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RESEARCH PROJECTS OF STUK 2003 - 2005

Sisko Salomaa (Ed.)

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Foreword

The primary goal of STUK, Finnish Radiation and Nuclear Safety Authority, is to protect man, society, environment and future generations from the harmful effects of radiation. The research conducted by STUK yields new information related to the use, occurrence and effects of radiation. STUK research projects 2003 - 2005 summarizes STUK's own research activities on radiation protection. In addition to these, STUK also supervises and funds research projects related to safety of nuclear energy, and nuclear waste and materials that are carried out in other research institutes. Information on the research projects and related publications is also available on STUK's WWW pages at www.stuk.fi.

STUK's research focuses on radiation protection and health effects of radiation. During 2003 - 2005 the main emphasis will be on projects supporting the Finnish national environmental health action plan, the health risks of radiation, nuclear emergency preparedness and protection of biota. EU directives on radiation protection and medical radiation exposure also influence the course taken by the research carried out at STUK. New research priorities also include studies on non-ionising radiation, especially the effects of mobile phone frequency radiation. STUK's research networks involve well over 100 national and international partners. During 2003 - 2005 STUK is actively participating in the 6th framework research programmes of EC.

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Avainsanat säteilysuojelu, ionisoiva säteily, ionisoimaton säteily, terveyshaitat, radioekologia, onnettomuusvalmius

Alkusanat

Säteilyturvakeskuksen (STUK) tehtävänä on ihmisten, yhteiskunnan, ympäristön ja tulevien sukupolvien suojeleminen säteilyn haitallisilta vaikutuksilta. Tutkimus tuottaa säteilyn käyttöön, esiintymiseen ja vaikutukseen liittyvää uutta tietoa ja tukee viranomaisvalvontaa. Tutkimushankkeet 2003 - 2005 on yhteenveto Säteilyturvakeskuksen omasta säteilysuojeluun liittyvästä tutkimustoiminnasta. Näiden lisäksi Säteilyturvakeskus ohjaa ja rahoittaa ydinenergian käytön ja ydinjätehuollon turvallisuutta koskevia, viranomaistarpeista lähteviä tilaustutkimuksia, joita tehdään muissa tutkimuslaitoksissa. Tutkimushankkeet ja niistä kertyvät julkaisut ovat nähtävissä myös Säteilyturvakeskuksen www-sivuilla (www.stuk.fi).

Säteilyturvakeskuksen oma tutkimustoiminta keskittyy säteilysuojeluun ja säteilyn terveyshaittoihin. Vuosina 2003 - 2005 tutkimuksen painopisteinä ovat Suomen kansallista ympäristöterveysohjelmaa tukevat hankkeet, säteilyn terveysriskit, säteily- ja ydinonnettomuusvalmius ja eliökunnan säteilysuojelu. EU:n säteilysuojelua ja lääketieteellistä säteilyaltistusta koskevat direktiivit suuntaavat osaltaan Säteilyturvakeskuksessa tehtävää tutkimusta. Myös ionisoimattomaan säteilyyn, erityisesti matkapuhelintaajuuksiin liittyvä tutkimus on vahvana painopistealueena. Säteilyturvakeskuksen tutkimustoiminta on vahvasti verkottunut niin kotimaassa kuin kansainvälisestikin. Vuosina 2003-2005 STUK osallistuu aktiivisesti EU:n tutkimuksen 6. puiteohjelmaan.

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1 Medical use of radiation

1.1 Diagnostic use of radiation

DIMOND 3 – Measures for optimising radiological information and dose in digital imaging and interventional radiology

Objectives:

The MED directive (97/43/EURATOM) identifies interventional radiology and mammography as areas that require particular attention. The EU-funded project DIMOND III (FIGM-CT2000-00061) contributes to the radiation protection in these procedures and digital radiology in general by investigating approaches to assess radiation doses and the risk to patients with a view to optimise the image quality and patient dose. Technical and clinical approaches are being developed.

Studies on the optimisation of x-ray equipment and procedures are especially important in digital x-ray imaging and interventional radiology because they do not have a similar instant feedback on high patient doses as film-based radiology. High doses or dose rates are sometimes needed to reach sufficient image quality, and the duration of all procedures cannot always be foreseen. This can sometimes cause high patient doses or even acute radiation injuries in interventional radiology. Carefully optimised technical and clinical protocols are therefore important.

Description of the work:

The project contains six work packages, each comprised of a series of sub-projects. The three first packages are for basic underlying scientific and clinical research: Clinical quality criteria and technical parameters (WP1), Physical aspects of image quality (WP2) and Reference values and justification (WP3). The other three work packages are aimed to bring the basic research into clinical practice: Clinical evaluation projects of the special radiology procedures of interventional radiology (WP4), cardiology (WP5) and digital mammography (WP6). STUK participates mainly in the work of WP2–WP5.

