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NEWSLETTER

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A message from the Editor

I wanted to take a moment to thank the IUR President, IUR Secretariat, and IUR members for the opportunity to serve as your new editor of the IUR Newsletter. I view the IUR Newsletter as an important communication and networking tool for IUR members to keep current on and become more involved in IUR- and IUR member-sponsored applications of radioecology. Just as important, our Newsletter provides outside readers with a window into the world of the IUR: it provides an image and reflection of who we are – as IUR members and as an IUR organization. In both cases, the content and appearance of the Newsletter sends an important message about the contributions that the IUR is making in the field of radioecology in response to current needs, as well as the value of becoming an active member of the IUR.

Internationally, there is clearly a growing interest and resurgence in the field of radioecology. This comes at a time when basic and applied knowledge gained from radioecological studies is increasingly needed to support: (1) better assessments of site cleanup alternatives, approaches to long-term stewardship, and management of risks at radioactively-contaminated sites; and (2) the development of a framework (including requirements, methods, and guidance) for protection of the environment from the effects of ionizing radiation. Through our Newsletter, we can improve the awareness of the value of our work in radioecology, and how it supports these current needs. Please forward your articles for consideration in upcoming issues of the IUR Newsletter, and your ideas for improving the IUR Newsletter, to me at Stephen.Domotor@eh.doe.gov. I look forward to working with you in broadening the Newsletter's content and availability to meet the needs of the IUR and its members, and to promote the value-added of our work in the field of radioecology.

News from the Secretariat

OSPAR Convention for the Protection of the Marine Environment of the North East Atlantic

Protection of the environment from radiation and reduced releases to the North East Atlantic were important topics at the meeting of the Radioactive Substances Committee (RSC) in the Oslo-Paris convention meeting hosted by Norway and held in Tromsø in Janaury this year. The main issue of discussion was how to implement the Sintra statement made in 1998 by the environmental ministers, which stated goals for reducing discharges of radioactive substances to the marine environment. An important aspect is how to evaluate whether the contracting parties are acting in accordance with the Sintra statement and the OSPAR strategy with regard to radioactive substances . The basis for evaluating the environmental detriment, the concentrations in the environment and the doses to man arising from discharges of radioactivity, are questions which needs a common understanding. Working groups were established to work on these items. At the annual meeting reports on liquid discharges from nuclear industries are presented. These reports give indications on whether discharges are reduced. National implementation of best available technique (BAT) and best environmental practices (BEP) were presented and discussed.

According to the Sintra statement the committee shall, by 2003, report on progress in the work on establishing a framework for protection of the environment from radioactive contamination.

The European Commission gave information on the new project MARINA 2 which will give information on radionuclide concentrations in the environment. The project will be headed by NCC.

Ireland and Norway expressed their concern for the high releases of technetium-99 to the Irish Sea from Sellafield. At present the British Environment Agency has published its intentions with respect to the review of release authorisation of Tc-99 from Sellafield. There is now a public consultation on the EA recommendation, which is to keep the 90 TBq limit until 2006 and then reduce it to 10 TBq following the implementation of new abatement techniques.

Depleted Uranium – Another Challenge for Radioecology?

By John Cobb

Uranium exists in nature as three radioactive isotopes, uranium-238, uranium-235 and uranium-234; the atomic abundances of these isotopes are 99.2745%, 0.7200% and 0.0055% respectively. Uranium is used as a fuel in nuclear fission reactors, but in order to sustain the fission reaction, the uranium-235 needs to be enriched from the natural content to typically 3.5%, or higher. A by-product of the process used to enrich uranium in uranium-235 is depleted uranium, which has a uranium-238 content higher than that in nature and a uranium-235 and uranium-234 content lower than that in nature. The uranium-235 content of depleted uranium resulting from the enrichment process is less than 0.3%.

The high density and strength of uranium metal coupled with the low cost and availability of depleted uranium has resulted in depleted uranium being used in aircraft counterweights, radiation shielding, tank armour and armour piercing ammunition. In recent times, the use of depleted uranium in armour piercing ammunition has resulted in its release into the environment, thereby providing a route for man to become exposed to its radiation and chemical effects.

Depleted uranium from the impact of armour piercing ammunition is released into the environment as particles of low solubility. The particles will become adsorbed onto surface soil particles and may be slowly dissolved by the action of rainwater. In the solublized form, the depleted uranium may be transported through the soil and into groundwater, depending on the geology of the area of contamination.

Man can become exposed to the released depleted uranium in a number of ways. These include external exposure to the radiation emitted by depleted uranium, the inhalation of depleted uranium particles and the ingestion of depleted uranium that may become incorporated in the food chain. The ingestion pathway may be by direct ingestion of contaminated vegetation or indirectly via consumption of animals that graze on the contaminated vegetation.

Depleted uranium entering the body via inhalation may be transported to the lungs or the gastrointestinal tract. Larger, less soluble particles will remain in the lungs whereas smaller, more soluble material may become absorbed into the bloodstream. Ingestion of depleted uranium will result in some absorption via the gastrointestinal tract depending on the solubility of the ingested material. The absorbed fraction is then rapidly cleared from the body via the kidneys in urine, although a fraction may be deposited in the skeleton. Health problems that can occur from exposure to depleted uranium include a chemical effect that causes kidney disfunction and the effects of exposure to its radiation. Although, depleted uranium has a low specific activity, lower than that of natural uranium, it must still be considered to present potential cancer risks.

Although man is constantly exposed to the chemical and radiation effects from natural uranium, the release of depleted uranium into the environment presents man with an increased risk of potential exposure to the effects of uranium. Therefore, the behaviour of depleted uranium in our environment is of interest to us.

ICRP Task Group on Protection of the Environment

In 1999, at the Main Commission meeting in St. Petersburg, a new Task Group on protection of the environment was set up. The Commission concluded that this was an important issue for the future. Lars-Erik Holm from the Swedish Radiation Protection Institute is the chairman of this Task Group which started its work in 2000.

The following persons have been invited and accepted to be in the Task Group:

Rudolf Alexakhin, RIARE, Russia
Jan Pentreath, Environment Agency, UK
Kristin Shraeder-Frechette, Notre Dame University, USA
Per Strand, NRPA, Norway
Patsy-Ann Thompson, CNSC, Canada

FEES 2001

Enclosed with this Newsletter is the 2001 Subscription Renewal Form. If you have not paid, please could you do so, preferably by providing the treasurer with credit card details. If you want to arrange other methods of payment please contact the treasurer.

Membership grade	CIS, China Cuba, Colombia	Central Europe	Other countries			
	$	$	EURO	$	BEF	£
Student	7	10	20	21	800	13
Regular	14	20	50	53	2000	32
Senior	21	30	70	74	2800	45
Fellow	21	30	70	74	2800	45
Emeritus	7	10	20	21	800	13
Honorary	0	0	0	0	0	0
Supporting	>140	>200	>400	>420	>16000	>260

NEW MEMBERS

From October 2000, the Executive Committee has accepted 4 new members to IUR:

Nadezhda Gonchorova	Belarus
Massimo Brambilla	Italy
Kathryn Higley	USA
Daniel S. Jones	USA

Professor Dr. Ward Whicker: Fellow of the IUR

Author: Gilbert Desmet

Professor Whicker was awarded the title of Fellow of the IUR a few years ago now. It is about time he is been given honour for that title! Most of us have known Prof. Whicker for many years through personal contacts, through his research activities and publications, and through discussions in important meetings and a Summerschool organised by our Scientific Society, the International Union of Radioecologists!

Prof. Whicker on each of these occasions has demonstrated his exceptional level as a scientist but equally as a great teacher, with a talent for making his "message" comes across to students and senior scientists! His work in connection to this as an Associate Editor of the "Journal of Environmental Radioactivity" has given this Journal an extra impetus and a real upgrade, which is now acknowledged as the key journal in radioecology!

As to the question of putting Prof. Whicker on a comparative scale to other colleagues, his excellence can no better be illustrated than by the general acceptance and universal application of his radioecological model called "PATHWAY". This model has certainly played an important role in the endeavours of the International Committee of Radiation Units and Measurements (ICRU), to come to a harmonisation and standardisation of Radioecological Units! His decisive role in this has been internationally recognised, and his suggestions acknowledged! His model is a template for anybody who endeavours to structure his acquired knowledge in his specific area!

All awards prof. Whicker has received, are relevant to demonstrate his scientific standard, especially the one granted by the Health Physics Society, the leading Society in our field of research and authoritative in matters of radiation protection.

It is really an honour to the entire radioecological research society to have prof. Whicker among our IUR ranks! We hope he will remain active for the many years to come, and give a strong support to our IUR activities!

Radiological Benchmarks for Effects on Aquatic Biota at the Oak Ridge Reservation

by: Daniel S. Jones
Oak Ridge National Laboratory, USA

Radiological benchmarks for aquatic biota were developed for use at the U.S. Department of Energy's (DOE) Oak Ridge Reservation as screening values to determine the spatial extent of potential ecological effects and to identify the need for additional site-specific investigation. A paper describing the development and application of these radiological benchmarks has recently been published in the journal, AHuman and Ecological Risk Assessment@ (2000. Vol. 6, No. 5, 789-807).

The Point Source Dose Distribution approach was used to calculate water and sediment activities for selected radionuclides that result in a total dose rate to small and large fish of 1 Rad d^{-1}, which is the National Council on Radiation Protection and Measurements= recommended acceptable dose rate to natural populations of aquatic biota. These screening values incorporate internal and external exposures from parent isotopes and all short-lived daughter products. They also include exposures from all major alpha, beta, and gamma emissions for each isotope. Unlike exposures to chemicals, exposures to radionuclides are expressed as the dose rate received by the organism. Dose rates that account for the biological effects to the organism are additive. If the total dose rate from all radionuclides and pathways exceeds a recommended acceptable dose rate, further analysis is needed to determine the hazards posed by radionuclides. If, however, the total dose rate falls below an acceptable dose rate, radionuclides may be eliminated from further study.

The approach used to develop the radiological benchmarks for the Oak Ridge Reservation is conceptually consistent with the approach being used by DOE=s Biota Dose Assessment Committee to develop ABiota Concentration Guides - BCGs@ for use as generic screening values for DOE-wide application. Contact Daniel S. Jones for further information.

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A Radiecological Study at the Pickering Nuclear Generating Station, Ontario, Canada

By: Dr. Nava C. Garisto
SENES Consultants Limited

A Screening-Level Ecological Risk Assessment (ERA) was carried out to assess potential environmental effects from current operations of the Pickering Nuclear Generating Station (PNGS). The station is located on the north shore of Lake Ontario, 42 km east of Toronto. The ERA was done to identify the key effects on non-human biota.

The PNGS ERA follows the guidelines of the Canadian Council of Ministers of the Environment. This process is similar to the U.S. EPA framework for ERAs. It is based on an iterative, tiered approach beginning with an ERA Work Plan and a Screening-Level Assessment, or a tier 1 ERA, that provides a relatively simple and highly conservative analysis. Depending on the results of these two stages, there may be a need for a more detailed ERA (see Figure 1). The higher tiers represent more sophisticated and realistic analysis, removing some of the conservatism inherent in a tier 1 analysis. The higher tiers involve an explicit analysis of uncertainty and sometimes require gathering of additional field data.

Although the study follows standard ERA methodology, it is unique in the complexity and scope of the stressors, pathways and receptors being assessed. The stressors include over **20 radionuclides**, about **20 non-radioactive chemicals**, **direct losses** (e.g., impingement) and **physical effects** (e.g. from thermal emissions). The pathways include emissions to air, surface water, groundwater and soil. The receptors, referred to as indicator species, include over 20 species, including a variety of aquatic, wetland and terrestrial organisms selected based on scientific and sociological criteria. The results of the study are used to screen out some stressors and to define a follow-up program to refine conservative models, reflect variability in parameter values and close data gaps.

Scientific issues discussed at a screening level in tier 1 of the PN ERA study and continued to be addressed in the follow-up program include:

- the feasibility of and the methodology for evaluating multi-stressor (radioactive and chemical) effects;
- the use and determination of an RBE (Relative Biological Effectiveness) factor or a similar weighting factor for non-human biota;
- geometric corrections of Dose Conversion Factors (DCFs) to account for biota size;
- accounting for spatial and temporal variability;

- the interpretation of the spatial extent of radioecological impacts; and
- the interpretation of probabilistic ERA results.

