectrometers including graphite and hydrid systems. •UV-Vis Spectrometers. •Network of computers.The procedure for radionuclides analyses have been accredited by the National Office for Normalisation for ISO-NC-17025 and it is recognized by the International Atomic Energy Agency through ARCAL XXVI IAEA Regional Project

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Organism types:
Marine: Crustaceans; Fish; Molluscs; Plants

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Tropical M

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes
Details of facilities, species of interest, and licences are in place:
Laboratory equipment for pre-treatment of samples •Analytical Balances •Mechanical Balances •Rotary Evaporators •Refrigerated incubators •Freezer for storing samples •Refrigerator for preserving samples •Muffle furnace •Dry Freezer •Microwave •Digester Kjeldar Radiochemistry Laboratory •Low-level gamma spectrometric system with HPGe detector well geometry, SILENA Type PRGC 1522 BL. •Low-level gamma spectrometric system with HPGe detector well geometry. Ortec. •Low background, gas-flow, anticoincidence Alpha-beta Counter. Radioecology Laboratory •Gamma Spectrometric System with various NaI (Tl) detectors •23 Glass Aquariums (30*20*20 cm)Tracer Metals Laboratory •Atomic Absorption Spectrophotometer equipped with graphite furnace and hydride generator Water and Atmosphere Laboratory Motorboat for sampling in the coastal environment Certificates •The radiometry laboratory of CEAC has been accredited by National Normalization Office for ISO NC 17025 and it is recognized by the International Atomic Energy Agency through ARCAL XXVI IAEA Regional project •CEAC has licences for importing, storing and handling radioactive material and is endowed with all the relevant equipment and personnel Conference room accommodating 30 people

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements:	No
Can undertake experiments where you can manipulate radionuclides within model ecosystems:	No
Study biomarkers:	No
Links with researchers with other relevant biological or ecological disciplines:	Yes

CIEMAT (Research Centre for Energy, Environment and Technology)

CIEMAT (Research Centre for Energy, Environment and Technology)
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Our main strength is to develop prospective and retrospective radiological impact evaluation methods derived from radioactive materials present in the environment from natural origin, effluent discharges and waste disposal practices. In order to carry out this objective the working group have gained experience on the development, implementation and application of safety assessment methodologies, parametric data bases, mathematical codes and other tools intended to the environmental radiological impact assessment of the nuclear and radioactive facilities, in normal or accidental situations.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate T

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
The laboratory is furnished with the necessary means and capabilities to assist large demand of analyses and to support R+D projects with radioanalytical measurements. These capabilities are distributed among the following Laboratories: Sample preparation; Radiochemistry of natural radionuclides; Radiochemistry of artificial radionuclides; Radiochemistry of gases; High resolution Gamma spectrometry; High resolution Alpha spectrometry; Low-level Liquid scintillation counting (ENAC accreditation (144/LE 471) for H-3 in water samples); Total alpha and beta Laboratory; Computing and Quality Assurance Office; Radioactive Installation IR-05, which supports the activities of the Laboratory of Environmental Radioactivity, by providing the storage and spiking of radioactive standards and the use of radioactive tracers for different purposes such as the setting up of new analytical procedures or the development of experimental assays for R+D projects (a plant growth chamber (fitotrón) installed in the IR-05 allows to carry out laboratory experiments on the study of the soil-to-plant transfer of radionuclides by using radioactive tracers, under controlled environmental conditions and all the Safety and Radiological Protection standards.

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
Our main experience refers to: Laboratory studies in mice; Effects of acute irradiation at high dose rates; Deterministic (mortality) and stochastic effects (carcinogenesis) studies; Cytogenetic analysis (chromosomal aberrations); Molecular changes induce by radiation (LOH, gene expression).

Organism types:
Terrestrial: Mammals

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
CIEMAT has an X-ray machine facility to irradiate mice. It also has the necessary facilities to feed mice (rats) with contaminated food. We have recently acquired an inhalator machine that allows administration of radionuclides via inhalation (mice and rats).

Conducted (considered conducting) RBE studies: Yes

Details of RBE studies:
We have done studies on RBE of reference radiation (Co-60 and x-rays) using in vitro approaches (cell suspensions were in vitro irradiated, analysing afterwards several cellular and sub-cellular parameters). In the future we plan to do some RBE studies with other radiation types, but always using in vitro approaches.

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
CIEMAT has an External Dosimetry Service (TLDs and Active detectors) and also an Internal Dosimetry Service (Whole body counter; bioelimination laboratory). There is also a group working on biokinetic models of radionuclides in rats.

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: Yes

Details of biomarker studies:
Chromosome aberrations. Free radical production (after high doses of radiation). Cell cycle-related parameters (i.e. mitotic index).

Links with researchers with other relevant biological or ecological disciplines: No

Democritus University of Thrace

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Radionuclide Transfer

Conduct studies on transfer processes in environment: No

Conduct field studies on radionuclide transfer to biota: No

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: Yes

Details of biomarker studies:
$LD_{50;}$ $LC_{50;}$ NOAEC; growth; Ache; Freshwater fish and plants; Pesticides and Growth Regulators

Links with researchers with other relevant biological or ecological disciplines:
Assoc. Prof. Maria Chrysayi, Athens Agricultural University, Pesticide Laboratory

Details of links:
Pesticide potential of bioactive substances, e.g. pyrenophorin and their toxicity on freshwater fish
Assoc. Prof. Maria Chrysayi, e-mail: mchrys@aua.gr

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ECOMAtters Inc.

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Soil K_d, soil to plant transfer, bioavailability, radiation effects, chemical ecotoxicity

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Background sites, sites contaminated by U processing

Radioanalytical facilities, isotopes analysed and accreditation status:
None, use accredited commercial labs

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Experience and strengths in studies on radiation effects on organisms:
Did such studies in the past

Organism types:
Terrestrial: Plants

Ecosystem types: Temperate: T

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: Yes

Details of effects studies conducted at contaminated field sites:
waste dump

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
Ecotoxicology

Environment Agency

Environment Agency
Chemical Sciences
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
We have studied transfer pathways for radionuclides in the context of impact assessments of ionising radiation on wildlife and humans. For example, we have funded work to experimentally determine dose coefficients for tritium in Cardiff Bay flounder because of the problem encountered where increased concentrations were observed in the environment. Determining unusual pathways of transfer off of nuclear licensed sites.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
We collect samples from the environment (biota, media (water, soil, air) and foodstuffs) and analyse for a range of radionuclides. The Agency's analytical results are now published as part of the RIFE documentation. We are also currently undertaking a study in the Tees Estuary in support of validation studies concerning the impact assessment of ionising radiation on non -human species. However please see comments below about analytical facilities.

