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WELCOME ADDRESS

Catherine Day
Director General DG Environment
European Commission

Good morning, ladies and gentlemen. I am very pleased to be here this morning to start this important conference and I would like first of all to bring you greetings from the Environment Commissioner Margot Wallström who is not able to be here today but who is extremely interested in the outcome of your discussions.

As you know we have organised this Stakeholders' Conference and invited you here to discuss approaches to the management of environmental radioactivity and the primary purpose of this conference is that we can hear from you. So, I would invite you all over the next two days to take every opportunity to participate, to express your views, and to join in the discussions, because this will be the most useful outcome that we can get from the conference. We hope that you will find it both useful and an enjoyable experience.

As you all know environment policy at European Union level is a very broad policy area. It covers water, air, soil, chemicals, …. It also increasingly covers integration into other policy areas. But today we want to focus more narrowly on the issues of environmental radioactivity and ionising radiation. These are important areas where we are working to monitor and control exposure and to improve the situation for human health and for our environment. I'd just like to set the wider context in which these discussions are going to take place and then you will be able to concentrate on the subjects you came here to talk about.

As many of you probably know, our overall environment policy at Union level is set out in a 10-year programme, which is called the Sixth Environmental Action Programme. The great advantage of having set out a 10-year programme is that we now have publicly available and accessible not only to policy makers but also to the general public a statement of our priorities for future action in what we hope is a coherent framework. But there is one disadvantage to this Sixth Environmental Action Programme: it does not address matters covered by the Euratom Treaty. You know that there are separate treaties with separate legal bases and different procedures and therefore the Environmental Action Programme doesn't cover environmental radioactivity. So we have decided for the subjects which fall under the Euratom Treaty to produce an equivalent framework action programme. One of the many things that we will do with the outcome of the discussions for the next two days is to use it as input as we frame and formulate the Environmental Action Programme under the Euratom Treaty. So your views will be useful to us on several levels in the future.

We all know that there are very different and very strongly held views on issues of environmental radioactivity and how to manage it and that is why we have invited a broad range of opinions to come to Luxembourg for this conference. So, among the audience we have scientists, government representatives, representatives of NGOs, journalists, industry as well as consumer and local residence groups, and we want to hear from everybody on how you think we should manage these issues at European level. Our hope is that by hearing a wide range of views we will be able to understand your concerns and see how best to reflect them in future European policy. I think a very interesting programme has been arranged, and at this point I would like to say a very sincere Thank You to all of those who have agreed to be participants, to lead debate and to help us share in their expertise so that we can have as constructive and wide ranging a discussion as possible.

Now, my role here today was to introduce Ken Collins but he has already introduced himself. Let me just say that we are very pleased and honoured that Mr. Collins has agreed to be the Chairman for our conference. He is the Chairman of the Scottish Environmental Protection Agency and he has a very long history of involvement and campaigning on behalf of environmental issues. He has been a long serving member of the European Parliament and has chaired the Parliament's Environmental Committee. So there really is nobody better to take us in charge and to lead us through our discussions for the next two days.

On behalf of DG Environment I would like to wish you all a very interesting, fruitful and successful conference and we look forward to hearing what you have to say and to building it into our future policies. So, thank you for coming and I wish you every success in your work and I am now going to hand over to the Chairman, Mr. Ken Collins. Thank you!

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INTRODUCTION TO CONFERENCE

Ken Collins
Scottish Environment Protection Agency

Can I join Catherine in welcoming you all to the conference today, particularly those who have had quite a difficult journey to get here. Luxembourg is not the easiest place to get to and it is very good that we have such a big audience. I would like to thank the Commission very much indeed for inviting me to chair this conference. It is an area of policy in which I have had a great deal of interest for a good many years. I would like to join Catherine in thanking the Programme Committee for putting together the programme. At the end we can judge just exactly how good it has been but it certainly looks good from the front-end.

The purpose of the conference is to obtain your views on issues concerning the regulation and management of radioactivity in the environment. We know what the Commission thinks, more or less, we know broadly speaking what the European Parliament thinks, we sometimes know what the Council of Ministers thinks but what we need to know is what you think and that is what this conference is about.

Now, over the next two days we are going to hear a good many presentations from a good many eminent experts. Can I make a special appeal to everybody who is participating in the conference: We have given a challenge to the speakers to present us with clear, concise information to set the scene for the discussions that are going to take place. But it is sometimes in the nature of eminent experts that they use language, which is not able to be understood by non-technical people. I should like to encourage you therefore to communicate in language that is available and accessible to ordinary non-technical people and I include myself in that. So the ultimate test is if you can make me understand it then you can make anybody understand it and that would be very, very useful indeed!

The presentations are deliberately short to allow us more time for discussion. There is going to be a poster exhibition and I hope that you will look at the posters because they are important and they are a very informative contribution to the conference.

The Commission is planning to develop an Environmental Action Programme under the Euratom Treaty. The reasons for it not being in the Sixth Programme have already been outlined by Catherine, and whether you think it is good that it is not in the Sixth Environmental Action Programme or bad is beside the point. I personally think that it is bad but there you are. The fact is that's the way it is and it is very good, nonetheless, that the Commission is preparing or going to prepare a draft Action Programme, which will be prepared in the coming period and it is hoped that a formal Commission interservice consultation will take place perhaps at the end of next year. A Commission proposal could be firmly formulated in spring 2004 and although I think that the timetable that has been written down for me is a bit optimistic, it does say here that it could be adopted in autumn 2004. I think that is wonderfully optimistic but nonetheless I am in favour of optimism, and so why not? What is good, however, is that the Commission is preparing to do it and is building in this consultation process.

Unavoidably there will be a considerable time before we will see the proposed Programme. I think it is very good that the Commission is seeking news on the matter at the formative stage, before the ideas have been crystallised, before proposals become too fixed and potentially difficult to change. That is exactly how consultation should be taking place and the Commission is to be congratulated on it.

I believe that this is a good time to consider the development for such an Environmental Action Programme because we are in a period of considerable activity in the development of those policy and scientific principles relating to the protection of the environment from radioactivity. The International Commission on Radiological Protection is fundamentally reviewing its guidance and several groups are working on the development of frameworks for protection of biota from radiation. It makes considerable sense therefore to consider how existing European instruments can incorporate these developments and to have a clear programme setting out the priorities.

As far as the structure of the conference is concerned, it has been arranged in a way to begin with sessions on legislative frameworks and scientific standards. It moves on to sessions describing radioactivity in food and how exposure to radiation is assessed. These initial presentations, we hope, will set the scene for further discussion on risk, on principles for protection of the environment and case studies illustrating some of the points made. I do have Co-chairs working with me to ensure that we keep the time and cover the required content in each session. As the sessions arrive I will introduce the Co-chairs to you. It is important to emphasise that this conference is for you and we are very keen to have questions from the floor during discussion sessions. They will be reflected in the published proceedings of the conference next year and there are arrangements for you to produce questions, to write them down and pass them to the conference secretariat or write discussion topics on one of the flip charts.

Finally, I look forward to this conference being recognised as having made a useful, constructive contribution to European policy in what is a crucial area and to that policy being seen as relevant at local and national levels as well as at the level of the European Union.

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ROLE OF THE EUROPEAN COMMISSION IN SETTING STANDARDS

Stephen Kaiser
Acting Director DG ENV.C - Environment and Health
European Commission

Article 2b of the EURATOM Treaty (1957) requires the Community to establish uniform safety standards to protect the health of workers and the general public. Chapter 3, Title II, Health and Safety elaborates the scope of the standards and the procedures for their adoption and implementation.

Over 45 years this has led to the adoption and regular update of five Directives and some 20 other pieces of legislation (regulations, recommendations, etc.) for specific aspects. The areas covered are occupational exposure (see slide 3), foodstuffs and feeding stuffs. The areas of work covered by unit C4 also include education, training and information.

The procedure for adoption of legislation under the EURATOM Treaty is different to that under the EC Treaty. On the one hand, there is an independent body of scientific experts established under Article 31 of the Treaty, on the other hand the European Parliament has no co-decision power. Also, the rules for implementation are specific: under Article 33, Member States provide the Commission with all draft legislation, and the Commission makes recommendations on such drafts within 3 months.

The two main Directives are:

- the Basic Safety Standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation (Council Directive 96/29/EURATOM);
- the Directive for the protection of the health of individuals against the dangers of ionizing radiation in relation to medical exposure (Council Directive 97/43/EURATOM).

Currently we are in the process of adopting the following new legislation:

- a Directive on the control of sealed sources (the Commission has adopted a proposal, the Economic and Social Committee has given its opinion and a modified proposal will soon be discussed in the Council and the European Parliament);
- a Council Recommendation on minimum criteria for environmental inspections;
- Annexes to the Drinking Water Directive (98/83/EC) on the monitoring of the parametric values for radioactivity;
- a Commission Recommendation on the placing on the market of certain wild foodstuffs;

- the revision of the Directive on shipments of radioactive waste (92/3/EURATOM).

Chapter 3, in addition, includes directly applicable provisions on the monitoring and evaluation of levels of radioactivity in the environment:

- Article 35: requires Member States to establish facilities for monitoring and gives the Commission a right of access for verification purposes.
- Article 36: requires Member States to communicate information on the checks referred to in Article 35.
- Article 37: requires Member States to submit general data on plans for the disposal of radioactive waste, on which the Commission gives an opinion within 6 months.

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ICRP: TOWARDS A NEW SYSTEM OF PROTECTION OF MANKIND AND THE ENVIRONMENT

Roger H Clarke
Chairman, ICRP

INTRODUCTION

ICRP has been stimulating discussion on the best way of expressing protection philosophy for the next publication of its Recommendations, which it hopes will be by 2005. The present recommendations were initiated by Publication 60 in 1990 and have subsequently been complemented by additional publications.

In the 1990 Recommendations, a fundamental change was made to the principle of optimisation which, since 1977 (Publication 26), had been recommended as a formal cost-benefit procedure to address the question, 'How much does it cost and how many lives are saved?' This introduced Collective Dose, which emphasised the protection of **SOCIETY** and was unable to take account of individual risk. The 1990 recommendations stated that, in relation to any source within a practice the doses should be as low as reasonably achievable, social and economic factors being taken into account. It then says:

> *'This procedure should be constrained by restrictions on the doses to individuals (Dose Constraints),….., so as to limit the inequity likely to result from the inherent economic and social judgements.'*

This introduction of the constraint recognised the importance of bounding the optimisation process with a requirement to provide a basic minimum level of protection for the individual.

Recommendations since 1990 are therefore in terms of; firstly restrictions on individual dose and then a requirement to optimise protection, thus reflecting a shift to include the recognition of the need for individual protection. The following eight publications have provided additional recommendations for the control of exposures from radiation sources.

Publication 63	Principles for intervention for Protection of the Public in a Radiological Emergency
Publication 64	Protection from Potential Exposure: A Conceptual Framework
Publication 65	Protection against Radon-222 at Home and at Work
Publication 68	Dose Coefficients for Intakes of Radionuclides by Workers
Publication 75	General Principles for Radiation Protection of Workers
Publication 77	Radiological Protection Policy for the disposal of Radioactive Waste
Publication 81	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste

Publication 82 Protection of the Public in Situations of Prolonged Radiation Exposure

There exist more than 20 different numerical values for 'Constraints' in these current ICRP recommendations. Further, they are justified in at least 4 different ways which include;

- individual annual fatal risk,
- upper end of an existing range of naturally occurring values,
- multiples or fractions of natural background, and
- formal cost-benefit analysis.

The question is whether, for the future, fewer constraints may be recommended and on a more uniform consistent basis. The new recommendations should be seen, therefore, as a consolidation of recommendations from Publication 60 and those published subsequently, to give a single unified set that can be simply and coherently expressed. The opportunity is also being taken to include a coherent philosophy for natural radiation exposures and to introduce a clear policy for radiological protection of the environment.

THE SYSTEM OF PROTECTION

The system of protection is now to be expressed as:

- The responsibility for introducing a new practice leading to exposures lies with the appropriate regulatory authority **(JUSTIFICATION)**
- **Basic levels** of protection are applied for the most exposed individuals, which also protect society **(CONSTRAINTS to OPTIMISATION)**
- There is a further duty to optimise so as to achieve a higher level of protection when feasible and practicable **(AUTHORISED LEVELS or ACTION LEVELS)**

This is to be seen as a further clarification of the principles of Publication 60. This system of protecting individuals and groups is intended to provide a higher standard than the previous one. A necessary basic standard of protection from each relevant source is achieved for individuals by setting constraints which are values of quantities, usually dose, but may be activity concentrations, and are usually annual values, but may be a single value depending on the circumstances.

JUSTIFICATION OF A PRACTICE

'Justification' was treated as the first principle of radiological protection for the Recommendations in Publication 60. The Commission now recognises that there is a distribution of responsibilities for judging justification, which lies primarily with the appropriate authorities. They make decisions for reasons that include economic, strategic or defence considerations and in which the radiological considerations, while present, are not always the determining feature of the decision. The Commission now deals with this requirement and the system of protection is applied to practices only when they have been declared justified.

FACTORS IN THE CHOICE OF NEW CONSTRAINTS

The starting point for selecting levels for action is the concern that can reasonably be felt about the annual dose from natural sources. The existence of natural background radiation provides no justification for additional exposures, but it can be a basis of judgement about importance.

Suggested levels of concern are illustrated in Table 1 expressed as fractions or multiples of the natural background. Having dealt with radon separately under the Exclusion section of this paper, the natural background exposures now exclude the contribution from radon. The remaining effective dose from natural sources varies by at least an order of magnitude around the world and demonstrably leads to no major hazard to human health.

Table 1. LEVELS OF CONCERN AND ANNUAL NATURAL BACKGROUND DOSE (GLOBAL AVERAGE IS 2.4 mSv)

HIGH	>100 mSv
RAISED	10 to few 10s mSv
LOW	Typically 1 - 10 mSv
VERY LOW	Increments < 1 mSv
NONE	< 0.01 mSv

The present system, which has used at least four different methods to determine numerical values, has set maximum doses that are about ten times average natural background as usually being deemed to require some action, whether they are once-off or repeated exposures. Additional doses far below the natural annual dose should not be of concern to the individual and should also be of no concern to society.

OPTIMISATION OF PROTECTION

The Commission wishes to retain the words 'Optimisation of protection' and applies it both to single individuals and to groups. However, it is applied only after the meeting the restrictions on individual dose defined by the Protective Action Levels. It is now used as a short description of the process of obtaining the best level of protection from a single source, taking account of all the prevailing circumstances.

The previous procedure had become too closely linked to formal cost-benefit analysis. The product of the mean dose and the number of individuals in a group, the collective dose, is a legitimate arithmetic quantity, but is of limited utility. It aggregates information excessively and for making decisions, the necessary information should be presented in the form of a matrix.

The process of optimisation in future may best be carried out by involving all the bodies most directly concerned, including representatives of those exposed, in determining, or in negotiating, the best level of protection in the circumstances. It is not obvious how the Commission's recommendations will deal with this degree of societal process.

NATURAL SOURCES

The Commission intends to include recommendations for protection from natural radiation sources. It is clear that it is the controllability of the exposures which determines whether the exposures are excluded from, or included in, the system of protection. In particular, the control of radon-222 is a special case because of its ubiquitous nature.

The Commission's Recommendations for radon-222 in Publication 65 have been widely accepted and the Commission proposes they should continue. These suggested ranges of activity concentration within which an optimised action level would be found. As now, the recommendation would be that for exposures above the action level, the system of protection is applied. Exposures below the designated action level are then excluded from the system.

The Commission now intends to include a policy for protection from the other natural sources and is considering an approach analogous to that for radon-222. The criterion, as with radon, should not be expressed in dosimetric quantities, but rather it is activity concentration that is probably the most appropriate quantity and a value at the upper end of the existing natural range.

RADIOLOGICAL PROTECTION OF THE LIVING ENVIRONMENT

In ICRP 60 it was stated that 'The Commission believes that the standards of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk'. The human habitat has probably been afforded protection through the application of the current system of protection. However, there are circumstances where the ICRP statement is insufficient or wrong. These include environments where humans are absent or have been removed and situations where the distribution of radionuclides in the environment is such that exposure to humans would be minimal, but other organisms could be exposed.

The need and goals for protection of the environment have been defined by society. The role of ICRP should be to define how radiological protection can contribute to achieve these goals. This would help regulators demonstrate compliance with existing international and national environmental requirements and demonstrate that radiological protection is consistent with international principles. It would provide advice with respect to intervention situations and help to inform stakeholders. ICRP will reflect its commitment for the environment in its organisation of work and composition of experts. A Task Group of the Main Commission has drafted a report for consultation, which is currently on the ICRP website (www.icrp.org), the principles of which will be incorporated into the new recommendations. Jan Pentreath gives an indication, in his paper, of the criteria under consideration for setting radiological protection guidance. It is noticeable that they parallel the policy being developed for protection of humans.

PROPOSED TIMESCALES

The Main Commission is discussing the justification for its new recommendations, which should be made widely available early in 2003. The intention is to have draft recommendations prepared for discussion with the four Committees late in 2003 so that a well-developed draft is available for the IRPA 11 Congress in May 2004. It is planned to produce the final version in 2005.

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PROSPECTS FOR THE DEVELOPMENT OF AN ENVIRONMENTAL ACTION PROGRAMME UNDER THE EURATOM TREATY

Augustin Janssens
Acting Head of Unit ENV.C.4 - Radiation Protection
European Commission

1 INTRODUCTION

Since the signature of the Euratom Treaty (Rome, 1957, Treaty establishing the European Atomic Energy Community) the European Union has built a comprehensive set of legislation for the protection of the health of workers and members of the public against the dangers arising from ionizing radiation (Article 2b of the Treaty and Chapter III, Health and Safety). The Basic Safety Standards, as well as the directly applicable Treaty provisions (Articles 34 to 38) also ensured the protection of the environment, albeit not for its own sake. The environment is merely the biosphere in which transfer pathways lead to the exposure of the population.

Radiation protection thus originally related solely to human health, and indeed radiation protection was for a long time part of DG V, now SANCO (Health and Consumer protection) and EMPL (Employment). In 1988 the Unit was transferred to the rather young DG XI, now Environment, and this was the start of a development towards increased attention given to levels of radioactivity in the environment. The Chernobyl accident in 1986 had woken up the whole world and caused the possibility of widespread contamination of the environment to be taken very seriously. While being part of DG ENV radiation protection nevertheless remained rather isolated from the rapidly developing environmental policies in other areas as a result of:

- the different legal basis (EURATOM versus EC Treaty)
- the different roles of institutions under the Treaties (no co-decision of the European Parliament under the EURATOM Treaty)
- the impossibility (with very few exceptions) to include nuclear installations and in general ionizing radiation or radioactivity within the scope of EC environmental legislation (a dual legal basis not being permitted as a result of the different procedures for adoption).

This became strikingly apparent with the adoption of the 6th Environmental Action Programme. While in earlier programmes radiation protection was included, this was not the case for the latest EAP. It was offered by the Commission for adoption by the Council and the European Parliament. It is not possible to do so at the same time under the EC Treaty (co-decision) and under the Euratom Treaty.

DG ENV now endeavours to establish a separate EAP, the first of this kind, under the Euratom Treaty. This will encompass the whole range of activities, including the protection of workers and medical applications, and will receive input from other DG's, in particular DG RTD and JRC. Within the scope of this Conference however this presentation will concentrate on the approaches to the management of environmental radioactivity, from the perspective of DG ENV.

2 APPROACHES TO THE MANAGEMENT OF ENVIRONMENTAL RADIOACTIVITY

In addition to the need to define the broader framework of environmental policy with regard to radioactivity as part of the EURATOM EAP, there are two main driving forces for a fundamental revision of current policies. One important development is external to the EC. For nearly five decades the EU legislation was strongly inspired by the recommendations of the International Commission on Radiological Protection (ICRP). ICRP has undertaken a complete review of the system of radiological protection with the aim of simplifying it and making it more understandable to the users. The second important consideration is that the European Union is at the eve of its most prominent enlargement from 15 to 25 Member States, which is cause for review of the role of the Commission and requires priorities to be set by its services. This is even more true in the light of diverging policies adopted recently in Member States with regard to the future of nuclear energy.

2.1 The International radiological protection system

There are many good reasons for a revision of the protection system which ICRP has taken on board, as highlighted in the presentation of Professor Clarke at this Conference. While on the one hand the current system has overall permitted a very good level of health protection, the subtleties of the system have been cause of misunderstanding. Among the unsatisfactory issues, the most important from a regulatory point of view seem to be the following:

– the distinction between *practices* and *intervention* is not always clear and is often not very useful

– natural radiation sources (cosmic rays, radon gas, primordial radionuclides in the earth's crust) are not yet dealt with in a way which is fully coherent with the control of artificial radionuclides

– among the three main principles of the system (justification, optimisation and dose limitation), it is questionable whether the societal context for the application of the first principle, and in part also for the second, are within the remit of radiological protection

– the concept of "collective dose" has often been misused and it is necessary to define new approaches for expressing the global detriment of a practice, while preserving the use of the concept for the purpose of optimisation.

The changes to the system considered by ICRP reflect not only the need for simplification and clarification, they also reflect societal changes. ICRP takes now much more explicitly ethical considerations into account, but at some stage this will need to be subject to societal debate rather than expertise. Within the new societal perspective taken by ICRP the most prominent change is the extension of radiological protection to "non-human biota".

2.2 Protection of the natural environment

Indeed it is now widely recognised that ICRP's paradigm that a detriment to the environment is not plausible where human health is protected does not necessarily hold in all circumstances.

This important development will be discussed later at this Conference. The European Commission has not waited for ICRP to take this initiative. In fact the EC has been one of the driving forces for the protection of the "natural environment" and within DG ENV we have been looking into the applicability of the major environmental principles to radiation protection, in particular:

- the Precautionary Principle: the lack of knowledge about environmental detriment and overall uncertainties on biological effects could be cause for invoking this Principle, if there is evidence of a possibly serious and irreversible detriment

- Sustainable Development: while the concept of "collective dose" was shown to be a poor instrument for quantifying the global health detriment, it is felt that this assessment should not ignore the impact on the natural environment.

ICRP has looked into the above and quite a few other approaches to environmental protection, as laid down e.g. in international agreements, but has constrained its analysis to such aspects for which a rational scientific basis could be put forward. We feel that in this way people's concerns may not be met entirely, and that in addition to the quantifiable detriment consideration should be given to less tangible aspects such as people's aversion for any detectable radioactivity, as being an alien substance from which nature should be preserved.

Such considerations are indeed driving policies on radioactive discharges, the most striking example being the strategy on radioactive substances in the marine environment adopted in the framework of the Oslo and Paris Convention on the protection of the North East Atlantic (to which the EC is a Contracting Party). The strategy aims at a substantial reduction of radioactive discharges by 2010, with resulting levels of radioactivity concentrations "close to zero" for artificial substances. The political commitment to achieve the OSPAR strategy, endorsed by the EC, is difficult to translate in terms of radiological significance. The European Commission has launched a major study (MARINA II) for the assessment of levels of radioactivity in the North Atlantic. It will be presented at this Conference and officially handed over to the OSPAR Representative. The study will serve as a baseline for judging the achievement of the OSPAR objectives, and looks inter alia into a possible impact on biota.

Among OSPAR's objectives is also the preservation of "legitimate uses of the sea". In our view this implies that possible contamination of seafood and consumers' reluctance to purchase fish, molluscs or crustaceans caught in contaminated areas should be addressed. This again is not a matter for scientific assessment alone.

A development similar to OSPAR has led the European Commission to adopt the Water Framework Directive (2000/60/EC). This Directive relates both to surface water and to drinking water. While, as an exception to the rule, parameters on radioactivity were included in the EC Drinking Water Directive (1998/83/EC), it was not possible to find consensus for the explicit inclusion of radioactivity in the Framework Directive. From our point of view this was unfortunate since it would have given us a legal basis for the protection of the natural environment against ionizing radiation well before the idea spread and developed at international level.

2.3 Need for a revision of the Basic Safety Standards

The revision of the international radiological protection system is welcomed because it will clarify a number of issues, at least for radiation protection experts. It may also help competent authorities and national administrations to deal more efficiently with borderline cases such as the remediation of contaminated areas on international trade of slightly contaminated commodities, including foodstuffs. Whether it will be cause of better understanding and acceptance by the population at large is another matter.

Public concern about ionizing radiation and radioactivity is emphasised by the context of nuclear energy. The historical background cannot be ignored (nuclear weapons, Three Mile Island, Chernobyl), nor the socio-political context (secrecy in relation to military applications, the need for strict security measures, distrust of powerful industries). In addition the fact that radiation is not perceptible by our senses but on the other hand is easily detectable by instruments down to extremely low concentrations, and the fact that members of the public (as opposed to workers) and even more so biota have no means of avoiding or controlling their exposure, enhance the aversion to radiation.

People are aware that there is no safe level of exposure. It should be underlined that this is not a fact, but merely a consensus ("linear – no threshold approximation") for estimating the risk of exposure (at least the stochastic risk, i.e. cancer induction or genetic damage). The hypothesis is also in agreement with our current understanding of the interaction of radiation at cellular level, but in reality we have no complete picture or understanding how these interactions may eventually lead to cancer. Advances in molecular biology will hopefully lead to a much better understanding within the next decade or so.

It may be appropriate to wait for the outcome of research in this area, which receives an important part of the funding under the 6th Framework Programme of DG Research, before fundamentally changing the radiation protection system. The Basic Safety Standards (1996) developed under the old system (ICRP publication 60, 1990) offer adequate protection to workers and members of the public. We tend to give priority to ensuring that the Basic Safety Standards and other Community legislation is correctly implemented in Member States and Candidate Countries, rather than undertaking a fundamental revision. Amendments or complements to the Standards would result from operational experience (in particular in new areas such as natural radiation sources, clearance) rather than from new international guidance, at least in the next decade.

The ongoing clarification of the radiation protection system is on the other hand very welcome for the efforts that we should undertake to gain better public acceptance for the level of protection offered by the Basic Safety Standards. It will help to explain things better. Nevertheless, we must go beyond explaining our expert view, it is important to involve the stakeholders at an early stage so as to allow us to answer the right questions.

2.4 Role of the European Union

The development of an Environmental Action Programme is also a good opportunity for reflecting on the role of the European Union, and the European Commission, in setting standards of protection. This role has been very important over 45 years, and there are few areas where Community legislation has led to such a degree of uniformity in national legislation and operational procedures. With an expanding Union, and given the scarcity of resources, this role can be kept only with great difficulty. This should be reflected in setting priorities, on the basis of consideration of subsidiarity and proportionality (even though these concepts are not in the EURATOM Treaty). Thus further harmonisation should be pursued and priority could be given to those issues, which have a transboundary dimension. Examples of transboundary issues are obviously trade (e.g. shipment of sources, radioactive waste, materials for recycling or reuse, consumer goods, foodstuffs), but also countermeasures in case of a radiological emergency. Many nuclear installations are sited close to national borders and beyond bilateral arrangements for emergency preparedness and response there is a need to harmonise intervention plans. With regard to people, transboundary issues are for instance the accountancy of doses to outside workers in nuclear industry as well as the recognition of qualified experts in radiation protection.

In the context of the enlargement the Commission is also focussing on implementation rather than new developments. The focus on implementation is not really new to the radiation protection legislation as a result of its 45-year long development. A specific instrument in the EURATOM Treaty is the procedure under Article 33 whereby the Commission makes recommendations on draft national legislation and administrative measures. This in principle would ensure better transposition of the legislation, but the human resources needed for this task are such that in reality we have to fall back on a posteriori conformity checks and if necessary infringement procedures.

With regard to operational implementation on certain aspects of legislative transposition we consider putting up a mechanism comparable to IMPEL under the EC Treaty and set up forums or networks for specific areas (making extensive use of web-based applications).

The EURATOM Treaty offers a further unique competence to the Commission to ensure operational implementation of its requirements: Article 35, 2nd indent of the Treaty gives the Commission a right of access to facilities for monitoring environmental radioactivity to verify their functioning and adequacy. Verification activities have been taken up since 1990 but resources do not allow more than a few sites to be visited each year. Nevertheless it is an important means of implementation which has shown to yield a high added value, without substituting itself, to national inspections.

In this context the Commission intends to establish minimum criteria for national inspections, through a Council Recommendation similar to one adopted under the EC Treaty. On a longer timescale the requirements on Member States for complying with Article 35 1st indent ("Member States shall establish the facilities necessary to carry out continuous monitoring of the level of radioactivity in the air, water and soil and to ensure compliance with the basic standards.") should be laid down more explicitly so as to facilitate future verifications. Other means of strengthening and harmonising environmental radioactivity monitoring should also be pursued (technical guidance, laboratory accreditation, etc).

2.5 Research

While this presentation focuses on the role of DG ENV attention should be drawn to developments in the research programme, because these run very much in parallel to those in DG ENV. The areas covered by the 6th framework Programme 2002-2006 are the following:

- quantification of risks at low and protracted doses
    - epidemiological studies
    - cellular and molecular biology research
- better integration of European research on
    - medical exposures and natural sources of radiation
    - protection of the environment and radioecology
    - risk and emergency management
    - protection of the workplace

The research programme will thus play an important role in the developments in radiation protection discussed above, in particular with regard to the quantification of risks to humans as well as to the protection of the environment.

3 NEW APPROACH

3.1 Stakeholders involvement

The paradox of radiation protection is the following: one the one hand it has a good scientific basis and an elaborate protection rationale which all but very few radiation experts agree that it yields a high level of protection and no observable health detriment in normal circumstances. On the other hand people in general still rank radiation and radioactivity high among their concerns for health or the environment.

There seems to be little hope that a revision of the philosophy or amendments to the legislation would allow to gain better acceptance. Nor would better information campaigns help (even though we could do a lot to improve the way we communicate, while some experts still prefer to blame the poor scientific background of people rather than their poor communication skills).

It is important to start answering the questions the way people understand them, which may require the experts to abandon scientific or consensual paradigms on which the system was built. We should on the one hand deepen our societal and ethical knowledge, on the other hand involve stakeholders directly in the development of our policies. Important categories of stakeholders are the industry, radiation workers, consumer organisations, the health profession and environmental NGO's representing the interest of the environment (or of those people for whom the environment represents a high value), the media, local communities, etc.

There is one important hurdle to stakeholders' involvement in radiation protection. It is clear that people's perception of radiation risks relates to their views on the justification of nuclear energy, e.g. whether they regard this to be a sustainable means of ensuring future energy demands. While the Commission has contributed to the development of energy policies, the actual choice of energy vectors and whether this includes nuclear is a matter for Member States to decide. Thus we cannot engage in a pro- or anti-nuclear debate, and must try to look into environmental radioactivity irrespective of its source.

Up to recently many would have stated that in addition the Commission's legal competence in nuclear safety and radioactive waste management is limited to specify radiation protection issues. The Commission has now announced its intention to go ahead with a proposal for two Directives in this area, on the basis of the same chapter of the EURATOM Treaty on which radiation protection legislation has been based for 45 years.

Some of the stakeholders have more impact on developments in radiation protection than others. Scientists and the health profession are well represented in the main advisory body the Commission. A Group of Experts is established under Article 31 of the Euratom Treaty, which gives an opinion on all legislative initiatives of the Commission. It is a very effective and highly respected body, which is keen to preserve its independent status, even though some of the Experts have important functions in national regulatory bodies. The Group adopted in 2000 rules of procedure and a code of ethics which will benefit to its independent scientific status.

The industry is not consulted directly except on technical matters for which the industry is keen to provide the necessary information to allow adequate and efficient provisions to be included in the legislation. Industry is in addition a posteriori consulted through the Economic and Social Committee, where also workers (Unions) are represented. Member States discuss the Commission's proposals at the level of the Council (Atomic Questions working group). The European Parliament is consulted but has no co-decision powers under the EURATOM Treaty.

3.2 Environmental Action Programme

The involvement of other stakeholders by the Commission can proceed on a voluntary and case-by-case basis. It is more efficient however to involve them in a broader framework, such as the Environmental Action Programme, rather than on individual pieces of legislation. The Environmental Action Programme will also be an opportunity for involving the European Parliament, even though its views will be defended only indirectly through the Commission's interactions with the Council.

We should incorporate views to define the scope of the action programme, its objectives and, although this is more difficult, indicators allowing the achievement of objectives to be measured and milestones to be defined along the road.

The usefulness of indicators in radiation protection depends on the way objectives are set. Many experts would argue that radiation protection has reached such a high standard that it is meaningless to try and improve things further. One indicator has proved very efficient over the last two decades: the concept of optimisation has led to a substantial reduction in doses to workers in nuclear industry. One indicator in this process is the number of workers exceeding the dose limit, which has become very rare. The other indicator, collective dose, has reached a level where, at least in nuclear industry, little further progress can be expected. With regard to population exposure however, further reductions are possible, but in general at such a high cost that the balance of cost and benefit would no longer be ALARA (As Low As Reasonably Achievable).

Among the key environmental priorities in the 6th EAP under the EC Treaty:

- climate change
- nature and bio-diversity
- environment and health and quality of life
- natural resources and wastes

the second and third are fully applicable to radiation protection. The issue of climate change is relevant to nuclear energy generation (since it contributes little to greenhouse gases), but is not within the remit of radiation protection. The last point is not quite relevant either. The volume of radioactive waste generated is comparably small, even though the technical and political hurdles to construct final repositories are huge. The design of nuclear installations (e.g. the properties of metals used in the primary circuit of a Nuclear Power Plant) can help to reduce the amount of waste generated by activation, but by and large there is little control on the amounts of radionuclides that are generated, and which will be either stored, disposed or dispersed with effluent. On the other hand, in terms of natural resources, it is important to allow materials arising from the dismantling of nuclear installations (metals, building rubble) to be reused or recycled where there is no or extremely little contamination.

It is broadly recognised in the radiation protection community that strict priority should be given to confinement of radioactive waste rather than to dispersion in the environment. In addition, where releases of low concentrations of activity with effluent or as materials for recycling or reuse are authorised, there should be absolutely no dilution of radioactive waste with uncontaminated materials to meet release criteria. It is worth noting that these important principles are as yet not written down in any radiation protection legislation, nor can be derived from the main principles (justification, optimisation, dose limitation). The Community guidance on the concept of clearance which Member States are required to take into account under the Basic Safety Standards nevertheless makes clear statements to this effect1.

I think that the means identified in the 6th EAP for achieving the objectives:

- raise awareness
- dialogue with stakeholders
- analyse benefits and costs
- internalise environmental costs
- improve scientific knowledge
- data and information on the state and trends of the environment

as well as the strategies that could be developed for this purpose:

- voluntary agreements with enterprises
- environmental quality criteria

[1] Published as Radiation Protection 122, part I

- definition of health and environment indicators
- vulnerable groups (children)
- waste prevention initiatives

are relevant to radiation protection as well and could be incorporated in the EURATOM EAP. In some areas current achievements are quite good, e.g. a lot of attention is given to children as a vulnerable group. In other areas, e.g. the definition of environmental quality criteria there will be big problems in finding a sound scientific basis (similar to OSPAR's problems with "close to zero").

4 CONCLUSION

The 6th EAP under the EC Treaty is a sound basis for the 1st EAP under the Euratom Treaty. However, while in many areas the programme would not yield a significant modification of current radiation protection philosophy and legislation, there are a few areas where there is as yet no firm basis for the new developments. There is good hope however that with regard to the protection of the environment the research programme will offer a good scientific basis, together with growing international consensus on the underlying philosophy and ethics.

The most apparent innovation of the EURATOM EAP will hopefully be a firm commitment to involve all stakeholders, in particular local communities and environmental NGO's in the process. This is not an easy way however and it will take a lot of effort to obtain a fair representation of the views and a good mutual understanding.

We hope that the start of this process with this conference will give a clear orientation to the scope and objectives of the first EURATOM EAP, as well to possible indicators for measuring the future achievements.

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DISCUSSION SESSION 1

Radiation and Environmental Policies

Question 1

Richard Bramhall (Low Level Radiation Campaign)

Very intrigued to hear Augustin Janssens talk about abandoning paradigms because we have always said that the paradigm that should be scrapped immediately is that of the International Commission on Radiological Protection and I was already thinking of the following question: What could be done to redress the three layers of democratic deficit which exist in the European Union's approach to Radiation Protection? Those three are: that there is no co-decision, that the Commission relies on the undemocratic Article 31 Group which adheres to ICRP, and the 3rd layer is that ICRP itself has been widely criticised as an unaccountable self-sustaining NGO. So that is the question: Do you really think that this new Environmental Action Programme could cope, could it be democratic enough to balance this bias especially since you just said, Dr. Janssens, that people's views on nuclear power plants' safety and waste are an obstacle to stakeholder involvement?

Augustin Janssens (EC)

I did not want to imply that people's perception of use on nuclear energy are an obstacle to stakeholder involvement. We want to proceed with stakeholder involvement but it may be difficult at some times from the stakeholders' perspective to separate their views on nuclear energy and their views on environmental radioactivity or on radiation protection. The dialogue might be biased if people would use their concern about radioactivity in fact to oppose nuclear energy as such, for different reasons. So that's one point. But you are right, there is this democratic deficit and we are regretting this for quite a long time. The Convention reviewing the functioning or the role of the Commission may tackle the Euratom Treaty but this is not yet clear. So, we personally regret the democratic deficit as probably every citizen would do, but it is in the Treaty as it was written and we cannot change it. That would be the remit of the Convention looking into the role of the Commission and the Council and the European Parliament. It concentrates on the EC Treaty but possibly it will take on board this particular point of the Euratom Treaty. This would also simplify life for us because the different procedures, as I said, preclude the adoption on a dual legal basis - Euratom and EC Treaty - of quite a number of environmental legislation. We support the application of such general legislation but now have to duplicate all of it under the Euratom Treaty, and this is really cumbersome.

I would not qualify the Article 31 Group of Experts as undemocratic. They are of course not democratically elected, they are nominated by the Scientific and Technical Committee. They are proposed by Member States, that is right, but they have clearly a role as independent experts. They are advising the Commission irrespective of their national views and they are very keen to preserve that independence. It is worthwhile looking into the rules of procedure which the experts have adopted and the code of ethics, which is now a standing model for quite a number of organisations. The Code of Ethics underlines their independence and the scientific nature of their advice, and states that priority should be given to health rather than any other considerations.

Roger Clarke (ICRP)

Only, I think for the formal position that ICRP is one of three Commissions established by the International Society for Radiology, the others being the International Commission on Radiation Units and Measurements and the International Commission on Education in Radiology. If the International Society of Radiology who make our rules were unhappy with the way any one of its three Commissions is operating then the International Society would abolish or reorganise the situation. We belong to the radiologists and I am very pleased to be involved with them.

Ken Collins

But how would you answer the charge that you are self-sustaining, which I take is very different from being sustainable.

Roger Clarke (ICRP)

We are constituted in exactly the same way as any academic institution. An academic institution elects its members. We have a Commission and at present four Standing Committees. People are elected to those - elected certainly within the system, but if the International Society of Radiology was unhappy they can modify these things at any time. We are accountable to the profession of radiology! So we are not unaccountable! They at any time can change our rules, our membership, whatever. So I think we are all accountable and the radiologists behave as any other professional body.

Question 2

Ian Fairlie (independent consultant)

I am an independent consultant and here representing Greenpeace International. I wish to make it plain that I am not representing any other organisation, in case people know me from wearing other hats.

First of all I would like to thank the European Commission for holding this stakeholder dialogue. Congratulations! I think it is a good first step and most Environmental NGOs will welcome it. I hope that in future the EC will hold further stakeholder dialogues.

That said, may I offer some constructive criticisms. The first is that there are relatively few people here who represent Environmental NGOs. By my reckoning, there are more official people here sympathetic to our views than there are from the Environmental NGOs themselves, which is quite interesting indeed. However I agree it is difficult to find people in NGOs who are well-versed in radioecology, radioactivity and radiation risks. But they do exist and in future, should you need help, we will give you more names. You have my sympathy in this respect.

May I make a practical suggestion, Chairman, to help it to make this a real stakeholder dialogue? One step you could take is, instead of asking the NGOs, who really give the stakeholder dialogue its true meaning, to speak from the floor, why don't you invite them to speak from the podium? Perhaps it may be too late to do that today, but certainly in future stakeholder dialogues, they should be directly invited to give contributions, so we can all clearly hear what they have to say. By the way, that is not a criticism, one is just trying to be helpful for the future.

Augustin Janssens (EC)

Thank you for the suggestions. This will not be the end of the process. Certainly, when our views on the Environmental Action Programme are advancing, so that we have something to challenge actually, we will have other opportunities for meeting the stakeholders, in particular the environmental NGOs who have a great interest in this matter. We are also a little disappointed by the fact that rather few NGOs have shown up for this conference, and we would like this to be much better on the next occasion. We can talk about how to do that without an open-ended invitation to all possible NGOs, looking into the funding capabilities as well, but we certainly must find ways to get this better in the future.

Question 3

André Maïsseu (WONUC) (taken from translation from French to English)

I have a small observation, a comment and two proposals that I would like to put to you. First, the observation is that I would have preferred on Mr. Janssens' slide industry and workers should be shown on two separate lines but not on the same line. It is a detail but you can see the spirit behind that.

The general remark is this: The world we're in is an interplanetary one, lots of countries on the planet, look at the European Union and take it as a model, in ionising radiation and obviously behind that there is a whole nuclear problem. I would like to draw the attention of the EU that there is a development towards a regulation which could be different from the IAEA. I would have liked that work not to have been done in parallel but rather it should be done in the context of the United Nations. If the regulations we end up with were to be different, we would have a problem of credibility with those regulations. There would be a problem of confusion and, more seriously, there would be the problem of interpreting those different regulations in a different manner. They may be interpreted in different ways by different actors. Whatever opinion you might have of the United Nations, they are the people, the guarantors of a planetary order at world level. That is what we wish them to be. In the nuclear field it is important that an inter-planetary authority be involved. There is an immediate example: If the regulations are different, then you could imagine that some power somewhere in the world might use that difference to have an advantage. Or some other political leader in another part of the world might say, seeing as the European Union finds that the international regulations are severe enough (I am not thinking of anybody specific when I say that) but if those regulations are not severe enough why do I have to follow them, why do I have to follow the conclusions of a UN mission which has been sent somewhere in the world at the moment. Therefore I would solemnly ask the European Union to start this work within the context of the United Nations, within the context of the authorities of the UN, which are the IAEA and UNSCEAR. We have organisations which are open, open to dialogue, willing to dialogue and it is really important that the European Union should not throw discredit onto the way in which those UN bodies work.

I have got two proposals to make. ICRP: Because obviously the new regulations are of great importance to us, I would like to thank and congratulate Prof. Clarke for the clarity and relevance of his presentation. I have done that often and we certainly congratulate him for the competence of that institution, although occasionally we do not agree with them, we know with ICRP there is a dialogue which is possible, a frank scientific dialogue. Now, first we talk of 2.4 millisieverts as being the world average. How is it calculated? I do not know. We would like that it would be used in a different way, a different average. Look at the zones of the planet where there is little or no leukaemic cancers or where they are very low, and then look at the natural radioactivity of those areas, those zones. So that instead of using a planet mean you'd use a figure of the average figures, which would correspond to a very reduced, low impact.

The second observation is about the use of a linear relationship between doses and effects of the doses. This is a scientific debate, as to the use - and I am not bringing in a value judgement - as to the use of the low scale of values. How to explain a logarithmic scale for regulation values founded on a linear function (LNT)?

Ken Collins

I wonder if you could clarify for me and, I suspect, some other people in the room, your organisation: how far is it representative, for example, of existing Trade Unions who are organised in the nuclear industry, for example, in France or the United Kingdom? I ask the question because when I was in the European Parliament I used to be quite strongly associated with the Engineering Union in the United Kingdom which had quite frequent contacts with the Commission on things nuclear. I wonder if you would clarify the relationship between your organisation and the Trade Unions for the benefit of me and for the rest of the organisation. Then I'll ask the panel to comment.

André Maïsseu (WONUC)

28 countries are member of WONUC. Organisation members of WONUC are the trade unions. We are approximately 1,5 million members. E.g. the Trade Union of nuclear workers in Russia is about 650.000 people, 250.000 in Ukraine, 50.000 in Canada, but a very few in Iran, India or in Morocco. Our representativeness is not

the same from one country to another one. In France some "sections syndicales" of CFE-CGC (Confédération Française de l'Encadrement – Confédération Générale des Cadres), CFTC (Confédération Française des Travailleurs Chrétiens) and UNSA (Union Nationale des Syndicats Autonomes) are members of WONUC.

Roger Clarke (ICRP)

On the technical point that André made about the variation of natural background dose around the world: The natural background does vary by at least an order of magnitude, if you take the non-radon dose, even more if you include radon. I use that variation in my mind to explain why we begin to take action at a dose equivalent to about 10 times that natural background, because that range that is found across the globe does not lead to observable ill health effects. It seems to me that it supports the rationale for taking action at levels of doses that are about 10 times the average natural background. I think whether scales are logarithmic or linear is something we can discuss outside the meeting.