The project investigates and develops

- (1) methods of improving image quality without increasing doses,
- (2) optimisation of the image quality/dose relationship,
- (3) radiological image content and quality criteria,

- (4) equipment requirements and specifications,
- (5) dosimetric approaches,
- (6) methods of presenting the interventionalist with understandable dosimetric information.

Exploitation of results:

WP2 will study the relationship between the physically measured image quality and the clinical image quality. Work packages 4 to 6 cover the application of quality assurance and the use of reference values in the three above-mentioned specific clinical areas and the implementation of the methodologies developed in work packages 1 to 3. The three clinical evaluation projects ensure that the results of scientific and clinical research will be implemented in radiology departments. They will also enable the industry to improve its medical equipment to meet the demands of clinical protocols and facilitate the widespread introduction of the digital imaging techniques in European radiology.

Collaborators:

Quality Assurance Reference Centre, Newcastle (UK, coordinator), Azienda Ospedaliera Santa Maria Della Misericordia, Udine (Italy), Delft University of Technology, Delft (Netherlands), Diakonissen Krankenhaus, Karlsruhe (Germany), General Hospital Evagelismos, Athens (Greece), Haughton Institute, Dublin (Ireland), Katholieke Universiteit Leuven (Belgium), Krankenhaus des Barmherzigen Brüder Trier (Germany), Radiation Protection Department, Ministry of Health (Luxembourg), Regional Medical Physics Department, Newcastle (UK), San Carlos University Hospital and Complutense University, Madrid (Spain), and University of Innsbruck (Austria).

Publication plan:

The results will be published in progress reports, scientific meetings and scientific journals.

Timetable:

The project should end 31.3.2004.

Responsible scientists:

Antti Kosunen, Tuomo Komppa, Markku Tapiovaara

Optimisation of the use of CT equipment**Objectives:**

To settle out the application of the optimisation principle in the use of CT equipment in Finland and to develop a plan to improve the optimisation of the current practices.

Description of the work:

The parameters used for the assessment of image quality and the quantities used for the determination of patient dose, as well as the equipment needed for these procedures in CT examinations, are reviewed. Based on this review, a set of methods is established and used to study the image quality and patient dose in a representative number of CT equipment in Finland, in connection with regular inspections of the CT equipment. The practices of CT examinations by different users are recorded. The results are analysed in order to derive conclusions on the application of the optimisation principle. A plan for improved optimisation is prepared based on the findings.

Exploitation of results:

The results are reported for information to the users of CT equipment. The preparation of appropriate guidance to the users and suitable training in optimisation procedures are initiated.

Publication plan:

The results and conclusions will be published in a scientific journal.

Timetable:

2003-2004

Responsible scientist:

Juhani Karppinen

The relationship between measured and visual image quality**Objectives:**

We have earlier developed a measuring system for the measurement of the accumulation rate of SNR^2 in fluoroscopic imaging, and studied the relationship

between the measurement result and visual performance in simple imaging tasks with homogeneous phantoms. The objective of this study is to extend these studies to more clinically relevant imaging tasks and anatomic phantoms and, additionally, see whether the results can be understood on the basis of Monte Carlo calculations of image quality.

Description of the work:

Visual performance will be studied by using the MAFC (multiple alternative forced choice) or ROC (receiver operating characteristic) paradigm, supplemented with more simple observations of contrast-detail performance. The test phantoms and details will be chosen in order to mimic clinically important features as closely as possible. Measures of visual performance will be compared against objective physical measurements and Monte Carlo calculations.

This project is part of ongoing collaboration with the Radiation Physics Department of Linköping University (Sweden), who will be the main contributor in the project. The contribution of STUK has not been fully specified yet.

Exploitation of results:

The project will provide information about the optimisation and evaluation methodology of x-ray examination techniques. If the results support the present understanding of the problem, Monte Carlo simulation and the measurement methodology will provide excellent tools for minimising patient dose in fluoroscopic imaging.

Collaborators:

Radiation Physics Department, Linköping University, Sweden.

Publication plan:

The results of the study will be submitted for publication in a scientific journal.

Responsible scientist:

Markku Tapiovaara

Radiation doses to the staff in interventional radiology**Objectives:**

The procedures of interventional radiology are developing and increasing rapidly. During some interventional procedures it is possible that the patient and the staff may receive a relatively high radiation dose. The objective is to study the radiation dose to the staff from various examinations or interventional procedures and to test the usability of different dosimetric methods.

Description of the work:

The staff doses are measured, using different dosimetric methods simultaneously, in various radiological procedures in the clinical practice of different hospitals. The same methods are also compared in laboratory conditions.

Exploitation of results:

The project will provide basic information for radiation protection of the staff in radiological interventions.

Collaborators:

Finnish hospitals, interventional radiology units, manufacturers.