Radioanalytical facilities, isotopes analysed and accreditation status:
The Agency has no radioanalytical facilities but we have agreements with a number of external laboratories to undertake such analysis and these laboratories are all accredited to ISO17025

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
The Environment Agency has an in-house ecotoxicology laboratory. Also, in collaboration with organisations such as CEFAS, the Agency funds experimental work on the effects of ionising radiation on non-human species. For example work has been funded on the effects of chronic ionising radiation on the soil fauna, woodlice and worms and work is currently being funded on the effects of chronic ionising radiation on macroalgae.

Organism types:
Terrestrial: Crustaceans; Invertebrates; Soil Fauna
Marine: Crustaceans; Fish; Invertebrates; Molluscs; Plants
Freshwater: Invertebrates
Other: Amphibians to be studied but not to date

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M; F

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
Yes we have facilities for the feeding of contaminated foods (not radioactive) and radiation experiment facilities may be obtained under contract.

Conducted (considered conducting) RBE studies: Yes

Details of RBE studies:
We would consider RBE studies but only in collaboration with other organisations who have the appropriate facilities.

Conducted radiation effects studies at contaminated field sites: Yes

Details of effect studies conducted at contaminated field sites:
Through funding other organisations: The Environment Agency has funded work in the Chernobyl exclusion zone conducting experiments on mammals, invertebrates and plants.

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Details of radionuclide manipulation experiments:
Not in house but potentially may fund other organisations to do so.

Study biomarkers: Yes

Details of biomarker studies:
A number of biomarkers are studied in house. Full details are not available at the moment but assays are continually being developed both in house and through collaboration/funding of other research organisations. Endpoints studied include direct toxicity, mortality, mutation, reproduction and morbidity.

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:

Many organisations within the UK research community.

Enviros Consulting Ltd

Enviros Consulting Ltd
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Enviros currently works alongside UK and European regulators, the nuclear industry and numerous international organisations on a variety of studies. This includes environmental monitoring studies in the UK and the Ukraine, development of assessment methodologies for environmental regulators, and design and application of novel bespoke modelling systems to assess radionuclide transfer through the environment.
Examples include the BIOPROTA international forum that aims to provide both data and assessment criteria for assessing potential environmental impacts from the storage of radioactive waste in long -term underground storage facilities.
Similar environmental process assessments and modelling has been undertaken for various IAEA international initiatives and waste disposal facilities, for instance in the UK, United States, Japan and elsewhere in Europe. Enviros has recently been commissioned by the UK CoRWM working group to produce strategy papers on the environmental implications of waste disposal options in the UK.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)

Temperate:	T; M; F
Arctic/Tundra:	T

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Assessment of ecological transfers and impacts of contamination in the Chernobyl exclusion zone and environmental monitoring in the UK to provide data to support validation of transfer and impact models.
Key strengths:
Experience of environmental monitoring in a wide range of environments
Skilled and competent staff
Access to wide range of field instrumentation and equipment

Radioanalytical facilities, isotopes analysed and accreditation status:
Enviros deals with a number of UK accredited radioanalytical laboratories and can provide a full service across a broad spectrum of radionuclides and environmental media.

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
Population dynamics of small mammals in the Chernobyl exclusion zone.
Various desk -based assessments on the impacts of radionuclide discharges to terrestrial, marine and freshwater environments have been conducted using both UK and International approaches. This has included revision and review of methodologies and, for instance, during the assessment of the radiological exposure to marine biota from fuel fragment particles new assessment methods have been developed.

Organism types:
Terrestrial: Invertebrates; Mammals

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted radiation effects studies at contaminated field sites: Yes

Details of effects studies conducted at contaminated field sites:
Ecological impacts within the Chernobyl exclusion zone

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
Enviros works with a number of UK academics involved in genotoxicity, ecotoxicity and radioecology

Fisheries and Oceans Canada

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Bioaccumulation and tissue distribution studies of metals, organometals, and organic chemicals in marine organisms with the aid of radiomarkers (in vivo gamma counting, pharmacokinetics, whole-body autoradiography, bioaccumulation modelling, and synthesis of radiolabelled organometals)

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate; Cold environments: M

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
New laboratory under construction. Will include the following equipment:
- wet lab dedicated to experiments with radiomarkers
- 4 x 400 -L tanks
- 10 x 70 -L tanks
- 12 x 30 -L tanks
- 6 x 3000 -L mesocosms (2006)
- in vivo gamma counting (2 x 3" NaI detectors)
- counting room (3 Xtra 50% Ge detectors, Wizard gamma counter, TriCarb LS counter)
- liquid nitrogen generator (10L/h)
- autoradiography laboratory (Leica CM3600 cryomicrotome for large specimens, Cyclone PhosphorImager for electronic autoradiography)

- radiochemistry laboratory (HPLC -FSA, vent hood for radioisotopes, glove box for synthesis of radiolabelled chemicals, high pressure gas booster, high pressure reaction vessel)
- underground laboratory (-20 m) for the measurement of weak radioactivities (Gamma Analyst gamma spectrometer, Quantulus ultra -low background LSC)
- Owner of a radioisotope license from the Canadian Safety Nuclear Commission

We have extensive wetlab facilities solely dedicated to the use of radiomarkers to study the direct and trophic transfer of contaminants (PAHs, PCBs, pesticides, metals, organometals) in a variety of marine organisms (mussels, clams, shrimps, crabs, fish, polychaete worms).

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: Yes

Details of radionuclide manipulation experiments:
We will have a system of 6 x 3000 -L mesocosms operational in 2006

Study biomarkers: No

Details of biomarker studies:
Not yet.

Links with researchers with other relevant biological or ecological disciplines: Yes

Active collaboration with the Marine Environmental Laboratory of the International Atomic Energy Agency (IAEA) in Monaco, Federal University of Parana in Curitiba, Brazil, McMaster University in Hamilton, Ontario, Canada, and Hong Kong University of Science and Technology, Kowloon, S.A.R. Hong Kong. Use of whole-body autoradiography (equipment not available elsewhere) to study the tissue distribution of radiolabelled contaminants in marine organisms.

