



Radiation Research Department annual report 2003

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Radiation Research Department Annual Report 2003

Edited by B. Majborn, A. Damkjær and S.P. Nielsen



**Radiation Research
Department
Annual Report 2003**

Edited by B. Majborn, A. Damkjær and S.P. Nielsen

Abstract This report presents a summary of the work of the Radiation Research Department in 2003. The main research areas were dosimetry, nuclear emergency preparedness, radioecology, and radioanalytical techniques. Lists of publications, committee memberships and staff members are included.

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1 Introduction

The research of the department is primarily based on competences in radiation physics, radiation chemistry, radioecology, and nuclear measurement techniques and methods. In 2003 the main research areas were dosimetry, nuclear emergency preparedness, radioecology, and radioanalytical techniques. It was decided to install a cyclotron and establish a new isotope laboratory which opens up for a new development of biomedical tracer techniques in co-operation with nuclear medicine departments at hospitals, university institutes and pharmaceutical companies. It is planned to install the cyclotron in the autumn of 2004 and operate the new laboratory from the beginning of 2005.

In 2003 the department was organised in two research programmes: "Radiation Physics" and "Radioecology and Tracer Studies", in addition to the task "Dosimetry", which includes personnel dosimetry and industrial dosimetry. In 2004 a new research programme "Biomedical tracers" has been initiated. This programme will make use of the planned cyclotron and associated new isotope laboratory.

2003 was the second year of the third performance management contract between Risø and the Ministry of Science, Technology and Innovation. Risø's main areas of research are (with the approximate share given in parenthesis): energy (50%), industrial technology (25%), bioproduction (15%), and radiation research (10%).

The research and development work of the department is carried out in close co-operation with Danish and foreign universities and research institutes and also with the Danish nuclear and radiation protection authorities. The department participates in national and international research programmes including the European Commission research programmes and the Nordic Nuclear Safety Research Programme. More recently, increasing emphasis has been put on medical applications of nuclear methods, particularly in dosimetry. This trend will be continued with the planned efforts in the new programme "Biomedical tracers".

This report presents a summary of the work of the department in 2003 with an emphasis on the results of the research and development activities. Lists of publications, committee memberships and staff members are included.

2 Radiation physics

The Radiation physics programme carries out research and development in the fields of radiation dosimetry and emergency management. The work is focused on luminescence methods for retrospective dosimetry and for dosimetry in medical radiation therapy and diagnostics. Also methods for high dose fundamental dosimetry are developed. In the field of emergency management databases and technologies aimed at decision support systems are developed.

2.1 Luminescence dosimetry

EU- FP5-LUMINATE

Mayank Jain, Kristina Thomsen, Lars Bøtter-Jensen

A new technique for retrospective luminescence dosimetry using Optically Stimulated Luminescence (OSL) was successfully developed. Single grains of quartz are extracted from unheated building materials such as mortar and concrete. Grains that were sufficiently bleached (zeroed) in the past are isolated and the accident dose subsequently determined. The three year project was finalised in October 2003.

Ultra fast OSL decay component for age determination

Mayank Jain, Kristina Thomsen, Phil Denby, Henrik Christiansen, Lars Bøtter-Jensen

In the further development of OSL for dating it is important to isolate the ultra fast component of the OSL signal as this represents the part of the OSL signal that was most efficiently zeroed by sunlight in the past. The isolation of different decay components of the quartz OSL curve was achieved using various stimulation light sources with different emission wavelengths.

Isothermal TL and IRSL

Mayank Jain, Kristina Thomsen, Jørgen Jakobsen, Henrik Christiansen, Finn Willumsen, Lars Bøtter-Jensen

In an attempt to control the anomalous fading of luminescence signals in feldspars both isothermal TL on multiple grain samples and IR stimulation of single grains were investigated. Particularly the single grain measurements using a focused IR laser showed that trapped electron populations could be isolated that did not show any significant fading. However more measurements are needed to fully document this feature.

Daresbury experiments

Mayank Jain, Claus E. Andersen, Lars Bøtter-Jensen

The low-energy photon beams at the Daresbury Cyclotron Facilities were used to investigate the recombination characteristics and the dose response for quartz, feldspar and carbon doped aluminium-oxide samples at low photon energies. The EU supported experiments produced a large number of data, which are being analysed.

2.2 OSL instrument development

Red emission detection system

Phil Denby, Kristina Thomsen, Henrik Christiansen, Finn Willumsen, Finn Jørgensen, Lars Bøtter-Jensen

A new system was developed for the detection of red emission TL and OSL signals. The design consists of a cooled PM tube with extended red sensitive cathode and optimised filter combinations, which allow both isothermal TL and infrared (IR) and blue OSL measurements. The new system, which is a task within the Nordic Centre of Excellence (NCoE), aims at investigations of fading phenomena of the luminescence from feldspar. (NCoE is a centre consisting of The Nordic Luminescence Laboratory and the OSL group. The centre is financed under the Pilot Programme 2002-2007 of the Nordic Science Research Councils).

