Integrating environment protection, a new challenge: strategy of the International Union of Radioecology

Protection de l'environnement, un nouveau chantier: stratégie de l'Union Internationale de Radioécologie

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Résumé:

Née dans les années cinquante avec l'émergence des technologies nucléaires, la radioécologie est une discipline scientifique qui traite des questions environnementales utiles à la radioprotection. Forte de l'adhésion de près de 600 membres à travers le monde, l'Union Internationale de Radioécologie a été fondée dans les années soixante dix en tant que société savante à statut d'association internationale non-gouvernementale dédiée à la promotion de cette discipline. Les directions scientifiques poursuivies en radioécologie ont largement été influencées dans le passé par l'accident de Tchernobyl qui a stimulé une focalisation sur les aspects du transfert de la radioactivité dans l'environnement afin d'alimenter les besoins urgents de la radioprotection humaine. De nos jours, une évolution profonde se développe vers une appréhension plus écologique appuyée sur des études et recherches concernant les effets des radiations, sous la double pression d'une plus grande sensibilité sociale vis-à-vis des problèmes environnementaux et du redémarrage concomitant de l'industrie nucléaire pour faire face aux besoins énergétiques grandissants de la planète. L'IUR joue un rôle central dans cette évolution qui est ici présentée en détail avec une description de ses quatre principaux outils d'action : des groupes de travail dédiés ; des workshops, séminaires et conférences ; des cours et formations ; un site web dévolu à l'information et à la communication. Enfin, saisissant l'occasion de l'élection récente d'un nouveau Bureau pour diriger l'Union, les grandes lignes de son plan stratégique pour les années à venir sont exposées.

Abstract:

Born in the fifties together with the emergence of the nuclear technologies, radioecology is a scientific discipline that addresses environmental issues relevant to radioprotection. With a current membership of nearly 600 worldwide, the International Union of Radioecology was founded in the seventies as a non-governmental knowing society dedicated to the development and the promotion of this discipline. The scientific directions taken in Radioecology have been drastically influenced in the past by the Chernobyl accident, which forced a focus on environmental transfers through the environment to feed human radioprotection needs. Currently, a profound evolution is underway towards more ecological effects research and studies, under the driving pressure of the raise of society's concern on environmental issues and the concomitant re-boost of nuclear industry to face

global warming and the future energetic demands. The IUR plays a central role within this evolution which is described here in more details along a description of its four major tools of action: dedicated task groups; workshops, seminars and conferences; training courses; web site tool for information and communication. Finally, together with the recent election of a new Board of Council to manage the Union, the main lines of the new strategic plan for the coming years are given.

1. INTRODUCTION

The process which has led to the publication early this year of the new ICRP recommendations has prompted tremendous discussion and confrontations worldwide, as strengthened in this issue's editorial (Métivier, 2008). For the first time in its history, ICRP has included within its scope the issue of environment protection. This means that the overall system of radiological protection to emerge will embrace all living beings, humans of course, but also animals and plants which are no longer to be dissociated. This is a very important and non-return step that has been accomplished, and which deserves especial consideration within the scope of radioecology. This movement also reflects a general trend that is under way towards a better recognition of the ecological relationships that link humans, animals and plants altogether with their abiotic surrounddings within functional ecosystems.

1.1 Sustainable development: a societal emphasis over the environment

One begins to understand that our well being is intimately bound to the quality of the environment and the maintenance of its functionalities, and that we cannot afford anymore neglecting to care for it. The race to growth and development is now facing the physical boundaries of our planet that cannot accommodate (dilute) anymore the parallel (uncontrolled) growth of some impacts which are now durably disturbing the overall biosphere. This begets a drastic evolution within human society that is currently growing. Precursor signs have already become apparent in several layers of its organisation. Many believe that this is a necessity-driven process, but still non-obvious in its perception as we have not reached yet sufficient understanding, back visibility, and consequently adequate consciousness to be able to fully implement the required change.

Pioneer philosophers, economists, scientists and more recently politicians, led by their precursor conviction, have grasped the issue and promoted the emergence of the concepts of sustainable development and its companion tool, precaution, that are now widely accepted. Because of their impacts on the environment and health, human activities will need to be driven in conformity with these concepts. There are strong resistances however among traditional economical, industrial and institutional managers, often dominated by short-term constraints, to accept this mental evolution towards a long-term driven decision making. Also, the trouble caused by this huge evolution is prompting fears which in turn generate retrograde and sterile behaviours with a tendency to reject all technology-driven change. The best perennial solution that humankind can afford in this context is to adopt a movement that is **knowledge**-driven. Far from being banned, technological innovation is actively searched for, and especially to solve humankind dimension problems, but in a context of knowledge that is as complete as possible, i.e. where impacts are anticipated, good and harm consequences are properly evaluated, and ultimately risk is mastered, known and accepted. This rationale also applies to the field of radioecology that handles the impacts of nuclear activities on the environment and human health.