Augustin Janssens (EC)

Regarding the relationship with the UN family and IAEA in particular: Of course we carry on, and we'll carry on working very closely together with IAEA even if we will proceed a certain path to this Environmental Action Programme in our own way. The dialogue, of course, will be maintained and we will seek coherence with the International Atomic Energy Agency. The Commission, and the European Union, has a political responsibility and it would certainly not be democratic to delegate that responsibility to a UN organisation. That would be even more remote from the legislative process and the involvement of the European Parliament than is already the case at this stage.

With regard to the distinction between industry and workers, of course, that is fair. I just wanted to put on one line those whose primary concern is not per se the protection of the environment. Of course workers are important stakeholders in terms of occupational exposure and if the presentation was on this aspect then this would certainly be an important individual stakeholder. I am puzzled also by the fact that workers' representatives tend to take industry views on board rather than views on protecting their colleagues and themselves from ionising radiation.

Ken Collins

Can I make a point. If people want to discuss the institutional point of whether or not e.g. the Treaties are of conducive to democracy or not, I think the point here is that the Commission is acting within the existing Treaties and there's very little else they can do. But since this audience is made up of citizens from a good number of Member States if they really do think that co-decision is a good thing in this context and they really do think that the Commission should in a better world be operating in a more democratic system, can I suggest that they might contact their people who are operating in the Convention at the moment and try to persuade their national governments that the Euratom Treaty could be altered, because without that there is not going to be any change and the Commission would be forced to continue along the lines that it's working on just now 490. So, in this case I find myself actually defending the Commission and those of you who have watched me over the years will know that that's not always been my position but here I am defending them. It's not their fault and don't kick them just for the minute. Please go back and tell your Member States to fight for change in the Convention and let's change the Euratom Treaty. It should have been changed long ago. That applies particularly, I would guess, to United Kingdom and France.

Question 4

Gilbert Pigrée (ACRO) (taken from translation from French to English)

Taking up the previous question, have you planned how to reconcile things with stakeholders? There is a difference of means between NGOs and operators, particularly between all organisations that may have some repercussions if only one view is taken account of. I am really speaking here on behalf of plurality of expression, many voices being heard.

Augustin Janssens (EC)

That is, I think, a fair comment but it is not easy to resolve it. It is maybe useful, first of all, to state (maybe to the surprise of some, but the representatives of the nuclear industry here would confirm): We do not talk to the industry very often. We do talk to them because we must make sure that the legislation which is proposed can work in practice. They have the practical experience, they have information which is sometimes essential. But we, and certainly our body of experts under Article 31, act essentially on the basis of scientific opinion and certainly not reflecting the industries' views.

It is fair to say also that industry is of course in a much better position to have its say and that for many NGOs financial and other limitations could be a hurdle. For this conference we have addressed this problem as much as we could and for further opportunities we will try and find means to overcome that hurdle as well.

Question 5

Rick Nickerson (KIMO)

I represent KIMO, which is the local authorities' international environmental organisation. We are a green NGO representing coastal municipalities in ten Northern European countries, roughly representing 5 million people on the coast of Europe.

I have a couple of comments for Augustin and one question for Roger Clarke. But first, can I also congratulate the Commission for bringing stakeholders together. I have been in the past quite a vigorous complainer about the lack of transparency with the Commission as compared to other conventions such as OSPAR and IMO. So I would welcome this opportunity to be here and to be involved in the process.

On page 11 of your presentation you mention in terms of legitimate uses of the sea. Our organisation focuses on marine pollution in particular and how that affects coastal communities and you express your view that the OSPAR objectives should have implied that the possible contamination of seafood consumers etc. should be addressed. Can we remind you at this point that there are other legitimate users of the sea that do not eat shellfish and fish, such as people that go to the beach and swim, such as industries that may actually want to develop the seabed which they would not be able to do if it was contaminated. We would ask you to bear that in mind. I also have a question. I know that it is not in the program and I realised that there is a directive in formation at the moment. Why hasn't the issue of transportation of nuclear wastes been considered as part of this concept? It is part of the management of the nuclear industry and could have a substantial impact on coastal communities, particularly if you bear in mind the scenes in Spain this week as a result of an oil tanker being involved in an incident.

Finally for Roger Clarke, I would like to ask you, why are you focusing on background levels rather than those man-made levels in terms of your paper. Background levels are something we can't do about but certainly man-made levels we can do something about. Certainly it is very frustrating for a lay person to sit and hear the industry say that there is nothing to worry about, you'll probably get a higher dose from walking along the street in Aberdeen than you will get from the nuclear industry.

Roger Clarke (ICRP)

I did say that the existence of background was not a justification for any additional use, but maybe it is useful to make a judgement about the importance. My observation this morning was that we have had a complex system, using at least four different methods, one of which was the comparison of fatal risk from a radiation exposure with, say, fatal risks in industry but we have used other methods as well. My observation is that, in fact, we always take action for radon in homes, for controlling exposures of workers, for intervening in emergencies and they all happen to be numerically - an observation! - about 10 times background. I am suggesting that may be a useful way of explaining the action we take. Similarly, the observation is for whatever reasons added increments from industrial uses have been restricted to about 10 % of background. My observations leave me to ask whether there is a use for explaining levels of activity rather more simply than we have in the past. It is an exploratory process. This is a stakeholder involvement process. I hope, Chairman, people would believe ICRP – whatever its limitations – is open and transparent and willing to put its ideas out for legitimate discussion in the hope that we end up with a better system in the future.

Augustin Janssens (EC)

Transportation of nuclear waste is not in the remit of this Conference in the same way as nuclear energy is not part of this Conference even though, of course, there is a stakeholder interest in nuclear energy and nuclear safety, and waste management, but for the reasons I explained this is not in the remit of this exercise. I took the OSPAR objective featuring legitimate uses of the sea. I gave you the example of foodstuffs, on which topic we will discuss further this afternoon, because for me it is a clear example (I am not saying that there are no other legitimate uses of the sea which might be at stake) of the fact that not all is in the remit of scientific expertise. People's possible aversion to eating radioactively contaminated food is a societal reality influenced by quite a number of factors including scientific expertise but certainly not exclusively. If there is such an aversion then this may affect fisheries. That is why it is important to address these irrespective of radiological protection criteria. It does not help very much to say to people, well you are not eating more than a few kilograms of this or that, so you will not exceed 1 millisievert, so just eat it. If the consumer does not want to eat it he does not and that is his good right. It can be a problem in case of, what we hope will never happen, a next major nuclear emergency where there might not be so much clean food available so as to allow people to make it a choice.

Question 6 - Comment

Roger Coates (World Nuclear Association)

Because various stakeholders have been already party to this debate and the nuclear industry has been mentioned, I would just like to make a couple of comments if I could. I believe that the nuclear industry does have a constructive role to play in this particular debate. I acknowledge that we are only one party and that all parties have their say. I believe that we are one party with some practical pragmatic and relevant experience in this particular area and ultimately we have to put into practical effect the ultimate output of these considerations be it in law, standards or regulatory requirements.

Question 7

Ian Fairlie (independent consultant)

I would like to reply to Dr Clarke's presentation. His new proposals for changing ICRP risk and dose limits are very disturbing. Essentially Dr Clarke is saying that doses of about 10 mSv per year are of little concern, and should not be regulated. However his new proposed dose level appears to be an order of magnitude higher (ie more lax) than the current limit for the public of 1 mSv per year, and the current dose constraint of 0.3 mSv per year. Are other members of the audience perturbed by this rather surprising set of recommendations from the ICRP?

Dr Clarke should be quite clear there is little likelihood of his strange proposals being implemented by official bodies. Of course, they will be strongly opposed by environmental NGOs and officials au fait with NGO views.

Roger Clarke (National Radiological Protection Board)

I did not propose changing dose and risk limits. What I OBSERVED was that the CURRENT levels at which we take action for people - the occupational limits, evacuation of people in emergencies, or action to remediate radon in domestic dwellings - are of the order of 20 mSv. Similarly we currently restrict ADDED increments from discharges to 0.3 mSv in a year.

For the future, the suggestion is we consolidate the many numerical values to a smaller set at similar levels.

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RADIOACTIVITY IN FOOD FROM THE SEA

Peter I. Mitchell and Luis León Vintró
Departmental of Experimental Physics, University College Dublin, Dublin 4, Ireland

Summary

Past and present concentrations of anthropogenic and naturally occurring radionuclides in seafood are reviewed in this paper with emphasis on fish and shellfish harvested in the seas surrounding the European Union. Radionuclides considered include ^{14}C, ^{90}Sr, ^{99}Tc, ^{137}Cs, $^{239,240}Pu$, ^{241}Am, ^{40}K, ^{210}Pb, ^{210}Po and ^{226}Ra as these are considered to be the most important from the radiological perspective or, like ^{99}Tc, have been the subject of considerable public concern in recent years. The main sources of these (and other) radionuclides and how they come to be present in seafood are briefly described, as is the methodology by which radiation doses to exposed populations (i.e., seafood consumers) are calculated. Actual doses to members of the most exposed populations and the general public are also discussed and placed in the context of everyday risks.

Naturally occurring radioactivity in the marine environment

Naturally radioactive elements have always been present in our environment; they are ubiquitous and are to be found in all living organisms including man and in every conceivable environmental material. Everything we eat and drink, including fish and shellfish from the seas and oceans, is therefore slightly radioactive. Consequently, our bodies always contain a small amount of natural radioactivity - enough to give each of us a radiation dose of between 0.2 and 0.4 mSv/year.

Uranium, thorium and potassium are the main elements contributing to natural marine and terrestrial radioactivity. Uranium has two primary isotopes, ^{238}U and ^{235}U, which occur in the proportion 99.3% ^{238}U to 0.7% ^{235}U at the present time. Both have long and complex decay chains. Thorium on the other hand has only one isotope, ^{232}Th, and a relatively simple decay chain. All three (parent) isotopes have very long half-lives and their decay series all terminate in stable isotopes of lead. Of the three naturally occurring isotopes of potassium, ^{39}K, ^{40}K and ^{41}K, only ^{40}K (with an isotopic abundance of 0.012%) is radioactive, again with a very long half-life. From the marine foodstuffs perspective, by far the most important isotope associated with any of these series is ^{210}Po. The dosimetric impact of other isotopes, e.g. ^{238}U, ^{232}Th, ^{226}Ra, ^{210}Pb, and ^{40}K is usually much less significant.

In addition to the natural occurrence of these isotopes, there are several ways in which natural radioactivity levels can be augmented by human activity; these include coal mining and the mining of phosphate rock for use in fertilisers and other products, and the extraction of crude oil and natural gas from the continental shelf by the petroleum industry.

Coal and phosphate rock both contain traces of uranium and radium. Although the concentrations are usually very low, the quantities extracted are very large and the material becomes widely distributed, either directly as phosphate fertiliser or indirectly by the burning of coal and consequent release of fly ash via the stack. In particular, the practice (which has largely ceased within the EU since 2000) of discharging radium-rich phosphogypsum to the marine environment during the production of phosphoric acid by the fertiliser manufacturing industry has given rise to detectable enhancements in the concentrations of ^{226}Ra, ^{210}Pb and ^{210}Po in local waters and biota therein. Moreover, the pumping of oil and gas from off-shore reservoirs by the injection of seawater produces large quantities of contaminated water (known as 'produced' water), scale and sludge, and leads to the release of significant quantities of ^{226}Ra, ^{228}Ra and ^{210}Pb to the overlying water column. Industries such as those just referred to are sometimes called NORM industries, where the acronym stands for Naturally Occurring Radioactive Material and it is implicit that the activities involved have technologically enhanced the concentrations of radionuclides in NORMs, thereby increasing the potential for exposure.

Sources of anthropogenic radioactivity in the marine environment

The European Seas have received inputs of anthropogenic radionuclides from a variety of different sources, chiefly: (i) global fallout from atmospheric nuclear weapons testing; (ii) liquid discharges from European reprocessing plants at Sellafield and Cap de la Hague; and (iii) fallout from the accident at Chernobyl. In addition, much smaller releases from nuclear power plants, fuel production facilities, research facilities and hospitals, as well as the dumping in the past of low-level packaged radioactive waste in the deep NE Atlantic (and in European inshore waters), have also contributed to the overall inventory. From the radiological perspective, the most important radionuclides include ^{14}C, ^{90}Sr, ^{99}Tc, ^{137}Cs, ^{238}Pu, ^{239,240}Pu and ^{241}Am. Of lesser importance are nuclides such as ^{3}H, ^{60}Co, ^{106}Ru and ^{129}I.

By far the highest input of liquid radioactive waste to European waters has been that to the NE Irish Sea, with Sellafield accounting for approximately 52% of the total discharged by the European nuclear industry, followed by Cap de la Hague at 32%. Present day anthropogenic concentrations in marine animals and plants from the Irish Sea are predominantly due to historic discharges from Sellafield that, in the main, peaked in the mid-1970s when they were roughly two orders of magnitude higher than they are today. There are some exceptions to this picture; significant increases in the quantities of certain radionuclides released, in particular ^{99}Tc, but also ^{129}I, ^{60}Co and ^{14}C, were reported in the past decade. However, technetium discharges are now declining, having been reduced by about 75% since they peaked in 1995–96.

The Chernobyl accident had a significant impact on the Baltic Sea in that for about a decade prior to the accident in 1986 there was a net inflow of ^{137}Cs (of reprocessing plant origin) to this zone, whereas subsequently there has been a net outflow (Chernobyl fallout).

Radionuclide pathways to humans

Key pathways

Consumption of marine foodstuffs, particularly fish and shellfish, is demonstrably the main pathway by which populations are exposed to natural and man-made radioactivity in the marine environment. Although some sea plants are also consumed (e.g. *Chondrus chrispus*) or have been in the past (e.g. *Porphyra umbilicalis*), this practise is not common in Europe.

Uptake of radionuclides by fish and shellfish

The processes which regulate the accumulation of radioelements in marine animals are complex and lead to wide differences in contamination levels according to radionuclide type and form, water chemistry, fish/shellfish species, size and feeding patterns (e.g. differences in feeding habits between small and large fish, whereby small fish may consume plankton and invertebrates, and large fish may consume small fish). A few examples may help to illustrate the complexities involved. For radiocaesium, the most important pathway into fish is via the intake of food and the relatively high concentration factors observed are as a result of accumulation through the food chain beginning with phytoplankton. Moreover, the so-called size effect results in increasing contamination per unit weight of fish with increasing size and appears to follow a power law. Regarding plutonium, polonium and other highly particle-reactive radionuclides, the high accumulations observed, for example, in mussels can be directly attributed to the strong affinity of these radioelements for fine particulate matter coupled with the filter feeding nature of these organisms.

Concentrations of naturally occurring radionuclides in seafood

Naturally occurring radionuclides such as those from the uranium and thorium decay series and ^{40}K are the dominant sources of radiation doses through the ingestion of seafood. Polonium-210 is by far the most important nuclide in this group as it is found in relatively high concentrations in shellfish and, as an alpha particle emitter, has a high dose coefficient.

Various laboratories have reported data on ^{210}Po concentrations in fish and shellfish harvested in European waters. For species such as cod, herring and plaice, mean concentrations were found to lie in the range 0.2–4.4 Bq/kg (fresh weight) and showed no detectable variation with salinity. In contrast, concentrations in the common mussel were considerably higher, typically in the range 10–70 Bq/kg (fresh weight). Levels reported for other species of shellfish were generally somewhat lower, e.g. lobsters 2–10 Bq/kg (fresh weight); winkles 6–25 Bq/kg (fresh weight). The ranges quoted here can be taken as representative of the natural baseline. It is noteworthy that ^{210}Pb concentrations in mussels were reported to be less than 10% of the ^{210}Po concentrations, indicating that in excess of 90% of the latter is unsupported polonium. Again, ^{210}Po content in mussels showed a clear correlation with mussel weight. Further, as more than 90% of the polonium in the water column is associated with suspended particulate, the relatively high concentrations found in mussels is not surprising, given that these organisms are filter feeders.

Concentrations of anthropogenic radionuclides in seafood

The highest concentrations of anthropogenic radionuclides in seafood from the European seas are found in the North-eastern Irish Sea near Sellafield. Nevertheless, for most radionuclides these concentrations are now lower and in many cases much lower than at any time in the past few decades. Scrutiny of published data shows clearly that, in general, radionuclide concentrations in fish and shellfish sampled in the vicinity of Sellafield peaked in the early- to mid-1970s and declined thereafter, in conformity with the pattern of reduction in radioactive waste discharges.

The reduction in the concentrations of fission and activation products (about two orders of magnitude) has been greater than that of the transuranium nuclides (about an order of magnitude), due to a longer lag period between the decrease in transuranics discharges and its reflection in environmental materials. By 2001, mean concentrations of ^{137}Cs in cod, lobsters and winkles had fallen to 6, 4 and 15 Bq/kg (fresh weight), respectively, while concentrations of ^{99}Tc in the same species were 2, 4000 and 300 Bq/kg (fresh weight), respectively (RIFE, 2002). Equivalent concentrations for $^{239,240}Pu$ were approximately 0.04, 0.3 and 20 Bq/kg (fresh weight), respectively, while ^{90}Sr concentrations were similarly very low at about 0.07, 0.4 and 5 Bq/kg (fresh weight), respectively (RIFE, 2002).

Although elevated concentrations of ^{3}H (above baseline levels) have been observed in seafood from the vicinity of many nuclear and radiochemical plants (RIFE, 2002; McCubbin et al., 2001), the levels recorded are of little radiological significance as the radiotoxicity of tritium is very low. Elevated concentrations of ^{14}C have also been observed near these sites but, again, doses from this nuclide to individual members of the most exposed groups are generally very low (Cook et al., 1998). However, in the global context, the collective dose from ^{14}C, integrated over 10000 years, comprises about 25% of the collective dose from the complete nuclear fuel cycle (UNSCEAR, 1993).

Doses to seafood consumers

Dose calculations for intakes of radionuclides by ingestion are based on dose coefficients recommended by the International Commission for Radiological Protection (ICRP, 1996). These coefficients, often referred to as 'dose per unit intake', relate the committed dose received to the amount of radioactivity ingested. Thus, to determine actual doses to consumers, reliable data on radionuclide concentrations in the various species of fish and shellfish consumed, as well as data on realistic consumption rates by members of the most exposed populations or critical groups and the general public, are essential. Once this information is to hand, calculation of the doses involved is straightforward.

To this end extensive monitoring of radionuclide concentrations in seafood has been conducted by the Member States of the European Union for many years past. These on-going surveys are supported in some Member States by regular dietary habits surveys in order to ensure that the calculated doses are as realistic as possible. In addition, the European Commission has had a number of wide-ranging studies carried out in order to collate data on radionuclide discharges into European marine waters and on radioactivity concentrations therein, and to provide an assessment of their impact. We refer here to studies such as MARINA I (CEC, 1990), Marina-Med (EC, 1994), Marina-Balt (EC, 2000) and MARINA II (EC, 2002).

The latter study is of particular relevance to the work of the OSPAR Commission in the light of agreement by the contracting parties to the OSPAR Convention to prevent pollution of the maritime area from ionising radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, in order to achieve concentrations in the environment that are near background levels for naturally-occurring radioactive substances and close to zero for artificial radioactive substances. In particular, the Commission is tasked with ensuring that, by the year 2020, discharges, emissions and losses are reduced to levels where the additional concentrations in the marine environment above historic levels (resulting from such discharges, emissions and losses) are close to zero.

The recent MARINA II study has confirmed that since 1986 the radiological impact on the most exposed groups of populations, i.e. critical groups of heavy consumers in the vicinity of the major nuclear sites at Sellafield and Cap de la Hague, have been consistently and significantly below the ICRP and EU Basic Safety Standard limit for members of the public (from practices involving controllable sources of radiation) of 1 mSv per year (EU, 1996; ICRP, 1991). Specifically, the range of individual doses for the two sites in the period 1988–99 was 0.01–0.4 mSv per year (EC, 2002; RIFE, 2002; GRNC, 1999). Throughout this period, doses in the Sellafield area show no obvious trend, though for Cap de la Hague there is a decreasing trend. Interestingly, most of the seafood (and, for that matter, external) exposure attributable to Sellafield derives from historic discharges. Recent and current discharges of ^{99}Tc, about which there has been some controversy, contribute only about 15% of the dose to the Sellafield seafood consumers (RIFE, 2002).

In the nearest Member State to Sellafield, namely Ireland, the annual dose to a heavy consumer of fish and shellfish has declined from an estimated maximum of 0.16 mSv in 1976 to approximately 0.0013 mSv by 1999, while the annual dose to a typical Irish seafood consumer has fallen from a peak of almost 0.03 mSv to about 0.0003 mSv in the same period (RPII, 2000). These and similarly small doses to consumers elsewhere in the European Union are but minute fractions of the above-mentioned annual dose limit for members of the public, namely 1 mSv. By comparison, the annual dose to a heavy consumer arising from the presence of naturally occurring ^{210}Po in fish and shellfish is estimated to be about 0.150 mSv, while the corresponding figure for the typical consumer is about 0.030 mSv (RPII, 2000). In general terms doses to seafood consumers throughout Europe from naturally occurring ^{210}Po are approximately two orders of magnitude higher than those from anthropogenic radionuclides.

These doses to seafood consumers may also be compared with the annual average dose of approximately 3 mSv from all sources of radiation received by members of the European public. Of this, approximately 80–90% is due to naturally occurring radiation, with the remainder arising mainly from medical uses of radiation.

In terms of collective dose rate, the overall radiological impact of the nuclear industry on the European population (from the OSPAR area) has decreased from a peak of 280 man-Sv/year in 1978 to 14 man-Sv/year in 2000, primarily due to decreases in discharges of ^{106}Ru and ^{137}Cs (EC, 2002). Further, discharges from nuclear power generation, fuel fabrication and research reactors contributed just 2% to the total collective dose from marine discharges in the same year. However, the contribution of so-called NORM industries to the overall collective dose rate has been considerably greater in the same period, peaking at 600 man-Sv/year in 1984 and declining more or less steadily thereafter to about 120 man-Sv/year at the present time (EC, 2002).

Finally, it has been estimated that a dose of 0.1 mSv to an individual corresponds to a risk of developing a fatal cancer of approximately 1 in 200000, while a dose of 0.001 mSv confers a risk of about 1 in 20 million (ICRP, 1991). Although the comparison is, perhaps, invidious, these levels of risk seem small when compared with those fatal risks, self-imposed or otherwise, that are part of everyday life, such as accidents on the road, accidents in the workplace or in the home, death from natural causes (40 year old), etc. Here the annualised risks involved are typically in the range 1 in 1000 to 1 in 50000.

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EUROPEAN MARITIME AREAS AND MARINE FISH

Hartmut Nies and Günter Kanisch

Bundesamt für Seeschifffahrt und Hydrographie
(Federal Maritime and Hydrographic Agency)
D-20305 Hamburg/ Germany

Bundesforschungsanstalt für Fischerei
(Federal Fisheries Research Centre)
Institut für Fischereiökologie
Marckmannstr. 129b
D-20539 Hamburg/Germany

Introduction

Since the discovery of nuclear fission the European maritime areas have been contaminated with artificial radioactivity from different sources:

- Global fallout, primarily during the fifties and sixties from atmospheric nuclear weapon tests,
- Discharges from nuclear reprocessing plants at Sellafield (UK) and at Cap de La Hague (F);
- Fallout from the accident at Chernobyl in April 1986;
- Discharges from nuclear power plants and other nuclear reactors directly or via rivers draining into the European maritime area, e.g. from research and medical facilities;
- Releases from accidents at sea, e.g. from the sunken nuclear submarine "*Komsomolets*" in April 1989;
- Dumping of low-level radioactive wastes in the North-East Atlantic at depths of more than 4000 m;
- Dumping of radioactive wastes in the Arctic Seas by the former USSR, mainly in the Barents and Kara Sea.

These sources are different in size and nuclide composition, respectively. In European Seas the three sources mentioned first are the most relevant as far as concentrations and doses to the public are concerned. However, it should be mentioned that there exists also a natural radioactivity in the marine environment. This natural radioactivity consists of elements from primordial or cosmogenic origin. In most cases the concentration of natural radionuclides are significantly higher than those of technogenic origin. This is also valid for the radiation exposure received from the consumption of marine food. It was shown in several studies that the alpha-emitting nuclide ^{210}Po (Polonium-210) is the highest contributor for the radiation dose from marine food (Aarkrog et al., 1996). This nuclide belongs to the decay chain of the long lived nuclides ^{238}U (Uranium-238) and ^{226}Ra (Radium-226). For artificial radionuclides, in most cases, ^{137}Cs (Caesium-137) is the most relevant nuclide for marine radiation dose to man due to enrichment in fish and other marine food (IAEA, 1994). There is a direct correlation between concentrations measured in water and concentrations found in fish or biota. This paper gives a short review on levels and temporal trends of artificial radioactivity in European Seas.

European Maritime Areas

Northeast Atlantic Ocean / Mediterranean Sea

All European maritime areas are regional seas of the Northeast Atlantic Ocean. Their currents are driven by the current system of the Atlantic. The primary source of radioactivity in the Atlantic is global fallout from atmospheric weapon tests in the fifties and sixties. Typical fallout nuclides with sufficient long half-lives to be detectable nowadays in the environment, are Tritium (half-life=12 years), ^{137}Cs (30 y), ^{90}Sr (29 y), ^{238}Pu (88 y), ^{239}Pu (24000 y), ^{240}Pu (6700 y), ^{241}Pu (14 y) and ^{241}Am (430 y). These nuclides show a characteristic vertical concentration pattern in the water column. The fallout occurred on surface water. Tritium, ^{90}Sr and ^{137}Cs show the highest concentrations in the euphotic surface layer down to about 500 m. Bio-geochemical enrichment in phytoplankton and other biota and physical processes and subsequent vertical transport lead to subsurface maximum concentrations of the plutonium isotopes at a depth between 800 and 1200 m. The present surface concentration in sea water of the Northeast Atlantic Ocean of ^{137}Cs, ^{90}Sr and Pu-Isotopes is given in Table 1. The data are decay corrected from a data set in 1997 (Nies and Herrmann, 1999). The activity ratios between ^{137}Cs and ^{90}Sr are almost typical for fallout ratio, where one can expect a theoretical ratio of about 1.5. This is also the case for the ratio between ^{238}Pu and ^{239,240}Pu[2], where a ratio of about 0.04 is typical for fallout plutonium.

The main source of ^{137}Cs and ^{90}Sr for the Mediterranean Sea was the global weapon fallout. However, the fallout of the accident at Chernobyl contaminated in particular the eastern part and the Black Sea. This source is still detectable in these regions, significantly. The activity concentrations of ^{137}Cs and ^{90}Sr in surface water of the western Mediterranean Sea is also given in Table 1.

Table 1: Activity Concentration of artificial radionuclides in surface water of the Atlantic Ocean and Mediterranean Sea.

	^{137}Cs	^{90}Sr	^{239,240}Pu
Northeast Atlantic	2.1 ± 0.2 Bq/m^3	1.3 ± 0.2 Bq/m^3	2.7 to 9.0 mBq/m^3
Mediterranean Sea	2.3 ± 0.4 Bq/m^3	1.6 ± 0.3 Bq/m^3	9 to 16 mBq/m^3

[2] Plutonium isotopes are mostly determined by means of alpha-spectrometry. This method does not allow to distinguish between the alpha particles of ^{239}Pu and ^{240}Pu. Therefore, the concentrations are given as a sum parameter $^{239+240}$Pu.

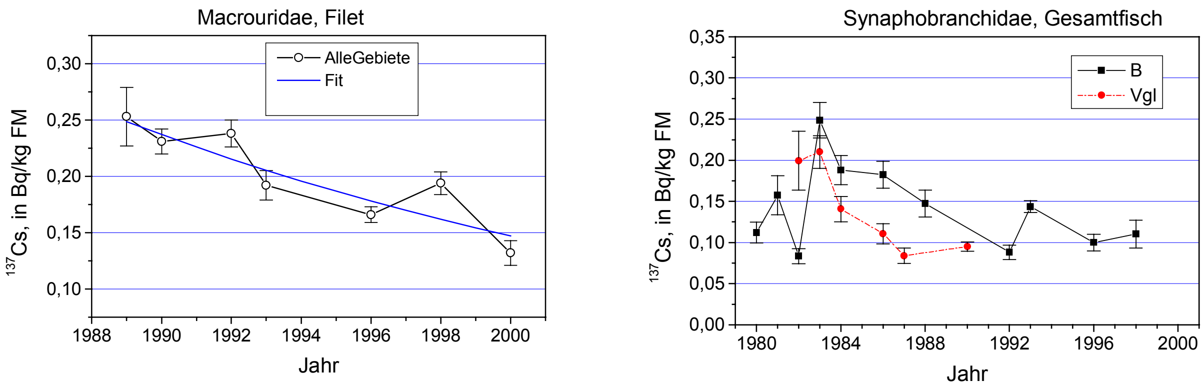

Fig. 1: Temporal trend of ^{137}Cs in Macrouridae and Synaphobranchidae in the NEA-dump site B and area for comparison („Vgl"). The left figure for Macrouridae (Filet) is a synopsis of samples from the dump site B and areas for comparison.

Low-level radioactive waste was dumped at the NEA deep sea dump site in the Northeast Atlantic until 1982 (NEA, 1985). Several investigations were carried out in this deep sea region to detect potentially released nuclides from the dumped drums (NEA, 1989). However, the measured levels of nuclides in water, sediment and biota close to the dumped waste were so low even at the sea bottom that they were indistinguishable from fallout levels. Mostly, they were close to the limit of detection. The dumped waste plays practically no role for radioactivity in European regional seas. Figure 1 shows the temporal trend of ^{137}Cs in Macrouridae filet and Synaphobranchidae fish caught in the dump site area and areas for comparison, both in a depth of about 4700 m. The calculated apparent decay in the fish filet shows an effective half-life of about 14.5 years (± 4.1 years). This is in the same order as also determined for water concentration in most of the oceans. This again reveals the correlation between the surface water concentrations and the associated levels in biota.

Irish Sea

The northeast Atlantic current system transports its surface water into European Shelf Seas. Since the beginning of the fifties, the nuclear plant at Sellafield (former: Windscale) releases nuclear liquid discharges into the eastern Irish Sea. This contamination is transported by the prevailing current system northwards around Scotland into the North Sea. However, large quantities of less soluble and particle reactive nuclides were deposited in the fine mud sediments. The discharges peaked in 1975. Since then, there is a general reduction of the liquid discharges into the Irish Sea. Maximum levels of ^{137}Cs in the eastern Irish Sea close to the discharge pipeline were measured slightly above 200 Bq/m^3 in November 2000. The average value at that time is about 63 Bq/m^3 ± 54 Bq/m^3 (1 std. dev.) with a wide range of values between 7.2 and 202 Bq/m^3. Since 1990 the rate of reduction has slowed down and, especially in recent years, the ^{137}Cs levels have remained almost constant. This is due to the remobilisation of ^{137}Cs deposited in sediments during the time of high discharges in the seventies.

Since 1994, the ^{99}Tc levels have increased significantly, in 1996, 2000 Bq/m^3 of ^{99}Tc near Sellafield, 60 Bq/m^3 in the North Channel, and 5-10 Bq/m^3 in the northwest

North Sea were observed. Figure 2 shows the distribution of ^{99}Tc in seawater in November 1999 to the North Sea and the Irish Sea.

North Sea

The North Sea is flown through by the inflow through the Channel in the south entrance and around Scotland in the north. By these currents the North Sea receives the contaminated water both from Sellafield from the Irish Sea and from the discharges at La Hague. In former years these two sources gave a geographically characteristic contamination pattern in the North Sea. However, due to reductions at both sources, the levels for ^{90}Sr and ^{137}Cs concentrations decreased significantly. They are presently only slightly above fallout levels of Atlantic surface water. This results also in a decrease of contamination in fish and other marine food. Figure 3 shows the temporal trend of the concentrations of ^{137}Cs in marine fish from the North Sea. In addition to the measured values a box model was applied in order to calculate the concentration in fish both without and with remobilisation of ^{137}Cs from sediments in the Irish Sea.

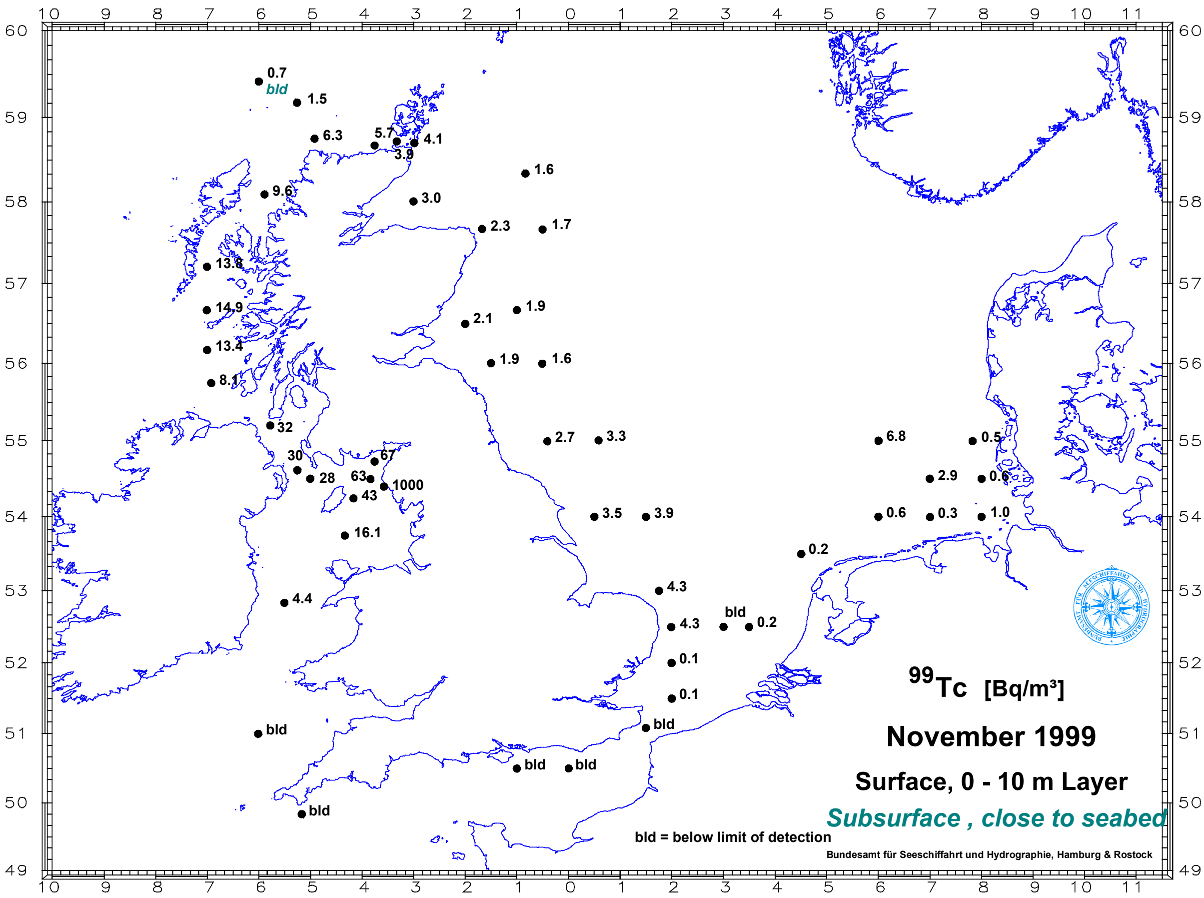

Fig. 2: Distribution of ^{99}Tc in seawater of the North Sea and the Irish Sea. The Sellafield source is noticeably detectable by the elevated concentrations.

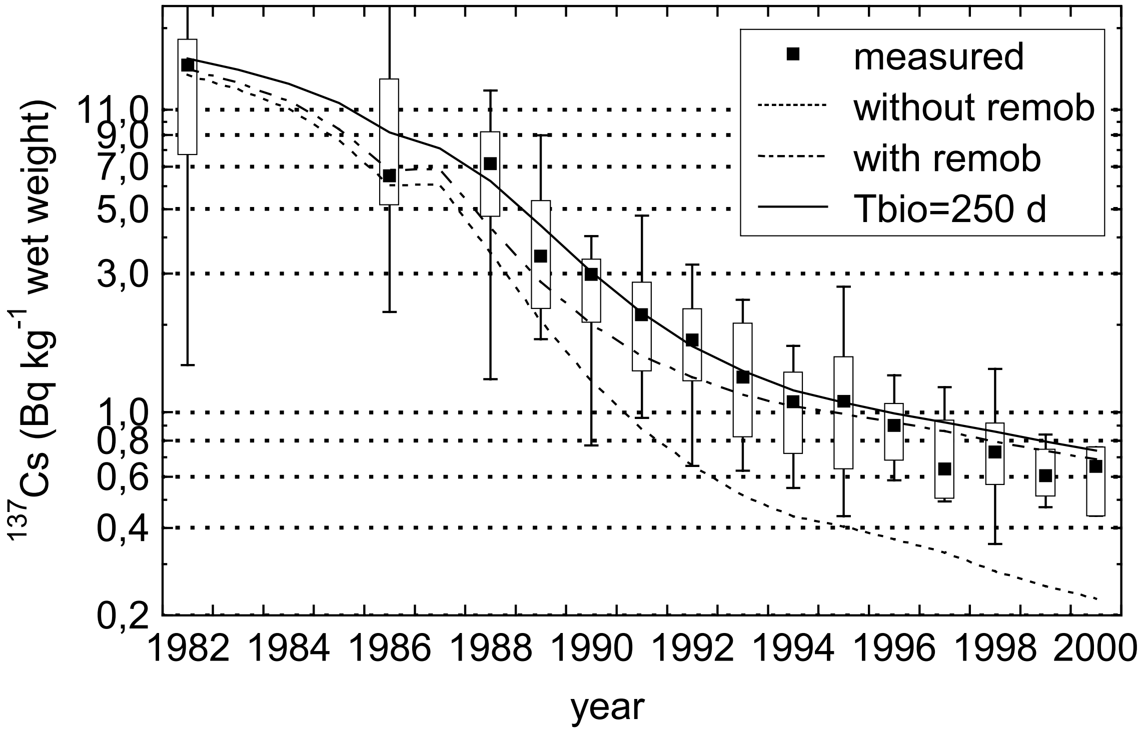

Fig. 3: Concentration of ^{137}Cs in Cod from the North Sea and calculated concentrations with a box model. The biological half-life is about 250 days.

Baltic sea

The Baltic sea received large amounts from the Chernobyl fallout in 1986. This fallout occurred primarily in the northern part of the Baltic Sea (Nies and Nielsen, 1996). Before this accident there was an almost linear relation between ^{137}Cs and salinity due to the inflow of Sellafield derived contaminated water. Due to its geographical situation as a semi-enclosed sea area the Chernobyl contamination will remain for longer periods in the Baltic Sea. The dominant nuclide for contamination is the ^{137}Cs from Chernobyl. The outflow into the North Sea can clearly be seen by the ^{137}Cs levels in the Kattegat and Skagerrak. Fig. 4 shows the temporal trend of the concentration of ^{137}Cs at a location in the western Baltic Sea and Fig. 5 reflects the levels in fish from the Baltic Sea. The levels of ^{90}Sr were almost unchanged by the Chernobyl fallout. ^{90}Sr shows a lower affinity to soil particles. Therefore, the concentration of ^{90}Sr were higher influenced by river water run off after the global fallout in the sixties. The levels were rather constant for many years and the decrease is mainly due to physical decay.

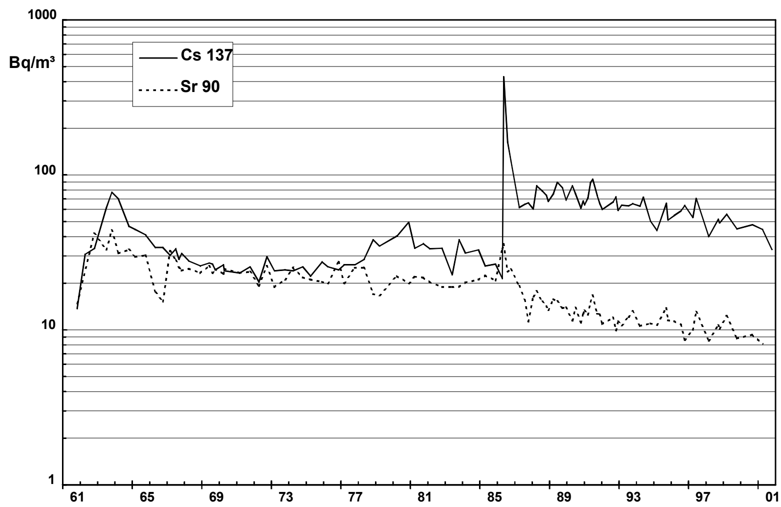

Fig. 4: Temporal trend of the ^{137}Cs and ^{90}Sr concentration at the position "Schlei-mündung" in the western Baltic Sea. The Chernobyl fallout can clearly be seen in 1986.

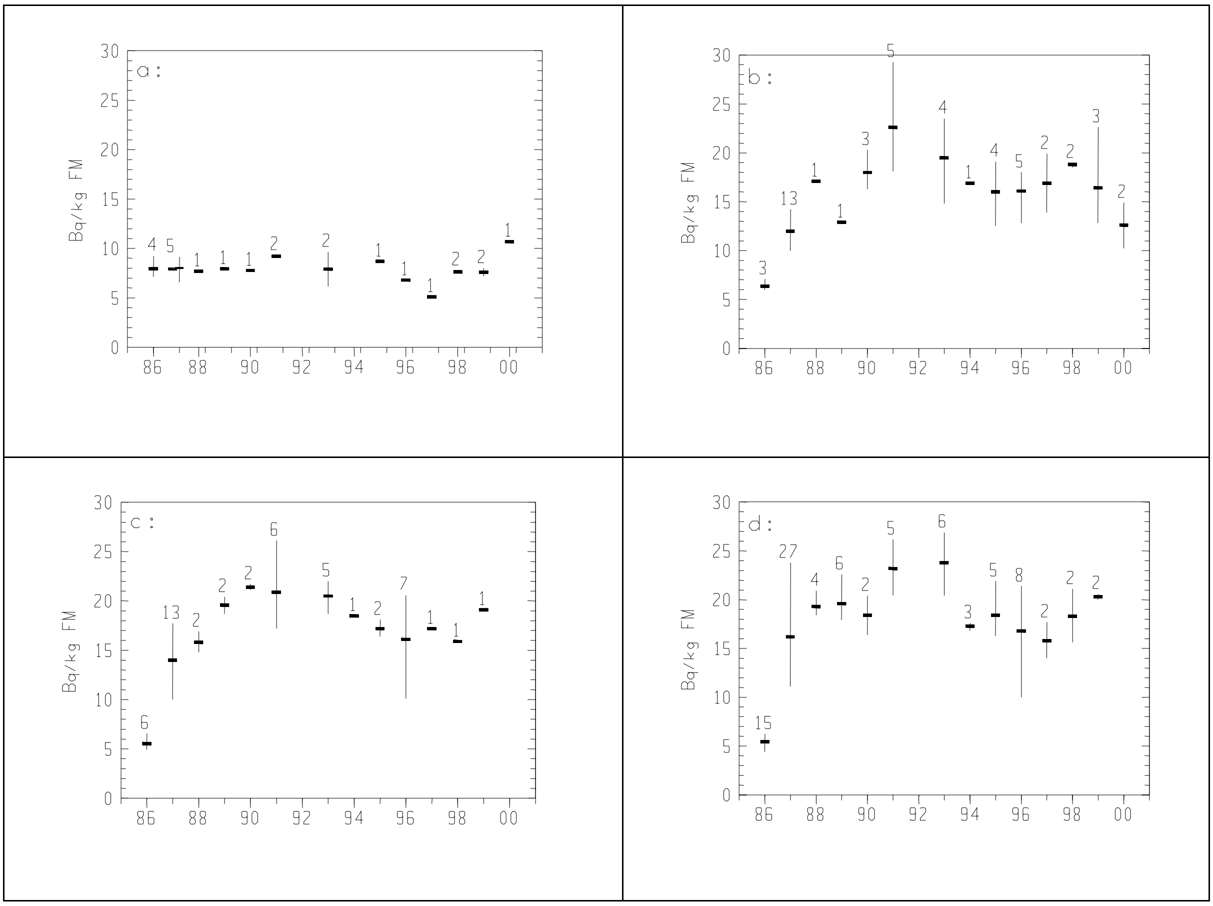

Fig 5: Temporal trend of the ^{137}Cs-content (data are given in Bq/kg Fresh Weight and mean-values with Min-Max-ranges and number of samples) in Cod flesh from different areas of the Baltic Sea. West to Eastern direction: above left: Kiel Bight; above right: Arkona Sea (12° to 14° 50' E); below left: Bornholm Sea (14° 50' to 16° 30' E); below right: Southern Central Baltic Sea (16° 30' to 18° 50' E). The fish was caught in December, respectively.