X-rays and new powerful LEDs in OSL dosimetry

Phil Denby, Kristina Thomsen, Claus E. Andersen, Jørgen Jakobsen, Finn Willumsen, Finn Jørgesen, Lars Bøtter-Jensen

The replacement of ^{90}Sr / ^{90}Y radionuclide sources in TL/OSL instrumentation with X-ray generators will make it possible to operate a software controlled dose rate over approximately three decades. In addition such a system has advantages in relation to radiation protection. Two mini X-ray generators were developed and tested for that purpose. Also new powerful blue, green and IR light emitting diodes (LEDs) with significantly enhanced stimulation efficiency have been tested with very promising results. Both the X-ray generators and the new LEDs are foreseen to improve the new generation automatic Risø TL/OSL readers and to facilitate the development of portable OSL instrumentation. The latter is a task within the NCoE.

Luminescence dosimetry in medical radiation therapy and diagnostics using optical fibre cables and $\text{Al}_2\text{O}_3:\text{C}$ crystals

Marianne Aznar, Jens Morgenthaler Edmund, Carl Johan Marckmann, Claus E. Andersen, Finn Willumsen, Lars Bøtter-Jensen

A new optical-fibre dosimeter system has been developed for medical applications such as in vivo radiation dose verification in cancer radiation therapy. The system is based on measuring the radioluminescence and optically stimulated luminescence from small (e.g. 2 mg) solid-state dosimeters of carbon-doped aluminum oxide ($\text{Al}_2\text{O}_3:\text{C}$).

The first patient measurements were carried out in 2003 at Copenhagen University Hospital (radiation treatment of head-and-neck tumours) and at Malmö University Hospital (mammography). A new algorithm that corrects for RL-sensitivity changes was developed, and also techniques for producing thin dosimeter probes were initiated (see figure below).

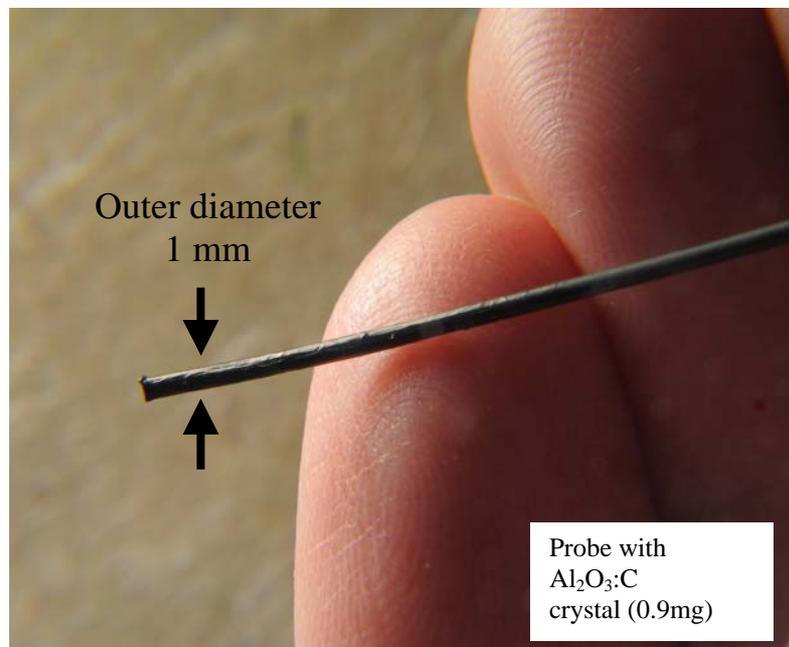


Figure 2.1. Luminescence dosimeter probe for in vivo measurements.

2.3 Emergency preparedness

RESUME 2002 exercise data comparisons

Bent Lauritzen

Within the EU ECCOMAGS project (European Calibration and Coordination of Mobile and Airborne Gamma Spectrometry) the RESUME 2002 exercise for airborne and ground based gamma spectrometry was conducted. An important aim of the exercise was to evaluate the possibility from airborne measurements to produce consistent dose rate and radionuclide deposition mapping following radioactive fallout.

Risø has participated in the statistical analysis of the exercise with the objective of validating European measurement protocols for the use of airborne gamma spectrometry following a nuclear emergency. In 2003 the final report on the exercises results was published in "An International Comparison of Airborne and Ground Based Gamma Ray Spectrometry", SUERC (Eds. D.C.W. Sanderson, A.J. Cresswell and J.J. Lang).

Data assimilation of off-site gamma radiation data

Bent Lauritzen, Martin Drews

A Kalman filter method using off-site radiation monitoring data is proposed as a tool for on-line estimation of the source term for short-range atmospheric dispersion of radioactive materials. The method is based on the Gaussian plume model, in which the plume parameters including the source term exhibit a "random walk" process. The embedded parameters of the Kalman filter are determined through maximum likelihood estimation making the filter essentially free of external parameters.

In 2003 the method has been analysed using simulated data and tested against preliminary data from an argon-41 atmospheric dispersion experiment. The method has been shown to be numerically stable and accurately to reproduce the known radionuclide source term and main dispersion parameters.

The Danish early warning stations

Flemming Nielsen, Jørgen Jakobsen

Risø maintains the measuring equipment of the Danish early warning system according to an agreement with the Danish Emergency Management Agency. The data are exchanged in the EU Radioactivity Data Exchange Platform hosted by ISPRA in Italy. In 2003 Greece stopped and Estonia, Bulgaria and Belgium joined the data exchange system increasing the number of countries to 25.