1.2 The International Union of Radioecology

Radioecology is a highly multidisciplinary scientific discipline that has emerged concomitantly with the civil use of nuclear energy during the 50s, and that is situated at the crossroads between risk induced by environmental radioactivity and its consequences on both, man and the environment. The International Union of Radioecology was therefore founded in the 70s, registered as an International

Association under Belgian law, and declared as a non-political and non-profit scientific organisation dedicated to the development of radioecology. Currently, the Union gathers nearly 600 active members from the 5 continents around the world. The overall objective of the Union is to promote radioecology worldwide, in all its dimensions, from research activities up to expert advice and operational management. Essentially focused on radioactive elements, radioactivity being potentially toxic for life, radioecology contributes to the worldwide effort that is continuously undertaken towards the sustainable development of nuclear activities, especially the civil use of nuclear energy.

The overarching role of the Union is to perpetuate a “think tank” capacity on radioecology issues through the maintenance of a network of scientists and professionals. This drives the Union’s activity to be based upon four major tools: thinking and development work in dedicated task groups, scientific meetings/workshops/conferences, training courses and communicating via its website that link all members within the network.

- Dedicated Task Groups are mobilised and formed in response to various contextual drivers (daily news, need, recent discovery, especial creativity arising from a group of members, etc.) allowing to reach a critical mass on a given subject and to support its longer term maintenance.
- Congresses, workshops and seminars are organised, sometimes in association with other partners, to review recent knowledge advances and to promote discussions that fund the emergence of consensus or the specification of problems to be solved in priority.
- The network daily life is maintained and supported by its web site (www.iur-uir.org), being together a dissemination tool (newsletter, publications, conferences announcements, etc.) and a tool for exchanging information within the membership.
- Teaching is undertaken to stimulate young talents and transmit knowledge, further supplemented by the provision for prices and awards, « Young Investigators » and « V.I. Vernadsky » awards recently created.

2. THE CURRENT SCIENTIFIC DIRECTIONS OF IUR: AN OVERVIEW

The core scientific activity within IUR is currently mediated through a set of Task Groups that advance several aspects of radioecology based upon various international groups of active members. These Task Groups develop their own methods of work, depending on their leaders and membership, often through gathering in dedicated workshops or conferences, and more and more also nowadays through the Unions’ web site that offers modern tools for on-line collaborative work.

2.1 Human radioprotection dedicated Task Groups

2.1.1 Radioecological parameter values: Update of TRS 364 (IAEA/IUR)

This joint IAEA/IUR Task group has been launched in 2003 as part of the IAEA EMRAS programme ("Environmental Modelling for RAdiation Safety"). It is aimed at reviewing and updating a previous IAEA document published in 1994 within its Technical Reports Series No. 364 (TRS 364) with the support of IUR, and entitled "Handbook of parameter values for the prediction of radionuclide transfer in temperate environments". Over the years, it has proved to be a valuable reference for radioecologists, modellers and worldwide authorities, and has been quoted in numerous impact assessments. However, TRS-364 was based on a review of available data up to the end of 1992. A number of high quality critical reviews have been produced in recent years for some of the transfer parameter values which merit consideration. Thus, the overall objective of this Task Group is to provide both revised transfer parameter values and missing data.

The specific task of TRS-364 development was to provide reference values for the most commonly used transfer parameters in radiological assessment models. However, some important details and recommendations on how to use these parameters were often omitted that did not allow making relevant choice of necessary parameters. This problem has been resolved by the preparation of two separate but well linked documents, i.e. the Technical Reports Series document focused on the reference information intended for radiological assessment and an IAEA TECDOC intended for justification of radioecological information used to derive reference values.

The TECDOC to be delivered shortly is a supportive document for the updated TRS-364 overcoming the limitations of the former document, and comprises both revised transfer parameters values, missing data, key transfer processes, concepts and models which were found to be important for radiation safety. The revised TRS 364 (to be used as a handbook) is expected for publication in 2008 and will be substantially extended compared to the former document, but more concise than the TECDOC. Ultimately, the final document package will cover the needs of both regulators and assessors in radioecological data for assessing site-specific, past, present and future radiation exposures to humans and biota species in terrestrial and freshwater environments.

2.1.2 Radioecological sensitivity: an operational tool in federating radioecological knowledge

The “Radioecological sensitivity” Task Group has been launched in 2007 after a prior forum of IUR scientists who delivered some thoughts and recommendations in 1998 (Howard *et al*., 2002). The scientific needs in radioecology are now requiring to take due account of uncertainties, modern techniques of spatialization, as well as spatial and temporal variabilities. Also, the society needs require to be appropriately captured within the methodologies of risk assessment. The operational tools for decision making need, within all this knowledge, to make sense. This Task Group, is exploring the possibilities of using the radioecological sensitivity concept in order to fulfill all the above-mentioned needs.