A paper describing the screening-level ERA has been submitted to the journal Human and Ecological Risk Assessment for publication. Based on the PN Screening ERA conclusions and recommendations, PN will implement a follow-up program (Figure 1). This program will address the data gaps and uncertainities identified in the screening-level analysis. Biodiversity enhancement initiatives are also currently underway at PN.

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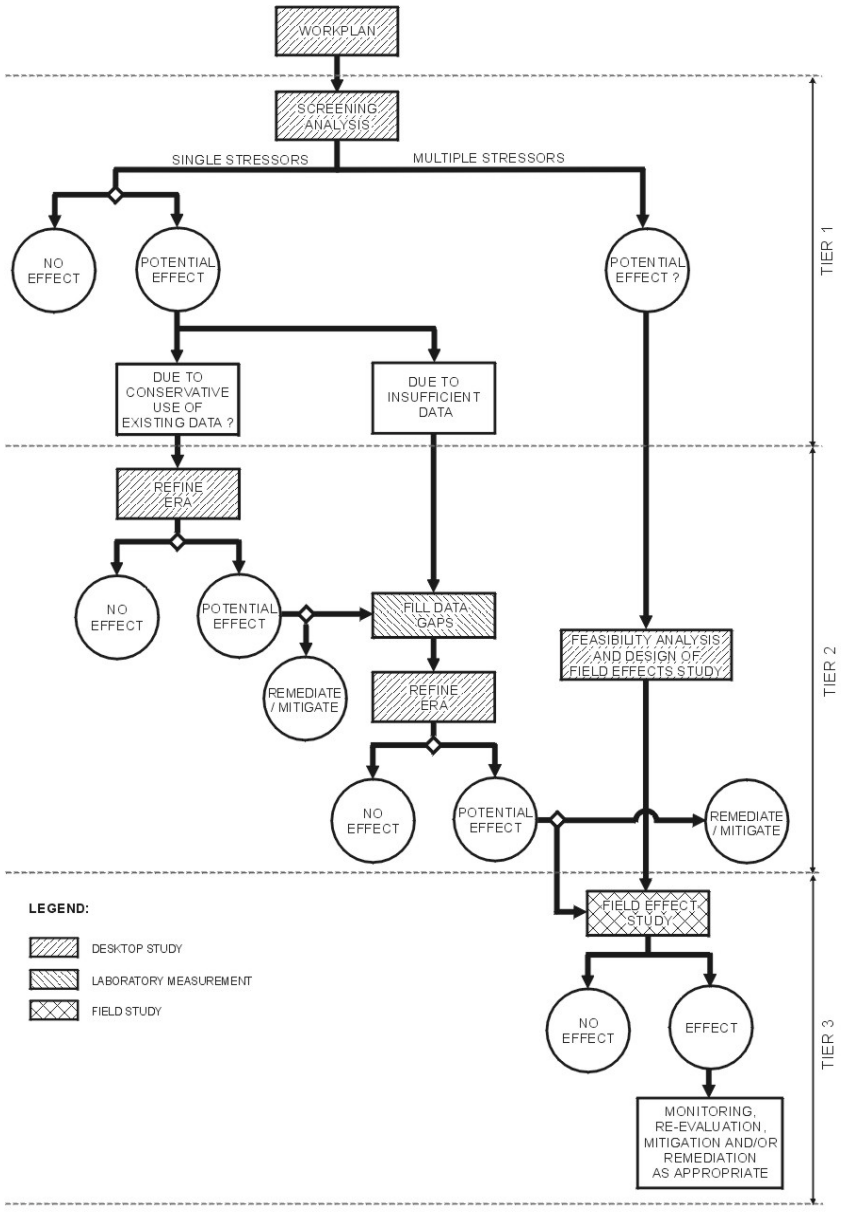
FIGURE 1

THE PN ERA PROCESS



OPERA network : Permanent Observatory of Radioactivity

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The French Nuclear and Safety Protection Institute (IPSN) offers to the public on its Internet site, http://www.ipsn.fr/opera/, the results of measurements of environmental natural and artificial radioactivity, in Metropolitan France and in its overseas territories. These measurements are made within the framework of the PErmanent Observatory of RAdioactivity (network OPERA). This network is a major tool that allows the IPSN to study the behavior and the dispersion of the natural and artificial radionuclides in the environment. These results provide ambient radioactivity levels (at trace level), used as reference for comparison in ecological impact assessment of nuclear plant discharges or after a minor accidental contamination of the environment. The OPERA network is operated by the ''Radioecology Study and Research in Naturel Environment Division'' (SERNAT). It consists of 34 sampling stations in the environment (air, sea, land, river). Most of them are located apart from any zone of direct and immediate influence of nuclear plant discharges. The samples are collected by three SERNAT laboratories : the ''Laboratoire d'Etudes Radioécologiques Continentales et de la Méditerranée'' (LERCM in Cadarache), the ''Laboratoire d'Etudes Radioécologiques de la Façade Atlantique (LERFA in Octeville) and the ''Laboratoire d'Etudes et de Surveillance de l'Environnement'' (LESE on the island of Tahiti). The samples are sent to the ''Laboratoire de Mesure de la Radioactivité de l'Environnement'' (LMRE in Orsay). This laboratory is accredited for radioactivity measurements in the environment and is one of the national reference laboratory of the WHO measurement laboratories network.

The activities of natural and artificial radionuclides are providing information at microBequerel.m^{-3} level in atmospheric aerosols and at mBq.kg^{-1} or mBq.l^{-1} levels for the other matrices. The Internet site shows for each station, the results of the measurements carried out over the last twelve months. These results are updated on a regular basis. Results of daily measurements of ambient gamma radiation on six stations are also available on the Internet site. Without constituting a control or alarm network of the atmospheric contamination in France, those on-line measurements could detect even a slight increase of the ambient radioactivity such as the one that occurred after the Algesiras incineration of a ^{137}Cs source in June 1998.

Development of an Environmental Decision Support System (EDSS) to Identify Radioecological Sensitive Areas for Radiocaesium in Chile (CHIRSA)

G. Voigt, GSF-Institute of Radiation Protection**,** Neuherberg, Germany
and

P. Schuller, Physics Institute, Universidad Austral de Chile, Valdivia, Chile

Chile is hardly prepared to envisage and manage problems arising from environmental radioactivity either man-made or naturally occurring. Therefore there exists an urgent need to establish an information system about risks related to existing and potential radioactive contamination of the country. This might even provide support to better face a potential future accidental release of radionuclides into the environment affecting this region in the Southern Hemisphere. The German VolkswagenStiftung (foundation) is supporting a 3 year project on the development of an Environmental Decision support System for Chile to be performed by GSF-Institute of Radiation Protection and the Institute of Physics of the Universidad Austral de Chile.

The main objective of this project is the development of an environmentally based decision support system for Chile to identify areas which are sensitive or resilient after radioactive contamination. Its overall aim is to produce an environmental management package integrating over areas contaminated by radioactive fallout from nuclear weapons' testing in the 60th based on an understanding of the nature of contamination, the processes and routes by which radioactivity is transferred in agricultural and semi-natural ecosystems (excluding aquatic), and the estimation of radiation doses to humans.

Within an EC project of the 4th framework programme in Nuclear Fission Mastering Event of the Past (RESTORE 'restoration strategies for radioactive contaminated ecosystems') an EDSS (Environmental Decision Support System) has been developed which can be adapted to the ecological and site specific conditions of Chile by using information on soil properties, soil contamination and soil-plant transfer factors of ^{137}Cs for characteristic Chilean soil types and crops. These data can be used to identify areas which are potentially radioecological sensitive i.e. will result in elevated radiation doses to people living and using these areas, and further more where countermeasure actions might be requested. The EDSS will use modern tools such as GIS (geographical information systems) and

geostatistical methods, and recently developed dynamic transfer models to determine fluxes of radiocaesium, and dose calculation models.

The models described in RESTORE have been tested in the NIS (New Independent States) countries for the implementation of remediation strategies, they now can be used and adapted to Chilean conditions. It is very important for its verification to apply the developed EDSS for different ecological conditions, the Chile specific conditions are representing a perfect test scenarios to test for the robustness of the models used and validate the model predictions. In addition, the generic applicability of the RESTORE-EDSS can be evaluated. For this purpose existing data in addition to foreseen field work in selected sites in Chile on contamination of soils, deposition, land use, land cover, production and production rates will be used to draw an overall picture of the contamination with radiocaesium due to weapons' fallout. It will allow the user to identify areas which are resilient or radioecological sensitive due to either high production rates or consumption habits of 'critical' population groups. As has been shown areas in Chile with the highest soil contamination represent high production sites of Chile. Food product contamination and fluxes of radiocaesium therefore might be higher than generally expected, and appropriate measures to reduce contamination levels in food products of doses to humans might be required or advised. The results of the implementation of an EDSS (provision of maps and software to demonstrate radiocaesium levels in soils and food products and dose distributions) will enable authorities and decision makers to i) assess the present radioecological situation in Chile and ii) direct countermeasures if necessary and iii) provide information on the radiological situation to the public. Furthermore, this project may represent a pilot study for similar studies in South American countries.

THE MAIN SCIENTIFIC ACHIEVEMENTS OF THE "PEACE" PROGRAMME

François BRECHIGNAC

IPSN, Department for Environmental Protection, Division for Laboratory Radioecological Research and Studies (SERLAB)

ABSTRACT

The Programme for Evaluating the impact of Accidents Contaminating the Environment (PEACE) has been driven by IPSN since 1997 with the collaboration of various european Institutes and Universities[1]. Its objectives were designed to study the consequences on agricultural environments of a radioactive contamination as would be released in the atmosphere following a severe accident on a PWR electro-nuclear reactor. More precisely, it was aimed at quantifying, explaining and modelling the behaviour within soils of two long-lived radionuclides (approximately 30 years half-life), caesium 137 and strontium 90 : in-depth migration and transfer to the plants via the roots in various soils and western Europe climates conditions.
The results obtained have demonstrated that the variations of the plants contamination rates observed cannot be accounted for based on the soils textural properties alone. As an interface compartment, the soil interstitial water plays an essential role, its chemical composition being the result of the double interaction with the soil solid matrix in the one hand, and the root absorbing surface in the other hand. It is through its chemical composition that parameters such as « soil type », agricultural practices, time and climatic conditions are therefore inducing a variability of the transfer factors. In-depth vertical migration is reduced and the resulting profiles are established early on after the contamination event, a feature which suggests the importance of the soil moisture status upon deposition and the very first rains. Migration prediction cannot be achieved from a soil knowledge reduced to the classical K_D concept (soil-water distribution coefficient). Exploiting these data has promoted the development of mechanistic models which describe the transfer of these two radionuclides in the soil-plant system. Such models allow to improve the predictive performances of more global operational models which will be used in radioprotection in order to define realistic assessments of contaminated environments.
The experiments have essentially been conducted at the Cadarache Centre (Institute for Nuclear Protection and Safety, France) within a 2000 m^2 unique laboratory featuring large-scale lysimeters installed in advanced greenhouses with complete artificial reconstruction of climates, and further associated with a leak-proof dedicated system for producing radioactive contaminating aerosols. Numerous usual crops have been studied (barley, lettuce, beans, rye-grass, lucerne, etc...) on various

1
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Imperial College of London, UK : Georges Shaw, Joanna Marchant, John Tompkins, Adrian Butler
Swedish University of Agricultural Sciences, Uppsala, Sweden : Sverker Forsberg, Klas Rosen Institute for Nuclear Protection and Safety, Cadarache Center, France : Chantal Madoz-Escande, Marc André Gonze, Claude Colle
CEC-DG Research, Brussels, Belgium : Ernst-Hermann Schulte

soil monoliths sampled throughout western Europe and submitted to different agricultural practices (tilling, mulching, deep placement, ...).