2.4 Contamination Physics

EU- FP5-INDOOR DOSE

Jørn Roed, Kasper Andersson, Henrik Prip, Xiaolin Hou, Svend Olsen

The overall objective of the project is to examine the processes of airborne contamination in the indoor environment and their implications for radiation dose. Both aerosol and gaseous contaminants are investigated experimentally, and a model has been developed for calculation of doses originating from contaminant deposition on human skin, hair and clothing, as well as from deposition on different surfaces and inhalation in the indoor environment.

In 2003, the effort was particularly targeted on investigations of deposition of elemental iodine gas. A series of experiments with live hairless rats were carried out at Rigshospitalet in Copenhagen. The experiments, which are believed to be the first ever investigations of the mechanisms of elemental iodine deposition to skin, showed high deposition velocities, thus stressing the importance of con-

sidering elemental iodine gas in connection with releases following a nuclear reactor accident.



Figure 2.2. Set-up for iodine deposition experiment in an exposure chamber.



Figure 2.3. Sampling of rat skin, marked with an aluminium template.

EU-FP5-STRATEGY

Kasper Andersson, Jørn Roed

The overall objective of the STRATEGY project was to establish a framework for selection of strategies for the management of radioactively contaminated areas. The management should include sustainable remediation technologies. The main requirement of this framework was the development of databases containing state-of-the-art information on individual countermeasures. These featured, e.g., technical, social, environmental, ethical and economical aspects.

In 2003, the project was finalised and the results were published. Catalogues of urban countermeasure descriptions including benefits and cost were supplemented with calculations of averted dose in different types of inhabited areas and descriptions of options for management of the waste that would be generated by some of the countermeasures.

NKS Urban conference

Jørn Roed, Kasper Andersson, Henrik Prip, Svend Olsen, Merete Larsen, Lis Rasmussen

With the support of NKS (Nordic Nuclear Safety Research) an international conference on radioactive contamination in urban areas was held at Risø on 7-9 May 2003. The aim was to create a forum for presentation of new knowledge. This provided a basis for a much-needed improvement of preparedness strategies for inhabited areas in Europe, and at the same time helped to pinpoint areas where further investigations are needed.

A total of 53 papers were presented at the conference, including 5 invited presentations. The conference reflected the great complexity of urban contamination problems. The presentations revealed a serious lack of data, and that current preparedness models for the urban environment are generally inadequate. The presentations and extended abstracts were placed on an open Internet site, and a peer-reviewed proceedings issue of J. Environmental Radioactivity is under preparation.

Aerosol characterisations

Kasper Andersson, Henrik Prip

With the financial support of ELSAM, a series of measurements were made to characterise the flue gas in a coal fired and a coal/straw co-fired boiler at Stud-

strup power plant in Jutland. The ultimate objective was to identify the causes of some problems that have been observed in boilers co-fired with straw.

Size-resolved samples were taken using a Berner low-pressure impactor. A specially constructed ejector-probe was applied to dilute the highly concentrated flue gas, in order to avoid overloading the impactor. The exposed impactor foils were subsequently subjected to EDX (energy dispersive x-ray analysis) at DTU. Also samples for scanning electron microscopy analysis were taken, and a scanning mobility particle sizer was used to assess the size distribution of the particles.

2.5 Reactor Safety

Calculation of the γ -radiation energy deposition in the moderator tank of Forsmark 3 boiling water reactor

Erik Nonbøl

Forsmark Kraft is planning a 25% increase of the maximum allowed power of its nuclear reactors. The increased power will also increase the heating of the moderator tank due to absorption of γ -radiation. The maximum operation temperature of the moderator tank is limited to 300 °C due to stress conditions in the walls.

Monte Carlo calculations with the MCNP-code have shown, that the planned power increase will lead to a steady state temperature of the moderator walls which is well below the allowed maximum of 300 °C. It was also found that the allowed maximum of 300 °C will be reached with a 50% power increase.

Determination of Source Terms for Accidents with Russian Marine Reactors

Povl L. Ølgaard

The project aims at determining the amount of radionuclides released during various types of nuclear accidents involving marine reactors and their fuel. The accidents include criticality accidents, loss-of-cooling accidents, sinking of nuclear vessels, loss-of-shielding accidents and radionuclide leakage from nuclear facilities. The project is carried out under the Nordic Nuclear Safety Research Programme.

The following topics were covered: Development of the Russian marine propulsion, the Russian marine systems, Russian nuclear submarine decommissioning, and accidents with Russian nuclear vessels.

Nuclear Knowledge Preparedness

Anders Damkjær, Bent Lauritzen, Benny Majborn, Erik Nonbøl, Povl L. Ølgaard

The project aims at maintaining a sufficient level of knowledge of the global development of nuclear power and nuclear safety. This is done through the publication of an annual report in co-operation with the Danish Emergency Management Agency and through the arrangement of two seminars per year where topics of current interest are covered.

The report "The International Status of Nuclear Power 2002" (in Danish) was published. Two seminars were held, covering point models for the modeling of nuclear releases, the nuclear activities in North Korea, the new isotope laboratory at Risø, the use of the ARGOS program for non-nuclear applications, the problems at Barsebäck-2 and Oskarshamn-3 and the nuclear development in Iran.