Publication plan:

The results of the study will be published in STUK's report series, congress reports or scientific journals.

Timetable:

2003-2005

Responsible scientists:

Teuvo Parviainen, Antti Kosunen

Optimisation of radiation dose to patients in paediatric x-ray examinations**Objectives:**

The imaging methods, including digital imaging, are developing rapidly in

paediatric x-ray examinations, and up to date information is needed about the trends in radiation dose and image quality. Dosimetry, image quality assessment and optimisation have been performed during recent years in co-operation with some Finnish hospitals. Further objectives are to measure patient dose and image quality systematically in various examinations and to study optimisation and dosimetric methods.

Description of the work:

Radiation doses to children of different ages in various examinations are measured in different hospitals. The dose and image quality are followed during the turn to digital imaging. Different examination techniques are compared in terms of optimisation.

Exploitation of results:

The project will provide basic information for optimising the dose and image quality in paediatric examinations during a period of rapid development in x-ray examination techniques.

Collaborators:

Finnish paediatric hospitals and units.

Publication plan:

The results of the study will be published in STUK's report series, congress reports or scientific journals.

Timetable:

2003-2005

Responsible scientists:

Teuvo Parviainen, Antti Kosunen

Investigation of mammography imaging techniques

Objectives:

The imaging techniques used in mammography are turning to digital in the next few years. Data on the dose and image quality in mammographic examinations have been collected during several years in Finland. The collected data will be analysed for comparisons with the future imaging techniques.

Description of the work:

The earlier collected material on dose and image quality are analysed and supplied with new measurements, using the actual technique each time. The results are compared with the most recent recommendations and the European guidelines. Future digital mammography techniques will be compared with the conventional screen-film technique.

Exploitation of results:

The project will provide basic information on the dose and image quality in mammographic examinations during a period of rapid development in the imaging techniques.

Collaborators:

Finnish mammography imaging units.

Publication plan:

The results of the study will be published in STUK's report series, congress reports or scientific journals.

Timetable:

2003-2005

Responsible scientists:

Teuvo Parviainen, Antti Kosunen

Development of dosimetric methods**Objectives:**

As a National Metrology Laboratory for ionising radiation, and also related to the research on dosimetry in medical use of radiation, STUK is developing calibration and measurement techniques. Methods need to be developed for the calibration of dosimeters measuring metrologically new types of derived quantities, such as:

- (1) the dose-area product (DAP) for projection x-ray imaging, fluoroscopy, and dental panoramic tomography,
- (2) the dose-length product (DLP) for computed tomography.

Description of the work:

Available primary calibration services will be looked for and secondary calibration methods will be planned in co-operation with other standard laboratories. The necessary equipment will be constructed and tested in the laboratory. Test calibrations at hospitals will be performed.

Exploitation of results:

Calibration services will be available for the users of equipment and for companies offering further calibration services. The guidance for calibrations of field dosimeters at hospitals will be published.

Publication plan:

The methods will be documented as a part of the internal quality system. The guidance for the users will be published in STUK's report series. A description of the methods and results may be published also as a congress report or in a scientific journal.

Timetable:

2003-2005

Responsible scientists:

Antti Kosunen, Tuomo Komppa

Development of computer programs for radiation protection in radiology

Objectives:

STUK has produced a number of computer programs for helping in radiation protection problems; some of these programs are intended solely for STUK's own use, while some are also being offered for the use by others. These programs include:

- (1) PCXMC (which calculates the organ doses and effective dose in x-ray examinations),
- (2) ESD calculation (for calculating and analysing entrance surface doses in x-ray examinations),
- (3) a program for calculating the required shielding in x-ray rooms,
- (4) a program for estimating the risk based on the organ doses, age and gender (the program is based on the modified relative risk model)

published in the BEIR V report, and Finnish demographic and cancer statistics), and

(5) several programs for measuring, correcting, calculating and analysing x-ray spectra.

Most of the programs require updating to present Windows operating systems and improving their user interface. Other programs will be developed as well if the need arises.

Description of the work:

The old Fortran and Basic programs will be rewritten using Delphi Object Pascal and their user interface will be improved for better usability. Improvements to the other existing programs will be made if a need is seen, e.g., by getting feedback from the users.

Exploitation of results:

The programs will be used in regulatory control work and STUK's research work concerning medical radiology. The improvements in the commercial programs should benefit also their present users outside STUK. Calculation of effective doses and organ doses will be used, for example, in the assessment of the collective effective dose and for the estimation of the foetal dose in pregnant patients.

Publication plan:

The programs will be documented either as internal documents or in STUK's report series. The commercial programs will be presented also on STUK's web-pages (e.g., the presently existing pages <http://www.stuk.fi/pcxmc>).