SCIENTIFIC ACHIEVEMENTS OVERVIEW

The PEACE European programme has studied the consequences on the agricultural environment of a radioactive contamination as would be released in the atmosphere in case of a severe accident occurring in a PWR nuclear reactor. Beyond the quantification of traditional radioecological transfer factors, this programme has been oriented towards a better understanding of the **mechanisms** which govern the behaviour of radioactive pollutants in soils and their further transfer to plants by root absorption. It has been executed based on the unique IPSN Controlled Lysimetric Environmental Facility, which allows to simulate a radioactive contamination in controlled conditions. The facility consists in soil monoliths sampled throughout Europe and set up in original lysimeters within which natural hydrological profiles can be artificially reproduced. Placed in a greenhouse where the climatic conditions prevailing at the sampling site are artificially reconstructed, the soil surface of the lysimeters is cultivated, after contamination, in controlled environmental conditions. This approach has been specifically designed such as to feed, with well mastered experimental data, the development of mechanistic models describing the transfer of ^{137}Cs and ^{90}Sr in the soil-plant system, in order to yield an amelioration of the predictive performances of global assessment models used in radioprotection.

The essential but complex role of the soil interstitial water

The soil interstitial water composition, not only with respect to Cs and Sr but also to competitive ions (K and Ca-Mg, respectively), is central to resolve the variability of these radionuclides root transfer to plants. As an interface compartment, its chemical composition results from interactions located on the one hand, at the soil solid matrix (submitted to the properties of the soil adsorbing complex), and on the other hand, at the root absorbing surfaces (submitted to plant physiology). The soil moisture reduction in particular promotes an increase of radionuclides concentrations. Such an increased availability appears at first prone to favour root uptake. However, it also promotes an increase in the concentrations of competitive ions which in turn reduce radionuclide absorption by the roots (competition at the membrane transport systems level). It is therefore the superimposition of these two mechanisms which determine the resulting contamination of the plants. If parameters such as soil type, agricultural practices, time and climatic conditions (soil moisture) all promote a variability of the transfer factors, this is essentially due to their various effects on the chemical composition of the soil interstitial water.

Reduced migration on mineral agricultural soils

The description of soils along the classical K_D concept does not allow an accurate prediction of the vertical migration of Cs and Sr. KD is a partition coefficient between the soil solid matrix and the soil water which is most often measured in vitro (aggregated structure of the soil destroyed) and usually in water saturated conditions and after reaching equilibrium (conditions rarely encountered in real nature). The profiles observed 4 years after contamination remain very similar irrespective of the soil type (varying from sandy to loamy), and more surprisingly with a very weak differentiation between Cs and Sr in disagreement with their quite different respective K_D values ($K_DCs >> K_DSr$). Furthermore, their migration rates observed year after year (about 1 cm/year) do not agree with the profiles shapes that are predicted by the mechanistic model. It appears that migration profiles are established very early on (less than one month) after the contamination event, with a very limited subsequent evolution. Such features suggest the importance of climatic conditions prevailing upon contamination such as the soil moisture status and the first rains. Finally, it appears that migration can be better simulated in modelling by introducing a "global retention coefficient", rather than the classical K_D, which accounts not only for mineralogy and texture (the K_D concept) but also to other soil properties influencing retention. Amongst such properties, the soil structure (degree of particles aggregation) which develops in the superficial layers and is sustained by bio- and microbiological processes at work in the root exploration zone could play a paramount role.

Influence of soil type and climate on transfers

The classification of the observed transfer factors often does not agree with the soils physico-chemical characteristics alone (clay content, K_D, CEC), because they also depend on their productivity (availability of nutritive ionic elements) and plant growth as governed by climatic conditions. The effect of soil type and climate on the soil-to-plant transfer essentially acts through the chemical composition of soil water and the plant physiological characteristics prone to influence it. Indeed, the radionuclides being absorbed by the K and Ca membrane transport systems, their transfer to the plant is also governed by its physiology. Integrated in the mechanistic model of transfer, a number of observed variations are now consequently more accessible to explanation. In brief, K availability and plant growth are key elements for Cs transfer whilst Ca availability and plant transpiration appear important for Sr transfer.

Time evolution of transfers

The radionuclides transfer to plants first undergoes variations with short characteristic time, during the development cycle. These are explained on a physiological basis (activation of root transporters with distinct affinities depending on the cultivation conditions) or on the basis of modifications of the hydric soil conditions (driven by the climate). Next, the observed variations from year to year can still result more from anthropogenic modifications of the soil water composition (fertilising treatments) than from ageing manifestations (chemical availability evolution). In the longer term, finally, and over the 4 to 5 years of observations on permanent crops (ryegrass), the transfers slowly decline, but with an ecological half-life difficult to estimate on such a reduced time span due to the above-mentioned shorter-term variations.

Influence of agricultural practices on transfers

Overall, the traditional agricultural practices poorly and similarly affect the Cs and Sr bioavailabilities. When considering the soil water, the repeated addition of fertilisers (such as K, in particular) promotes two superimposed and opposite effects: it reduces the plant affinity for Cs (reduction of the Concentration Factor CF) whilst increasing its availability in soil water (reduction of K_DCs). Depending on the soil type considered, one or the other effect will dominate the transfer. In general terms, the bioavailability depends more on the influence of analogues over the radionuclides availability than on their total activity in the soil.

Inter-plant variability

In all instances, Sr transfers are always larger than those of Cs, irrespective of the soil type considered (within this study). The plant anatomical and physiological differences and their various organs with agronomic value (leaves, roots or seeds) determine their different potential for radionuclides bioaccumulation. As an example, accumulation in leaves is more intense than in seeds (where transfer must cross supplementary steps of translocation). In a radioprotection perspective, the potential prospect for reducing radionuclides bioavailability in agricultural systems relies on an appropriate selection of both, crop type and fertilising plan.

Implications for radioprotection

The soil water composition is central to resolve the variability of radionuclides transfer to plants. The classical K_D-based description of soils is inadequate to provide acceptable migration predictions from assessment models. The very early soil and climatic conditions prevailing upon and immediately after contamination are important. The knowledge generated by mechanistic models is most profitable to the improvement of more global assessment models. For such later models to work in the long-term, an improved understanding of the "bioavailability" concept is more important than taking into account climatic intermittence or soil type.

PUBLICATIONS

- **Bréchignac F., Rongier P., Hugon J., Dubois E., Colle C. and Madoz-Escande C.** 1998 Controlled lysimetric environmental facility at IPSN: assessing accidental radioactive contamination. In *Proceedings of International Meeting on Influence of Climatic Characteristics upon Behavior of Radioactive Elements, Rokkasho, Aomori, Japan, October 14-16, 1997*, pp. 35-42.

- **Sauras T., Vallejo V.R., Valcke E., Colle C., Förstel H., Millàn R. and Jouglet H.** 1998 ^{137}Cs and ^{90}Sr root uptake under close to real controlled conditions. *In Proceedings of the 8th Annual Meeting of SETAC-Europe, Bordeaux, 14-18 April, 1998.*

- **Madoz-Escande C., Colle C., Bréchignac F., Jouglet H., Fernandez V.** 1998 Time dependent evolution of Cs-137 and Sr-90 deposited as aerosols on vine. In *Proceedings of the 8th Annual Meeting of SETAC-Europe, Bordeaux, 14-18 April, 1998.*

- **Waegeneers N., Camps I Vila M., Smolders E., Merckx R., Sauras T., Madoz-Escande C.** 1998 Uptake of radiocesium by lettuce crops : the effect of potassium in soil solution. In *Proceedings of the XXVIIIth ESNA Annual Meeting, Brno (Czech Republic), 26-29 August, 1998.*

- **Marchant J.K., Butler A.P., Shaw G., Tompkins G., Wadey J.A., Wheaters H.S.** 1998 Observations of caesium-134 and strontium-85 migration in column experiments following surface contamination. In *Proceedings of the XXVIIIth ESNA Annual Meeting, Brno (Czech Republic), 26-29 August, 1998.*

- **Roca Jové M.C., Vallejo Calzada V.R.** 1998 Pretricting radiocaesium and potassium root uptake using the Barber-Cushman model. In *Proceedings of the XXVIIIth ESNA Annual Meeting, Brno (Czech Republic), 26-29 August, 1998.*

- **Aoustin E.** 1998 Spatial distribution of ^{137}Cs and ^{90}Sr in contaminated german experimental ploughed soil. In *Proceedings of " Environmental Engineering Research Event 1998; Environmental Engineering in Australia: Opportunities and Challenges ". A.I. Schäfer, L. Basson, B.S. Richards, eds, Avoca Beach, New South Wales, Australia, 6-9 December 1998.*

- **Madoz-Escande C., Bréchignac F., Colle C., Dubois E., Hugon J., Jouglet H., Moutier M., Rongier P., Sanchez A., Schulte E.H., and Zanon R.** 1999 Experimental installation for radioecology research on defined ecosystems subjected to contamination in controlled conditions. *Nuclear Science and Engineering*, 133 ;178-191.

- **Sauras T., Vallejo V.R., Valcke E., Colle C., Förstel H., Millàn R. and Jouglet H.** 1999 ^{137}Cs and ^{90}Sr root uptake under close to real controlled conditions. *Journal of Environmental Radioactivity*, 45(3) ; 191-218.

- **Madoz-Escande C., Colle C.** 1999 Simulation d'accidents nucléaires en serre. *Encyclopaedia Universalis, Enjeux et Actualités,* 231-234.

- **Vandecasteele C.M., Baker S., Förstel H., Muzinski M., Millan R., Madoz-Escande C., Tormos J., Sauras T., Schulte E.H. and Colle C.** 2000 Interception, retention and translocation of radiocesium and radiostrontium from a simulated accidental source. *Science of the Total Environment*. In press.

- **Forsberg S., Rosén K., Fernandez V., Juhan H**. 2000 Migration of ^{137}Cs and ^{90}Sr in undisturbed soil profiles under controlled and close-to-real conditions. *Journal of Environmental Radioactivity*, 50(3);235-252.

- **Forsberg S., Rosén K., Bréchignac F.** 2000 Chemical availability of ^{137}Cs and ^{90}Sr in undisturbed lysimeter soils driven under controlled and close-to-real conditions. *Journal of Environmental Radioactivity*, in press.

- **Bréchignac F., Thiry Y., Waegeneers N., Vallejo R., Sauras T., Casadesus J., Shaw G., Marchant J., Forsberg S., Madoz-Escande C., Gonze M.A., Colle C.** 2000 Soil-radionuclides interaction and subsequent impact on the contamination of plant food products based on a simulated accidental source. *In Proceedings of SPERA 2000 Conference "Environmental Changes and Radioactive Tracers" , 19-23 June, Nouméa, New Caledonia,* in press.

- Gonze M.-A., Bréchignac F. 2000 Modelling the fate of radiocaesium and radiostrontium in a soil-plant system: empirical versus mechanistic approaches. In *Proceedings of International Workshop on Distribution and Speciation of Radionuclides in the Environment, 11-13 October 2000, Rokkasho, Aomori, Japan,* in press.

- **Bréchignac F., Madoz-Escande C., Staunton S.** 2001 Vers une prévision du transfert sol-plante du radiocésium: une étude en lysimètre. *In Eléments traces dans les sols: présentation d'études de cas, INRA ed.,* in press.

- **Bréchignac F., Madoz-Escande C., Gonze M.-A., Schulte E.-H.** 2001 Controlled simulation on lysimeters of accidents yielding a radioactive pollution of the agricultural environment: overview on research carried out at IPSN. *Radioprotection*, submitted.

Assessment of uncertainty associated with Soil Sampling in Agricultural, Semi-natural, Urban and Contaminated Environments (SOILSAMP)

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Introduction

The environmental contamination represents a growing source of public concern. Data on environmental contamination are used to evaluate health and safety to human and the environment. Such data are also used in relation to the decision making process to ascertain compliance with regulatory statutes that place limits on acceptable characteristics of the environment.

Therefore the evaluation of the pattern of environmental contamination is vitally dependent on reliable data, which derive from complex analytical processes, in which each step of the process, i.e. sampling, sample transportation, treatment, analysis and evaluation and interpretation of the results, can affect to some degree the accuracy and precision of the final analytical data.