Food Standards Agency

Food Standards Agency
Emergency Planning, Radiation and Incidents
Aviation House,
125 Kingsway
London
U.K.
WC2B 6NH

Website: www.food.gov.uk

First Contact Details:
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Senior Scientific Officer in Nuclear Assessments Branch
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Modelling of transfer of radionuclides into the food chain and subsequently humans

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M; F

Conduct field studies on radionuclide transfer to biota: No

Details of field studies of radionuclide transfer to biota:
We contract out research but do none ourselves

Radioanalytical facilities, isotopes analysed and accreditation status:
We contract out analysis but do none ourselves

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

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Georgian Institute of Agroradiology and Ecology

Georgian Institute of Agroradiology and Ecology
Laboratory of plants radiology and ecology
Institute of Agroradiology and Ecology,
ZAHESI,
Mtsheta's district
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Georgia

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scientific worker
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ekapopiashvili@yahoo.com

Radionuclide Transfer

Conduct studies on transfer processes in environment: No

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
We are studying transfer of 137Cs in plant organism.

Radioanalytical facilities, isotopes analysed and accreditation status:
beta analizator 137Cs, 40K

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
The radiation effects studies on different structural -functional levels of plant organism.

Organism types:
Terrestrial: Plants
Freshwater: Plants

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
We have the possibility to irradiate the organisms by different doses of gamma -radiation (137Cs, 60Co). We have the licences to conduct these studies.

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: Yes

Details of biomarker studies:
We are studying bioindication on plants, organs and cells.

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
We have links with Scientific -Research Institute of Radiology and Agroecology in Russia (Obninsk) and Scientific -Research Institute of Cell Biology and Genetic Engineering in Ukraine (Kiev).

Health Protection Agency

Health Protection Agency
Environmental Assessments Department,
Radiation Protection Division
Harwell International Business Centre
Chiltern
Oxfordshire
England
OX11 0RQ

Website: www.nrpb.org

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Migration of radionuclides through geosphere (aquifer) transfer of radionuclides in biosphere in general, including plants and animals

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Conduct field studies on radionuclide transfer to biota: No

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: No

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IAEA - Marine Environment Laboratory

IAEA - Marine Environment Laboratory
Radiometrics Laboratory
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Marine radioecology, Radiotracers to study environmental processes (aquatic environment)

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate; Tropical; Polar; Coastal: M

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
Underground low -background gamma detector systems (6)
Underground low -background liquid scintillation system (1)
Low -background alpha spectrometry systems (60)
Low -background liquid scintillation system (1)
Low -background gamma detector systems (2)
Radiochemistry laboratories, fully equipped (6)
Training laboratory in radiochemistry
Training laboratory in low -level counting

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
The radioecology laboratory at MEL can conduct studies on the uptake and release of radionuclides in marine organisms

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: Yes

Details of radionuclide manipulation experiments:
Could be conducted in collaboration with the Radioecology Laboratory in MEL

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
MEL has a Radioecology Laboratory, expert in the study of transfer of radionuclides to marine biota.

Institute for Environmental Sciences

Institute for Environmental Sciences
Department of Radioecology
1-7 Ienomae, Obuchi, Rokkasho-mura
Kamikita-gun, Aomori
Japan
039-3212

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hirot@ies.or.jp

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Migration in soil; soil-to-plant transfer

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T

Conduct field studies on radionuclide transfer to biota: No

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

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Institute of Biology, Komi Scientific Center, Ural Division of RAS

Institute of Biology, Komi Scientific Center,
Ural Division of RAS
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Radionuclide Transfer

Conduct studies on transfer processes in environment: No

Conduct field studies on radionuclide transfer to biota: No

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
Dependencies between dose and effect of gamma -radiation, radionuclides, heavy metals in plants.
Studies of the heavy natural radionuclide effects in plants
Studies of toxic and genotoxic effects of combined acute and chronic exposure of low doses and concentrations of such common pollutants as heavy, alkaline, alkaline earth metals and heavy natural radionuclides in plants

Organism types:
Terrestrial: Plants
Freshwater: Plants

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate; Zone of middle Taiga: T

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
We use irradiation sources listed below:
1. stationary gamma -ray irradiation apparatus (Issledovatel)
2. natural radionuclide salts (thorium and uranium nitrates)
3. natural water sources from high natural radiation background territories

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: Yes

Details of effects studies conducted at contaminated field sites:
We study heavy natural radionuclides and external gamma -irradiation contributions to genetic diversity of *Vicia cracca* and *Pinus sylvestris* populations growing on high natural radiation territories 35 and 20 years respectively.

Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
We can make dosimetry measurements of radon and external gamma -irradiation exposure

Can undertake experiments where you can manipulate radionuclides within model ecosystems: Yes

Details of radionuclide manipulation experiments:
We use model water solutions and soils, containing different concentrations of radionuclides

Study biomarkers: Yes

Details of biomarker studies:
To test sample genotoxicity we use ana -telophase chromosome aberration assay in *Allium* sp. Bulbs, *Vicia cracca* and *Pinus sylvestris* seedlings root tip, somatic mutation in *Tradescantia* (clone 02) stamen hair cells. Toxicity is estimated based on root proliferation (mitotic index), loss of reproduction integrity of stamen hairs and inhibition of *Chlorella* culture growth.

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
We have closed links with Russian Institute of Agricultural Radiology and Agroecology (Obninsk).

Institute of Industrial Ecology

Institute of Industrial Ecology
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director
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Study of radiation contamination after accidents at Mayak plant. Study of radionuclides transfer due to oil industry

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
Multi channel gamma -spectrometer (certificate of Russian Standard System)

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:

Institute of Nuclear Energy Research

Institute of Nuclear Energy Research
Health Physics
1000, Wunhua Rd., Chiaan Village
Longtan
Taoyuan
Taiwan
325

Website:
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Hsin-Fa Fang

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Fax:

Second Contact Details:

Phone:
Fax:

Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Our study is major on soil-to-plant transfer factor.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Tropical: T

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
Our organisation's radioanalytical laboratory is operating based on ISO 17025.The laboratory is accredited by TAF, one of the ILAC's members, for Sr-90 and gamma spectrum analysis of soil and plant.

