Radiation Protection

OECD

Radiological Protection of the Environment

Summary Report of the Issues

AEN NEA

NUCLEAR • ENERGY • AGENCY

Radiation Protection

Radiological Protection of the Environment

Summary Report of the Issues

Summary Report of the NEA Forum on
"Radiological Protection of the Environment:
The Path Forward to a New Policy?"

held in collaboration with the
International Commission on Radiological Protection (ICRP)

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996); Korea (12th December 1996) and the Slovak Republic (14th December 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 28 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

FOREWORD

In recent years, member countries of the Organisation for Economic Co-operation and Development (OECD) have shown an increasing interest in identifying opportunities to enhance protection of the environment as part of their initiatives for sustainable development. One aspect of the protection of the environment of relevance to the OECD Nuclear Energy Agency (NEA) is radiological protection of the environment. This issue has gained renewed attention recently, leading to special interest within the NEA membership to contribute to the international activities being conducted to develop a rationale for radiological protection of the environment that is comprehensive and can be implemented in an efficient manner.

In order to promote and establish a process of developing a policy for radiological protection of the environment, the NEA proposed to conduct, in close collaboration with the International Commission on Radiological Protection (ICRP), a series of fora on radiological protection of the environment. Currently, three fora are planned: the first at the beginning of the development of new ICRP recommendations in order to provide a rationale for radiological protection of the environment, the second forum following reflections and draft considerations by the ICRP; and the third following the issuance of a new ICRP recommendation.

The first forum was entitled "Radiological Protection of the Environment: The Path Forward to a New Policy?", and was held in Taormina, Sicily, Italy on 12-14 February 2002 on the kind invitation of the Italian *Agenzia Nazionale per la Protezione dell'Ambiente* (ANPA).

The objective of this first forum was to develop, together with other interested parties, a sound technical basis and criteria for an ICRP recommendation on the radiological protection of the environment. This first meeting focused on the questions:

- How best can we inform the process of developing a radiological protection philosophy for the environment?

- What harm do we wish to prevent and how will we measure that harm?
- How could the systems for the radiological protection of the environment and the radiological protection of humans be integrated, and are there any inherent conflicts that need to be considered?

This report summarises the key issues discussed at the forum, including sustainable development, identification of what to protect, the definition of detriment, the necessary level of regulation, an integrated approach to protection, the use of similar approaches for humans and the environment, practical foundations for a system of environmental protection, and consequences in terms of training.

TABLE OF CONTENTS

1. INTRODUCTION

The International Commission on Radiological Protection (ICRP), has addressed the radiological protection of the environment in several of its recommendations. ICRP Publication 26, issued in 1977, says in paragraph 14; "*… the level of safety required for the protection of all human individual is thought likely to be adequate to protect other species, although not necessarily individual members of those species. The Commission therefore believes that if man is adequately protected then other living things are also likely to be sufficiently protected*" (ICRP 1977). In its Publication 60 (ICRP 1991), issued in 1990, it states in the paragraph 16; "*The Commission believes that the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species. At the present time, the Commission concerns itself with mankind's environment only with regard to the transfer of radionuclides through the environment, since this directly affects the radiological protection of man.*"

These suggest that the application of the optimisation principle (to assure that doses are ALARA – As Low As Reasonably Achievable) should lead, according to the human radiological protection system, to the protection of other species.

Although many specialists still believe that this assessment is valid, events in the non-nuclear field of human activities show that protecting man does not automatically imply protection of the environment. The best example being the ozone stratospheric depletion as a result of human use of chloro-fluorocarbons (CFCs), which are non-toxic chemicals for humans but have caused significant damage to our natural environment.

Other human activities, such as the dumping of nuclear waste, decommissioned nuclear vessels, and reactors in the Arctic, pose new threats to the environment, although humans might not be directly affected. Moreover, people are becoming increasingly sensitive to environmental protection, even in uninhabited regions. There are many reasons – some ecological, others anthropomorphic – or the need to keep these areas pristine: for subsequent settlement or simply to develop tourism activities for example. Scientific knowledge, as popularised by the media, has made people acutely aware of the fact that we live in a world in which all sorts of interactions are possible, especially those between humans and the environment.

Radiological protection of the environment is currently being addressed by various international initiatives. The International Commission on Radiological Protection (ICRP) has launched a task group of its Main Commission to address this issue as a part of developing new recommendations. The European Commission has established the *Framework for Assessment of Environmental Impact* (FASSET) project (Larsson 2002). The International Atomic Energy Agency (IAEA) has established a work programme to develop safety guidance on the protection of the environment from the effects of ionising radiation, that will take account of these and other developments (Robinson 2002). IAEA is also holding a series of Meetings and Symposia on the subject in order to facilitate information exchange and co-operation.

In light of growing interest in developing an integrated approach to the management of all environmental risks, the process of developing a policy for radiological protection of the environment should not be constrained by the current national, international organisations or current ICRP approach to radiological protection. From the beginning of discussions, the possibility of taking a fundamentally different approach to radiological protection of the environment should be considered, and is encouraged.

This summary report will focus on the main questions posed during the NEA Forum held in Taormina (Sicily):

- What problem are we trying to solve? Is there an international rationale behind the wish to protect the environment from radiation?
- Do we have enough scientific information to develop and define a broadly accepted policy?
- What are the socio-political dynamics, beyond science, that will influence policy on radiological protection of the environment?
- What are the characteristics of the process for developing a system of radiological protection of the environment?