Advance in analytical techniques and improved laboratory practice have reduced many sources of uncertainties which can originate during the laboratory analytical procedures, but the assessment of uncertainty associated with sampling of environmental components has not been fully considered in the past, since collaborative field studies require noteworthy organizational efforts. The problem is more severe in the case of terrestrial ecosystem, where the soil sampling and sample preparation/processing are known to carry large (more than 50 %) but typically unknown uncertainty contribution to the final analytical data.

In this framework, the National Environmental Protection Agency of Italy (ANPA) is funding a collaborative field study with the aim of assessment of uncertainty components connected to soil sampling in agricultural, semi-natural, urban and contaminated environments.

Mainly, the project would assess the overall soil sampling uncertainty, comprehensive of soil sample collection, preparation, handling and storage. The chance to assess the two different sampling uncertainty components, such as sample collection and sample preparation, will be considered during the project.

The project will be carried out over a period of 36 months.
In addition, the project aims 1) at defining limits and field applicability of some of the most widely used soil sampling methodologies in agricultural, semi-natural, urban and contaminated environments, 2) and at validating the different soil sampling procedures and to propose them to standardization bodies.

Work Programme

The project will be carry out by different Working Team (WT):

- WT Expert Advisory Group;
- WT on agricultural, semi-natural and urban soil sampling;
- WT on contaminated soil sampling;
- WT on analytical activity.

The activity of the first WT covers all the project phases and will guarantee that all results and the decisions made relating to the project development are subjected to the consensus of the participants. To this end an Expert Advisory Group (EAG), responsible for the management of all the phases of the project is formed. The EAG, co-ordinated by ANPA, is composed by experts in the field, that, according to its own field of competence, will contribute directly to the elaboration of the technical reports, by evaluating the work outcomes and discussing the technical documents needed. All the procedures, protocols, and reports (intermediate and final) will be based on the consensus within the EAG.
The WT on sampling and analytical operations are involved in experimental activities.

To quantify the uncertainty contribution associated with the most widely used soil sampling methodologies and to eliminate the interlaboratory errors:
- soil sampling will be performed in well-suited and thoroughly studied areas;
- soil sampling with the different methodologies and samples treatments will be performed at each site by only one research group;
- trace elements measurements in all the collected soil samples will be performed by only one research group using the Neutron Activation Analysis, where little or no sample treatment prior to analysis is required.

The synthetic scheme of the project is the following.

Selection of testing areas and sampling methods
- selection of specific testing areas in Italy representative of different kind of soil, including agricultural soil (directly connected with application of chemicals or by atmospheric deposition), semi-natural soil (potentially contaminated by atmospheric deposition), urban soil (such as parks and gardens, potentially contaminated by atmospheric deposition), contaminated sites (affected by industrial pollution or illegal hazardous wastes dumping);
- definition of the sampling strategy for each testing area;
- selection of the most widely used soil sampling methodologies, to be tested in the project.

Development of soil sampling procedures
- preparation of different sampling procedures (i.e. equipment, sample volume, sample preservation requirements, decontamination procedures, materials needed, selection and preparation of sample containers, samples collection, samples preparation, maximum holding time to sample analysis, transport requirements, health and safety procedures).

Reference contamination values of testing areas
- preliminary determination of the metal content in each testing areas to be used as reference value.

Intercomparison of soil sampling devices
- collection of soil samples in the testing areas with different soil sampling methodologies.

Analysis
- execution of analysis of all samples from the testing areas, performed by a single qualified laboratory.

Evaluation of results

This activity will be carried out by the WT EAG. Geo-statistical methodologies could be used to evaluate the results of reference sampling. *Kriging* would provide good interpolation based on a geostatistical study of the spatial correlation structures of the attributes being mapped. Besides the predicted values of all unsampled locations at the grid, kriging interpolation also provides estimations of the prediction errors at these same locations. The evaluation of the data will be supported by geographical information systems (GIS).

Data collected in the field should be subjected to analysis of variance after previous analysis of the data populations.

Contribution of sampling uncertainty (samples collection, comprehensive of sample preparation and handling) associated to each sampling procedure tested, as part of overall uncertainty of analytical process, could be assessed. In order to take in account the distinct contributions in terms of uncertainty associated to sample preparation and the sample collection, an evaluation on the variability of the soil data referred to sub-samples could be carried out.

Definition of guidelines and recommendations

All participants to the EAG will contribute to the formulation of recommendation on variability in sampling methodologies applied in soil analysis. With reference to each different type of soil sampled and to overall pollutants examined, it could be indicated which sampling methodologies would guarantee the right quality of the data. Indication of possible sources of systematic errors and limitation in comparability will be a part of the

results of the project. At the end of the project, following the validation process stated according with the EAG, there will be all the elements needed for the proposal of the soil sampling procedures to the Italian national normalization body.

Workshop

A workshop, including experts of the scientific community involved in methods validation, uncertainty estimation applicable to the soil characterization, will be held during the project progress.

Project Organization

The project is based on a collaborative approach, involving public laboratories, organizations of the EU Member States and international scientific organizations (such as the International Union of Radioecology – IUR) involved in the environmental field. This is the only reliable way to harmonize procedures that can produce for the coming years at length comparable results in laboratories. The project will be co-ordinated by the Italian National Environmental Protection Agency (ANPA). ANPA will be responsible for maintaining full liaison between all partners, for establishment of the working meetings of the EAG and the communication framework and for the preparation of the progress and final reports.

The IUR is involved in this SOILSAMP project.

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Intercomparison of freshwater and suspended particles sampling methodologies used on environmental radioactivity monitoring

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Under the terms of Articles 35 and 36 of the Euratom Treaty, national authorities for radiation protection of each Member State of the European Union, shall periodically communicate to the Commission data on environmental radioactivity levels. Such data are collected by the different laboratories participating in the national environmental radioactivity network of each Member State and they are also used in relation to decision making processes to ascertain compliance with regulatory statutes that place limits on acceptable characteristics of the environment. Therefore the evaluation of the pattern of environmental contamination is vitally dependent on reliable data, which derive from complex analytical processes, in which each step of the process, i.e. sampling, sample transportation, treatment, analysis and evaluation and interpretation of the results can affect to some degree the accuracy and precision of the final analytical data.

Advances in analytical techniques and improved laboratory practice have reduced many sources of uncertainties which can originate during the laboratory analytical procedures, but the assessment of uncertainties associated with sampling of environmental components has not been fully considered in the past, since collaborative field studies require noteworthy organisational efforts. Sampling of suspended particles and sample preparation/processing, are known to carry large, but typically unknown uncertainty contribution to the final analytical data.

Surface water is one of the compartments into which authorised discharges of radioactive effluents from nuclear installations are made. In addition, after radionuclide deposition, as was the case after the Chernobyl accident, the water pathways represents in the long-term, the only real way by which material with different content of radionuclides can be transferred from contaminated areas (as the evacuated zone around Chernobyl) to uncontaminated areas (as the Black Sea).

In surface water the distribution of radionuclide between the solid (particulate matter in suspension) and liquid phase is of key importance in determining its mobility, as well as its uptake by biota. Suspended matter originates from different sources (washed out from the surrounding watershed with different soil types, originates from different river tributaries or from resuspension from the bottom sediments, etc.) and consequently the nature, size, density, composition and the water contact time are variable and the particle grains differ in their potential for adsorbing radionuclides. By convention, particulate matter in suspension is defined as the material that is retained on a 0.4 to 0.5 µm pore size filter. Particles with smaller diameter of a particle, which pass through the filter, are considered to be "dissolved".

Suspended particles concentration varies by several orders of magnitude from river to river (from 1 to 10000 mg l^{-1}) and for given water body it may vary over 3 orders of magnitude. Total radionuclides content in water may be considerably influenced by the contribution of radionuclides associated with suspended particle, especially for radionuclides that exhibit high

affinity with inorganic suspended material, like radiocaesium. Data on radioactive contaminants in freshwater samples, in which the contribution of radionuclide associated with suspended particles and those dissolved in the liquid phase are not determined, can make the interpretation and comparison of data across Europe difficult.

The onerous procedures required for the collection of large amounts of suspended material, as necessary in the case of environmental radioactivity analysis, made development of sampling methodologies very limited. Anyway several methods have been developed to separate "in-situ" suspended material from natural waters and to measure afterwards the radioactivity on particulate and dissolved forms. These methods have been developed for research purposes and in some cases they are also used for environmental monitoring. They derive from techniques used for determination of suspended material concentration in surface water, for which only small amount of suspended material is necessary. To collect samples to be used for environmental radioactivity measurements, these systems have been modified in order to allow the filtration of high volumes of water. Unfortunately there is a lack of qualitative and quantitative data on the comparability of results achieved by the different sampling methods. In some research activities, different sampling methodologies have been used for the collection of water and suspended particles in the same sampling site. For a given radionuclide, the results have shown a high variability (up to a factor 10) on the concentrations in the liquid and solid phases. This variability needs to be investigated in more details in order to define limits and field of applicability of the different sampling methodologies. This will be extremely useful for the national environmental radioactivity networks of each Member State and will permit easier interpretation and comparison of data across Europe.

To this end an intercomparison programme was founded by the European Commission, in which Institutions from the European Union and from Ukraine will participate using their own "in-situ" methods for collection of suspended material and fixation of dissolved radiocaesium. The expected outcome of this study is the definition of limits and field applicability of the most widely used sampling methodologies for water and suspended particle in aquatic environments. In addition, the project aims to validate the different sampling procedure through standardisation bodies.

The following institutions are involved in this intercomparison exercise:

- ANPA :Agenzia Nazionale per la Protezione dell'Ambiente Italy (Co-ordinator)
- ARPA-ER:Agenzia Regionale per la Protezione dell'Ambiente -Emilia Romagna (Sezione Provinciale di Piacenza) Italy
- EDF-DER :Electricité de France France
- UHMI :Ukrainian Hydrometeorological Institute Ukraine
- UT :Università degli Studi di Trieste - Dipartimento di Scienze Geologiche, Ambientali e Marine Italy

The intercomparison exercise will be carried out in two different scenarios:

- downstream of a French nuclear power plant during a scheduled discharge of radioactive liquid effluents;
- in the Kiev Reservoir (the first reservoir of the Dnieper cascade in Ukraine).

The site downstream the French nuclear power plant represents an environment in which the radiocaesium is mainly in dissolved phase. On the other hand, the Kiev Reservoir can represent an environment in which the radiocaesium solid-liquid distribution can be considered in equilibrium, about 15 years after the Chernobyl accident.

The techniques used for "in situ" collection of suspended matter are essentially the same in rivers, lakes, estuaries and the sea. The most widely used are following reported:

- "in-situ" normal flow (dead end) filtration. The flow of the entire feedwater stream in one direction, directly through the filter media. The flow is usually "normal" – or perpendicular – to the media surface area;
- "in-situ" crossflow (tangential) filtration. A type of filtration that uses the shear force of tangential flow across the membrane surface (during suspension recirculation) to keep the particle build-up on the surface to a minimum;
- "in-situ" concentration with a continuous flow centrifuge. This techniques is based on the use of centrifugal forces to separate suspended particles from dissolved species;
- emergent decanter (settler). It is essentially a large vessel in which the feedwater stream from the bottom to the top through inclined honeycombed lamellar structure;
- floating sediment trap. Are essentially cylindrical collector bottles placed along the vertical profile of a water body in which water is allowed to flow inside;
- bottom fixed sediment trap. Consist of collectors fixed on the bottom of the water body, that are open on one side and with a sediment-collecting device on the other.

The following sampling devices will be tested during the intercomparison exercise:

- Dead end filtration : Nylon cartridge filter
- Crossflow filtration : Cellulose cartridge filter
- Centrifugal filtration : Cellulose disk filter
- Decanter (Settler) :
- Bottom fixed sediment trap :
- Floating suspended particle trap : Point-integrating
  : Point-integrating
  : Point-integrating
  : Point-integrating
  : Point-integrating
  : Point-integrating
  : Point-integrating
  : Depth-integrating

Any IUR members interested in the results or can give any suggestions to the project are asked to contact Umberto Sansone (sansone@anpa.it) or Maria Belli (belli@anpa.it).

