EUROPEAN COMMISSION
Community Research

# FUTURAE

(Contract Number: FP6 - 036453)

## Annex 1 of DELIVERABLE 2:

## Background material

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The objective of the FUTURAE project is to evaluate the potential for establishing deeper and sustainable collaboration in radioecology in Europe possibly in the form of Network(s) of Excellence.

The project started in October 2006 and is to end by September 2008.

**Project Coordinator: Institute for Radiological Protection and Nuclear Safety**

**Contractors:**

| | |
|---|---|
| Institute for Radiological Protection and Nuclear Safety | IRSN |
| Swedish Radiation Protection Authority | SSI |
| Centre for Ecology and Hydrology | CEH |
| Belgian Nuclear Research Centre | SCK·CEN |
| Research Centre in Energy, Environment and Technology | CIEMAT |
| University of Antwerp | UA |
| Radiation and Nuclear Safety Authority | STUK |
| Jozef Stefan Institute | JSI |
| Norwegian Radiation Protection Authority | NRPA |

# Executive Summary

Within FUTURAE, the overall objective of work package 2 (WP2) is to "assess the present and future needs of end-users (authorities, industry, decision-makers, scientists, higher education, international organisations *e.g.* IAEA, ICRP), and the related requirements with respect to the assessment and management of the impact of radionuclides on man and the environment". To achieve this, WP2 collated information on future needs and requirements from end-users of radioecological research/expertise within Europe, including regulators, industry, international and non-governmental organisations. A workshop was then organised to discuss the results and formulate radiological needs for the next 5-10 years.

### *The Questionnaire*

The questionnaire was designed to collate information on end-user needs. The questions asked were:

1. Identify areas of interest within the field of radioecology (tick one or more):
   - Human exposure
   - Protection of the Environment
   - NORM/TeNORM
   - Multi-contaminants (radionuclides + heavy metals or organic chemicals etc)
   - Nuclear waste repositories
   - Remediation
   - Prevention of potential malevolent use of radioactive materials
   - Others.

2. Has your organisation published of research requirements?
   If yes, please provide web address or other details of how they can be obtained. What period do these documents cover?

3. Briefly summarise any radioecological needs you foresee over the next 5-10 years [Include research/monitoring/modelling as appropriate].

Appendix 1 record the findings of Question 2 and Appendix 3 details the respondents answer to Question 3.

### *The workshop*

The FUTURAE WP2 one and half day workshop was divided into three sessions with associated group discussions relating to different issues:

- Session I. Setting the broad perspective of radioecology within Europe.
- Session II. Radioecological needs identified in the WP2 questionnaire.
- Session III. Bring together all gathered information and formulate radiological needs for the future.

All sessions were recorded anonymously. Appendix 3 records all group discussions for each of the three sessions.

Moberg *et al.* [2007] summarise the findings of the WP2 FUTURAE survey and provides recommendations for the next stages of the project.

**FUTURAE D2:**

Moberg L, Zinger I, Howard B, Beresford N, Vandenhove H and Gariel JC (2007) A study of stakeholders views on radioecological needs in Europe in the next 5-10 years. FUTURAE Deliverable 2. EC project Contract N°FI6R-CT-2004-508847.

Acknowledgment

The FUTURAE Consortium would like to thank all the End-User Group participants who attended the workshop and especially those stakeholders who have filled in the questionnaire for their valuable contributions and inputs.

**Participants of the FUTURAE Workshop on radiological needs for the future, held in Stockholm 11-12 June 2007**

**List of all organisations that contributed to the making of this report, i.e. the End-Users Group, Respondents to the questionnaire and Consortium members.**

| Country | Organisation |
|---|---|
| | European Commission |
| | International Atomic Energy Agency |
| Belgium | Agency for Radioactive Waste and Enriched Fissile Materials - NIRAS/ONDRAF |
| Belgium | Belgian Nuclear Research Centre - SCK·CEN |
| Belgium | Federal Agency for Nuclear Control FANC |
| Croatia | Institute for Medical Research and Occupational Health - IMI |
| Finland | Ministry of the environment |
| Finland | Posiva OY |
| Finland | Radiation and Nuclear Safety Authority - STUK |
| Finland | TVO |
| France | Agence Nationale pour la Gestion des Déchets Radioactifs - ANDRA |

| Country | Organisation |
| --- | --- |
| France | Commissariat à l'Énergie Atomique – CEA |
| France | Electricité de France |
| France | Institute for Radiological Protection and Nuclear Safety - IRSN |
| Germany | Federal Office for Radiation Protection – BsF |
| Germany | National Research Centre for Environment and Health – GSF |
| Italy | ENEA- Marine Environment Research Centre (ex-employee) |
| Netherlands | Ministry of Housing, Spatial Planning and the Environment - VROM |
| Netherlands | Nuclear Research and consultancy Group – NRG |
| Norway | Institute for Energy Technology - IFE |
| Norway | Norges naturvernforbund |
| Norway | NorseDecom |
| Norway | Norwegian Food Safety Authority |
| Norway | Norwegian Radiation Protection Authority - NRPA |
| Norway | Reindeer Husbandry Administration |
| Norway | The Norwegian Oil Industry Association – OLF |
| Poland | Central Mining Institute - GIG |
| Romania | CNE Cernavoda |
| Slovenia | Jožef Stefan Institute |
| Spain | Research Centre in Energy, Environment and Technology - CIEMAT |
| Sweden | Swedish Nuclear Fuel and Waste Management Co - SKB |
| Sweden | Swedish Radiation Protection Authority - SSI |
| Switzerland | Federal Office of Public Health |
| UK | Centre for Ecology and Hydrology - CEH |
| UK | Environment Agency (England & Wales) |
| UK | Foods Standards Agency |
| UK | Scottish Environment Protection Agency - SEPA |
| UK | Welsh Assembly Government |
| USA | Savannah River Ecology Laboratory |

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# Appendix 1. Publication of research requirements

Answers from respondents – as submitted.

| |
|---|
| Respondent has participated in research on radioactivity in produced water and LRA. Thematic pamphlet 2002 on radioactivity. Different reports and IFE (Institute for Energy Technology, N) work presently; Radium in produced water. |
| 1) Radioactive waste management covering aspects such as:<br>- Disposing of very large volumes of VLLW<br>- Review of practices for dealing with HLW<br>- Addressing societal perceptions with regard to site selection for a repository<br>- Developing approaches and guidance for reworking waste packages<br>- Developing supporting site information for site selection of a repository<br>- Understanding HLW and spent fuel safety cases and implications for waste acceptance<br>- Assessing different conditioning options for dealing with challenging ILW waste forms<br>- Dealing with policy changes that may occur over the next five years<br>2) Radioactive Substances Risk Assessment Issues:<br>- Developing assessment models (confirming model parameters, atmospheric modelling, GIS implementation of the assessment models, dealing with uncertainties etc)<br>- Standard settings for radioactive substances (dealing with ICRP recommendations, defining exemption levels)<br>- Testing and validating assessment approaches (particularly for protection of the environment)<br>- Evaluating the appropriateness of sampling and monitoring programmes (including MCERTS programme)<br>- Emergency preparedness<br>- Developing the process for responding to media claims/public doubts<br>- Dealing with policy changes that may occur over the next five years<br>A mixture of contracting out and in house effort will be used to perform the above work. |
| www.sepa.org.uk – typically cover 1 or 3-5 year periods |
| http://www.food.gov.uk/science/researchpolicy/researchfunding/rrd/requirements/ |
| Posiva Oy 2006. TKS-2006 - Nuclear waste management of the Olkiluoto and Loviisa power plants: Programme for research, development and technical design for 2007 - 2009. (available on http://www.posiva.fi/)<br>Ikonen, A. T. K. 2006. Posiva Biosphere Assessment: Revised structure and status 2006. POSIVA 2006-07. (available on http://www.posiva.fi/)<br>Vieno, T. & Ikonen, A. T. K. 2005. Plan for Safety Case of Spent Fuel Repository at Olkiluoto. POSIVA 2005-11. (2005-2013; http://www.posiva.fi/raportit/Posiva-raportti_2005-01.pdf) |
| STUKs strategy for 2007 - 2011: www.stuk.fi, English version (more detailed in Finnish, published also in print version) |
| Yes - Law 15 April 1994 Art.23 (Belgium Official Journal) |