2. UNDERSTANDING EMERGING SOCIETAL EXPECTATIONS TOWARDS RADIOLOGICAL PROTECTION OF THE ENVIRONMENT

The question

When discussing radiological protection of the environment, often, the first question raised is: What is the real problem? Until now, many have viewed the statements of the ICRP to be more than adequate to respond to this question and to public concerns. However, increasingly an evolving society is not satisfied with such an approach, and it is becoming imperative to demonstrate that the environment is protected. Moreover, as we gain more information about the Former Soviet Union, examples of catastrophic environmental management have been revealed and the public has become aware of the fact that society is quite capable of endangering not only itself, but also its environment.

Furthermore the confusion has been sustained by those who have seized upon these social discussions to stigmatise the risks of nuclear power and demand stricter regulations to protect the environment, hence forgetting that accidents like Chernobyl resulted from a combination of malfunctions involving mechanical design and an inadequate safety culture. One of the primary lessons from such an accident is that the resultant pollution will never be averted solely by regulations that protect the environment, but rather by implementation of an integrated system that combines equipment safety with protection of people and protection for the environment. Nevertheless since accidents will always be probable, it is obvious that to limit their consequences for both humans and the environment, the priority must lie in making facilities safer.

Even strict regulations would not be more effective in coping with situations like the deliberate dumping of waste into the Techa River by the Soviet leaders of the day. Deliberate acts of dumping into the environment would be outside the scope of any new environmental protection recommendations.

While the question of environmental protection seems clear-cut for society, and commands a consensus in most countries, the response is still vague when one seeks to specify the objectives of such a policy and how to set about demonstrating and achieving them.

Scientists would begin to address this question by asking; What is the goal to be achieved? What must we protect and from what? What harm do we wish to prevent, and how will we measure that harm? If these questions can be answered, then one could study the current state of scientific knowledge in order to propose a protection policy that would be both effective and universally accepted.

It can be noted that the societal concerns for the radiological protection of the environment are echoed more or less rapidly in the political realm, but that these are completely out of phase with the questions that scientists are asking. Today's political leaders are faced with societal pressure to which they need to respond, but when they turn to scientists, they often fail to get a clear answer. This highlights that the problem is not uniquely scientific. The risk then is that, for lack of a clear and rapid response, political leaders may believe that the problem is not a pressing one and will dismiss it as an essentially philosophical question, namely what are we going to leave to future generations?

At this stage in our discussion it is necessary to define what is meant by; "the environment". How the environment is defined can considerably influence the way in which the current system is judged

If the environment is confined to the human habitat, the existing system of radiological protection, if applied correctly, is sufficient; by protecting people on an individual basis the environment is respected, as the ICRP claims. Under current practices, for example, the environment is monitored to ensure that the public is not overexposed. To this end, regulatory limits are imposed on what can be discharged into water or the atmosphere, and regulators already take these factors into account when licensing facilities. Such aspects are also considered when contaminated sites are rehabilitated and subsequently re-occupied by the public. While this anthropomorphic approach protects humans and their immediate environment, this view seems today to be insufficient in the face of societal pressures.

If the definition of the environment is broader than just humans and their immediate surroundings, and extends to uninhabited areas, then the ICRP's tenet of "protection through protection of man" remains to be proven, and would, in fact, seem not to hold true under all circumstances. Under this definition, the ICRP's current position does not respond to questions posed by regulators or by the public, and does not offer any proof of its truth.

For example, the ICRP's position fails to address the issue of sites from which humans are absent, such as the Kara Sea, but which is nonetheless the subject of deep concern (Strand, 1996). Nor does it address the issue of environmental protection in connection with the management of deep geological disposal sites, even though as much as possible is being done to ensure that the current and future impacts on humans are either negligible or acceptable (OECD/NEA, 1999). Other "hybrid" cases can also be imagined, such as releases which cause little exposure to humans or to parts of the human food chain, but which significantly expose other components of the environment.

Finally, with regards to acceptability, a decision needs to be made regarding the abiotic part of the environment, which is merely a roundabout way of asking the simple question: "Do we or do we not give ourselves the right to release man-made radionuclides into the environment?"

Therefore a clear definition needs to be established of what we mean by the environment before we give further thought to what we should protect. A number of international organisations, such as the International Atomic Energy Agency (IAEA), Nordic Nuclear Safety Research (NKS), the International Union of Radioecologists (IUR), etc., have already examined these issues, and before proceeding any further the results of their work should be taken into account.

The notion of sustainable development

The anthropocentric vision is no longer accepted by some components of society, and this fact was clearly recognised in the Rio Declaration, which enshrined the notion of sustainable development. The OECD, and many international organisations, have addressed these issues (OECD, 2001a, OECD, 2001b).

The concept of sustainable development first emerged in the late 1980s when it was defined in the Bruntland report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In its broadest sense, sustainable development encompasses equity between countries, generations and among a nation's citizens, and it includes economic growth, environmental protection and social welfare. The definition clearly shows the need for a system that integrates a myriad of conflicting components of community life. Today, radiological protection of humans and their environment must take these various components into account.

Shortly after the concept of sustainable development was introduced, a second, complementary concept emerged – that of biological diversity. Today, many people view such diversity as vital to the safeguard of ecosystems.

This new objective of our societies calls for development of a system that combines protection of humans with the protection of the environment. This objective goes beyond the narrow confines of radiological protection to take account of other systems of protection against other technological risks, not only the most obvious, such as chemical hazards, but also those arising from advances in the life sciences.

> The notion of sustainable development, which is accepted by an increasing number of social partners, will have to be taken into account by the system of radiological protection of the environment, and must be considered when making trade-offs and choices in the energy sector.

What to protect?

Before addressing the question of what needs protecting, one must first understand the impact that radiation has on the environment. It is probably here that the first "cracks" begin to emerge in the initial consensus over the need for environmental protection.

At this stage in the discussion, reference to the protection of humans, and to the historical background to the current system of radiological protection, cannot be avoided.