The main questions that are being explored are:

- how can we simplify representing the effects of radioactive contamination on a territory ?
- what are the radioecological criteria shared by stakeholders (criteria used by decision makers as a basis for decision / criteria of significance for people living in the territory of concern)?
- how can spatial data be acquired in real time on the status of the main components of environments sensitive to pollution ?

2.1.3 Radioecology and waste

This quite productive Task Group has been launched during a Workshop that had been co-organized by IUR and ANDRA in Nancy (France), in April 2002, and entitled "Mobility in Biosphere of Iodine, Technetium, Selenium and Uranium". From the participants of this Workshop emerged a consensus on the high priority for radioecology to tackle the problem of the management of high level radioactive waste. The Task Group was therefore assigned the objectiveof promoting an optimised cooperation between radioecologists working in the field of radioactive waste management.

The Task Group, through the gathering of four successive Workshops (Merlewood, UK, 2003; Madrid, Spain, 2003; Aix-en-Provence, France, 2004; Mol, Belgium, 2006) dedicated to va rious series of waste relevant radionuclides, ultimately published a report (IUR report n° 6, 2006) providing its recommendations and indentifying further research needed to improve the prediction of radionuclide transfer in the environment in connection with safety assessments of repositories for high level radioactive waste.

Currently, the Task Group embarks in a new phase of investigations dedicated to additional radionuclides of concern, with an additional workshop planned in Madrid, in mid October 2007.

2.1.4 Radioecology of rice

Few years ago, the Board of Council decided to encourage the creation of Task Group dedicated to the "Radioecology of rice" given the quite reduced radioecological knowledge that exists over a major food product especially in Asian regions. This Task Group has therefore been launched on the occasion of the 3rd International Conference on contaminants in soil Environments in Australasian-Pacific Regions that was organized in Beijing, in November 2003. Led by asian scientists, its objectives are to collect transfer parameters in the paddy field ecosystems, to compare the parameters obtained in different regions and countries, to structure a database on behaviours of radionuclides in these ecosystems, and finally to develop a transfer model for predicting the behaviour of the nuclides in the systems.

The Task Group work currently evolves upon previous collaboration of IUR with FAO and IAEA on similar issues, especially on tropical and sub-tropical environments, and it is being conducted in close relationship with the IAEA/IUR Task Group on the Updtae of TRS 364 previously mentioned.

2.2 Environmental radioprotection dedicated Task Groups

2.2.1 Protection of the environment

This issue of protection of the environment against ionising radiation has been identified by IUR, as early as 1997, as an upcoming strategic issue for which intitial thoughts and directions were recommended by its membership in a Report entitled "Protection of the Environment: Current Status and Future Work" (IUR Report n° 3, 2002). More detailed developments along these initial directions are now being tackled under the auspices of various internaional organisations, among which ICRP who created a 5th Committee on this purpose, IAEA who develops an action plan designed to coordinate international effort towards reviewing and updating safety standards, and the European Commission that has been supporting several successive research projects aimed at constructing a framework for the radiological protection of non-human biota and its associated risk assessment tools.

Given this successful context, the Task Group embarked in 2003 in a second phase that has been designed to unravel the identification and prioritisation of the research requirements in this field of protection of the environment from ionising radiation. There is a pressing need to identify and 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 into the environment. There is a vast list of key issues but there is a need to identify all of them 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.

The Task group has therefore been assigned the goals to identify knowledge gaps, to prioritise research requirements to address them, and 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. This effort, tackled through gathering information collected via a web based questionnaire, is dominated by an ultimate general objective of constructing a Worldwide Research Network in Radioecology. Initial steps along these lines have been published lately (IUR report n°5, 2006).

2.2.2 Radioecology and non-radioactive pollutants

The launch of this Task Group took place during an IUR-SETAC Meeting held in Antwerp (Belgium) in February 2002 on the "Application of Radioecology to Other Contaminants" (SETAC: Society of Envrionmmental Toxicology and Chemistry). The aim was to bring together experts involved in

experimental research and model development in closely related areas of environmental chemistry and toxicology. Pollution science combines a multitude of highly specialised disciplines and the Task Group was assigned the objective to bridge the gap between radioecology and other areas of environmental contamination and toxicology through identification of synergies.

Environmental contamination by heavy metals and other conventional contaminants and radionuclides is a phenomenon that has accompanied human activities, mainly associated with mining activities, industrial processes, energy production, manufacturing, and the disposal of domestic and industrial wastes. The most prominent examples of multipollutioin is the pollution associated with the "naturally occurring radionuclides" industry (NOR-industry) associated with abandoned waste dumps and the surroundings of industries involved in the extraction or processing of raw materials containing NORs. Examples are the residues of uranium mining and milling, the sludge heaps and the surroundings of the phosphate processing industry, the ashes from power production from coal and the surroundings of metal smelters. Contamination with NORs is often accompanied with contamination by heavy metals. Radioactive elements such as ^{238}U, ^{226}Ra and ^{232}Th, and non-radioactive elements such as Cd, Zn, Cu, Ni, and As can simultaneously occur in a polluted area. When evaluating the impact of a contamination at a site the multipollution and mixed nature of this contamination should not be neglected because an action decreasing the exposure to one contaminant possibly enhances the availability of other contaminants present. Element availability, bioaccumulation patterns and effects may also be changed in a multipollution context: effects caused by a single pollutant may be exacerbated or reduced by the interaction with other pollutants present simultaneously.