Arctic Sea (Norwegian Sea, Barents Sea, Greenland Sea)

The European Northern Seas receive contaminated waters from southern areas from the Irish Sea, Channel, North Sea and Baltic Sea. The Norwegian coastal current transports these waters into Arctic areas such as the Barents Sea, Arctic Ocean and the Kara Sea. Figure 6 shows two scenarios of calculated ^{137}Cs contamination of Northern Sea due to the Sellafield discharges over many years (Nies et al., 1998). The typical transport pattern by the current system is explicitly be visible. There was the concern that the Arctic waters could be polluted by dumped high level wastes in the Barents and Kara Seas by the former Soviet Union. However, various studies have shown that there is only a minor risk from these sources in northern European waters (IAEA, 1999). In Arctic waters there is no indication of long range contamination from nuclear wastes and other radioactive objects dumped by the former USSR. There is also no significant release and long-range transport and contamination from the sunken nuclear submarine "*Komsomolets*" in the northern Norwegian Sea at a depth of 1700 m.

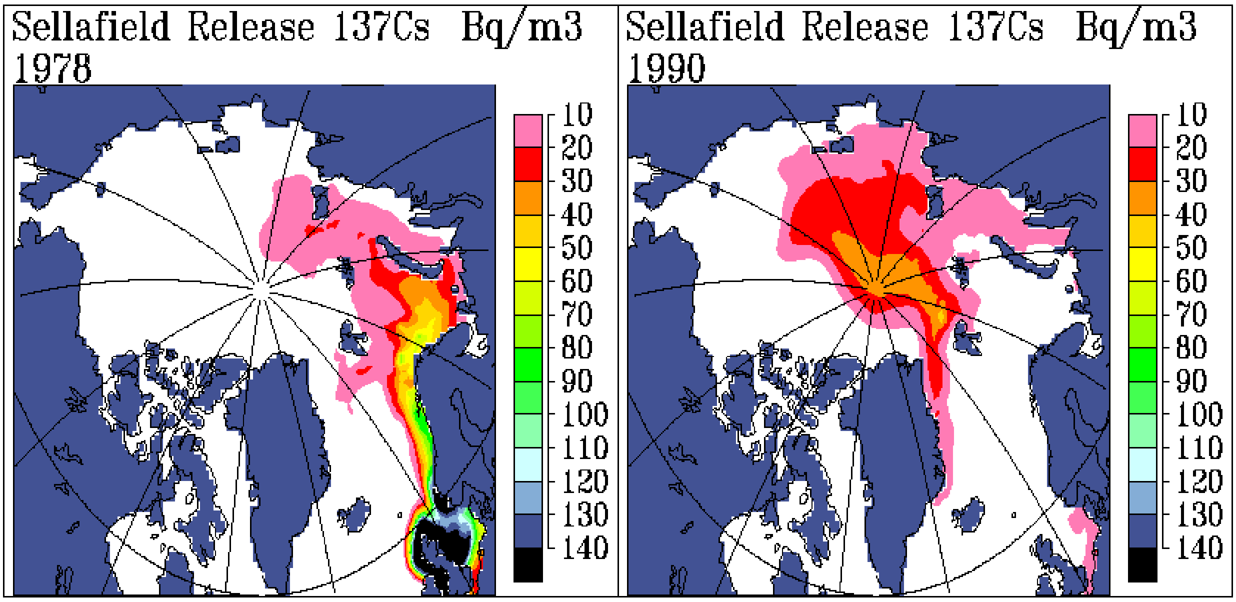

Fig. 6 Calculated ^{137}Cs concentration in surface water of European northern Seas. The real discharges into the Irish Sea are used as input function. Two scenarios are given: the distribution in 1978, three years after the highest discharges at Sellafield, and 1990, when the discharges were decreased significantly. The pictures were taken from the paper Nies et al., 1998.

Conclusions

The dominant sources of artificial radionuclides in European waters were the global fallout and the discharges from the reprocessing plants Sellafield and La Hague. The fallout from Chernobyl in 1986 contaminated primarily the Baltic Sea, where the levels of ^{137}Cs are still higher than in other sea areas. The levels in fish reflect mostly the contamination of its living habitat. Generally, a downward trend in the levels of radioactivity in water and marine fish could be ascertained in recent years by the significant reductions of liquid discharges at the nuclear reprocessing plants, both at Sellafield and La Hague. The discharges of a few nuclides were increased. However, this gave no general increase in doses to man from consumption of marine food.

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RADIOACTIVITY IN TERRESTRIAL AND FRESHWATER FOODSTUFFS

Howard, B.J.
Centre for Ecology and Hydrology – Merlewood, Grange-over-Sands,
Cumbria, LA11 6JU, UK

Introduction

For most people, internal doses from food are small compared to external and medical sources (eg an average of 10% of total doses in the UK). Humans are exposed to both natural and artificial radionuclides from many sources, which are transferred through the environment to the food we eat.

Each radionuclide has different physical and chemical properties. The most important radionuclide contributors to human exposure to radiation via food are often present in relatively high concentrations, have a relatively high dose per unit intake, and/or are environmentally mobile. The environmental mobility of different radionuclide varies considerably. Radionuclides with a potentially high environmental mobility are often analogues of essential elements and include ^{40}K, ^{131}I, $^{134/137}$Cs, ^{90}Sr, ^{14}C, ^{3}H and ^{35}S, whereas those with low environmental mobility include large atomic weights radionuclides such as $^{239/240}$Pu and ^{241}Am.

The source and chemical form of a radionuclide in the environment can influence its availability for transfer to foodstuffs. For instance, radionuclides associated with nuclear fuel particles (which will be deposited close to the source) tend to be less mobile than other types of contamination.

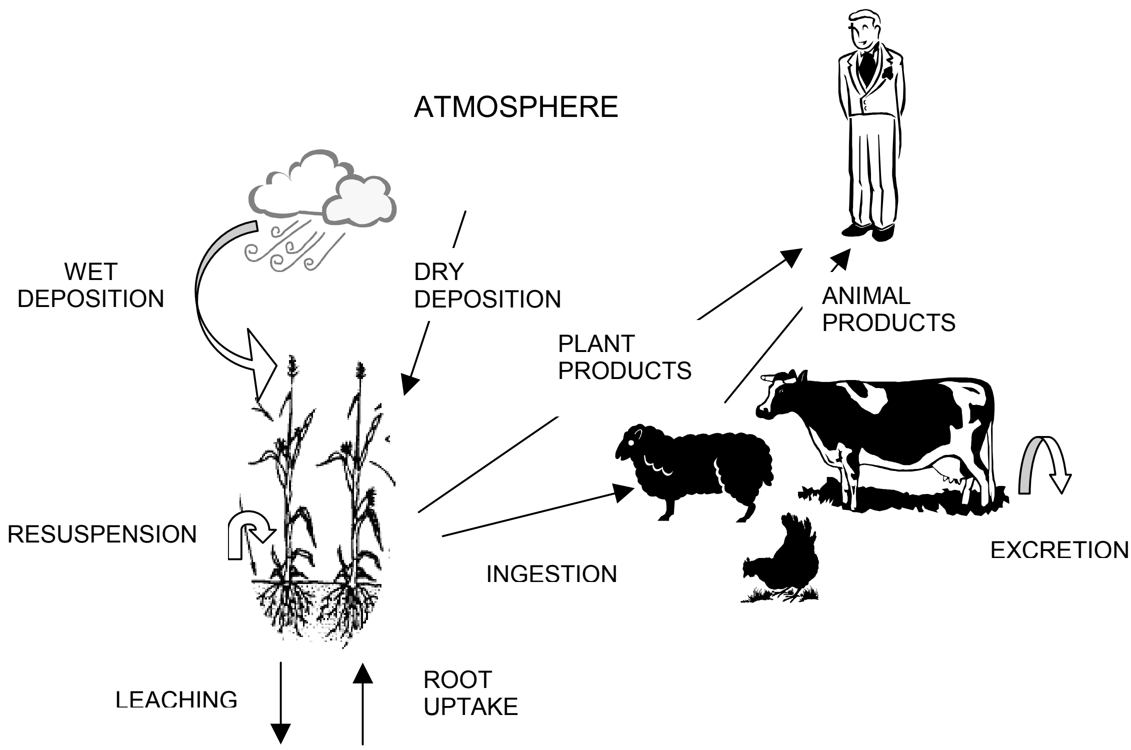
Natural radionuclides in food

The origin of natural radionuclides is either cosmic (of which ^{14}C and ^{7}Be are the most significant) or terrestrial (such as ^{40}K, ^{87}Rb and the uranium and thorium decay series). Of the cosmogenic radionuclides, ^{14}C and ^{3}H are isotopes of essential elements and are therefore present in all living things. Terrestrial radionuclides from rocks and soil, such as ^{226}Ra, ^{210}Pb and ^{210}Po can also be transferred along foodchains to foodstuffs. Some foodstuffs can accumulate high concentrations of natural radionuclides, examples are Brazil nuts which have high concentrations of ^{226}Ra and reindeer which have high concentrations of ^{210}Po. Mineral water may contain high concentrations of ^{226}Ra. Doses arising from ingestion of the cosmic radionuclides are much lower than that of terrestrial sources, the most important of which is ^{40}K. Potassium is an essential element and its concentration is controlled in the body to be constant. Therefore, ^{40}K concentrations in tissues do not reflect that eaten.

The content of natural radionuclides in food can be enhanced by a variety of factors including wastes arising from mineral extraction and processing, coal burning and the use of fertiliser made from phosphate-containing rocks.

Man-made radionuclides in food

A range of different man-made radionuclides have been deposited from nuclear weapons testing, are emitted routinely by nuclear power plants and can be emitted during a nuclear accident. Often, ingestion of contaminated foods is a major route of radiation exposure to such radionuclides. The most important route of contamination by man-made radionuclides of land and freshwater is via the atmosphere since radionuclides are often released into the air, and this can also occur during accidents. Contamination of terrestrial and freshwater ecosystems then occurs when the radionuclides are deposited, either in dry conditions or in wet conditions (such as rainfall or snow). If it rains or snows during the passage of a contaminated air mass then subsequent contamination if often much higher than if there is no precipitation.



Main terrestrial pathways for man-made radionuclides to humans

Contamination of lake surfaces can also be significant but that directly to rivers is often small due to the lower surface area. Additional inputs of radionuclides to rivers and lakes occurs from the catchment after deposition. This occurs through surface runoff, loss of radionuclides from soil and erosion of soil particles. The importance of catchment input varies with soil type, with higher inputs over longer periods of radiocaesium from catchments dominated by peat bog soils.

The foodstuffs of most concern in the event of a nuclear accident vary with time and with radionuclide. In the early stage of an accident, external contamination by radionuclides on plant surfaces is an important source of contamination of foodstuffs either directly on plants or indirectly through animals grazing the plants. The extent of interception of radioactivity by plants depends on the density of the canopy, and is therefore much higher in a coniferous forest than in a pasture. The outer leaves of leafy green vegetables, such as cabbage and spinach may become highly contaminated and this is obviously most important if this occurs just before harvesting. Gradually, most radionuclides are lost from plant surfaces in a weathering process. The concentration of radionuclides in plants also decreases due to dilution by plant growth.

Radionuclides in soil

Soil is either directly contaminated or receives radionuclides lost from plant surfaces. Once in the soil, radionuclides are often retained in the upper soil layers and rates of migration down soils profiles are often slow. One of the major factors influencing the extent of contamination of food is the rate of transfer from contaminated soil to plants. Plant roots absorb nutrients and contaminants from the water surrounding soil particles. It is therefore the relative amount of each radionuclide in the soil water rather than absorbed to soil constituents which determines the uptake by plants.

Radiocaesium is strongly absorbed onto clay particles, where it is gradually effectively immobilised. However, in organic soils radiocaesium remains mobile. Radiostrontium absorbs to many soil components, but not strongly. Its availability for plant uptake is affected by the calcium status of the soil. For the short-lived ^{131}I, plant uptake is not so important as it decays rapidly. As radionuclides are gradually fixed in the soil, the rate of plant uptake declines and food products become less contaminated with time.

Transfer to plant products

After the initial period, contamination of foodstuffs largely arises from soil to plant uptake. Thus, radionuclides can be taken up by a wide range of plants, including vegetables and cereals. The ability of different plants to absorb radionuclides from soil varies. For instance, the heather, *Calluna vulgaris*, becomes much more highly contaminated by radiocaesium than other herbaceous plants. Conversely, uptake by cereals into the grain is generally low.

Transfer to animal products

Grazing by animals of contaminated plants leads to contamination of milk, but also may lead to a gradual build up of contamination in animal tissues. Obviously, the extent to which an animal eats contaminated food is one of the major factors affecting contamination of animal products. Thus, the proportion of pasture grass, hay and silage (all of which may be more highly contaminated than cereals and other plants) fed to animals is generally important.

Some radionuclides are completely absorbed into the body from the gut, others hardly at all. Radioiodine absorption from the gut is generally 100% and that of radiocaesium generally exceeds 80% although the latter may vary by a factor of 50 depending on the chemical form of the radiocaesium. Radiostrontium absorption is around 20% and depends on calcium intake. In contrast, only about 0.05% of plutonium in the gut is absorbed into the body.

Once absorbed, different radionuclides are accumulated in different tissues. Radioiodine is accumulated in the thyroid but is also transferred to milk. Radiocaesium is distributed in all soft tissues, so much of it ends up in muscle, and is transferred to milk. Radiostrontium is taken up in bone and is transferred to milk. The rate of uptake into tissues and its subsequent loss depends on the biological half-life. For mobile radionuclides, such as I, Cs and Sr, biological half lives in milk are about 1 day. For many radionuclides (eg Ag, Co and Ru), accumulation occurs in the liver and other offal but the rate of transfer is lower than for Cs, I and Sr due to lower gut uptake rates and longer biological half lives.

Agricultural and seasonal factors

The time at which the accident occurs in relation to the farming cycle is critical. Accidents occurring just before harvest or in the period of outdoor grazing by animals are likely to give rise to higher doses than those occurring in winter.

Semi-natural ecosystems

Since the Chernobyl accident it has become clear that transfer of radiocaesium to a wide range of food products from forests, uplands and other natural areas can be much higher than for agriculturally improved areas and that the high uptake can persist for decades. Very high ^{137}Cs concentrations have been measured in mushrooms and game such as roe deer and wild boar. For mushrooms there is great variability in the extent of contamination between species; highly contaminated, commonly eaten species include some bolete species and the chanterelle. For game species, the extent of radiocaesium contamination depends on which plants species are eaten and when; ^{137}Cs concentrations in roe deer increases each autumn because the deer are eating mushrooms. Feeding strategies are also important in freshwater, with predatory fish generally containing more radiocaesium than other species.

Effect of diet

For most people, the major foodstuffs contributing to radiation dose will be those for which the rate of transfer is higher than other products and/or which are eaten in large quantities. Such products include milk, meat and potatoes. Certain groups may be exposed to higher doses than others due to their dietary preferences. An example is people who harvest foods from semi-natural ecosystems or consume lots of freshwater fish who can receive larger amounts of radiocaesium.

Comparison of doses due to ingestion

For most people in European countries, the majority of the dose currently received by ingestion of food is due to natural radionuclides, and particularly ^{40}K. For example, the average member of the UK population receives a total of 2.6 mSv/y, 85% of which is from natural radiation. The ingestion dose is about 0.27 mSv/y of which 0.17 is due to ^{40}K with ^{210}Po and ^{210}Pb also contributing significantly. The average contribution of man-made radionuclides is less than 0.005 mSv/y. In some areas, doses from ingestion are higher due to (i) locally enhanced amounts of natural radioactivity, (ii) local emissions of man-made radionuclides from nuclear power plants, (iii) deposition from nuclear accidents, including those at Windscale and Chernobyl and (iv) high levels of global fallout in areas receiving high amounts of rainfall or snow.

In the event of an accident, there is the potential for ingestion doses to have a significant impact. A clear example is the high doses of radioiodine received by people in Ukraine, Belarus and Russia after the Chernobyl accident. Because radioiodine is transferred from herbage to milk very quickly and efficiently, the ingestion of contaminated milk provided radiation doses which were sufficiently high to cause thyroid cancer in almost 2000 people. Over the longer term, doses from the long lived ^{137}Cs remain above 1mSv/y in some rural areas of the Former Soviet Union due largely to consumption of forest products and milk from privately owned cows.

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CONSUMER ATTITUDES TOWARDS FOODSTUFFS FROM RADIOACTIVELY CONTAMINATED AREAS

Salt, C.A. (1), Grande, J. (2), Hanley, N. (3) & Alvarez-Farizo, B. (3)
(1) Department of Environmental Science, University of Stirling, Stirling, FK9 4LA, UK
(2) Department of Resource Science, Nord-Trøndelag College, Steinkjer, Norway
(3) Department of Economics, University of Glasgow, Glasgow, G12 8RT, UK

Introduction

Human perception of a risk depends on the severity of the associated health hazard, the degree of self-control and familiarity (Slovic, 1987; Sparks & Shepherd, 1994). Hence risks connected with radioactive contamination of foodstuffs are likely to be regarded as greater than those connected with familiar activities which are within a person's control such as sunbathing. In addition previous experience, income and education play a role in the formation of consumers beliefs. Attitudes towards risk are shaped by these beliefs and together with social norms attitudes will determine intentions and finally behaviour.

In the event of an accidental release of radioactivity the contamination of many foodstuffs can be minimised through 'countermeasures', which alter the agricultural production process. These may amongst others involve treatment of soils or animals, changes in management or import of uncontaminated animal feed (IAEA, 1994). Such measures can save food from disposal and preserve farm incomes. However, consumers may be unwilling to purchase products from affected areas despite assurances that radioactivity levels are within Government approved 'safe' limits.

This study was undertaken as part of the EU-funded CESER project (Countermeasures: Environmental and Socio-economic Responses – a long-term Evaluation). The aim was to investigate links between attitudes to risk, risk-reducing behaviour and willingness to pay (WTP) to avoid perceived risks from food made safe through countermeasures. Data was collected through a questionnaire survey to consumers in Norway and Scotland. The full results can be found in Grande et. al. (1999). Key outcomes including statistical analyses will be published shortly (Alvarez-Farizo et al., in press).

Methodology

In 1998 two consumer surveys were carried out in Norway and in Scotland, using very similar questionnaires. In Norway 2000 questionnaires posted to a random selection of addresses achieved a response rate of 50.6%. A certain bias towards people more sensitive to food safety/quality issues was detected in the 1003 responses. In Scotland 200 face-to-face random interviews were conducted in people's homes since Scottish mail surveys have been shown to suffer from a very low response rate.

The questionnaire initially explored people's perceived risk from fifteen non-food as well as food sources (e.g. traffic accidents, sunbathing, pollution) in terms of the likelihood of suffering ill health (beliefs) and how concerned they were about this (attitudes). Then respondents were are asked general questions about nuclear power and food safety followed by questions on the likelihood of suffering ill health (beliefs) from eight food safety problems (e.g. chemical additives, genetic engineering, BSE) as well as their degree of concern (attitudes).

Risk-averting behaviour was explored through questions on food buying behaviour immediately after the Chernobyl accident and over the longer term as well as changes in behaviour in response to other food risks such as BSE. This was followed by questions on level of trust in information sources and preferred sources of food safety information.

Willingness to pay for risk reduction was measured via the contingent valuation method (Bateman & Willis, 1999). Respondents were asked to choose between an imported food product from an area not affected by radioactive fallout ('untreated') and a 'treated' but safe product from an area where countermeasures had been applied. Then they were asked to decide how much more they would be willing to pay for their preferred choice compared to the normal average price. The products tested were lamb and milk in Scotland and milk in Norway.

Results and Discussion

The consumer model underpinning this study was developed from Ajzen and Fishbein (1980) and is shown in Figure 1.

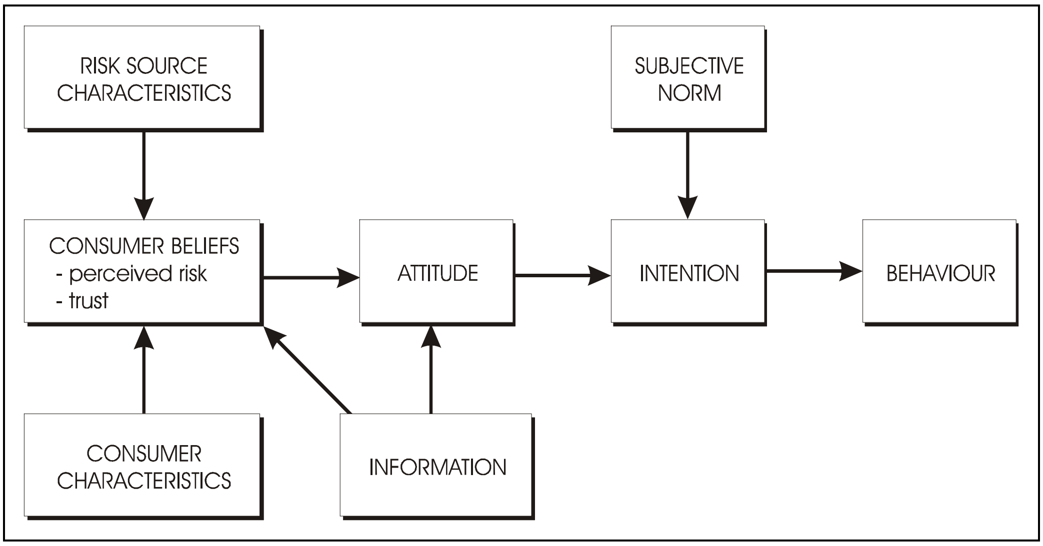

Figure 1. Consumer model: factors influencing consumer attitudes and behaviour in food safety issues (Grande *et al.*, 1999).

Examination of food and non-food risks showed that Norwegian respondents rated chemical additives in food as the highest perceived risk while the Scottish respondents ranked bacterial infection highest. In comparison risks from radioactive food contamination scored at or below the mean level of a total of 20 investigated risks. While Scottish respondents generally thought it more likely they would suffer ill health than Norwegians, they were less worried. Ratings for food risks were mostly similar between the two countries.

In both countries the highest level of trust was placed in information from 'experts' (researchers, scientists) and health authorities with least trust in politicians (see Table 1). The most preferred types of information in the event of a future accident were food labelling and television.

Table 1. Trust in different sources of information on food safety (percentage of responses). Adapted from Grande et al., (1999).

	No/little trust		**Indifferent**		**Some/high trust**	
Information source	Norway	Scotland	Norway	Scotland	Norway	Scotland
Experts	14.8	29.5	34.2	22.0	51.0	48.5
Health Authorities	20.7	35.0	18.5	31.9	47.4	46.5
Food Industry	58.3	48.5	30.4	28.0	11.4	23.5
Radio/TV	47.2	44.5	34.1	33.5	18.7	22.0
Newspapers	54.3	56.0	30.0	30.0	15.7	14.0
Politicians	63.7	61.5	28.7	28.0	7.5	10.5

Risk reducing behaviour was higher in Norwegians compared to Scottish consumers. This applied to short-term and long-term adjustments in behaviour due to the Chernobyl accident (see Table 2.) as well as other concerns about food safety.

Table 2. Short and long term changes in consumption due to the Chernobyl accident. Percentage of respondents indicating reduced consumption (Grande et al., 1999)

	Short term reductions		**Long term reductions**	
Food Product	**Norway**	**Scotland**	**Norway**	**Scotland**
Lamb	43.9	32.7	20.8	17.0
Beef	16.5	28.1	8.8	15.0
Reindeer	47.4	---	27.0	---
Wild mushrooms	40.4	19.0	24.4	10.0
Game (moose/venison)	37.2	17.0	21.2	11.0
Milk	7.8	19.6	4.1	7.0
Wild berries	---	20.3	---	9.5
Honey	---	16.3	---	8.5

In the willingness to pay (WTP) part of the study 89% of Scottish respondents favoured lamb and milk from non-affected areas and 55% of Norwegians opted for the untreated lamb. Twenty-five percent of Norwegians selected the lamb treated with countermeasures and 20% were indifferent. Mean WTP for lamb from unaffected areas was +29% and +37% of the current price, respectively, in Scotland and Norway. For milk in Scotland mean WTP was higher at +60% of the current price.

A set of indices was constructed to investigate the influence of risk perception and risk-averting behaviour on WTP for risk reduction. A pooled analysis for the two countries showed that WTP for untreated lamb was significantly affected by the Radiation Risk Behaviour Index, family status, degree of trust in health authorities and country, with Norwegians willing to pay more. However the Radiation Risk Perception Index had no significant effect.

Conclusions

Consumers are concerned about risks which 'scientific opinion' does not recognise. This is illustrated by the willingness of Scottish and Norwegian consumers to pay more for lamb and milk from areas not affected by radioactive fallout compared to the same products made 'safe' through countermeasures. Risk perception and risk-averting behaviour with respect to radiation risks from food are not closely correlated but risk perception can influence willingness to pay for risk reduction. Risk perception can most likely be influenced through information from experts and health authorities. However, potentially strong influences from previous experiences of food safety issues (Grobe & Douthitt, 1995) may make it difficult for authorities to increase the acceptability of countermeasures in food production. Further research should explore whether increased information on countermeasures is able to modify the consumer's perceived risks and make products more acceptable in the event of future contamination scenarios.

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DISCUSSION SESSION 2

Radioactivity in Different Foods

Question 1

Richard Bramhall (Low Level Radiation Campaign)

This is a question for the organisers of this Conference really. I am very concerned that this session had such an emphasis on the questionable concepts of average dose and average concentrations and dietary uptakes. The question is, why is there no presentation on sea-to-land transfer of radionuclides particularly their particulates - there is transfer to land other than through the food chain or food web - and its effects on human populations? Why was an expert such as Chris Busby not invited?

Ken Collins

There is a session right at the very end of the conference which allows you to raise points which you think have been omitted and you can raise it there. In the meantime the organiser of the conference will now have taken note of what you just said and will be happy to answer it then.

Question 2

Ian Fairlie (independent consultant)

I would like to ask Dr. Mitchell about technetium-99. We would like to hear his comments on the gross contamination of seafood from the Irish Sea with technetium-99 discharged from Sellafield.

Peter Mitchell (University College, Dublin)

In 20 minutes it is very difficult to cover everything. I think we would all accept that. The reality is that the doses that accrue to the critical group, the Sellafield critical group of consumers, are not dominated for example by technetium-99, rather they are dominated by plutonium and americium, both of which are of historic origin, arising as they do from the heavy discharges of the mid-seventies. An exception, of course, would be the one I did mention and I made reference to the levels, the high levels, of technetium-99 in, for example, certain types of crustacea, in particular lobster, and I recall making that point.

The other point I would make is that the radiotoxicity of technetium-99 is not very high. It is relatively low in the pecking order if I recall the table we had, and its half-life is very long. So, it is not particularly radioactive and further it is not a particularly energetic beta emitter and, of course, it is a pure beta emitter. I think these are as many comments as I can make at this stage.

Question 3

Heleny Florou (National Centre for Scientific Research "Demokritos")

My question is a technical one. I am asking Dr. Nies about the biological half-life evaluation made in codfish. How did you estimate it, by field measurements, i.e. from field observations (sampling from contaminated waters), or in lab experiments, or maybe in a combination of the two approaches?

Hartmut Nies (Bundesamt für Seeschifffahrt und Hydrographie)

In this case the model was set up to follow the concentration which was measured finally, and in addition a biological half-life of 250 days was applied to the fit in this case; the application of this biological half-life improves the model simulation to even a better fit to the measurements.

Question 4

Deborah Oughton (Agricultural University of Norway)

A question to Carol Salt: I really liked your pointing out that when you were asking your population to give responses on risk that this was perceived risk. I think this is an important point. My experience is that one of the main problems with communication of risk between experts and the public is that experts often assume that risk means probability of harm. The public has a completely different interpretation of risk and it doesn't necessarily have anything to do with probability of harm. If I understood correctly, you were specifically asking the population what they felt their likelihood of getting ill was?

Carol Salt (University of Sterling)

We asked them two things. First we asked them what they thought the likelihood was of them contracting the illness. That was the first question: How likely do you think it is that you will become ill from one of these risks? And then we also asked: How worried are you about this? Because we also thought that this was an important piece of information to get.

Deborah Oughton (Agricultural University of Norway)

Were they correlated?

Carol Salt (University of Sterling)

No, there was an inverse relationship. When we looked at all the risks (food and non-food), Scottish people overall thought they were more likely to become ill than Norwegian respondents, but we also found that they were less worried about ill health than Norwegian respondents.

Question 5

Gerard Menezes (Trinity College, Dublin)

I have seen one or two figures about the contamination of fish, not necessarily compared to contamination of fish in the 1970s, but more compared to contamination of fish in different oceans. I am wondering if Prof. Mitchell can comment on that. We just saw figures comparing to the 1970s and if you say that the 1970s were particularly bad then it looks like our figures for now are particularly good. But that does not really mean anything. It should be compared to fish caught in South America or in the Antarctic or in the Pacific Ocean.

Peter Mitchell (University College, Dublin)

It is a big question, but I think that one should appreciate that global fallout was heaviest in the northern hemisphere. It was concentrated largely at mid-latitudes and there would have been a significant level - compared to today - of caesium and so on in fish, and this is before significant discharges from spent-fuel reprocessing commenced. But if you go to the southern hemisphere, in general, radioactivity levels - artificial ones from fallout - were very, very much lower. As a ball-park figure you could perhaps take a factor of four or five as the difference between the levels. The easiest way to do it is look at seawater concentrations - I do not have them in front of me - and using the figure that was given by Hartmut Nies earlier, for example, for cod with a concentration factor of some multiples of ten, you can work out roughly what it would be. But basically very much lower than they were in the mid 70s, for example, in the eastern Irish Sea. Very much lower.

Question 6

Gilbert Eggermont (SCK-CEN and University of Brussels)

I have a question to Mrs. Salt. You presented a very interesting talk on perception. Can you apply your methodology on the perception and the behaviour of people regarding "clearance" tomorrow? We had with this issue a major change in the radiation protection policy of the recent years. We got criticism from the steel industry that the perception towards slightly radioactive products, consumer products, like for instance steel for the car industry, was not looked for in our clearance approach, as we did not consider the perception of the public either. Is your methodology applicable in a correct way to clearance?

Carol Salt (University of Sterling)

Yes, I would say the methodology that we applied is based on a big body of knowledge on how to ask people about these things. This is a methodology that can be applied to what you were talking about. I think it would be very interesting because of the way in which people's perceived benefits influence the way they balance risks and they see trade-offs. If there is a product that they see a large benefit in then they may be more willing to make a trade-off with the risk.

Question 7

André Maïsseu (WONUC)

My question is a technical one. It is about the model used, about measuring the radioactivity close to the North Pole. I did not understand clearly what is possible and I would like to have, but in very short words, some information about the model. Is the speed of the movement of the ice coherent with the results presented for the eventually possible Sellafield effluents' consequences? Is it only a model or did you make some measurements at the North Pole to verify your calculations?

Hartmut Nies (Bundesamt für Seeschifffahrt und Hydrographie)

I'll try to answer. I am not quite sure if I fully understand the question. We used a model which is used normally for climate change modelling and we know that the ocean water is the main player in the field of climate change. We used the model, which comprises the North East Atlantic including the total Arctic Ocean, in order to trace the real discharge from Sellafield, well soluble material, the caesium-137, through the North Sea and finally along the Norwegian coastal current. This current system is well-known, very well-known for many years. We were very happy that our model that we used in this case represents very well the measurements over many years. As far as you said that in the Arctic Ocean the movement is controlled by ice, this is partly true, that's a little bit more complicated, because you have the transpolar drift of the ice. There came up the question if this ice could move over the Arctic Ocean into the East Greenland Current very rapidly and could carry highly contaminated material from the former dump sites of the Soviet Union in the Kara Sea or the Barents Sea. But we came to the conclusion that this contribution is relatively low. In this case you have very different types of water movements and current systems in the North East Atlantic and also in the Arctic, and this was all included in the model.

Question 8

Rick Nickerson (KIMO)

My question is to Carol Salt. I found your talk very interesting in terms of perceptions but on your 'league table of trust', did you do any surveys on consumer groups and the advice they give?

Carol Salt (University of Sterling)

We had to be very selective in the survey because we had to cover a number of sources of trust in both countries without overloading people too much. We were already very worried that the questionnaire was far too long and a lot of people would refuse to do it because it was many, many pages to fill in. From other literature I understand that consumer organisations rank very highly as sources of trustworthy information on food safety. So I would not disagree at all.

Question 9

David Cancio (CIEMAT)

After the presentations and the conclusions concerning the marine, fresh water and terrestrial environment it is clear that most of the dose comes from natural radioactivity, by orders of magnitude. Also the results in some contaminated areas such as the Irish Sea for example and of the Chernobyl catastrophe show this. Are we really concerned with man-made radioactivity or do we have to look preferentially to the natural one? This is a question for probably Brenda or Peter.

Brenda Howard (Centre for Ecology and Hydrology - Merlewood

I think it depends on whether you are looking at collective dose or individual dose, and also the time over which you are looking at the doses. For terrestrial ecosystems, agriculture associated with improved ecosystems as opposed to extensive ecosystems provides a majority of foodstuffs for the majority of people in Europe. So they are very important sources of food and therefore even if transfer is lower to them they still provide most of the intake. But for individuals, some groups in society select products from semi-natural ecosystems which then becomes relatively important.. So, I think it depends on your criteria and what you are looking at.

Question 10

Tom Ryan (Radiological Protection Institute, Ireland)

My question is for Dr. Salt. One of the interesting conclusions of your study was that there was a memory effect, that many years after the Chernobyl accident many people were still not buying or still not consuming some products. And I was just wondering, did you compare that conclusion with other types of statistics like consumer statistics, retail statistics, and was your conclusion borne out by those statistics?

Carol Salt (University of Sterling)

I am having to severely scratch my head here. As part of the project we did look at general consumption statistics to try to distinguish between general trends and reactions to the Chernobyl accident. For instance some of the reduction in the consumption of red meat was at least partially a general trend. We had asked people very specifically whether they thought that they were still making adjustments in their consumption as a result of the Chernobyl accident and so if we were inferring otherwise we would say they hadn't been truly reflecting their behaviour so they were giving us these figures based on changes in behaviour due to Chernobyl, not due to anything else. But I think people do sometimes mix these things up because we found that with beef in Scotland people said they were eating a lot less beef. However we believe that they were more likely doing that because of mad cow disease and not because of the radioactive contamination. So there is always scope for confusion about which food risk consumers are actually responding to and it would be preferable to be able to dig a little bit deeper and actually try to get into a dialogue with people.

Question 11

Ian Fairlie (independent consultant)

This is a question for all members of the panel. Your talks were very interesting indeed. At the present moment, "Community Food Intervention Levels (CFILs) exist which I'm sure you're all aware of. Very roughly, these impose nuclide limits in food of about 1000 becquerels per kilogram – with different limits per radionuclide and for adults or children . Do they think that these levels are adequate? Or are too conservative? Or just about right? It's an important question, Chairman, because we've been talking here about food uptake after accidents. The Commission has recommended food intervention levels and it would be interesting to know what the panel thinks as to whether these limits are adequate or not.

Ken Collins

These figures were developed as a result of Chernobyl, in fact.

Brenda Howard (Centre for Ecology and Hydrology, Merlewood Research Station)

This is a purely personal view, because I'm not an expert on dose at all. I understand how to calculate some of it somehow but it is not my discipline, but I do co-ordinate a project called "STRATEGY", which looks at countermeasures after accidents. As part of that we have been holding some extensive stakeholder consultations with groups in five countries across Europe under something called the FARMING network, which is co-ordinated by Ann Nisbet at the NRPB. We have been doing a lot of work on different countermeasures and also integral to that is how they relate to the sea fills and we have been consulting very widely on consumer organisations, milk producers, etc.. I think it's quite clear from their response, this stakeholder response to the sea fills that there's a lot more which will go into the decision about whether those sea fills are used and how they're used, not only by, well not necessarily by regulators but perceived by the public and how they would be considered by the people who actually handle the food and whether for instance the milk industry would be prepared to accept milk, which was under the CFILs or not and under which circumstance. So it's not a direct answer but I think there's going to be a huge number of other factors which come into those decisions other than just a number which is published by a certain authority.

Peter Mitchell (University College, Dublin)

I share Brenda's view, but I reflect back on the immediate post-Chernobyl experience. Certainly in my country considerable difficulties arose regarding milk exports to far-away countries - I shan't name them - where they sought zero radioactivity levels which, of course, had not existed since the commencement of weapons' testing, and that presented certain difficulties. In short, the constraints imposed by certain countries had little or nothing to do with modern radiological protection practice. In other words, those who have to harmonise basic scientific, if you like, radiological protection with other important issues such as the psychological aspects and public opinion, are compelled to compromise. And I think that's what's been done.

Ken Collins

There is an interesting institutional feedback from that particular question to the points that were being made this morning about the democracy or otherwise of Euratom and so on, because when the Commission made these proposals way back after Chernobyl, it was a Euratom based proposal if I remember rightly. What happened was the European Parliament led – if I may say so – by me at the time argued that this wasn't Euratom at all but was really an Internal Market matter relating to the Food Industry and Food Supply. Now, the institutional sophistication of this argument was that if there had been an internal market matter it would immediately have given the Parliament two readings instead of one and it would have introduced a greater level of democracy. We actually went to the European Court on it and the European Court found against the European Parliament and in favour of the use of the Euratom Treaty. I'm merely demonstrating the point that was made this morning that if you want to change it then you get at the heads of state in order to change the Treaty, but there's a limited room for manoeuvre if you use the present institutional arrangements.

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CURRENT APPROACHES FOR ASSESSMENT OF DOSES TO THE PUBLIC

Jane R Simmonds
National Radiological Protection Board, Chilton, UK

Radioactive material may be released into the environment routinely as a result of normal operations, due to an unplanned incident or following the disposal of solid radioactive waste. These releases can occur due to the use of radioactive material in nuclear power production, hospitals, industrial operations and for research purposes. An important part of the system of radiological protection is the assessment of the radiological impact of such releases. This paper outlines the methods used for assessing radiation doses to the public, the endpoints of such assessments and the models required.

Radiation doses may be estimated for both individuals and for population groups (the collective dose). Doses to individuals can be compared with the appropriate dose limits or constraints, while collective doses can be used to estimate health detriment, in the form of the number of possible health effects. Both individual and collective doses can also form an input into the optimisation procedure for effluent treatment systems.

The most obvious method for assessing doses to the public is through extensive monitoring of the environment, e.g. measuring activity concentrations in foods, air etc. and conducting surveys of habits of local people, e.g. the amount of locally grown food eaten, the amount of time spent on the beach etc. However, this approach is generally not feasible, due to the resources needed to obtain sufficient measurements and because in many cases levels in environmental media are below analytical limits of detection. Also if the radiation doses in the future are required then measurements are not possible. It is therefore necessary to use models to carry out dose assessments and a number of models are available with IAEA, 2001 and Simmonds et al, 1995 being useful references. Any models used should be robust and fit for purpose. Measures should have been taken to ensure that the models are valid. This means that the models should have been tested to ensure that they are behaving as intended and are an adequate representation of reality. This could be done by a comparison of model predictions and measurements of concentrations in the environment. An assessment may need to take account of accumulation in the environment and progeny ingrowth, e.g. if a site discharges plutonium-241 the dose from the progeny americium-241 must also be considered.

For any release of radionuclides to the environment the following basic approach is used to estimate radiation doses.

- The first step is to determine the source term – how much of each radionuclide is released into different environments. The chemical and physical form of the radionuclide also needs to be determined.
- The second stage is to determine the transfer of the radionuclides in the environment so that concentrations in relevant materials, such as air, water and food, can be estimated. Measurements could be used if available.

- Thirdly, the ways in which people can be exposed to radiation, the exposure pathways, need to be determined.
- Appropriate dosimetric models can then be used to estimate the radiation doses.

Radionuclides may be released to atmosphere or to water bodies and models are required to describe the transfer of radionuclides through the relevant parts of the environment to people. For example, radionuclides released to the atmosphere are dispersed due to normal atmospheric mixing processes. Radionuclides in air can lead to radiation doses through two main routes, external doses from photons and electrons emitted by radioactive decay and internal doses following their inhalation. As they transfer downwind radionuclides may be deposited from the atmosphere by impaction with the surface or due to rainfall. This transfer onto land surfaces may lead to further radiation doses by three main routes: external doses from deposited radionuclides; internal doses from inhalation of radionuclides resuspended into the air; internal doses from ingestion of radionuclides in food. The relative importance of these pathways depends on the radionuclide. Appropriate dosimetric models and habit data are also required to determine radiation doses.

A significant concept in the assessment of individual doses is the identification of groups in the population likely to receive the highest doses; so-called reference or critical groups. The term reference group as used in the European Union's Basic Safety Standards Directive (Directive of the Council 96/29/Euratom (CEC, 1996)) corresponds to critical groups as defined by the International Commission on Radiological Protection (ICRP) (ICRP, 1977)(ICRP, 1991). Two broad approaches are possible in specifying reference groups. The first involves carrying out surveys of the local population to determine their habits, where they live etc. From these surveys the people who are receiving or who received the highest doses can be identified. The second approach involves using more generalised data to establish generic groups of people who are likely to receive the highest doses. The two approaches can be used separately or a combination of both used for example local surveys of consumption of seafood used in conjunction with consumption rates of terrestrial food based on more generic data.

An important factor in carrying out a dose assessment is whether the aim is to be realistic or cautious. Cautious assessments may be carried out to ensure that dose limits or constraints are unlikely to be exceeded. The assumptions adopted regarding the location and behaviour of the reference group would be cautious, for example, for releases to atmosphere people may be assumed to live within a few hundred metres of a discharge point and to obtain all of their food there, which is eaten at high rates. Article 45 of the EU's Basic Safety Standards Directive (CEC, 1996) explicitly requires that Member States competent authorities shall ensure that estimates of dose from practices subject to prior authorisation shall be made as realistic as possible for the population as a whole and for reference groups. The group of experts set up under the terms of Article 31 of the Euratom Treaty have recently issued guidance on the realistic assessment of radiation doses to members of the public due to the operation of nuclear installations under normal conditions (EC, 2002). This guidance considers all stages in the assessment of doses to reference groups and discusses the balance between realism and simplicity. The most important recommendation is that to perform a realistic assessment then as much site-specific information as possible should be collected. The effort put into achieving a high degree of realism must be commensurate with the radiological significance and some simplification is possible. The report provides guidance on how a fair balance between realism and simplicity can be achieved.

Assessments of doses necessarily entail a series of assumptions about the behaviour of the reference group and about the transfer of radionuclides in the environment. The estimated mean dose to the reference group is therefore within a distribution of possible doses. There are two aspects to this distribution referred to as the uncertainty and the variability. The uncertainty reflects the amount of knowledge about the system being investigated and relates to how accurately the dose can be estimated; for example, how well are all of the parameter values in the calculation of doses known? The variability refers to the actual differences that occur both in transfer in different environments and between individuals within a group; for example, differences in how much of a particular food is eaten or where individuals spend their time. This topic is discussed in more detail in (IAEA, 1989) and in further papers at this conference.

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UNCERTAINTIES IN RISK ASSESSMENT

Experience from the Nord-Cotentin Radioecological Study

A. Merle-Széréméta, J. Brenot, E. Chojnacki
Institut de Radioprotection et de Sûreté Nucléaire, B.P. 17, 92262 Fontenay-aux-Roses, France

Abstract: *The Nord-Cotentin radioecological study was launched in 1997 to assess the leukaemia risk in the Beaumont-Hague canton of the Nord-Cotentin region that could be induced by the radioactive discharges from nuclear facilities located in the region. The risk estimate published in 1999 was very low in comparison with the incidence of leukaemia recorded by previous epidemiological studies and a debate irrupted, partly because the uncertainty associated with the risk estimate was not evaluated. As a consequence, an in depth uncertainty analysis was initiated in 2000 and its results published in 2002. This paper presents the methodological approach retained, the choices that were necessary to go forward, the results with their limitations. The scientific benefit of the analysis and the difficulty to communicate its results are underlined.*

1 INTRODUCTION

In 1997 French authorities commissioned the Nord Cotentin Radioecology Group (GRNC) to assess the risk of radiation-induced leukaemia in the Beaumont-Hague canton of the Nord-Cotentin region. The GRNC submitted its findings in 1999. The expected number of excess leukaemia cases for people aged 0 to 24 in the canton of Beaumont-Hague exposed to the radioactive discharges from the nuclear facilities located in Nord-Cotentin was estimated at roughly 0.002 cases for the period 1978-1996 [1]. This result was considered as the best estimate in the present state of knowledge, but the associated uncertainty was not quantified. Also in 2000, French authorities asked the GRNC to conduct a study about uncertainties associated with the main parameters of the estimation of leukaemia cases attributable to the Nord-Cotentin nuclear facilities.

This study was conducted in four stages: definition of the scope of the study and identification of predominant parameters, determination of the probability distributions and ranges of values of the predominant parameters, sensitivity analysis (not presented here), and finally uncertainty analysis.

Where lie uncertainties in risk assessment?

- on parameters which characterize the nuclear facility and the area in question, i.e. the canton of Beaumont-Hague. This basically means radioactive discharges from the Cogema reprocessing plant at La Hague[3], the atmospheric transfer coefficients (ATC), and the lifestyles of canton residents – particularly their dietary habits and time budget. The values of these parameters are taken from measurements or surveys, or are extrapolated;

[3] The impact of the other nuclear facilities in Nord-Cotentin is negligible.