3 Radioecology and tracer studies

The research programme on radioecology and tracer studies focuses on the occurrence and transport of anthropogenic and naturally occurring radionuclides in the environment and the radiological impact on man. The basic competencies on chemical analytical techniques are applied in national and international projects concerning studies of stable and radioactive isotopes in terrestrial and marine environments and in waste materials. The main project activities are listed in the following.

Analysis of stable elements in graphite

Lars Frøsig Østergaard, Lis Vinther Kristensen

Information on stable elements in construction materials is essential for the decommissioning of Risø's nuclear facilities. The information is used to calculate neutron activation of the construction materials such as steels, graphite, concrete, aluminium and lead during the operation of the research reactors.

Analytical equipment that relies on inductively coupled plasmas (ICP) coupled to detectors based on optical emission spectrometry (OES) and mass spectrometry (MS) offers rapid multi-element analyses with parts per trillion (or lower) detection limits, good precision and a wide dynamic range.

The chemical inertness and high refractory character of graphite makes complete dissolution of graphite difficult without using concentrated perchloric acid or concentrated sulphuric acid at elevated temperatures. Acid leaching procedures using $\text{HNO}_3/\text{H}_2\text{O}_2/\text{HF}$ and HNO_3/HCl as well as direct sample input procedure (slurry sampling) were used in the analysis of different graphite reference materials as well as a graphite sample from the research reactor DR1. The development work was done for Danish Decommissioning.

Determination of ^{55}Fe and ^{63}Ni in nuclear waste and environmental samples

Xiaolin Hou

In the decommissioning of nuclear facilities, the radioactivity of various materials needs to be assessed. Gamma emitting radionuclides in nuclear waste are easily measured by gamma spectrometry, whereas beta and gamma emitters have to be separated from matrix and other radionuclides before counting. An analytical method for ^{63}Ni and ^{55}Fe in various waste and environmental samples was developed. The method for decomposing sample was first investigated using ashing, acid digestion and alkali fusion. Hydroxides precipitation was used to separate ^{55}Fe and ^{63}Ni from matrix elements; ion exchange was used to separate ^{55}Fe and ^{63}Ni from many interfering radionuclides and from each other. The separated ^{55}Fe and ^{63}Ni was further purified by extraction chromatography individually. The purified ^{63}Ni and ^{55}Fe was then measured by liquid scintillation counting. The solution used for dissolving Fe and Ni before LSC was investigated to obtain a high counting efficiency. The chemical yields of the chemical procedure for both of ^{55}Fe and ^{63}Ni are higher than 80%, the decontamination factors for all interfering radionuclides are higher than 10^5 . The detection limits for ^{55}Fe and ^{63}Ni are 0.035 and 0.015 Bq, respectively. The developed method has been successfully used for graphite, concrete and steel samples. The development work was done for Danish Decommissioning.

Investigation of adsorption of protein on the surface of different materials using radiolabelling techniques

Xiaolin Hou

Understanding the mechanisms of blood protein interactions with synthetic materials is essential for the development of materials used in implanted devices. In blood contacting devices, the adsorption of plasma proteins induces platelet adhesion and subsequent thrombosis. Several proteins, e.g. fibrinogen, fibronectin, vitronectin, are all known to be capable of mediating platelet adhesion and aggregation on biomaterial surfaces. Many techniques can be used to measure the protein concentration on the materials surface and among them, the radiolabelling method is most sensitive and quantitative. In this work, ^{125}I labeled fibrinogen was used to investigate the adsorption level of protein on the surface of different materials. The effect of contact time, protein concentration, and temperature on the protein adsorption was investigated.

Radioactivity in Danish drinking water

Per Roos, Annette Schou, Lis Vinther Kristensen, Sven P. Nielsen

An investigation of radioactivity in Danish drinking waters was called upon by the Danish Environmental Protection Agency due to the European Council Drinking Water Directive of 1998. Measurements of total alpha and total beta activity were performed in samples from about 300 water works and single wells, representing about 10% of all water works in Denmark. Screening levels of 0.1 Bq/L for total alpha and 1 Bq/L for total beta activity were used for the investigation. Further analyses of uranium isotopes and ^{226}Ra were performed for those water works where concentrations exceeded the screening levels. The concentrations of radioactivity in the drinking water at the water works studied were below the screening levels in general. In those cases where the concentrations were above the screening levels, the presence of elevated uranium concentrations (up to 0.2 Bq/L of ^{238}U) could explain the higher activity levels.

Thorium Cycling Project

Per Roos, Svend Olsen

Much of what is known about rates and fluxes of water and particles in the world oceans is derived from isotope data, especially radioisotope data. The relative oceanic abundances of these stable and radioactive isotopes have been used to study biological, geological, physical and chemical processes. This approach has probably been one of the most productive in furthering our understanding of what we normally call the 'crustal-ocean factory'. Since Th-isotopes have played a key role in both determining the particle scavenging rates *and* the sediment reworking and accumulation rates in the oceans it is of outermost importance that thorium closely mimics the particle/colloid behaviour, not only in the water column but also once deposited into the sediments. Any deviation from this has so far not been discovered in the open oceans. This project deals with studies of Th-isotopes in a Norwegian fjord (Framvaren) where Th behaves distinctly different from other marine environments. The aim with the project is to understand why and if similar behaviour could occur in the open ocean. The project is supported by the Danish Natural Science Research Council (SNF).