Radioecological research activities carried out by the Division for Laboratory Radioecological Research and Studies (SERLAB) of the French Institute for Nuclear Protection and Safety

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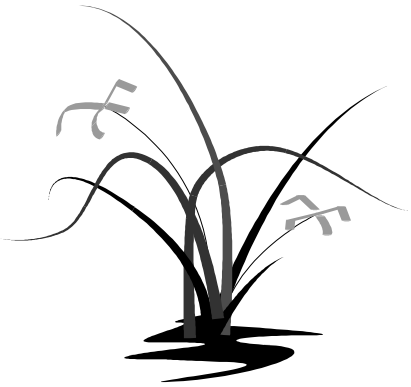
The Department for Environmental Protection of IPSN (Institut de Protection et de Sûreté Nucléaire, France) undertakes different activities and research programs within the field of radioecology, in order to provide the French authorities with both expert advice for radioecological assessments, and knowledge of the risks associated with any contamination of the environment. These programs are based on field monitoring, experimental laboratory studies under controlled conditions and mechanistically based modelling of the behaviour of radionuclides in the environment.

Within this framework, the Division for Laboratory Radioecological Research and Studies (SERLAB) located at Cadarache is responsible for research into the behaviour of radioactive substances in continental ecosystems. All projects in progress aim to clarify the short and long term behaviour of radionuclides in the various physical and biological compartments of terrestrial and aquatic ecosystems, by integrating the complementary approaches of modelling and experimentation. Experimental research carried out by the Experimental Radioecology Laboratory (LRE), is based on radionuclide transfer studies under controlled conditions performed in simplified ecosystems representative of agro-ecosystems and freshwater



trophic nets. The main aim of the experimental studies is to acquire the necessary knowledge for the development and implementation of mechanistically based models, for prediction of the spatial and temporal distribution of important radionuclides between the compartments of terrestrial and freshwater ecosystems. Modelling developments are carried out by the Laboratory of environmental modelling and data management (LMODE) responsible for the initial development of explicative research models (oriented towards a phenomenological description of processes), and the subsequent convergence towards operational models with a reduced number of parameters, and duly justified simplifications. The establishment of high quality radioecological environmental databases is another key responsibility of LMODE, used principally for the calibration and validation of developed models. In addition to national multidisciplinary collaboration with several universities and institutions, SERLAB's program enjoys international partnerships in the field of radioecology: Centre for Ecology and Hydrology (UK), National Radiological Protection Board (UK), Imperial College of Science, Technology and Medicine (UK), UIAR (Ukraine), Swedish Radiation Protection Institute (Sweden).

1. EXPERIMENTAL RESEARCH UNDER CONTROLLED CONDITIONS

All projects in progress are designed in order to understand and quantify the two main processes governing the distribution of any radionuclide in the environment :

(1) the radionuclide behaviour in physical compartments of the ecosystems (soil, sediment,

water) *i.e.* its mobility linked to the physical and chemical speciation of the considered element ;

(2) the radionuclide bioavailability *i.e.* its transfer to biological components in terms of contamination level, uptake and elimination dynamics, internal distribution and speciation in the studied organism.

1.1 Terrestrial ecosystems

Terrestrial lysimetric mesocosms : RESSAC and PEACE programmes.

In order to clarify the short-term and long-term consequences of a nuclear accident causing significant contamination of the environment *via* radioactive aerosol deposition, the IPSN Lysimetric Environmental Facility was constructed, featuring large-scale undisturbed monoliths of various agricultural soils sampled throughout Europe and installed as instrumented lysimeters (controlled soil hydric potential), cultivated in a greenhouse under controlled climatic conditions (artificially reproducing various European climates). A unique radioactive aerosol generation device, referred to as POLYR, has been developed to realistically contaminate crops on the lysimeters' surfaces with ^{137}Cs and ^{90}Sr.

In the first phase, IPSN led the RESSAC programme (Rehabilitation of Soils and Surfaces in case of Accident, 1991-1996), assembling several European research teams and co-sponsored by the CEC and EDF (*Electricité de France*), which quantified the foliar interception of radiocontaminants by a wheat crop, its consequences on the contamination of wheat grains, and on the setting up of an efficient soil surface decontamination technique.

In the second phase, the European PEACE programme (Programme for Evaluating the consequences of Accidents Contaminating the Environment) co-sponsored as previously, commenced in 1997, and has been focused on the interaction processes of soil-radionuclides and the modelling of their impact on the contamination of plant food products. With the support of partners from the United Kingdom, Belgium, Spain and Sweden, the experimental phase of this programme has been completed. It has unravelled the long-term influence of soil characteristics upon 1) the migration of radionuclides within soils, 2) their bioavailability to plants, 3) the soil-to-plant root transfer (barley, beans, lettuce, woody plants such as vines,...), and has resulted in the development of the TRANSSOL model capable of predicting the contamination behaviour within the soil-plant-atmosphere system. On behalf of the European Commission within the 4th Framework Programme, IPSN has led an Association of several European Projects in terrestrial radioecology including PEACE and two other *in situ* research programmes, LANDSCAPE and EPORA.

Role of biological components in soil-to-plant transfer : BORIS.

This new international project, namely BORIS (Bioavailabity Of Radionuclides in Soils) co-sponsored by the CEC within the 5th Framework Programme, is currently promoting research in order to improve predictive models of radionuclide root transfers in plants. Experiments under controlled conditions will be designed to understand the role of different biological components of the soil (microorganisms, plant and mycorrhizal fungi), and to compare it to the influence of the mineral and organic soil components and to the role of the soil physical structure. Three radionuclides characterized by different behaviour linked to their theoretical chemical speciation and their role within the plant physiology will be studied : Cs, Sr and Tc. The influence of additional pollutants (xenobiotics used in agriculture and heavy metals) will also be investigated. Acquired knowledge will be integrated in an assessment radioecological model taking into account the abiotic processes affecting radionuclide partitioning between soil and soil solution and biotic processes involved in the phyto-availability of radionuclides.

Long-term behaviour of long half-life actinides and halogens in soils and its impact on their phyto-availability.

A number of radionuclides have been previously investigated to quantify their soil-to-plant transfer factors. This transfer is largely determined by the solid-liquid phase partitioning behaviour in the soil system, which regulates the concentration of the radionuclide in the soluble compartment and hence the bioavailability for root absorption within the soil. The behaviour of some elements can be adequately described by soil solid-liquid partition coefficients (Kd); however, others such as the actinides undergo complex chemical speciation that affects their long-term bioavailability. Based on experiments carried out in controlled greenhouses which permit the regulation of plant growth conditions, the research undertaken aims at clarifying and modelling the bioavailability of Np, Am and Pu with particular emphasis on their interaction with soil organic acids (prone to promote solubility) and on the influence of the soil hydric conditions (which influence the partition coefficient, Kd, in the soil unsaturated zone). This experimental approach has been extended to radioactive halogens with long half-lives such as ^{129}I and ^{36}Cl.

Radionuclide foliar transfers.

Within the context of radioactive aerosol

deposition after a nuclear accident, the foliar transfer in agro-ecosystems is very poorly known for radionuclides such as the actinides and for main fission products other than Cs and Sr, namely Te, Ba and Ce. Experiments under controlled conditions are carried out in order to quantify basic parameters necessary in assessment models (for example, ASTRAL) and to investigate the influence of : the plant physiological state; the climatic conditions immediately after the radionuclide deposition; and the use of different xenobiotics in agricultural practices. The importance of the "splash" phenomenon (soil resuspension and particle deposition on leaves) will be quantified in order to estimate its significance in models.

Water soil erosion on agricultural lands.
Ten years after the massive release of radioactive aerosols from the Chernobyl accident, some soils sampled on the French territory show significant levels of contamination which appear to be distributed in local patches, this seems to be due to a horizontal redistribution by run-off water and associated soil erosion. If the radiocontamination of rivers due to dissolved radionuclides in run-off water is well documented and modelled, the transport of radionuclides adsorbed on disaggregated soil, as particles, by water erosion has been very poorly addressed. IPSN has developed a research to fill this gap, based on controlled experiments featuring artificial contamination (Cs and Sr) of agricultural soils (with the POLYR device) with various slopes, which are subjected to artificial rain (rain simulator). A concomitant modelling effort is also underway.

1.2 Freshwater ecosystems

Experimental kinetic rates as basic knowledge for modelling radionuclides transfers through trophic nets and characterisation of bioindicators.
This programme has evolved (1991-1996) as a thorough experimental examination of radionuclide transfer through freshwater trophic nets, and the characterisation of bioindicators such as aquatic mosses and bivalves (zebra mussels and asiatic clams). Model trophic chains, typically featuring up to four trophic levels, from phytoplankton to carnivorous fish, have been used under controlled conditions in the laboratory in order to quantify the transfer kinetics of radionuclides at each trophic level (accumulation, elimination, tissular distribution), and to understand how these are later influenced by biotic parameters (species, biomass, growth, nutrition, ...) and abiotic parameters (water and sediment physico-chemistry). The accumulated knowledge led to the development of the TRANSAQUA model which allows prediction of the radioactive contamination levels in aquatic organisms, resulting from a given chronological contamination scenario, with due consideration of the river hydro-ecological cycles. This biological module has been integrated in a complete operational code named CASTEAUR, developed as a tool for assessment of radionuclide transfers within a watercourse included in a whole watershed. On the basis of a simple description of the hydrographic network, this code incorporates main hydraulic and sedimentary processes. For different types of radionuclide release (point-source, chronic discharge, linear input from run-off on the watershed...), it allows the prediction of spatial and temporal development of radionuclide concentrations within the main physical (sediments, suspended matter and water) and biological (phytoplankton, zooplankton, macrobenthos, prey fish and predator fish) compartments.

The multipollution context in freshwater radioecology.
Further to bioindicators and transfer to organisms, current developments (since 1997) have focussed on a new line of investigations on the influence of the multipollution context on radionuclide bioaccumulation by freshwater organisms, following the ecotoxicological approach. Since most freshwater ecosystems are now polluted to various extents with different categories of xenobiotics (such as heavy metals or organic pollutants), freshwater radioecologists have to understand how these xenobiotics that can induce stress or alter biological components, act and/or interact on the behaviour of radionuclides within biological systems. The effect of disturbances due to these xenobiotics on radionuclide bioaccumulation, has never been dealt with from this point of view by the freshwater radioecological community. The final aim is to enhance the realism of radioecological evaluations while taking into account the deleterious influence of stable xenobiotics on aquatic organisms which can be physiologically stressed, and therefore can modify their response to bioaccumulation of radioactive pollutants. Experiments are presently designed in the context of multipollution, involving heavy metals (Cd, Zn), organic pollutants (PCBs, PAHs, oestrogenomimetics) and radionuclides, such as isotopes of Co, Cs, and Ag. The chosen biological models are two freshwater bivalves (*Dreissena polymorpha* and *Corbicula fluminea*) and a predator fish (*Oncorhynchus mikiss*). Initial results have shown that prior chronic metallic waterborne exposure (1µg/l Cd and or 150 µg/l Zn) to organisms led to decreased radionuclide bioaccumulation by a factor 2 to 10 with respect to the considered radionuclide (radioactive isotopes of Cs, Co, Ag), the observation level (whole organism, target tissue or subcellular level) and to the biological model. On the contrary, prior exposure to organic micropollutants enhanced ^{57}Co and ^{137}Cs uptake kinetics from water and retention time in fish. The radionuclide contamination level of exposed

groups is always higher than this obtained for the control group (+10% to +60% as a function of the organic micropollutant). These first results underline the importance of this research field.

Physical and chemical speciation of radionuclides (U, ^{210}Pb) and bioavailability in freshwaters.