| |
|---|
| "Overview of CEA research in the field of radionuclide migration" - Rapport CEA-R-6111 (2006)<br>Authors: POINSSOT Christophe, TROTIGNON Laurent, TEVISSEN Etienne<br>Editor: Direction des systèmes d'information ISSN 0429-3460. Period covered: 2000-2005<br>http://www-ist.cea.fr |
| Radioecological data concern mainly Cs and Sr<br>Andra 2005 report (www.andra.fr) and review/High activity level waste: three prior radionuclides I-129, Cl-36, Se-79<br>Cl-36 modelling development<br>Chlorine speciation in environment<br>Foliar transfer<br>Long term behaviour of elements in soils<br>2/3D modelling |
| Our organisation can mandate Swiss laboratories to develop specific scientific research.<br>The laboratories can also ask for funding (national funding programmes). Swiss experts can participate the international, mainly European working groups. |
| A research plan is published annually. There is also a long-term strategy for radiation protection research financed by the SSI. Both documents are in Swedish and available at the SSI web site (www.ssi.se) |
| R&D (FUD) regularly every 3 year, last published in 2004. R&D-Programme 2004. Programme for research, development and demonstration of methods for the management and disposal of nuclear waste, including social science research. SKB TR-04-21, Svensk Kärnbränslehantering AB (SKB) Stockholm Sweden. Next is coming in fall 2007. All on www.skb.se |

# Appendix 2. Radiological needs for the next 5-10 years

Answers from respondents – as submitted.

**Regulators**

*Respondent 3*

These are highlighted and are particularly focused on preparing *Respondent 3* for dealing with applications for new nuclear build and the site selection and planning process for the development of an underground repository.

*Respondent 4*

Environmental impact assessments on man and biota, especially when potential effects on ecosystems are better understood and any revision to EC Basic Safety Standards occurs. High quality information will be needed on accumulation, retention and effects of different radionuclide's in different forms and with a range of other stressors/contaminants, through research and modelling and then backed up by monitoring programmes. Potential impacts from the disposal of long lived alpha material needs to be considered in greater detail especially from any new/existing landfill site/repository, which may be authorised to receive such wastes. Information will also be needed to determine whether the OSPAR objective of close to zero has been achieved.

*Respondent 5*

Our main interests are in the exposure of humans and species/habitats to radioactivity, taking account of environmental monitoring of contaminant levels, and contaminant pathways from routine and accidental/terrorist incidents. The exposure by species is an increasing concern. Also the biological effects on susceptible groups of the population.

*Respondent 6*

Effects of speciation on transport of RA material through the food chain (particularly S-35). Possibly "new nuclides" being discharged as a result of new medical practices. Possibly work related to disposal of solid waste. Research is likely to be site specific and therefore is dependent on the identification of a site for any UK waste repository.

*Respondent 12*

Environmental (ecological, social and health) impacts of naturally occurring radioactive materials (NORM) from uranium mines.

*Respondent 13*

Verification of human dose assessment models by means of survey

Monitoring (results)

Research for nuclear waste repositories (biosphere analytics, behaviours: environment and human); especially long-lived nuclides (like I-129); -> 2022

Maintaining competence for potential emergencies beyond the borders (esp. North-west Russia)

Environmental research in the vicinities of potential uranium mines

Uranium with other pollution (multi-contaminants)

*Respondent 14*

Continued routine live-monitoring of reindeer before slaughter. Monitoring of reindeer meat (in slaughterhouses). Implementation of new monitoring equipment and evaluation of monitoring methodology. Research on the long-term behaviour of radiocaesium in the reindeer's foodchain. Modelling tools for the management of the Chernobyl fallout in reindeer herding.

*Respondent 21*

Monitoring of food and feed, monitoring of live terrestrial animals for human consumption, monitoring of seafood.

Monitoring around old waste depositories (exists already)

Monitoring around nuclear facilities and all over the country air monitoring (exists already)

Airborne water dispersion modelling (idem)

Drinking water monitoring (idem)

*Respondent 22*

Establishment of a good general transfer model from release to man

Radium/radon remediation techniques

Control strategy for radioactive source malevolent transport

*Respondent 25*

Research on NORM/TENORM waste impact on environment including: models of radionuclides migration, transfer factor evaluation, elaboration of a system of units for dose to non-human biota assessment in order to provide a reliable data base for creation a good European law in his matter.

Phytotechnologies for NORM/TENORM contaminated areas land reclamation.

Associated contamination: radionuclides and other pollutants especially in cases of NORM/TENORM occurrences and assessment of synergistic /antagonistic effects.

Protection of crucial human resources against malevolent use of radioactive materials (mainly water resources and waterworks).

*Respondent 26*

- In general, knowledge about the processes that influence transport of radioactive substances in the environment and their uptake in food chains.

- Migration of radionuclides in order to better understand the long-term behaviour of radionuclides in the environment, in particular in relation to repositories for radioactive waste.

- Better knowledge about naturally occurring radionuclides. In addition to field studies and laboratory experiments there is a need for more reliable prediction models.

- The research area between radioecology and biology/radiation biology of importance for protection of the environment. Lack of information has been identified concerning the biological effects of ionising radiation on non-human biota. To estimate the risks for non-human biota (as well as for humans) knowledge is needed on the dose-response curve and the long-term changes in the distribution and concentrations of radionuclides in the environment. Of particular interest are low doses and chronic exposures.

- for radiation preparedness, reliable models and strategies for the collection and interpretation of data, predictions, and recommended actions in case of incidents are needed.

- radioactive contamination in the urban environment and how the radiation dose out-doors and in-doors is dependent on different processes including remediation. Measuring techniques are important in this research.