- on parameters that are integral parts of the models, such as marine and terrestrial transfer coefficients. The values of these parameters are often generic, although some can be adapted to the study area;
- on models themselves, which represent complex transfer phenomena with varying degrees of precision.

In this study, in compliance with the authorities demand, the sources of uncertainty considered are those related to the parameters and models were not re-examined. Once the uncertainties are quantified, one must see how they combine to produce uncertainty in the risk assessment. To do so, the probability method, i.e. the Monte-Carlo simulation, was adopted first because it is usual; the uncertain parameters are modelled by random variables. The risk probability distribution is obtained by using models of transfer, impact and risk that link the risk to the uncertain parameters. Results of this method were discussed and a second method less demanding in terms of available information was proposed, the possibilistic method [2].

2 METHODOLOGY FOR THE UNCERTAINTY ANALYSIS

2.1 Selection of parameters

The risk calculation involves several thousand parameters used to model atmospheric dispersion, marine dispersion and transfers of the radionuclides released in marine and terrestrial compartments, and to deduce from that the dose to the population concerned and then the associated leukaemia risk (cf. Figure 1).

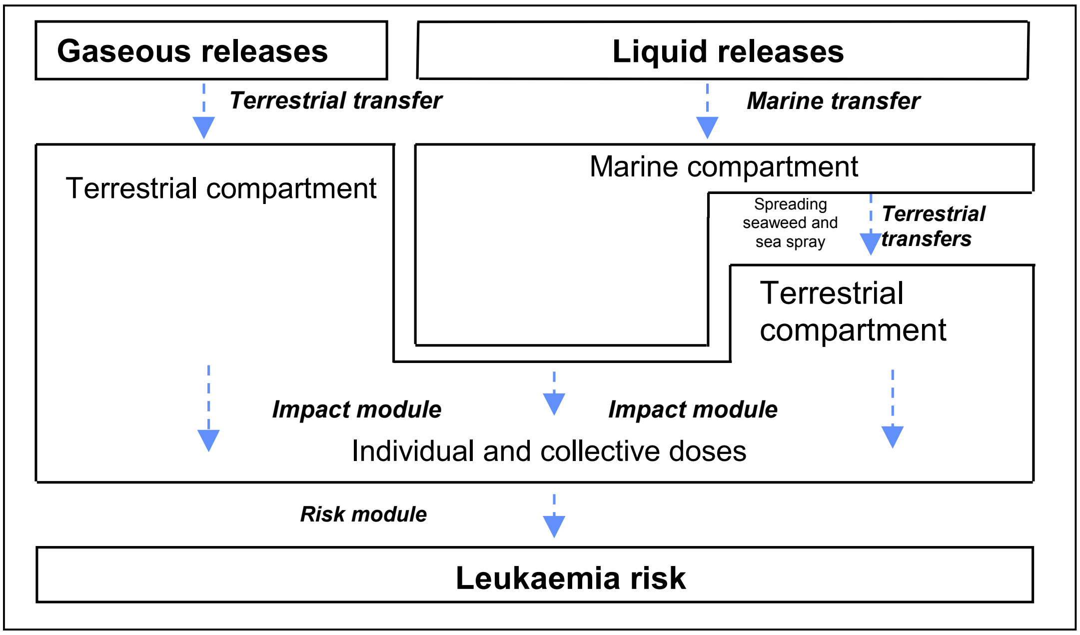

Figure 1: General description of the calculation procedure

It is impossible to estimate the uncertainty of each parameter involved in the risk calculation. The selection of the parameters for which uncertainty was dealt with has been carried out in two steps: limitation of the scope of the study and identification of the predominant parameters. Unselected parameters kept the values previously attributed by the GRNC when the best estimate of the leukaemia risk was calculated.

To limit the scope, the uncertainty study focused on the collective *ex utero* risk of leukaemia associated with routine discharges from the nuclear facilities located in the Nord-Cotentin region (0.0009 cases of leukaemia for the period considered), denoted more simply as "risk" in the rest of this paper. No uncertainty was assigned to dose or risk coefficients, for which there is an international consensus.

The predominant parameters were identified by examining each step of calculation. Selection criteria were devised to ensure that these parameters represented at least 95% of the risk. The criteria were as follows: a radionuclide in an exposure pathway was selected if it alone contributed to more than 0.5% of the risk; a transfer or lifestyle parameter in an exposure pathway was selected if its contribution to the risk was greater than 0.15%. This selection approach led to the choice of 214 predominant parameters to be varied for the purposes of the uncertainty analysis.

2.2 Distributions of the predominant parameters

When constructing the probability distribution of the values attributed to each parameter, three situations occurred:

- specific data on the nuclear facility and the study area were available from previous specific studies conducted on site. Then the distributions of possible parameter values were specific to the site;
- no data were available from specific studies conducted on site, but bibliographical references could provide "generic" values or values close to the conditions existing on the site;
- no data are available, whether from specific studies conducted on site or from bibliographical research. Then parameter distributions are constructed from hypotheses based on analogies or expert opinion.

Local data were taken in preference to national or international data, average levels of radioactivity in the environment rather than extreme values and average lifestyles rather than particular behaviours. These choices reflect the fact that the calculation concerns a large cohort of individuals, aged 0 to 24, living in the whole Beaumont-Hague canton, and who could have been exposed to the radioactive discharges from the La Hague facility over a long period (since 1966).

To determine the joint distribution of the entire set of parameters, dependencies between parameters were first examined qualitatively. Dependencies, even when easily identified, are difficult to quantify. Nevertheless this task is important: the fact that some parameters are correlated (i.e. do not vary independently of each other) has a major influence on the probability distribution of the estimated risk, especially the probability of the extreme values. Independence was assumed for most of the parameters (either because it seemed logical, or by default) and correlation coefficients close to 1 or -1 were only associated with the obvious dependencies.

2.3 Uncertainty analysis by the probabilistic method

The probabilistic method is widely used to analyse uncertainty [3] [4]. It involves a Monte Carlo simulation that consists of making a random sample of *n* values for each of the parameters so as to calculate *n* values for the risk, and from that deduce its probability distribution. This means performing the calculation n times. The distribution obtained can be described by fractiles, i.e. the risk values associated with a given level of probability. The quality of the fractiles is measured by confidence intervals whose width depends on the number of calculations performed and is not affected by the number of uncertain parameters. The 5% and 95% fractiles can be accurately estimated from a sample of 1000.

2.4 Uncertainty analysis by the possibilistic method

To implement the probabilistic method properly, one must know not only the distributions of each parameter and the dependencies between the parameters, but also the joint probability distribution of the full set of parameters. This latter information is not available and in practice numerous hypotheses must be made [5] which strongly affect the results [6]. For these reasons, it appeared appropriate to develop a complementary method, the possibilistic method [7] that would require fewer hypotheses.

Possibilistic analysis calls for breakdown of the risk into basic components, each representing the risk associated with an age group, exposure pathway or, where appropriate, type of food. The uncertainty inherent in each of these components is evaluated by the probabilistic method. Based on its probability distribution, each risk component is also assigned a "possibility distribution"[4]. The final possibility distribution of risk is obtained by "summing" the basic possibility distributions. The upper and lower bounds for this final result are the sums of the corresponding bounds of the basic components.

3 RESULTS

3.1 Probabilistic method

In Figure 2, the risk is expressed as a percentage of the reference risk (the risk estimated by the GRNC at 0.0009 cases). The probability distribution of the risk is very narrow (factor 2 to 3 between the 95% fractile and the 5% fractile). Moreover, the reference risk is located in the low values of this distribution (2% fractile). These results are due to the use of the Monte Carlo simulation and to the hypotheses adopted (large number of parameters selected, assumed independence of most parameters, distribution of parameters generally asymmetric with a mean higher than the mode).

[4] To determine a possibility distribution for a variable, each numerical value is assigned a possibility coefficient ranging from 0 to 1. For each basic component of risk, values higher or lower than the extremes obtained by Monte Carlo simulation are considered impossible (possibility = 0), median values obtained by Monte Carlo simulation are deemed fully possible (possibility=1) and intermediate values are assigned possibility coefficients proportional to their fractiles.

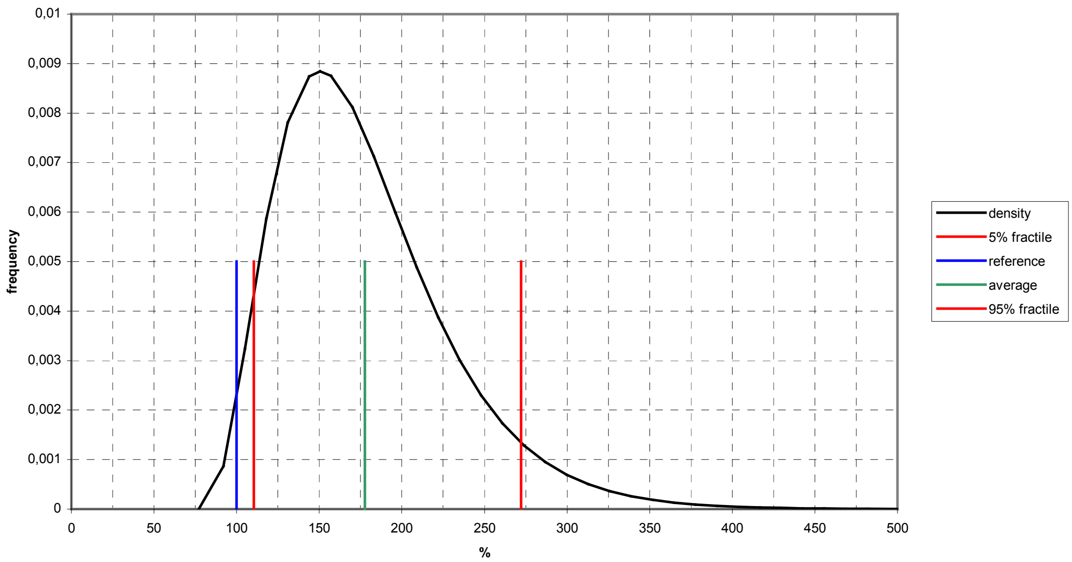

Figure 2: Distribution of the risk, obtained by the probabilistic method

3.2 Possibilistic method

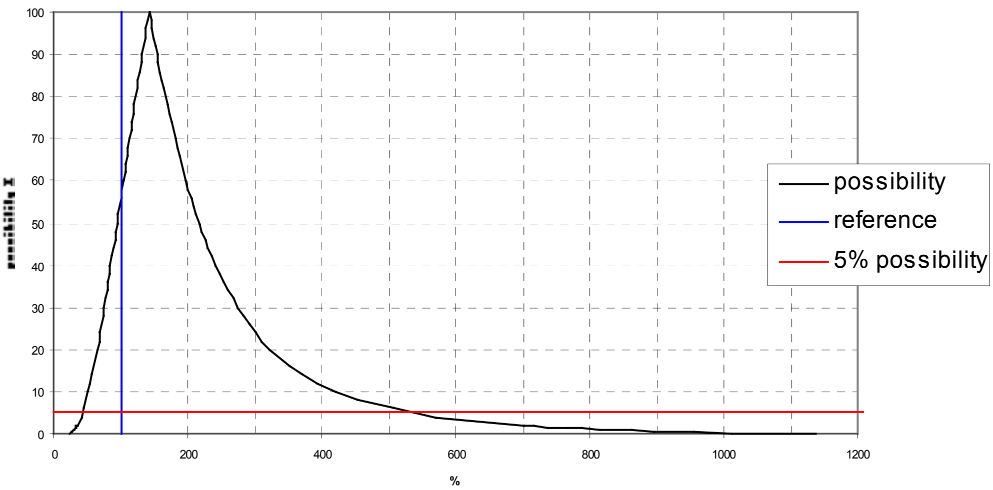

Figure 3: Distribution of the risk, obtained by the possibilistic method

The possibility distribution of the risk is shown in Figure 3. In this graph, as before, the risk is compared with the reference risk estimated by the GRNC at 0.0009 cases. The uncertainty calculations using the possibilistic method produce a wider risk distribution: risk values with possibility greater than 5% are between 0.4 and 5 times the reference value. This wider distribution is due to the fact that hypotheses concerning parameters' dependence or independence are not required. The reference risk value corresponds to a possibility of 60%, so it is slightly off-centre towards the low values. That is because the approach uses risk component distributions that are the result of running a Monte Carlo simulation both on environmental radioactivity and on lifestyles parameters for which the distributions are asymmetric.

4 CONCLUSION

Uncertainty analysis used two complementary methods – probabilistic and possibilistic – to determine ranges of variation for the risk. Probabilistic analysis resulted in a range of values from 1.1 to 2.7 times the reference risk (or 0.001 to 0.0024 cases of leukaemia); and the possibilistic approach yielded a range from 0.4 to 5 times the reference risk (or 0.0004 to 0.0045 leukaemia cases). All of these estimates were well below the number of cases of leukaemia actually observed in the same population over the same period (4 cases while the number of cases expected from regional public health statistics is only 2) and far less than the estimated risk of radiation-induced leukaemia from all (natural, medical and industrial) sources of exposure combined (0.84 cases). At this stage, a negative answer can be given to the question: are the 2 cases observed in excess due to the routine discharges of radioactive effluents from nuclear facilities?

Nevertheless, the uncertainty study performed has some limitations. One concerns the scope of the study. Since the study covers only the risk of leukaemia resulting from *ex utero* exposure to routine discharges, estimated at 0.0009 cases (reference risk), the risks associated with either incidents and accidents (fewer than 0.0012 cases) or with *in utero* exposure (0.0003 cases) are dismissed. There is another noteworthy limitation: uncertainties relating to dose and risk coefficients could not be considered here because scientifically accredited data on the subject are missing. Another limitation lies in the fact that models used were not challenged; at the time of the study they were the best available or the only ones. Discussing the models is a matter for research.

An uncertainty study conducted on the scale described here for radiological impact evaluation is exemplary in more ways than one: diversity of the models used, parameters processed by the hundreds, choice of different methods to quantify uncertainty. Efforts devoted to determining variation ranges and parameter distributions require much more time than giving initial values to parameters. One must focus on the entire knowledge available at the time of the study and avoid hypothetic considerations. The goal is to obtain a distribution as realistic as possible for the risk, even if the best estimate which results from expert judgment is not considered as such. Efforts made are valuable because but they enhance existing know-how by providing a database for future sensitivity and uncertainty studies. Application of possibility theory to this type of evaluation merits also further reflection.

Presentation of uncertainties in risk assessment to lay persons is uneasy for various reasons. Concepts of probability, possibility, distribution, risk are already difficult to understand because of various acceptions and the "good common sense" does not fit the scientific definitions that are essential to undertake calculations. Moreover when concepts are associated through statements such as "the 0.95 probability interval of the risk is ...", the difficulty is increasing necessarily. A qualitative description of the uncertainties associated with basic parameters is understood in general, quantification of uncertainties is considered as the job of specialists, and propagation of uncertainties is mysterious. Making uncertainties in risk assessment clear in people's minds constitutes a real challenge to risk communicators.

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COMMUNICATING UNCERTAINTY TO THE PUBLIC

Zitouni Ould-Dada
Food Standards Agency
Radiological Protection and Research Management Division
Room 715B, Aviation House, 125 Kingsway
London WC2B 6NH, United Kingdom.
Tel: +44 (0) 207 276 8774 ; Fax: +44 (0) 207 276 8779
E-mail: zitouni.ould-dada@foodstandards.gsi.gov.uk

1. Introduction

Estimation of public exposure to radioactivity is not a precise process as there are a number of sources of uncertainty and variability in the radiation dose assessment process (Smith *et al.*, 1998; Thiessen *et al.*, 1999; Ould-Dada *et al*, 2002). The uncertainty reflects the current degree of knowledge and the level of accuracy in estimating doses. The variability relates to the differences in environmental transfers and people's habits. Estimated doses to members of the public from radioactive discharges are therefore subject to uncertainty and may cover a significant range of possible values. Advances in computer technology and applied statistics have provided the opportunity to investigate and quantify uncertainty. It is important, however, that uncertainty is communicated effectively and clearly to members of the public to ensure that they understand the message and to enable them to make informed decisions about their exposure. However scientifically sound the results may be, they are of limited use unless they are explained clearly to a non-specialist audience.

The Food Standards Agency (FSA) was set up to protect the interests of consumers in relation to food and base its decisions and advice on the best available scientific evidence. It recognises the need to consider uncertainty and variability in its risk assessment process to provide better protection for consumers. For these reasons, and through its policy of openness, the FSA is developing new approaches to addressing and communicating risk and uncertainty. For example, the FSA is developing probabilistic models to characterise uncertainty in model predictions and the estimated radiation dose to members of the public. It is also conducting pilot studies with members of the public to evaluate how best to communicate results from probabilistic assessment to non-expert audiences.

This paper presents some general principles of communication of uncertainty to the public. Results from a small pilot study conducted with focus groups are also presented.

2. Some key Aspects

There are some general aspects that are important when considering communication of risk and uncertainty with the public. For example, the public is not a single entity but is a mixture of individuals with different levels of knowledge and perception of risk. To communicate effectively with the pubic, it is therefore important to use material that matches the level of understanding of the audience. Communication should also use language and methods that are suitable for the intended audience. The public is also usually represented by pressure groups and these should be considered when communicating with the public. When communicating with the public, it is important to note that the public is more interested in substantive information than in statistics. More importantly, perception is reality for the public. All these make communication of uncertainty a challenging task. Members of the public, however, need to understand the process of exposure assessment and risk if they are to understand the uncertainty associated with the estimated dose or risk.

3. Methods of Communication

Uncertainty in dose estimates can be communicated in the form of tables or graphs. Material should be tailored to the needs of the audience and the terms used to express uncertainty need to match the audience's level of understanding. When using tables or graphs, it is important to aim to convey a single message for the public to understand. The table or graph should also illustrate a clear and simple message. For example, graphs showing probability density functions should be avoided as they are meaningless to the public. As stated earlier, because the public is not a single entity, different methods of communication may be needed for different audiences. It is important to note, however, that there is no step-by-step recipe for a successful communication. In the early stage of developing a communication approach, it is important to identify the intended audience and its level of understanding. The best way then to find out whether or not the communication approach would be suitable is to test it with the intended audience. The feedback from the audience should then be considered in revising the approach and this process may be repeated as necessary until a satisfactory communication approach is achieved. The main stages in developing a communication approach are summarised in Figure 1.

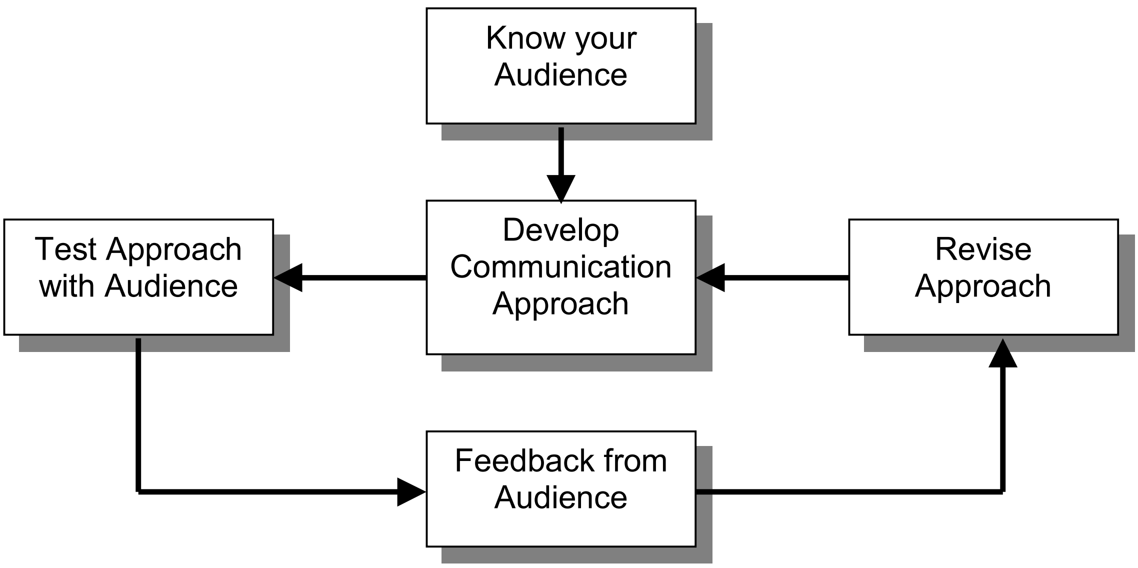

Figure 1. Key stages in developing a communication approach

4. Example from a Pilot Study

In its framework of developing probabilistic assessment approach to address uncertainty in dose estimates, the FSA commissioned a small pilot study on how best to present results from probabilistic assessments to the public (Collier and Wright, 2002). The study was conducted with three audiences: local residents, 'informed' non-residents (people living away from nuclear sites who have some general knowledge of nuclear issues), and NGOs (i.e. environmental campaigners). The three audiences were presented with a worked example which is a report of a dose assessment for a nuclear site. Participants were sent copies of the worked example to read and consider for comments. Participants were then interviewed and a questionnaire sent to them to evaluate their understanding of the information presented in the dose assessment document. The main information presented in this study regarding uncertainty in dose estimates is similar to that shown in Table 1.

Dose (μSv/y)	Adults		Children		Infants	
Upper estimate (97.5th percentile)	245	Food 1	200	Food 1	225	Food 1
Mid estimate (50th percentile)	200	Food 2	125	Food 2	160	Food 2
Lower estimate (5th percentile)	55	Food 3	25	Food 3	40	Food 3

Table 1. Presentation of uncertainty/variability in dose estimate.

With regard to uncertainty, the feedback from the public can be summarised as follows:

- The public understood the information presented with no confusion.
- The public preferred a short and simple version but wants full information to be given to NGOs.
- The public wanted access to information on demand.
- The public expressed confidence in the FSA's assessment method and communication approach. This was a response to FSA activities being carried to reduce uncertainty associated with dose estimates (e.g. research, monitoring and model validation).

5. Conclusion

Communicating uncertainty to the public is a challenging task and there is no step-by-step recipe for success. Communication uncertainty is more than just choice of words and numbers. For example, communicating uncertainty may not in itself be effective if people don't understand the dose assessment process and the radiation risk concept. Communication is also likely to fail if the source of information is not trusted. Communicating uncertainty is also communicating about what gives you confidence in the dose assessment process.

Communication should use material and terms that are suitable for the intended audience. To establish a communication approach, it is important to identify the intended audience and its level of understanding of the issue. The best way to find out whether or not a communication approach would be suitable or not is to test it with the public and consider feedback to improve it. More than one communication method may be needed to communicate with different audiences.

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DISCUSSION SESSION 3

Assessment of Population Exposure

Question 1

Richard Bramhall (Low Level Radiation Campaign)

So many questions could be asked of this session but I have only to Dr. Simmonds: In the context of realism and conservatism, could you say what is a realistic mass of tissue for which to consider dose in respect of a small particle of for example plutonium oxide immobilised in a child's tracheo-bronchial lymph nodes?

Jane Simmonds (NRPB)

I'm afraid this is a far too specific question for me to answer, because I don't do the radiation effects parts of assessments, but I do radiation transfer through the environment assessment.

Question 2

Ian Fairlie (independent consultant)

To all members of the panel: We've been discussing uncertainty this morning. In their view, do they think that the levels of uncertainty that they have identified in their dose assessments are so high that they are unreliable for use in a regulatory way?

Jane Simmonds (NRPB)

No I don't think that they are so high that you can't use dose assessments in a regulatory way. I think that when the dose limits and dose constraints were set it was taken into account that there were uncertainties in the way that you assess doses. I think that when we do assess doses the tendency is always to err on the side of caution anyway. Even when you're trying to be realistic you tend to always assume things that are cautious, so that in general you are more likely to overestimate than underestimate any doses. There is good evidence from situations where you have been able to measure radiation in people, for example at Seascale a number of years ago, that then showed that the dose assessments were overestimating what people were actually getting into their bodies, and this gives confidence in the dose assessment process. So, we have to recognise the uncertainties but, no, I don't think they are too high.

Zitouni Ould-Dada (Food Safety Authority)

Yes, I do agree with Jane. When estimating future exposure to members of the public, a series of cautious assumptions are made to deal with uncertainty in order to overestimate rather than underestimate doses. For example, discharges from nuclear sites are assumed to occur at 100 % of the discharge limits but doses based on environmental monitoring data around nuclear sites in the UK have always been lower than estimated doses. Efforts are also made to reduce uncertainty through research projects, surveillance, monitoring as well as model testing and validation. It is important that uncertainties are recognised, minimised and quantified wherever possible.

Question 3

Roger Coates (World Nuclear Association)

I actually think that my question has been answered by Jane Simmonds. Whilst acknowledging clearly that uncertainties exist within modelling there are occasions when the opportunity has been available to calibrate the models by measurements on humans. And I was intending to ask what information has come out of that calibration process. I think Jane has started to indicate or given the answer.

Jane Simmonds (NRPB)

I think I did answer the question. It does depend on the particular situation. At Seascale we tended to overestimate the doses because we were assuming that people were getting all of their food from local sources and they obviously weren't. For Chernobyl, where the distribution of activity was much more widespread the models were more in keeping with the doses that were obtained directly from measurements of people.

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RADIOACTIVITY AND ENVIRONMENTAL PROTECTION

R J Pentreath
Environmental Systems Science Centre, The University of Reading, Whiteknights, Reading RG6 6Al, UK

Introduction

The ICRP, in its 1977 set of *Recommendations* [1], stated that it believed that "*….if man is adequately protected then other living things are also likely to be protected*", although not necessarily at the level of the individual. This was later qualified and expanded upon in its 1990 *Recommendations* [2], in which it stated that, because of the high level of standard of environmental control necessary to protect man, by way of the transfer of radionuclides through the environment, it believed that other species are not put at risk. It also introduced other concepts by stating that occasionally "*…individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species*." This is still the current position, and great reliance has been placed upon these ICRP statements by regulatory and other bodies.

The statements have, nevertheless, attracted much comment and elicited a number of observations, such as:

- the ICRP did not define what it meant by any of the key words in its statements;
- it proffered no scientific evidence to back them up;
- in most 'natural environment' situations, humans are likely to be the least exposed to radiation;
- what if humans are absent from that environment;
- what if they have been removed for their own safety; and
- how do these statements relate – if at all – to any ethical, social, legal, or any other aspect of environmental protection?

It is probably this last point that has been the cause of much recent activity on the subject. The issue would however be much easier to resolve if there was a reasonably clear and general understanding of what was meant by the concept of 'environmental protection'; plus a reasonably coherent analysis and understanding of the effects of radiation on living things in general.

Fortunately, attempts are now being made to address some of these problems in the context of radiation protection of the environment, particularly by way of the ICRP [3] and research projects in Europe such as FASSET and EPIC [4].

The concept of environmental protection.

The sensible place to start in order to define the concept of environmental protection is that of environmental ethics, and this has indeed been the subject of a recent IAEA study [5]. Three dominant 'ethical views' were identified as having particular relevance to the development of the concept. These views apparently arise from debates about the basic philosophical questions of what has moral standing in the world, and why. The three may be briefly summarised as follows, bearing in mind that there are, of course, considerable ranges of views within each of them.

- The *anthropocentric* view is that in which human beings are the main or only thing of moral standing, and thus the environment is largely of concern only in so far as it affects human beings.
- The *biocentric* view is that in which moral standing can be, and actually is, extended to individual members of other species, and thus certain obligations towards such individuals arise as a consequence.
- And the *ecocentric* view is that in which moral standing can be extended to virtually everything in the environment, including abiotic features such as rivers and mountains, but the focus lies more with the entirety and diversity of the ecosystem rather than the moral significance of each and every individual component of it.

At an international level (either arising from, or in spite of, these various ethical views!!) there is now a good level of agreement, as reflected in international declarations and treaties, on the concept of environmental protection by way of what one might term the 'general principles' of attaining sustainable development, maintaining biological diversity, and the need to protect natural habitats on a large scale. There is, nevertheless, clearly a lack of coherence between some of these ethical views and principles and the way in which we (that is to say, different societies) 'manage' the environment. For example, with regard to general environmental management frameworks one might be able to identify, again, perhaps at least three different approaches:

- *environmental exploitation*, such as fisheries, forestry and agriculture;
- *pollution control*, where the aim is not to harm the environment generally; and
- *nature conservation*, where the aim may be to protect individuals, populations, ecosystems, or habitats from a wide range of potentially damaging activities.

Thus the practical consequences of all of these ethical and societal views, the adoption of general principles, and the application of different management practices, is that at national and international level there may now be a wide range of requirements that have to be satisfied, as expressed in different legal ways.

Radiation effects in an environmental context

Because of the lack of any overall framework, or systematic approach, to organising our knowledge on the effects of radiation on species other than man, it has been extremely difficult to answer questions about the environmental impact of radiation. This is in contrast to the success of the ICRP in its objective of, and approach to, the protection of the human animal. It has therefore been argued that there is a need to develop a similar systematic approach in order to demonstrate, explicitly, that the environment will also be protected, or that appropriate action could be taken when it was not, possibly by developing one or more sets of the equivalent of Reference Man; in other words, Reference Fauna and Flora [6,7,8].

Implicit in such an approach is an admission of the fact that we cannot yet provide a general assessment of the effects of radiation on the environment as a whole. But, by using a reference set of dosimetric models, plus a reference set of environmental geometries, applied to one or more reference sets of fauna and flora then, when applied to actual (or calculated) distributions of radionuclides in that environment, one should be able to make some sort of statement about the probability and severity of the likely effects of that level of radiation exposure on such individuals. The most useful broad categories of effect would be in terms of early mortality (and possibly morbidity), reduced reproductive success, and cytogenetic effects. These, in turn, would enable the issues raised with respect to environmental exploitation, biological diversity, and nature conservation to be answered.

Numerical values for managing different situations

With regard to the actual making of dose-effect assessments for the purposes of managing different situations, there are several possibilities. One is to draw comparisons with the range of natural or historic background radiation levels obtaining in a given area, plus the use of information on levels of radiation (doses and dose rates) that have been shown to have certain harmful effects. Thus logarithmic bands of what have been called *Derived Consideration Levels* for such Reference Fauna and Flora [7] could be compiled from the following sets of information:

- dose rates relative to normal, natural-background, dose rates; and
- dose rates that are known to result in early mortality (or cause morbidity), have an adverse effect on reproductive success, or result in scorable cytogenetic effects for such faunal and floral types.

One could then make an assessment of the likely consequences for individuals, the relevant population, or for the local environment generally, using these and other environmental data.

The *Derived Consideration Levels* banding could also be essentially on the same basis as that proposed for man [9] in terms of 'concern or *Protective Action Levels*', in that additions of dose rate that were fractions of background might be considered to be trivial or of low concern; and those that were one, two, three or more orders of magnitude greater than background would be of increasing concern because of their known adverse effects on individual fauna and flora. Other (non-radiobiological) factors would also have to be taken into account, particularly with regard to the nature and numbers (or fraction of the local population) of fauna and flora that were liable to be exposed within the different radiation exposure bands.

Discussion

There would be clear advantages if a systematic approach to evaluating impacts on the environment could be developed in a way that was similar to that for the protection for human beings, particularly in an environmental context. Thus, for any given spatial and temporal distribution of radionuclides in the environment, from any source, under any circumstance, one should be able to approach management decisions armed with a knowledge of both the relevant *Protective Action Levels* with respect to members of the public (based on Reference Man – or his secondary relatives) and, via the *Derived Consideration Levels*, with respect to the environment (based on Reference Fauna and Flora). These two '*bands*' would be independent of each other but derived in a complementary manner; and based on the same underlying understanding of the effects of radiation on living matter. And, in a practical sense, the two '*bands*' would (or could) each be related to the same concentration of a specific radionuclide, within a specific environmental material, at any particular site.

The manner of application of such a Reference Fauna and Flora approach would clearly depend upon the objectives of the evaluation exercise – again, essentially, with respect to what particular question one was trying to answer. This could be a general one, or relate to specific legal requirements. Thus it might be sufficient to demonstrate that an evaluation, appraisal, assessment or whatever had been done: for example, in relation to the provision of public or political reassurance, or in response to 'what if' questions in a public inquiry. Equally, however, it may be necessary to demonstrate how particular situations are to be handled, or how compliance with existing or forthcoming legislation is to be achieved. As already indicated (in addition to protection of the public) this latter requirement may now relate to environmental exploitation, pollution control or to nature conservation legislation.

An example of the implications of the last of these is provided by some European Directives. Two of them, in relation to particular species and habitats, collectively require that steps be taken to ensure that designated areas are maintained in, or restored to, "*favourable conservation status*" [10,11]. This 'status' may be differently, and explicitly, biologically defined for each and every site in a numerical way – such as percentage changes in the numbers of certain species, ratios of different species to each other, structures of populations of species and so on. Similarly, a third Directive [12] requires action to be taken to ensure "*good ecological status*" of aquatic ecosystems. It will probably therefore be necessary to demonstrate in all of these cases that controllable activities, including discharges from nuclear sites, would not have a detrimental effect on such factors, as variously defined for specific locations. This could be met by reference to the categories of biological effects discussed above.

Therefore the need to be able to demonstrate that different practices are 'safe' for the environment as well as for man is an ever-growing one. With respect to radiation, its development at this stage therefore needs to maintain a fair degree of flexibility. Nevertheless, it does open up the possibility of forming the basis for a more common approach to the impact of energy generation from all sources on both the human population and the environment [13].

Acknowledgements

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THE IUR CONSENSUS CONFERENCE STATEMENT

D.H. Oughton (1) and P. Strand (2)
(1) Isotope Laboratory, Environmental Chemistry Section, Agricultural University of Norway, P. O. Box 5028, N-1432 Aas, NORWAY
(2) Norwegian Radiation Protection Authority, P.O. Box 55 , Østerås, NORWAY

INTRODUCTION

A number of international organisations are focussing on a revision of radiation protection policy from the existing system that addresses only effects on man, to one that also addresses effects on the wider environment. These developments are expected to affect a wide range of stakeholders, including industry, regulators, scientists, users and the public. However, the development of such a system raises a number of challenging ethical questions, and many organisations have expressed the need to also consider the ethical and philosophical basis behind frameworks for environmental protection (IAEA, ICRP, IUR). In practice, the changes reflect the increasing challenges that the nuclear industry, authorities and regulators are facing within application of policy, including the need to address more widely such values as public acceptability, perception of nature, transparency and stakeholder involvement.

A number of the ethical issues are already familiar, if still controversial, within environmental philosophy and risk analysis, such as valuing the environment, animal rights, environmental justice, the precautionary principle, and differing cultural and social attitudes towards nature [1]. Practical management questions for radiation protection include the definition of harm, genetic change, the level at which damage is occurring (individual, species, ecosystem), and comparison of natural and man-made radiation. Other relevant issues are the public's perception of radiation risks and similarities between attitudes towards biotechnology and nuclear technology. Finally, authorities need to consider the increased public awareness and concern for environmental issues in general, and from the evolving integration of environmental protection into international convention and legislation, (i.e., Rio declaration, OSPAR, the Aarhus convention, the forthcoming World Summit on Sustainable Development) [2-6].

It is clear that developments in radiation protection of the environment will affect a wide range of stakeholders, including industry, regulators, scientists, users and the public. With this in mind, The International Union of Radioecology, supported by the Nordic Reactor Safety (NKS), arranged a "Consensus Conference" as part of an international seminar on *Radiation Protection in the 21st Century: Ethical, Philosophical and Environmental Issues* [7]. The purpose of the consensus procedure was to implement the consensus procedure at the start, rather than at the end of the development of legislation, giving stakeholders the opportunity to influence the ongoing procedure, without constraints that the consensus has to be reached at a legislative level [8]. The final consensus statement identified significant areas of agreement on protection of the environment from ionising radiation including guiding principles.

"Consensus Statement"

The next decade is likely to bring significant improvement in radiation protection. A number of international bodies are currently considering the development of systems for protection of the environment from ionising radiation. The nuclear industry, authorities and regulators are faced with increasing challenges on the practical application of policy, notably the need to address more widely such values as transparency and stakeholder involvement. In order to discuss these issues, 45 international experts representing various disciplines including Environmental Science, Health Physics, Radioecology, Ethics and Philosophy convened at the Norwegian Academy of Science and Letters, Oslo, 22-25th October 2001. The participants represented a wide spectrum of perspectives bearing on the question of radiation protection of the environment. The conference aims were to provide a forum for discussion of current issues in radiation protection and the environment, an input into international developments related to the protection of the environment, and to encourage wider participation in the debate. Participants met in working groups and *in plenum* to develop the main areas of agreement, which were as follows.

Guiding Principles

Humans are an integral part of the environment, and whilst it can be argued that it is ethically justified to regard human dignity and needs as privileged, it is also necessary to provide adequate protection of the environment.

In addition to science, policy making for environmental protection must include social, philosophical, ethical (including the fair distribution of harms/benefits), political and economic considerations. The development of such policy should be conducted in an open, transparent and participatory manner.

The same general principles for protection of the environment should apply to all contaminants.

Statements

- As part of the effort to revise and simplify the current system of radiological protection for humans, there is a need to address specifically radiological protection of the environment.
- There are several reasons to protect the environment including ethical values, sustainable development, conservation (species and habitat) and biodiversity.
- Our present level of knowledge should allow the development of a system that can be used to logically and transparently assess protection of the environment using appropriate end points. The development of the system ought to identify knowledge gaps and uncertainties that can be used to direct research to improve the system.
- The best available technology including consideration of economic costs and environmental benefits should be applied to control any release of radionuclides into the environment in a balanced manner with respect to other insults to the environment.

- When a product or activity may cause serious harm to the human population or to the environment, and significant uncertainties exist about the probability of harm, precautionary measures to reduce the potential risk within reasonable cost constraints should be applied. In making such assessments and decisions, an improved mechanism for incorporating developing scientific knowledge needs to be established.
- To assess the impact on the environment there is a need to take into account inter alia radiation type, type of organism, and biological endpoints (impact-related). In order to improve the transparency of assessing environmental impacts, the authoritative bodies should consequently give consideration to the development of quantities and units for biota, with the intent to avoid unnecessary complexity.

The above statement represents the views of the individual participants themselves and not necessarily their organisations'.

CONCLUSION

The success and innovation of the conference is the response and ongoing interest of the original participants, and the interest at an international level. The statement has been referred to in most of the international documents and international meetings pertaining to protection of the environment [9-13]. Although the final consensus statement identified significant areas of agreement on protection of the environment from ionising radiation, participants also noted the need for furthering the debate through ongoing work. Notable issues were the harmonisation of standards for radiation with other environmental stressors, guidance for balancing different interests and values within practical management, and the needs for assessment criteria. They also noted the need for consensus on a number of issues including an evaluation of the implications of practical principles (e.g., best available technology, precautionary principle, polluter pays, public participation) and further consideration of approaches to the "protection" of both the biotic and abiotic environment. Future developments in the protection of the environment from radiation are likely to be of interest not only to those working within radiation protection, but for environmental risk management in general.

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ICRP-PROPOSED FRAMEWORK FOR NON-HUMAN PROTECTION

Carl-Magnus Larsson and Lars-Erik Holm
Swedish Radiation Protection Authority
S-171 16 Stockholm, Sweden

The requirement for assessments of the environmental effects of radiation, i.e. effects on non-human biota, is increasing due to growing public concern for environmental protection issues and integration of environmental impact assessments into the regulatory process. Thus, there is a strong need to establish a framework for the *assessment* of environmental impact of ionising radiation, as well as a system for *protection* of the environment from harmful effects of ionising radiation. These ambitions are reflected in a number of international efforts and various 'systems' have been proposed or are under development [1-7]. This paper considers the current discussions on environmental protection within the International Commission on Radiological Protection (ICRP), as part of the Commission's ongoing revision of its recommendations as laid out in Publication 60 [8].

Previously, the ICRP has not explicitly dealt with protection of the environment, except in those situations where radionuclide levels in non-human organisms were of relevance for the protection of man [8]. Hence, there is little ICRP guidance as to how radiological protection of the environment directly should be carried out, or why. There are several reasons why ICRP now has considered it necessary to revise its position and future role with regard to protection of the environment, including:

- the need to demonstrate that radiological protection principles are consistent with existing international conventions and recognise the inter-dependence of man and other components of the environment;
- the necessity for operators and regulators to demonstrate compliance with existing international and national environmental requirements;
- the need to provide advice with respect to intervention situations; and
- the necessity to demonstrate explicitly how knowledge of the potential extent of effects of ionising radiation on the environment can be used to inform stakeholders.

To this effect, the Commission set up a Task Group in the year 2000 with the aim of developing a protection policy framework for environmental protection. The conceptual framework of this area of work would then feed into the Commission's recommendations for the beginning of the 21st century.

The Task Group has limited its scope to *effects of radiation on non-human biota*; effects on abiotic components of the environment have been excluded. Although it may be completely legitimate and justified for various reasons to consider also the abiotic components, it is highly unlikely that there will be *radiation effects* in those components under ambient radiation levels; hence, the limitation of scope.

For biotic components of the environment, it is knowledge of the dose to, and effects on, individuals that forms the initial basis for drawing conclusions on what actions that need to be taken in different exposure situations. For human beings, the Reference Man [10] is the primary reference for dose assessments, supported by a secondary set of data for a foetus, a child etc. Such data enable dose estimates to be made for 'hypothetical' or representative individuals under different circumstances of exposure. For environmental protection, a similar set of primary *reference fauna and flora*, or *reference organisms*, has been proposed as representatives of the biotic component of the environment [5].

The selection criteria for reference organisms will include many scientific considerations, and will depend on to what extent they are considered to be *typical* representative fauna or flora of particular ecosystems. A reference organism does not represent an average or a sentinel organism, but would serve as a point of reference for making comparisons with other sets of information on other organisms. The ICRP Task Group intends to propose a stylised system for radiological protection of the environment, harmonised with the principles for the radiological protection of man along the lines described above. This system will be designed so that it can be integrated with methods that are already in use in some countries. The objectives of a common approach to protect man and the environment might be to safeguard human health by

- preventing the occurrence of deterministic effects;
- limiting stochastic effects in individuals and minimising them in populations;

- and to safeguard the environment by
- preventing or reducing the frequency of effects likely to cause early mortality, reduced reproductive success, or scorable DNA damage in individual organisms to a level where they would have a negligible impact on
- conservation of species, maintenance of biodiversity, or the health and status of natural habitats or communities.

A common approach to the achievement of these objectives could be centred on a set of reference dose models, reference dose per unit intake and external exposure values, plus reference data sets of doses and effects for both man and the environment. Such models have already been used and are being further developed with a number of on-going projects at the international level.

The report of the Task Group is available at the ICRP website, www.icrp.org, and comments are welcome until 15 December 2002.

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RELEVANCE OF BYSTANDER EFFECTS TO CANCER RISK FOLLOWING LOW DOSE EXPOSURE TO ENVIRONMENTAL OR MEDICAL IRRADIATION

Carmel Mothersill and Colin Seymour
Radiation and Environmental Science Centre, Dublin Institute of Technology
Kevin Street, Dublin 8, Ireland

SUMMARY

The recent upsurge of interest in the phenomena now known as radiation-induced bystander effects is largely due to the increased awareness of the contribution of indirect and delayed effects, such as genomic instability, to cellular outcomes after low dose exposures. It is also due to the availability of tools such as the microbeam and advanced cell culture and the ability to study endpoints such as gene or protein expression at low doses which were previously difficult to study. This review briefly examines the current data and controversies which are now beginning to resolve the mechanistic questions concerning the induction and transmission of both bystander effects and genomic instability and discusses the possible impact of data concerning radiation-induced bystander effects on environmental radiation protection and medical uses.

INTRODUCTION

The "bystander effect" in radiation science refers to the detection of responses in unirradiated cells, which can reasonably be assumed to have occurred as a result of exposure of other cells to radiation. In vitro experiments have shown that indirectly affected cells may not even need to be present at the time of exposure. Medium transfer experiments show clear evidence of production of a factor, which cannot require gap junction mediated transfer from cell to cell (1,2). The RIBE has been detected in numerous cell lines, and after both densely ionising and sparsely ionising exposures, (3-6). The effect also occurs in vivo in humans as there are reports going back to the late 1950's, showing the presence of clastogenic factors in the plasma of radiotherapy patients and there is a considerable literature on "abscopal effects" following radiotherapy which occur in organs or parts of organs, which are remote from the original irradiated field.

BRIEF OVERVIEW OF THE DATA

The reader is referred to recent reviews by Mothersill and Seymour (7) and Goldberg and Lehnert (8) for further details of the data which are summarised here.

The response of cells to the bystander signal can include induction of apoptosis, induction of genomic instability or delayed death, induction of enhanced cell growth, or induction of mutations (7-10). Altered levels of proteins associated with the above effects and with a generalised stress response have also been detected. There is evidence for genetic predisposition in response to radiation from several sources; for example, genetically different strains of mice respond differently.

Among humans, clinical studies show wide variation in normal tissue response (11,12). In specific relation to the bystander effect, there have been some studies, showing differences in signal production or response, which are likely to be due to intrinsic factors. Whether these are genetically based is not clear. Our group (13) has also shown using human urothelium that there is considerable variation in the production of a bystander factor into medium.