As in the case of humans, the environment is subject to deterministic effects that a modern protection system should protect against. Considerable knowledge has been acquired as a result of major accidents such as Kyshtym in Russia, or Chernobyl in Ukraine, and of practices which are now deemed unacceptable, such as the discharge of radionuclides into the Techa River or, to a lesser extent, waste management at the Hanford site during the height of the Cold War. To the knowledge accumulated as a result of both accidental and deliberate situations must be added the results of high-dose plant irradiation experiments. All of these data were recently analysed by UNSCEAR (UNSCEAR, 1996).

Today, the system of radiological protection of humans does not seek merely to prevent early, deterministic effects, but also to limit stochastic, delayed effects. Should this same objective apply to the environment as well? Should we go beyond the elimination of early deterministic effects in the current environment, and institute a system to protect the future environment from delayed effects (ex. cancers and hereditary effects), as does the system of radiological protection for humans?

With regard to certain components of the environment, mammals in particular, scientific knowledge of radiation effects does exist, since the stochastic effects on humans have not only been evaluated from human epidemiological studies, but also from animal experiments. However, the effects of radiation on other species and on flora are currently not as well known, due to the lack of definitive studies.

It is highly tempting for scientists to adopt the same approach towards acquiring environmental knowledge as that applied to human radiation biology. This would simply consist in defining endpoints and establishing dose-effect relationships, with the specification of either thresholds or limits at values that lead to effects deemed acceptable or negligible.

This procedure would seem difficult to put in place for a number of reasons: 50 years after the ICRP defined the system of radiological protection, debate still rages over the nature of the dose-effect relationship in humans for an endpoint that has nonetheless been identified – the appearance of cancers (OECD/NEA, 1998). While there is no consensus among scientists, this has not precluded institution of an effective protection system based on the precautionary principle, and on the adoption of a simple, linear relationship, without a threshold, between exposure and effects. Today it would not seem feasible to establish dose-effect relationships for a number of different components of the environment within a reasonable amount of time, assuming it were viewed relevant to try.

As well as alerting society, it is also necessary to alert the scientific community to the increasingly unlimited options for observing biological effects, given the extreme sensitivity of the tools being developed by molecular biology. Today it is possible to develop "DNA chips" that show a given effect on the genome. Even so, there has never been consensus within the scientific community over the linkage between these effects, which some might propose as markers, and life-threatening pathologies.

The second question pertains to the nature of what we should be protecting. Should an individual fish, insect or flower, or a population of fish, insects or flowers, or more generally an ecosystem containing fish, insects and flowers be protected? The first ICRP-NEA forum showed clearly that there is no simple ethical rule for forging a system of environmental protection.

If the current anthropocentric approach is being challenged today, through no failings of its own, it is because of society's comprehensive approach to environmental protection. This can be seen in approaches being taken in response to, for example the problem of the ozone layer or fear of climate changes, both of which result from human practices. This can also be seen in responses to accidents, such as Chernobyl and a succession of oil tankers shipwrecks.

The biocentric approach which has emerged to succeed the anthropocentric approach is probably not the best solution either, insofar as it merely shifts the monitoring of the environment from man to one or more species designated by man on the basis of criteria that are difficult to establish and scientifically defend. Should humans protect a fish rather than a butterfly? This answer varies according to one's affinities.

This is why an ecocentric approach, based on the preservation of ecosystems, would seem best suited to protecting the environment as a whole. This is supported by the growing ability of scientists to demonstrate that an action at one level, however trivial, can have a delayed impact in both time and space (Bréchignac, 2002).

Even so, the choice to be made will have to be based on scientific evidence. Programmes such as FASSET in Europe will provide invaluable assistance in this respect. For the future, FASSET should be used as the basis for developing internationally recognised scientific consensus, as, for example, UNSCEAR is in the area of radiological risk to humans. Nevertheless, scientific knowledge cannot be used effectively until a clear-cut societal answer has been given to the question "what do we want to protect?"

Before giving further consideration to this question, it should be remembered that there are still many outstanding questions about the effects of radiation on humans, especially concerning low doses of exposure. These questions can easily be transposed into a cognitive approach to environmental protection. For example, what is the effect of co-factors in the impact of radiation on the environment? This question has been considered in the case of humans, and the complexity of the system is such that, to date, no clear-cut approach has yet been proposed (OECD/NEA, 1998). In addition, the co-factors classically studied for humans, namely chemical, physical or bacteriological toxins, are more extensive in the case of the environment. Here, in addition to this initial set of factors, account must be taken of human activities such as fishing and hunting if the aim is to conserve an entire animal population, or forestry if the aim is to protect forests. In another example, the potential alteration of the reproductive functions of fish as a result of exposure to radiation may prove negligible compared with the over-harvesting of marine resources. Paradoxically, the terrestrial fauna in the evacuation area around Chernobyl is richer today than it had been prior to the accident. This example clearly shows that endpoints must not be defined on the basis of laboratory observations alone, but on a genuine assessment of problems *in situ*.

Lastly, note should be taken of the total inconsistency in current discharge authorisation procedures between anthropomorphic discharges and the natural radiological situation which will need to be addressed if a coherent system that can be readily understood by the public is to be proposed. It is no longer the risk itself that is stigmatised, since it is well below that caused by the level of background radiation, but simply the notion of discharges into the environment at any level at all.

This problem is not unique to the environment, and the new proposals put forward by the ICRP attempts, for example, to refocus the debate on the notion of acceptability in comparison with the situation engendered by unavoidable natural risks (Clarke, 2001).

Deliberations based on scientific knowledge, but open to all segments of society, are therefore needed to define what we must protect or what we would like to protect.