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: No

Institute of Radioprotection and Nuclear Safety

IRSN
Direction of scientific and technical assessment (DESTQ)
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Didier.champion@irsn.fr

Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Terrestrial mesocosms experiments - transfer/migration studies
Analytical ecotoxicological experiments in controlled laboratory conditions (e.g. fish, daphnia, mussel, cray fish, mice and rats, microalgae, beans, higher plants)
Laboratory trophic nets
Regional scale assessment of radionuclide dispersion and accumulation processes
Environmental surveillance (e.g. air, water, soils, food products)
Radionuclide fate and pathways modelling (e.g. empirical/operational for emergency planning and crisis management, mechanistic)

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M; F
Tropical: T; M

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
IRSN holds all facilities for alpha, beta and gamma emitters measurements, in abiotic and biotic environmental matrices, including low dose radiation measurements in the environment

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
3 IRSN Laboratories involved in such studies: LRE (Laboratory of Radioecology and Ecotoxicology), Cadarache LRTOX (Laboratory of Radiotoxicology), Pierrelatte LRC (Laboratory of Radioecology of Cherbourg), Cherbourg

Organism types:
Terrestrial: Bacteria; Crustaceans; Mammals; Molluscs; Plants; Soil Fauna
Marine: Crustaceans; Fish; Insects; Invertebrates; Molluscs; Plants
Freshwater: Bacteria; Crustaceans; Insects; Invertebrates; Molluscs; Plants

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)

Temperate:	T; M; F
Tropical:	T; M

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
All 3 laboratories have such licensed facilities, including for handling transuranic alpha emitter elements.

Conducted (considered conducting) RBE studies: Yes

Details of RBE studies:
This is currently planned as part of the ENVIRHOM program

Conducted radiation effects studies at contaminated field sites: No

Details of effects studies conducted at contaminated field sites:
This has not yet really been done, but past experience on external irradiation

Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
Dosimetry measurement experience is existing in the Direction for Human Radioprotection (DRPH)

Can undertake experiments where you can manipulate radionuclides within model ecosystems: Yes

Details of radionuclide manipulation experiments:
microcosms and mesocosms as well as laboratory trophic networks are quite feasible at IRSN

Study biomarkers: Yes

Details of biomarker studies:
Metallothionein, and oxidative stress related biomarkers essentially (also for heavy metals contamination)

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
Focus is essentially on traditional ecotoxicology at the moment.

IRD/CNEN

Instituto de Radioproteção e
Dosimetria-Comissão Nacional
de Energia Nuclear. IRD/CNEN.
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Studies of soil to plant transfer, Studies about the impact of fertilizers on containing of radionuclides in vegetables, studies of radionuclides uptake by aquatic plants, investigations of sediment sorption and radionuclides behaviour in surface water and groundwater.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Tropical: freswater and terrestrial T; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:

Soil to plant transfer of radium, uranium and thorium in a region rich in monazite: Plants were cultived in situ.
Behaviour of natural radionuclides in a coastal lagoon. Samples of water, sediment and aquatic plants were collected and analysed. The data showed the influence of high pH values on the radium behaviour and the role of the aquatic plant concerning uptake of the radionuclides. Sediments were characterized and the sorption of radionuclides were estimated, additionally sorption studies were performed in a laboratory.
Influence of phosphate fertilizers on the content of radionuclides in vegetables. Plants were cultivated in an experimental field under organic and phosphate fertilizer conditions. The data showed the influence of the chemical fertilizer on the uranium uptake by the vegetables.

Nowadays I am performing some research concerning Radium adsorption by detritus of plants-aiming fitoremediation and have a project concerning the radionuclides behaviour and migration in groundwater.

Radioanalytical facilities, isotopes analysed and accreditation status:
We have radiochemical laboratories and measurement laboratory- Which are able to perform gamma spectrometry by HPGe detectors, Beta and alpha counting by proportional counting of low background, beta counting by Liquid Scintillation Counter, alpha spectrometry by barrier detector. The laboratories perform the analysis of environmental samples for the program of control of monitoring programme of Brazilian nuclear facilities.

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

iThemba Laboratory for Accelerator Based Sciences

iThemba Laboratory for Accelerator Based Sciences
Environmental Radioactivity Laboratory (Physics Group)
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7129

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
main technique: gamma -ray spectroscopy using germanium detector (in lab) and scintillator detector (with GPS) in field. We make measurements of radioactivity in soils, vegetation and water

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Thus far we only measured radioactivity (gamma -ray emitting) in e.g. soil and associated plants.

Radioanalytical facilities, isotopes analysed and accreditation status:
We have a HPGe (with 10 cm lead castle) and MCA system. We also use a MEDUSA CsI + GPS system to map radioactivity in the field. We are not accredited yet but are currently working towards ISO9001: 2000 certification.

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: Yes

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
Yes if dose conversion factors are known (e.g. soil concentrations used to calculate dose).

Can undertake experiments where you can manipulate radionuclides within model ecosystems:	No
Study biomarkers:	No
Links with researchers with other relevant biological or ecological disciplines:	Yes

Details of links:
Dr. Kobus Slabbert (head of Radiobiology at our laboratory). He studies effect of dose on cells (e.g. micronuclei density)

Loughborough University

Loughborough University
Chemistry
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Loughborough
Leics
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LE11 3TU

Website:http://www.lboro.ac.uk/departments/cm/pages-research/environment/enviro.html