This project will start at the beginning of 2001. According to the hydroecological seasonal cycle of any watercourse, the impact of the variation in the principal constituents of natural water (pH, calco-carbonic hardness, dissolved organic matter, suspended matter) on the distribution pattern of the physical and chemical forms of U and Pb will be assessed from the theoretical point of view (using speciation software such as MINEQL+, WHAM and CHESS). It will serve as a basis for the constitution of more relevant scenarios for the study and modelling of transfer to the biological components of ecosystems. The programme will contribute to the development of methods for the experimental investigation and modelling of the bioavailability of a radioactive metal type pollutant, taking into account the kinetics of the possible reactions with the main inorganic ligands and organic molecules (for example citrate) in water, by quantifying the respective importance of adsorption and cellular internalisation processes. The model, adapted to two chosen organisms (a plant of the class of aquatic bryophytes and an animal of the class of molluscs, will be calibrated for two pollutants with major radioecological and ecotoxicological importance in the context of the aquatic environment of uranium mining sites. This model, based on an understanding of the fundamental mechanisms, will formalise all the knowledge necessary for the proper utilisation of aquatic bryophytes and zebra mussels as radioindicators of contamination taking into account the physiological state in relation with the multipollution context.

2. MODELLING

2.1 Explicative models

Such models are developed in close relationship with experimental research. They are aimed at describing as closely as possible the various transfers between the biosphere components as much as acquiring an analytical understanding of the mechanisms involved. Detailed multiparameter algorithms are constructed and tested by fitting to experimental data. A major example is the TRANSSOL model, which attempts to integrate the modelling of the input of rain and run-off water on natural or agricultural lands, the vertical migration of radionuclides in the soil profiles and the root uptake from the soil solution (both aspects having been supported by experimental investigations on lysimeters within the European Commission PEACE Programme), accounting for the liquid-solid partition of radionuclides in the soil. The modelling of forest ecosystems has been recently undertaken through the participation in the development of the European RODOS tool. Such a work was deemed appropriate since forest ecosystems have demonstrated a very specific behaviour with the efficient recycling of radioactive elements through the litter, leading to a very limited decrease of radiocontamination with time. In another realm, the TRANSRIV model attempts to integrate the previously modelled physical dispersion mechanisms in rivers with the biological transfers.

2.2 Operational models

Operational models are meant to provide authorities with rapid previsions in case of radioactive contamination of the environment. They are either empirical, when no analytical knowledge is available, or derived from explicative models with thorough, but duly justified, simplification of the algorithms in order to allow for non-specialist use. Within this scope, the ASTRAL model has been developed to predict the radioecological consequences of a nuclear accident. It is currently being modified to improve the predictive ability in the longer term, introduce semi-natural ecosystems (forests), and asses the impact of counter-measures. ASTRAL has been compared with other operational models developed by IPSN on similar subjects but in different contexts (MIRRAGE and ABRICOT), and it has also recently been compared to the German PARK and the European RODOS codes, during a French-German intercomparison exercise, related to the assessment of decision making tools for emergency management. Concerning the operational modelling of contamination levels of river compartments through space and time, the CASTEAUR model has been developed, supported by the TRANSRIV programme. Moreover, a long-term effort is being undertaken by IPSN in order to harmonise all these operational models to allow the results of one model to be directly usable for another one.

2.3 Radioecological environmental data bases

Models are useless without input data, and their predictive efficiency is totally subordinated to the quality of these data. IPSN undertakes a broad effort in developing appropriate data bases on all topics concerned in radioecology. This involves data collection followed by its rational and detailed classification, both radioecological and environmental, with intelligently chosen criteria allowing for evalu-

ating uncertainties. The methodological points supporting such developments were addressed through the formation of the «data selection» working group of the IAEA / BIOMASS programme. The COTRANS data base, recently initiated, will assemble in a coherent package all radionuclides transfer factors within the environment with emphasis on the tracability of the origin of these data (publication, experimental or *in situ* measurements, conditions of obtention). The GAIA data base will assemble all activity measurements performed on environmental samples collected over a number of years for assessing the radiocontamination impact of nuclear installations on the environment. Thematical data bases are also being developed for acquiring all appropriate descriptions of the environment, supported by GIS, on various aspects such as physical geography (climates, topography, ...), biogeography (forest extension and types, fauna distribution, ...), human geography (cultivated areas, crops, agricultural methods, demography, ...). These data bases are designed in such a way as to be automatically accessible from operational models in the future.

2.4 Variability and uncertainties

Experience clearly shows the limitations of producing crude model results in isolation : it is now necessary to be able to characterise the level of confidence that can be ascribed to the calculation outputs, and to highlight the prominent variables to which these output are the most sensitive. Accordingly, IPSN has developed methods and tools for performing sensitivity and uncertainty analyses. They were previously tested through the participation in the former BIOMOVS II programme, and they are applied today to explicative models, like TRANSSOL, and operational ones, like ABRICOT. Variability, as a topical source of uncertainty, is also specifically addressed through the issue of data assimilation, i.e. the management of the interplay between modelling and field measurements, especially when dealing with emergency management.

Main publications :

Baudin, J.P, Adam, C. and J. Garnier-Laplace (2000). Dietary uptake, retention and tissue distribution of ^{54}Mn, ^{60}Co and ^{137}Cs in the rainbow trout (*Oncorhynchus mikiss* Walbaum). *Wat. Res.* **34**(11), 2869-2878.

BIOMASS, (1999). Guidance for the application of data to assessment models. *BIOMASS/T1/WD04, IAEA Draft TecDoc.*

Bréchignac F., Vallejo R.V., Sauras Yera T., Casadesus J., Thiry Y., Waegeneers N., Forsberg S., Shaw G., Madoz-Escande C. and M.A. Gonze (1999). PEACE : Programme for Evaluating the impact of Accidents Contaminating the Environment - Soil-radionuclides processes of interaction and modelling of their impact on contamination of plant food products. *Final Report, European Atomic Energy Community Contract F14-CT96-0039a, IPSN-DPRE/SERLAB Report 99-017(P),* 60 pages.

Bréchignac F., Thiry Y., Waegeneers N., Vallejo R., Sauras T., Casadesus J., Shaw G., Marchant J., Forsberg S., Madoz-Escande C., Gonze M.A. and C. Colle (2000). Soil-radionuclides interaction and subsequent impact on the contamination of plant food products based on a simulated accidental source. In *Proceedings of SPERA 2000 Conference "Environmental Changes and Radioactive Tracers" , 19-23 June 2000*, Nouméa, New Caledonia, in press.

Calmon Ph.,and A. Rantavaara (1999). Model description of the forest food chain and dose module FDMF. *CEC RODOS report No. WG3-TN99-53.*

Calmon Ph. (2000). Sampling and measuring operation for mushrooms and berries in a forested massif belonging to the National Park of Mercantour. *Radioprotection*, vol. 35, No. 1, pp. 11-20.

Claval, D., Réal, J., Mauger, S., Sellier, L. and R. Rouxel.(2000). Fixation of ^{134}Cs and ^{85}Sr on detached particles during two disaggregation processes. *European Soil Science*, in press.

Forsberg S., Rosén K., Fernandez V.and H. Juhan (2000). Migration of ^{137}Cs and ^{90}Sr in undisturbed soil profiles under controlled and close-to-real conditions. *Journal of Environmental Radioactivity*, 50(3);235-252.

Forsberg S., Rosén K.and F. Bréchignac (2000). Chemical availability of ^{137}Cs and ^{90}Sr in undisturbed lysimeter soils driven under controlled and close-to-real conditions. *Journal of Environmental Radioactivity*, in press.

Fraysse, B., Baudin, J.P., Garnier-Laplace, J., Boudou, A., Ribeyre F. and C. Adam (2000). Cadmium Uptake by Corbicula fluminea and Dreissena polymorpha. Effects of pH and Temperature. *Bulletin of Environmental Contamination and Toxicology* **65** (5).

Garnier-Laplace, J., Adam, C. and J.P. Baudin (2000). Experimental kinetic rates of food-chain and waterborne radionuclide transfer to freshwater fish : a basis for the construction of fish contamination charts. *Arch. Environ. Contam. Toxicol.* **39**, 133-144.

Garnier-Laplace, J., C. Adam, T. Lathuillière, J.P. Baudin and M. Clabaut (2000). A physiological model for radionuclide transfer from water to rainbow trout (*Oncorhynchus mikiss* Walbaum). *J. Environ. Radioactivity* **49**(1), 35-53.

Gonze M.A. and F. Bréchignac (2000). Modelling the fate of radiocaesium and radiostrontium in a soil-plant system : Empirical versus mechanistic approaches. *International Workshop on Distribution and Speciation of Radionuclides in the Environment, Rokkasho (Japan),* October 11-13, 2000.

Madoz-Escande C., Bréchignac F., Colle C., Dubois E., Hugon J., Jouglet H., Moutier M., Rongier P., Sanchez A., Schulte E.H., and R. Zanon (1999). Experimental installation for radioecology research on defined ecosystems subjected to contamination in controlled conditions. *Nuclear Science and Engineering*, 133 ;178-191.

Roussel-Debet, S., Colle, C., Hurtevent, H.and M. Morello (2000). Influence d'acides organiques sur la désorption de l'américium 241 et du neptunium 237 à partir d'un sol cultivé acide. *Radioprotection* **35**(4), 367-380.

Roussel-Debet S., Garnier-Laplace J., Mourlon C. and Ph. Calmon (2000). Modelling transfers of carbon 14 emitted by pressurised water reactor under normal operating conditions, *Journal of Environmental Radioactivity*. (submitted)

Plant availability of radiocaesium in soil: facts, mechanisms and modelling

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Radiocaesium (^{137}Cs) is an isotope that can be absorbed from soil by plants and, in this way, can enter the food chain. Food chain contamination by ^{137}Cs can be a persistent source of radiation to the population after a nuclear accident. The transfer of ^{137}Cs from the soil to the crops is perhaps the most variable among all other steps leading to food chain contamination. As an example, a critical review of the crop-soil ^{137}Cs concentration ratio's (the so-called Transfer Factors) shows that ^{137}Cs availability to major crops such as cereal grains, potato tubers and vegetables varies 100-1000 fold(1) . It is often speculated that this variability is related to the soil type. The direct correlation's between the Transfer Factors and soil properties such as the clay content or organic matter content are, however, weak or insignificant. The ^{137}Cs availability to crops is generally high if the soil is very high in organic matter (e.g. peat soils) or if the soil is depleted of nutrients, particularly potassium (K). The lack of a clear correlation between the transfer factor and the clay content of the soil is certainly in contrast with what a soil chemists would predict. Soil chemists have indeed shown over and over again that ^{137}Cs is selectively sorbed on high affinity binding sites on clay, especially on the weathered mica's such as illite.

The uptake of any element from soil by plants is the net results of reactions taking place in soil, at the soil-root interface and within plants. The ^{137}Cs availability in soil is certainly not only related to the soil chemistry, which predicts its mobility only. Crop scientist know that an element in soil is not available when it is not mobile (unless it is mobilised at the soil root interface). However, a mobile element in soil may not necessarily be absorbed by plant roots if there is no demand for that element (as in the case of plant nutrients) or if the root uptake system is blocked. This means that mobility and bioavailability do not necessarily go hand in hand !

The soil-plant ^{137}Cs pathway is conceptually depicted in Fig. 1 using 3 parts: the soil solids (minerals, particulate organic matter), the soil solution and the plant. The exchange between the soil solids and the soil solution is the soil chemical reaction. The uptake of ^{137}Cs from soil solution is the reaction that is under control by plant physiology i.e. the ion uptake process in the root cells and the translocation to the above-ground parts. The ion uptake process has a particular role in the entire soil-plant transfer process. Several studies in solution culture have now come to the same conclusion that root uptake ^{137}Cs is sharply reduced with increasing concentrations of K (2). Caesium is not a nutrient but may be absorbed by the transport systems of its nutrient analogue K. High concentrations of K^+ ions effectively reduce the chance that a Cs^+ ion enters the plant through the K channels or carriers in the membranes of root cells. This leads to the concept that plant availability of ^{137}Cs in soil is controlled by both its mobility in soil *and* by the K concentration in the soil solution.