How to evaluate detriment

Once the target of protection has been identified, the problems of assessing effects and estimating risks remain to be resolved. Current arrangements constitute a relatively coherent system for assessing the stochastic risks that are the endpoints of the system of radiological protection of humans.

An exposure results in a dose received by an individual or an organ; this is called the "absorbed dose". Certain simplifications were needed to make such an approach amenable to radiological protection purposes – simplifications that in some cases were viewed unacceptable by certain scientists. Indeed, the absorbed dose is defined for radiation protection purposes at the level of an entire organ, and may not reflect the heterogeneity of radiation. To assess risk to an organ, quality factors were estimated for each type of radiation, and for some radiation as a function of energy. These quality factors are intended to reflect the ability of a particular type and energy of radiation to produce a particular biological effect so that different exposures could be compared and summed. Current discussions clearly show the limitations of such a simplified approach, which, by definition, may not fully reflect reality. Since humans are is the ultimate objective of the protection system, the ICRP has weighted the probability of each stochastic effect at the level of the various organs – the risk of cancer or hereditary effects – to assess an overall risk for humans: this is the concept of "effective dose", which is the basis for regulation. Thus, starting with exposure, the radiological protection system provides a structure to calculate an effective dose. Based on epidemiological and experimental data, a level of dose not be exceeded is selected, such that the risk of delayed stochastic effects are either negligible or acceptable.

Should this simplified approach be applied to the environment? It is unclear whether such a procedure would be useful, insofar as it would surely be difficult to implement. Indeed, it would entail identifying endpoints, and in addition, in the event of internal contamination of the species to be protected, it would entail the construction of kinetic models for the development of dosimetric models.

If preservation of a population is the chosen criterion, an initial, more simple approach could limit calculations to gonads, so that it would be possible to check the fertility of species and their reproductive ability.

For even such a simplified approach, however, the immense difficulty of its development and application is self-evident, whereas societal pressure demands rapid action. As such, other approaches could be considered. For example, the notion of exposure could be represented by dose rate, assuming that the radiation is external to the species or biota to be protected.

Another method could be the representation of the notion of exposure by radionuclide concentration in the environment. Radionuclide concentration has the advantage of being easily measured, and would lead to an environmental protection system that could be readily implemented, and easily understood by regulatory authorities and the various societal stakeholders. The example of radon shows that a public health policy can be established without using the concept of dose. All of the countries that have legislated acceptable levels of radon in the air of residential areas or workplaces in order to protect the public have simply used exposure in Bq/m^3 rather than a calculated dose. For workers in uranium mines, radiation safety officials have used another notion – the "working level month" – that combines exposure and working hours. This example shows that it is not always necessary to develop a complex dosimetric system to put proper radiological protection in place.

Estimating the detriment entails an exposure reference expressed either as a dose, as for humans, or as a dose rate or concentration. The example of radon shows that the concept of dose is not necessarily relevant to environmental protection and, in addition, is very difficult to implement.

Regulation at what level?

The task of regulators is to establish criteria and standards for radiological protection, put these in place through regulations, and then provide for enforcement. Any criteria developed must be firmly rooted in scientific fact, although pressure from society may be such that regulators will want to go farther or faster. Whatever the case, guidance for the application of standards and regulations must be very clearly stated.

Given the global nature of environmental protection, it would seem necessary to devise a system that is coherent at the international level, but which provides guidance and boundaries at the international level that are sufficiently clear and specific to preclude differing local interpretations of environmental protection levels.

However coherency does not necessarily mean uniformity, and the environmental protection system will have to be flexible enough to allow for local initiatives, in the broad sense of the word, since public acceptance of an environmental protection policy requires consensus between stakeholders at different levels.

Clearly, in the case of what may be referred to as highly mobile pollutants that are able to cross borders easily, and that can be found anywhere on the planet, an **international consensus** is desirable; such is the case for air pollution and pollution of the seas and oceans. This has been experienced in connection with atomic weapons testing and extremely serious accidents, such as Chernobyl.

In other situations, in which the impact of discharges is confined to a certain space, it is obvious that a **regional consensus** is enough; bringing together a number of affected countries but not going beyond the limits of a given geographical area. This is the case with certain factory discharges that, because of their ecological behaviour or half-life, will affect limited geographical areas only. An agreement will have to be reached between the countries concerned.

For pollutants with limited dispersion, such as radioactive waste that is to be stored deep underground, the **consensus** will have to be achieved at the **national**, or even **local**, level, because populations living tens of kilometres from a storage site may not perceive the site's hazards in the same way as those living close nearby.

This geographic definition alone may greatly help in resolving certain potential conflicts. For example, some populations in locally contaminated areas may prefer to run slightly higher risks rather than lose jobs or be forced to relocate. Such an approach would be feasible as long as the recommendations set by international bodies are appropriately flexible. Recent experience in this area should inspire great prudence and humility when defining such a system of radiological protection.

The time dimension will also have to be taken into account. While a given approach may be acceptable today, societal changes or technological progress may alter the situation, and the system will therefore have to incorporate some measure of pragmatism and flexibility.

After the release of radionuclides into the environment, it is important to be able to readily identify major pathways of radiation exposure, the most highly exposed individuals or populations and geographical areas. Radio-ecological sensitivity can be broadly defined as the extent to which an ecosystem contributes to an enhanced radiation exposure to humans and biota. Radio-ecological sensitivity attempts to determine and identify the most radio-ecologically sensitive areas (Howard *et al.*, 2002). This concept suggests that the regulators could define some specific regulations for specific sites or ecosystem according to their sensitivity. This specific approach requires the definition of a critical load for different ecosystems to diagnose the resilience of the environment

The concept of specificity was introduced to protect humans from internal contamination in the workplace. Its application has posed difficulties between workers and regulatory authorities.