INDOFERN Project

Henning Dahlgaard, Elis Holm, Sven P. Nielsen

Bioindicators are used as monitors of environmental pollution. By definition there are two aspects 1) when real effects are seen on plants or animals or 2) when they show high transfer and concentration factors without any effect. The latter is at present levels the case for radioactive elements. Risø has participated

in the INDOFERN project investigating well-known bioindicators for radioactive elements and trying to identify new suitable ones. Common bioindicators are lichens and mosses in the terrestrial environment and mussels and algae in the marine environment. Several plants were tried and most promising are the less common used such as ferns (e.g. Bracken, *Pteridium aquilinum*) and the fresh water plant, Horse tail (*Equisetum fluviatile*). These show high uptake of radiocaesium but also accumulate plutonium and americium. Even if the uptake of transuranic elements is low, this behaviour is rather unique for plants. Future work will be directed to understand mechanisms and how they can be used for mapping deposited radioactivity in an emergency situation. The INDOFERN project was supported by the Nordic Nuclear Safety Research Programme (NKS).

EcoDoses Project

Sven P. Nielsen, Jytte Clausen

The aim of the EcoDoses project is to improve the radiological assessments of doses to man from terrestrial ecosystems. The work in 2003 has focussed on an extensive collation and review of both published and unpublished data from all the Nordic countries for the nuclear weapons fallout period and the post-Chernobyl period. This included data on radionuclides in air filters, precipitation, soil samples, milk and reindeer. Based on this, an improved model for estimating radioactive fallout based on precipitation data during the nuclear weapons fallout period has been developed. Effective ecological half-lives for ^{137}Cs and ^{90}Sr in milk were calculated for the nuclear weapons fallout period. For reindeer the ecological half-lives for ^{137}Cs were calculated for both the nuclear weapons fallout period and the post-Chernobyl period. The data were also used to compare modelling results with observed concentrations. This was done at a workshop where the radioecological food-and-dose module in the ARGOS decision support system was used to predict transfer of deposited radionuclides to foodstuffs and subsequent radiation doses to man. The project was supported by the Nordic Nuclear Safety Research Programme (NKS).

MYRRH Project

Per Roos, Lis Vinther Kristensen, Lars Frøsig Østergaard

Arbuscular mycorrhiza fungi form a symbiosis with more than 90% of all plant species. In the EU-funded 'MYRRH'-project the dependence of this symbiosis for the uptake of uranium by plants has been studied. Several experiments has been set up to determine the transfer of uranium from different types of soil as well as uranium mining rock debris and rock phosphate available to the *Medicago truncatula* plants used. Some plants were inoculated with *Glomus intraradices* mycorrhiza while the remaining were not. After some weeks the plants were harvested with plant parts and root parts separated and every visible sign of soil contamination removed from the samples. The samples were analysed for uranium (^{238}U) on the Risø HR-ICP-MS without any radiochemical treatment. The experiments have shown that the mycorrhiza does not only promote plant growth significantly but it also seems to help the plant discriminate against uptake of some substances, like uranium studied in this case. Similar, but not yet quantified, results were obtained for a range of heavy metals in the same study.

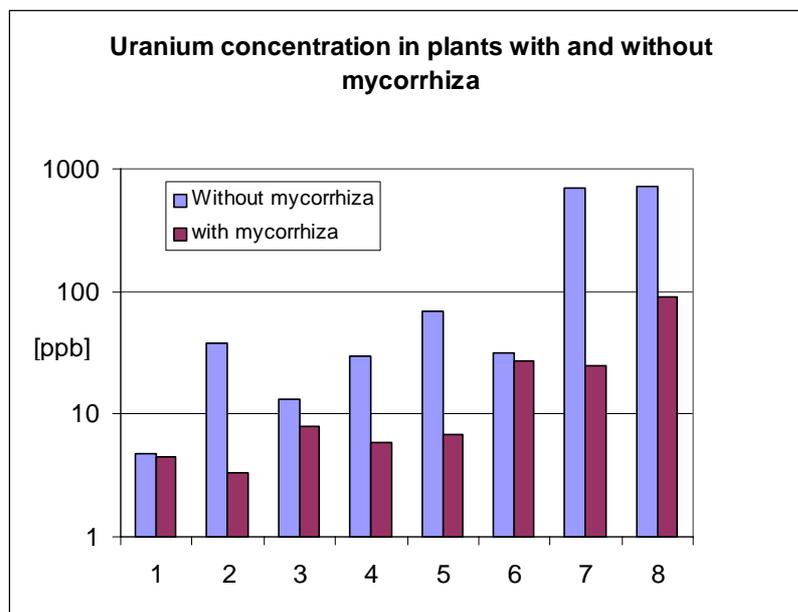


Figure 3.1. Uranium concentrations in plants grown with and without mycorrhiza.