Appropriate predictions of potential future environmental impact and public exposure and the development of adequate remedial technologies or landuse, requires the understanding of the mechanisms ruling element mobility and behaviour in and between the different environmental compartments (mineral, solution, microbial, phytobiomass, ..). One of the first steps in assessing the effects of a (multi)pollution is knowledge on how soil, plant and microbiota properties influence the availability and the uptake of the contaminants. A second step is to know how the multipollution context will affect the behaviour of each single contaminant. A third step is to know how and from which critical concentration pollutants affect the organisms considered and if multipollution effects play a role.

Recent efforts from this Task Group have essentially been invested in networking with a worldwide identification of scientitsts involved/interested, scientific programmes currently in development and research facilities (IUR Report n° 4, 2006).

2.2.3 Arctic and Antarctic regions

This Task Group has the overall objective of contributing to the understanding of the processes governing the behaviour of radionuclides in Arctic and Antarctic ecosystems. The remit covers a consideration of experimental activities, field studies and modelling.

A key focus for the Task Group over the last few years has been interaction within the activities of the radioactivity expert group of the Arctic Monitoring and Assessment Programme (AMAP). Particular input has been provided into the second Arctic Monitoring and Assessment report, specifically on Amchitka in the USA and Iceland, responding to data omissions in the first AMAP report. The coordination work conducted under the auspices of this Task Group yielded a number of publications in the open literature during the past years, relating to various radioecological aspects specific to these northern regions of the planet. Currently, the Task Group is being reorganised to tackle new objectives the definition of which still be pending.

2.2.4 Speciation

This important issue in radioecology has been more specifically tackled based on gathering a Task Group in 2002, the members of which first met in Monaco (september 2002). Its main objective is to strengthen the competence internationally on environmental impact assessment. This is to be achieved based on using adequate techniques to characterize radionuclides species, linking and quantifying radionuclides species to sources and release scenarios, linking and quantifying radionuclides species to environmental airborne, marine or freshwater transport processes including models, identifying and quantifying radionuclides species and transformation processes influencing mobility and bioavailability of radionuclides, relating the distribution of different radionuclide species to external doses, and relating radionuclides species to internal redistribution within organisms to improve dose estimates for biota.

Various successive meetings and Workshops have been held since then under the auspices of this active Task group, the most recent of which being entitled "Radionuclide Speciation Workshop" held in conjunction with the 53rd Annual Radiobioassay and Radiochemical Measurements Conference (27–28 October 2007, Jackson Hole, WY, USA).

2.3 IUR publications, media and audience

Given the number of previous data bases, reports, or proceedings and conclusions from workshops and seminars, that were produced by various IUR Task Groups during the three decades of IUR existence, and which became difficult to access at later stages, an IUR series of publications has been launched in the early 2000s with proper official international registration (ISBN numbers). The 6th report in the series has been published last year. All reports are now being published as electronic copies with free access on the web site, and hard copies are being printed and disseminated to all members.

The successive Boards of Council of the Union have promoted as much effort as possible to maintain the production and publication of the Union's Newsletter as a link between the members. In the first times, the Newsletters were printed as hard copies, sent to all members by surface mail, and formed the only regular communication tool through the membership. In the early 2000s, in an effort to reduce the associated significant costs, decision has been made to produce it only in electronic format for dissemination on the web site. The last Newsletter issue has been produced in September 2007, as n° 44.

The Union's resources are being used not only for publications, but also to stimulate and help researchers to gather, communicate and promote scientific thinking. This is done by morally and financially supporting a number of seminars, workshops and conferences whenever the subjets are relevant to radioecology. A list of recent and past such events are displayed on the Union's web site (www.iur-uir.org).