We have set-up a pot trial to test this concept. Thirty soils that were artificially contaminated by ^{137}Cs in the laboratory and were grown by ryegrass in greenhouse conditions (3). The availability of ^{137}Cs to the grass differed over 1000-fold between the soils, confirming that ^{137}Cs availability is particularly depending on soil properties! There was a remarkable *absence* of a relationship between the soil clay content on uptake of ^{137}Cs. Higher uptake of ^{137}Cs was related to higher concentrations of ^{137}Cs in the soil solution (i.e. the mobile fraction), but this correlation did not explain all the differences. It appeared that the soil solution concentration of K was also important in controlling the uptake of ^{137}Cs. Overall, higher uptake of ^{137}Cs was found when the mobility of ^{137}Cs is high combined with low soluble K concentrations. Over 90% of the variability was explained by these two parameters. It was also explained why the clay content had no effect of

^{137}Cs availability: increasing clay reduces, on the one hand, the ^{137}Cs mobility in soil but, on the other hand, also reduces K mobility leading to a higher chance of a $^{137}Cs^{+}$ ion being absorbed. These 2 effects are counteracting each other.

This concept was used to model field and lysimeter data that were published earlier (4). The model basically predicts the soluble ^{137}Cs and K concentrations from the clay content and the exchangeable K content in soil. It also accounts for the ageing of ^{137}Cs in soil since ^{137}Cs becomes gradually less available through time due to fixation processes. This model was able to explain a large extent of the variability of Transfer Factors of agricultural crops. As an example, 71 % of the variability of the transfer factors to wheat grain (n=78) were explained by this model. That model has also been incorporated in a Geographical Information System predicting food chain contamination for a known ^{137}Cs deposit in W. Europe.

The soil-plant transfer of ^{137}Cs in semi-natural systems may even be more variable than in agricultural systems. Uptake of ^{137}Cs bentgrass grown on a variety of peat soil from U.K. was also related to soil solution ^{137}Cs and K concentrations. Elevated transfer in these soils is due to very low soluble K (soils are not fertilised) and high mobility (low clay content and important NH_4^+ concentrations blocking the sorption sites). Modelling ^{137}Cs transfer at field scale in semi-natural systems with this detailed model is less reliable than in agricultural systems due to e.g. the variety of plant species, and the difficulty in predicting soluble K and NH_4^+ concentrations at such a scale.

The concept outlined above illustrates that bioavailability of a contaminant is the result of the interaction of biotic and abiotic reactions. The risk of an isotope in an ecosystem is even more complex by taking the pathways and interaction beyond soil-plant transfer into account. The analysis outlined above has shown that the complexity of at least the first step in this chain is not impossible to overcome.

Reference:

1. Nisbet AF, Woodman RFM.*Health Physics* **2000**, 78,279-288.
2. Zhu Y-G., Smolders E. and Nisbet A. F. (2000). *J. Exp. Bot.* 51:1635-1645.
3. Smolders, E, Van den Brande K and R. Merckx. *Environ. Sci. Technol*, **1997**, 31,3432-3438.
4. Absalom J.P., Young S.D.,Crout N.M.J., Nisbet A.F., Woodman R.F.M., Smolders E and Gillett A.G. *Environ. Sci. Technol.***1999**, 33:1218-1223.

For more information contact about the Caesium soil-plant transfer model with regard to its use in relation to Phytomanagement contact:

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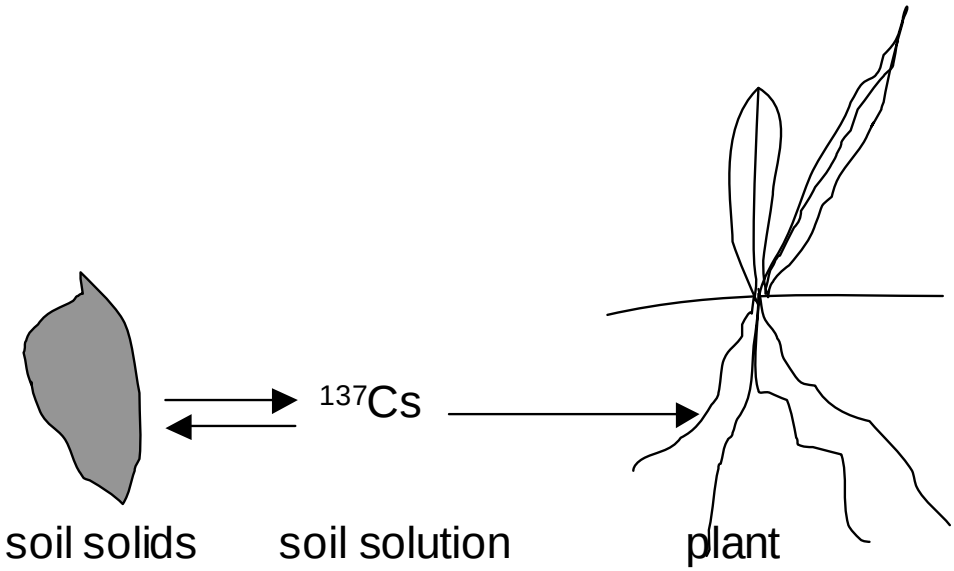

Fig. 1 A conceptual presentation of the soil-plant transfer of ^{137}Cs. The isotope must first be released to soil solution prior to absorption by plant roots. The solid-liquid distribution and the solution-plant reaction control the net soil-plant transfer

PhD Thesis
Presented to obtain the Doctor grade of the Paris XI – Orsay University
Speciality : Radiochemistry

Optimasation of the Measurement Protocols of ^{129}I and $^{129}I/^{127}I$. Methodology Establishment for the Measurement in Environmental Matrices.

By **Carole FRECHOU**

Presented on October, 13th to the following jury members :
M. Michel GENET
Professor IPN-Orsay - Université Paris XI - Orsay
M. Dominique CALMET
Head of the Radioecology Study and Research in Natural Environment Division – IPSN (France)
M. Bernd GRAMBOW
Head of the Radiochemistry Section, Laboratoire Subatech – Ecoles des Mines de Nantes (France)
M. Elis HOLM
Head of the Departement of Radiation Physics - Lund University (Sweden)
M. Rolf MICHEL
Head of the Centre of Radiation Protection Institute – Hanover University (Germany)
Ms Susan Parry
Huxley School of Environment, Earth Sciences and Engineering – London Imperial College (UK)
M. Marc Himbert
Professor of Metrology – Head of BNM-INM – CNAM Paris (France)

Iodine-129, is a natural long-lived isotope, with a half-life of 15,7 million years. It was also artificially generated during past nuclear device explosions in the atmosphere. Produced in nuclear power plants, ^{129}I is discharged in the environment in the liquid and gaseous effluents of the nuclear fuel reprocessing plants. In the environment, ^{129}I integrate all biological compartments at different activity levels, depending on their distance from the emission source and organisms ability to metabolise iodine.

A comparison of the performances of the different ^{129}I and $^{129}I/^{127}I$ measurement techniques available, namely Radiochemical Neutron Activation Analysis, Accelerator Mass Spectrometry, direct g-X spectrometry with self-absorption correction and liquid scintillation was performed in this thesis. Associated radiochemical preparation steps were optimised for the two first techniques and adapted to the characteristics of the major environmental matrices.

In a first step, the radiochemical protocols were developed and validated for standard sources. In a second step, interlaboratory intercomparison tests, between RNAA, SMA and g-X spectrometry, were organized on various biological matrices, marine seaweeds as well as terrestrial plants, presenting different ^{129}I activity levels. Results given by the three techniques on different environmental matrices for activities varying from 0.2 to 200 $Bq.kg^{-1}$ dry weight showed no statistical differences. As a conclusion, a methodology for the measurement of ^{129}I and $^{129}I/^{127}I$ ratio in environmental samples is proposed. It includes a decisional diagram taking into account the characteristics of the matrices, the detection limits requested and the measuring time to obtain the result.
A complementary study on the losses of ^{129}I during the calcinations of a marine algae (*Fucus serratus*), from 80°C to 1000°C, was lead by direct g-X spectrometry. Applied studies were performed to measure ^{129}I levels in different biological compartments issued from various locations: ^{129}I activity interspecific variation in different species of seaweeds from the French channel coast under the influence of La Hague, ^{129}I levels in bovine thyroids from the Cotentin area and ^{129}I in vegetal samples collected around the nuclear fuel reprocessing plant of Marcoule.

Short comment : The lack of international certified reference sample for ^{129}I in biological matrices compelled us to constitute a reference sample and to qualify its homogeneity to allow its use in type B intercomparison tests. A sample of 100 kg fresh weight of the brown algae *Fucus serratus* was collected in October 1998 at a station under the direct influence of La Hague discharges of low-level radioactive liquid effluents. The seaweeds were rinsed with seawater on site and drained. At the laboratory the samples were dried in an oven at 80°C till getting a constant weight. Then, it was first roughly blended in 1 l Waring blender and secondly ground in an ultracentrifuge blender from Retsch with a 250mm sieve. Thus, 20 kg dry weight of the reference material were thoroughly mixed. It was aliquoted with a rotating sample divider PT 1000 from Retsch and vacuum packed in sampling bags by fraction of approximately 200 g dry weight. Once its homogeneity qualified by two different measurement techniques, this material was used for an interlaboratory intercomparison test between the three techniques. The recommended reference mean value for ^{129}I activity is 68.7 ± 10.2 $Bq.kg^{-1}$ dry weight.

Amount of this reference material is available. Some aliquots were distributed to European measurement laboratories that were interested in. Request for sample of this reference material must be addressed to:

IPSN/DPRE/SERNAT
CEN Saclay
Bât 130
F-91191 Gif sur Yvette Cedex
FRANCE
Fax : 33 (0)1.69.08.40.87

Evaluating Radiation Doses to Ecological Receptors - A SETAC 2000 Session

by: Daniel S. Jones
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The following is a summary of a session held at the 21st annual meeting of the Society of Environmental Toxicology and Chemistry (SETAC) on November 15, 2000 in Nashville, Tennessee, USA. The session was chaired by IUR members Daniel Jones (Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA) and Stephen Domotor (US Department of Energy, Washington, D.C., USA).

This technical session focused on recent advances and the breadth of issues inherent in the assessment of radiological risks to non-human biota. Specifically addressed were methods for estimating doses to biota (including allometric scaling techniques), transfer factors used to estimate internal (i.e., biological uptake factors) and external (i.e., sediment and soil K_ds) exposures, the relative biological effectiveness of radiation types in non-human receptors, screening tools for rapidly evaluating environmental data, spatial-temporal considerations in delineating an assessment area, ecological risk-based approaches for addressing the issues of radiological exposure and effects, and related on-going research.

The impetus for this session was the work of the U.S. Department of Energy (DOE) Biota Dose Assessment Committee (BDAC). The BDAC is a technical standard committee comprised of academia, national laboratory, private sector, and government representatives, several of whom gave presentations in this session. The DOE, through its BDAC, has developed a graded approach for evaluating radiation doses to aquatic and terrestrial biota. Other US and international agencies are beginning to address radiation dose limits for non-human biota in earnest. This session was intended to highlight the aforementioned issues for a broad-cross section of the environmental science community. The target audience was scientists, managers, and stakeholders dealing with contaminated waste streams requiring an evaluation of radiation as a potential ecological stressor.

The session was comprised of ten presentations. The title, presenting author, and brief summary of each talk is presented below.

Principles and Issues in Radiological Ecological Risk Assessment. *Daniel Jones, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA.* Ecological risk assessment (ERA) principles can be used to demonstrate protection of the environment from anthropogenic sources of radiation. This presentation bridged the gap between radiological ERA and chemical ERA and provided a technical frame-of-reference for the more detailed discussions that followed. Issues unique to radiological ERA were introduced and comparisons were drawn to ERA for chemicals wherever possible.

DOE=s Graded Approach for Evaluating Radiation as a stressor to Aquatic and Terrestrial Receptors. *Stephen Domotor, US Department of Energy, Washington, D.C, USA.* In the US and internationally, no standardized methods have been adopted for evaluating doses to ecological receptors. In this regard, the DOE has developed a graded approach for evaluating radiation doses to aquatic and terrestrial biota. This paper introduced the three-phased process and discussed the science, policy, and partnerships used to develop the graded approach.

Derivation of Lumped Parameters for Biota Dose Assessment Using Probabilistic Methods on an Allometric Model. *Kathryn Highley, Oregon State University, Corvallis, Oregon, USA.* The derivation of a series of "lumped parameters" which related maximal predicted nuclide concentrations in biota to concentrations in environmental media was described. These lumped parameters were derived by applying probabilistic methods (uncertainty and sensitivity analysis) to allometric equations used to describe the relationship between organism size and potential radionuclide concentration in tissues.