Timetable:

2003-2005

Responsible scientists:

Markku Tapiovaara, Tuomo Komppa

1.2 Radiotherapy

Dosimetry of BNCT (Boron Neutron Capture Therapy)

Objectives:

The overall objective is to prepare European recommendations for BNCT dosimetry. The Code of Practice recommendations provide detailed guidelines with proven methods for the basic characterisation and dosimetry of epithermal (and thermal) neutron beams. While the focus in the dosimetry is for brain cancer treatments and for boron as capture agent, most of the recommendations are also applicable to the dosimetry for treatments of other sites and other capture agents. The guidelines apply to the dosimetry in the beams used in pre-clinical research as well as in clinical trials. The objective is to ensure the level of accuracy, reliability, reproducibility and traceability that is generally required in radiotherapy.

Description of the work:

This is the finalisation step of a joint study (a Shared Cost Action, 1998-2003) within the EC fourth research framework programme on Standards, Measurement and Testing. It is based on theoretical reviews and analysis of the available knowledge and experiences gained in BNCT applications, by systematic comparisons of the methods at the available European BNCT beam facilities, and by comparisons of experimental results with theoretical calculations to determine the critical physical parameters affecting the overall accuracy of the measurement. The draft recommendations resulting from the project are distributed for comments to selected experts outside the project group and then finalised for publication.

Exploitation of results:

The recommendations can be used for the treatment of brain cancer patients with BNCT at European research reactors and accelerators, and also applied for the dosimetric verifications as part of regulatory control.

Collaborators:

Netherlands Energy Research Foundation; Netherlands Cancer Institute; Institute for Advanced Materials of the Joint Research Centre of the Commission of the European Communities (Netherlands); University of Helsinki (Finland); University of Birmingham (UK); Nuclear and Technological Institute, Sacavém

(Poland); Technical University of Budapest (Hungary); Nuclear Research Institute, Rez (Czech); Technical Research Centre of Finland; Universitätsklinikum Essen (Germany).

Publication plan:

The recommendations are published as a special report (to be agreed with the EC) and (a brief version) in a scientific journal.

Timetable:

2003

Responsible scientist:

Hannu Järvinen

Verification of the accuracy of dose planning for brachytherapy sources**Objectives:**

The objective is to develop a method for routine verification of the accuracy of dose planning for brachytherapy sources, to be used in connection with regular inspections at radiotherapy departments.

Description of the work:

The method is based on the principles described in IAEA TRS 398 and TECDOC 1097. The absorbed dose measurements are carried out using ionisation chambers in appropriate phantoms. The specific phantoms and adaptors needed are designed, manufactured and tested in practical measurements. A specific guide for the use of the method is prepared.

Exploitation of results:

The method will be used in the regular verifications by STUK at radiotherapy departments in Finland. The guide will be part of the Quality Manual of the regulatory activities.

Publication plan:

A description of the method and practical experiences on measurements will be published in a scientific journal.

Timetable:

Development of the method and preparation of the guide: 2003.

Publication: 2004

Responsible scientist:

Petri Sipilä

2 Natural Radiation

2.1 Indoor radon

Indoor radon mapping

Objectives:

The work aims at maintaining a qualified data base for radon research, communication and training and at providing information for national and local authorities for decision making.

Description of the work:

STUK maintains the indoor radon database utilised in research and communication. The database has been collected largely in co-operation with the local authorities in order to locate homes exceeding the action level of 400 Bq/m³ and to locate areas where the target level for new houses 200 Bq/m³ is exceeded. The database includes information of radon measurements, building techniques, and location of houses and the geology of building sites.

STUK maintains nationwide and regional maps and statistical summaries concerning indoor radon. Radon maps and statistical summaries show areas where the most active measures should be taken and will be used in national and municipal decision making, in media information as well as published on STUK's Internet pages. STUK promotes local radon campaigns, providing local radon data for campaign information.

Exploitation of results:

Decision making of authorities, public, communication, research.

Publication plan:

www-pages, radon communication, radon campaign reports.

Timetable:

A continuous programme.

Responsible scientists:

Ilona Mäkeläinen, Hanna Niemelä

Sampling study on indoor radon in Finland

Objectives

The study aims at exploring the exposure to radon of Finns and indoor radon concentration in Finnish dwellings as well as the factors affecting using a representative random sampling from population register. The previous representative study has been carried out in 1990-91.

Description of the work

A random sample of approx. 5000 Finns will be taken from the central population register of Finland. Based on this sample indoor radon concentration in the dwellings of approx. 3000 Finns will be measured. Integrating alpha track detectors and the total measuring period of one year will be used. A detailed questionnaire on house characteristics will be used, including details e.g. on foundation and base floor construction, building materials and ventilation strategy. Information of preventive measures and indoor radon mitigation will be inquired also.

Exploitation of results

The study will reveal the trends in indoor radon concentration of Finnish housing including the effect of present house construction practices. The results will be utilized in decision making and directing of Finnish radon policy as well as in estimation of the exposure to radon and resulting health effects.