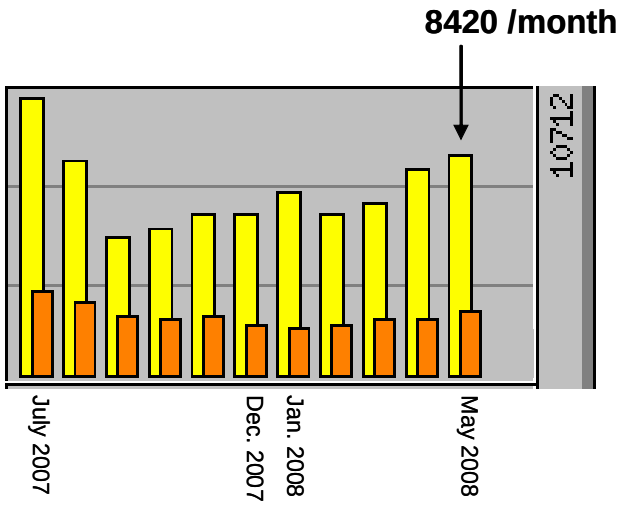

Figure 1: *Monthly rates of visits to the IUR web site from July 2007 to August May 2008, exceeding 10,000 in July 2007.*

The Union's audience is best illustrated by the continuoulsy growing rate of visits of its web site each month. It currently reaches 8420/month in May 2008, but has achieved more than 10,000 visits/month during last July 2007 after publication of the last IUR report (Figure 1).

The web site is first used as a communication tool at the disposal of its members, with various dedicated domains and page areas restricted to members, or Task Group members, upon entry of personal ID and password (provided by the webmaster).

3. AN HISTORICAL ANALYSIS OF RADIOECOLOGY EVOLUTIONS

Since almost 30 years of existence, the historical evolution of radioecology and its activities have been strongly influenced by the occurrencce of the Chernobyl accident that happened in April 1986.

Prior to this tragic event, investigations had been focused on studying p athways of transfer to man and studying the effects of external γ irradiation on various animals, plants and ecosystems. The Chernobyl accident drastically boosted the human radioprotection needs (pathways of transfer) as a consequence of the urgent need to assess the impact on human health of the contamination (essentially ^{137}Cs and ^{90}Sr) spread over large territories. This led to spending large efforts on modelling the transfer of radionuclides within the environment towards man, through ingestion, inhalation or by external irradiation, during more than one decade, at the expense however of radioecotoxicological studies on wild species and their related ecosystems which were assigned a lower priority during this period.

Afterwards, the past decade has been submitted to two major influences. First, the Chernobyl boost effect, which concerned CIS and european countries in priority, started to vanish out some years ago, with tougher competition for appropriation of international funding, and the concomitant dis-aggregation of non-critical mass research groups, a feature which led some observers to question the future of Radioecology, either as a scientific discipline (its "last gasp") or as a unique expertise to parallel atomic energy activities (Stone, 2002). Meanwhile, a vigorous political debate has evolved almost worldwide questioning the public acceptance and usefulness of considering further atomic energy developments to face the growing planetary energetic needs. Some countries, essentially in Europe, decided to withdraw from the further use of nuclear energy technology, due to emphasis placed on its danger. A major consequence for these countries has resulted in the disruption of many of their research groups and competence in radioecology. In the recent years however, it is obvious that a worldwide movement back to using nuclear energy production systems is now on its way. This movement is driven by closer attention to the requirements for sustainable development, greater awareness of climatic disruption promoted by fossil fuel burning, and increased economical pressure from the continuous rise of the fuel rates. Second, it is the upcoming general context of environmental protection, driven by recent societal concerns rooted in several large scale environmental critical issues, such as climate change and biodiversity decline, that has impacted radioecological priorities towards better appraisal of effect studies on nature, and the methodologies necessary to assess the potential risks.

This recent evolution promotes a rebalancing of efforts towards effect studies on non-human biota and their ecosystems, as illustrated by two recent projects supported under the Euratom programme (Fasset, 2004; Erica, 2007). The quite anthropocentric view prevailing in the past, which restricted the consideration of the environmment to a simple vector of transfer of radioactivity from a source to man, is now abandoned for a more holistic and integrated view where the environment is made of functional ecosystems where man is interacting with other living beings (Figure 2). However, this rebalancing of effort happens within a context of worldwide funding and manpower devoted to radioecology that is

still critically reduced. This difficulty defines one major challenge for IUR in the future: to anticipate, stimulate, and support the development of the best radioecological competence that will be needed to ensure the safe and socially accepted civil use of nuclear energy. Such a challenge is also pursued and supported regionally by the European Commission which recently funded a concerted action aimed at clarifying the feasibility of a european network of excellence in radioecology to maintain high level competence in Europe.