Considerations of a Radiation Weighting Factors for Alpha Particles in Protection of Non-Human Biota. *David Kocher, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA.* A radiation weighting factor of 20 is sometimes used to account for the greater biological effectiveness of alpha particles, compared with photons and electrons. However, this weighting factor is intended to apply to stochastic health effects, whereas deterministic effects are of primary concern in protection of biota. This paper described an analysis of the deterministic radiation weighting factor for alpha particles.

Defining the Spatial Area for Application of a Biota Dose Assessment Methodology. *Randall* Morris, Environmental Science & Research Foundation, Inc., Idaho Falls, Idaho, USA. *In order* to apply any biota dose assessment methodology, assessors need a way to decide the spatial scale over which it should be applied. An approach was described which satisfies all the requirements for a useful scaling procedure by using site knowledge of, and professional judgement about, environmental contamination and ecological habitats to develop maps of the largest patch sizes over which biota dose assessment parameters can be averaged.
Case study Using the Biota Dose Assessment Committee=s Screening Methodology. *Ernest An-*

tonio, Pacific Northwest National Laboratory, Richland, Washington, USA. Radionuclide data collected at the Hanford Nuclear Reservation were used to test the utility of the U.S. Department of Energy's Biota Dose Assessment Screening Methodology for protection of plants and animals from ionizing radiation. This presentation used these data to demonstrate the steps in the methodology.

FASSET: An International Project to Develop a Framework for Radiation Protection of the Environment. *Dennis Woodhead; Centre for Environment, Fisheries, and Aquaculture Science in the UK; Lowestoft, Suffolk, United Kingdom.* This presentation described an international (Sweden, Germany, Spain, Finland, Norway, and the UK) project to produce a decision-making framework for the assessment of effects of increased exposure to ionizing radiation on native flora and fauna. The final framework is intended to be understandable by both the regulators and the general public.

An Assessment of Radiological Impacts of Uranium Mill Tailings on Aquatic Biota. *Gerry Eddlemen, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA.* This case study described the assessment of aquatic impacts of a large uranium mill tailings pile adjacent to the Colorado River in Moab Utah (USA). Potential radiological and chemical effects were assessed and contrasted in this presentation.

An Allometrc Approach to Biota Dose Assessment. *Kathryn Highley.* This paper describes how allometric equations were combined with kinetic models to develop site-specific limiting radionuclide concentrations for water, sediment and soils that can be used as part of DOE's Graded Approach to assess compliance with proposed biota dose limits.

Radiocesium in Two Species of Frogs (*Rana esculenta* and *R. terrestris*) Collected Near Chornobyl, Ukraine. *Travis Glenn, University of Georgia, Savannah River Ecology Laboratory, Aiken, South Carolina, USA.* Two sympatric frog species were sampled from highly contaminated areas within the Chornobyl exclusion zone and from relatively clean areas to the south of the power plant in September 1999. The data indicated that whole body radiocesium concentrations were higher in R. terrestris than in R. esculenta, probably due to dietary differences between these species.

For more details on the SETAC session or on any of the papers highlighted above, please contact:

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Workshop on Phytomanagement of Contaminated Environments

15-16 May, 2000, Mol Belgium

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The Belgian Nuclear Research Centre (SCK•CEN) organised at its premisses in Mol, Belgium (15-16 May 2000), *Topical Days* on *Phytomanagement of Contaminated Environments.* These two days were dedicated to explore and discuss the role of phytomanagement techniques in environmental remediation and the state-of-the-art of the technology and to identify research needs.

Topics covered general aspects of phytomanagement, plant, soil and rhizosphere-related factors and processes affecting bioavailability, the cycling of contaminants in a soil-perennial vegetation system and examples of practical experience.

At the workshop most attention was dedicated to phytoextraction and phytostabilisation as phytomanagement techniques for environments contaminated with radionuclides and heavy metals. The major conclusions were the following.

Although the phytoextraction potential is generally too low to be effective (annually less than 1 % of the soil activity is extracted), there are some cases where extraction percentages of up to 10 % were obtained. Since this green clean-up technology may be cheap compared to other remediation options, there is continued interest in this technology. In this context, the need was acknowledged to continue our search for hyperaccumulator plants (or methods to increase uptake by genetic modification or other means) with a high biomass production potential and to increase contaminant availability. At both levels the influence of microorganisms (bacteria, fungi, mycorrhiza) and rhizosphere processes should not be overlooked. A better knowledge of these process will indicate the routes on which to concentrate for further in depth research.

The establishment of a vegetation cover for the stabilisation of a contaminated site (phytostabilisation) may be a very low-cost remediation option for (relatively) extended contaminated areas. Though phytostabilisation of some contaminated sites was successfully applied, there were some important needs indicated. Knowledge on transfer processes but also the necessary databases are lacking to reliably describe the functioning of elements cycling in this perennial vegetation system and to develop

modelling tools which can predict the effect of a perennial vegetation cover on the dispersion of the contaminants and hence on its effect on public exposure. Little is known about the long-term stability of the vegetation cover and on ways to compare the phytostabilisation option with other remediation options.

It was acknowledged that the number of economic and social (public acceptance) evaluations of the phytomanagement options, is scant, although these are important criteria for the feasibility of the proposed remediation options.

Though many areas were indicated where further research and development is needed, the general appreciation of these technologies is positive for these green technologies are generally cheap and at least effective in reducing exposure.
The workshop proceedings can be obtained at the above address. "Topical Days on Phytomanagement of Contaminated Environments", 15-16 May, 2000, Mol Belgium, SCK•CEN BLG-844.

Proceeding contents

General aspects

Major sources of radioactive contamination, problems and possible remediation options and role of phytostabilisation. *H. Vandenhove, SCK•CEN, Belgium*

Phytoremediation : general principles and overview of methods *J. Vangronsveld, LUC, Belgium*

Fluxes of metals and radionuclides in soil-plant systems. *E. Smolders, K.U.Leuven, Belgium*

Selecting plants for phytoextraction of heavy metals and radionuclides. *A. Baker, University of Sheffield, UK*

Rhizosphere processes and micro-organisms affecting radionuclide and heavy metal uptake and availability

Root-induced rhizosphere processes affecting trace metal mobilisation, *Ph. Hinsinger, INRA, France*

Rhizosphere processes affecting radiocaesium mobilisation of radiocaesium in forest soils. *B. Delvaux, UCL (N. Kruyts – UCL, H. Bouchama – UCL, N. Lewyckyj – VITO), Belgium*

Potassium depletion in the rhizosphere of willows enhances radiocaesium mobilisation from the interlayer of phyllosilicates. *A. Gommers, SCK•CEN (Y. Thiry – SCK•CEN, B. Delvaux – UCL), Belgium*

Effect of micro-organisms on the radionuclide availability to plants. *M. Mergeay, SCK•CEN, Belgium*

Ectomycorrhizal fungi protect their host plants against heavy metal toxicity. *J. Colpaert, LUC (K.K. Van Tichelen – LUC, J. Vangronsveld – LUC), Belgium*

How do rhizosphere processes and bacteria affect heavy metal bioavailability? *N. van der Lelie, VITO (S. Taghavi – VITO, Ph. Corbisier – VITO, J. Vangronsveld – LUC), Belgium*

Cycling of radionuclides and heavy metals in perennial vegetation systems

Uptake and cycling of natural radionuclides in vegetation developed on uranium mining heaps and tailings. *G. Dudel, TU Dresden, Germany (C. Brackage, A. Dannecker, H. Dienemann, K. Heblack, L. Stolz, J. Rotsche – TU Dresden)*

Dynamics of radiocaesium cycling in contaminated forests. *F. Goor and Y. Thiry, SCK•CEN, Belgium*

Practical experience in phytomanagement of contaminated sites

Practical experience of phytomanagement for restoration of former industrial sites in Northern France. *D. Petit, INRA, ISA, Pôle de Competences Sites et Sols Pollués, France*

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INTERNATIONAL CONFERENCE ON RADIOACTIVITY IN THE ENVIRONMENT

2-5 September 2002

The International Conference Centre, Principality of Monaco

The Journal of Environmental Radioactivity (JER), in association with the International Union of Radioecology (IUR) and Elsevier Science Ltd, and in co-operation with the International Atomic Energy Agency, is pleased to announce a major international conference on Radioactivity in the Environment. The conference is expected to be the most significant of its kind ever held. It is being sponsored by the IUR and additional sponsorship currently under discussion will be acknowledged in subsequent announcements.

Like JER itself, the conference will celebrate the science of all aspects of the study of environmental radioactivity, from its use to trace and time natural processes to its radiological assessment and remediation. On the one hand, whole fields of science have depended, and indeed still depend, on the unique kinetics and sensitivity of detection of radioactive decay for understanding of the time-scales and mechanisms of processes. On the other, radioactive contamination from a range of man's activities has for a century occupied the attention of the scientific community, which has extensively studied its environmental pathways and health effects, without always communicating effectively with society. This conference, besides taking a broad scientific view of its field, will also feature focused special sessions on current and future "hot topics". The conference will mark 20 years of the Journal of Environmental Radioactivity and will be held in Monaco where it began. The scientific committee for the conference is the international Editorial Board of JER. The possible "hot topics" thus far identified for special emphasis include:

- Remediation & restoration of contaminated ecosystems.
- Health effects of environmental radioactivity for flora and fauna.
- Radionuclides as environmental tracers
- Environmental radioactivity and society
- Speciation of radionuclides.
- Radioactivity in extreme environments: subtropical and tropical environments, forest ecosystems, the Arctic, and S-E Asia.
- Microbiological cycling of radionuclides.
- Radioactive aerosols.
- Modelling environmental transport of radionuclides.
- Modelling and risk assessment.
- Technologically enhanced radioactivity from non-nuclear industries.
- Advanced analytical methods and their latest applications to the earth & environmental sciences.

However, the agenda will primarily be set by the conference participants and your interest and involvement are urgently requested. The conference Chair is Murdoch Baxter with Co-chairs Gabi Voigt, Tom Hinton, Yoichiro Ohmomo, Per Strand, Hugh Livingston & George Hunter.

For further details and to express your initial interest, please contact Gill Heaton, the Conference Secretary, at e-mail address jer@heaton-connexion.co.uk or phone +44 1865 373625, fax +44 1865 375855 or mail to: Environmental Radioactivity Conference Secretariat, Hillside Cottages, Wheatley Road, Islip, Oxford, OX5 2TF, UK.

Vacancy

at GSF-Institut fuer Strahlenschutz

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I look for a biologist with molecular genetic experience to establish a genetic molecular lab in my new section (radioecology) in the GSF institute of radiation protection. to identify div. ecotypes of Arabidopsis t. in respect to Cs-uptake cytogentic studies in plants under chronic low level exposures (Semipalatinsk) to develop FISH technologies for plants for biodosimetry purposes.

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The position is BAT IIa (which is around 4 200 DM net for a young (wo)man with one child), goes at present for 3 years but can be expended for further 2 years.

Person to contact:

Dr. Gabriele Voigt
GSF-Institut fuer Strahlenschutz
Ingolstaedter Landstr. 1
D-85764 Neuherberg
Tel +49 89 3187 4005
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E-mail: voigt@gsf.de

1st ANNOUNCEMENT

AND CALL FOR PAPERS

THE 5th INTERNATIONAL CONFERENCE ON ENVIRONMENTAL RADIOACTIVITY IN THE ARCTIC AND ANTARCTIC in ST. PETERSBURG, RUSSIA – JUNE 16 – 20, 2002

ORGANISATION:
The conference is organised by:
Norwegian Radiation Protection Authority (NRPA)
and
Russian Federal Service of Hydrometeorology and Environmental Monitoring (ROSHYDROMET)
in co-operation with
International Union of Radioecology (IUR)
Arctic Monitoring and Assessment Programme (AMAP)
and
International Atomic Energy Agency (IAEA)

TIME AND VENUE :
This Fifth International Conference on Environmental Radioactivity in the Arctic and Antarctic will take place in St. Petersburg, Russia – June 16-20, 2002.

Please look for more details in the Announcement enclosed with this Newsletter.

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