REMOTRANS Project, Processes Regulating Remobilisation, Bioavailability and Translocation in Marine Sediments

Henning Dahlggaard, Per Roos, Elis Holm, Yu Yixuan

The overall aim of the project is to study transport and remobilisation of radiologically important radionuclides (^{137}Cs , Pu-isotopes, ^{99}Tc , ^{129}I and others) from sediments of different characteristics in different European marine environments. This included evaluation of the radiological consequences and transboundary exposure including uptake in biota and radioecological modelling. The results will provide more extensive knowledge of the long-term effects on the environment and man from past and present sources, and encourage a more informed debate on waste management of controlled releases of radioactivity in the marine environment. Important additional objectives were to enhance European competence in the field of environmental radioactivity, encourage the transfer of skills, provide training and increase mobility for younger scientists. The project was supported by the European Commission.

Radioactivity certificates for export of foodstuffs

Jytte Clausen, Annette Eva Jensen, Annette Schou, Sven P. Nielsen

Since 1968 when the Chernobyl accident occurred, Risø has offered analytical services to companies needing documentation that their products for export (food products and other) are not contaminated with radioactivity. Risø offers gamma spectrometric analyses for that purpose on a day-to-day basis. In 2003 more than 300 samples were processed and a corresponding number of certificates issued. The sample types tested have included mainly milk products, animal fodder, peas, sugar, cod, juice, and cereals. Other analytical services are offered for dating of sediments using a combination of ^{210}Pb analysis by gamma spectrometry and determination of ^{210}Po by chemical analysis and alpha spectrometry.

Thule 2003 Project

Henning Dahlggaard, Svend Olsen, Per Roos, Annette Schou, Yu Yixuan, Abdirahman M. Yusuf, Annette Eva Jensen, Jytte Clausen, Qingjiang Chen, Sven P. Nielsen

In 2003 the Danish Environmental Protection Agency sponsored a new investigation of the plutonium contamination at Thule in Greenland. In January 1968 a B52 aircraft carrying nuclear weapons crashed on the sea ice 14 km southwest of the American air base at Pituffik, Thule Air Base. The wreck and the remains of the nuclear weapons were collected after the accident and about 3 kg of plutonium removed from the sea ice. Following the clean-up operations and the subsequent melting of the sea ice during summer, a small amount of finely dispersed plutonium remained in the marine environment primarily in the marine sediment under the point of impact.

The plutonium contamination at Thule has caused public concern. The advisory group from the public Thule hearing, which was held October 1995 in Copenhagen, recommended that environmental monitoring of the plutonium contamination should be carried out for scientific reasons and in order to provide documentation of the contamination and development with time. Furthermore, the advisory group found that continued monitoring would be essential in order to provide information to the local population.

A successful sampling campaign was carried out August 2003 in the Thule area providing samples of seawater, sediments, biota and soil. Analyses of plutonium in the samples are in progress.



Figure 3.2. Sunset on 28 August 2003 at Mount Dundas, Thule, Greenland.

Joint Baltic-Danish Co-operation Project on Radiation Protection, 2001-2003

Jytte Clausen, Henning Dahlgaard, Elis Holm, Xiaolin Hou, Annette Eva Jensen, Susanne Kjørulff, Majbritt Nielsen, Susanne Thyssing Nielsen, Sven P. Nielsen, Svend Olsen, Per Roos, Annette Schou, Yu Yixuan, Abdirahman M. Yusuf, Lars Frøsig Østergaard

The Danish Emergency Management Agency and Risø National Laboratory have signed an agreement for 2001-2003 covering assistance to Poland, Estonia, Latvia and Lithuania in the field of radiation protection with emphasis on environmental monitoring and radioecological studies. Bilateral sub-agreements between the radiation protection institutes in the Baltic countries and Risø were drawn up outlining work plan and economy for the co-operation. Activities during 2003 have included an intercomparison exercise on laboratory analyses of radioactivity in environmental samples, a workshop on radioecological modelling, training visits for Baltic scientists at Risø and supplies of equipment and consumables to Baltic laboratories.

Monitoring of radioactive substances in the Baltic Sea

Henning Dahlgaard, Svend Olsen, Annette Schou, Yu Yixuan, Abdirahman M. Yusuf, Annette Eva Jensen, Jytte Clausen, Susanne Kjørulff, Majbritt Nielsen, Sven P. Nielsen

Denmark is a contracting party to the Helsinki Convention on protection of the marine environment of the Baltic Sea. In collaboration with the National Environmental Research Institute and the Admiral Danish Fleet, Risø National Laboratory is monitoring levels of radioactivity in Danish waters belonging to the Baltic Sea area. The work is carried out according to the HELCOM Recommendation 18/1 and results reported annually to the Helsinki Commission. Samples of seawater, sediments and biota are collected and analysed for content of man-made radionuclides.

Overall the levels of radioactivity in the Baltic Sea water, sediments and biota have shown declining trends since the Chernobyl accident in 1986, which caused significant fallout over the area. Radioactivity is slowly transported from the Baltic Sea to the North Sea via Kattegat. Minor amounts of radioactivity from Sellafield are transported in the opposite direction. Routine discharges of radioactivity from nuclear power plants in the Baltic Sea area are small and only detectable locally.