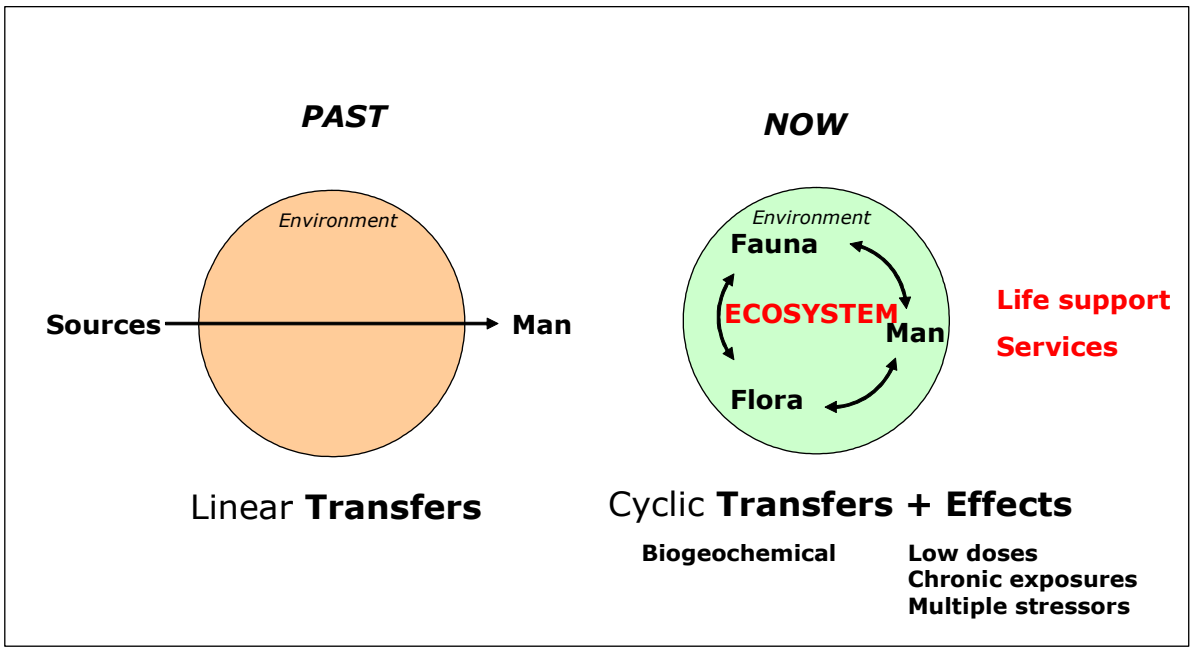

Figure 2: *The scope of radioecology is under strong evolution moving from a past concept of linear transfers – from a source to man through the environment – to a present more holistic concept that reintegrates man within ecosystems featuring interactions with fauna and flora.*

4. THE IUR STRATEGY FOR THE FUTURE

Building an advanced knowledge on the relationships between ionising radiation and the environment is a prerequisite to further development and acceptance of the civil use of nuclear energy. The environment, which is the core of the professional skills gathered within the IUR, is therefore the central driver of the Union's strategy for the future and the roles it will play. The Union holds an expertise which embraces all together radioactivity, the environment, health and the assessment of risk. This is a highly strategic position and a remarkable integration of skills that lead to identifying 3 essential roles that the Union will aim to fulfil.

4.1 Prospective view and promotion of scientific innovation

In the field of radioprotection, IUR constitutes the most significant worldwide pool of scientists and experts dealing with radioactivity impact on the environment and the related evaluation of risk to man. Under strong social pressure driven by current environmental concerns, all environmentalists are called upon to construct scientific knowledge, concepts and principles suitable to ensure acceptable mastering of ecological risk.

Although a large amount of radiobiological and radioecological information has been gathered over the last fifty years, the IUR also stresses the existence of significant knowledge gaps, which require the elaboration of better data base and improved understanding of processes and mechanisms. Critically, the IUR is currently concerned by the crucial lack of emphasis devoted, on a world wide scale, to filling these gaps. Regulating without a strong scientific foundation will necessarily yield criticisms, unsound recommendations and potentially detrimental management decisions. It would be a mistake to believe that stakeholders' concern will be resolved only by promoting some regulations. Stakeholders have often proven their need, their will and ability, to understand the problems and the related scientific knowledge. It is indeed the only way to ensure that regulations will be developed that will actually meet their protection goals.

The most significant knowledge gaps have been identified by IUR in a statement paper published in 2003 (Bréchignac F. *et al*., 2003). One can mention those which are felt to require some priority and prone to yield innovative results:

- Relationships between low chronic doses and their resulting effects on a number of wildlife species with proper understanding of propagation towards the ecosystem level,
- Potential interactions within multipollutant mixtures and proper understanding of the overall resulting effect as opposed to that from single stressors,
- Improving the radioecological processes and environmental parameters prioritisation to feed human risk assessment,

4.2 Coordination and networking

Based in the first stage on the work undertaken by two Task Groups "Protection of the environment", and "Radioecology and non-radioactive pollutants", the idea of designing a Worldwide International Research Network in Radioecology has been launched in 2003. Using fit-for-purpose detailed web-based questionnaires, it started to collect and assemble information on 1) the research teams currently involved or interested in research and development on the related issues, 2) their existing experimental research facilities and what they are being used for, and 3) how they identified, tackled and ranked priorities in research. The first results of this worldwide investigation have been published in 2006 (IUR Report n° 4, 2006; IUR Report n° 5, 2006). This effort of networking will be pursued actively, in order to include other pertinent radioecological themes, also with especial dedication to supporting southern regional teams and the associated local issues (american, african and asiatic continents).