*Respondent 23*

*Naturally occurring radionuclides/ situations with enhanced levels (remediation of former U-mining sites, NORM sites)*

- Occurrence and behaviour of natural radionuclides in the environment including the use of natural radionuclides as tracer for release and transport processes
- Determination and modelling the release and transport of natural radionuclides from heaps by seepage, investigation of the role of microorganisms inside
- Understanding of processes causing elevated $^{222}$Rn-exhalation on heaps, $^{222}$Rn-release from NORM sites
- Modelling of groundwater contamination by abandoned (industrial/ mining) sites; modelling of transport processes of natural radionuclides in sediments
- Predicting the long-term effectiveness of remediation measures (e. g. stability of covers, role of natural weathering processes and vegetation); long-term monitoring requirements
- Advancement of analytical methods for the determination of concentrations of natural radionuclides in different matrices
- Improvement of the accuracy in assessing the radiation exposure due to natural radionuclides

*Transport-·and transfer processes in the biosphere (classic radioecology)*

- Identification of key processes concerning migration of radionuclides in soils, sediments and rocks with special respect to speciation (e.g. of natural radionuclides as well as of long-lived radionuclides, which are important concerning final nuclear waste repositories).
- Quantification of the soil-plant-transfer considering soil- and plant-characteristics, particularly using stable isotopes or chemically analogue elements. The soil-plant-transfer and the translocation within the plant are commonly quantified using empirical parameters. For radiocesium, as an example, these parameters may cover several orders of magnitude. For many radionuclides the root uptake can not be quantified using results of laboratory experiments or soil properties.
- Quantification of the water-sediment/rock-transfer considering sediment/rock and water characteristics
- Water bound transport processes in unsaturated and saturated soil zones (these play, among other things, a major role when discussing clearance of radioactive substances, effluents resulting from NORM industries, which require regulatory control, assessing of radiological residues following mining/milling and when questions arise concerning final radioactive waste repositories). So far there are only strongly simplifying or extremely conservative models available. In addition, the effective transport velocity also depends sensitively on model parameters, which may vary according to the properties of individual soil zones by several orders of magnitude.
- Identification and characterisation of special pathways and contaminations relevant in ecosystems, which may cause exceptionally high accumulations of radionuclides and/or unusual contamination time series. Even 20 years after Chernobyl, for instance, the Cs-contamination of wild boars is unexpectedly high in some areas of Germany and in some cases still rising.
- Transport of radioactive substances in surface waters and groundwaters. There are still knowledge gaps concerning the adsorption of radionuclides to suspended particles/colloids and desorption processes from sediments and rocks.
- Development of generic biosphere models in proof of long-term safety of nuclear waste repositories, taking climate changes into account.

**Industry**

*Respondent 1*

*Respondent 1* works on these issues will be dependant on authority requirements for discharge reporting and scale storage.

*Respondent 7*

*Respondent 7* established an environmental monitoring program to fulfil the requirements national and European regulation.

A. Providing an early indication of the appearance or accumulation of any radioactive material in the environment caused by the operation of the station.

B. Verifying the adequacy and proper functioning of station effluent controls and monitoring systems.

C. Providing an estimate of actual radiation exposure to the surrounding population.

D. Providing assurance to regulatory agencies and the public that the station's environmental impact is known and within operational targets.

E. Providing standby monitoring capability for rapid assessment of risk to the general public in the event of unanticipated or accidental releases of radioactive material.

F. Allowing an assessment of the Derived Emission Limits (DEL) calculations based upon empirical rather than theoretical data. Besides we initiated a study of plant operation impact on terrestrial and aquatic biota and we intend to extend this study eventually as a PHARE project.

*Respondent 8*

Radiological doses defined for biota. NORM geometry

*Respondent 9*

In general, greatest advantage might be gained by efforts on joining the ecological, ecotoxicological and radioecological expertise instead of having them as clearly separate disciplines with little communication between. However, it will be distinctive to radioecology (hopefully seen as a branch of ecotoxicology) that a wide range of substances showing different behaviour in the environment needs to be assessed within the same case ("multi-radiocontaminants"), sometimes associated with non-radiotoxic contaminants. This makes it challenging to acquire and model the data and to gain the overall picture – and this is where radioecology-specific future efforts should be focused on, in addition to steps towards integrating the branches of ecotoxicology.

Considering the empirical research activities, the focus should be set on filling the known data gaps (cf. E.g. FASSET, EPIC, ERICA, EMRAS, BIOPROTA Forum and IUR Task Force "Radioecology and Waste"). Some aspects in experimental protocols require long experience from the group both in practical arrangements and in reporting to ensure the appropriateness and compatibility of the data from different sources (e.g. Controlled geohydrochemical conditions when Kd's are measured or in using analogue elements/radionuclides to study metabolism). On some aspects the issue is mainly on plain field/laboratory work that requires suitably educated and experienced personnel also long into the future. It seems, though, that despite of the well-known data gaps and needs, available funding and overall coordination of the research topics are inadequate. New funding and coordination arrangements should be developed to avoid unequal burden to those organisations whose programmes are advancing fastest when the new research benefit the whole (radio)ecological community.

On the monitoring side, radionuclides per se are not included in *Respondent 9*'s programme, yet, but will be there after the construction of the disposal facility has begun (2013—2014). At the moment, the monitoring programme of the Olkiluoto nuclear power plant at the same site provides us with sufficient background information on the radioactivity levels in the environment, and no major challenges are expected from its expansion for the spent fuel disposal activities (see e.g. STUK-YTO-TR199). Availability (and cost) of independent sampling and laboratory services might become an issue, however, if the current domestic situation declines significantly.

In modelling, the main needs are, firstly, to maintain the current expertise and number of experienced personnel, and, secondly, to develop more realistic models by efficient application of the knowledge on different geo-eco-scientific disciplines. New simulation tools enable improved dynamic modelling that requires more process-specific understanding and parameterisation. With advances in the repository programmes, for example, the needs on site-specificity tend to increase as the site understanding and site-specific data is gained; at minimum, the confirmation of the appropriateness of site-generic models and data is required. Briefly, possibilities for detailed modelling are improving vastly, and the key issues will be the representativeness of the parameterisation and input data, and prioritisation of the efforts needed since they tend to increase as fast. Thus, needs for radioecological expertise in the modelling work seem to be less than in the experimental work, provided that empirical research and monitoring are carried out with qualified personnel and the knowledge is effectively communicated to and with the modellers.

*Respondent 16*

Relation between radioecology (research/modelling) and 'reference' biospheres (modelling) for estimating long-term radiological impacts from repositories of radioactive waste.

Modelling of human exposure (biosphere modelling) for repositories of radioactive waste focussing on a limited list of citical radionuclides (long-lived mobile fission and activation products); research work mostly to be done on an international level.

Following the evolution of international and national regulations the radiological assessment of protection of the environment for radioactive waste repositories

Long-term impacts on Man and the environment of long-lived low-level waste type NORM/tenorm (Ra, Th, U isotopes)

Long-term environmental monitoring of repositories

*Respondent 19*

Necessity to have **tools and methodologies** in order to evaluate and manage risks for man related to nuclear activities. Existing tools have to be adapted or modified to integrate new scientific knowledge and to answer other issues. Important to have both:

A Phenomenological approach: mechanism description, understanding of processes, implementation of such processes in models,

An Operational approach: simplified approach but validated by the knowledge of phenomenological description, integration of different processes in particular for impact calculation tools

Hence a need in modelling activities with the support of corresponding experimental research

*Respondent 20*

See EMRAS program (2004-2007)

Technical Report Series 364 revision: **lack of radioecological data**

Many radiation protection models need to predict transfer of a large number of radionuclides. This requires information on transfer of many more or less mobile radionuclides, which do not usually comprise an important component of discharges or dose. Such information is often sparse and difficult to collate. TRS 364 provides an important source of such information, and is one of the key cited sources for many models. It is thus essential that such information is kept up-to-date and that any relevant recent literature is included, especially considering the **paucity of existing data sources**.