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Water chemistry (speciation, stability constants, kinetics, modelling). Since groundwater and surface water movement is a major factor in pollutant and contaminant transport through the terrestrial environment. Current research investigations are concerned with metal interactions with inorganic colloids (silica, iron, manganese and aluminum), low molecular weight natural organics (citrate, acetate etc.), anthropogenic species (EDTA etc.) and naturally occurring organic colloids (humic and fulvic acids). These species may be present in natural waters and many are known to bind metals (and in some cases, organic pollutants) to form water soluble complexes. They are therefore important transport agents through the Geosphere. Factors which affect reactions of metals with these species, such as temperature, pH, ionic strength, competition reactions etc. are under investigation.
Surface interactions (metal and metal-complex interactions with mineral and clay surfaces in the presence and absence of humic materials). Since these interactions largely govern the mobility of species present in waters. Kinetics and strengths of surface interactions are studied by batch and column methods. Distribution ratios are measured as a function of pH, temperature, ionic strength etc.
Mobility of aqueous species. The mobility of aqueous complexes is studied in column experiments. Recently we have developed methods which allow humic and fulvic acids to be covalently labeled with either 14C or 125I so that the mobility and the interactions of these acids with aquifers and other species present in waters can be studied more easily. Fulvic acid, labeled with 125I has been used in a field test at the BGS experimental borehole array at BNFL's Drigg site in Cumbria.
Predictive computer modelling. Safe disposal of radioactive wastes requires predictive computer modelling. Through EC MIRAGE sponsored projects a large number of scientists from different European countries are co-operating in an attempt to formulate a suitable computer code which can be used to predict the mobility of pollutants through the environment. Laboratory experiments are also conducted which are designed to validate these models. Methods of predicting stability constants, which are required for inclusion in data bases, are also investigated and recently these methods have been coded into a programme for use by other scientists.
Current field tests and field investigations. Organic material, taken from MOL in Belgium, has been radiolabelled and injected into Boom Clay in the underground laboratory at MOL to determine the diffusion rates of natural organic material through the Boom Clay. An ongoing project concerning the role of colloids as transporters of radionuclides is funded by BNFL and requires samples being taken from the Drigg site by anaerobic micro purging to determine the colloid type and population and, the radioactivity associated with the colloids.

Land remediation. Humin (the insoluble organic fraction of soils and peats) is being evaluated to determine its ability to extract and concentrate metals from contaminated land.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
All radionuclides

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

McMaster University

McMaster University
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Radionuclide Transfer

Conduct studies on transfer processes in environment: No

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
Exposure of live fish and fish tissue to very low doses of gamma radiation (less than 10mGy). Development of in vitro systems and in vivo/in vitro validation of toxicity data

Organism types:
Terrestrial: Mammals
Marine: Crustaceans; Fish
Freshwater: Fish

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate; Semi-Arctic: M; F

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
Fully equipped freshwater aquarium for rainbow trout or zebra fish. Multiple Tanks. Access to hatchery (experimental) at Guelph for lifespan studies.

Conducted (considered conducting) RBE studies: Yes

Details of RBE studies:
Interested in the Alpha-RBE question at environmentally relevant doses

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
Health Physics and chemistry departments provide this service

Can undertake experiments where you can manipulate radionuclides within model ecosystems: Yes

Details of radionuclide manipulation experiments:
We have freshwater mesocosms (collab with Chris Wood) and access to the Savannah River Site (Tom Hinton)

Study biomarkers: Yes

Details of biomarker studies:
Apoptosis, gene manipulation, genomic instability and bystander effects, comet assay, micronucleus assay, protein up regulation

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
Life Sciences at McMasters: Jim Quinn (microsatellites in birds); Chris Wood (metal toxicity in fish). University of Waterloo: Niels Bols (cell biology in fish)

National Institute of Radiological Sciences Japan

National Institute of Radiological Sciences Japan
Japan

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Radionuclide Transfer

Conduct studies on transfer processes in environment: No

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Experimental microcosm: F

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
Our National Institute of Radiological Sciences has a facility for exposing radiation to experimental animal and aquatic species. As aquatic species, genetically modified medaka fish, zebra fish, daphnia etc. are produced for low dose radiation and acute high dose of gamma and neutron. We have electrostatic accelelator, PIXE equipment, ICP-MS, ICP-AMS analyses facility for environmental radioecological assessment. We have a Nakaminato branch for marine radioecology, at the coast of Ibaraki, Tokai at the vicinity of nuclear plants and fuel reprocessing plant in Tokai, Ibaraki prefecture, Japan.

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
Effects of radiation on the Morbidity of each species of Microcosm have been experimentally and theoretically analyzed. Impacts of these morbidity and mortality of each individual level have been analysed as the populations and community level imbalance by complex system analysis with particle-based computer simulations.

Organism types:
Freshwater: Bacteria; Protozoa; Algae

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Microbial artificial ecosystem F

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:

Closed microbial ecosystem with producer (algae), consumer (protozoa) and decomposer (bacteria) experimental facility and equipment have been exposed to both chemical and radioactive toxicants.

Conducted (considered conducting) RBE studies: Yes

Details of RBE studies:
Acute and chronic exposure of chemicals and radioactive materials with alpha, beta and gamma emission should be compared to the dose to a specific organ and their impacts on morbidity, mortality, detectable DNA damage and reproductive success.

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: Yes

Details of radionuclide manipulation experiments:
As above

Study biomarkers: Yes

Details of biomarker studies:
Negative grabitaxis and radiation Photosynthesis yield and radiation mobilization and radiation have been studied with bacteria, protozoa and algae.

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
Mathematical biologists and ecologists have been included as coworkers of the research.

Newcastle University

Newcastle University
Biology
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Website:

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Jim Clapp

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Phone:
Fax:

Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Study of radiocaesium transfer by birds; the bioconcentration of environmental nuclides in the form of guano deposition.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Red grouse on heather moors North UK

Radioanalytical facilities, isotopes analysed and accreditation status:
Was CEH; research not deemed important

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
In field collection of samples from fallout impacted north of England site.

Organism types:
Terrestrial: Birds

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T

Study biomarkers: Yes

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:

Newcastle University biology dept.

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Norwegian Radiation Protection Authority

Norwegian Radiation Protection Authority
Emergency Preparedness and Environmental Radioactivity
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Modelling of transfer of natural and artificial radionuclides in ecosystems, e.g. biokinetic allometric modelling in marine ecosystems. Data collation and review Monitoring and sampling of radionuclides in the environment Analyses of a suite of radionuclide (HPGe gamma spectrometry, beta counting, radiochemical methods and alpha counting)

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Recent field experimental studies on assimilation and depuration of radionuclides by reindeer. Transfer of radionuclides in semi-natural ecosystems (berries, mushrooms, grouse) Transfer of radionuclides in marine systems - mollusc, crustaceans, fish, seal

Radioanalytical facilities, isotopes analysed and accreditation status:
Analyses of gamma emitting radionuclides by HPGe and NaI (primarily Cs-137 but has included Co-60, isotopes of Eu etc.) Tc-99 (Beat counting), Sr-90 (Quantalus), Pu,239,240, Am-210, Po-210 (radiochemical separation and alpha counting)Accredited laboratory

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
Work in Collaboration with Norwegian University of Life sciences Supervisory work PhD on radiation effects on terrestrial soil fauna

Organism types:
Terrestrial: Soil Fauna

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)

Temperate: T

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
Field experimental studies on assimilation of radionuclides by reindeer.