Meanwhile, the need to construct better linkage between science and the many measurements data that are collected for control and regulatory purposes has emerged. Surveillance and monitoring networks are now existing in many parts of the world and accumulate quite substantial amounts of measurement data in a variety of abiotic and biotic compartments of the environment. However, these remain largely useless for scientific investigations, due to lack of prior consideration of scientific objectives, and lack of appropriate and harmonized structuring within data bases. Therefore, whilst continuing the effort of networking the scientific community, IUR is now launching the construction of an **International Observatory**, also following the recent recommandations from an OECD/NEA expert group (OECD/NEA, 2007) that will have the main role of International programme harmonisation.

This would include in particular international data registry and assessment for environmental radiological protection, with:

- Centralized data registry for contaminants from areas of high background, from experimental investigations, also other contaminants,
- Network of experimental facilities,
- Network of existing research and experimetal programmes (bio-geo-chemical cycles),
- Network for data base collection and assessment of environmental measurement data around nuclear installations,
- Assess current data collection,

- Identify additional measurements that could be added to better characterize environmental protection (as opposed to human protection).

4.3 Liaison with other international organisations

Appropriate links have been established with governmental and non-governmental international organisations dealing with radioactivity and risk such as the International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP). Members of IUR are involved in the activities of many expert groups led by IAEA (EMRAS Programme, etc…), and even an IAEA-IUR joint Task Group has been working for some years, as already mentioned above. The current composition of the ICRP Committee 5 dedicated to the radiological protection of the environment is largely based upon IUR members who previously contributed, within the pioneer Task Group formed in 1997, to the foundation of the paradigm shift in environmental radioprotection.

An observer role has been granted to IUR also to follow up the work of consolidation of the published scientific results which is continuously undertaken by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). One Board of Council member is regularly assigned the task to participate in UNSCEAR Meetings in order to express the IUR positions and recommendations, whenever relevant.

Within this quattuor, both IUR and UNSCEAR hold roles that deal with science. IUR operates on the anticipation side: promoting science, with strategic anticipation of new directions to stimulate. UNSCEAR operates at a later stage on the science which has been achieved: consolidating the already published knowledge and validating it through international expertise. IAEA and ICRP operate both towards more operational purposes, designing international standards for the first one, and elaborating recommendations in a regulatory context for the second one. All four organisations therefore synergistically contribute to radiological protection with their own and complementary skills and attributes (Figure 3).

IUR further includes within its strategic plan for the coming years to establish wider links with other international organisations such as the the Natural Radioactivity Environment Association (NREA), the South Pacific Environmental Radioactivity Association (SPERA), and also outside the nuclear world, such as the United Nations Environmental Programme (UNEP), the Food and Agriculture Organisation (FAO), the World Health Organisation (WHO), the Society of Environmental Toxicology and Applied Chemistry (SETAC).

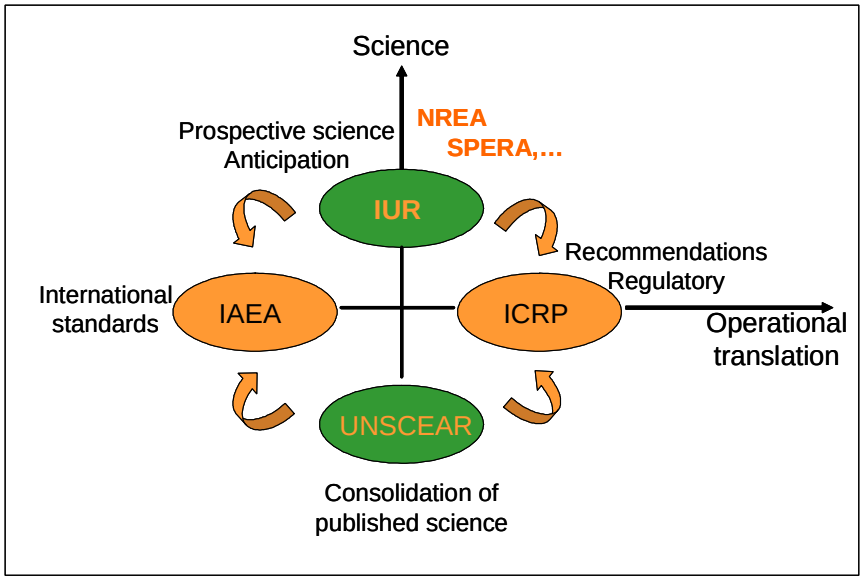

Figure 3: *Scheme illustrating the synergistic relationships between four international organisations active in the field of environmental radiological protection (International Union of Radioecology, International Commission on Radiological Protection, International Atomic Energy Agency, United Nations Scientific Committee on the Effects of Atomic Radiation).*

5. CONCLUSION

Although featuring quite an obvious evolution of its community, especially one decade after the Tchernobyl acccident, Radioecology, as a discipline, has continued to regularly gather hundreds of scientists as demonstrated by the successive international conferences that IUR co-sponsored during the last decade (Ecorad, 2001, 2005; International workshop on the mobility of iodine, technetium, selenium and uranium in the biosphere, 2003; International conference on radioactivity in the enviornment, Monaco, 2004; Radioactivity in the Environment, 2007). Currently, the International Union of Radioecology is recruiting primarily within the young scientists population, although at various rates depending on countries. This is promising a renewed level of vitality to replace the past generation of radioecologists that experienced the Tchernobyl accident.