The proposed system will have to be flexible enough to adapt to local, regional and international circumstances, and to reflect the diversity of ecosystems, thus paving the way for an appropriate social dialogue that could make it acceptable to people in their everyday lives.

An integrated approach to protection

Radiological risk is just one of many risks entailed in human activities. This is as true for humans as it is for their environment. The radiological protection system is sometimes considered too isolated from other protection activities and might create a societal rift between the nuclear community and other human activities.

In addition, there seems to be no clear social consensus as to whether radiological risks to humans are being over-estimated or under-estimated when compared with other risks. From the scientific standpoint, an OECD/NEA report concludes that ionising radiation at dose levels of interest for radiation protection is considered to be a weak carcinogen. (OECD/NEA, 1998).

For the environment, the issue is the same. When endpoints are defined, it will be necessary to compare the proposed system with those proposed for other economic activities, and to do everything possible to ensure coherency. It would be futile to try to institute a bold, binding system effectively protecting one specific component of the environment if another sector of human activity were to operate within that sector with either no restrictions at all or subject to regulations that were far less binding. To maintain equity between the various sectors of activity, it will be necessary to build an integrated system for all components of human activities. Based on this, the relationship between the level at which an effect (morbidity or mortality) is observed and an agreed-upon level of regulatory limitation can be established for each activity. It would be unfair to force one sector of activity to comply with limits that are only a tiny fraction of the levels at which an effect is observed if a less restrictive system is imposed on another sector.

One pathway to achieving this equity could be based on analytical capabilities. It is fairly easy to detect radioactivity, and it is often straight-forward to associate environmentally detected radioactivity with a particular human activity. The same cannot be said for chemicals. Achieving equity (scientific, social, regulatory) between the various sectors of activity will thus demand considerable effort. Analytical results must be comparable, at some meaningful level, across all sectors. Progress is being made in terms of the analysis of environmental levels of various chemicals as a result of the continuing development of new agricultural, industrial and pharmaceutical products. In this context, the notion of releases and concentrations that are "analytically zero" becomes important. In constructing an integrated system it will be necessary to define this notion of "analytical zero" clearly. It will also be important to compare it with the levels at which effects are observed on the target in question, for in some cases current analytical capabilities may not be sufficiently sensitive. Societal demands for such analytical comparisons are growing, and unless they are satisfied the public will continue to be reluctance to accept scientific and technical progress (Académie des Sciences, 2000).

Another problem that will have to be resolved is that of the background. The earth is naturally radioactive, to differing degrees depending on location. In addition to this natural background of radionuclides in the air, water and soil, some past human activities (above-ground nuclear weapons testing and accidents) have added naturally existing and man-made radionuclides to our environment. All of this constitutes our current "background" level, which is very geographically inhomogeneous. This background results in human exposures that are often orders of magnitude above those caused by current human activities (radionuclide releases from nuclear power plants, hospitals, industrial and research facilities, for example). Our current level of knowledge, however, does not generally allow us to distinguish health effects that may have been caused by exposure from "natural background" from those that may have been caused by exposure from "man-made" radionuclides released into the environment. This is equally true of radiological exposures to the environment. Thus, the existence of "natural" and "anthropomorphic" background levels of radionuclides, as well as of toxic chemical and biological substances in our environment will have to be addressed by any holistic system of environmental protection that is developed. In its latest proposals for man, the ICRP (ICRP, 2002) has included a reference to exposure to natural radiation – a benchmark that is realistic as well as readily understandable to the public.

> Once comparisons have been made among all human activities, the development of an integrated system of protection will inevitably define a level at which discharges are acceptable. This will most likely not be based on discharges that are "zero" or "close to zero", but on discharges that are some precautionary factor below a level at which health effects have been observed.

The same approach for humans and the environment

Humans are just one component of the environment as a whole, the only one that can single-handedly alter that environment considerably. To date, humans have dealt primarily with their own protection, believing that as a result the environment will also be protected. Earlier it was shown that this is not always the case.

Building on the acknowledged success of the system of radiological protection of humans, it is necessary to develop a system in which the protection of humans is consistent with that of the environment, thus facilitating explanations of the system to stakeholders and all segments of society.

The coherency between the two systems is described in Figure 1 (Pentreath, 2000). Just as for humans, the new system will have to define various levels of radionuclides (for example, acceptable and/or unacceptable) in the environment, and criteria for "optimising" residual environmental concentrations. These nuclides will interact with what the ICRP has defined, for the sake of regulatory simplicity, as "reference man" to cause human exposures. In a parallel fashion, consideration must be given to how to define reference flora or fauna, or a reference ecosystem.

For humans, the ICRP has defined secondary references to allow for the differential impact of radionuclides or radiation, depending on age. Similarly, it would seem possible to define secondary fauna, flora and ecosystems to take particular account of local or regional circumstances.

Both systems would then recommend action levels, both for humans and for the environment.

> Today it seems obvious that systems for protecting humans and their environment should take coherent approaches. While this will be necessary for societal acceptance, it does not mean implementing strictly identical systems, which could be difficult to achieve.

What are the practical foundations for a system of environmental protection?

The construction of a new radiological protection system will have to incorporate the environment as one of its major components. Humans, however, will remain at the core of the system, whether this is explicitly acknowledged or not.

The new system should cover all components of the environment, and although this concept must still be defined, it will be projected in both space and time, encompassing the vulnerable components of the environment.

The system will have to be built on solid scientific foundations, and lead to the formulation of clearly defined regulations so that situations can be properly assessed and monitored. While predicated on scientific considerations, it will have to include social, philosophical, ethical, political and economic considerations as well. It will also draw upon the principle of precaution, appropriately defined for this application.