**Translocation data** and foliar transfer: data only for Cs and Sr

The current classifications of soil systems used in TRS364 are rather simplistic and limited to only four categories: sand, loam, clay and peat; they are somewhat inadequate to account for the soil parameters that govern the behaviours of different RN. The values were based on a relatively low number of experiments for a limited number of soils within each category. In recent years the number of data for each category has greatly increased, and analysis of the data distribution has shown a high variability and high degree of overlap. Revised classification systems are currently developed which are based on **mechanistic information** including consideration of parameter values such as ph, soil nutrient status, % clay, exchangeable K and Ca in soil, moisture content of soil, organic matter content and the time that a radionuclide is present in a soil. Numerous multi-regression analyses have been developed and give reasonable predictions on a local scale but have not been proven on a worldwide scale. At least for some radionuclides (e.g. Cs, Sr, U, Tc) a semi mechanistic approach should be used.

We need information on **biological half-lives**

It is important to include **semi-natural ecosystems** for caesium because the range of products harvested differs greatly from other ecosystems and the rate of transfer to food products is often much higher than for other ecosystems. Furthermore, the ecological half-lives of caesium in many products harvested from these ecosystems is much longer than in agricultural systems. For some populations, consumption of semi-natural products is common, for others it is confined to certain special groups. For both cases, such consumption can form a major proportion of ingestion dose in the mid-long term after deposition. Semi-natural ecosystems was largely based on simple aggregated transfer coefficients, since the **inherent variability and complexity** of such systems make predictions using other approaches difficult. Recently, some **dynamic models** have been developed which allow the estimation of transfer to certain forest products, but the number of products considered is limited. It is therefore recommended that the same parameter should be used in the revision to be able to include as wide a range of products as possible. The extension of the radionuclide spectrum should also be sought. Fortunately, data availability has greatly increased since 1992, largely from the considerable focus in both Europe and the CIS on caesium transfer to forest products.

Necessity to have **tools and methodologies** in order to evaluate and manage risks for man related to nuclear activities. Existing tools have to be adapted or modified to integrate new scientific knowledge and to answer other issues. Important to have both.

*Respondent 27*

a) Understanding of processes affecting radionuclides in surface ecosystems usually includes a wide scientific expertise in ecology, chemistry, hydrology, geology.

b) Specific hydrology and transport modelling in surface ecosystems.

c) Modelling tool development to able to handle process models.

d) General knowledge of the fate and fluxes of elements in various ecosystem.

**Other categories (excluding regulators and industry)**

*Respondent 2*

Maintain competence in radioecology and related fields / recruitment of students. Improved models for rapid decision making after a contamination event (accident, terrorist attack…). Rapid and reliable radiochemical methods. Leakage and uptake of radionuclides from radioactive waste repositories. NORM/TeNORM: mobility and uptake of natural radionuclides, waste disposal. Develop analytical methods for rare radionuclides (very low activity level), relevant for both decommissioning of nuclear installations and dirty bombs.

*Respondent 18*

Adapt radio-ecological models to changing environment (*e.g.* due to climate changes). Include other endpoints in radio-ecological modelling besides human.

Include radionuclides in radio-ecological research that are not necessarily distributed in the environment by 'standard' accident scenarios but may be obtained from illicit sources and used e.g. For dirty bombs or other threats

*Respondent 24*

Development of the philosophy and the system of protection of the environment, and achievement of the international consensus on:

- 'representative' subjects (*e.g.* Individual species vs. Groups) for the protection of the environment;
- set of principles of the protection of environment; *e.g.* Resolving of the controversial issue: whether stochastic effects in non-human biota should be considered?;
- integration of the system of protection of the environment with the existing system of radiological protection: with current principles of justification and optimisation, with the concept of exclusion, exemption and clearance of radioactive materials, etc.

Sustainability of the radioecological researches, particularly in: - mechanisms and parameters of the transfer of radionuclides in the environment;

- long-term prediction of the transfer of radionuclides in the environment for the purposes of safety assessments of radwaste repositories;
- effects of ionising radiation on biota (incl. Human);
- biokinetics in human and non-human biota;
- modelling (incl. Dynamic models and probabilistic approaches) of the transfer of radionuclides in the environment;
- dose assessments for human and non-human biota;
- monitoring techniques for the environmental monitoring for purposes of radiological protection and protection of environment.

Improvement and development of new implementation guides and computer tools for assessments of the radiation exposure of human and non-human biota.

Inter-comparison exercises on measurements of the environmental radioactivity.

Inter-comparison exercises on assessment of the public exposure with involvement of international organisations and organisations, responsible for the control of public exposure:

- inter-comparison of methods;
- inter-comparison of computer codes.

Development of the radioecological databases.

Remediation methods.

Methodology of the safety assessment for radwaste repositories.

Methodology of the safety assessment for the NORM industry.

*Respondent – additional submission*

It is my personal view, obviously influenced by personal bias, resulting from particular base of knowledge and experience. That is, mainly in the MARINE environment. Actually the radioecology was dominated by research in terrestrial environment (with little extension to wetland and tidal flats). The attention to the marine environment has been relatively scarce (Sheppard, JER 68, 2003), with some exception regarding "hot spots" (Irish Sea, North Sea, Baltic, Arctic).
The draft only mentions "marine environment of special importance", without any other specification. Nevertheless, the needs regarding the marine environment are –from my experience- largely the same as described in the draft.
More precisely they can be divided essentially into two main groups:

a) Coming from most of the countries, having less well-equipped labs, requiring standardised, simple methods and tools. Basically: monitoring.
b) from industrialised countries (minority), that are asking for more sophisticated concepts /applications / developments of the radioecology (including "marine"). Basically, "radioecology as a sort of service to nuclear industry" (Hunter, 2001)

As regards the marine environment,

a) The first group ("basic" issues, from less industrialised countries) include
   - develop and standardise simple protocols for sampling;
   - use of simple, reliable analytical methods, in order to improve radioecological database (task not yet achieved in less-industrialised countries)
   - establish external (international) network for QC
b) The second group ("industrialised") include.
   - long-term processes;
   - impact on non-human biota;
   - develop coupled dynamic models (physical + bio);
   - decommissioning of nuclear facilities;
   - waste disposal sites;
   - environmental remediation of contaminated areas;
   - preparedness for rad-emergencies at sea and accidental scenarios (including terrorism).

In addition. there is a growing attitude of the marine scientific community toward a third group of needs, regarding:

- multi-contaminant approach. Integrating disciplines. Dynamic models coupling geosphere and biosphere;
- use of primordial radionuclides as dating tools, and as tracer of marine processes (including the interfaces);
- long-term impact of low-level natural radionuclides (NORM) in coastal environments (chronic exposure).

Some points can be selected by criteria ("why", "where"):

**Why?**

long-term contamination
multi-disciplinary + multi-contaminant approach
Develop coupled dynamic models emergencies at sea

**Where?** *E.g.* special sites

a) European Arctic (+ climate change and radioecology *E.g.* radionuclide from melting permafrost)
b) North Sea &The Channel, North-West Mediterranean.
c) Eastern Mediterranean is a "strategic area", and it will be in principle one of the most sensitive areas in the world

Try to promote an integrated European Mediterranean Policy. Regarding the Mediterranean, and open to a broader participation. Just to avoid the bizarre situation (already experienced in many fields) of creating a two-lane Europe, with enormous differences North-South, but also West-East). An integrated, sound scientific programme, having added value for the Europe. A kind of Rad-EuroMediterranean Partnership, with well-established relationship (like those between EC and AMAP, for instance).