The Union is quite conscious of the particular responsibility it holds in contributing to the mastering of human and ecological risk with respect to the various fates and uses of ionising radiation, because it is the only organisation that is fully centred on, and dedicated to, radioactivity in the environment. As such, the Union gathers a large array of expertise, from fundamental science to application in assessment, management and regulation, and from pure environmental sciences to human health oriented approaches and goals. From its history and very nature, the International Union of Radioecology is therefore best suited to provide guidance on the coordination of international efforts in a balanced manner, and much of its future actions are to be directed to achieving this goal.

REFERENCES

Bréchignac F., Polikarpov G., Oughton D.H., Hunter G., Alexakhin R., Zhu Y., Hilton, J., Strand P. (2003) Protection of the environment in the 21st century : Radiation protection of the biosphere including humankind. Statement of the International Union of Radioecology. *Journal of Environmental Radioactivity*, 70: 155-159.

ECORAD (2001) The Radioecology – Ecotoxicology of continental and estuarine environments. F. Bréchignac, ed., *Radioprotection – Colloques* 37(C1), EDP Sciences, 1357 pages.

ECORAD-2004 (2005) The Scientific basis for environment protection against radioactivity. J.C. Barescut, J.C. Gariel J.M. Peres, eds., *Radioprotection – Colloques* 40(Suppl. 1), EDP Sciences, 983 pages.

ERICA (2007) An integrated approach to the assessment and management of environmental risks from ionising radiation. Final Report of the EC 6th Framework Programme, *Contract n° F16R-CT-2004-508847*.

FASSET (2004) Framework for Assessment of Environmental Impact, Final Report of EC 5th Framework Programme, *Contract FIGE-CT-2000-00102*, 111 pages.

Howard B.J., Strand P., Assimakopoulos P., Bréchignac F., Gascó C., Métivier H., Moberg L., Smith J.T., Tamponnet C., Trueba C., Voigt G., Wright S. (2002) Estimation of radioecological sensitivity. *In*: The Radioecology – Ecotoxicology of continental and estuarine environments ECORAD 2001, Bréchignac F., ed., *Radioprotection – Colloques* 37(C1) 1167-1173.

International Conference on radioactivity in the Environment, Monaco, 1-5 September 2002 (2004) In: P. Strand, P. Boerretzen, eds., *Journal of Environmental Radioactivity, Special Issue,* Vol 74 (1-3), 283 pages.

International workshop on the mobility of iodine, technetium, selenium and unranium in the biosphere (2003) In: S. Sheppard, ed., *Journal of Environmental Radioactivity, Special Issue,* Vol 70(1-2), 154 pages.

IUR (2000). Dose and effects in non-human systems. Summary of the work of the Action group of IUR. International Union of Radioecology, IUR Report 01, Osteras, Norway. (www.iur-uir.org)

IUR (2002). Protection of the environment. Current status and future work. International Union of Radioecology, IUR Report 03, Osteras, Norway. (www.iur-uir.org)

IUR (2006). Radiological Protection of the Environment. IUR web based questionnaire results: Research, Facilities and scientific priorities. International Union of Radioecology, IUR Report 05, Warrington, UK. (www.iur-uir.org)

IUR (2006). Radioecology in a multipollution context. IUR web based questionnaire results: Research, Facilities and scientific priorities. International Union of Radioecology, IUR Report 04, Warrington, UK. (www.iur-uir.org)

IUR (2006). Recommendations for improving predictions of the long-term behaviour of ^{14}C, ^{36}Cl, ^{99}Tc, ^{237}Np and ^{238}U. Findings of the IUR "Radioecology and waste" Task Force. IUR Report 06, Warrington, UK. (www.iur-uir.org)

Métivier H. (2008) La fin d'un travail titanesque: les nouvelles recommandations sont arrivées. Editorial. *Radioprotection* 43(1) ; 11-12.

OECD/NEA (2007) Scientific issues and emerging challenges for radiation protection. Report of the expert group on the implications of radiological protection science, NEA/CRPPH/EGIS(2007)1, 83 pages.

Radioactivity in the environment, including the Arctic and Antarctic (2007) The international Conference in Nice, France, 2-6 October 2005. In: P. Strand, ed., *Journal of Environmental Radioactivity, Special Issue,* Vol 96 (1-3), 156 pages.

Stone R. (2002) Radioecology's coming of age, or its last gasp? *Science*, 13(297): 1800-1801.