In relation to the mechanism by which the bystander signal is produced transferred and received, very little is currently known. It is known that calcium signalling, mitochondria, HMP shunt biochemistry, are all involved (a calcium signal has been shown to occur within minutes when recipient cells are exposed to medium harvested form irradiated cells (14)) but the precise details of the pathways and the nature of the signal(s) are currently the subject of speculation.

One of the major effects of exposure of cell populations to the bystander signal is the induction of delayed effects and genomic instability in surviving progeny. Seymour and Mothersill (10) showed lethal mutations (delayed cell death) in the progeny of human keratinocyte cells receiving medium from irradiated cells. Lorimore et al (5) showed that if primary bone marrow cultures were partially shielded then irradiated with lethal levels of alpha particles, the shielded parts of the culture showed genomic instability. Nagasawa and Little (15) found high levels of de novo mutations in the progeny of cells from populations exposed to very low fluences of alpha particles.

The dose response curve for both bystander effects and delayed effects induced by direct or bystander irradiation has been found to be already saturated at a dose of 2mGy gamma radiation. The full effect is also expressed in systems, where dose response work has been done, following single track microbeam irradiation or single track alpha particles (13,15,).

RELEVANCE TO RISK ESTIMATION

There are two major arms of radiation protection/risk assessment where bystander effects could be of practical importance. The first is in medicine and includes diagnostic radiation exposures and systemic effects of radiotherapy and the second is in risk assessment, It may be necessary to redefine what we mean by "field" and to consider a "biological penumbra" as well as a physical one. Basic biological principles, including dose-response relationships, that have become dogma in the context of targeted effects of ionising radiation must now be viewed as subjects for re-investigation in order to distinguish unequivocally between the direct effects of radiation and the bystander components. In other words investigations are required to determine to what extent bystander effects contributed to the overall response profiles of the cells.

It may be necessary to factor in bystander effects when calculating dose to both normal tissue and tumour mass. Further, it is likely that the relative effects on normal and tumour tissue will differ and the difference may not always be predictable.

In relation to the implications for radiotherapy, there is a body of data, which have never really been understood, concerning abscopal effects of radiation. That is where an organ or tissue, which was not in the field responds to the experimental irradiation or radiotherapy. Clearly, radiation induced bystander effects may provide an explanation for abscopal damage. Again the literature is diffuse, sporadic and spans about 30 years. Most interesting are the reports of contra-lateral or positional effects. These have been reported for lung tissue. (16). These data imply that bystander signals may be systemically circulated but also specific in that only like tissue cells can respond. If this is true, it has major implications for studies of normal tissue effects. The positional effects for lung are even more interesting. These show that irradiating the apex can affect the bottom of the lung but not vice versa (*AL. Brooks, personal communication*). Directional differentiation is well known in embryology and is thought to be controlled by diffusible signalling molecules (*17*). Clearly there is an interesting field of study in determining the impact of bystander effects, however caused on the treatment planning for radiotherapy. Further practical questions are raised for therapy when multiple field treatments are used. Here the treatment volume that receives the maximum dose is carefully designed. Essentially though, a whole segment of the body is irradiated to varying degrees, with efforts being made to keep the dose to vital or particularly sensitive organs within permissible limits. This planning is all on the assumption that a dose of radiation to a cell is necessary to produce cell death and that the relationship between dose and cell killing is constant. Bystander effects introduce uncertainty into this dosimetry, especially at the edges of the conventional radiation field. It allows for non-linearity of effect within the field and for abscopal effects without the field. It is also possible that it has an effect on the metastatic deposits, depending on the strength and / or receptiveness to the bystander factor of the original tumour.

In relation to medical diagnostic exposure and environmental radiation protection , the issues concern the uncertainty in quantifying or predicting low dose effects. It is likely that ultimately, even when mechanisms become clearer, we will have to accept uncertainly as a feature of radiobiology which may be particularly relevant in the low dose range that is environmentally relevant, The interesting questions will concern individual variation in sensitivity and effects of complex mixed exposures of radiation and chemicals which may potentiate the indirect effects. The role of bystander-related events in the induction of genomic instability referred to above also need to be examined. If only indirectly affected cells lead to genomic instability, then this has important implications for mechanistic studies and also for risk assessment since it makes the calculation of incident dose potentially irrelevant in relation to processes such as carcinogenesis. A similar argument might apply to mutation induction by low doses given the data from Little's laboratory and the Columbia group (15, 10) that mutations can be detected in cells which did not receive an alpha particle hit to the cell or to the cell nucleus.

Finally, the existence of radiation-induced bystander effects raises important questions for the way radiation dose is measured and modelled. Radiation dose at low particle fluence or low dose of x- or □-rays may not be as meaningful a concept as it is at high doses. At low doses the radiation response, because of bystander effects, may be considerably greater than the assessment of dose alone would suggest. On the other hand it may not, as the cell may not produce the signal or may not respond to it. Even if the cell does respond, it may and/or may not respond in a way which is favourable to the tissue/organ/organism in the short or long term. It is therefore very difficult at low doses to predict the biological "effect" of the dose. It is also difficult to differentiate between the effects of radiation per se and the bystander effects. The biological effect of low dose radiation exposure is likely to vary between individuals and between organs in the same individual. Instead of dose per cell, it may be better to think of dose per tissue, and it may also be necessary to try to define a biological dose (BioD) as opposed to a physical dose. This BioD would have to involve *response capability* as part of the unit. Field size, or total cells exposed, would be important since certainly for low LET radiation experiments in the authors' laboratory, the factor appears to be produced at a certain number of units per cell irrespective of dose delivered to the cell population. Dose effect will become intrinsically variable at low radiation doses, suggesting perhaps that a probability model should be adopted.

Once mechanisms and models have been established, it will be important to test them using data sets where the results do not fit established models. It is likely that effects such as hormesis, adaptive responses, HRS and other discontinuities in the dose response curve at low doses, can be accommodated using models that take account of bystander effects.

Whatever the practical relevance of radiation-induced bystander effects, this area of study is clearly an important field in radiobiology where the most exciting questions are still far from being answered. It raises the question of how certain we are about the basic assumptions upon which we base our radiation protection science. It probably makes it untenable to extrapolate form high and acute dose epidemiological data to chronic low dose exposure situations. This is not to say that low doses are necessarily more dangerous than previously thought, just that the risk is not quantifiable with our present knowledge.

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DISCUSSION SESSION 4

Protection of the Natural Environment

Question 1

Sylvain St. Pierre (COGEMA)

It's more a talk. Like a number of people here I have participated in a series of seminars and conferences on the same topic over the last two years or so, and I'm here to seek new emerging thoughts that will help us to progress. So one of these emerging thoughts seems to me the arising, I hope, evolution from an in-depth reflection or thinking on the notion of protection to a recognition of the necessary balance with the notion of benefits. There are two things that I have particularly noted today: Those are from Jan Pentreath. First there was this notion of radionuclides in the environment - at least the ratio of it to energy produced in terms of gigawatt (it doesn't really matter what's the denominator as long as it's energy) and the second was derived human and environmental index per energy and if I can say, the first one to me lacked a little bit of perhaps signification, whereas the second one as an index is probably of great interest to access potential benefits.

The second thing that I note was from Deborah Oughton on ethics and I'm by far not a specialist on it but I was glad to see that it's also including a fair distribution of harms and benefits. So, to me having attended many of those conferences I'm glad to start to see that we start to move from the pure notion of protection and thinking about it to starting to thinking as well about benefits.

Deborah Oughton (Agricultural University of Norway)

Just a comment on importance of benefits. A focus on the distribution of benefits and harm is important, and should be incorporated in the idea of justification. Justification isn't just a question of the balance of harms and benefits. We also have to consider whether their distribution is fair. And this is something that has also been raised as an ethical issue in environmental protection, namely environmental justice. Here the distribution of harms and benefits can become quite complicated, especially when you are looking at things like transboundary pollution and future generations.

Question 2

Jean Brenot (IRSN)

ICRP has transposed to environmental radiation protection its concepts and the methods for human radiation protection. To go ahead, is ICRP the legitimate place? That's my first question.

Second: Environmental radiation protection is developing and it must earn autonomy and independence of thinking. An independent place, commission or association to do so is not necessary.

Carl-Magnus Larsson (SSI)

My view is that international agreements and guidance are necessary. Otherwise national authorities - because national authorities will still be left with this problem - will have to develop their own approaches. That can probably be done, and as I also indicated, it's not so many different ways you actually can go; you always need an analysis of dispersion, of ecological transfer, of effects as well as a characterisation of risk, on which you base your management decisions. It would be advantageous to have international collaboration on this. And my personal view is that ICRP - at least presently - is best placed to take this within its remits, and to be responsible for making recurrent reviews and updates to integrate new information as this becomes available.

Jan Pentreath

I'd like to add to this, because there are various ways you can look at this issue in order to simplify things. One can either try to extend the basis of protecting man from radiation to the way we aspire to protect man from other things in the environment, or one could try to come up with some common approach to protecting the environment from all the various threats upon it. I think it would be a great pity if looking at protection of everything other than man was to be divorced from protecting man, in relation to radiation, because there's so much commonality about the basic science. I don't personally think there's anything unique about the human species, it's just yet another species on the planet and we need to set down, from the scientific point of view, that underlying basis. So, I think ICRP is the best place for dealing with this subject.

Question 3

Jill Sutcliffe (English Nature)

I have two questions. I welcome these developments of looking at the natural environment. There's one question for Carmel Mothersill: To what extent will the findings of her work impact on epidemiology? Traditionally, the understanding of what effects of radiation are having, have looked at populations of people, and from my understanding of her work it means we could be getting effects scattered among a population which could result in rather varied effects, and these won't necessarily show up in traditional epidemiological studies. That's number one.

Number two was for, as I've got a chance, Jan Pentreath: Firstly, what have been the changes that have driven this need for a look at environmental and species. You made it clear what you think will take it forward, but where has it come from? I'm of the opinion that there's a lot of work to do in understanding the impacts on wildlife. Perhaps you could elucidate further: You think it's only a small task.

Carmel Mothersill (Dublin Institute of Technology)

The problem with human epidemiology is that it's based on very few data sets and it mainly refers to acute exposures at relatively high doses where effects can be observed. At the environmentally relevant doses we have virtually no data. As well as that, there are so many confounding factors, such as life style, smoking, the genetic background, all these things, that makes it impossible to distinguish radiation as a cause of a particular cancer, there is no sort of signature. That means that we have to get away from relying on epidemiology, I think. When you get down to wildlife, are you going to measure the number of abnormal newts? There isn't really a way of measuring it.

Jan Pentreath

Around the world, I think, the driving factor has been radioactive waste disposal and the various issues which arise from it. And I say that because I don't think the driving force comes from the routine discharges from nuclear reactors. It's the longer term issues which arise from radioactive waste disposal that are driving many of these questions. Apart from that, the changing nature of wildlife legislation around the world, which is a fallout really of the Rio Convention, and it's consequences, are also cascading down into different countries in different ways. In terms of the magnitude of the job, I think one would be amazed about how much information there is already available, that one could make better use of if one had some sort of strategy, and some objectives, and some real hard questions to answer. A lot of this information was collected initially in relation to the impact of nuclear war, and some of it has been collected out of sheer scientific interest and so on. But it could be really aggregated and used much better. There will be holes in it, but relatively simply experiments could fill those holes and give us a much better structure for making assessments and answering the sorts of questions which we are increasingly being asked.

Carl-Magnus Larsson (SSI)

I can only just say that within the EC FASSET project, there is a systematic approach to organise effects data into a database, grouped according to effects that we believe - when observed in individuals - may have population or ecosystem effects. Those categories are reproductive success, morbidity, mortality, and finally more subtle molecular effects - that might even incorporate effects that Carmel was talking about previously. The categorisation into different effect categories and also into different wildlife groups, have revealed that there is a wealth of data for certain combinations, and a complete lack of data for other combinations. This data base is going to be publicly available, on the FASSET project web site 'www.fasset.org'.

Question 4

André Jouve (Autorité de Sûreté Nucléaire)

I wanted to ask a question to Mrs. Mothersill. You have shown a diagram exhibiting a quite large variability of response to what you call the 'bystander effects'. Do you think this variability is genetically driven? And do you think it would be interesting to look into the genes which are responsible for that?

Carmel Mothersill (Dublin Institute of Technology)

The effect is partly genetically driven, but it's also life-style driven, because smokers tend to fall out as a different subgroup (I didn't show that data). So you can't say it's all genetically driven, it's life-style and genetics, but there is a very strong genetic component. In one of the EU projects that I'm involved in we are trying to pull out the genes by doing back-crossing and linkage analysis as we are trying to pull out the genes from the mouse strains because they are clear and clonal.

Question 5

Ian Fairlie (independent consultant)

I, too, very much welcome the ICRP's approach to considering radiation protection for the environment. I strongly welcome the ethics-based approach to this matter: indeed, it's very heart-warming. Perhaps one of these days we could have radiation protection system for humans based on the same ethical considerations.

I have two questions, one to Carmel and one to Jan.

My first one to Carmel is that I found your presentation extremely stimulating and thought-provoking. May I summarise my understanding of it and you can tell me whether I am wrong or not. There seems to be a direct effect from radiation which exists down to a dose of about 50 millisieverts or so. This is the classical effect of radiation– double strand breaks, etc.. Below that level of dose, a different set of effects also begin to kick in, including the genetic instability and bystander effects, and things begin to get a bit fuzzy and unclear. Below that level, we have both sets of effects. That is, in the classical way of looking at it, we have both a supralinear effect and also sublinear effects. And below that level it seems to me that the whole notion of "dose", ie joules per kilogram, begins to break down. Have I got that right?

And my second question is to Jan Pentreath. I found your talk very interesting, indeed. I think perhaps that we all when we speak should identify where we are coming from. I think I have a biocentric approach to risks and indeed I'd like to quote a very famous Scottish poet, Rabbie Burns, who also was biocentric. He said in a famous poem ('To a Mouse') 'I'm truly sorry man's dominion has broken Nature's social union'. I sympathise with that and I'm glad to see the ICRP is dealing with this. My question is this: Where are there specific instances of damage or danger to flora and fauna from radiation? I can think of reindeer who eat radioactive lichen in Lapland and I can think of the poor fish eggs being spawned in the radioactive Irish Sea. Are there other specific instances to which you would draw our attention?

Ken Collins

You omitted to say to the audience that the gentleman who you quoted, Mr. Robert Burns, did not in fact use that quote as a commentary on radiation, for the very excellent reason, that he wrote it in the eighteenth century.

Carmel Mothersill (Dublin Institute of Technology)

You have got it right in that definitely the relationship between dose and effect breaks down as we go to lower and lower doses. I think the determining factor of whether an effect is supralinear or sublinear depends first on what effect we are measuring. Some will be supralinear and some will be sublinear, it just depends on the context. It also depends on the response mounted by the recipient of that dose or that signal. And therefore I think we've got to acknowledge that this is a big grey area that we absolutely cannot define what the effects will be, because it's going to be more like a chaotic model rather than a sort of a cause-and-effects model that we are going to have to go to, I think.

Jan Pentreath

Answering your first point, I think it depends on what biological endpoint you chose to indicate whether damage in the environment actually is being done or has been done. The more important issue however, is whether or not it matters. You've already said, perhaps a fish egg here and something else there. I think this is one of the crucial points: not just what damage may or may not be done, but whether or not it matters, both to people or to the organisms themselves. These are really sorts of "externalities" as they call them, these ethical bits, which I think should not be internalised in the system of radiation protection. Radiation protection should stick to its knitting and what it knows in terms of science. It has to do so within a broader framework, because of these ethical and other considerations, but they shouldn't prejudge them, although it should be able to answer them. The scientific community should be able to answer scientific questions, wherever they come from, in a scientific way. We have a problem at the moment because we can't consistently provide scientific answers to different sorts of questions. And it's not a question again as to whether the damage has already been done, but what damage could be done and how could it be avoided, and what can we do about it if it does occur throughout the entire nuclear fuel cycle. Now these are still questions, which are reasonably asked. They should be reasonably answered by the scientists. And I don't think we are far from that. It's just a question of getting our act together.

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RADIOLOGICAL RISK MANAGEMENT IN PERSPECTIVE

Jacques Lochard
Centre d'étude sur l'Evaluation de la Protection dans le domaine Nucléaire
Fontenay-aux-Roses, France

Abstract

The management of radiological risk is founded on three basic principles that have been progressively elaborated by the International Commission on Radiological Protection during the second half of the last century. The first principle is the justification of practices. It stipulates that the introduction in the human environment of radioactive sources must correspond to a social benefit. The second principle is the optimisation of protection. It aims at keeping exposures as low as reasonably achievable, taking into consideration social and economical factors characterising the sources under control. This principle has been introduced as a response to the uncertainty concerning the existence of a dose threshold for the development of stochastic effects. The third principle is the limitation of individual exposure. Its objective is to ensure that the exposure of any individual is not exceeding a level considered as unacceptable by the society according the exposure situation: at work, at home or as a member of the general population.

The objective of the presentation is to review the rationale behind these principles and to put them in perspective with the evolution of the social concerns and values that are structuring our societies.

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PERCEPTION OF RISK: IS RADIOACTIVITY DIFFERENT?

Britt-Marie Drottz-Sjöberg
Department of Psychology,
Norwegian University of Science and Technology, 7491 Trondheim, Norway

Summary

The presentation will include material on research findings from the following four areas: i) Differences and similarities between risk ratings of experts and the general public, including radiation risks. ii) Factors known to influence perception of risk, and improvements of early models. iii) Different reactions to radon, exposure to UV light, electromagnetic fields and ionising radiation, and iv) conclusions; especially the influence of an underlying value system, attitude or "world view" for the understanding of and reaction to radiation.

Earlier research has pointed to different types of relationships between experts and the general public regarding estimations of risks. For example there is an area where risk estimates of the experts and the public are similar to a large extent. It usually concerns everyday events frequently reported in the media and where risks or negative events may have direct personal relevance or may, at times, be based on personal experience. The common denominator is their well-known character.

A different type of relation between risk estimations of experts and the general public concerns the area where the experts warn against certain behaviour or conduct but where the public to a great extent disregards the warnings. Such warnings often involve information of long-term health effects due to choice of life-style or other kinds of voluntary risk taking. The common denominator includes privacy, personal choice and responsibility. Risk information involving these kinds of risks is seldom appreciated or immediately adhered to, and the experts or relevant authorities usually worry about the situation.

A third type of relationship between experts and the public involves possible but rare or hypothetical events. These kinds of risks are often estimated on the basis of infrequent events and extrapolated from theoretical models that are known to contain uncertainties, including their more or less explicitly expressed value bases. The common denominator contains risk events with very small probabilities but extensive consequences would they occur. These types of risks tend to worry the public considerably more than they concern the experts. Perceptions of risk related to radiation, or e.g. perceptions of health hazards due to exposure to ionising radiation, belong to this category.

Thus, compared to risks related to everyday life and to voluntary life style risks, radiation is perceived as different. Radiation is not the only hazard, however, belonging to the category of risks described by low probability and high consequences. The latter category also involves e.g. genetic modification of foodstuffs and disease transmitted via the food chain.

The large amount of research that has been developed since the 1970's, when the risk perception research area started to emerge as a more comprehensive field of study, cannot be easily defined or delineated. However, the table below summarizes some of the important dimensions that have been shown to influence the experience of risk. The table provides a basis for taking a closer look at perception of radiation and for investigating whether or not it is different from perceptions of other types of risks.

Table 1. Factors shown to be related to perception of risk.

Type of factors	Specific factors
Factors related to the type of hazard	Catastrophic potential, degree of voluntariness, personal control, degree of controversy, type of consequence, number of people affected, history (development over time), reversibility, warnings, scientific uncertainty, etc.
Factors related to social contexts	Distribution of risks and benefits, distribution of justice, media attention, trust, availability of information, emotional content of information, involvement of children, identity of victims, etc.
Factors related to methods (specificity, operationalisations)	Risk to whom? Personal definition of risk, contextual framing, etc.
Factors related to individual characteristics	Gender, age, education, income, skill, knowledge, psychological sensitivity, previous experience, etc.

Ionising radiation is associated with production of nuclear energy and nuclear weapons, as well as waste products from these processes. It is also associated with health hazards and health effects, e.g. cancer in various forms. Radiation is invisible and otherwise undetectable to human senses and therefore not under personal control. The possible long-term health effects are feared and could be irreversible. The exposure would be involuntary and feared if an accident occurred, in contrast to e.g. sunbathing or exposure to UV radiation that people generally do not fear. Avoiding exposure, and management of risks or contamination, depends on warning systems and that trustworthy information has reached individuals at risk. Individual life circumstances, e.g. having small children, and personality factors, such as risk sensitivity or specific skills, also help explain some part of the variance in risk perception.

Public reactions to radiation vary greatly, however. Few people bother to investigate the level of radon in the home, most people find the medical uses of radiation beneficial, and many people react negatively to radiation related to production of energy by nuclear power or to the waste products. Thus it seems as if the reactions depend on the context in which radioactivity or radiation is encountered. In this respect radiation risks differ from risks that only have negative attributes or consequences, e.g. diseases.

A number of public reactions and protesting activities have been seen during the last decades. One focus has been radioactivity but that is not always the case. People protest the introduction or use of a number of technologies, including wind power plants, but they also sometimes protest non-technological changes such as building centres for juvenile criminals or for mentally retarded children. It therefore seems as if protests, negative attitudes or non-acceptance are not solely directed against industry or any specific industry for that matter.

The current attention to radioactivity can be due to a number of factors. People still remember previous accidents, there is much attention to building repositories and the attached localisation processes. Another explanation could be related to available alternatives, and the many ways to produce energy could result in preferences that do not involve the nuclear option. The perceived use, or benefit, to products or a technology has been suggested as important for the perception of risk. Mobile phones have become extremely popular and, nevertheless, a discussion on hazardous electromagnetic fields seems underway. Yet another possible explanation to differences in perceptions of risk involves basic values and attitudes. This explanation draws on rather deeply embedded cognitive or affective structures that are used to feel and express preferences, to distinguish between right and wrong, and to guide behaviour and action. These functions belong to humans' basic value system.

Rather recent research has shown that perception of risk is related to how one perceives nature and what is "natural". For example, in a study based on a representative sample of the Swedish population[5] it was shown that most people found the "primeval forest", as well as the "corn-field", to be natural (>90%). Many people found e.g. the "breeding of new kinds of dogs" and "production of new types of fruit by genetic change" unnatural (77% and 82%, respectively). "Uranium" was regarded as natural by 43 percent of the respondents, whereas 25 percent marked it as unnatural. With respect to "radioactivity" 26 percent responded that they perceived it to be natural, but 47 percent perceived radioactivity to be unnatural. Considering only men, the corresponding figures were 35 and 40 percent, whereas the results indicated that 18 percent of the women found radioactivity natural and 54 percent responded that it was unnatural. Together with other data showing association patterns related to "nature" and the "environment" respectively, the results indicated that "nature" was perceived as something clean, beautiful and benevolent in contrast to the "environment" that was more often associated with environmental pollution and industrial discharges.

Perceptions of nature and what is natural seem to have relevance for perceptions of risk. Environmental concern and discussions of how to value, or protect, other species than the human being has expanded the content of the issue from psychology to also include philosophy, i.e. of what is to be considered ethical, or morally right. The environmental issue has become highlighted in our time, and it influences a variety of domains, e.g. public concern about health and welfare, certifications of products as well as industrial processes, perceptions of the future, etc. The issue

[5] Drottz-Sjöberg, 1997.

has now been developed to such an extent that some environmental organisations or environmental ideologies today offer, not just their views of the state-of-the-art, but comprehensive life-style receipts including moral values relating to the overall biosphere system. See for example the following citation from Landis Barnhill and Gottlieb (2001, p. 1):

> "Of course every breath, hut building, and berry picking alters "nature". But the global effects of what we have done over the last century or so are so monumentally larger than anything we might have ever dreamed of before. Even if we think of "nature" as including human beings, we find that one part of nature – ourselves – is having vastly disproportionate and unsettling effects on the other parts".

The concept of "tampering with nature" has been detected to underlie argumentation against new technologies and change. It has also been shown to provide additional explanatory power in predictions of perceived risk.[6] The following model was published in Journal of Risk Research and shows the variable "tampering with nature" as the foremost driving factor of "perceived risk" as well as an explanatory factor to the traditional psychometric dimensions of "dreaded risk" and "new risk".

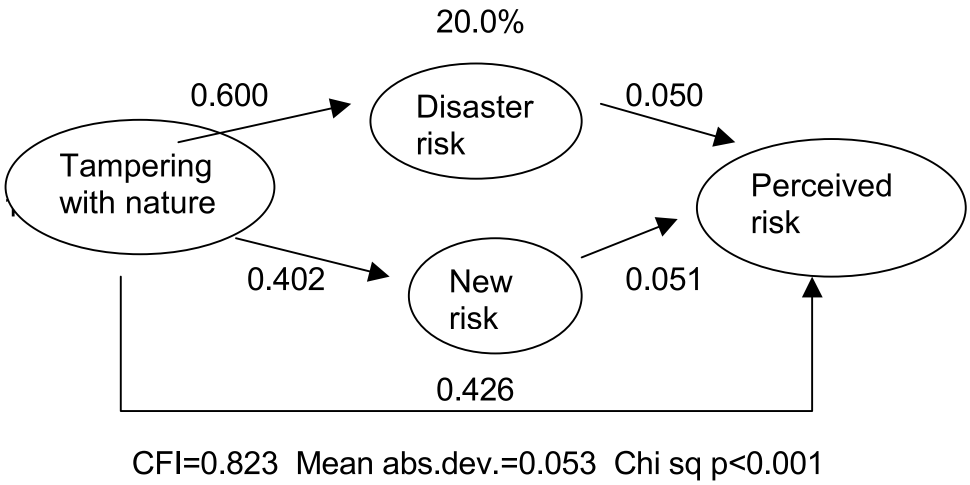

Figure 1. Model for three dimensions of the extended psychometric model of perceived risk. From L. Sjöberg (2000, p. 364).

One could argue that risk perception would logically lead to increased requirements for safety and risk reduction. A study in 1994[7] investigated what drives demands of risk reduction. In traditional studies people are asked to estimate "the risk" in relation to specified hazards and much of the available early literature in the risk perception field is based on this format. This simplistic perspective was developed, however, and people were asked to estimate the "probability", the "severity", and the "risk" for several hazards, as well as to rate their demand for risk reduction in each case. They did so for themselves, as well as

[6] L. Sjöberg, 2000.
[7] L. Sjöberg, 1994.

for "people generally". The results showed that "risk" and "probability" were closely related, and that perceived "severity" and demand for risk reduction were closely related. Risk and demand for risk reduction, however, were only weakly correlated. Thus, demands of risk reduction are related to perceptions of consequences, which makes peoples' perceptions of the world and its risks important social and political tools for forming the future. In the daily life one tends to disregard certain events with a low probability but with large, potential consequences. In industrial and societal situations, however, the opposite seems to be true. Therefore, in risk communication related to policy, people seem to react to the seriousness of potential damage or injury, not the probabilities.

In conclusion, all hazards are unique in one way or another. Radiation is interesting since it is perceived as "natural" as well as a product of technology, and reactions differ in line with the associations. However, the very distinction made between natural and man-made, or technological, must be better investigated. It seems biased towards a misleading and unproductive dichotomization between humans and their products on the one side, and nature and the Garden of Eden on the other. In this respect, perceiving a difference between "natural" and "technological" substances or phenomena seems in itself to be a potentially good predictor of attitude to, or valuation of, technologies and industrial products. This is not to say, however, that everything is natural and therefore benevolent. A widespread disaster, consequences remaining thousands of years and potentially affecting people over many generations are serious matters. It is important to distinguish between facts and fiction, and the risks represent potentially realisable catastrophes regardless of public perceptions. The latter understandings affect approaches to problem solving, information campaigns, and e.g. choices of technological systems. Knowledge and familiarity with specific risks are related to lower risk ratings, and to help improve knowledge as well as personal skills in risk management could transfer radioactivity to a resource instead of a threat.

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DISCUSSION SESSION 5

Risks

Question 1

André Jouve (Autorité de Sûreté Nucléaire) (translated from French)

I have a question for Jacques Lochard. Do you think a scale of communication on radiological risk similar to INES (International Nuclear Event Scale) might be a useful tool for communicating with stakeholders?

Jacques Lochard (CEPN)

Well, I think, in addition to the INES scale, which is well used as a dialogue tool (I think it is no more important than that), it would be good to supplement it with a radiological protection side. This could be of use if there is an accident or an incident which has a security component, so that you could assess the event in terms of safety so far on the scale and then of radiological protection as another point on the scale. It would exchange dialogue, it would be a communication tool, but I wouldn't overestimate the importance of such scales, it's more the work surrounding those scales. It's not the fact that you got a scale in itself, which will improve the social debates on the fundamental issue.

Question 2

David Cancio (CIEMAT)

From this morning we have been discussing a lot about risk and also about uncertainties. In particular, Mr. Ould-Dada, for example, said that it is necessary to explain uncertainties to the public. First of all Monsieur Brenot explained that it is a really difficult task to explain uncertainties, in particular regarding measurements.

Jacques Lochard mentioned also the new approach called Governance of Radiological Risk. But all people are emphasising the stakeholders' participation. It seems to me that in France there is a unique experience, it's the Nord-Cotentin Study that was mentioned several times today and it is a real case of public participation. In particular, I remember an action plan called 'angry mothers' – 'femmes en colère' in French – that organised a lot of measurements (in particular, one team from my organisation was participating there), doing measurements with different instruments. People from different institutions all around Europe and the public participation on that, it seems to me something interesting to explain. I don't know if Monsieur Lochard may explain something more about the Nord-Cotentin experience.

Jacques Lochard (CEPN)

Well, I think it would be much better to ask the question to Annie Sugier or to Jean Brenot. From the risk management point of view, I think that when you have such debates like the one around the La Hague plant where basically the roots of the debate are in the fact that there are uncertainties about the real impact of the radioactivity and behind, the debate about the potential health impacts related to this radioactivity, you need to be quite accurate with all stakeholders and the process in which you involve them, of course with the help of organisations which have the expertise, I think this is the only way to organise a dialogue where in the end people have the feeling that all important aspects have been taken into account. and the result of this process is not necessarily a consensus. At the end it's a statement by all stakeholders about what they think is under control, what they think is not under control, what they think needs to be looked at in more detail, and all together it improves the role of the authorities and the role of the public authorities. At the end they can make much better decisions.

Question 3

André Maïsseu (WONUC)

Since the start of this meeting we are speaking more and more about the perception of risk by the public. As I am in charge of the working conditions of nuclear workers I will move from the perception to the reality of the risk. Our concern, it's our working conditions. May I remind you that we are working in the nuclear plant (I was working for ten years in Hague), and when you speak about the public around this facility you are speaking about the families of the nuclear workers. So I will ask the people of this meeting and you not to forget this very important point, which is the reality of the risk.

I would like to make a real proposal, and this proposal was in our poster. Unfortunately we have some difficulty to propose you our poster. What it is: There are at least four parts in the world where natural radioactivity is said to be very high, which are very interesting to have a real idea, a practical idea of the effect of ionising radiation on human health, on biotopes and on environments. These four parts of the world are Ramsar in Iran (132 mSv/y) Kerala (India) Yangjiang (China) and Guarapari (Brazil) where millions of people are involved for thousands years. We are currently asking European Union to fund research in these areas for more real information about the effects of these low doses of ionising radiation on human health and biotopes in these areas.

Question 4

Patricio O'Donnell (Consejo de Seguridad Nuclear)

The new ICRP framework for radiation protection states a basic level of protection through constraints and a higher level of protection by optimisation, in which the stakeholders have a role. Regarding non-human species, does a similar principle apply? How would the stakeholders' involvement be dealt with in this particular case?

Jacques Lochard (CEPN)

Regarding protection of the public and workers ICRP will not change drastically their principles of managing risk.

I'd like to say first we want to protect the people to a minimum level and then apply optimisation because of the precautionary principle. And part of this optimisation is stakeholder involvement, as far as the public is concerned, and work force empowerment and involvement as far as the workers are concerned, which is a new way of finding these practical levels of protection where all concerned parties have the feeling at the end that the level of protection achieved is reasonable, taking into account all the constraints, I mean economical, social, ethical, any values that are important for those who are concerned. I don't know exactly if the limitation and optimisation principle can be used with the environment because it is difficult to set up limits, but why not? Maybe at the end of the day the scientists, the experts with environmental problems will come with values that could be applied for example in terms of concentration levels for water, for soil, where they would consider that this is something that has to be achieved to ensure a good state of the environment for the future generations. But I think anyway, it's not because any levels will be put in a document, that this will stop people to discuss about going further, because the precautionary principle will apply in a way also to the state of the quality of the environment and I think there is no reason why not to also involve stakeholders to discuss the quality. At the end of the day this is a matter of discussion: Which is the quality of the environment we want all together around an installation or somewhere in a territory. And I think stakeholder involvement is going to play a key role also for the environment.

Britt-Marie Drottz-Sjöberg (Norwegian University of Science and Technology)

Yes, I agree that stakeholder involvement is becoming more and more important. However, I think it's appropriate to have a clear distinction between roles here. Stakeholders - as I see it - should be involved to provide more information, good questions and ideas about how things should be managed. That is not the same thing as participating in a political process and deciding on these matters but to participate to provide the basic material for the further process of decision making.

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OVERVIEW OF THE MARINA II PROJECT ON DISCHARGES OF RADIOACTIVE SUBSTANCES INTO THE NORTH EAST ATLANTIC

LMC Dutton (1), MY Gerchikov (1), S Nielsen (2), J Simmonds (3), T Sazykina (4), G Hunter (5)
(1) NNC Limited, UK
(2) Risø, Denmark
(3) NRPB, UK
(4) SPA Typhoon, Russia
(5) DG Environment, European Commission

The primary objective of the MARINA II study was to provide an input from the European Commission into the work of the OSPAR Commission in implementation of the OSPAR strategy with regard to radioactive substances and the work of the European Commission in respect of this strategy. It also provided information on radioactive discharges, concentrations and an assessment of their impact on humans and marine biota.

It was found that the overall civil nuclear and other anthropogenic inputs of radioactivity into the North East Atlantic decreased by several orders of magnitude for α- and β- emitters and for tritium since the maximum levels were reached in 1960s and early 1970s. Over the same time period this resulted in reductions in radionuclide concentrations in the marine environment and in the individual doses to members of critical groups and in collective doses to the public.

Since mid-1980s, the main contribution to discharges of β-activity into the OSPAR region are from the nuclear reprocessing plants while the discharges of α-activity have been dominated by the phosphate industry and, later by oil production in the North Sea. As a result, the latter sources currently make the major contribution to the dose to the population of the European Union from industrial activities.

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IS ACTIVITY A GOOD INDICATOR TO ASSESS RISK?
THE NORD-COTENTIN RADIOECOLOGICAL STUDY

Caroline Ringeard, Catherine Rommens, Annie Sugier
Institut de Radioprotection et de Sûreté Nucléaire
DPHD/SEGR/SAER, B.P.17,
F-92265 Fontenay-aux-Roses Cedex, France

In 1995, an epidemiological study suggested first the existence of a cluster of leukaemia, related to people aged 0 to 24 years and who have been living in the French canton of Beaumont-Hague (a 10 km wide area including the La Hague reprocessing plant) between 1978 and 1992. Four cases of leukaemia were observed compared with 1.4 cases expected. In 1997, a second study suggested a possible causal relationship between the observed incidence of leukaemia and the exposure to radiation. To respond to public concern, both a complementary epidemiological study was carried out by professor Alfred Spira and a radioecological study has been performed, commissioned by the French ministries of Environment and Health.

The radioecological study considered all the nuclear facilities located in the area of the canton (Cogema La Hague reprocessing plant, ANDRA's shallow-land radioactive waste disposal center, EDF's nuclear power station of Flamanville and the French Navy's dockyards of Cherbourg). A Working Group including nuclear operators, international experts, members of non governmental organizations and institutional experts was set up chaired by Annie Sugier, director of Protection at the French Institute for Radiation protection and Nuclear Safety (IRSN). A total of more than 50 experts were involved in the study[8]. The working Group Radioécologie Nord-Cotentin carried out a very exhaustive systematic critical analysis of the data available regarding the radioactivity in the Nord-Cotentin area. The methodology of this study was based on two approaches:

- estimate the risk of radiation induced leukaemia due to all sources of exposure during the period from 1978 to 1996,

[8]BfS (Bundesamt für Strahlenschutz-Germany), IRSN (Institut de Radioprotection et de Sûreté Nucléaire-France), NRPB (National Radiological Protection Board-United Kingdom), OFSP (Office Fédéral de la Santé Publique-Switzerland), CNRS (Service d'écotoxicologie EP61-France) ANDRA (Agence Nationale pour la gestion des Déchets Radioactifs-France), COGEMA (Compagnie Générale des Matières Nucléaires-France), EDF (Electricité De France-France), GEA (Groupe d'Etudes Atomiques - Arsenal de Cherbourg-France, ACRO (Association pour le Contrôle de la Radioactivité dans l'Ouest-France), CRII-RAD (Commission de Recherche et d'Information Indépendante sur la Radioactivité-France), GSIEN (Groupe de Scientifiques pour l'Information sur l'Energie Nucléaire-France), ISTE (Institut des Sciences et Techniques de l'Environnement (Université de Montbéliard) – France), LDA (Laboratoire Départemental d'Analyse de la Manche-France) CEPN (Centre d'étude sur l'Evaluation de la Protection dans le domaine Nucléaire-France), CSPI (Commission spéciale d'information près l'Etablissement de La Hague-France)

- search for particular situations of exposure corresponding to the most exposed groups of population due to locally higher radiation exposures and extreme lifestyle habits.

The two approaches were modelled similarly in terms of estimation of the dispersion and the transfers of radionuclides into the environment. However, parameters characterizing the habits and geographic situations of habitants and the calculated dosimetric indicators are specific to each approach: annual doses delivered to the red bone marrow for the cohort and effective doses engaged over life for the particular scenarios.

The total estimated number of radiation induced leukaemia due to all sources of exposure is 0.836 cases, 74% due to natural exposures, 24% due to medical exposures, 2% due to the Chernobyl accident and nuclear weapons testing and less than 0.1% due to the releases from the local nuclear facilities (i.e. around 0,002 cases during the period 1978-1996, to be compared to the 4 cases of leukaemia observed during the same period).

These results are based on the estimation of activities of radionuclides present in gaseous and liquid releases from nuclear facilities. The identification of radionuclides was as exhaustive as possible. More than eighty radionuclides have been taken into account. The impact of each radionuclide released depends of course on the amount of activity released, but this study also shows how much this impact depends on transfer pathways in the environment, on exposure pathways of individuals and the organ target considered (red bone marrow or whole body). If we focus on the activity, which corresponds to a 1 µSv dose, we can observe several orders of magnitude between radionuclides. For example, ^{85}Kr requires about 200 000 TBq to reach such a dose whereas ^{14}C requires only 20 TBq.

For the same radionuclide, there may be also several orders of magnitude between the levels of effective dose and red bone marrow dose due to the same amount of activity released. For example, ^{129}I is a small contributor to the red bone marrow dose and therefore to leukemia risk, but a main contributor to the effective dose. At the opposite, ^{90}Sr is a main contributor to the red bone marrow dose but a small one to the effective dose. At last, the particular situations of exposure show the impact of choices of lifestyle habit and location of individuals on the level of doses. For example, there were several orders of magnitude between the estimated effective dose for a fisherman due to the ^{60}Co released and the effective dose for a farmer due to the same release.

This study shows the importance of choosing an appropriate indicator to assess the radiological risk for population.

All the results of the Working Group Radioécologie Nord-Cotentin are available on the web site : http://www.irsn.fr/nord-cotentin/

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REPORTS BY CO-CHAIRS

(Summary of Sessions 1 to 5 given by the respective Co-chairs)

SESSION 1: RADIATION AND ENVIRONMENTAL POLICIES (PALOMA SENDÍN)

Role of the European Commission in setting standards:

- The Commission has a sound basis for action under the EURATOM Treaty;
- There are even directly applicable provisions for environmental protection;
- Specificity of rules for adopting EURATOM legislation: science basis, no co-decision.

Reasons for a new ICRP system of protection of mankind and the environment:

- Consolidate publications since 1990 and clarify general principles, enhancing individual protection;
- Need of a coherent philosophy for natural radiation exposures;
- Inclusion of an explicit policy for radiological protection of the environment.

Prospects for a EURATOM Environmental Action Programme (EAP):

- Fundamental need to revise current policies: ICRP changes and enlargement;
  - ICRP: priority on implementation of present BSS, new challenges;
  - Enlargement: Increase attention to transboundary issues;
- Other driving forces: environmental principles, legislation, conventions;
- New approach "EAP": gain acceptance (ethics, stakeholders), integration of policies.

Discussion - Inputs from Stakeholders:

- Demand to overcome the "DEMOCRATIC DEFICIT" of the EURATOM treaty;
- EURATOM EAP framework is welcomed. Recommendations to improve dialogue;
- EU developments have to be duly co-ordinated with IAEA and UNSCEAR;
- Controversial views on the use by ICRP of natural radiation background as a basic reference for a new system.

SESSION 2: RADIOACTIVITY IN DIFFERENT FOODS (GERALD KIRCHNER)

Radioactivity in food from the sea:

- Major sources of radioactivity in marine food include both anthropogenic radionuclides and TENORM;
- The process which regulates the accumulation in marine animals is quite complicated and not well understood;
- 50 % of artificial radionuclides released into European seas originate from the Sellafield site followed by 32 % by Cap de la Hague;
- Present day anthropogenic concentrations in marine animals and plants from the Irish Sea are predominantly due to historic discharges from Sellafield. These have decreased by several orders of magnitude compared to the peak values during mid-70;
- <u>On average, approximately 85 % of radiation dose due to foodstuff is caused by natural, 15 % by artificial radionuclides.</u>

European maritime areas and marine fish:

- ^{210}Po is the largest contributor for the radiation dose from marine food. For artificial radionuclides, ^{137}Cs is the most relevant nuclide for marine radiation dose to man due to the enrichment in fish and other marine food;
- Global fallout from atmospheric weapons test and the discharges from the reprocessing plants Sellafield and La Hague are the main source of artificial radioactivity in European waters.
- The fallout from Chernobyl in 1986 contaminated primarily the Baltic Sea;
- Levels in fish reflect mostly the contamination of its living habitat;
- A downward trend in the levels of radioactivity in water and in marine fish could be ascertained in recent years due to the significant reduction of liquid discharges from reprocessing plants;
- No general increases in doses to man from consumption of marine food.

Radioactivity in terrestrial and freshwater food:

- Transport via food chains and accumulation of artificial radionuclides in terrestrial food depend on the physical and chemical forms of the deposited radionuclides, on competition by major elements and on ecosystem;
- By far the highest transfer rates are observed in semi-natural environments.

Consumer attitudes towards foodstuff from radioactively contaminated areas:

- Consumers are concerned about risks, which scientific opinion does not recognise;
- Risk perception can influence willingness to pay for risk reduction;

- Consumers do not believe that countermeasures make food products safe.

Discussion - Inputs from Stakeholders:

- Despite comparably high concentration of ^{99}Tc in seafood, radiation doses to man are not dominated by this isotope;
- If focus is on individual doses rather than on averages, the contamination levels in food from sensitive ecosystems is of importance;
- Risk perception by the public may differ from that by experts;
- In addition to recommendations by authorities and experts, consumers also trust in recommendations given by NGOs, consumer organisations ...;
- Intervention levels in the order of 1000 Bq/kg or Bq/l have been questioned.

SESSION 3: ASSESSMENT OF POPULATION EXPOSURE (ANNIE SUGIER)

Assessment of doses to the public:

- RAIN guidance (expert Article 31 group approach);
  - Realism versus conservatism;
  - Retrospective versus prospective;

Uncertainties in risk assessment:

- Variability and uncertainty analysis (GRNC approach);
  - Best estimates versus range of values;
  - Limitation in the scope;
- Communication on uncertainty (Food Standards Agency approach);
  - Effective and clear communication.

Discussion - Inputs from Stakeholders:

- How cautious has to be the final step of the calculation? (Dose and risk factors)
- No question on the collective dose?

SESSION 4: PROTECTION OF THE NATURAL ENVIRONMENT (GEORGE HUNTER)

The IUR Consensus Statement:

- Need to have a logical transparent system to address protection of the environment (quantities and units for biota);

- Best available technology and precautionary principles to be considered;
- Radioactivity has to be treated just like other contaminants.

Radioactivity and Environmental Protection - ICRP-proposed framework for non-human protection

- Ethical, social and legal aspects need to be addressed in a balanced way for environmental protection;
- EPIC and FASSET research projects are ongoing;
- ICRP is proposing stylised system, harmonised with that for man;
  - Derived consideration levels for reference flora and fauna;
  - Set of reference doses; sets of 'dose-effects' for man and the environment.

Possible effects of radiation not considered in the ICRP framework:

- Radiation-induced bystander effects: delayed effects, genomic instability after low-dose radiation exposures. Need to be taken into account in radiation protection and radiotherapy.