Publication plan

Scientific journals, STUK-report, international meetings.

Timetable

Design 2004, measurements 2005-2006, reporting 2006-2008.

Responsible scientists

Ilona Mäkeläinen, Heikki Reisbacka, Hanna Niemelä, Hannu Arvela

Decay products of radon and thoron in indoor air**Objectives:**

In previous decades STUK has largely focused on radon gas monitoring. When estimating the health effects of radon concentration of radon progeny and the fine particle characteristic of indoor air play an important role. The main goal is to study the aerosol related factors affecting the inhalation dose from radon and thoron: equilibrium factor and unattached fraction as well as the activity-weighted particle size distribution of radon progeny. Second the purpose is to determine the contribution of radon-220 (thoron) to the radon concentrations measured and to the dose from radon to Finns.

Description of the work:

During this study the integrated air concentrations of radon and thoron, their progeny concentrations and integrated progeny size distributions will be measured in the indoor air of selected Finnish private residencies and workplaces. The effect of indoor air characteristics (fine particle concentration, ventilation etc.) to equilibrium factor and to unattached radon progeny fraction is studied. Field measurements will be carried out using radon gas monitors, radon progeny monitors, passive Rn/Th monitors and particle size distribution measurement devices. The radon progeny doses determined are compared to published indoor models.

Exploitation of results:

The implications to dose and risk estimates will be assessed.

Publication plan:

Scientific journals.

Collaborators:

NY University School of Medicine, Helsinki University

Timetable:

2003-2006

Responsible scientists:

Tuomas Valmari, Hannu Arvela

Radon sources and factors affecting indoor radon concentration

Objectives:

The project aims at exploring the effect of building structure, geological factors and available uranium mapping data on radon concentration in the indoor air as well as the trends of radon concentration in new housing. The seasonal and long-term variations in the radon concentration of single family houses will be established.

Description of the work:

The study is based on the indoor radon database of STUK including a specific survey in an area with high indoor radon concentrations. The houses are classified according to the house construction, foundation type and building soil. Factors affecting the radon concentration in indoor air are investigated using regression analysis. The trend of the radon concentration in new dwellings is studied, with a special focus on the effect of foundation type. The usability of different data of uranium in Finnish soils will be assessed.

The measurement data acquired in 300 small-houses on seasonal variation in indoor radon concentration will be analyzed. New data will be collected from houses of a new long-term follow-up study which will be launched in 2003. The results of the measurements will be compared to the estimates that are based on modelling studies.

Exploitation of results:

The results provide data for decision making in radon prevention. Expertise on the structural and geological factors and the effects of the gravel will be utilised when planning the national radon policy. Knowledge of seasonal and long-term variations benefits studies on the health effects of radon. This knowledge is also essential when estimating the annual average of the radon concentration based on short-term measurements (duration less than one year), e.g. in epidemiological studies.

Publication plan:

Scientific journals, international meeting.

Timetable:

1995 - 2010

Responsible scientists:

Ilona Mäkeläinen, Hannu Arvela

Development of the measurement techniques**Objectives:**

The work aims at improving the passive radon detector used in indoor radon studies at STUK.

Description of the work:

The efficiency of alpha track detector used in passive radon dosimeter will be analysed. The radon measurement procedure will be optimised based on simulation of alpha trajectories inside the dosimeter, and on experimental testing using detectors exposed in a radon chamber. The dosimeter is to be conveniently operated up to a radon exposure of 600,000 Bq d/m³, corresponding to a radon concentration of 10,000 Bq/m³ at a collection time of 2 months. The factors studied include filter and absorber properties, detector etching conditions and image processing procedure. The feasibility of new methods of determining air-borne radon retrospectively will be studied (surface-trap or volume-trap).

Publication plan:

Scientific journals.

Timetable:

2003-2004

Responsible scientists:

Tuomas Valmari, Heikki Reisbacka, Hannu Arvela, Teemu Siiskonen

Transfer of radon from household water into indoor air**Objectives:**

Studies abroad have indicated that the transfer coefficient of radon from household water to air is about $1 \cdot 10^{-4}$ (1000 Bq/l in water results in 100 Bq/m³ in indoor air). Finnish houses, however, have special characteristics due to the long cold season; tight insulation and low ventilation rate. In order to make more accurate estimates of the doses that follow from the use of radonbearing household water to the population, the transfer coefficient in Finnish dwellings must be examined.

Description of the work:

STUK has comprehensive databases of both indoor radon and radon in household water. Households where both values are measured will be extracted and the results will be viewed in terms of water usage and house factors.

In addition measurements will be carried out in households where radon removal equipment has been installed. Indoor radon measurements before and after the remediation will be analysed.

Publication plan:

Scientific journals.