Monitoring of environmental radioactivity in Denmark, Euratom Treaty

Henning Dahlgaard, Svend Olsen, Annette Schou, Yu Yixuan, Abdirahman M. Yusuf, Annette Eva Jensen, Jytte Clausen, Susanne Kjørulff, Majbritt Nielsen, Sven P. Nielsen

As a member of the European Union, Denmark is obliged to monitor the levels of radioactivity in air, soil and water according to the Euratom Treaty and to report the findings to the European Commission. Risø National Laboratory carries out this work according to the Commission Recommendation 2000/473/Euratom and reports results to the Commission annually. The monitoring programme covers samples of air, precipitation, soil, grass, groundwater, lake and stream water, sea water, marine sediments, marine biota, cereals, vegetables and fruit, potatoes, imported foods, milk, meat, fish and human bone. The monitoring is primarily focused on the man-made radionuclides ^{137}Cs and ^{90}Sr .

Monitoring of environmental radioactivity at Risø

Svend Olsen, Annette Schou, Yu Yixuan, Abdirahman M. Yusuf, Annette Eva Jensen, Jytte Clausen, Susanne Kjærulff, Majbritt Nielsen, Sven P. Nielsen

A monitoring programme on environmental radioactivity at Risø National Laboratory has been carried out since the laboratory was established in the late 1950's. The objective of the programme, which covers the area within a 30-km radius from Risø, has been to demonstrate that the operation of the nuclear facilities do not give rise to unacceptable levels of radioactivity and radiation in the environment and to determine levels of radioactive contamination in the environment in case of an uncontrolled release of radioactive material. Even though the nuclear facilities have been shut down, the possibility of a release of radioactive material to the environment still exists particularly in connection with the decommissioning of the nuclear facilities. The monitoring is done for Danish Decommissioning.

Isotope and irradiation services

Jesper Jørgensen, Kirsten Madsen, Mads Wille, Majbritt Nielsen

The Isotope Laboratory continued operations in 2003 to supply radioactive material. Irradiation services at Swedish and Norwegian research reactors were used to provide radioisotopes to customers and to maintain a production of radiochemicals as ^{203}Hg , ^{75}Se , $^{110\text{m}}\text{Ag}$ and ^{35}S . Irradiations of ^{82}Br were supplied to Danish leak detection companies and for production of radiochemicals for use at Risø and commercially. Shipments of other radioactive products were sent to domestic and foreign institutes, industry and hospitals. For educational purposes sealed radioactive sources were supplied to the Nordic countries. The sources are classified and tested according to ISO 2919. Deliveries of specially prepared radioisotopes were made for research applications at Risø. Production was made of ^{64}Cu radiochemicals for the J.F. Kennedy institute based on irradiation of ^{64}Ni in the cyclotron at the University Hospital in Copenhagen.

4 Dosimetry

Risø High Dose Reference Laboratory (HDRL)

Arne Miller, Hanne Corfitzen, Nina Jensen

Risø HDRL is accredited by DANAK for calibration and absorbed dose measurements in the kGy dose range. It services the radiation processing industry nationally and internationally, and in particular that part of the industry that uses radiation for sterilization of medical devices.

In 2003 the laboratory issued 116 dosimeter certificates and 115 dose measurement reports, and arranged 3 courses on "Validation and Process Control of Electron Beam Sterilization".

Calibration for Irradiation with Low Energy Electrons

Jakob Helt-Hansen, Arne Miller

Irradiation by electrons in the energy range 50-200 keV are investigated for sterilization of product surfaces made from materials that are sensitive to radiation. Electrons in this energy range penetrate only a few microns into the material, and thus the negative effects of the radiation are minimized.

There is a need to verify the response of dosimeters used to measure the dose delivered by the low-energy radiation. We have developed a calorimeter that can serve as a reference for dose measurements in this energy range. The first

tests of dosimeters have shown that their response to 100 keV electron irradiation is comparable to that at 10 MeV.



Figure 4.1. Prototype calorimeter for dose measurement at 80-125 keV electron irradiation.

RisøScan

Jakob Helt-Hansen, Arne Miller

Thin film dosimeters are used for measurement of dose and dose distributions, in particular for irradiation at electron accelerators. The colour intensity of the dosimeter films can be recorded on an office scanner, and we have developed the “RisøScan” system for analysis of such images of irradiated dosimeter films. RisøScan is written in LabView®, and a validation package was developed. RisøScan is now marketed by GEX Corporation, our partner in USA.

Personnel dosimetry

Arne Miller, Hanne Corfitzen, Nina Jensen

Risø Personnel Dosimetry Laboratory measures dose for personnel at Risø whose work involves ionizing radiation and for the personnel at Danish Commissioning. In 2003 a total of 4400 dosimeters were issued and 400 dosimetry reports were written.

5 Education

The department is involved in educational activities at Risø, and staff from the department also contributes to education at the universities.

In 2003 one Ph.D. project was finalized in co-operation with the University of Copenhagen and the degree was awarded at the university. At the end of the year two Ph.D. students were carrying out projects in the department in co-operation with the University of Copenhagen and the Technical University of Denmark.

Staff from the department contributes to courses on isotope techniques at the Royal Veterinary and Agricultural University, the University of Copenhagen and the Technical University of Denmark, a course on nuclear instrumentation and health physics at the Technical University of Denmark, and a course on health physics at Risø conducted by the Applied Health Physics section of Risø Decommissioning.