Discussion - Inputs from Stakeholders:

- A need for balance of ethical, social and legal aspects;
- Is ICRP the best body to do this?
- Does the concept of 'dose' break down at low levels?
- Is there any evidence for environmental damage from high levels of natural radiation?

SESSION 5: RISKS (IAN MCAULAY)

Radiological risk management in perspective:

- It can not be proven that there is no harm at low doses;
- Basic protection principles: justification, optimisation and limitation.

Perception of risk: Is radioactivity different?

- For radiation risk, perception of risk is stronger for the public than for experts;
- Politicians and public assess risks to similar degrees;
- Perception of risk related to perception of what is 'natural';
- There is no consistent perception of radiation risk: it depends on whether the source is considered as 'natural' or 'man-made'. This distinction needs further investigations.

Discussion - Inputs from Stakeholders:

- Stakeholder involvement is becoming a striking feature in policy development for management of risks to health and to the environment;
- Stakeholder involvement results in empowerment of stakeholders;
- Improvements in knowledge and in risk management skills could transfer radioactivity to consideration as a resource rather than as a threat.

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ADDITIONAL ITEMS AND COMMENTS FROM AUDIENCE

Additional items by participants (flip chart)

The following items were put down by participants on flip charts for eventual further discussion:

- So – do we have protection (standards) for the environment?
- Some epidemiology of internal radioactivity (not the epidemiology, Roger) may show no effect, but some, e.g. cancer near contaminated estuaries, shows mortality doubled.
  - But the standard of these surveys is currently under examination.
  - So are the others – e.g. Doll, Darby et al, Nordic Leukemia Study, British test veterans follow-up and others.
- Is there any evidence for actual environmental damage resulting from natural radioactivity, particularly where this is high?
- Medical exposures are major source of radiation to the public. Should EC be more pro-active in ensuring that medical doses are reduced by using best available practice and by requiring replacement of obsolete equipment?
  - They should require a cessation of waste incineration and disposal to sewers.
- "DAD" is dead, but UNCLE is killing the NGOs: Unlimited Nuclear Consultation Leads to Exhaustion. (Funding for NGOs is vital)
- Why are there no presentations from people who do NOT accept that ICRP's system provides adequate protection for mankind?

Comments from the Audience

Ken Collins

We have had lots of comments over the two days. What we are looking for at the moment is further guidance on where, up to now, there are things you think for example that we have missed, things that we should have been discussing and have not yet. Have we concentrated on areas that you approve of or disapprove of or whatever. The floor is yours for the next half hour and I should say that at the end of all of this not only the presentations will be on the Commission Web Site but the session summaries will be on the Commission Web Site as well. Now it is your turn still, let us hear what you think about the show so far.

Comment 1

Richard Bramhall (Low Level Radiation Campaign)

I hesitated to put my hand up first because I do not like to be unkind but there are some things I feel I really have to say about this event and they are not all very nice. To share the blame a little bit I've discussed most of what I have to say with Rick Nickerson who was sitting here on my right but he has had to go and he agreed with a lot of it and he asked me to represent him in this respect.

Jacques Lochard said earlier on we need stakeholder involvement to overcome the problems of challenges to science and experts. I congratulate the Commission for convening this conference but I feel that it is only a toe in the water. It has been dominated by lectures nearly all from the status quo side of the fence rehearsing well-known positions. That's a quote from the ground rules of stakeholder processes in the UK. They are rehearsing those positions as experts. There has been a lot of unnecessary repetition particularly about radioactivity levels in the environment and food and a lot of explicit reassurance by reference to risk factors, which are widely contested. Here I will refer to my attempted question yesterday, which was about sea to land transfer and what we believe to be a consequent doubling of cancer mortality in populations which live close to the areas of contaminated mud. I used the phrase just now about well-known positions deliberately because in stakeholder dialogues in the United Kingdom such repetition is actively discouraged. Dialogue is not a matter of making the public "understand" in terms that you choose and it is not a matter of communicating the establishment point of view and refining your techniques if the public fails to believe you. That is not communication, it is propaganda. In stakeholder dialogues in the United Kingdom, run by the Environment Council, there are no experts, no presentations and no audience, only active participants working together on a basis of equality and in this context I commend the Oslo Consensus Conference of last year, which was highly structured and inclusive ("inclusive" is the word of emphasis here), and it used presentations only to inform and stimulate the intervening plenaries and workshops. The outputs from such conferences and dialogues can be surprising and novel. I should add that the steering groups organising stakeholder dialogues in the United Kingdom are increasingly composed of the same range of opinions and positions as the dialogues themselves. So they are not being driven by the usual suspects.

I have two recommendations: one that the Commission should take on board these experiences of the UK and perhaps even come and see how they work; and secondly that this body should be reconvened on a more inclusive model within a few months, at any rate at a stage early enough to influence the drafting of any new legislation.

Ken Collins

Can you remind us how long these stakeholder dialogues have been taking place in the UK?

Richard Bramhall (Low Level Radiation Campaign)

There are various ones. Roger Coates could tell me how long the BNFL national stakeholder dialogue has been running but it is by no means the only one.

Roger Coates (World Nuclear Association)

Richard has referred to the BNFL UK national stakeholder dialogue process. That was set up between 4 and 5 years ago with the objective of engaging a wide range of stakeholder input to advise BNFL, and it is advising BNFL specifically with regard to our environmental policies and strategies. I think, as Richard has indicated, we have used a well-known and well-respected organisation to provide a facilitation service and I think it is a widely shared experience and view that that has worked surprisingly well, and on this particular issue I have got a fair degree of common cause with what Richard Bramhall has just said.

Ken Collins

I simply wanted to establish the point that this is a comparatively recent development in the United Kingdom. It is not as if it was born 25 years ago and has been rooted in the British culture. It has not. It is a very new development indeed. It does not make it a bad development, I think it is very good, but we need to know the historical context nonetheless.

Comment 2

André Maïsseu (WONUC) (taken from translation from French to English)

First of all I would like to thank the EU and its representatives for having convened this meeting, as representatives of the work force workers. I have to assure the European Union that even if in certain cases we do not necessarily share the points of view expressed by the participants, we do in fact respect them and we will do our best to ensure that EU regulations which, I hope, will be consistent with the International Atomic Energy Agency, the workers in fact will respect these regulations. I think it is worth telling you that in the end it is we that will have to apply these rules and implement the directives and we very often take the consequences of not doing so, so we will continue our very keen interest and productive participation in the process of democratising the discussion. As you have noted from the brochure that we distributed to all participants we are and will be going on to organise scientific conferences and discussions and will publish in the International Journal of Low Radiation (Interscience Editor), presenting in an objective way what affects us in the first line.

Comment 3

Gilbert Eggermont (SCK-CEN and University of Brussels)

First of all I would like to welcome this initiative for such a stakeholder meeting taken by the European Commission and also the first step ICRP has taken in broadening its scope to the environment. I think however, that it is only the first step.

Some suggestions when we evaluate this initiative for considering it again:

- The experience built-up in COWAM (a concerted action on community participation experiments of stakeholders in nuclear waste management over Europe), financed by DG Research, yields very interesting results and indicates a lot how to improve organisation of involvement and how to find balances between stakeholders.
- The major group of the public exposed to ionising radiation, the patients, has not been involved in this conference. When we are discussing in our country environmental reporting we include also the medical field, not only hospital waste but also doses to patients. Since a short time ICRP has rediscovered radiology, where high doses can occur, as well for workers as for the patients, in particular in intervention radiology. In our country now the average dose from medical exposures is 2 millisievert per year, essentially from radiology with growing importance of CT, responsible almost for half of this amount. There is a high increase of collective dose over some decennia. Considering the potential public health impact and the dose reduction opportunities we should look how to organise stakeholder involvement for patients. As nothing has been said about the subject during the discussions and as it is a real challenge for radiation protection, I suggest the Commission to improve co-ordination already with DG Research to pay more attention to this priority for radiation protection. When we see the drafts for the new Framework Programme, only minor importance is given to radiation protection in the medical field, only a small budget for a CT aspect. That does not conform with the risk for public health as indicated.
- A last remark: I am missing in the new ICRP approach the atmospheric environment and this is a contradiction. Climate was put forward as a key priority. It is a key priority at world level but it was excluded from our nuclear discussions. Due to an anthropocentric approach similar as we have applied up to now in radiation protection, carbon dioxide was neglected for the environment regarding its marginal health impact over many years. In the nuclear field we should also look if similar problems of smaller scale can occur. I refer to some radioactive noble gases from reactors and in particular from reprocessing, which are slowly mixing over the whole atmosphere, because we do no longer consider them as a risk for health. In the background comparative reasoning by Mr. Clark, we already have seven orders of magnitude more radioactive noble gases mixed over the whole atmosphere than 50 years ago, before the nuclear era. It concerns mainly krypton-85. The basic research we have done on its potential climatic effects, is rather limited. Only some research has been done, while now in the climate research dynamics experimental opportunities exist, for large scale experiments to check interaction of radiation with non-radioactive chemical pollutants, UV, etc.. I think we should consider this environmental uncertainty in a precautionary approach as well in ICRP as in the Commission. It could be important for our environment tomorrow.

Comment 4

Pedro Carboneras (ENRESA)

My question or the point I would like to rise is very direct and is rather simple, at least it is simple to be enunciated. My point is, what should be the most important characteristics of a set of stakeholders: to be, at the same time, complete and the most appropriate at any particular time. I can easily imagine that such a set of stakeholders could be different, depending on the situation and the issue under consideration being either generic or specific and local or global. I will appreciate someone to respond to the point I've raised and I would appreciate to focus on the essence, because the radiation protection community could be in a difficult position by opening the dialogue and having a never-ending story. We could perhaps never find "the appropriate set of stakeholders" and we could be involved in an endless and to some extent, purely speculative discussion.

Comment 5

Ian Fairlie (independent consultant)

You asked where does the Commission go from here and I would like to make a radical proposal. Actually it is already required to be done; but it is just not done. Under Euratom Directive 96/29, all Member States are required to introduce legislation to bring into effect the provisions of the Directive. In particular, provisions on justification, optimisation and limitation of practices giving rise to radiation exposures. Most Member States have limits in force but few, if any, have provisions on justification. I'm on slightly shaky grounds here: I know the UK and France have no provisions on justification, I am unsure of the others, but I doubt it.

I think that it is very necessary that Member States should bring in provisions on justification. Let me give one example of this. By far the most important of all the practices giving rise to radiation exposures which have an environmental impact is the practice of reprocessing spent nuclear fuel. The actual process of reprocessing is very messy with over 150 discharge streams: it results in large-scale discharges with very large impacts both in terms of collective dose and individual doses. One of my colleagues has already mentioned high emissions of radioactive noble gases: that is just one aspect.

The problem is that, as far as I am aware, there has never been any justification study carried out for the current reprocessing plants. Not one! It becomes even more strange when one considers the fact that most other countries do NOT reprocess their fuel. We simply do not have to reprocess our spent nuclear fuel. For example, Canada and the United States store their fuel. Many IAEA publications are emphatic in their support for dry storage: they recommend and exhort Member States to progress towards dry storage. But, willy nilly, European countries continue full steam ahead with environmentally disastrous reprocessing, and no-one questions why.

By the way, we all know that British Energy, in Britain, has recently faced the wall in bankruptcy. The main reason is they could not afford for the crippling charges for reprocessing, 1.5 million ecus per tonne of spent fuel. In other words, reprocessing is not only messy, dirty and unnecessary, it is also extremely expensive. Justification requires that we actively look into the alternatives. No-one in Europe, as far as I am aware, has ever commissioned a study to look at the alternatives to reprocessing, to find out what other countries are doing around the rest of the world. I strongly recommend the EC to commission a study into the alternatives of reprocessing and to what other countries are doing. I also recommend they ask Member States to do the same under their legal duty to introduce legal provisions on justification.

Comment 6

Jill Sutcliffe (English Nature)

When I first got my current job I was asked at interview what made for a good meeting and my answer then and now is: a clear set of objectives, a timetable running to time, actions that people take away from the meeting, and good food and drink. Now if I assess this meeting according to that, I am actually no longer clear what the objectives were for this meeting. If it is the review what should be the content of an Environmental Action Programme under Euratom to parallel that of the 6th EAP framework, then perhaps we should arrange to meet again in time to look at a proposed content for that Environmental Action Programme. The timetable fell apart today, it was going quite well yesterday but we have made up grounds, and the food and drink was fine, but I do think we need actions to take away from the meeting.

Comment 7

Sylvain St. Pierre (COGEMA)

I'm changing subject a little bit. I think you said a few words about the maturity of the subject somehow and I see it in two ways. The first one is the protection of non-human species. I am not sure how many people of us have done studies like this before, which explain somehow maybe the out of focus of our discussions a little bit, which sometimes range from maybe education for some of us, learning a little piece of this, a little piece of that, to reflections and then to maybe something like stakeholder participation a bit. I would say the second axis of the new things is more the concept of stakeholder. By no means I am a specialist in the question but there is, I believe, a fundamental difference between the field experience that we had for some specific environmental projects and what we try to debate now as an international stakeholder if I could say so, I am not sure what is the recipe. How can you have something that is an active participation? And maybe one critique is, and I am not sure once again what is the recipe, but of course if "stakeholder" means everybody does a kind of a magistral presentation followed by anybody else's questions, it is a bit weak. We do not have as much as we could.

Comment 8

Roger Coates (World Nuclear Association)

I am minded for the moment just to reflect on one of the early inputs from the Commission that we heard yesterday and that referred to the principle of proportionality, and it was stated that this should be a principle that guides the Commission action. If we think about what we heard at this meeting I think it is fairly clear that we do need to develop the scientific and conceptual framework for the protection of non-human biota. Linking back to the principle of proportionality we do however need to ensure that the framework is developed in a way which is proportionate to the level of harm and threat, which is or is not evident within the environment. It also needs to take account of all aspects which contribute to exposure, of which nuclear is a part but I think as we also saw during the meeting is not currently a dominating part. We also need to ensure that as the framework develops forward it does take account of the overall balance between detriments and benefits.

Comment 9

Peter Mitchell (University College, Dublin)

I would just like to comment on an issue that has cropped up more than once at the meeting, this concept of the establishment and us. I am getting tired of being pigeon-holed by those who would perhaps describe themselves as anti-establishment but whom I would not dream of insulting by using such a term. I come from the university, I have spent, as it happens, more than 30 years in radiation protection research at various levels, and frankly I resent that type of description of me or others like me. I have had enough of it. I think we are all on the same side here. We may have come from different backgrounds in the past but it is what matters in the future from now on that should be determining how we operate our business. When I see the recommendations of, for example, the ICRP, I would like to think that I bring some degree of critical analysis to bear and in general accept them for myself. I would request that in future people like I and many others here perhaps, though I should not speak for them, should not be described or pigeon-holed in that way.

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REFLECTIONS ON STAKEHOLDERS' INPUT ON 1ST ENVIRONMENTAL ACTION PROGRAMME UNDER THE EURATOM TREATY

Augustin Janssens
Acting Head of Unit ENV.C.4
Radiation Protection

Thank you Mr. Chairman for giving me this opportunity for reflecting, from the Commission's point of view, on the outcome of this conference. The purpose of the conference was essentially to get an input at the start of the development of the first Environmental Action Programme under the Euratom Treaty. We have done so through a stakeholders' conference, but it is fair to say that a large part of the time and certainly of the content of the conference was taken up by the presentations by the experts that we had invited. There has been relatively less time for discussion than we originally would have hoped for and that we had planned for.

These contributions were excellent, I think, and I am very grateful to the speakers for the effort they have put in their presentations, and to the Programme Committee for laying out the structure of this conference. These presentations did not reflect, and I would take up Peter Mitchell's words again, the "establishment's" point of view. For part of the Radiation Protection Community the trends indicated in these presentations are really new. A few years ago the protection of the natural environment was a minority point of view. Now it has become fashionable and at this conference it is even almost taken for granted that we are going to do so. But it is new, and in part this conference meant to consolidate the approaches in this area and in quite a number of other areas. These new progressive trends will be incorporated in the Environmental Action Programme since they have not very much been challenged by the participants in this conference.

For ease of presentation I will go sequentially through the topics that have been covered, starting with the introductory part including my presentation on the outlook for an Environmental Action Programme. The most important message that was confirmed in this conference is the so-called democratic deficit, which is important and which we, I think, all regret as citizens. It is a matter of history, which is not directly in our hands to change. Possibly, through the Convention looking into the role of the different institutions of the European Union, this may happen. It is in our remit however, that we involve as much as we can the European Parliament in the development of the Environmental Action Programme, even if in the end it is for the Council to decide.

From the discussion on the radiation protection system, the international ICRP system and other thoughts on this matter, I retain as a quite strong message from a number of participants that the reference to the natural background, that was built into the system in its current draft as a reference for setting standards, is debatable. The wording used by Roger Clarke was very careful. He said this is an observation, it is not a justification for the scale. Also Jacques Lochard clearly emphasised that the system should be built up, taking risk and natural background into account in establishing the scale. But it is certainly not an undisputed reference and my feeling is that we should set standards on the basis of accepted risks and put these in perspective to the natural radiation background where the analogy is obvious. It is obvious, for instance, for external radiation. It also holds for most of the radionuclides causing internal gamma irradiation, where the effect is exactly the same. It might not be as obvious for a number of other radionuclides. It would not be as obvious for radon, which is the major source of natural radiation exposure. We must distinguish here, I think, and not put everything into the big bag of effective dose.

The science of the radiation protection system was disputed by some of the participants, as were the basic radiation effects and the science regarding the pathways of exposure to man and to biota. This, in my view, is not directly a matter for stakeholder involvement. Science should be a matter for scientists. Within the scientific community there are different views and scientists do discuss amongst themselves alternative points of view. I think it is out of phase to leave scientific debate in the hands of stakeholders.

It is true that a major part of the first day's sessions was devoted to food. This was our choice in the sense that food is the most important and direct pathway of exposure through the environment. It is also because, based on the experience of the Chernobyl accident and the fact that we have to plan for a potential future emergency, the possible contamination of food is a very important parameter. I was very interested to listen to Ms. Salt regarding the experience that we have got from the Chernobyl accident. Possibly we can draw lessons also from other food scandals - dioxins etc. - to learn to understand the attitude of consumers and to try, but with great difficulty, I am afraid, to plan for the consumer attitudes in case of a widespread contamination. There is a mechanism already in place, 'FARMING' from the research programme, that involves stakeholders. We have to build on this and expand the FARMING network of stakeholders, consumers' organisations, farmers, etc. to the decision level within the European Commission.

In terms of assessment of population exposure, in my feeling we have in fact a very good understanding of the transfer pathways, certainly to man and increasingly to biota.

I learned that the uncertainties on assessments do not invalidate the regulatory system, they do not invalidate the possibility to ensure compliance with the standards. I learned also that a tremendous amount of effort goes into the analysis of uncertainties and I wonder if it is worth all that effort and whether we should reflect on the amount of work that should be put in similar exercises.

The same observation is valid for the discussion about realism. We favour a realistic assessment of population exposure but realism should not be mixed up with complexity. There is a need for a comprehensive but, to the extent possible, simple and transparent assessment of population exposures.

With regard to the natural environment the reference to background exposure is, in my view, still relevant because biota have evolved and have adjusted to the prevailing background environment and to the incorporation of naturally occurring radionuclides. It may be much more meaningful in this area to look into background exposure as a reference than for the protection of man.

One of the conclusions, I think, was also that dose limits are not a useful instrument for the protection of biota. But that leaves us with the discussion of what are useful indicators for the protection of the environment? Is it dose, dose to biota, is it concentrations, concentrations in the environment? And there I am coming back to the observation I made in my own presentation. It is not all about conservation of nature and looking into detriment to biota, but it is also how people feel about the environment and concentrations. High numbers of becquerels per litre are of certain significance to people's perception. That relates also to the very nice discussion by Britt-Marie Drottz-Sjöberg about what is nature, what is perceived to be natural and how people understand the natural environment. Discussing what is a good measure of risk really depends on the perspective that one takes. One perspective is that you want to ensure compliance with regulatory requirements, and then effective dose is a good indicator. On the other hand, referring for instance, to the Nord-Cotentin study, in terms of epidemiology or, in more common terms, the question whether there is an observable risk or not, this is not so much a matter of effective dose, it is organ dose that matters. In general, I think, there is merit in trying in each specific situation to find the indicators that express really the question that one wishes to address, and avoid enveloping concepts that may hide the actual issue.

Regarding the very purpose of this conference – namely to involve stakeholders – this conference was not as successful as it might have been, but we have learned a lot from the process. The approach we had followed was to have an open invitation to all possible people interested in this matter and we hoped this would attract the NGOs that we have learned to know in the past and some others that we would not have known. A more pro-active invitation of NGOs as stakeholders requires a different approach, and the first step of that would be to establish a network through our web page or by other means – we have to think about that. Thus, we could have a good overview of who are the NGOs active in this field, what they represent, what their area of expertise is and what input they can deliver to the process, so that we can have a more structured approach to the involvement of NGOs in this process.

For one type of NGOs or stakeholders I think the Commission is not in as good a position to involve them: the real stakeholders are the people living close to nuclear installations, the local communities. The European Union actually is far away from the local people. This is a matter to be dealt with rather at national level. We hope to incorporate in the Environmental Action Programme an encouragement, if not an obligation, to Member States to involve local stakeholders in the process. At our level we would welcome that local stakeholders, local communities, local information committees, etc. would liaise with each other and that the lessons learnt from their involvement at national level would be brought to the attention of other Member States and the Commission, so that we can learn how well stakeholders at local level are involved in the process.

This is not the endpoint. We will proceed now with the drafting of the Environmental Action Programme. This will take some time. Optimistically, we plan for spring 2004 to have a draft ready that would have clear cut views on where to go, and which can be offered for debate at an extra round of stakeholder involvement.

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CLOSING REMARKS

By Ken Collins

When I was asked if I would chair this, a good many months ago, I thought what a contrast it was to my earlier experiences with the European Commission on the way that it went about consultation. In the "bad old days" the European Commission used to draft a directive and send a draft out for consultation to a variety of people and then they would receive the observations and then they would draft another one and then they would send that out to consultation, and then draft another one, and send that out to consultation and so on. For example, the Directive on Environmental Impact Assessment went through 23 drafts before it finally was published as a final item. The consequence of that was that people were still commenting on draft number 15 when they really were at draft 22. That was extremely confusing, it was very closed, there were no conferences like this and the contrast therefore is enormous. I do think that we are at a stage in the European Community where we need to be inclusive, where we do need to be open and we do need to try to be a great deal more democratic than the present Euratom Treaty allows us to be. But as I said yesterday on the question of the Euratom Treaty: Don't necessarily kick the Commission because the Commission is there and it has to be the guardian of that Treaty so long as it exists. If you want to change this Treaty then you have to go back to the Member States and encourage them to join the movement to democratise it. Some Member States speak a lot about that but don't necessarily vote on it.

I think the question that we have been addressing here is a very familiar question: About how you take the credible, reputable science and make it understandable to citizens who are not necessarily scientific, without devaluing the science. As soon as you start devaluing the science you take away the potential long-term credibility. But as soon as you eliminate the NGOs and the citizens then of course you produce a gulf between what the scientists are doing and what they understand and what we must proceed with and how it is perceived. We have to bring this together and I take the point there that was made by Dr. Mitchell - that we shouldn't be making divisions between types of people who come along here because ultimately we are talking about stakeholders, 370 million in number, who have a legitimate interest in what this conference is doing. When we start driving wedges between groups, then of course, I think, we are devaluing the process.

It is very good that this process is happening and I would like to commend the Commission for taking the initiative. It isn't in the tradition of the Commission and it isn't in the tradition of some Member States. Stakeholder dialogues have existed in Scandinavia and in The Netherlands for a very long time. They have been discovered in some other Member States more recently. We ought to recognise that we need to learn from each other and not simply explain how wonderful we ourselves are. The Commission has to be commended. And one thing I would warn everybody about, if you've ever had a baby in the house and that baby begins to take its first few uncertain steps you don't shout at it for having failed to walk a kilometre the first time it tries. Instead, you commend it and you say, gosh, what a clever child you are. By encouraging it you allow it to develop its capacity to do better and I think that, rather than kick the Commission for failing to have delivered perfection today, we actually ought to be saying, well that's very good, and it is. It isn't the end product, it isn't the final say or anything like it, it isn't the model of future public participation or stakeholder dialogue but it is a very, very good attempt and I think we ought to recognise that.

When Augustin says that things will not happen quickly, I must say that I agree with him. I don't remember anything ever happening quickly in the European Community but there is an old story, which I cannot resist telling, about some years ago when Jacques Delors was still president of the Commission. The story is that a newly born baby was found on the steps of the Berlaymont. It was only just nearly born and it was a great scandal in Belgium. So the Commission went into emergency session to discuss this newly born baby that had been found on the steps of the Berlaymont. After a very lengthy meeting of the Commission they had a Press Conference and a statement was issued at the Press Conference that they were not at all responsible for this newly born baby because in the first place they could never have produced anything quite so perfect and in any case they certainly could not have done it in nine months. So you shouldn't really expect this to happen in such a short time but I do think that it has been a good effort and I would especially like to thank one or two people. Steve, of course, for enabling the thing to take place, to Augustin Janssens, for Eberhardt Henrich, to George Hunter who together took this conference from the very beginning to delivery, maybe not in nine months but not bad all the same. Eberhardt, I know, has worked extremely hard, especially yesterday and today to keep things together. His "command of the mouse" is wonderful. I would certainly like to thank Paloma, Carlos, Ian, Gerhard, Annie, Campbell and Maria for their roles in planning the conference and helping to draw out the key points we have addressed. One day there will be a perfect exercise in stakeholder involvement. I don't think it will be this week and I don't think it will be before Christmas or even next Christmas, but I think nonetheless that this has been a good effort and I am very pleased to have been associated with it. Thank you for being such a co-operative and helpful audience.

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POSTER ABSTRACTS

ADVANCED INSTRUMENTAL ANALYTICAL TECHNIQUES FOR ENVIRONMENTAL RADIATION MONITORING AT JRC-ITU

Laura Aldave de las Heras, Gabriele Tamborini, Maria Betti

European Commission - Joint Research Centre - Institute of Transuranium Elements
P.O. Box 23 40, D-76125 Karlsruhe, Germany

ABSTRACT

A variety of systems and processes may introduce radioactivity in the environment. Human activities, for instance, involving nuclear weapons and nuclear fuel cycle (including mining, milling, fuel enrichment, fabrication, reactor operation, spent fuel stores, reprocessing facilities, medical applications and waste storage) are important and may lead to a significant creation and release of radioactivity. Human technology also releases pre-existing natural radionuclides, which would otherwise remain trapped in the earth's crust. For instance, burning of fossil fuel (oil and coal) dominates direct atmospheric release of pre-existing natural radioactivity.

The distribution pattern of radioactive fallout depends on the weather conditions (i.e. wet or dry) and on the nature of the surface and the physical-chemical form of radionuclides, which may vary depending on release and transport conditions in addition to elements' properties. A general distinction can be made between gases, aerosol and particulate material. Particles with higher activity concentration, known as "hot particles", may result from atmospheric nuclear weapon tests or nuclear reactor accidents. This activity is diluted as material is transferred to soil and water directly or via vegetation and movement through other biota. Therefore, for monitoring radioactivity in the environment it is necessary to analysis bulk samples from all biosphere compartment as well as single microparticles.

During the 5th Framework Program (FP5) of the European Commission, at the Institute for Transuranium Element (ITU) a reference laboratory for the measurement of radioactivity in the environment (MaRE lab) has been set up. MaRE Lab provides scientific and technical support to the policy of the General Directorate Transport and Energy of the European Commission, both for the implementation of the requirements on environmental radioactivity surveillance (Art. 35-36 of the Euratom Treaty) and in the framework of the OSPAR (Oslo-Paris, Convention) strategy on the management of radioactive substances for the protection of marine environment of the North-East Atlantic.

The first paragraph of Article 35 of the Euratom Treaty states that *"Each Member State shall establish the facilities necessary to carry out continuous monitoring of the level of the radioactivity in the air, water and soil and to ensure compliance with the safety basic standards."* Thus it is the cornerstone of extensive programmes for monitoring levels of radioactivity in the environment established in Member States and the prime responsibility for ensuring compliance with the Safety Basic Standards remains with Member States. The formulation "air, water and soil" is understood to be embracing and to include all compartments of the biosphere. The second paragraph of the same Article asserts that *"The Commission shall have the right of access to such facilities; it may verify their*

operation and efficiency". The primary objective of the Article 35 verifications is to establish the efficiency of the facilities installed by Member States for the measurement of environmental radioactivity and of radioactive discharges, and to establish the adequacy of the environmental monitoring programme. Verifications are started:

- Where and when the Commission estimates it to be appropriate
- On request (invitation) of national authorities
- On request by the European Parliament
- On request by a Member State (to verify a neighbouring Member State)

The general scope and conduct of verification is negotiated with Member States and the results of these negotiations are laid down in protocols. Verification activities cover:

- Sampling procedures
- Analytical procedures
- Quality control and assurance programme
- Data management
- Consistency of source data (operational records) with values reported under Articles 36 and 37 of the Euratom Treaty.

The role of MaRE lab is to provide DG Transport and Energy H.4 (Radiation Protection Unit) technical support carrying out sampling and/or analytical campaigns, examining emergency sample and setting-up analysis methods for fast detection of radioactive emission in case of radiological alarm. Standard methodologies for environmental monitoring of the terrestrial and aquatic environments as well as potential ecological detriment have to be developed. For coping with these tasks, a clean room laboratory (where the risk of contamination of samples is almost zero) and highly advanced analytical instruments are in operation at MaRE lab for the detection, for instance, of minute amounts (10^{-9} g) of uranium and plutonium and other radionuclides in environmental microparticles. Low level background radiometric instruments and highly sophisticated mass spectrometers are used for the determination of actinides and fission products even at very low level of concentrations. The samples may stem from different compartment of the biosphere (air, water, soil, foodstuffs) and ecosystems close or far from all installations discharging radioactive substances. Among these, nuclear fuel cycle installations (mainly power stations and reprocessing facilities); radioactive isotope production facilities; users of radioactive isotopes (i.e. hospitals); industries discharging effluents containing enhanced level of natural radioactivity (e.g. phosphate industry); merit to be mentioned. According to the mission of ITU to protect the European citizens from all kind of nuclear activities, in the laboratory studies on the bio-available form of the radionuclides from environment to biota and human being are also carried out.

Collaborations with scientists from Member and Candidates States are very strong in order to reach a harmonisation of the analytical procedures in use in the different labs for the monitoring of the radioactivity in the environment as well as for developing a common Quality Assurance / Quality Control programme.

In this poster, some examples of the activity of the MaRE lab are given.

IMPACT OF IONISING RADIATION ON WILDLIFE –A TERRESTRIAL EXAMPLE

S Bielby[a], S Jones[b], I Zinger-Gize[c], D Copplestone[a]
[a]ERC, University of Liverpool, Vanguard Way, Birkenhead, CH41 9HX, UK
[b]Westlakes Scientific Consulting, Westlakes Science and Technology Park, Moor Row, Cumbria, CA24 3LN, UK
[c]Environment Agency, Knutsford Road, Warrington, WA4 1HG, UK

ABSTRACT

The UK Environment Agency has a legal requirement to assess the impacts of consents and authorisations on the environment for discharges under the Habitats Regulations (1994). This poster provides a summary of Environment Agency R&D Publication 128 (Copplestone *et al.,* 2001) which details the method devised for conducting a generic impact assessment of ionising radiation on wildlife. This methodology is intended as an interim assessment tool, which can be used pending the outcome of current international developments such as the European co-funded project, 'Framework for Assessment of Environmental Impact' (FASSET).

The methodology is based on the concepts of reference ecosystems and reference organisms. Absorbed dose to wildlife is calculated through internal and external exposure, using either literature derived values or empirical measurements of radionuclide concentrations at the site of interest. The data required to enable dose calculations are:

- Concentrations of each radionuclide in the soil/sediment, water or air (from empirical or modelled approaches);
- Concentration factors (CFs) for each radionuclide in each organism to be assessed relative to soil, water or air (based on literature values or actual measurements at the site of interest);
- Organism dimensions (as an ellipsoid);
- The proportion of time the organism spends in different 'compartments' of the ecosystem.

Several radionuclides were selected for the impact assessment:

- Estuarine and freshwater ecosystems: ^{3}H, ^{14}C, ^{99}Tc, ^{90}Sr, ^{137}Cs, $^{239+240}$Pu, ^{238}U, ^{129}I, ^{210}Po, ^{60}Co, ^{106}Ru, ^{131}I, ^{234}Th, ^{234m}Pa, ^{241}Am, ^{32}P, ^{125}I.
- Terrestrial ecosystem: ^{3}H, ^{14}C, ^{35}S, ^{90}Sr, ^{137}Cs, $^{239+240}$Pu, ^{238}U, ^{129}I, ^{226}Ra, ^{60}Co, ^{106}Ru, ^{131}I, ^{234}Th, ^{234m}Pa, ^{241}Am, ^{32}P.

Dose calculations for the selected radionuclides have been programmed into Microsoft® Excel spreadsheets. The interim methodology defines 'default' radiation weighting factors for alpha and low energy beta radiation and concentration factors for reference organisms, which are used in the calculation of doses to biota. The default settings can be used to calculate generic doses to wildlife, or the user can set CF's and their own weighting factors for site specific investigations.

Based on the conclusions of UNSCEAR and IAEA, dose rates of 40 and 400 µGy h^{-1} are used as 'reference guidelines', which are unlikely to cause harm to terrestrial and aquatic ecosystems respectively. In order to demonstrate the method an example scenario is conducted for coastal grassland and the predicted dose rates to biota are reported.

The devised interim methodology has shown that it is practicable to put together an approach for the assessment of radiological impacts on the environment using the reference ecosystem/reference organism concepts, and has identified a number of challenges, which can feed into the ongoing international developments.

THE ROLE OF THE INTERNATIONAL UNION OF RADIOECOLOGY (IUR) IN ENVIRONMENTAL RADIOPROTECTION

François Bréchignac[1], Deborah Oughton[2], George Hunter[3]

International Union of Radioecology
[1] IRSN, DPRE- SERLAB, Centre d'Etudes de Cadarache, 13115 St-Paul-lez-Durance, France
[2] Agricultural University of Norway, P.O. Box 5003, 1432 As, Norway
[3] SEPA, Erskine Court, The Castle Business Park, Stirling, FK9 4TR, UK

ABSTRACT: Environmental radioprotection is an area which has always been central to radioecology, but the context within which it is being tackled is now under strong evolution. Whilst the issue was previously driven by an exclusive and immediate concern for human health, it is now growing to include also the environment itself, with its constituent biota and biotopes. The International Union of Radioecology has strongly influenced this evolution and therefore holds a particular responsibility and role to continue. Based on the large array of environmentally focused expertise that it can call upon from its members, IUR is well suited to provide international guidance and recommendations towards the successful fulfilment of the ultimate goals. The Union particularly stresses the need to tackle a number of scientific knowledge gaps which are revealed in this new context.

INTRODUCTION

Paralleling current developments that reconsider the scope of the link between environmental protection and human health, as driven by large scale concerns (climate change, GMOs, reproductive problems in some biota populations, …), radioecology is enlarging its focus from the protection of man only to the protection of the environment as a whole, including man (IUR, 2001, 2002; Pentreath & Woodhead, 2001; Bréchignac, 2003; Oughton, 2003). As a highly integrated and multidisciplinary scientific discipline, this evolution drives radioecology beyond the well developed understanding of transfers of radioactivity in the environment towards man (exposures, often received primarily via the human food-chains) to the study of long-term effects on ecosystems and their biota, with particular emphasis on low doses.

CURRENT INTERNATIONAL CONTEXT

For various reasons rooted in the nations concerned, there is currently a strong political pressure to establish some sets of principles, standards and criteria for radioprotection of the environment. This is particularly well reflected in the prolific recent developments undertaken under various international auspices such as the IAEA, the EC, the ICRP and the IUR, in which the "framework" keyword is recurrent. Hence, it is observed that there is a danger that the current international effort will be driven more by practical goals (assessment and management) than by science (requirement for understanding).

Furthermore, this effort is spread over several organizations not always pursuing the same objectives, and without any clear coordination that would optimise the efficiency. IAEA is focusing on development of safety standards for international guidance, including a focus on the consensus on ethical and legal principles (IAEA, 1999, 2002). Through two research projects, FASSET and EPIC, the EC aims at structuring the already existing scientific knowledge to derive a framework for future regulations (Strand & Larsson, 2001). The ICRP is primarily involved in the reconsideration of its previous position which claimed that human protection standards ensure an adequate protection of the environment (ICRP, 1977, 1991). As such, the ICRP is largely constrained by an approach that consists of widening the scope of the radioprotection principles existing for man to the environment. Finally, the IUR has played an essential role in actively promoting a mobilisation of the radioecological community on this issue through the operation of a dedicated Task Group (IUR, 2001, 2002).

CURRENT SCIENTIFIC BASIS FOR ENVIRONMENT PROTECTION

The increased interest in environmental protection has highlighted a number of knowledge gaps in the scientific data on sources and effects of radiation in non-human species. This may be surprising given the large amount of scientific literature reviewed on several occasions (NCRP, 1991; IAEA, 1992, UNSCEAR, 1996), but it essentially addressed acute and short-term effects of large radiation doses on biota individuals, whereas the concern now is more about long-term chronic effects of low doses on biota populations and related ecosystems. The current scientific knowledge is therefore largely not relevant, and one can briefly mention the following gaps requiring further attention.

Although the transfer of radionuclides is quite well known within some food-chains, there are very little data on the behaviour of radionuclides in non-temperate zones and on uptake to species that do not form part of the human food chain. There is a need to develop transfer models (flux, dynamic, ecosystem, etc.) and monitoring tools (e.g. biomarkers such as FISH, micronuclei techniques, DNA/RNA markers) that are capable of allowing impact assessments at a variety of species, population and ecosystem levels and that could also deal with other environmental stressors. Knowledge of the doses and effects of background radiation is lacking, as are dose-effect relationships (RBE) for a variety of species, doses and especially low dose rates. Interaction of radioactivity with other stressors, including possible synergistic effects, is only just starting to be investigated.

THE ROLE OF IUR

Given the large amount of radiobiological and radioecological information that has been gathered over the last fifty years, the IUR considers that this can be used to start introducing an overall framework for the systematic protection of the environment from ionising radiation. But meanwhile, the IUR also stresses the necessity to fill the knowledge gaps, with 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.

In this context, and following its pioneer role in this field, the IUR holds a particular responsibility. 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.

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THE INTERNATIONAL JOURNAL OF LOW RADIATION

Gérard Chupin, André Maïsseu
WONUC/Low Radiation International Center
49, rue Lauriston, F-75116, Paris

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THE ENVIRONMENTAL RADIOACTIVITY PROGRAM OF THE NUCLEAR TECHNOLOGY LABORATORY OF THE ARISTOTLE UNIVERSITY OF THESSALONIKI

A. Clouvas, S. Xanthos, M. Antonopoulos Domis

Nuclear Technology Laboratory
Department of Electrical and Computer Engineering,
Aristotle University of Thessaloniki
GR-54124 Thessaloniki

http://nestoras.ee.auth.gr

ABSTRACT

The **Environmental Radioactivity Program** of the Nuclear Technology Laboratory started in 1986 just after the Chernobyl accident with main objective the study of the consequences of the Chernobyl accident on the agricultural production and natural ecosystems at Northern Greece. During the following years the **Environmental Radioactivity Program** broadened its activities in other areas such as the methodology of in situ gamma spectrometry, the development of Monte Carlo simulations for environmental radioactivity problems, the study of indoor radon, cosmic radiation etc. In the present report will be reported briefly the different research activities as well as the main corresponding publications.

INDOOR AND WATER RADON MEASUREMENTS IN TRANSYLVANIA-ROMANIA.

C. Cosma, D, Ristoiu, C. Baciu

University Babes-Bolyai,
Environment Science Department, Kogalniceanu 1,
3400-Cluj-Napoca, Romania

ABSTRACT

Romania is a country with 237.000 km^2 (21 millions of inhabitants) having a continental climate, with +21°C in July and –6°C in January as average temperatures. Transylvania as north-western part of Romania presents moreover a cold season prolonged. In the last years more than 500 integrating and Lucas cell measurements for indoor radon in houses and public buildings were made. Also about 400 radon in water determinations were carried out using a Luk-3A instrument. There is an obvious correlation between the radon content of groundwater and the geological structure of the regions. Some georadioactivity anomalies were identified in areas with ascendant water fluxes. An average of 17.25 Bq/l in drinking water was found.

Integrated winter indoor measurements for 105 dwellings in Cluj county (centre of Transylvania) show an average mean about 160 Bq/m^3.

The influence of the heat preservation in the cold season and also the building material influence on the indoor radon concentration in dwellings were observed. These results (Herculane and Cluj areas) show that in the winter season the indoor radon concentration is about 2 times higher than in the summer season. This fact is due that in the cold season there is an evident tendency to preserve the heat, that is, the natural ventilation is very feebly. The influence of building materials on indoor radon concentration is clearly shown for the namely Stei region which is placed in the neighbourhood of an uranium mine and in some of these houses uranium wastes were used as building materials.

REPORTING ENVIRONMENTAL RADIOACTIVITY IN THE EC:THE JRC REM DATABASE AND ITS APPLICATIONS

Marc De Cort, Gerhard de Vries, Brian Doherty, Tore Tollefsen

ABSTRACT

The Radioactivity Environmental Monitoring (REM) data bank was set-up by JRC-Ispra in 1988 as a support to DG ENV C.4 to bring together and store in a harmonized way environmental radioactivity data produced in the aftermath of the Chernobyl accident. The data bank has therefore mainly two objectives:

- to keep a historical record of the Chernobyl accident, for further scientific study
- to store the radioactivity monitoring data of the EC Member States in order to prepare the annual reports on Environmental Radioactivity in the European Community. By means of these reports EC Member States are informed of the radioactivity levels in the environment in the European Community, as stated in Art. 35 - 36 of the Euratom Treaty.

The data are sent to the JRC in electronic form. To assist Member States, a special data processor, called EasyProteo, has been developed. After eventual digitising and checking, the data are coded into the standard REM data exchange format (card image format) and up-loaded in the REM data bank. Most of the data in the bank are available to external users.

THE USE OF BIOINDICATORS IN ENVIRONMENTAL QUALITY ASSESSMENT

H. FLOROU

NCSR "Demokritos"
Athens

ABSTRACT

Marine pollution levels tend to increase worldwide and, require control strategies and routine monitoring. Radioactive pollution results in long term effects on ecosystems but even their impact has no visible influence, in comparison to other pollutants. Evaluation of marine radioactivity levels is based not only on direct measurements of the abiotic components but also on measurements of the abundance and availability of radionuclides in selected marine organisms. The bioaccumulation of isotopic contaminants by tissues and organs by marine organisms has been studied in an extent scale and led to the adoption of the bio-indicator concept for the environmental quality assessment. In addition, by using biomonitors a radiological risk could be assessed early and support the countermeasures for public protection warning.

Several approaches have been reported as for bioindicator selection based primarily on the concentration factor of the organism selected, sensitivity, habitat, abundance, status in the trophic chain etc.

Bioindicators as a tool for environmental quality assessment can be used down to cytogenetic or molecular level, increasing the sensitivity of the methodology for the determination of pollutant impact (an example is presented in relation to radionuclide levels in the Mediterranean ecosystem).

Key words: Bioindicators, Radiological quality, Marine Radioactivity

Microbial Processes in Radioactive Waste Repository

Gazsó, L.G., Gyöngyi Farkas and G. Diósi

"Fodor József" National Center of Public Health, "Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene, Budapest, 1775. P.O.Box 101. Hungary

ABSTRACT

Bacteria are much more diverse in comparison with plants and animals. Among the huge diversity of bacteria there are microorganisms capable to grow at or adapt to extreme conditions. Some bacteria grow at temperature above 100°C, other thrive in high salinity such as 20-30% NaCl, still others can live at pH lower than 2 or pH higher than 10 or exhibit high radioresistance. Due to accelerated disarmament and nuclear energy activities, large quantities of radioactive waste and nuclear fuel are being placed in storage areas. The awareness the microbial activity could potentially effect the performance of a system for geological disposal of radioactive waste gained acceptance in the early to middle 1980s, and as a result many countries considering developing programmes to study and quantify microbial effects in terms of their own particular disposal concept.

Our programme concerns several major items that may have an influence on the mobility of radionuclides in direct and indirect ways thereby being important for the safety analysis. They are uptake and transport of radionuclides by microorganisms, diversity and distribution of subterranean bacteria in typical repository environments, environmental limitation and bacterial activity, effect of bacterial activity on the mobility of radionuclides, microbial gas production and consumption, bacterial recombination of hydrogen and oxygen from radiolysis, and microbially induced corrosion of waste canister.

The Permian Boda Claystone Formation in the Mecsek Hill area is being considered for high level waste disposal. Groundwater, technical water, rock and surface samples were collected and gas, organic acid, siderophore production, biosorption of radionuclides and radiosensitivity of isolates were studied.