Exploitation of results:

More knowledge about the doses in houses with private drilled wells will be attained. The results can be further utilized when considering costs and benefits of domestic radon removal.

Timetable:

2003-2006

Responsible scientists:

Tuukka Turtiainen, Pia Vesterbacka, Hannu Arvela

Total radon exposure of Finns (RATVA)

Objectives:

The study aims at determining the total exposure from inhaled radon in Finland. Indoor radon both at home and at the workplace, and the time spent outdoors and elsewhere is taken into account.

Description of the work:

The survey was performed as a random sampling study. At the first stage a questionnaire was sent to 4,000 Finns randomly selected from the central population register of Finland. Using a questionnaire, willingness to have an indoor radon measurement at home and/or at the workplace, and willingness to carry a personal radon monitor was asked. Other questions concerned the

hours spent at work or at school, at home, outdoors, etc. Seasonal variation in these hours, and the time spent at a summer residence were asked. The site and type of the office or work place (underground/first floor/upper floor, mobile, etc.) and other related questions were asked as well.

All subjects willing for measurement at home and either a measurement at workplace or a personal dosimeter were selected for radon measurements. Subjects selected for home and the work place measurements received radon dosimeters, and a letter to be handed to the employer. Questionnaires concerning the dwelling and the work place (especially the ventilation) were filled in by the study subjects. Those carrying the personal monitors were asked to account for their stay at home, outdoors, at work, and elsewhere.

The radon concentration at an individual work place will be obtained using the measurement results in this study. Corrections due to different air exchange rates during working days and at nights and weekends will be made by utilising additional one-week measurements using continuous radon monitors and data from previous measurements in other workplaces.

The proportion of time spent at home, at the workplace and outdoors will be obtained from the survey. The indoor and outdoor radon concentrations are known from previous studies, and the mean concentration at work places will be obtained from this study. Using these figures, the total radon exposure for males and females of different ages will be calculated. The data from the personal radon monitors will be compared with these results.

Exploitation of results:

The results of this study will help us to expand our knowledge of the radon exposure of Finns. This kind of information is useful when interpreting the risk estimates from epidemiological studies and applying them to the Finnish population.

Publication plan:

An article in a scientific journal

Timetable:

Measurements 2000-2001, final analysis and reports 2002-2005.

Responsible scientists:

Ilona Mäkeläinen, Tuukka Turtiainen, Heikki Reisbacka, Hannu Arvela

Radon mitigation in dwellings and at workplaces

Objectives:

Gathering of information of radon mitigation in dwellings and at workplaces, aiming at production of new guidance material.

Description of the work:

Sub-slab-suction, radon well, sealing of entry routes and measures based on ventilation and depressure control are the basic methods of radon mitigation. In 2002-2003, a questionnaire was sent to 1000 house owners having carried out radon mitigation. Experience on mitigation at workplaces has been collected from specific workplace studies. The results and factors affecting the success of mitigation will be analysed.

Exploitation of results:

New guidance material and authority information.

Publication plan:

New mitigation guidance 2004- 2005.

Timetable:

2002 - 2003

Responsible scientists:

Hannu Arvela, Heikki Reisbacka, Tuomas Valmari

Radon protection in new buildings

Objectives:

The project aims at follow-up of the implementation of the guidance for radon-safe building and finally at developing the methods and practices of radon-safe construction and guidance published by the authorities.

Description of the work:

The guidance for radon-safe construction has been renewed in 2003. The implementation of the guidance will be studied in building sites of single family houses. The construction documents and the practices on building site

including the experiences of responsible building groups will be controlled and documented by the researchers of the project. Indoor radon concentration in the research houses will be measured. The subject houses will be chosen in co-operation with municipal authorities.

Exploitation of results:

Radon-safe practices improve the quality of Finnish housing and improve the quality of indoor air. The project delivers information for decision making for authorities, builders and building companies.

Publication plan:

STUK-A-Series report, building journal articles, international meetings.

Collaborators:

Local building authorities, building companies

Timetable:

2003-2005

Responsible scientists:

Hannu Arvela

2.2. Natural radioactivity in household water

Household water as a source of radiation to Finnish people - the random-sampling survey (TAVES)

Objectives:

The primary goal of the study is to define the radiation exposure from private well water to Finnish people. The most critical group of the population are those who consume water from drilled wells. The study provides a representative average concentration of radon, uranium, radium, lead and polonium in the drilled wells.

Description of the work:

Water samples were collected from 473 households, which cover 163 municipalities in Finland. Radionuclides concentration (^{222}Rn , ^{226}Ra , ^{234}U , ^{238}U , ^{210}Pb and ^{210}Po) was determined all of the samples. In addition to radionuclide determination, Geological Survey of Finland (GTK) analysed over 50 other water quality parameters for each sample.