Conducted (considered conducting) RBE studies: Yes

Details of RBE studies:
Previous studies cell line (rodent) RBE for different LET radiations Norwegian research Council study - daphnia, zebra fish, earthworm, internal Cs-137 and Po-210 : completed. No current Studies

Conducted radiation effects studies at contaminated field sites: Yes

Details of effects studies conducted at contaminated field sites:
At Kraton and Krystal sites (PUNEs), Russia. In collaboration with Institute of radiation Hygiene.

Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
Ionising chamber dosimetry, TLD, Biological dosimetry, Fricke dosimetry

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: Yes

Details of biomarker studies:
Experience in use of biomarker but no experimental facilities

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
Biomarker work Norwegian Institute for Public Health, Norwegian University of Life Science

Norwegian University of Life Sciences

Norwegian University of Life Sciences
Department of Plant and Environmental Sciences
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
TENORMs and Transuranics in the environment, together with other radionuclides and also trace elements.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Transfer studies of radionuclides to plants and also fish, mussels etc.

Radioanalytical facilities, isotopes analysed and accreditation status:
We have here laboratories and facilities for measuring alpha-, beta- and gamma-radiation together with a ICP-MS for both long-lived radionuclides and other trace elements.

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
We have a gamma-source where organism can be radiated with defined distance from source and time do get the dose wanted.

Organism types:
Terrestrial: Bacteria; Insects; Invertebrates; Mammals; Plants; Soil Fauna
Marine: Bacteria; Crustaceans; Fish; Invertebrates; Mammals; Plants
Freshwater: Bacteria; Crustaceans; Fish; Invertebrates; Mammals; Plants

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M; F

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
In our laboratory facilities we can provide any type of feeding experiments, both in specially designed fish tanks and in specially designed set ups in lab.

Conducted (considered conducting) RBE studies:	Yes
Conducted radiation effects studies at contaminated field sites:	No
Can make in-house dosimetry measurements:	Yes
Can undertake experiments where you can manipulate radionuclides within model ecosystems:	Yes
Study biomarkers:	Yes
Links with researchers with other relevant biological or ecological disciplines:	Yes

Riso National Laboratory

Riso National Laboratory
Radiation Research
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Monitoring programmes since the 1960's have covered the main constituents of the human food chain

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Long time series (several decades) of field data on transfer of radioactivity to biota

Radioanalytical facilities, isotopes analysed and accreditation status:
Gamma, alpha and beta spectrometry at low levelsSr-90, Cs-137, Tc-99, Po-210, Ra-226, Pu-239, Pu-240, Am-241, Np-237, I-129

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

SENES Oak Ridge, Inc., Center for Risk Analysis

SENES Oak Ridge, Inc., Center for Risk Analysis
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President
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Radionuclide Transfer

Conduct studies on transfer processes in environment:	No
Conduct field studies on radionuclide transfer to biota:	No

Radionuclide Effects

Conduct studies on radiation effects on organisms:	No
Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods:	No
Conducted (considered conducting) RBE studies:	No
Conducted radiation effects studies at contaminated field sites:	No
Can make in-house dosimetry measurements:	No
Can undertake experiments where you can manipulate radionuclides within model ecosystems:	No
Study biomarkers:	No
Links with researchers with other relevant biological or ecological disciplines:	No

SKB (Swedish Nuclear Fuel and Waste Mngmt Co)

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Elemental uptake release , mechanistical modelling, holistic ecosystem approach

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate; Brackish Water; Polar; Tundra; Permafrost: T; M; F

Conduct field studies on radionuclide transfer to biota: No

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: Yes

Details of effects studies conducted at contaminated field sites:
We conduct studies on natural co-occurring elements

Can make in-house dosimetry measurements: No

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: Yes

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SPA "TYPHOON"

SPA "TYPHOON"
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Dynamic radioecological models of radionuclide migration in aquatic ecosystems

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: M; F
Arctic: M

Conduct field studies on radionuclide transfer to biota: No

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
Creation of database on radiation effects in natural flora and fauna based on publications in Russian

Organism types:
Terrestrial: Birds; Insects; Invertebrates; Mammals; Plants; Soil fauna
Marine: Fish
Freshwater: Amphibians; Bacteria; Crustaceans; Fish; Molluscs

Ecosystem types:
Temperate: T; M; F
Arctic: T; M

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements:	No
Can undertake experiments where you can manipulate radionuclides within model ecosystems:	Yes
Study biomarkers:	No
Links with researchers with other relevant biological or ecological disciplines:	Yes

Centre for Environment, Fisheries & Aquaculture Science (CEFAS)

The Centre for Environment, Fisheries &
Aquaculture Science (CEFAS)
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Use of natural & artificial radionuclides to describe and quantify behaviour and transport processes in sediments and seawater; in coastal, shelf and deep-ocean

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: M
Arctic: M

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Use of macro-algae as bioindicator

Radioanalytical facilities, isotopes analysed and accreditation status:
Beta counting, gamma & alpha spectrometry, radiochemistry; wide range of natural & artificial radionuclides in wide variety of biotic and non-biotic media; UK NAMAS accreditation, IAEA intercomparisons

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
Gamma irradiation facility allowing 3 dose regime and near-continuous irradiation of living organisms

Can make in-house dosimetry measurements: Yes

The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences

The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Pu, Sr-90 and Am transfer to bones of different animals (mammals and birds). Aforementioned radionuclides and Cs-137 transfer to insects and plants are also under study. Relatively high Pu and Am transfer to skulls of small mammal (rodents, insectivorous) was found.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)