In any case it will be essential to maintain expertise in marine radioecology in a wide sense. Sea-radioecologists must continue to be marine scientists. Monitoring criteria must be derived from the knowledge of the marine environment.

# Appendix 3. Notes from the FUTURAE WP2 workshop

A workshop on radioecological needs for the future was organised by WP2 in Stockholm, 12-13 June 2007, to review the results of a questionnaire sent to regulators, industries and other experts.

Three sessions were set and group discussions held related to different issues. Discussions within all sessions were anonymous. Notes from each group are given, from which conclusions and recommendations have been drawn in the main report.

## Session I. Setting the broad perspective of radioecology within Europe

Groups in this section were divided into End-Users categories, i.e. industry (group 1), regulators (group 3) and others (group 2). Each person was asked to discuss the issue in their experience within their own country and organisation. Table 2.1b was also provided to promote discussions.

**Note of caution: none of the EUG members officially represented a country, but rather gave their views on some issues of relevance for the discussion.**

### Group 1 notes

Group mainly from industry, mainly nuclear energy.

Netherlands Various topics were driven by needs doing some research on sources production, medical exposure, radiobiology, emergency, nuclear power design, Norms and decontamination.

The law stimulates research: you have to calculate the dose to human for instance for exemption level.

France Priority domain of interest

(1) dismantling and remediation of the sites after decommissioning - Lack of criteria on environmental protection to decide on the future use of a given site - same for human radiation protection - specific radionuclides that are different from those routinely released – no data on some tritium, C-14, Cl-36 - needs for indication on those limits for opening the site for the public – this is of high economic interest - challenge due to the high quantity of wastes highly dependant upon those limits challenge on multi-contamination (*e.g.* metals, organics) we need an homogeneous framework to assess

(2) Wastes deep disposals - Need with regard to the law and human radiation protection criterion - final criteria expressed in Sv for man in this field - needs for specific radionuclides (Cl, I, Se) the problem is that so far the models are those used for radionuclide elements (mostly metallic elements) and they are not relevant to be used for such elements - classical radioecological models to be improved to take into account their chemical properties - lack of knowledge and models for those special radionuclides - need for modelling data available are scarce - biosphere models are really uncertain - problem of conservative assumption the biosphere part was not considered so important research activities devoted to other aspects

(3) Routine releases from NPP - Some limits from monitoring not focused on protection of the environment (speciation not taken into account: a limit for assessing RP of the environmental conservative models not relevant for these releases *e.g.* tritium to compare releases from the atmosphere and from liquid effluents: more realistic models are needed problems of validation for those transfer models some inter-comparison were made but difficult to use

(4) Accidental releases - Shared by some industry concerning special radionuclides use of "ecological" fluxes models - data exist but in the wrong community- community dealing with Radionuclides and with stable element separated - few people can work on these ecosystem models expectations from TRS - problem of the good scientific values of data used - problem of the conservative assumption for these models - same problem but not so many concerning human exposure.

Bioprota — Good review of the background data and database main focus on the ground repository difficult to validate difficult to translate from lab to field discussion right now.

Transfer factors are really dangerous. More precise data are needed.

We currently model laboratory and field data but future developments in this area may benefit from there being fewer laboratories in Europe developing the models and that these labs should also be responsible for the collation of field/lab data to test, develop and validate the models.

Field studies on stable elements and natural radionuclides.

Good data set to gain something on modelling instead tuning for fitting models – understanding goes down while doing that. Since the budget are reduced, only modellers survive still need not close the door.

We can have a quite advanced model but difficult to defend or just stay with simple one we need optimisation –the complexity of the model is not an aim keep it as simple as possible.

Combine 2 groups of people: models and experiments.

Spain — Decommissioning problem to decide after remediation problem of the time scale for prediction problem of Palomares Pu particles what to do there the method for concentrating this contamination 50 years after the context can be completely different (*e.g.* urban areas). The accepted level can be a problem Radioecology can not work alone in this case needs for geostat to well characterise the site. Comparison of artificial and natural radionuclides in a given area.

Norway — Management strategy integrated holistic environmental strategy (metals, radionuclides, …) for the Barrent sea making radioecology amenable to other issue. Radium isotopes lacking in models.

NORMS in specific marine food chain terrestrial long term model in semi natural ecosystems in recent paper (reindeer eating lichen Cs) heavy metals and organics people clever to integrate the global climate change programme –releases of radionuclides connected with organic carbon – long time series sampling are very important to analyse properly trends – problem of access this time series.

Funding: European funding could be devoted to share these "unique" facilities (capacity to implement experiments in lab or filed). Industry does not have the capacity to fund such own facilities collaboration important in that field.

## Group 2 notes

Group members proposed radioecological needs (note although these are identified by 'country' this predominantly is because of how they were first introduced into discussion rather than a measure of national research needs).

| | |
|---|---|
| Germany | Dose reconstruction and epidemiology<br>Emergency management research for urban areas (complex environments, different surfaces, wet and dry deposition) and seasonality of deposition events.<br>Link real time monitoring data to model predictions<br>For environmental impact assessment research is especially needed for long-term behaviour of long-lived radionuclides. |
| Italy | Research on marine environment is not complete, site-specific research is needed (e.g. Mediterranean, Baltic Sea, Arctic oceans) as is consideration of accidents within marine ecosystems |
| International Organisation | Harmonisation of protection of human and environment is needed<br>Solid scientific basis for environmental impact assessments of waste repositories |
| USA | Model validation and inter-comparison<br>Effect of chronic exposure on biota is needed (radiobiologist are not doing this so it is up to radioecologists)<br>Multi-contaminants |
| Finland + UK | Research on 'vulnerable areas' (e.g. Arctic, forests and other semi-natural ecosystems) (wild food)<br>Education/training of new generation of radioecologist is important (due to age profile of many current research groups) |

There was considerable discussion of these items (especially protection of the environment) on what knowledge we have and what we need, and how to compare human/biota doses. Three main tasks with specific needs were highlighted:

Dose reconstruction

- Model validation both for human and environment doses

Emergency management

- Linking modelling and monitoring (to help focus)
- International comparisons on models including emergencies

Research on site-specific areas (vulnerable areas)

- Lack or perhaps incorrect knowledge on behaviour of radionuclides in specific areas: *e.g.* forest and other semi-natural ecosystems, Mediterranean.

The group discussed funding of radioecological research with the conclusions that: EU funding will be negligible in the future; no change, or perhaps a decrease of national funding. If research on radioecologcal field is needed lack of funding must be resolved.

### Group 3 notes

Impression common that "Everything is known". Data gaps may need to be resolved, but specific in different countries. Maybe common radionuclides could be found to make a network of excellence.

In Belgium money spent on geological disposal, not so much in biosphere. Interest but no funding. Same felt by UK with surprise that no "back-up" to support statement is given. If a tool is available there is trust that nothing else is needed. Limitation of tools are not seen.

Radioecological needs with change of biosphere with time is recognised but not taken into account. They wait for outcome of major current initiative, *e.g.* BIOPROTA.