In 2003 three international courses on “Validation and Process Control for Electron Beam Sterilization” were arranged in the department.

A staff member from the department has been external examiner in physics at the University of Copenhagen and at the Technical University of Denmark.

A number of internal seminars were arranged in 2003:

- PET – Positron emission tomography Mikael Jensen
- American Nuclear Society. Winter meeting Povel L. Ølgaard
2002
- Data evaluation of airborne gamma spectrometry (ECCOMAGS project) Bent Lauritzen
- Beta-decay for pedestrians Anders Damkjær
- Calorimeter for dosimeter calibration at 80-100 keV electrons Jakob Helt-Hansen
- Measurements of dose and dose distribution for radiation sterilization of medical devices Arne Miller
- Retrospective dosimetry: developing alternative methodologies for unheated materials Mayank Jain
- Clean-up and other countermeasures and the 6. Framework Programme Jørn Roed
- Kalman filtration of radiation monitoring data from atmospheric dispersion of radioactivity Martin Drews
- EU radioactivity data exchange platform (EURDEP) from 1995 to 2003 Flemming Nielsen
- OSL and Pb-210 dating of estuarine sediments Anni Madsen
- Doses to inhabitants of a dry-contaminated village in the Bryansk Region (Russia) since the Chernobyl accident Kasper Andersson
- Prediction of radon concentrations in 23,000 houses for a Danish childhood cancer study Claus Andersen
- Cerenkov radiation in fibers? Carl Johan Marckmann
- New developments in RL/OSL medical dosimetry Marianne Aznar
- Development of a portable OSL field Instrument Phil Denby
- Energy deposition in the moderator tank of the Forsmark 1 BWR Erik Nonbøl
- Deconvolving OSL single grain dose Distributions Kristina Thomsen
- Trends in luminescence dating Andrew Murray
- OSL projects at STR Lars Bøtter-Jensen
- Akkreditering, hvad er det og hvorfor skal vi? Mats Eriksson
- ICP Analyser af sporelementer i bygningsmaterialer Lars Frøsig Østergaard
- ^{210}Pb , ^{210}Po & ^7Be in oceanic air from the North Pole to the Antarctic Elis Holm
- Determination of ^{14}C and ^3H in Graphite and Concrete from a Research Reactor Xiaolin Hou
- Radioactive contaminants in the Greenland Environment Henning Dahlgard

6 Committee memberships

6.1 National

The advisory committee on protection measures in the case of accidents in nuclear facilities (§ 9 stk 2)

B. Majborn and E. Nonbøl

The coordination committee of the Emergency Management Agency and Risø National Laboratory

B. Majborn and A. Damkjær

The coordination committee for nuclear safety in Central and Eastern Europe (Ministry of Foreign Affairs)

B. Majborn

The advisory coordination committee for research in environmental medicine (Ministry of Health)

B. Majborn

The Board of the Danish Nuclear Society

B. Majborn (chairman)

Danish National Council for Oceanology

H. Dahlgaard

Danish Medical Device Industry sterilization committee

A. Miller

Danish Standard, Sterilization committee

A. Miller (chairman)

6.2 International

European Union

Consultative Committee Euratom - Fission

B. Majborn

Articles 35 and 36 of the European Treaty (Environmental Monitoring)

S.P. Nielsen

Article 37 Group of Experts

S.P. Nielsen

National Correspondents on Assistance and Emergency Planning in the Event of a Nuclear Accident or Radiological Emergency

F. Nielsen

Group for Nuclear Safety Research Index, NSRI

E. Nonbøl

OECD/NEA

Nuclear Science Committee
Erik Nonbøl

NEA Data Bank Executive Group
Erik Nonbøl

Editorial Advisory Boards

Radiation Measurements
L. Bøtter-Jensen

Radiation Physics and Chemistry
A. Miller (Editor-in-Chief)

Radiation Protection Dosimetry
L. Bøtter-Jensen

Other Committees

The Board of the Nordic Nuclear Safety Research Programme, NKS
B. Majborn

Baltic Marine Environment Protection Commission Helsinki Commission
(HELCOM), Group of Experts on Monitoring of Radioactive Substances in the
Baltic Sea (MORS)
S. P. Nielsen

International Solid State Dosimetry Organization
L. Bøtter-Jensen

Standing Committee for the International Solid State Dosimetry Conferences
L. Bøtter-Jensen

ISO TC198/WG2, Radiation sterilization working group
A. Miller

CEN TC204/WG2, Radiation sterilization working group
A. Miller (convener)

ICRU report committee, Dosimetry for Radiation Processing
A. Miller

7 Publications

7.1 Publications in international journals, books and reports

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Majborn, B.; Damkjær, A.; Nielsen, S.P. (eds.), Radiation Research Department annual report 2002. Risø-R-1417(EN) (2003) 38 p.

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7.3 Publications in proceedings

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This report presents a summary of the work of the Radiation Research Department in 2003. The main research areas were dosimetry, nuclear emergency preparedness, radioecology, and radioanalytical techniques. Lists of publications, committee memberships and staff members are included.

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PROGRESS REPORT; RADIATION PROTECTION; RADIOECOLOGY;
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