Temperate:	T
Antarctic:	T; M
High mountains (The Tatra mountains):	T

Conduct field studies on radionuclide transfer to biota: No

Radioanalytical facilities, isotopes analysed and accreditation status:
Equipment: four gamma spectrometers with HPGe detectors (one with muon veto active shield and 2500 years old lead), eight alpha spectrometers with semiconductor detectors, Liquid Scintillation spectrometer (Wallac Guardian)
Radionuclides of interest:
1. by gamma: K-40, Cs-137, Be-7, Na-22, Ac-228, Pb-210 (in trials)
2. by beta: Pu-241, Sr-90, Tc-99 (in trials)
3. by alpha: Pu-238, 239+240, Am-241, U-238,U-234,U-235, Ra-226, Th

Accreditation - planned in near future for cesium and Pu - searching for founds

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

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Radionuclide Transfer

Conduct studies on transfer processes in environment:	Yes

Details of experience and strengths on transfer processes:
Time scale associated with particulate transfer

Ecosystem types: Marine (M); Freshwater (F)

Temperate:	M; F
Tropical:	M
Antarctic:	M

Conduct field studies on radionuclide transfer to biota:	No

Radionuclide Effects

Conduct studies on radiation effects on organisms:	No

Università Cattolica del Sacro Cuore, Faculty of Agricultural Sciences

Università Cattolica del Sacro Cuore,
Faculty of Agricultural Sciences
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Studies on soil to plant transfer, including time dependent transfer among plant compartments and studies on the transfer of Cs and Sr from plants, contaminated via leaves, to soil

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T

Conduct field studies on radionuclide transfer to biota: No

Details of field studies of radionuclide transfer to biota:
Transfer to plants

Radioanalytical facilities, isotopes analysed and accreditation status:
The Faculty of Agricultural Sciences in Piacenza is equipped with a Radioisotope Laboratory, a centralized facility where the researchers of the Faculty working with radioisotopes are admitted. The laboratory is equipped with a control of the air outlet, an area for the temporary waste storage, a climatic cell for studies in controlled conditions. Radioisotopes are used: (i) as tracers, by different Institutes, f.i. to study the accumulation and transport of photosynthesis products in plants, to identify strain of bacteria by hybridization of DNA, to study biodiversity in animals, to study the endocrinology in animals employing radioimmunological techniques or to follow the degradation of pesticides in controlled environment; (ii) for radioecological studies, to assess the behaviour of radiopollutants in terrestrial systems in controlled conditions. Analysed radionuclides are: artificial gamma emitters (by a HpGe) as 134Cs, 137Cs, 85Sr, 65Zn, 125I (by a NaI(Tl)), beta emitters as 14C, 32P. Radioecological studies are conducted in an experimental field annexed to the university and approved by the local health unit.

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

University of Bern

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
The Climate and Environmental Physics section at the Physics Institute of the University of Bern has a long tradition in the application of tracer methods (including radioisotopes) in environ-mental systems. The research includes studies of ocean circulation, dynamics of the atmosphere, exchange processes between atmosphere, hydrosphere and biosphere and the investigation of subsurface processes in groundwater and the adjacent rock phase. In the last few years special attention was put on the determination of groundwater residence times on a large range of time scales and the tracer transport through porous media (saturated and unsaturated zones).

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M; F
Tropical: T; M; F

Conduct field studies on radionuclide transfer to biota: No

Radionuclide Effects

Conduct studies on radiation effects on organisms: No

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: No

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: No

Links with researchers with other relevant biological or ecological disciplines: No

University of Georgia

University of Georgia
Savannah River Ecology
Laboratory
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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Cs dynamics in aquatic systems. Cs uptake in agricultural systems, particularly foliar uptake.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
see box above

Radioanalytical facilities, isotopes analysed and accreditation status:
We are located on a Department of Energy facility, although we are operated by the University of Georgia. We have 3500 sq ft. radioecology laboratory with typical analytical equipment. We have field sampling equipment, including boats.

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
We have a low dose rate irradiation facility. Dose rates range from background to 500 mGy per day. The facility is designed for chronic exposures to aquatic organisms. So, in addition to the low dose rates, the outdoor facility will house all life stages of Japanese Rice fish, also known as medaka, *Oryzias latipes*. The facility is described in Hinton et al. 2004, JER 74:43-55.

Organism types:
Freshwater: Amphibians; Fish

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
See note above.

Conducted (considered conducting) RBE studies: Yes

Details of RBE studies:
I am interested in doing such experiments. Our Low dose rate facility is external irradiation from Cs-137.

Conducted radiation effects studies at contaminated field sites: No

Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
We use TLDs

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: Yes

Details of biomarker studies:
Yes and No....we have several proposals in for review, but have not yet got the funds to do the work.

Links with researchers with other relevant biological or ecological disciplines: Yes

Details of links:
I am located at an Ecology Laboratory

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Cesium and uranium transport from soil to plants Transfer and distribution of radionuclides in river ecosystems Radon buildup

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; F

Conduct field studies on radionuclide transfer to biota: Yes

Details of field studies of radionuclide transfer to biota:
Uptake of uranium from soil

Radioanalytical facilities, isotopes analysed and accreditation status:
Low-level gamma-spectroscopy, all gamma-emitting radionuclides, accreditted for source activity measurements and gamma-spectrometer verification

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Organism types:
Terrestrial: Plants
Freshwater: Fish

Ecosystem types:
Temperate: T; F

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: No

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: Yes

Can make in-house dosimetry measurements:	Yes
Can undertake experiments where you can manipulate radionuclides within model ecosystems:	No
Study biomarkers:	No
Links with researchers with other relevant biological or ecological disciplines:	Yes

Westlakes Scientific Consulting Ltd.