If the system is to be applicable, it is obvious that regulators will require clear definitions of the objectives and of methods for attaining them. They will also need to show that the system is realistic. The same principles of protection should also apply to all environmental pollutants, be they radiological, chemical or biological. The system will have to be pragmatic if it is to be credible, and if it is to be understood by users and by the public.

The system must be defined internationally, but it must be pragmatic and flexible enough to allow for local solutions when necessary. For example, beyond national decisions regarding broad waste management approaches, discussions of waste storage locations concern almost exclusively local populations. In general, such populations do not readily accept the intrusion of distant partners whose positions might not be understood, or seen as being in the interests of the affected population. Thus, international consensus will be needed on certain numerical criteria, while guidance for the development of regional and local numerical criteria will also be necessary

The current notions of justification and optimisation will have to be redefined in order to integrate the environmental component into the broader system. Trends that go beyond the current anthropogenic definition of optimisation are already emerging. Indeed, there is currently a notable shift in the ALARA ("As Low As Reasonably Achievable") principle as it applies to the management of discharges into the environment. Under pressure from society, regulators have moved from ALARA to ALATA ("As Low As Technically Achievable"), incorporating the notion of BAT ("Best Available Techniques"). This clearly corresponds to the public's demands to discharge as little waste into the environment as possible – as a precaution, but also in response to a new notion of maintaining a "clean environment".

With evolving technology, the system will have to be flexible, and designed to allow for change. With the acceptability of some risks being subjectively judged at the local and/or national level, it is conceivable that the system allow for a given country's level of development, with more being asked of the most technologically advanced countries while not being lax vis-à-vis others. Protecting the environment will clearly be a long-term process, and the speed with which the system is applied will have to take societal context and national priorities into account. Such discussions, for example, are ongoing with regard to the atmospheric pollutants that threaten world climates, and consideration must be given to a similar approach to discussions between countries so as not to unduly penalise the developing world.

"Do not penalise unduly" is the motto of those who feel that excessively strict regulation is an impediment to the development of humanity. Through this view, in that exposing the environment does not directly affect humans, any new radiological protection system will have to prove that it offers some sort of benefit. From this standpoint, this is not an easy task for its designers, philosophical considerations aside.

There is no longer anyone who questions the essential need for dialogue with all segments of society before such a system is instituted, but this will also be necessary when the system is put in place. Populations face a variety of different social constraints, and foremost among these is the need for employment. Stringent protection that would jeopardise that paramount consideration would be rejected sooner or later, and it could trigger secondary effects in society that would be worse than the hazard being combated. Any international organisation that proposes a new system, such as the ICRP, will have to dialogue with, listen and be responsive to users.

Finally, regulators desire numbers in order to establish and monitor the application of a system for the radiological protection of the environment. Obviously, the simpler these numbers are, and the easier they are to check, the more likely the system will be implemented, because this will be essential for transparency and public comprehension. A performance based regulatory system may also be appropriate.

These figures could convey dose rates (Gy/Unit of time) to which targets (reference species for example) are subjected, and/or concentrations (Bq/Unit of mass or volume) at which targets live. To define an internal dose, as for humans, would seem almost impossible and unnecessary, and could only complicate the system. A simple dose rate or concentration approach would allow better comparisons with other environmental pollutants. For this, studies to define "sentinel species", representative of the "health" of an ecosystem, will be necessary.

The ICRP is currently trying to redefine its system in relation to natural background radiation. One approach that has been put forward for recommending actions is illustrated for mammals in the table below (Holm, 2002). This is an approach that could be extended to all components of the environment.

Table 1. **Example of derived consideration levels for a reference terrestrial mammal (Holm, 2002)**

Consideration level	Relative dose level	Likely effect on individual	Aspects of concern
Level 5	< x 1000	Early mortality	Possible remedial action considered
Level 4	< x 100	Reduced reproductive success	Action dependent upon type of fauna and flora affected
Level 3	< x 10	Observable cytogenetics	Action dependent upon size and nature of area affected
Level 2	Normal background		Some action considered
Level 1	< background	Low-trivial	No action considered

Some countries have already instituted systems of radiological protection of the environment – in most cases for certain components only, such as aquatic organisms. Before recommending a new radiological protection system, it will be necessary to assess existing systems to see whether something new and better is needed, lest it be rejected by authorities who have gone through the whole process already. This will entail an initial assessment of the proposed recommendations and models before a policy is definitively adopted. It will also be necessary to show that the effort demanded is commensurate with the concerns caused by the environmental impact of radiation.

The system of environmental protection to be proposed must be based on hard scientific data. It must be simple and flexible and enable a constructive dialogue with all parties involved in environmental protection. It will reassess notions of optimisation on the basis of new technologies. The work of the CRPPH has recommended a step-by-step approach, including broad discussions, debates of the various implications of new approaches, and the development of consensus.

Training consequences

It is professionals who will feel the practical consequences of the development of a new system of radiological protection.

At present, professional training courses addressing environmental protection are more cognitive than regulation-oriented. New managers will have to be trained who can incorporate the consequences of environmental management decisions into their businesses. Training would seem necessary, comparable, for example, to what has been done to train "Competent Experts" in Europe to ensure proper implementation of radiological protection for humans. The system being new, it will have to draw upon experience acquired with humans and be developed, if possible, at an international or regional level [European Commission (EC), International Atomic Energy Agency (IAEA), etc.]. The persons trained must not limit their focus to radiological risk alone, but must incorporate all human activity-related risks, with the aim of protecting the environment within a framework of sustainable development.

Regulators will also need to adapt their structures to the new system. In addition to training in the enforcement of newly established limits or reference values, regulatory staff will need procedural training in how to review particular cases, incorporating all components of the decision, including societal aspects, as discussed previously. Training in dialogue will also be needed.