Same in Germany – decommissioning work is about to start but is being delayed because lack of knowledge of what compounds are going to be generated. So emphasis is on monitoring. Germany has sponsored investigation projects but research funding is decreasing. There is a lack of young scientists.

Funding in Germany comes from Environment Ministry close to regulatory needs. Science ministry sponsors fundamental research. Final disposal place is difficult to find at the moment. Lots of manpower devoted to this.

In UK government may mandate industry to carry out research to fulfil regulatory requirements.

In Finland all of interest national programmes – in waste – dictates funding.

France – particular country with long-standing nuclear development, funding is slowing down because to privatisation. 80 % funding from government and rest from industry. Loosing 4/5 persons per year. Safety authority does not have expressed need but are interested at mobilise experts in case of emergency – so maintenance of expertise is more of value. Collaboration with IAEA with identified data gaps in repository processes. Work with long-life radionuclides is carried out. Industry feel that protection of the environment will develop as regulations are not there at present but will come into force in the coming years.

Industry feel that problem is not radionuclides but chemicals but are interest to develop methodology that combine both to demonstrate where the problem lies.

In France lots of monitoring programmes that may not be adapted to be good value for money. Same in Belgium and UK. Tritium and C-14 problems by the public because they are "visible". For UK S-35 is more of a problem.

France - emergency phase / crisis centre so atmosphere dispersion tool and rapid interpretation in field, comparison of real data *vs* prediction tools. Post-accidental phase is now being developed – especially in urban environment towards economic options, etc. expertise in dispersion and impact of how to deal with urban consequences. Germany put money into emergency with the military.

France - work around mines – especially with old mines evaluate risk to human and environment. Radioecology and emergency is getting merged. In Finland environment impact of mine other than radioecological are of concern. No knowledge whether different ministries sponsor in that area. Belgium monitoring and emergency but not merges.

Croatia small and non-nuclear. Own 50% of the power plant in Slovenia. Radioecological funding from ministry of Science to two institutes. Funding is not enough for big enough projects, so find funding in radioecology from Ministry of Economy (nuclear safety and emergency) and Ministry of Health (human exposure – food chain). Money is regulated for research. Drinking water protection, coastal zone, fish resource, biodiversity and terrestrial ecosystem are being prioritised in monitoring area and research. Not signed Euratom, so not yet too much funds in radioecology until then. Future apart of political issues, if money for radioecology arises the area to be prioritise will be in marine protection, and multi-contaminant. Privatisation is reducing the money available for protection. Political fight for solving inherited remediation problems.

UK perspectives – briefing notes, which have identified science needs for the next few years, will be sent. Nuclear waste, large volume from decommissioning, radioecologists views for new-build – i.e. communication, how to deal with challenging wastes (unknown waste by-products), monitoring (monitoring what how and how appropriate), incineration issues about products from that. Nuclear site issues.

Dismantling in France also with multi-contaminants and soils heavily polluted with different types of pollutants.

No involvement of radioecology in decommissioning in Belgium. Work on how to clean material. Only one reactor used for research being examined. UK involved radioecologists to help divide wastes for decommissioning options (controlled waste, local waste sites, etc).

Use of radioecology from elsewhere is being applied to decommissioning.

Comment: "similar experience from each countries". Few common items with network 2-3 issues that could be coupled. Not clear yet what is basic research *vs* underpinning research (need of expertise).

Overlap in waste management: if look at small time-dependent scales then you can look at the biosphere.

Interest in both short and long times. If research will support forthcoming regulation changes then EC would sponsor money.

Overlap between many countries. Discussions were a merge of Funding and areas of radioecological needs in different countries.

Suggestion to dividing needs into **Regulation – Basic Research and Applied Research:**

- **Regulation** – monitoring, performance assessment, biosphere models
- **Basic Research** – detection methods, data gaps to satisfy understanding of processes, processes underpinning models
- **Applied Research – specific** data gaps (*e.g.* transfer factors), application of models

The group did not decide on where waste disposal and decommissioning would fit into the above three choices.

The group summarised how national funding would develop in the next 5-10 tears in radioecological needs:

- slight decrease: France, Finland maybe, Germany for now;
- remain the same: Belgium, UK (given possible new-built and the development of a waste repository);
- increase: Croatia (*e.g.* safety area), Sweden.

It was noted that FP7 budget had overall increased from FP6 by 40 % but open competition between all proposals (not ring-fenced as in FP6) meant that probably it would be difficult to get funding in radioecology.

It was however felt that it was difficult to guess how funding would develop, and that political changes would have an impact on the process.

## Session II. Radioecological needs identified in the WP2 questionnaire

Groups were mixed, *i.e.* not divided into End-Users categories. Tables 2.1c and Table 3.1 (referred to the list in the discussions below).

### Group 1 notes

Is the list (the provided list) complete? This point addressed by the EUG (End-Users Group) to the consortium members. Followed by discussion as to a priority list to be developed.

The point was expressed that some structure was missing, some items being mentioned being sub-items of others (*e.g.* NORM-Mine wastes). Some EUG members noted that there could be some level of "competition" between fields and that a hierarchical structure may have been desirable.

There was some discussion as to the interplay between fields: modelling-monitoring-transfer processes for example. That some fields are reliant on others and therefore it may not be a good idea to prefer one over others if they are inter related.

One EUG member clarified that human exposure and protection of the environment are over-riding over others. The same EUG member expressed a desire to have the list numbered somehow, this point referring back to the idea of hierarchy.

The question was asked as to whether modelling actually protect the environment? One strong opinion expressed was that without harmonising modelling/monitoring/etc, there could be no synergy and this was bad. There should be bridge-building between these reliant fields.

One EUG member wanted to know if modelling, as referred to in the text, was using models or developing models. The same person had some issues with systemised approaches to environmental protection.

One EUG member pointed out that radioecology does not always have to only serve regulators and that there is a scientific basis as well as for doing the research.

It was pointed out that malevolent acts were not on the list at all. Also missing was any activity towards communication – how radioecology is communicated to people and other bodies.

The role of science was discussed and it was agreed that long-term and multi-disciplinary research was valuable.

The discussion moved to multi-contaminants. The transfer of knowledge between different disciplines studying different contaminants was discussed. The difference between multi-contaminants and multi-stressors was pointed out. It was agreed we should definitely think or focus on multi- contaminants / stressors.

The remainder of the discussion focussed on specific topics such as optimising models.

In general, it was agreed that prioritising radiological needs was needed. Related to the list provided, the inter play of some of the fields was pointed out so it may be detrimental to favour one over others. Multi-stressors/contaminants was seen as an important point. Communication was a field that may have been over looked.

### Group 2 notes

The group agreed that with the exception of 'impact of malevolent acts' all items within the 'Specified by one group' were included in broader topic areas lists by all groups responding to the questionnaire (e.g. speciation is an integral part of transfer process and long-term impacts).

The group then discussed each of the top areas in turn.

<u>Monitoring</u>

Routine monitoring was felt to be a requirement of industry and regulators and not a priority component of a radioecological NoE.

It was recognised that there were requirements to develop analytical approaches for some radionuclides (*e.g.* $^{63}$Ni, $^{55}$Fe) to reduce detection limits. However, this was agreed to be a radiochemical issue and not for consideration within a radioecological Network of Excellence (NoE).