RADIATION PROTECTION - ROLE OF THE EUROPEAN ASSOCIATION OF RADIOLOGY (EAR) AND EUROPEAN CONGRESS OF RADIOLOGY (ECR)

Gerard Hurley, European Association of Radiology (EAR)

ABSTRACT

EAR and ECR have many tools to enhance radiation safety and facilitate the implementation of radiation protection legislation. E.g. Liaison, education, guidelines, research, integration of radiation safety in day to day practice and public information at www.ear-online.org .

NATIONAL HEALTH SYSTEM AND REGULATIONS FOR ENVIRONMENTAL RADIOACTIVITY MONITORING

R. Karaivanova, M. Hristova, M. Periklieva

NATIONAL CENTRE OF RADIOBIOLOGY AND RADIATION PROTECTION
Bulgaria, 1756 Sofia, blv. "St.Kl. Ohridsky" 132

phone: 359-2-626037,fax: 621059, e-mail:ncrrp@ncrrp.org

ABSTRACT

This poster presents the National Health System and Regulations for Environmental Radioactivity Monitoring in the Republic of Bulgaria. Factors which determine radiation state of the environment in Bulgaria are included. The Bulgarian Regulatory Authorities and the radiation control which they carry out are presented. The density of the national networks and the radiation parameters monitored are given.

Bulgarian Basic Normative Documents and Regulations concerning the radiation protection are listed.

The poster points out as well the future priorities included in the National Environmental Health Action Plan.

RADON IN UKRAINE

Komov I. L.

Institute of Environmental Geochemistry
Palladin av, Kyiv-142, UA 030 680, UKRAINE
Tel. +380 44 290 10 35, Fax +380 44 451 02 36
E-mail: leon@ecocentr.carrier.kiev.ua

ABSTRACT

National data on indoor radon, radon in water, and geologic radon potential indicate systematic differences in the distribution of radon across the Ukraine. Radon gas is found in homes all over the Ukraine. Its maximum percentage is detected in uranium deposits (up to 30000 Bq/m^3). In indoor air from the penetration of soil gas into homes, so only very high concentrations of radon in water will make an important contribution to the airborne concentration.

Parameters that can be used to examine the possibilities of the appearance of hazard radon areas in the geologic medium in the Kiev area have been determined. The map was developed using five factors to determine radon potential: indoor radon measurements; geology; aerial radioactivity; soil permeability; and, foundation type.

We have proposed and are developing equipment of new type for complex investigation of movement and transformation of radon, thoron and their derivatives.

A number of methods can be used to reduce elevated radon levels in a home. These methods fall into two categories: (1) preventing radon from entering the house, and (2) removing radon after entry. Some actions may be taken immediately, and can be done quickly at minimal expense.

RADIOACTIVITY IN FOODSTUFFS OF LITHUANIA. SYSTEM OF MONITORING, IMPLEMENTATION OF EURATOM TREATY

Rima Ladygiene
Radiation Protection Centre, Kalvariju 153, Vilnius, Lithuania

ABSTRACT

Radiation Protection Centre is responsible for control of radiation protection of both public and radiation workers in Lithuania. Among other tasks are constant measurements of natural and artificial radioactivity. Measurements are carried out according to orders of the Minister of Health and approved plans. The laws and governmental decisions in the field of radiation protection in Lithuania were prepared on the basis of the International Basic Safety Standards for Protection Against Ionising Radiation and for the Safety of Radiation Sources, BSS No. 115, Council Directive 96/29/EURATOM of 13 May 1996 Basic Safety Standards for the Protection of the Health of Workers and the General Public Against the Dangers Arising from Ionising Radiation, European Drinking Water Directive (Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption) and according other directives and international standards.

Monitoring of drinking water, soil, fallout and foodstuff is constantly performed. This requirement is set in the Law of Radiation Protection of the Republic of Lithuania. Radiation Protection Centre is carrying out this type of monitoring since 1965. Sampling points have been selected in the different regions of country. Frequency of sampling at 9 monitoring points is typically 100 samples of food and 140 samples of drinking water per year.

Concentrations of gross alpha/gross beta activity in drinking water (excluding ^{3}H, ^{40}K radon and radon decay products) measured during the last 5 years are well below limits and typically do not exceed 10 mBq/l. No differences in concentrations of radionuclides in foodstuff and drinking water from Ignalina NPP region and other country were found. 34 spa water sources that are used or being explored for future use, also drinking water from private wells and community supply systems have been investigated for concentrations of radon. The measured radon concentrations in Lithuanian spa waters used for drinking did not exceed 10.4 Bq/l and are of the same range as those measured in water from municipal water supply systems and private wells. The highest radon concentrations were found in spa waters with the highest content of mineral salts from the wells bored in the deepest layers and did not exceed 50 Bq/l. From the beginning of the next year the radiological monitoring is decided to be performed according to the Commission Recommendation of 8 June 2000 on the Application of Article 36 of the Euratom Treaty Concerning the Monitoring of the Levels of Radioactivity in the Environment for the Purpose of Assessing the Exposure of the Population as a Whole. The regulation was approved on this. The regulation include a list of institutions are responsible to carry out radiological monitoring, the order of sampling and measurements, reporting of results.

Some wild products tend to accumulate radionuclides, so the activities of berry and mushrooms are analysed. At least 200 samples of mushrooms are analysed every year from different places of Lithuania. Average concentration of ^{137}Cs in bilberry in 2000 was (12±10) Bq/kg. Activity in mushrooms depends on the kind of mushrooms. Some kinds are tended to accumulate radionuclides more than other kinds. The one of the cleanest kind is a chanterelle. It was found that activity of caesium in the same kind of mushroom from the

different places might differ more than 100 times. It seems that activity of caesium depends on soil.

Doses due to radionuclides in foodstuff are calculated on the basis results of measurements of concentrations of radionuclides in main foodstuffs (potatoes, milk, meat, cereals, leafy vegetables, fish) and mushrooms. The mean total annual effective dose due to ^{90}Sr, ^{137}Cs and ^{40}K in foodstuff is 0.19 mSv. ^{40}K is responsible for 99% of this dose. Conservative estimation of dose due to ^{137}Cs in wild mushrooms gives 0.085 mSv of annual effective dose.

NATURAL AND ARTIFICIAL RADIOACTIVITY IN THE SPANISH ENVIRONMENT

Legarda, F.[1(*)],Romero, M.L.[2],Herranz, M.[1], Trueba, C.[2], Ramos, L.[3]

[1]Universidad del País Vasco, Alda. Urquijo, s/n. 48013 Bilbao (Spain)
[2] CIEMAT, Av. Complutense, 22. 28040 Madrid (Spain),
[3]Consejo de Seguridad Nuclear. Justo Dorado, 11. 28040 Madrid (Spain)

INTRODUCTION

The project presented in this paper will be developed within the framework of the general programme of the Spanish Regulatory Authority, the CSN, to asses and control the exposure of the population to ionizing radiation originating such at natural as at artificial sources present in the biosphere.

This project is orientated to get knowledge of the contents of man-made radionuclides in Spanish territory in order to establish a reference level. Current data are scarce and very few studies seem to exist about ^{137}Cs and ^{90}Sr fallout nuclides distribution in soil. There are some local studies, but they are not homogeneous and therefore are not comparable.

The aim of this work is to define a methodology to establish the inventory of ^{137}Cs and ^{90}Sr and other critical radionuclides in Spanish soils and to obtain relevant parameters of their behaviour in them for modelling purposes.

A collaborative project has been established between the UPV/EHU and CIEMAT under the auspices of the CSN to carry out the research work. The sampling program has been designed to determine the activity inventories at different locations in the Spanish territory, considering the varying soil types as well as Nuclear Power Plant sites. The results will be combined with precedent studies on the radiological vulnerability of Spanish soils for a ^{137}Cs and a ^{90}Sr contamination. The vulnerability is defined as the soil potential to mobilise and retain the radionuclides deposited, based on standard soil properties.

MATERIALS AND METHOD

The research work started with a review of existing data in Spanish territory, to identify the lacks of information related to ^{137}Cs and ^{90}Sr distribution in Spanish soils and other critical radionuclides. These have been identified as $^{239+240}Pu$, ^{241}Am, ^{237}Np, and ^{99}Tc, being relevant for the environmental impact assessment due to potential nuclear accidents and radioactive waste disposal.

The sampling program has been designed to determine the activity inventories at different soil types locations in the Spanish territory. A distribution grid of 30 sampling areas has been established, in each area two soil cores of 100 cm depth will be collected. The soil profiles will be sectioned at 5 cm. layers, and two sub-samples will be obtained from each section.

Radioactive determinations for the selected radionuclides will be performed in each sub-sample from core sections. Total inventory of each radionuclide in soil profile will be calculated.

The parameters governing the behaviour and migration of these radionuclides in soil profile would be evaluated in each soil type. Their migration within soil profile is supposed to follow a convective-diffusive model (Bachhuber, 1982). A case study has been developed for soils at the Biscay area whose parameters have been derived from local studies (Herranz, 2001). This modelling technique has produced good predictive results as it is shown in Figure 1, where the experimental results are compared with predictions produced by the model, in two sampling points of this area (43.26° N, 2.51°W and. 43.12°N, 2.52° W locations).

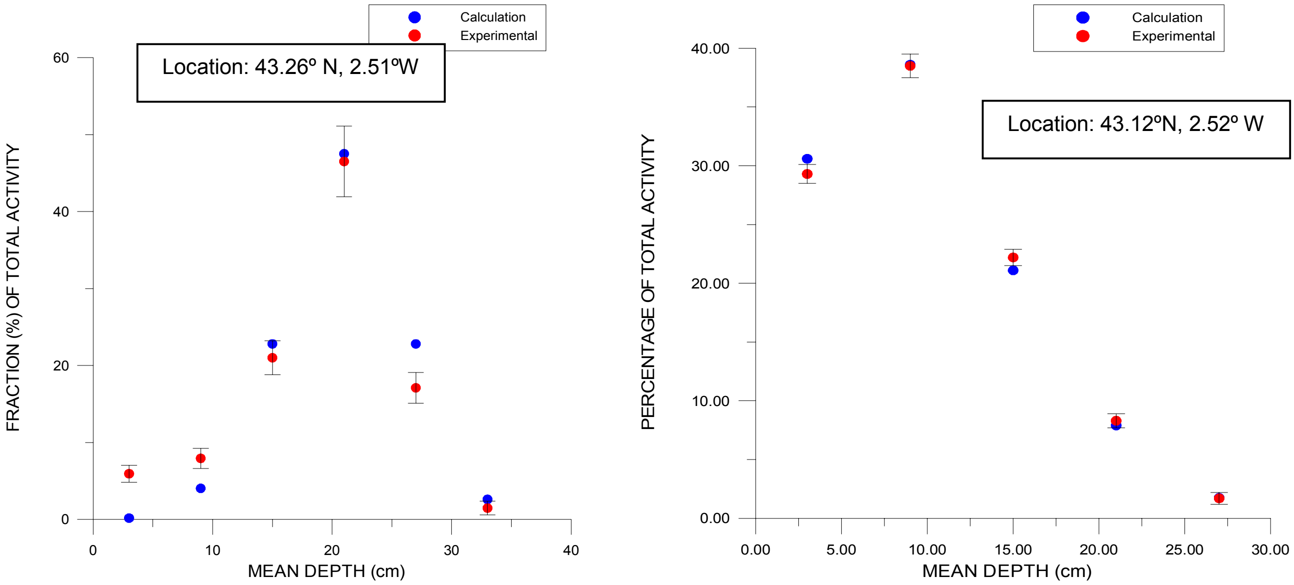

Figure 1. Comparison of the results predicted to experimental concentrations of total ^{90}Sr activity in two soil profiles from Biscay.

CONCLUSIONS

The results of the project would allow to acquire comparable data within the EU Member States and to assure the reliability of parameters so obtained for the Mediterranean conditions.

The project will supply relevant information for programmes related to protection of the environment, rehabilitation of soil contaminated areas, and to EU data bases on Environmental Radioactivity, providing an improved understanding of the environmental hazard associated with radionuclide redistribution and migration.

The results so obtained would constitute a tool for assessing the environmental impact in case of an accidental release of radioactive material, being a valuable basis to advice appropriate countermeasures to reduce the transfer of radionuclides from soil.

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RADON INDOORS IN A BULGARIAN TOWN WITH INCREASED LUNG CANCER INCIDENCE

D. Pressyanov*, Sh. Danon†, Z. Valerianova†

*Faculty of Physics, St. Kliment Ohridski University of Sofia, Bulgaria
†National Cancer Registry, National Oncological Centre, Sofia, Bulgaria

ABSTRACT

Chronically high lung cancer incidence has been observed for decades in the town of Rakovski (17000 inhabitants), Bulgaria. For the period 1981-1999 the standardized incidence ratio (SIR) for males was 2.06 (95% CI: 1.76 – 2.39), for males aged ≤ 49 y it was 3.31 (2.29 – 4.62) and for females 1.90 (1.25 – 2.77). Recent radon measurements in the town showed significantly increased concentrations, the average annual mean being 234 Bq m^{-3} and in about 50% of the houses the annual mean is >200 Bq m^{-3}. The concentrations in houses with a case of lung cancer were in average 27% higher than in controls, the difference being significant at 90% level. The results imply that the radon exposure may plausibly explain the risk, including the age dependence observed. Possibly, this population could be targeted for more detailed study that will be able to contribute for more precise radon risk estimates.

MEASUREMENTS OF RADON EMANATION COEFFICIENT IN ZIRCON MATERIALS

Serena Righi[a], Giorgio Mazzotti[b], Camilla Simonetto[a], Luigi Bruzzi[a]

[a] Environmental Science, University of Bologna, via Dell'Agricoltura 5, I-48100 Ravenna(Italy)

[b] Health Physics Service, Ravenna Hospital, Viale Randi 5, I-48100 Ravenna (Italy)

ABSTRACT

Humans are primarily exposed to natural ionising radiation from cosmic rays, and naturally occurring radioactive elements found in the earth's crust. On average two thirds of the dose people receive comes from natural terrestrial sources. The primary radioactive elements found in the earth's crust are potassium, thorium, and uranium. The predominant uranium isotope, ^{238}U, is of importance to human health because it is the parent nuclide of ^{222}Rn, which is a radionuclide of public health concern. In fact, the largest natural source of radiation exposure to humans is due to radon gas. The average American receives about 2 mSv/y from radon.

Radon, being a gas, can escape from the rock containing its parent, uranium, which occurs in many types of rocks. Most contain only 1 to 3 ppm of uranium, but some, like granites, dark shales, light-coloured volcanic rocks, and sedimentary rocks with phosphate, may contain as much as 100 ppm. Radon moving through soil pore spaces and rock fractures near the surface of the earth usually escapes into the atmosphere. In the outdoors, radon is diluted to such low levels that there is usually nothing to worry about. Once inside an enclosed space such as a home, however, radon can accumulate, depending upon the building's construction and the concentration of radon in underlying soil. Radon in indoor air ranges from less that 10 Bq/m^3 to about 100.000 Bq/m^3, but it probably averages between 30 and 80 Bq/m^3. The European Commission issued recommendations in 1990 on advisory levels for radon in residential dwelling (EC, 1990). For existing dwellings the limit for radon gas concentration is 400 Bq/m^3. For new construction the limit is 200 Bq/m^3. There are three basic entry routes into buildings: from soil, building materials, and water supplied. Building materials are the second source in terms of importance after soil for the indoor radon level. However this source is more readily controllable than the other radon sources. The prevalent transport mechanism of the radon generated in building materials through material's pores is recoil and diffusion. The fraction of the total amount of radon produced by radium decay that escapes from soil particles and gets into the pores of the medium is called *radon emanation coefficient*. It is a dimensionless parameter and is represented as either a fraction or a percentage. It is known to be in the order of 0.2-0.3 for common constituents of building materials. In this poster we present some measurements about radon emanation coefficient in zircon sand and flours used in ceramic tiles production.

EVALUATION AND NETWORK OF EC- DECISION SUPPORT SYSTEMS IN THE FIELD OF TERRESTRIAL RADIOECOLOGICAL RESEARCH

G.Voigt[1], N.Semioshkina[2], D.Tarsitano[2]

[1]IAEA-NAAL, 1040 Vienna, Austria
[2]GSF-Institut für Strahlenschutz, 85764 Neuherberg, Germany

INTRODUCTION

Within the 4th framework programme of the EC, a major objective of a variety of projects was to derive holistic approaches to reliably predict radionuclide activity transfer in aquatic and terrestrial ecosystems. These projects were constructed as DSS making use of new tools such as GIS and geostatistics and improved understanding on behaviour of radioactive material in the environment, to identify cost-effective countermeasures to be implemented and their potential environmental side-effects and waste production. This was undertaken to improve the modelling of the behaviour of radionuclides in the environment and also to develop a sound policy and practice in managing the impact of radiation (natural and artificial) on man and environment. Therefore, some projects additionally addressed the social-psychological-ethical aspects of remediation strategies, decision-making and post accidental management policy.

There is now an urgent need 1) to inform DSS developers and potential end users about the existing systems, of their capabilities, advantages, disadvantages, and 2) to interlink and compare the results of these projects with the RODOS system, a online decision support system for use in Europe. This will allow the identification of overlaps, weaknesses and strengths within these projects and simultaneously allow the integration of the best features of existing systems into one common product, which will be widely applicable in Europe. This challenge can only be addressed by creating a European network between system developers and their potential users such as decision makers, stakeholders and international bodies. In an iterative process, feedback from those user groups on needed improvements will be incorporated within the final product. The results of the joint efforts of the network will provide sound information on:

- What we currently know.
- What are the best available state of the art approaches.
- Where is future research and developments still needed.

OBJECTIVES

Accidental releases do not respect any borders, as was also experienced after the Chernobyl accident and long-lived radionuclides can be dispersed over many countries. Therefore, contamination of agricultural land and production areas and consequently of food products is not only a concern of an individual country or nationality but requires a joint effort of the countries affected. For this purpose, Decision Support Systems (DSS), which take into account national but also international and generic needs, and which are based on the understanding of the nature and the processes involved, are inevitably required to support a good management system when confronted with such situations.

Especially within the 4th framework programme of the EC, several projects were supported which derived environmentally-based DSS to more reliably predict the transfer of radionuclides (mainly radiocaesium) in ecosystems to derive management systems provided for potential decision makers and stakeholders in case of accidental releases or natural of artificial radioactive substances. The European DSS RODOS represents one of the most ambitious and challenging projects since it tries to cover all important radionuclides, all important processes involved into the dispersion and transfer mechanisms and appropriate countermeasure strategies for different phases after an accident. In addition to RODOS, however, a variety of other projects have been undertaken which covered particular topics in much greater depth, having the potential to improving the existing Europe-wide applicable RODOS system. Each of those have advantages and disadvantages, have been developed for special ecosystems, or cover one aspect such as the soil-plant transfer of radiocaesium or potential side effects of countermeasures in much more detail. Especially the application of countermeasures to reducing the radiological consequences after accidental releases may cause non-desired effects of ecological, economic and social nature. Such an assessment requires appropriate models to predict the radionuclide behaviour in the environment; but also techniques for assessing economic, socio-psychological and ecological impacts. These aspects need to be accounted for when assessing the global impact of the above effects.

Though the individual systems themselves had different objectives and addressed different tasks, there exists some overlap in the parameters used: A careful re-evaluation and comparison between the individual DSS is urgently needed. The objectives of this project therefore are:

1) to provide a summary and a synthesis of the existing DSSs
2) to identify weaknesses and strengths of the different approaches
3) to verify and provide compatibility of the DSSs
4) to integrate the DSSs for their holistic use for complete ecosystems and economic systems
5) to inform the user community about the existence and their potential for improving the assessment and management
6) to identify the potential to realise a holistic common approach for a wider application in Europe
7) to explore the user market beyond the strict use for radioecology and radiation protection
8) to provide information about further needed research in the field of radioecology and radiation protection which might find its implementation in the 6th framework programme.

A critical evaluation of projects which have developed DSS systems within the 4th framework programme has not yet been undertaken. This network will:

- Inform the scientific and user community and other interested parties on the existing DSS on terrestrial transfer of radioactive material
- Explore additional potential applications of DSS
- Compare the different DSS to identify its overlaps, its weaknesses and strengths
- Provide a synthesis of these different DSS
- Identify lack of knowledge in the present state-of-the-art in terrestrial radioecological science
- Provide a product capable of being incorporated into a European-wide useable DSS.

In addition, this network will help to continue existing scientific collaboration between institutions and will represent a forum for discussion of future research needs. The outcome of the project may directly be of value for the implementation of the 6th framework programme of the EC. The primary output of the project will considerably contribute to a framework aiding the selection of robust and practicable strategies to enable the long-term sustainable management of areas contaminated by nuclear accidents.

PROJECT WORK PROGRAMME

In the past, there have been many EC supported international projects dealing with the understanding and modelling of radioactive material in the soil-plant-animal system, quantifying the driving parameters, the transfer in human food chains and the resulting potential dose of humans from external and internal radiation exposure. A substantial financial and also moral support to the affected countries was especially provided after the Chernobyl accident which resulted in the creation of the so-called ECP and JSP projects directly addressing the problems of how to mitigate the consequences of this accident. Valuable information about the behaviour of radioactive material in terrestrial and aquatic ecosystems has resulted from these investigations, which emphasised the importance of different ecosystems in contributing to the dose of normal population or critical groups.

In the follow up, within the 4th framework programme, especially that of Mastering Event of the Past, one of the most interesting tasks was the determination of the potential for cost-effective countermeasures in these environments and the derivation of remediation strategies which addressed not only the effectiveness but also their psycho-social and environmental impacts. Within this context, the term flux has been used, referring to Bq export, and which can be used to identify those areas which are potentially at higher risk due to either their special ecological transfer behaviour, high agricultural production rates or special behaviour of inhabitants. This consequently lead to the concept of radioecological sensitivity of ecosystems with respect to the dose to man, which can be adapted to any condition in Europe or elsewhere or even with respect to dose to biota. In addition, the generation of waste and its impact and the environmental consequences of countermeasure applications in different ecosystems has, for the first time been evaluated and integrated into a DSS.

The development and use of modern tools such as Geographical Information Systems (GIS) and geostatistics in radioecology has dramatically increased the capabilities of DSS systems. GIS are general tools for storing and analysing spatial data. The limitations of GIS are not associated with computer power, but by the way in which users perceive the importance of objects and attributes and how these objects have to be recorded. In environmental studies, the inherent complexity of environmental systems is simplified and abstracted with key features to create 'models' of the considered area. This is influenced by the cultural norms of the observer and the purpose of the study. Two extremes in approaches to perceive space are either as being occupied by a series of entities, which are described by their properties and mapped using a co-ordinate system or as a continuous field of variation with no distinct boundaries. GIS uses a series of points, lines, pixels and polygons for exact entities, or tessellated units to describe the landscape for continuous fields. GIS can be easily connected to transfer models and will result in a representative presentation of data indicating also their uncertainties. The spatial resolution of a model can be improved by decreasing the grid size if information is available. Therefore, the major limitation of a GIS is the availability of appropriate data and their resolution in space and time.

The major projects which have made use of GIS and/or have created a DSS within the EC 4th framework programme in respect to terrestrial environments are:

CESER	FORECO	LANDSCAPE
RECLAIM	RESTORE	RODOS
SAVE	SAVE-EC	SEMINAT
STRESS	TEMAS	

The identified co-ordinators or major contributors are requested to contribute to four work packages which cover natural / semi-natural environments, agricultural environments and urban environments and the derived holistic approaches. They will also consult when the models derived will be tested, evaluated and compared by the co-ordinator. In addition to the four work packages, there will be a steering committee consisting of three selected members/leaders of the work packages, the co-ordinator, an EC representative and end users (national body and industry representative); the steering committee will be chaired by the co-ordinator. Within the work packages is foreseen to compare scenarios calculated by the different DSS within the different ecosystems as suggested and agreed by the steering committee. On this basis comparisons can be undertaken, evaluations been made and improvements to feed into RODOS been suggested.

For an improved information policy, a web page has been initialised, maintained and managed by the co-ordinator http://www.gsf.de/institute/ISS/evanet/evanet.html which contains the network description, all actual reports, a summary of the project results and conclusions and recommendations and links to the corresponding projects and software. This web page will be made public by different options such as announcement in the CORDIS, IUR newsletter and the J Environ Radioactivity and other appropriate media. For consultancy additional experts will be invited to the work package meetings relying mainly on the expertise of the IUR and its membership, which will further stimulate dissemination of progress and results of the network.

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http://www.cordis.lu/en/home.html

RADIOACTIVE MATERIALS IN SCRAP METAL

Richard van Sonsbeek

Röntgen Technische Dienst bv, Department Radiation Protection Services
P.O. Box 10065, 3004 AB Rotterdam, The Netherlands
telephone +31 (0)10 2088342, fax +31 (0)10 4158022, e-mail: rps@rtd.nl

ABSTRACT

In 2003 a decree on detection of radioactive scrap will come into force in the Netherlands. In accordance with this decree scrap metal traders are obliged to measure the radiation level of every incoming load. (Until now this has been done voluntarily.) Enhanced radiation levels have to be reported to the Environmental Inspectorate.

Only licensed companies such as RTD with sufficient expertise on radiation protection may inspect, and sort loads on which enhanced radiation levels have been measured. Precautions are taken to protect workers from (internal) contamination, and to avoid dissemination of radioactive material into the environment. The activities are performed in accordance with an approved plan of action. Radioactive materials isolated in this way are examined further.

Dose rates are recorded, inscriptions are noted, and photos are made. In case of radioactively contaminated objects, samples are taken, and analysed with a gamma spectrometer to identify the radionuclides, and their activity concentration. Sometimes even x-rays are made. Depending on the results of the examination, advice is given on how to dispose of the radioactive waste.

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ANNEX I

Bibliographical Notes of Chair, Co-chairs and Speakers

CHAIRMAN

Ken Collins (Scottish Environment Protection Agency, UK)

Mr Collins was educated at St. John's Grammar School and Hamilton Academy and obtained degrees at both Glasgow (B.Sc.(Hons)) and Strathclyde (M.Sc.) universities. His earlier career was as Planning Officer at Glasgow Corporation, and as Lecturer at Glasgow College of Building and Paisley College of Technology. From 1979 until 1999 he was a Member of the European Parliament for Strathclyde East and held positions as Chairman of the Committee on Environment, Consumer Protection and Public Health, Chairman of the Conference of Committee Chairmen, Deputy Leader of the Labour Group, and Socialist Spokesperson on the Environment, Consumer Protection and Public Health.

Mr Collins is a Fellow of the Royal Scottish Geographical Society and an Honorary Fellow of the Chartered Institution of Water and Environment Management, and Institute of Waste Management. He is a Board Member of the Institute of European Environment Policy, Forward Scotland and was Chairman then Board Member of Central Scotland Countryside Trust. He is a Member of the Management Board of the European Environment Agency (nominated by the European Parliament). He is also Honorary Vice-President of the National Society for Clean Air and Vice-President of the Royal Environmental Health Institute of Scotland. He is Ambassador for the National Asthma Campaign.

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CO-CHAIRS

Maria Betti (European Commission)

Maria Betti obtained her doctoral degree in Chemistry in 1984 from the University of Pisa, Italy.

International research experience at:

- JRC - Ispra;
- Technical University of Lund (Sweden);
- Dept. of Chemistry, George Mason Univ., Virginia – USA;
- J. Heyrovsky Institute of the Academy of Science - Praha – Czech Republic.

Since March 1st 1991, Dr. Betti has worked at the Institute for Transuranium Elements (ITU) at Karlsruhe, Germany (General Directorate Joint Research Centre of the European Commission). Her main task is to develop new analytical techniques for the determination of trace elements in contaminated samples. To that end, she has developed state-of-the-art techniques for the characterisation of nuclear material.

She has been Head of the Analytical Chemistry Section at JRC, Karlsruhe since 1991.

She has been conducting research on the use of GDMS in the characterisation of nuclear material since 1992.

From 1993 she has been responsible for the development of analytical methods for the identification of clandestine nuclear material and is a consultant to the IAEA and the Euratom Safeguards Office. In January 1999 she was invited by the Nuclear Material Control Centre (NMCC) of Japan to give lectures at the Japan Atomic Energy Research Centre (JAERI) and other Japanese organisations on analytical methods for the detection of nuclear clandestine materials. She works in support of EC with regard to OSPAR and in support of the verification inspections under Article 35 of the Euratom treaty.

To date, she is author of about 150 scientific publications concerning instrumental and radioanalytical chemistry for trace analysis in international journals. Furthermore she has made approximately eighty presentations at international congresses.

Appointed Contract Professor in 1998, she presents the course on "Instrumental analytical techniques for surface analysis" at the Department of Chemistry of the University of Pisa.

She is one of the official referees of international journals in analytical chemistry of the DOE (USA) and of the Italian Ministry for University and Scientific Research (MURST).

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George Hunter (Scottish Environment Protection Agency, UK)

Dr Hunter is currently Compliance Support Manager in the Radioactive Substances Unit of the Scottish Environment Protection Agency in Stirling, Scotland. He was on seconded to the European Commission, as a Detached National Expert working for the Radiation Protection Unit of Directorate General Environment in Luxembourg during the period June 1999 to June 2002. Prior to this he held the post of Head of Policy Co-ordination (Radioactive Substances) in SEPA from the Agency's creation in 1996 until moving to Luxembourg in June 1999. Before this he worked as a Principal Industrial Pollution Inspector with Her Majesty's Industrial Pollution Inspectorate for Scotland (HMIPI), based in Edinburgh, Scotland, after transfer there from the Atomic Weapons Establishment, Aldermaston, England, in 1986, where he had been an Assistant Plant Manager in the Waste Management Group since 1982 following a period of initial employment as a Process Development Chemist in the chromium chemicals industry, in Stockton-on-Tees, England, from 1980.

He obtained a BSc (hons) and PhD in chemistry at the University of Edinburgh, where he studied during the period 1973-1980. He is a fellow of the Royal Society of Chemistry, Chartered Chemist, and registered 'European Chemist', a member of the Chartered Institution of Water and Environmental Management, and a fellow of the Society for Radiological Protection, the International Union of Radioecology, and of the Eco-ethics International Union. He is an Honorary Associate of the Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP) of the

University of Dundee, Scotland, and a member of the editorial board of *Journal of Environmental Radioactivity*. He was elected as a Board Member of the International Union of Radioecology in September 2002.

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Stephen Kaiser (European Commission)

Stephen Kaiser trained in Mathematics and Statistics before working for British Nuclear Fuels plc (UK) in a variety of management service functions. In 1979 he joined the Directorate of Euratom Safeguards of the European Commission working on strategies and safeguards approaches. In 1987 he became Head of Sector in an Inspection Division, and subsequently Head of Unit responsible for teams of inspectors carrying out inspection missions in nuclear installations throughout the EU. In 1997 he moved to become Head of the Radiation Protection Unit of DG Environment, responsible for the development and implementation of legal instruments under Chapter 3 of the Euratom Treaty ("Health and Safety") for the protection of workers and the public against the dangers arising from ionising radiation. From September 2001 until January 2003, he was Acting Director of "Environment and Health" in DG Environment. He is again Head of the Radiation Protection Unit, but the Unit has now been transferred to DG Transport and Energy.

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Gerald Kirchner (Bundesamt für Strahlenschutz, Germany)

Education: Diploma in Physics (1978, Muenster); Dr. rer. nat. in Physics (1986, Bremen); Habilitation in Environmental Physics (1998, Bremen)

Professional career: Research scientist Univ. Bremen (1987-1998); Head, radioactivity measurement laboratory Univ. Bremen (1992-2001); Privatdozent Univ. Bremen (1998-); Member of the German Radiation Protection Commission (1999-2001); Head, Dept. Of Applied Radiation Protection, Federal Office for Radiation Protection (2001-)

Key qualifications: reactor physics, terrestrial radioecology, soil physics

Publications: 85 publications (21 in peer reviewed journals)

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Ian McAulay (Trinity College, Dublin, Ireland)

Professor McAulay is a physicist from Trinity College Dublin with interests in radiation protection and environmental radiation - he is the Chairman of the EC's EURATOM Article 31 Group of Experts which provides advice to the European Commission.

His research interests in recent years have been in the areas of radiation exposure of air crew due to cosmic radiation and of the distribution of natural radioactivity in the environment. He has also worked on the behaviour in the natural environment of the fallout from the Chernobyl nuclear accident and on estimating the radiation doses to the public due to the discharges into the Irish Sea from the Sellafield nuclear reprocessing plant.

In addition to his membership of the EURATOM Article 31 Expert Group, Professor McAulay has served on many advisory committees, including those dealing with the radiological hazards of depleted uranium, the recycling of metals from the decommissioning of nuclear installations, radioactivity in consumer products, and intervention levels for radioactivity in foodstuffs following a nuclear accident.

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Paloma Sendín (Consejo de Seguridad Nuclear, Spain)

Economist by the Autonomous University of Madrid (1974)

Member of the "National Body of Economists and Trade Technicians" (1983)

Director General for Exports Promotion: Spanish Institute for the Promotion of Foreign Trade (ICEX) (1990-1994)

Senior Advisor at the Prime Minister's Office

Organisation Committee of the Spanish Presidency of the EU Council (1994-1996)

Director General for Mining; Ministry of Industry and Energy (1996-2000)

Commissioner CSN: Nuclear Regulatory Commission of Spain (Since 2000)

She has also been Member of several Executive Boards, among other:

- National Industry Shares Company (SEPI)
- National Northern Coal Company (HUNOSA)
- Bank "Exterior de España" (BEX)
- Oil Logistics Company (CLH)
- Centre for Industry Technology Development (CDTI)

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Annie Sugier (Institut de Radioprotection et de Sûreté Nucléaire, France)

Professional background: Engineer in nuclear physics and chemistry (Orsay University)

Professional experience: Research & Development in Radioactive waste management, industrial operations of Decommissioning and Dismantling of nuclear installations, Radiological protection

Present position: Director of Protection at the Institute of Nuclear Safety and Radiological Protection (French abbreviation IRSN). IRSN is the main technical support of the French Authorities of Nuclear Safety and Radiological protection. It carries out research and expert evaluation in the field.

Other responsibilities as international expert in radiological protection:

Member of the International Commission of Radiological Protection (Main Commission, president of Committee 4 : Applications),

Expert of radiological protection for the European Union,

Former president of the French Society of Radiological protection.

President of the Nord-Cotentin Radioecology Task Group in charge of assessing the impact of the nuclear installations in the area (involving experts from NGO, institutional organisations, operators, foreign institutions).

President of the Program Committee of IRPA 11.

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SPEAKERS

Jean Brenot (Institut de Radioprotection et de Sûreté Nucléaire, France)

Jean Brenot belongs to the Nuclear Service Centre and he is heading the Risk Assessment Unit, dealing with various subjects such as epidemiology and operators' exposure as well as opinion surveys. He is working in the 'Ecological Group of Nord-Cotentin' that was set up with the objective of assessing the risk of radiation exposure due to the environmental effects of the nuclear reprocessing plant at La Hague. Jean Brenot was the person concerned with developing the analysis of uncertainties in risk assessment.

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Roger H. Clarke (National Radiological Protection Board, UK)

Professor Roger Clarke (BSc, MSc, PhD, FRCR, FRSA, FSRP) is the Director of the National Radiological Protection Board. The Board is the focal point in the United Kingdom for radiation protection research and advice to the government, industry and the public.

Professor Clarke is currently Chairman of the International Commission on Radiological Protection (ICRP). He is the UK Representative to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and a member of several Advisory Groups to the Commission of the European Communities.

In the UK, Professor Clarke is a member the Health and Safety Commission's Ionising Radiations Advisory Committee, and the Medical Research Council's Committee on the Effects of Radiation.

Professor Clarke is a Visiting Professor in the Centre for Environmental Technology at Imperial College of Science, Technology and Medicine, University of London, and Visiting Professor in Radiation and Environmental Protection at the University of Surrey. He has been elected an Honorary Fellow of the Royal College of Radiologists, a Fellow of the Royal Society for the encouragement of arts, manufactures and commerce, and an Honorary Fellow of the Society for Radiological Protection.

He has published more than 160 papers and reports in the scientific literature and at conferences. In recent years he has been the recipient of the G. William Morgan award from the Health Physics Society of the USA, the Ellison-Cliffe award from the Royal Society of Medicine in the UK, and the Hanns-Langendorff Medal from the Vereinigung Deutscher Strahlenschutzärzte, and has been made an Honorary Vice-President, Institution of Nuclear Engineers.

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Britt-Marie Drottz-Sjöberg (Norwegian University of Science and Technology)

Prof. Britt-Marie Drottz-Sjöberg works at the Department of Psychology, at the Norwegian University of Science and Technology. She has published in the field of risk research since the mid 1980's, especially in relation to public reactions to radiation and radioactive waste. She was involved in the EU-CIS collaborative project on social and psychological consequences of the Chernobyl accident (JSP-2) in the beginning of the 1990's, and has continued to study risk experiences, perceptions and communication issues in a context of health, environment and technology since then. Drottz-Sjöberg was the president of the Society for Risk Analysis-Europe 1998-99, and is a member of the Royal Swedish Academy of Engineering Sciences; The Swedish National Committee on Radiation Protection Research at the Royal Swedish Academy of Sciences; the Nordic Society for Radiation Protection; the Scientific Advisory Board of the Swedish Risk Academy; the Medicine and Health Committee of the Norwegian Research Council; the Global Change Committee of the Norwegian Research Council, and the Swedish National Council for Nuclear Waste (KASAM).

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Brenda Howard (Centre for Ecology and Hydrology - Merlewood, UK)

Brenda Howard gained a first class honours degree from York University in Biology in 1977 and a PhD in physiological heavy metal detoxification mechanisms in 1983. Brenda Howard is the leader of a radioecology section in the Centre for Ecology and Hydrology - Merlewood in the UK. She has been involved in radioecological research, focused on understanding factors affecting radionuclide behaviour in the terrestrial environment for 23 years. Her particular interests include transfer to animals, semi-natural ecosystems, development of countermeasures, arctic radioecology and spatial analysis of radioecological sensitivity. She has co-ordinated six EU framework projects. She has contributed to a number of International Atomic Energy Agency handbooks and is a member of the Expert Group on Radioactivity in the Arctic Monitoring and Assessment Programme. She has recently been awarded an MBE for her radioecological work.

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Augustin Janssens (European Commission)

Dr. Augustin Janssens has studied physics at the University Ghent (Belgium) and graduated with a PhD in nuclear physics in 1978. He has conducted research on radiation dosimetry (cavity theory, calorimetry, Fricke dosimeter) and radiation protection (^{85}Kr in air, radon, building materials) at the Nuclear Physics Laboratory, Ghent over the period 1972-1985.

In 1986 he joined the EC, Luxembourg, Nuclear Safeguards Inspectorate. In 1990 he returned to radiation protection (sector environmental radioactivity in DG ENV). He was promoted to Head of Sector in 2000 and at the time of the Conference, since autumn 2001, he was acting Head of Unit.

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Stephen Kaiser (European Commission)

see Co-chairs Stephen Kaiser

Carl-Magnus Larsson (SSI - Swedish Radiation Protection Authority)

Carl-Magnus Larsson studied chemistry and biology at Stockholm University 1970–1974 and obtained a PhD in Botany in 1980. Mr. Larsson has been employed at the Swedish Radiation Protection Institute (SSI) since September 1993. In 1996, he took up the position as Head of the Department for Waste Management and Environmental Protection at SSI. Responsibilities include all public health and environmental protection issues connected to the generation, management and disposal of radioactive waste, including spent nuclear fuel and discharges.

Mr. Larsson is the Co-ordinator of the European Union research project FASSET (Framework for ASSessment of Environmental impacT) which involves 15 organizations within seven European Countries. He is a member of the Radioactive Waste Management Committee (RWMC) of the OECD-Nuclear Energy Agency, is the vice-chairman of the RWMC Regulators' Forum, is a member of the expert group on radioactive waste established under Article 37 of the Euratom Treaty and is a corresponding member of the ICRP Task Group on Environmental Protection.

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Jacques Lochard (Centre d'Études pour l'Évaluation de la Protection dans le domaine Nucléaire, France)

Jacques LOCHARD was educated in Economics. He is the Director of the Nuclear Protection Evaluation Centre (CEPN), a non-profit organisation, founded in 1976, for research and consulting in the area of optimisation of radiological protection and comparative assessment of health and environmental risks associated with energy systems.

On the international scene, Jacques LOCHARD is currently the Vice-Chairman of the Committee on Radiation Protection and Public Health (CRPPH) of the Nuclear Energy Agency of the OECD, Member of Committee 4 of the International Commission on Radiological Protection (ICRP) and Executive Officer of the International Radiation Protection Association (IRPA).

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Peter I. Mitchell (University College Dublin, Ireland)

Professor Peter I. Mitchell PhD CPhys FInstP

Department of Experimental Physics, University College Dublin

Nationality: Irish

Professor Mitchell specialises in the related fields of Radioecology, Radiometrology and Radiation Protection, and has led the Radiation Physics and Radioecology Research Group at University College Dublin for over two decades. Much of his work has centered on understanding and modelling the speciation, mobility and ultimate fate of transuranium elements in the marine environment, with emphasis on plutonium and americium in the Irish Sea. He has published extensively in the international literature, is a regular invited speaker and chair at international conferences and symposia, and has contributed to the work of various national and international institutions, including the European Commission. He is a member of the Commission's Euratom (Article 37) Group of Experts, as well as the International Committee for Radionuclide Metrology (ICRM), the Environmental Radiation Advisory Committee to the Radiological Protection Institute of Ireland (RPII), and the editorial board of the international journal, *Applied Radiation and Isotopes*. He participated in the recently completed MARINA II Project, in which a detailed assessment was made of the radiological exposure of the European Community from radioactivity in North European marine waters on behalf of the European Commission. He has coordinated successive EC-funded multi-national research projects in the field of Radioecology for almost a decade and a half, is a former Vice- Dean of the Faculty of Science in UCD, and recently completed a three-year term as Head of the Department of Experimental Physics.

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Carmel Mothersill (Dublin Institute of Technology, Ireland)

Dr Carmel Mothersill is head of the Radiation and Environmental Science Centre at the Dublin Institute of Technology.

She is a zoologist with many years experience in radiobiological effects using cultured cells from animals and humans. She graduated from University College Dublin with a BSc (Hons) and obtained a PhD for work on mammalian stress responses. She has worked in both academic, semi state and hospital environments involving projects ranging from surveying sites of special scientific interest to evaluating patient tissues for radiation response.

Her group now focuses on low dose effects of ionising radiation on human and non-human biota with particular emphasis on delayed, non-targeted and trans-generational effects.

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Hartmut Nies (Bundesamt für Seeschifffahrt und Hydrographie, Germany)

Dr. Hartmut Nies has studied Chemistry at University Stuttgart and Technical University Berlin. His Diploma-Thesis at Hahn-Meitner-Institute for Nuclear Research, Berlin was in the field of Nuclear Chemistry. The Dissertation at the Institute of Organic Chemistry, Freie Universität Berlin had the title: ^{1}H- and ^{13}C-NMR-spectroscopic Investigations about the Drilling of the Double Bond in Styrene. On 11 August 1982 he was promoted to Dr. rer nat.

His occupational career began as Scientific Assistant at the Institute of Organic Chemistry of the Freie Universität Berlin. from where he moved to the Deutsches Hydrographisches Institut / renamed in 1990 to "Federal Maritime and Hydrographic Agency" Hamburg. In 1987 he became head of the Section "Radioactivity of the Marine Environment", in 1993: Head of the Sub-Department "Marine Chemistry" of the BSH. Also in 1993 he was appointed "Direktor und

Professor" at the Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency).

Dr. Nies is Head of the Analytical Chemistry Laboratory of the BSH with presently 43 staff members; Head of the Marine Radioactivity section of the BSH with presently 12 staff members; Chairman of the co-ordination group between Federal and State (Länder) laboratories of the Monitoring programme in the North Sea; Member of various international expert groups on monitoring the marine environment, e.g. OSPAR, HELCOM, NEA/OECD, partly as chairman; Member of the national co-ordination group of Federal Offices for environmental radioactivity monitoring in Germany ("Leitstellen"); Member of the Radio-Ecological Advisory Committee of the German Radiation Protection Commission to the Ministry for the Environment, Nature Conservation and Nuclear Safety (between Jan. 1992 and Dec. 1996); Member of the German Society of Chemists (GDCh) and its topic groups "Nuclear Chemistry", "Water Chemistry" and "Chemists in the public service" and Member of the International Union of Radioecologists (IUR).

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Deborah Oughton (Agricultural University of Norway)

Debbie Oughton is a professor of environmental chemistry with the Norwegian Agricultural University and a research fellow within the Norwegian Ethics Programme at the University of Oslo. She is also an IUR board member and has been closely involved in the formulation of the IUR Consensus Statement.

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Zitouni Ould-Dada (Food Standards Agency, UK)

Zitouni Ould-Dada has worked in the areas of risk assessment and risk communication for several years and with different organisations in the United Kingdom. He has been actively involved in a number of international programmes on testing and validation of dose assessment models. He has managed a large number of research projects in these areas.