The data collected in the survey will be analysed and the final report is written (in Finnish). The representative average concentrations and doses of naturally occurring radionuclides in drinking water are calculated. Isotopic ratios of different radionuclides are determined and correlations between them and other water quality parameters are examined. Follow-up samples are collected and seasonal and long-term variation of the radionuclide concentrations is evaluated. Different analytical methods for uranium determination are evaluated and advantages and disadvantages of the methods are discussed.

Exploitation of results:

The local authorities can utilize the results of the study in planning water supply especially in sparsely populated areas. The survey supports the national authorities to plan the implementation of the EU drinking water directive and the required national provision.

Publication plan:

Four scientific articles will be written during the years 2003 and 2005.

- Concentration of natural radionuclides in private well water and radiation exposure from ingested water to Finnish people.
- Radon sampling in drinking water
- Isotopic ratios of natural radionuclides in private wells
- Uranium concentration in drinking water—three different determination methods
- Water quality factors affecting the radionuclide concentrations in Finnish wells

Collaborators:

Geological Survey of Finland, T. Tarvainen, T. Hatakka.

Timetable:

2003 - 2005

Responsible scientists:

Pia Vesterbacka, Ilona Mäkeläinen

Natural radioactivity in household water from waterworks (VEERA)**Objectives:**

The aim of the study is to gather information on concentrations and retentions of natural radionuclides in waterworks with classical water treatment processes. Also the retention of radionuclides in the distribution system is studied. In addition, the raw water results will be compared to the STUK database to see the trends in natural radionuclide concentrations over a long time period.

Description of work:

Seventeen waterworks were chosen in this study. Usually the waterworks have several water catchments and in this study water samples were collected from 46 water catchments. As a source of raw water 38 of these water catchments used groundwater, 5 used bedrock water and 3 used artificial groundwater. Water catchments using surface water were not selected because the concentrations of natural radionuclides are low in surface waters.

Waterworks were selected to include a representative variety of water treatment processes. The most common treatment was alkalization and disinfection when necessary. Different kind of filtrations (mechanical, slow sand and nano) and aeration were used in some water catchments. Four of the water catchments did not treat the water at all. Water samples were taken from raw, treated, and network water. In every case it was not possible to collect all these three samples, for example if the water was not treated at all. The samples were collected in co-operation with municipal health inspectors and waterworks staff. Sampling was done in 4/2002-6/2002. Control samples were collected in autumn 2002 from eight water catchments.

Exploitation of results:

The results will provide advice in planning the monitoring program of natural radionuclides in Finnish waterworks. Knowledge on the effects of the traditional water treatment processes on radionuclide concentration is gained. Also the concentration levels and the changes in concentrations during a long time period can be evaluated.

Publication plan:

STUK A-series report about the results and a MSc. thesis will be written.

Timetable:

Samples were collected between 4/2002 and 6/2002 and the control samples in autumn 2002. Reports will be finalised in 2003.

Responsible scientist:

Kai Hämäläinen

Removing natural radionuclides from household water

Objectives:

A guidebook on methods for removing radionuclides from private water sources will be composed. The guidebook will be useful both for consumers and water treatment industry, thus allowing the selection of removal devices suited to specific needs.

Description of the work:

The research was divided into five different segments according to their subjects. The two first parts focused on the radon removal using aerators or granular activated carbon filters (GAC) and remaining parts of the research dealt with the removal of long-lived radionuclides.

During the research eight aerators, ten GAC filters and 21 ion exchangers were studied. The long term functioning of GAC filters and ion exchangers under different conditions was examined. Performance of the ion exchanger, where uranium was accumulated, was studied using different pressure, pH-value and water salinity. Simultaneous removal of radon and iron was studied at two test locations and simultaneous removal of fluorine and long-lived radionuclides was studied at two test locations. A questionnaire was forwarded to the test locations where the water treatment equipment was installed. The questionnaire sought information on the experience of clients with the particular water treatment equipment in use.

The results of the project were analysed and the final report of the project was written (in Finnish). The guidebook will be composed utilizing results from this research as well as from the earlier research.

Exploitation of results:

The results are used for writing a guidebook on methods for removing radionuclides from private water sources. The results can also be utilised for development of water treatment equipment and used in design of new equipment for the market. The guide will hopefully increase the sale of the water treatment equipment both in Finland and also in other Nordic countries, which have not yet carried out any experimental study on water treatment methods for removal of uranium, radium, ^{210}Pb and ^{210}Po from drinking water.

Publication plan:

Scientific articles will be written during the years 2003 and 2005.