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Radionuclide Transfer

Conduct studies on transfer processes in environment: Yes

Details of experience and strengths on transfer processes:
Our strengths in radionuclide transfer research are:- Using predictive physico-chemical modeling of the local marine/estuarine environment. - Innovative tools for quantitative risk assessment. Developing the methodologies of the future for making assessments more realistic. - Doses to biota. Involved with EA, EU: FASSET & ERICA, IAEA: EMRAS. Litigation support. - Biokinetic uptake experimental work leading to dynamic modeling of ecosystem and biota. - Innovative work on biokinetic modeling, transcending the present CF-based approach.- IPPC. Holistic assessment of the impact of pollutants with reference to environmental quality standards, from the ecological viewpoint.- Physical monitoring and analytical capabilities. Collection and analysis of marine biota (phytoplankton, zooplankton, molluscs, crustaceans, macroalgae, fish) and seawater and sediment for a range of alpha, beta and gamma emitting radionuclides. Use of fingerprint radionuclide ratios in sediment cores and seawater samples to elucidate source term contributions; chronological applications. Evolution of intertidal and saltmarsh environments from tidal, seasonal and annual timescales. Investigation of natural radionuclides (Po, Th, U) in marine and terrestrial environments. DGT sampling technology, novel low-level counting techniques for iodine, etc. All the above supports the key theme of fate and transport of radionuclides and environmental restoration. We have a twin commercial and scientific research edge. Our activities are underpinned by: Commercial consultancy, Research projects/Contract research, substantial publication and conference attendance record, PhD and MSc projects and close links with academia: MSc decommissioning modules in collaboration with Liverpool, Manchester & Lancaster Universities.

Ecosystem types: Terrestrial (T); Marine (M); Freshwater (F)
Temperate: T; M; F

Conduct field studies on radionuclide transfer to biota: Yes
Details of field studies of radionuclide transfer to biota:
Under contract with the Environment Agency we have developed a dose per unit concentration database for application to ecosystem assessments. Organisms are represented by ellipsoids of appropriate dimensions, and the proportion of radiation absorbed within the organisms is calculated using a Monte Carlo numerical routine for alpha, beta and gamma radiation implemented in a series of macro-based programs. Calculated absorbed fractions, along with a literature-researched concentration factor database, have been included in three bespoke assessment spreadsheets for the coastal, freshwater and terrestrial ecosystems which can be used

to assess dose rates to biota in situations where environmental radionuclide concentrations are in near-equilibrium with the surrounding environment. Our most recent work for the EA consists of the development of a method allowing assessments for organisms not listed in the original assessment spreadsheets, based on selection of a physical analogue for the dose conversion factors (based on area/volume parametrisation) and a biological analogue for concentration factors. This methodology allows us to represent this organism in terms of the organism categories of the assessment spreadsheets, and an estimation of the uncertainty incurred. Westlakes is currently involved in the EU ERICA project and also participated in its forerunner FASSET project. We have contributed to numerous work packages within these two research activities including the development of novel methodologies to calculate doses for reference organisms, systematic consideration of transfer data for radioactive pollutants in the marine and freshwater ecosystems, and studying the effects of radiation on biological organisms at an individual level. Our principal contribution to these projects is a method for calculating absorbed fractions by a random sampling method and the fitting of energy-dependent absorption functions, considering separately the photons and electrons emitted by the radionuclides of interest. This is the same method that was developed for EA work. Most recently we have become involved in the IAEA EMRAS programme, where Westlakes successfully participated in an inter-comparison exercise of biota dose calculation methodologies. We have tested the Westlakes dose calculated methodology against other models and are involved in discussions concerning the application of models/frameworks to estimate better the transfer of radionuclides to biota and doses received in contaminated environments. In parallel to the above we have an active research experience on biological uptake experiments and biokinetic modelling. Specifically, we have carried out dynamic modelling of the uptake of contaminants by marine biota (Tc and I in lobsters and winkles), laboratory studies of uptake and depuration of radionuclides in marine biota (especially radioiodine, Pu and Po in phytoplankton, seaweed and winkles). The main aim for this research is to reconcile field data with modelling data in self-consistent models for key radionuclides and species, driving towards a general representation of the ecosystem and its interrelationships capable of short and long-term endpoint determinations and more realistic assessments of environmental impact.

We have performed numerous studies in the field investigating the impact of natural and anthropogenic radionuclides on biota. These have consisted of sampling their immediate environs as well as a range of food items that may be available to the biota. Such studies have incorporated the investigation of the following radionuclides –^{40}K, ^{60}Co, ^{99}Tc, ^{106}Ru, ^{125}Sb, ^{129}I, ^{131}I, ^{137}Cs, ^{210}Pb, ^{210}Po, ^{226}Ra, ^{228,230,232}Th, ^{234,235,238}U, ^{238,238,240,241}Pu, ^{241}Am - in seawater, sediment, phytoplankton, zooplankton, macroalgae, molluscs, crustacea, fish, soil, earthworms, woodlice, grass, green vegetables, root vegetables and fruit. Much of the emphasis of this work has been on the exposure pathways back to man, however, as described above we are now employing such field data to determine exposure rates to biota.

Radioanalytical facilities, isotopes analysed and accreditation status:
High resolution gamma spectrometry: 2 HPGe detectors - 1 low-energy specialist detector. High resolution alpha spectrometry: 8 SSB detectors. Beta spectrometry: 1 Canberra/Packard 2750 LSC counter equipped with PSA alpha/beta discrimination. Radiochemical separation facility for alpha emitters (Po, Th, U, Pu, Am alpha-emitting isotopes), beta emitters (Tc, Pu-241), gamma emitters (between ~ 20 keV to 2.5 MeV). We cover numerous environmental matrices e.g. air filters, water, sediment/soil and biota. Accreditation status is ISO9001.

Radionuclide Effects

Conduct studies on radiation effects on organisms: Yes

Experience and strengths in studies on radiation effects on organisms:
Biomarker studies.

Organism types:
Terrestrial: Invertebrates
Marine: Crustaceans; Molluscs

Ecosystem types:
Temperate: T; F

Laboratory facilities for experimental work involving irradiation of biota or feeding of contaminated foods: Yes

Details of facilities, species of interest, and licences are in place:
Uptake of radioiodine, Pu and Po in algae, seaweed and winkles - low level work in aquaria.
Siefert Isovolt 320 X-ray generator

Conducted (considered conducting) RBE studies: No

Conducted radiation effects studies at contaminated field sites: Yes
Lobster (*Homarus gammarus*) and lugworm (*Arenicola marina*)

Can make in-house dosimetry measurements: Yes

Details of in-house dosimetry measurements:
Portable radiation monitors.

Can undertake experiments where you can manipulate radionuclides within model ecosystems: No

Study biomarkers: Yes

Details of biomarker studies:
We have extensive experience of studying biomarkers in relation to human exposure and have adapted some of the techniques for application to both aquatic and terrestrial species e.g. FISH chromosome analysis, COMET assay, micronuclei and mitochondrial mutations.

Links with researchers with other relevant biological or ecological disciplines: No

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