> Society has changed and is demanding a new system to protect the environment. The system must be integral, addressing with all aspects of pollution and incorporating the notion of sustainable development. To implement this system, a new generation of professionals will have to be trained. It will only be through the involvement of competent individuals placed at strategic levels in private companies that the system's implementation will be a success.

3. CONCLUSIONS

The participants at the Forum were unanimous in their view that the environment must be protected, and that a system of radiological protection of the environment should have, as its objective, to prevent environmental harm. This being said, the Forum felt that, in general, the environment is currently protected against the harmful effects of ionising radiation, but that the current system fails to demonstrate the level of protection. Further, there was agreement that we do, at this point, have sufficient knowledge and understanding to define a specific philosophical approach to the radiological protection of the environment, but that this should be approached in a pragmatic, step-wise fashion.

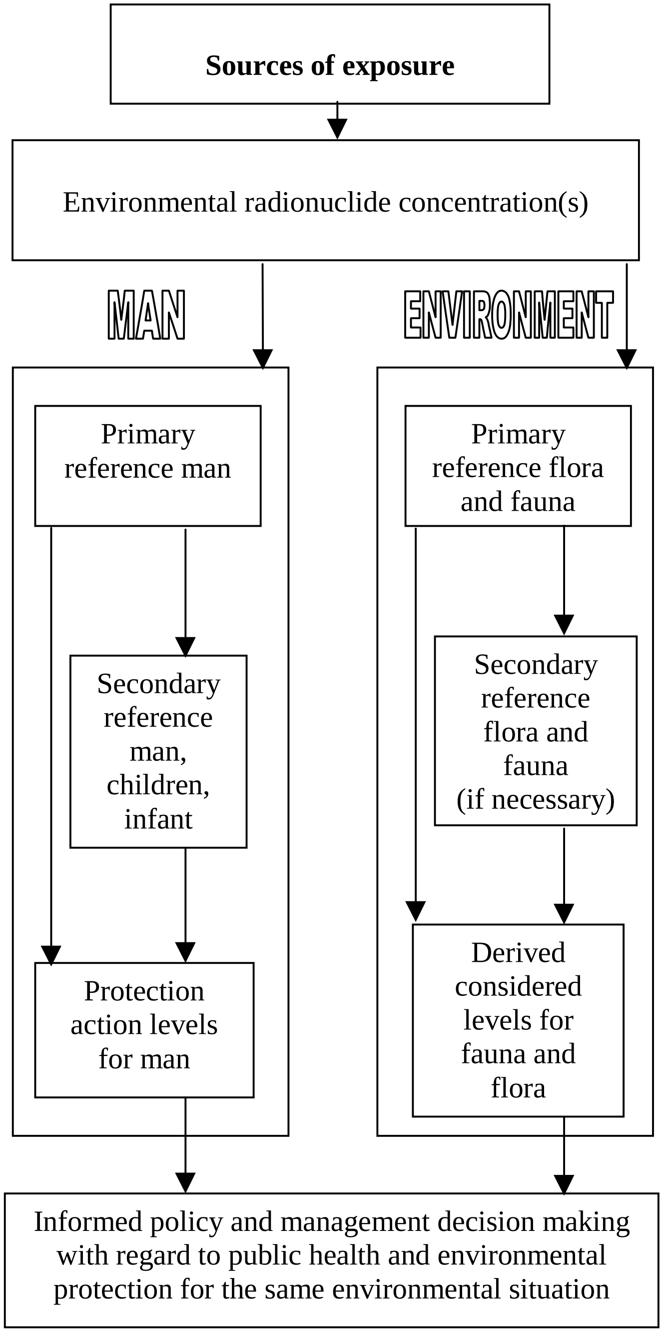
Specifically, there was agreement that scientific study of the effects of radiation on the environment, such as is now being carried out under the EC FASSET programme, should continue. However, Forum participants also felt that the state of current scientific knowledge was sufficient to proceed with the development of recommendations from which regulatory changes, if any are needed, could be made. The prime role of further scientific study, it was felt, is to identify gaps in current knowledge and to fill them in a prioritised fashion in support of policy and regulatory needs.

A key message from the Forum participants is that hazards and environmental stresses from radiation should not be considered in a vacuum, but together with other pollutants and stressors on the environment, such that resources are not disproportionately allocated. In parallel with this, the Forum felt that the system of radiological protection of the environment should be consistent with the protection system that is in place for humans. As such, a somewhat flexible approach is needed to accommodate solutions that may differ at the global, regional and local levels.

Broadly, then, the approach recommended by the Forum participants is to proceed in a step-wise fashion, being pragmatic and flexible, and being guided by the needs of policy makers and regulators. It was agreed that the ICRP was the best placed organisation to address the development of these protection recommendations. The development of these recommendations should include the wide circulation of draft materials, the conducting of “feasibility testing” of draft materials, and analysis and feedback of test results all leading to the finalisation of recommendations. Discussion of lessons learned, from the development process itself as well as from the implementation of the resulting recommendations, should then be pursued.

In summary, the Forum was very much in favour of a pragmatic approach to this important question. The ultimate acceptability of such recommendations from the ICRP will depend as much on the process used for their development as on their final content. Should the process of development not appropriately take into account the needs of all stakeholders (including policy makers, regulators, implementers, workers, the public, the environment, etc.), the acceptability of any recommendations, and the validity of the ICRP process, would certainly be brought into question. The ICRP can greatly accelerate implementation of their environmental protection recommendations, and thus provide more timely protection of the environment, through development of broad consensus on their recommendations with stakeholders. Timely implementation of ICRP recommendations, with stakeholder support, also enhances the effectiveness and relevance of the ICRP.