Zitouni Ould-Dada is currently working at the Food Standards Agency in London as a Senior Scientific Officer in the areas of risk assessment and emergencies. He is taking the lead in developing probabilistic assessment methods and producing guidelines to communicate uncertainty to the public. He is chairman of a national group addressing issues related to uncertainty and variability in the assessment of public exposure to radioactivity.

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Jan Pentreath (UK)

PROF. R. J. PENTREATH, BSc, PhD, DSc, CBiol, FIBiol, FSRP

<u>Currently</u>: Research Professor at the Environmental Systems Science Centre in the University of Reading; Visiting Professor at Imperial College of Science, London; Honorary Professor at the University of East Anglia; independent member of Joint Nature Conservation Committee; Member of International Commission on Radiological Protection's Task Group on Environmental Protection.

Formerly: Chief Scientist and Director of Environmental Strategy, Environment Agency, UK(1995-2000); Chief Scientist and Director of Water Quality, National River Authority (1989-1995); Head of Aquatic Environment Protection Division and Deputy Director of Fisheries Research, MAFF(1987-1989).

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Carol Salt (University of Stirling, UK)

Dr Carol Salt was trained as a Biologist at the Free and Technical Universities of Berlin. Since 1989 she has been researching the behaviour of radiocaesium in agricultural and semi-natural ecosystems in Scotland. In 1991 she was appointed to a Lectureship at the University of Stirling, Scotland where she teaches on a wide range of environmental pollution issues. Her presentation is based on the EU-funded CESER project, which she co-ordinated from 1997 to 1999. In this project the environmental and socio-economic impacts of countermeasures in radioactively contaminated agricultural systems were investigated.

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Jane R Simmonds (National Radiological Protection Board, UK)

Jane Simmonds, having studied Physics at University College London, joined the Assessments Department of the National Radiological Protection Board in 1975. She is currently joint leader of the Radionuclide Releases Group. She has been involved in a wide range of environmental assessments including: the EC methodology for assessing the radiological consequences of routine releases of radionuclides to the environment; the development of the PC-CREAM computer system; the EC guidance on the realistic assessment of doses to members of the public; the recent EC MARINA II project. She also took part in studies to assess intakes and doses to determine the risks of leukaemia and other cancers in Seascale from radiation exposure. She has acted as a consultant for the IAEA on a number of occasions and was an expert on the Nord-Cotentin Radiological Group.

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CASE STUDIES

Mark Dutton (NNC Limited, UK)

Dr. L M C Dutton joined the predecessor of NNC in 1964 when he started his PhD at the Birmingham Synchrotron and he has worked in the Nuclear Power Industry ever since. He has been involved in radiological, waste management, and environmental issues associated with the design of different kinds of reactors (Magnox, fast breeder, advanced gas cooled, high temperature and heavy water reactors and the Pressurized Water Reactor design for Sizewell B) and many other nuclear facilities. His activity has included decommissioning, waste management and environmental issues in the UK, Western and Eastern Europe, Canada and Australia. This year he has retired from being the business manager of NNC Environmental and Radiological Business and he is now a principal consultant with NNC. His presentation was co-authored by Mark Gerchikov, Sven Nielsen, Jane Simmonds, Tatiana Sazykina and George Hunter.

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Caroline Ringeard (Institut de Radioprotection et de Sûreté Nucléaire, France)

Caroline Ringeard has received a Master's degree in Chemistry at Pierre & Marie Curie University and her DESS (Post-graduate specialist diploma) from Orsay University.

She began her professional career as an engineer in radioecology and radiological protection at the Radiological Protection Analysis and Assessment Unit (SAER) of the IRSN Department for Human Health Protection and Dosimetry (DPHD). In 1998, she took part in defining a methodology for assessing the dosimetric impact of a nuclear facility.

After that she went on to join the Nord-Cotentin Radioecology Group (GRNC) in France. In 1999, she performed dose and cancer risk calculations within this group. Caroline Ringeard has since continued to participate in the activities of the GRNC, and is currently involved in assessing the impact of chemical releases from nuclear facilities.

Other contributions are:

- radiological protection examination of release permit applications (DARPE) for the French safety authority (DGSNR), and assessment of the environmental and health impact of chemical substances associated with radioactive effluents for the French Ministry of Ecology and Sustainable Development (DPPR);
- comparative study of methods for assessing the impact of releases from the Sellafield and Cogema-La Hague reprocessing plants.

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ANNEX II

Glossary of some Abbreviations and Acronyms

Abbreviation, Acronym or Symbol	Full Expression
ACRO	Association pour le Contrôle de la Radioactivité dans l'Ouest (France)
AGR	Advanced Gas Cooled Reactor
ALAP	As Low As Possible
ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
Am	Americium
ANDRA	Agence nationale pour la gestion des déchets radioactifs (France)
ANPA	Agenzia Nazionale per la Protezione dell' Ambiente (Italy)
ARC	Austrian Research Centres
ARCICEN	Association des Représentants de Collectivités Locales d'Implantation de Centrales Nucléaires (France)
BAT	Best Available Technology
BfS	Bundesamt für Strahlenschutz (Germany)
BNFL	British Nuclear Fuels plc. (UK)
Bq	Becquerel (unit of activity)
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Germany)
BSS	Basic Safety Standards
BWR	Boiling Water Reactor
Candu	Canadian Deuterium Uranium Reactor
CEA	Commissariat à l'Énergie Atomique (France)
CEH	Centre for Ecology and Hydrology - Merlewood (UK)
CEPN	Centre d'Études pour l'Évaluation de la Protection dans le domaine Nucléaire (France)
Ci	Curie (old unit of activity)
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (Spain)
COGEMA	Compagnie Générale des Matières Nucléaires (France)
COMARE	Committee on Medical Aspects of Radiation in the Environment (UK)

Abbreviation, Acronym or Symbol	Full Expression
Cs	Caesium
CSN	Consejo de Seguridad Nuclear (Spain)
DEFRA	Department for Environment, Food and Rural Affairs (UK)
EC	European Commission
EC ENV	European Commission, Directorate General Environment
EC RTD	European Commission, Directorate General Research
EC TREN	European Commission, Directorate General Energy and Transport
EC-JRC-IES	European Commission, Joint Research Centre, Institute for Environment and Sustainability (Ispra, Italy)
EC-JRC-IRMM	European Commission, Joint Research Centre, Institute for Reference Materials and Measurements (Geel, Belgium)
EC-JRC-ITU	European Commission, Joint Research Centre, Institute for Transuranium Elements (Karlsruhe, Germany)
EDF	Électricité de France
EEE Network	Environment - Engineering - Education Network
ENRESA	Empresa Nacional de Residuos Radiactivos, S.A. (Spain)
ERC	Environmental Research and Consultancy, University of Liverpool (UK)
EU	European Union
EURATOM	European Atomic Energy Community
FANC-AFCN	Federaal Agentschap voor Nucleaire Controle - Agence Fédérale de Contrôle Nucléaire (Belgium)
FSA	Food Standards Agency (UK)
GMF	Group of European Municipalities with Nuclear Facilities
GRNC	Groupe Radioécologie Nord-Cotentin (France)
GSF	Forschungszentrum für Umwelt und Gesundheit (Germany)
Gy	Gray (unit of absorbed dose)
H	Hydrogen
HLW	High Level Waste
I	Iodine
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IES	Institute for Environment and Sustainability (European Commission)
IKB	Agricultural University of Norway

Abbreviation, Acronym or Symbol	Full Expression
ILW	Intermediate Level Waste
INKA/GCFG	General Consumers' Federation of Greece
IRMM	Institute for Reference Materials and Measurements (European Commission)
IRPA	International Radiation Protection Association
IRSID	Institut de Recherche Sidérurgique / Research Institute of the French Iron and Steel Industry (France)
IRSN	Institut de Radioprotection et de Sûreté Nucléaire (France)
IRSN/CTHIR	IRSN/Centre Technique d'Homologation de l'Instrumentation de Radioprotection (France)
IRSN/DES	Département de l'Évaluation de Sûreté de l'IRSN (France)
IRSN/DPHD	Département de Protection de la Santé de l'Homme et de Dosimétrie de l'IRSN (France)
IRSN/DPRE	Département de Protection de l'Environnement de l'IRSN (France)
ITU	Institute for Transuranium Elements (European Commission)
IUR	International Union of Radioecology
JRC	Joint Research Centre (European Commission)
K	Potassium
KIMO	Kommunenes Internasjonale Miljøorganisasjon - Local Authorities International Environmental Organisation
LLW	Low Level Waste
NCSR	National Centre for Scientific Research "Demokritos" (Greece)
NEA	Nuclear Energy Agency (OECD)
NNC	National Nuclear Corporation (UK)
NORM	Naturally Occurring Radioactive Material
NRPB	National Radiological Protection Board (UK)
NTNU	Norwegian University of Science and Technology
OSPAR	Oslo and Paris (Convention, Commission)
Pb	Lead
Po	Polonium
Pu	Plutonium
PWR	Pressurized Water Reactor
Ra	Radium
RBE	Relative Biological Effectiveness

Abbreviation, Acronym or Symbol	Full Expression
RBMK	Russian type pessurised water cooled graphite moderated reactor design
Rn	Radon
RPII	Radiological Protection Institute (Ireland)
RSC	Radiation and Environmental Science centre, Dublin Institute of Technology (Ireland)
SCK-CEN	Studiecentrum voor Kernenergie - Centre d'Étude de l'Énergie Nucléaire (Belgium)
SEPA	Scottish Environment Protection Agency
SSI	Swedish Radiation Protection Authority
Sv	Sievert (unit of effective dose and equivalent dose)
T	Tritium
Tc	Technetium
TCD	Trinity College, Dublin (Ireland)
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
U	Uranium
UCD	University College, Dublin (Ireland)
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UoS	University of Stirling (UK)
VVER	Russian type pressurised water cooled water moderated reactor design (= WWER)
WHO	World Health Organization
WNA	World Nuclear Association
WONUC	World Council of Nuclear Workers
WWER	Russian type pressurised water cooled water moderated reactor design (= VVER)

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LIST OF PARTICIPANTS

Dr. Laura ALDAVE DE LAS HERAS EC-JRC-ITU P.O.Box 2340 D-76125 Karlsruhe Germany Tel.: 0049 (0)7247951357 Fax: 0049 (0)7247951186 E-mail: aldave@itu.fzk.de	Mrs Carolina ALVARO ENUSA Industrias Avanzada SA Carretera Salamanca-Ledesma km. 26 E-37115 Juzbado (Salamanca) Spain Tel.: 0034 (0)923 329704 Fax: 0034 (0)923 321369 E-mail: cap@fab.enusa.es
Mrs. Blanca ANDRES European Commission TREN.H.4 - Radiation Protection WAG C/340 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 32215 Fax: 00352 4301 36358 E-mail: blanca.andres-ordax@cec.eu.int	Mr. Anthony AQUILINA Environment Protection Directorate, M.E.P.A. Pollution Control Coordination Unit Quality Control Laboratory MT-PLA 08 Corradino, Paola Malta Tel.: 00356 21-678034 Fax: 00356 21-660108 E-mail: rita.cilia@mepa.org.mt
Prof. Panayotis ASSIMAKOPOULOS The University of Ioannina Department of Physics GR-45110 Ioannina Greece Tel.: 0030 (0)6510 98551 Fax: 0030 (0)6510 93418 E-mail: pasimak@cc.uoi.gr	Dr. Maria BETTI DG Joint Research Centre Institute for Transuranium PO Box 2340 D-76125 Karlsruhe Germany Tel.: 0049 (0)7247951 363 Fax: 0049 (0)7247951 186 E-mail: betti@itu.fzk.de
Mr Michael BICKEL EC-JRC-IRMM Retieseweg B-2440 Geel Belgium Tel.: 0032 (0)14 571734 Fax: 0032 (0)14 584271 E-mail: michael.bickel@irmm.jrc.be	Mrs Sally BIELBY ERC University of Liverpool Vanguard Way CH41 9HX Birkenhead UK Tel.: 0044 1516502275 Fax: 0044 1516502274 E-mail: bielby@liv.ac.uk
Mr Richard BRAMHALL Low Level Radiation Campaign The Knoll Montpellier Park LD1 5LW Llandrinood UK Tel.: 0044 (0)1597 824771 Fax: 0044 (0)1597 824771 E-mail: bramhall@llrc.org	Mr Peter BRAZEL Department of the Environment and Local Government Nuclear Safety Division 25 Clare Street IRL Dublin 2 Ireland Tel.: 00353 (0)1 6041562 Fax: 00353 (0)1 6041656 E-mail: PeterBrazel@transport.ie

Dr. François BRECHIGNAC IRSN/DPRE/SERLAB Centre de Cadarache Bât. 159, BP 3 F-13115 St. Paul-lez-Durance France Tel.: 0033 (1)4 42256343 Fax: 0033 (1)4 42254948 E-mail: francois.brechignac@irsn.fr	Mr. Jean BRENOT Institut de Radioprotection et de Sûreté Nucléaire DPHD/SEGR rue Auguste Lemaire, BP 17 F-92262 Fontenay-aux-Roses Cedex France Tel.: 0033 (0)1 58 35 81 59 Fax: 0033 (0)1 58 35 88 29 E-mail: jean.brenot@irsn.fr
Mr. Etienne BRIERE EDF 6, quai Watier F-78410 Chatou-Cedex France Tel.: Fax: E-mail: etienne.briere@edf.fr	Mr. François BRILLANCEAU European Commission TREN.H.4 - Radiation Protection WAG C/337 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 36420 Fax: 00352 4301 36358 E-mail: francois.brillanceau@cec.eu.int
Mrs Marianne CALVEZ CEA Centre de Fontenay-aux-Roses BP 6 F-92265 Fontenay-aux-Roses France Tel.: 0033 (0)1 46549248 Fax: 0033 (0)1 46549437 E-mail: marianne.calvez@cea.fr	Mr. David CANCIO CIEMAT Avda Complutense, 22 E-28040 Madrid Spain Tel.: 0034 91 3466628/6623 Fax: 0034 01 3466121 E-mail: david.cancio@ciemat.es
Mr Pedro CARBONERAS ENRESA Safety and Licensing Dept. Emilio Vargas, 7 E-28043 Madrid Spain Tel.: 0034 (0)91 566 8285 Fax: 0034 (0)91 566 8166 E-mail: pcam@enresa.es	Dr. Zhanat CARR WHO/Radiation and Environmenta; Health Program SDE/PHE/Rad L-125 20 Avenue Appia CH-1211 Geneva-27 Switzerland Tel.: 0041 (0)22 7914033 Fax: 0041 (0)22 7914123 E-mail: carrz@who.int
Mr Simon CARROLL Greenpeace International Keizersgracht 176 NL-1016 DW Amsterdam Netherlands Tel.: 0031 (0)20 5236222 Fax: 0031 (0)20 5236200 E-mail: scarroll@ams.greenpeace.org	Mr. Philippe CHINO ANDRA 1-7 rue Jean Monnet Parc de la Croix Blanche F-92298 Châtenay Malabry France Tel.: 34 (0)1 46118041 Fax: 34 (0)1 46118208 E-mail: philippe.chino@andra.fr

Mr. Gérard CHUPIN WONUC/Low Radiation International Center 49, rue Lauriston F-75116 Paris France Tel.: 0033(0)1 53708899 Fax: 0033 (0)1 53700008 E-mail: [Gérard Chupin] wonuc@wanadoo.fr	Prof. Roger CLARKE NRPB Chilton, Didcot OX11 ORQ OXFORDSHIRE UK Tel.: 0044 (0)1235 822632 Fax: 0044 (0)1235 822619 E-mail: Roger.Clarke@nrpb.org.uk
Mr. Françoise CLERGEOT WONUC-Lowrad 49, rue Lauriston F-75116 Paris France Tel.: 0033(0)1 53708899 Fax: 0033 (0)1 53700008 E-mail: wonuc@wanadoo.fr	Prof. Alexander CLOUVAS Aristotle University of Thessaloniki Department of Electrical and Computer Engineering GR-54124 Thessaloniki Greece Tel.: 0030 (0)310996353 Fax: 0030 (0)310996302 E-mail: clouvas@eng.auth.gr
Mr. Roger COATES WNA BNFL Risley WA3 6AS Warrington, Cheshire UK Tel.: Fax: E-mail: roger.coates@bnfl.com	Mr. Ken COLLINS Scottish Environment Protection Agency Corporate Office Erskine Court, The Castle Business Park FK9 4TR STIRLING UK Tel.: 0044 (0) 1786 457705 Fax: E-mail: Ken.Collins@sepa.org.uk
Mr. Constantin COSMA University Babes-Bolyai Str. Kogalniceanu, 1 RO-3400 Cluj-Napoca Romania Tel.: 00402 64405300 Fax: 00402 64191906 E-mail: amsoc@phys.ubbcluj.ro	Mr. Francesco D'ALBERTI EC/DG JRC/IES Via E. Fermi 1 TP 321 I-21020 Ispra (VA) Italy Tel.: Fax: E-mail: francesco.d'alberti@cec.eu.int
Mr. Paul DALE Scottish Environmental Protection Agency Erskine Court, The Castle Business Park FK9 4TR STIRLING UK Tel.: Fax: E-mail: paul.dale@sepa.org.uk	Mr. Jean-Louis DAROUSSIN European Commission TREN.H.4 - Radiation Protection WAG C/232 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 32297 Fax: 00352 4301 36358 E-mail: jean-louis.daroussin@cec.eu.int

Mr Fred DAWSON Ministry of Defence Directorate of Defence Health and Safety Policy St. Giles Court, Room 213, 1-13 St Giles High Street WC2H 8LD London UK Tel.: 0044 (0)20 780 70215 Fax: 0044 (0)20 721 83943 E-mail: dsefpol-hdhp@defence.mod.uk	Ir. Marc DE CORT EC/DG JRC/IES Via E. Fermi 1 TP 321 I-21020 Ispra (VA) Italy Tel.: 0039 0332 785095 Fax: 0039 0332 785466 E-mail: marc.de-cort@jrc.it
Dr. Bálint DOBI Ministry for Environment and Water Fö str. 44-50 H-1011 Budapest Hungary Tel.: 0036 (0)1 4573590 Fax: 0036 (0)1 2015280 E-mail: dobi@mail.ktm.hu	Prof. Britt-Marie DROTTZ-SJØBERG NTNU Dept. of Psychology N-7491 Trondheim Norway Tel.: 0047 (0)7359 7485 Fax: 0047 (0)7359 1920 E-mail: brittds@svt.ntnu.no
Dr. Mark DUTTON NNC Limited Booths Hall Chelford Road WA16 8QZ Knutsford, Cheshire UK Tel.: 0044 1565 843829 Fax: 0044 1565 843727 E-mail: mark.dutton@nnc.co.uk	Mrs Katalin EGED GSF Strahlenschutzinstitut Ingolstädter Landstraße 1 D-85764 Neuherberg Germany Tel.: 0049 89 3187 4015 Fax: 0049 89 3187 3363 E-mail: eged@gsf.de
Mr Gilbert EGGERMONT SCK-CEN Av. H. Debroux 40 B-1160 Brussels Belgium Tel.: 0032(0)2 6611983 Fax: 0032(0)2 6611958 E-mail: geggermo@sckcen.be	Mr Andris EGLAJS Ministry of Environmental Protection and Regional Development Peldu iela 25 LV-1494 Riga Latvia Tel.: 00371 (0) 7026531 Fax: 00371 (0) 7820442 E-mail: andris.eglajs@varam.gov.lv
Dr. Ian FAIRLIE CERRIE 115, Riversdale Road N5 2SU London UK Tel.: 0044 (0)20 7354 1512 Fax: 0044 (0)20 7354 1512 E-mail: ianfairlie@uklondon115.freeserve.co.uk	Dr. Michel FEIDER Division de la Radioprotection Ministère de la Santé Villa Louvigny, Allée Marconi L-2120 Luxembourg Luxembourg Tel.: 00352 4785670 Fax: 00352 467522 E-mail: michel.feider@ms.etat.lu

Dr. Heleny FLOROU NCSR "Demokritos" INT-RP Aghia Paraskevi 153, POB 60228 GR-15310 Athens Greece Tel.: 0030 (0)10 6503809 Fax: 0030 (0)10 6519180 E-mail: eflorou@ipta.demokritos.gr	Dr. Pascal FRANCO IRSN/CTHIR Bât. 389 Boîte Postale 68 F-91192 Gif-sur-Yvette Cedex France Tel.: 0033 (0)69085502 Fax: 0033 (0)69085650 E-mail: pascal.franco@irsn.fr
Dr. Peter GAAL State Health Institute of Slovak Republic SFZU SR Bajkalska 18 SK-82645 Bratislava Slovak Republic Tel.: 00421 (0)2 44372619 Fax: 00421 (0)2 44372619 E-mail: gaal@szusr.sk	Mrs Marie-Odile GALLERAND ANDRA 1-7 rue Jean Monnet Parc de la Croix Blanche F-92298 Châtenay Malabry France Tel.: 0033 (0)1 46118041 Fax: 0033 (0)1 46118208 E-mail: mo.gallerand@andra.fr
Mr Pierre GAUJÉ IRSID Voie Romaine BP 30320 F-57283 Maizières-les-Metz Cedex France Tel.: 0033 (0)3 87704194 Fax: 0033 (0)3 87704108 E-mail: pierre.gauje@irsid.usinor.com	Dr. Lajos GAZSÓ Natl. Res. Inst. Radiobiology and Radiohygiene Anna u. 5 H-1221 Budapest Hungary Tel.: 0036 (0)1 4822004 Fax: 0036 (0)1 4822005 E-mail: gazso@hp.osski.hu
Mr. Campbell GEMMELL Scottish Environment Protection Agency Corporate Office Erskine Court, The Castle Business Park FK9 4TR STIRLING UK Tel.: 0044 (0) 1786 457705 Fax: E-mail: Campbell.Gemmell@sepa.org.uk	Mr Carlos GIMENO Consejo de Seguridad Nuclear (CSN) Justo Dorado 11 E-28040 Madrid Spain Tel.: 0034 (0)91 3460502 Fax: 0034 (0)91 3460393 E-mail: cgs@csn.es
Dr. Irene GIZE Environment Agency Knutsford Road WA4 1HG Warrington UK Tel.: 0044 (0)1925 653999 Fax: 0044 (0)1925 415961 E-mail: irene.gize@environment-agency.gov.uk	Mr. Philippe GUETAT C.E.A. F-91680 Brûyère-le-Châtel France Tel.: 0033 (0)1 69 264543 Fax: 0033 (0)1 69267065 E-mail: philippe.guetat@cea.fr

Mrs Joelle GUILHOT-CLOUVAS Aristotle University of Thessaloniki Nuclear Technology Laboratory GR-54124 Thessaloniki Greece Tel.: 0030 (0)3 10996376 Fax: 0030 (0)3 10996376 E-mail: joelle@eng.auth.gr	Dr. Frank HARDEMAN SCK-CEN Boeretang 200 B-2400 Mol Belgium Tel.: 0032 14 332851 Fax: 0032 14 321056 E-mail: fhardema@sckcen.be
Mr. Eberhardt HENRICH European Commission TREN.H.4 - Radiation Protection WAG C/243 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 34705 Fax: 00352 4301 36280 E-mail: eberhardt.henrich@cec.eu.int	Mr. Michel HERZEELE European Commission TREN.H.4 - Radiation Protection WAG C/343 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 36396 Fax: 00352 4301 36358 E-mail: michel.herzeele@cec.eu.int
Dr. Brenda HOWARD Centre for Ecology and Hydrology Merlewood Windermere Road LA11 6JU Grange-over-Sands, Cumbria UK Tel.: 0044 (0) 15395 32264 Fax: 0044 (0) 15395 34705 E-mail: bjho@ceh.ac.uk	Dr. Erich HRNECEK ARC Seibersdorf A-2444 Seibersdorf Austria Tel.: 0043 (0)50550 2518 Fax: 0043 (0)50550 2502 E-mail: erich.hrnecek@arcs.ac.at
Mr. George HUNTER Scottish Environment Protection Agency Corporate Office Erskine Court, The Castle Business Park FK9 4TR STIRLING UK Tel.: 0044 (0) 1786 431763 Fax: 0044 (0) 1786 431795 E-mail: George.Hunter@sepa.org.uk	Dr. Gerard HURLEY European Association of Radiology (EAR) Adelaide and Meath Hospital Tallaght IRL Dublin 24 Ireland Tel.: 00353 (0)1 4143700 Fax: 00353 (0)1 4143805 E-mail: gerard.hurley@amnch.ie
Mr. Augustin JANSSENS European Commission TREN.H.4 - Radiation Protection WAG C/354 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 36395 Fax: 00352 4301 36280 E-mail: augustin.janssens@cec.eu.int	Mr. László JÉKI Central Research Institute for Particle and Nuclear Physics H-1221 Budapest Hungary Tel.: 0036 (0)1 3922514 Fax: 0036 (0)1 3922598 E-mail: jeki@rmki.kfki.hu

Mr. Daniel JOFFROY ARCICEN Mairie de Belleville-sur-Mer F-76370 Bellevue-sur-Mer France Tel.: Fax: E-mail: [D. Joffroy] commune.de.belleville.sur.mer@wanadoo.fr	Mr Jerome JOLY IRSN BP 17 F-92262 Fontenay-aux-Roses France Tel.: 0033 (0)1 5835 8515 Fax: 0033 (0)1 5835 7290 E-mail: jerome.joly@irsn.fr
Mrs. Mylène JOSSET ACRO 138, rue de l'Eglise F-14200 Herouville Saint Clair France Tel.: 0033 231943534 Fax: 0033 231948531 E-mail: mylene.josset@acro-ng.org	Dr. André JOUVE Autorité de Sûreté Nucléaire 6, Place du Colonel Bourgain F-75012 Paris France Tel.: 0033 (0)1 4019 8486 Fax: 0033 (0)1 4019 8790 E-mail: andre.jouve@asn.minefi.gouv.fr
Mr. Stephen KAISER European Commission TREN.H WAG C/320 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 33073 Fax: 00352 4301 36280 E-mail: stephen.kaiser@cec.eu.int	Mrs Rossitza KARAIVANOVA National Centre of Radiobiology and Radiation Protection blvd. Kliment Ohridski 132 BG-1756 Sofia Bulgaria Tel.: 00359 (0)2 626037-274 Fax: E-mail: r.karaivanova@hotmail.com ; r.karaivanova@ncrrp.org
Dr. Christian KATZLBERGER Austrian Agency for Health and Food Safety Vienna Department of Radiation Protection and Radiochemistry Spargelfeldstraße 191 A-1226 Wien Austria Tel.: 0043 (0)1 73216-3224 Fax: 0043 (0)1 73216-3225 E-mail: christian.katzlberger@lwvie.ages.at	Prof. René KIRCHMANN Université Liége rue Cardinal Cardyn, 5/18 B-4680 Oupeye Belgium Tel.: 0032 (0)4 2642564 Fax: 0032 (0)4 2642564 E-mail: rene.kirchmann@skynet.be
Mr. Gerald KIRCHNER Bundesamt für Strahlenschutz Fachbereich AS Köpenicker Allee 120-130 D-10318 Berlin Germany Tel.: 0049 (0)1888 333 4100 Fax: 0049 (0)1888 333 4105 E-mail: gkirchner@bfs.de	Mr Theo KLOMBERG Ministry of the Environment P.O.Box 30945 NL-2500 GX Den Haag The Netherlands Tel.: 0031 (0)703394956 Fax: 0031 (0)703391283 E-mail: theo.klomberg@minvrom.nl

Prof. Dr. Igor KOMOV Inst. of Environmental Geochemistry National Academy of Sciences 34, Pallavin av. UA-252680 Kyiv-142 Ukraine Tel.: 00380 (0)442901035 Fax: 00380 (0)44 4510236 E-mail: [I. Komov] leon@ecocentr.carrier.kiev.ua	Dr. Pawel KRAJEWSKI Central Laboratory for Radiological Protection Konwaliowa st. 7 PL-03-149 Warszawa Poland Tel.: 0048 (0)22 8140164 Fax: 0048 (0)22 8111616 E-mail: krajewski@clor.waw.pl
Ms Rima LADYGIENE Radiation Protection Centre Subdivision of Radiological Investigations Kalvariju 153 LT-2042 Vilnius Lithuania Tel.: 00370 (0)5 2 754693 Fax: 00370 (0)5 2 754692 E-mail: r.ladygiene@rsc.lt	Mr. Carl-Magnus LARSSON Swedish Radiation Protection Authority S-171 16 Stockholm Sweden Tel.: Fax: 0046 (0)8 7297108 E-mail: carl-magnus.larsson@ssi.se
Dr. Laurence LEBARON-JACOBS Atomic Energy Commission DSV/DIR/CARMIN CEA de Cadarache F-13108 Saint-Paul-lez-Durance France Tel.: 0033 4 42254446 Fax: 0033 4 42254656 E-mail: laurence.lebaron-jacobs@cea.fr	Mr. François LECOMTE Institut de Radioprotection et de Sûreté Nucléaire B.P. 17 F-92262 Fontenay-aux-Roses France Tel.: Fax: E-mail: jean-francois.lecomte@irsn.fr
Prof. Fernando LEGARDA Universidad del País Vasco - Dpt. Ingenería Nuclear Alameda de Urquijo E-48013 Bilbao Spain Tel.: 0034 (0)946014021 Fax: 0034 (0)946014159 E-mail: [Fernando Legarda] inpleibf@bi.ehu.e s	Mr Jean-Jacques LEGUAY CEA Cadarache DEVM Bât. 177 F-13108 St. Paul-lez-Durance Cédex France Tel.: 0033 442257088 Fax: 0033 442254656 E-mail: jjleguay@cea.fr
Mr Gerno LINDEN IRSN 31, Rue de l'Ecluse B.P. 35 F-78116 Le Vesinet France Tel.: 0033 (0)1 30155225 Fax: 0033 (0)1 30153750 E-mail: glinden@opri.fr	Mr. Jacques LOCHARD CEPN Route de Panorama BP 48 F-92263 Fontenay-aux-Roses Cedex France Tel.: 0033 (0)158358665 Fax: 0033 (0)140849034 E-mail: lochard@cepn.asso.fr

Mr. Mark LOOS SCK-CEN Boeretang 200 B-2400 Mol Belgium Tel.: 0032 14 332878 Fax: 0032 14 321056 E-mail: mloos@sckcen.be	Prof. André MAÏSSEU WONUC-Lowrad 49, rue Lauriston F-75116 Paris France Tel.: 0033(0)1 53708899 Fax: 0033 (0)1 53700008 E-mail: andre.maisseu@wanadoo.fr
Prof. Ian McAULAY Trinity College, Department of Physics University of Dublin IRL Dublin 2 Ireland Tel.: 00353 (0)1 6081772 Fax: 00353 (0)1 6711759 E-mail: imcaulay@tcd.ie	Dr. Ann McGARRY Radiological Protection Institute of Ireland 3 Clonskeagh Square Clonskeagh Road IRL Dublin 14 Ireland Tel.: 00353 (0)1 2697766 Fax: 00353 (0)1 2697437 E-mail: amcgarry@rpii.ie
Mr. Andreas MEISTER Vacu Tec Messtechnik GmbH Dornblüthstraße 14 D-01277 Dresden Germany Tel.: 0049 351 31724-35 Fax: 0049 351 3105085 E-mail: info@vacutec-gmbh.de	Dr. Gerard MENEZES Environmental Radiation Detection Laboratory Physics Dept., Trinity College SNIAM Building IRL Dublin 2 Ireland Tel.: 00353 (0)1 6081469 Fax: 00353 (0)1 6711759 E-mail: menezesk@tcd.ie
Prof. Peter MITCHELL University College Dublin Department of Experimental Physics Belfield, Stillorgan Rd. IRL Dublin 4 Ireland Tel.: 00353 (0)12 693244 Fax: 00353 (0)12 837275 E-mail: peter.mitchell@ucd.ie	Dr. Carmel MOTHERSILL Dublin Institute of Technology Radiation and Environmental Science Centre Kevin Street IRL Dublin 8 Ireland Tel.: 00353 87 2413 194 Fax: E-mail: cmothersill@rsc.iol.ie
Mr. Jochen NAEGELE European Commission TREN.H.4 - Radiation Protection WAG C/325 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 32297 Fax: 00352 4301 36027 E-mail: jochen.naegele@cec.eu.int	Mr Rick NICKERSON KIMO Secretariat Shetland Islands Council, Infrastructure Services Grantfield ZE1 0NT Lerwick, Shetland UK Tel.: 0044 (0)1595 744825 Fax: 0044 (0)1595 695887 E-mail: [R. Nickerson] kimo@zetnet.co.uk

Dr. Hartmut NIES Bundesamt für Seeschifffahrt und Hydrographie (BSH) Wüstland 2 D-22589 Hamburg Germany Tel.: 0049(0)40-3190-3300 Fax: 0049(0)40-3190-5033 E-mail: hartmut.nies@bsh.de	Dr. Cristina NUCCETELLI Istituto Superiore di Sanità Viale Regina Elena 299 I-00161 Rome Italy Tel.: 0039 06 49902732 Fax: 0039 06 49387075 E-mail: nuccetelli@iss.infn.it
Mr Patricio O'DONNELL Consejo de Seguridad Nuclear Justo Dorado 11 E-28040 Madrid Spain Tel.: 0034 (0)91 3460119 Fax: 0034 (0)91 3460497 E-mail: pot@csn.es	Mr. João OLIVEIRA MARTINS Instituto do Ambiente Rua da Murgueira, 9/9a – Zambuja PT-2721-865 Amadora Portugal Tel.: 00351 (0) 21 4728232 Fax: 00351 (0) 21 4719077 E-mail: emernu@iambiente.pt
Mr Peter OSBORNE BNFL Public Affairs Hinton House 380, Warrington WN1 2PW Risley UK Tel.: 0044 (0)1925 833811 Fax: 0044 (0)1925 835619 E-mail: pmo1@bnfl.com	Dr. Deborah OUGHTON Norwegian University for Agriculture Department of Chemistry and Biotechnology P.O.Box 5040 N Ås Norway Tel.: Fax: 0047 (0)64 948259 E-mail: deborah.oughton@ikb.nlh.no
Mr. Zitouni OULD-DADA Food Standards Agency Room 715B, Aviation House 125 Kingsway WC2B 6NH London UK Tel.: 0044 (0)20 7276 8774 Fax: 0044 (0)20 7276 8779/8751 E-mail: zitouni.ould-dada@foodstandards.gsi.gov.uk	Mrs. Anna PAIXÀ GMF Raval St. Pere, 31, 1°, 1° E-43204 Reus (Tarragona) Spain Tel.: 0034 (0)977 773120 Fax: 0034 (0)977 772215 E-mail: anna.paixa@gmfeurope.org
Mr. Sándor PELLET National Research Institute for Radiobiology and Radiohygiene Department for Radiohygiene Anna str. 5 H-1221 Budapest Hungary Tel.: 0036 (0)1 4820137 Fax: 0036 (0)1 2291931 E-mail: pellet@hp.osski.hu	Prof. Jan PENTREATH 6 Court Gardens Batheaston BA1 Bath UK Tel.: Fax: 0044 (0)1454 624055 E-mail: pentreath@supanet.com

Mr Jean PIECHOWSKI CEA/HC 3, rue de la Fédération F-75752 Paris France Tel.: Fax: E-mail: jean.piechowski@cea.fr	Mr Gilbert PIGREE ACRO 138, rue de l'Eglise F-14200 Herouville Saint Clair France Tel.: 0033 231943534 Fax: 0033 231948531 E-mail: gilbert.pigree@acro-ng.org
Mr André POFFIJN Federal Agency for Nuclear Control 36 rue Ravensteinstraat B-1000 Brussels Belgium Tel.: 0032 (0)2 2892136 Fax: 0032 (0)2 2892112 E-mail: andre.poffijn@fanc.fgov.be	Mrs Sirkka POYRY EEE Network Rue Archimede 58 B-1000 Brussels Belgium Tel.: 0032 (0)2 2350770 Fax: 0032 (0)2 6471810 E-mail: sirkka.poyry@eeenetwork.net
Dr. Dobromir PRESSYANOV St. Kliment Ohridski University of Sofia Faculty of Physics 5 James Bourchier Blvd. BG-1164 Sofia Bulgaria Tel.: 00359 (0)2 6256268 Fax: E-mail: pressyan@hotmail.com	Mr. Raivo RAJAMÄE Estonian Radiation Protection Centre 76 Kopli str. EE-10416 Tallinn Estonia Tel.: 00372 66603336 Fax: 00372 6603352 E-mail: raivo.rajamae@ekk.envir.ee
Ms Lucila RAMOS Consejo de Seguridad Nuclear Justo Dorado 11 E-28040 Madrid Spain Tel.: 0034 (0)913460492 Fax: 0034 (0)913460497 E-mail: lrs@csn.es	Mr. Martino RIGACCI Tel.: Fax: E-mail: martinoroma@tiscali.it
Ms. Caroline RINGEARD Institut de Radioprotection et de Sûreté Nucléaire IRSN/DPHD/SEGR/SAER 77-83, Av. du Général Leclerc F-92140 Clamart France Tel.: 0033 (0)1 58357258 Fax: 0033 (0)1 58358829 E-mail: caroline.ringeard@irsn.fr	Ms Carol ROBINSON IAEA P.O.Box 100 Wagramer Straße 5 A-1400 Wien Austria Tel.: 0043 (0)1 2600 22719 Fax: 0043 (0)1 26007 E-mail: c.robinson@iaea.org
Mr François ROLLINGER IRSN/DES/DIR BP 17 F-92262 Fontenay-aux-Roses France Tel.: 0033 (0)1 5835 8558 Fax: 0033 (0)1 5835 9795 E-mail: francois.rollinger@irsn.fr	Mr. Tom RYAN RPII 3 Clonskeagh Square IRL Dublin 14 Ireland Tel.: 00353 (0)1 2697766 Fax: 00353 (0)1 2697437 E-mail: tryan@rpii.ie

Mr Sylvain SAINT-PIERRE COGEMA BP4 F-78141 Vélizy Cedex France Tel.: 0033 (0)1 39263871 Fax: 0033 (0)1 39262722 E-mail: ssaintpierre@cogema.fr	Ms Rosario SALAS Consejo de Seguridad Nuclear Justo Dorado 11 E-28040 Madrid Spain Tel.: 0034 (0)913460408 Fax: 0034 (0)913460497 E-mail: rsc@csn.es
Dr. Carol SALT University of Stirling Department of Environmental Science FK9 4LA Stirling UK Tel.: 0044 (0)1786 467852 Fax: 0044 (0)1786 467843 E-mail: c.a.salt@stir.ac.uk	Mr Jean-Paul SAMAIN FANC Ravensteinstraat 36 B-1000 Brussels Belgium Tel.: 0032 2 2892101 Fax: 0032 2 2892112 E-mail: jean-paul.samain@fanc.fgov.be
Mrs. Mercedes SARRO VAQUERO European Commission TREN.H.4 - Radiation Protection WAG C/325 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 36389 Fax: 00352 4301 36358 E-mail: mercedes.sarro-vaquero@cec.eu.int	Mr. Klaus SCHNUER European Commission TREN.H.4 - Radiation Protection WAG C/331 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 36388 Fax: 00352 4301 36358 E-mail: klaus.schnuer@cec.eu.int
Mr. Ernst-Hermann SCHULTE EC DG RTD J04 - Nuclear Fission and Radiation Protection B-1049 Brussels Belgium Tel.: 0032 (0)2 295 7155 Fax: 0032 (0)2 295 4991 E-mail: ernst-hermann.schulte@cec.eu.int	Dr. Natalia SEMIOSHKINA GSF Ingolstädter Landstraße 1 D-85764 Neuherberg Germany Tel.: 0049 (0)89 3187 2904 Fax: 0049 (0)89 3187 3363 E-mail: semi@gsf.de
Mrs Paloma SENDÍN Consejo de Seguridad Nuclear (CSN) Justo Dorado 11 E-28040 Madrid Spain Tel.: 0034 (0)91 3460331 Fax: 0034 (0)91 3460393 E-mail: psc@csn.es	Mrs Françoise SICLET EDF R&D Département LNHE 6, quai Watier F-78400 Chatou France Tel.: 0033 (0)1 30877847 Fax: 0033 (0)1 30877336 E-mail: francoise.siclet@edf.fr
Mr Ioannis SIDIROPOULOS INKA 3, De la Salle Str. GR-57010 Thessaloniki Greece Tel.: 0030 (0)3 10672200 Fax: 0030 (0)3 10672201 E-mail: ioannis@inka.gr	Dr. Jane SIMMONDS NRPB Environmental Assessments Department Didcot, Oxfordshire OX11 0RQ Chilton UK Tel.: 0044 (0)1235 822778 Fax: 0044 (0)1235 833891 E-mail: jane.simmonds@nrpb.org.uk

Mr Jaroslav SLOVÁK State Office for Nuclear Safety Senovazne nam. 9 CZ-11000 Praha Czech Republic Tel.: 00420 (0)221624752 Fax: 00420 (0)221624710 E-mail: jaroslav.slovak@sujb.cz	Mr. Patrick SMEESTERS FANC 36 Ravensteinstraat B-1000 Brussels Belgium Tel.: 0032 2 2892129 Fax: 0032 2 2892112 E-mail: patrick.smeesters@fanc.fgov.be
Mr Richard SONSBEEK, VAN Röntgen Technische Dienst bv P.O.Box 10065 NL-3004 AB Rotterdam Netherlands Tel.: 0031 10 2088229 Fax: 0031 10 4158022 E-mail: r.van.sonsbeek@rtd.nl	Prof. Slawomir STERLINSKI Central Laboratory for Radiological Protection Ul. Konwaliowa 7 PL-03-194 Warszawa Poland Tel.: 0048 (0)22 8111616 Fax: 0048 (0)22 8111616 E-mail: [S. Sterlinski] dyrclor@clor.waw.pl
Dr. Rex STRONG British Nuclear Fuels plc Building B582/2 Sellafield, Seascale CA20 1PG Cumbria UK Tel.: 0044 (0)19467 74220 Fax: 0044 (0)19467 84805 E-mail: rex.strong@bnfl.com	Mme Annie SUGIER Institut de Radioprotection et de Sûreté Nucléaire 77-83, Av. du Général Leclerc F-92140 Clamart France Tel.: 0033 (0)1 5835 8336 Fax: 0033 (0)1 52357962 E-mail: annie.sugier@irsn.fr
Dr. Jill SUTCLIFFE English Nature Northminster House PE1 1UA Peterborough UK Tel.: 0044 (0)1733 455254 Fax: E-mail: jill.sutcliffe@english-nature.org.uk	Mr. Vesa TANNER European Commission TREN.H.4 - Radiation Protection WAG C/313 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 32297 Fax: 00352 4301 36280 E-mail: vesa.tanner@cec.eu.int
Dr. Giancarlo TORRI ANPA Via V. Brancati, 48 I-00144 Rome Italy Tel.: 0039 06 50072041 Fax: 0039 06 50072313 E-mail: torri@anpa.it	Mr. Claude TURMES European Parliament Rue Wirtz, ASP 8G116 B-1047 Brussels Belgium Tel.: 0032 (0)2 2847246 Fax: 0032 (0)2 2849246 E-mail: cturmes@europarl.eu.int
Mr Jan W.N. TUYN Health Council of the Netherlands Markeweg 3 NL-7864 TH Zwinderen Netherlands Tel.: 0031 (0)524 291843 Fax: 0031 (0)524 291843 E-mail: jan.tuyn@wxs.nl	Mr. Stefan VAN DER STRICHT European Commission TREN.H.4 - Radiation Protection WAG C/242 L-2920 Luxembourg Luxembourg Tel.: 00352 4301 37104 Fax: 00352 4301 36280 E-mail: stefan.van-der-stricht@cec.eu.int

Mr Mariano VILA D'ABADAL GMF Raval St. Pere, 31, 1°, 1° E-43204 Reus (Tarragona) Spain Tel.: 0034 (0)977 773120 Fax: 0034 (0)977 772215 E-mail: mvilaabadal@gmfeurope.org	Dr. Gabriele VOIGT IAEA-Agency's Laboratories Seibersdorf Wagramer Straße 5 P.O.Box 200 A-1400 Wien Austria Tel.: 0043 (0)1 2600 28248 Fax: 0043 (0)1 2600 28222 E-mail: g.voigt@iaea.org
Mrs Louise WRIGHT Scottish Executive Radioactive Waste Team Area I-J(N), Victoria Quay EH6 6QQ Edinburgh Scotland, UK Tel.: 0044 (0)131 2440197 Fax: 0044 (0)131 2440245 E-mail: louise.wright@scotland.gsi.gov.uk	Ms Karin WURZBACHER Umweltinstitut München e.V. Abt. Radioaktivität Schwere-Reiter-Straße 35/1B D-80797 München Germany Tel.: 0049 89 30774911 Fax: 0049 89 30774920 E-mail: kw@umweltinstitut.org
Mr Luis YAGÜE TECNATOM, SA Avda. Montes de Oca, 1 SS Reyes E-28709 Madrid Spain Tel.: 0034 (0)91 6598600 Fax: 0034 (0)91 6598677 E-mail: lyague@tecnatom.es	

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