However it was considered that linking monitoring data to modelling (to optimise what is monitored) for use in radioecological emergencies was a priority for consideration within a radioecological NoE. Emergency response was noted as missing from the lists of interests.

<u>(Te)NORM</u>

Relevant to many industries across Europe (to varying degrees). Whilst this issue tends to be a local problem it was felt worthy of consideration for a radioecological NoE as there are probably relatively few people involved in the field.

<u>Long-term impacts from repositories</u>

This was felt to be a requirement that is linked to modelling and transfer processes.

Current biosphere models give widely varying predictions and need to be improved.

<u>Multi-contaminants</u>

In addition to a discussion of multi-contaminant effects, harmonisation of approaches assessing exposure to radionuclides and other contaminants was felt to be justifiable. Discussion included the current disparities between models for radionuclides and other contaminants, which consider different pools for historical (and not always scientific) reasons. Harmonisation would promote a better use of resources.

The opinion that complete harmonisation would not be possible (*e.g.* pesticides are dangerous to some organisations by design).

Modelling/Transfer processes (including speciation)

It can be demonstrated that models need improving. Inter-comparison and methodologies to cope with missing data were agreed to be integral parts of model development. It was generally agreed that for some radionuclides (*e.g.* $^{36}Cl$) regulation mechanisms need to be taken into account within models and data maybe required to achieve this.

The ability to predict vulnerability of ecosystems/agricultural systems/urban areas (for emergency situations) was felt to be a key issue under transfer-modelling-speciation requirements.

Missing

Emergency management and remediation were noted as missing from the presented lists.

### Group 3 notes

The group believed that NORM did not require research, but rather better understanding of how they are regulated in Member States, what are the thresholds, methods and comparable approaches.

Monitoring is seen in emergency management, but there are used more as tools with development in more technology.

Need for real time monitoring coupled with modelling; needed for example for emergency management; would help guide first emergency responders.

A question was raised for monitoring which radionuclides? Gross alpha could help.

Monitoring costs a lot of money and does not give answers because if levels are below detection limits we cannot say what is a good monitoring programme. Question on which plants and organisms do we take? There is currently no harmonisation between countries. Radioecologists could give input on sampling of species and locations.

For human exposure there maybe adequate monitoring but for effects on environment perhaps existing systems are not the best.

Is there more need for marine modelling? Monitoring depends on ecosystem you study. Take into account OSPAR convention: radioecology can have input to indicate target species.

Need for standardisation for monitoring and for radioecologists there is a role to fit the programme to the process.

Monitoring can be ecosystem-based.

How much interest is there to standardise monitoring? European directives provide the overall guidance but implementation of the guidance is country-specific.

Some work on best techniques for environmental monitoring project

Standardisation of technologies among laboratories is needed. If you standardise, and this is not done on a routine-basis, they may not perform OK in emergency situations.

Monitoring can also be source-based.

Nuclear installations have the obligation; other organisations (e.g. universities, hospital) cannot be forced to engage in monitoring programme, which is the role of government.

Radioecology can help in monitoring by advice, not by science.

Would not put monitoring in the first place of priority.

**NORM**

Problem: what is the geogenic background?

Need for harmonisation here

U industry is regulated

Other NORM is not.

New mines need permission; how will you deal with your waste, related to preventing environmental contamination.

Finland explores for U; they are regulating the mines too

For NORM you would apply the same rules as for anthropogenic radionuclides; better not to focus on radionuclides but on issues e.g. effect of the environment

Candidate for mixed contamination

Restructuring things may help radioecology go further

Why is NORM on the list? This is because it becomes important as anthropogenic releases are decreasing and NORM levels become a primary source

There can be data gaps

Here there is an area where radioecology can contribute

**Long-term impacts from repositories**

Timeframe needs to be considered. Long timeframe will mean the environment will change and this will influence the speciation and bioavailability: lot of guesswork

But regulators require answer

There are specific data needs: transfer factors for I, Cl, Tc and Se

France does such experimental and field work, but without accounting for speciation

Industry sponsor the research they require; it is therefore industry-biased

UK disagree as they are aware of lot of lacks; they are aware of LT-effects but there are problems to get data;

In 10000 years Kd is not important 1 Bq in is 1 Bq out; Kd is important in the short scale

Are there predictions that those 4 isotopes can contribute significant to dose?

If you look at the constraints, Cl-36 is a problem on the limits (4 µSv/y; which is much lower than most natural radionuclides) not on the dose

Huge uncertainties in models

Data gaps: but *e.g.* Kd does not mean anything in the long-term

**Modelling and modelling supported by real data**

How do you sell the output of FUTURAE to the funding agencies who will have the problem that the output is not quantifiable, *e.g.*

- 'more monitoring is needed' is not quantifiable;
- 'sensitivity analysis of models' : if you could, by using the model, say that this area of research is needed, then you could pinpoint some areas for needs

Identify the need for and what can be the impact

Industry are not satisfied with conservative model, they need models where there is possibility of sensitivity analysis because they want to optimise situation, not more than they should because of conservative outcome

More dynamic models

Models comparison

**Multiple pollution**

No support from EC to finance multiple contaminant scenarios

Difficult to assess both; combined projects are not accepted

We should not avoid multi-contaminants because there is no funding because multiple pollution is the reality

Multiple pollution is in need of research

Protect where they compare radionuclides and other contaminants regulations

UK: multiple pollution: looks more at the effects on the environment from the start; human was considered for radionuclides or other contaminants

What is the best way to go forward: experiments or modelling

**Transfer processes**

For UK terminology should be more specific; UK: we have enough data on hydrologic modelling; better talk about uptake

Plant uptake easy to determine; transfer in food chain less so

**Other, additional items**

Urban areas could have been accounted for within 'transfer processes'

Effects of chronic exposure

## Session III. Bring together elements from Day 1 and formulate radiological needs for the future.

Groups were mixed, *i.e.* not divided into End-Users categories. A list of topics identified during discussions in Sessions I and II were collated and distributed. Each group was asked to prioritise, and if needed amend statements and add more items.

### Group 1 notes

Voting by the group members was recorded for each item separately.

| | | Votes |
|---|---|---|
| 1 | Use a list of radionuclides as the basis to build-up knowledge | |
| 2 | Radionuclides migration as biosphere changes with time | 9 |
| 3 | Handling of decommissioning waste due to its complexity and unknown radioecological impact | |
| 4 | Develop methodologies that combine radionuclides and chemicals to demonstrate where the problem may lie | 1 |
| 5 | How to deal with dispersion and impact in urban areas in post-emergency situation | 4 |
| 6 | Risk assessment of natural radionuclides from various sources (terrestrial, marine, etc) | 1 |
| 7 | Social perspective: communication of radioecological risk to stakeholders | |
| 8 | Model developments for specific radionuclides in the nuclear field (e.g. Cl-36, I-129) | 3 |
| 9 | Classical radioecological models to be improved to take into account their chemical properties | 8 |
| 10 | Development of realistic models for management of releases | |
| 11 | Validation of models using existing data | 2 |
| 12 | Develop and implement more ecosystem models instead of transfer factor models | 5 |
| 13 | Understand the underlying assumptions behind transfer factors | 10 |
| 14 | Lack of understanding of long-term decrease of radionuclide concentrations in semi-natural system | |
| 15 | Real-time monitoring coupled to dynamic modelling | |
| 16 | Effect of seasonal variation in risk assessment | |
| 17 | Integrating/harmonising radioactive substances with other types of contaminants and stressors in risk assessment | 2 |
| 18 | Standardisation of how to deal with NORM across Europe | |
| 19 | Modelling applicable to both human and biota exposure | 2 |

| | | |
|---|---|---|
| 20 | Design monitoring to also fulfil radioecological needs | |
| 21 | Design monitoring to demonstrate a decrease of concentrations in the environment | 3 |
| 22 | Effect of chronic exposure | |
| 23 | Transport and security issues (mainly related to possible accidental releases) and implications for the environment | |
| 24 | Dynamics of radionuclide concentrations in animal feedstuffs and food, animal and human exposure | |
| 25 | Remediation | 4 |
| 26 | Prevention of potential malevolent use of radioactive materials | |
| 27 | The importance of speciation in transfer processes | 4 |

Other items added to the above list included:

- long-term monitoring of environmental system
- vulnerable ecosystems
- inter-comparison of assessment results.