Figure 1. **Combined approach based on existing initiatives**



REFERENCES

ACADÉMIE DES SCIENCES (2000) *La chimie analytique: mesure et société, Rapport sur la science et la technologie*, C. Amatore et B. Blanzat Eds, Académie des sciences, Tec & Doc, Paris. 186 pages.

BRECHIGNAC F. (2002) *Environment* versus *man radioprotection: the need for a new conceptual approach?* Radioprotection, Vol 37, C1, 161- 166.

CLARKE R. (2001) *Nouvelles propositions pour le système de protection radiologique.*

HOLM L.E. (2002) *How could the systems for the radiological protection of the environment and the radiological protection of man be integrated?* in "Radiological Protection of the environment, The path forward to a new policy", Proceeding of a NEA/ICRP For a, Taormina 12-14 February 2002), OECD, Paris.

HOWARD B.J *et al.* (2002) *Radioecological sensitivity, Final report of an European Forum, Sept. 1998-March 2001),* Report of the Centre for Ecology & Hydrology/ NERC. Windermere, Cumbria, United Kingdom, 47 pages plus appendices.

ICRP (1977) ICRP Publication 26, Recommendations of the International Commission on Radiological Protection. Pergamon Press, Oxford.

ICRP (1991) ICRP Publication 60, 1990 Recommendations of the International Commission on Radiological Protection. Pergamon Press, Oxford.

LARSSON C-M. (2002), *Framework for Assessment of Environmental Impact (FASSET),* in "Radiological Protection of the Environment: The Path Forward to a New Policy", Workshop Proceeding of a NEA/ICRP, Taormina, Sicily, Italy, 12-14 February 2002. OECD, Paris.

OECD (2001a), *Policies to Enhance Sustainable Development*, OECD, Paris.

OECD (2001b), *Sustainable Development*: *Critical Issues*, OECD, Paris.

OECD/NEA (1998), *Developments in Radiation Health Science and their Impact on Radiation Protection,* OECD, Paris.

OECD/NEA (1999), *Confidence in the Long-term Safety of Deep Geological Repositories, Its Development and Communication, OECD,* Paris.

OECD/NEA (2000) *Nuclear Energy in a Sustainable Development Perspective,* OECD, Paris.

PENTREATH J. (2002) *Radiation Protection of Man and the Environment: Developing a Common Approach*. J. Radiol. Protection. 22, March 2002.

ROBINSON C. (2002), *Outcomes of the IAEA Programme on the radiological protection of the environment*. "Radiological Protection of the Environment: The Path Forward to a New Policy", Workshop Proceedings NEA/ICRP, Taormina, Sicily, Italy, 12-14 February 2002. OECD, Paris.

STRAND P, NIKITIN A.I., LIND B., SALBU B., CHRISTENSEN G.C. (1996), *Dumping of radioactive waste and radioactive contamination in the Kara sea, A joint Norwegian-Russian expert group for investigation of radioactive contamination in the Northern Areas,* Report of the Norwegian Radiation Protection Authority, Østerås, ISBN 82-993079-5-3, 55 pages.

UNSCEAR (1996), *Effect of Radiation on the Environment*, report to the General Assembly with Scientific Annexes, United Nations, New York.

ALSO AVAILABLE

NEA Publications of General Interest

2001 Annual Report (2002) *Free: paper or web.*

NEA News
ISSN 1605-9581 Yearly subscription: € 37 US$ 45 GBP 26 ¥ 4 800

Geologic Disposal of Radioactive Waste in Perspective (2000)
ISBN 92-64-18425-2 Price: € 20 US$ 20 GBP 12 ¥ 2 050

Radiation Protection

Radiological Protection of the Environment: The Path Forward to a New Policy? (2003)
Workshop Proceedings, Taormina, Sicily, Italy, 12-14 February 2002
ISBN 92-64-09969-7 Price : € 52 US$ 52 GBP 33 ¥ 6 050

Better Integration of Radiation Protection in Modern Society (2002)
ISBN 92-64-19694-3 Price : € 60 US$ 54 GBP 37 ¥ 6 050

Chernobyl – Assessment of Radiological and Health Impact (2002)
ISBN 92-64-18487-2 *Free: paper or web.*

The Way Forward in Radiological Protection (2002)
ISBN 92-64-18489-9 *Free: paper or web.*

ISOE – Information System on Occupational Exposures – Ten Years of Experience (2002)
ISBN 92-64-18480-5 *Free: paper or web.*

ISOE – Occupational Exposures at Nuclear Power Plants – Eleventh Annual Report (2002) *In preparation.*

Experience from International Nuclear Emergency Exercises – The INEX 2 Series (2001)
ISBN 92-64-18464-3 *Free: paper or web.*

Radiological Issues in Radiological Protection Decision Making (2001)
ISBN 92-64-18474-0 *Free: paper or web.*

Monitoring and Data Management Strategies for Nuclear Emergencies (2000)
ISBN 92-64-17168-1 Price : € 26 US$ 26 GBP 16 ¥ 2 850

Order form on reverse side.

ORDER FORM

OECD Nuclear Energy Agency, 12 boulevard des Iles, F-92130 Issy-les-Moulineaux, France

Tel. 33 (0)1 45 24 10 15, Fax 33 (0)1 45 24 11 10

E-mail: nea@nea.fr**, Internet: http://www.nea.fr**

Qty	Title	ISBN	Price	Amount
		Total		

❑ Payment enclosed (cheque or money order payable to OECD Publications).

Charge my credit card ❑ VISA ❑ Mastercard ❑ American Express

(Prices include postage and handling fees).

Card No.	Expiration date	Signature
Name		
Address	Country	
Telephone	Fax	
E-mail		

OECD PUBLICATIONS, 2 rue André-Pascal, 75775 PARIS CEDEX 16
Printed in France.