**Group 2 notes**

The group categorised the requirements into seven areas. Under each of these items were prioritised as listed below. The 'general group' was felt to include basics of radioecological research integral within all other areas. Some of the requirements were rewording and education was added. The group did not understand item 1 from the list *use a list of radionuclides as the basis to build-up knowledge* and hence did not consider this further.

Some items were unclear and will need re-writing (according to number in the list):
1. Unclear, we did not understand this
16. To be re-written (effect in radionuclide transfer and risk assessment)
20 and 21. Can be put together and re-written
22. Radiobiology as such, needs to be re-written: effect on biota
26. To be re-written: Radioecology of potential malevolent....

Missing idea: Training of new scientists (including to the general topics).

The group discussed harmonisation at international level and agreed that the problem was both scientific as well as political. There can be different national needs (and viewpoints, also economical ones). It is also possible to also include scientific considerations to complete the whole picture.

The supplied list was prioritised under seven main groups.

- emergency management;
- waste disposal;
- NORM/TeNORM;
- harmonisation;
- effect on biota;
- risk communication; and
- general topics.

Emergency management

**First priority**

5. How to deal with dispersion and impact in urban areas in post-emergency situation (considered to be the same issue as 23)
15. Real-time monitoring coupled to dynamic modelling
26. Radioecology of potential malevolent use of radioactive materials [Reworded]

**Second priority**

16. Effect of seasonal variation in radionuclide transfer (especially emergencies) [Reworded]
24. Dynamics of radionuclide concentrations in animal feedstuffs and food, animal and human exposure [also a general requirement]
25. Remediation

Waste disposal

**First priority**

*8. Model developments for specific radionuclides in the nuclear field (e.g. Cl-36, I-129)*

**Second priority**

2. Radionuclides migration as biosphere changes with time
17. Handling of decommissioning waste due to its complexity and unknown radioecological impact

NORM/TeNORM

**First priority**

6. Risk assessment of natural radionuclides from various sources (terrestrial, marine, etc.)

**Second priority**

18. Standardisation of how to deal with NORM across Europe

Harmonisation

**First priority**

19. Modelling applicable to both human and biota exposure

**Second priority**

17 + 4. Integrating / harmonising radioactive substances with other types of contaminants and stressors in risk assessment (considered to be the same issue as 4)

Effect on biota

**Priority**

22. Effect of chronic exposure on biota [Reworded]

Risk communication

**Priority**

7. Social perspective: communication of radioecological risk to stakeholders

General topics

All considered important integral components of radioecological research.

**Important**

9. Classical radioecological models to be improved to take into account their chemical properties
10. Development of realistic models for management of releases
11. Validation of models using existing data
12. Develop and implement more ecosystem models instead of transfer factor models
13. Understand the underlying assumptions behind transfer factors
14. Lack of understanding of long-term decrease of radionuclide concentrations in semi-natural system
20. Optimise monitoring using radioecological knowledge (considered to be the same issue as 21) [Reworded]
24. Dynamics of radionuclide concentrations in animal feedstuffs and food, animal and human exposure
27. The importance of speciation in transfer processes.

Education was an additional topic that was added by the group.

The group gave some consideration to which of the above lists required consideration at a European level. Whilst there may be different national needs and political considerations it was felt that combining disciplines and abilities would be beneficial.

**Group 3 notes**

All 27 'ideas' were re-grouped into eight topics. New items added and some re-wording are shown in bold. Priorities where given an asterix '*'.

- modelling / dynamics;
- waste;
- monitoring;
- emergency;
- multiple contaminants;
- risk assessment;
- others;
- all.

The list of items may have also been divided into five generic headings, but time did not allow for this re-distribution:

- regulation;
- understanding;
- tools;
- implementation;
- maintenance of expertise.

Modelling / Dynamics

| | | |
|---|---|---|
| 8 | Model developments for specific radionuclides in the nuclear field (e.g. Cl-36, I-129) | * |
| 9 | Classical radioecological models to be improved to take into account their chemical properties | |
| 10 | Development of realistic models for management of releases | * |
| 11 | Validation of models using existing data – **inter-comparison** | * |
| 12 | Develop and implement more ecosystem models instead of transfer factor models | * |
| 13 | Understand the underlying assumptions behind transfer factors | |
| 19 | Modelling applicable to both human and biota exposure | |
| 24 | Dynamics of radionuclide concentrations in animal feedstuffs and food, animal and human exposure – **or expanded categories** | * |
| 27 | The importance of speciation in transfer processes | |

Waste

| | | |
|---|---|---|
| 2 | Radionuclides migration as biosphere changes with time | * |
| 3 | **Determining the radiological impact of decommissioning waste due to its complexity (re-wording)** | * |

Monitoring

| | | |
|---|---|---|
| 20 | Design monitoring to also fulfil radioecological needs | |
| 21 | Design monitoring to demonstrate a decrease of concentrations in the environment | * |

Emergency

| | | |
|---|---|---|
| 5 | How to deal with dispersion and impact in urban areas in post-emergency situation | * |
| 15 | Real-time monitoring coupled to dynamic modelling | * |

Multiple contaminants

| | | |
|---|---|---|
| 4 | Develop methodologies that combine radionuclides and chemicals to demonstrate where the problem may lie | *<br>* |
| 17 | Integrating/harmonising radioactive substances with other types of contaminants and stressors in risk assessment | |

Risk assessment

| | | |
|---|---|---|
| 6 | Risk assessment of natural radionuclides from various sources (terrestrial, marine, etc) **or of other under-researched ecosystems – expanded to generic data gaps in models** | *22 |
| 14 | Lack of understanding of long-term decrease of radionuclide concentrations in semi-natural system | |
| 16 | Effect of seasonal variation in risk assessment | * |
| 22 | **Biological** effect of chronic exposure | *6 |

Others

| | | |
|---|---|---|
| 7 | Social perspective: communication of radioecological risk to stakeholders | * |
| 18 | Standardisation of how to deal with NORM across Europe | * |
| 23 | Transport and security issues (mainly related to possible accidental releases) and implications for the environment | |
| 25 | Remediation | |
| 26 | Prevention of potential malevolent use of radioactive materials | * |
| **28** | **Education** | * |
| **29** | **Interact with other disciplines** | * |

All

| | | |
|---|---|---|
| 1 | Use a list of radionuclides as the basis to build-up knowledge | * |