- Radon removal using aeration and granular activated carbon filters (GAC)
- Removal of long-lived radionuclides using ion exchanger and experience on accumulated uranium on filter
- Simultaneous removal of radon, iron and manganese
- Simultaneous removal of fluorine and long-lived radionuclides
- Binding of lead-210 and polonium-210 with particles of different size in drilled well water

Timetable:

2003-2005

Responsible scientist:

Pia Vesterbacka, Tuukka Turtiainen, Kai Hämäläinen, Laina Salonen

Measurement methods of natural radioactivity in household water**Objectives:**

The primary goals of the research are:

- to study the influence of sampling time and plumbing system on the concentration of lead (^{210}Pb) and polonium (^{210}Po) and to examine the proportion of particle bound lead (^{210}Pb) and polonium (^{210}Po) in various ground waters
- to develop new time-saving analytical methods for lead (^{210}Pb). Analytical method of lead via polonium deposition onto silver disk is improved.
- to develop the methods of liquid scintillation spectrometry in surveying natural and artificial radionuclides

Description of the work:

Influence of sampling time on lead and polonium concentrations will be studied by taking water samples in different circumstances of water consumptions. The portion of particle bound lead and polonium will also be studied using filtering experiments with different type of waters.

In order to test a new analytical method for lead-210 determination, a new selective resin supplied by Eichrom will be used. The determination method of lead via polonium deposition onto silver disk is improved using glass bottles (instead of plastic bottles) while sample storing and new tracer is taken into use in the second deposition.

The sub-project titled as "*Application of liquid scintillation spectrometry in surveying natural and artificial radionuclides in the environment*" encompass the development of liquid scintillation methods applicable in the low-level analysis of alfa- and beta-emitting radionuclides in the environmental samples. The thesis is based on five original publications, which involve the methods for tritium and carbon-14 in air and water samples, for strontium-89 and stromtium-90 in environmental samples, for radon, radium, uranium, gross alpha and gross beta in ground water sources. The summary of the thesis deals with the general principles of the current liquid scintillation spectrometry, the sampling and sample preparation methods and measurement techniques developed in this work. Some supplementary, unpublished results on the measurement techniques for radon in water are presented in order to compare the method developed in STUK with the other liquid scintillation methods employed more frequently. The summary also includes the results attained in various intercomparison runs using the present methods as well as unpublished results on the determining of carbon-14 in gaseous releases from Finnish nuclear power plants.

Exploitation of results:

Results from the study are utilized by improving sampling instructions used in surveillance and research. New analytical methods serve better research and give more accurate results.

Publication plan:

A doctoral thesis will be published from application of liquid scintillation spectrometry in surveying natural and artificial radionuclides.

Timetable:

2003-2005

Responsible scientists:

Laina Salonen, Pia Vesterbacka, Ilona Mäkeläinen

2.3 Other sources of natural radiation exposure

Radioactivity of building materials and exposure to natural radiation in industry (NORMA)

Objectives:

In this study, the exposure of the population and the workers to the natural sources of radiation are investigated. The exposure may take place in industrial work and in activities utilising materials or producing wastes that contain excessive amounts of natural radionuclides. New building materials have come on the market since the last Finnish study performed in 1986. These new materials need to be measured.

Description of the work:

The study has so far been based on literature and on the measurements and inspections previously carried out by STUK. A preliminary report was composed in 2001. If necessary, a set of complementary measurements will be carried out for materials and wastes that may contain significant amounts of natural radionuclides but for which there is no information about their specific activity. The work will be performed in co-operation with department of Radiation Practices Regulation. Building materials that have recently come on the market will be acquired from hardware stores, and measured by gamma spectroscopy.

Exploitation of results:

Based on the study, the necessity of taking measures against excessive radiation within different branches of industry will be established. This study also serves also as the national survey required by the implementation of the BSS directive. If building materials that exhibit higher levels of radionuclides than permitted are found, these will be reported to department of Radiation Practices Regulation.

Publication plan:

Final report in 2005. This study serves as the national survey required by the implementation of the BSS-directive.

Timetable:

2003 - 2005

Responsible scientist:

Tuukka Turtiainen, Hannu Arvela, Mika Markkanen

3 Environmental transfer of radioactive substances and nuclear emergency preparedness

New indicator organisms for environmental radioactivity (INDOFERN)

Objectives:

The objective of the project is to identify new indicator organisms and biomarkers for assessment of environmental radioactivity under normal and emergency situations. The mechanisms of uptake and accumulation will also be studied. Indicator organisms are valuable monitoring objects in emergency situations. Many organisms accumulate effectively, and also very rapidly radioactive substances from the medium. Thus, indicator organisms can give quickly information for defining nuclide composition and dispersion of nuclides in early stage of emergency situations.

Description of the work:

Traditionally, many organisms have been successfully used as indicators in radioecology (such as mosses, lichens, mushrooms, macro algae, especially *Fucus*, mussels, etc.). The objective of the project is to search new useful organisms accumulating effectively and specifically different radionuclides in different ecosystems (terrestrial, fresh water, marine). Since the Chernobyl accident, there is plenty of data on ^{137}Cs in biota, but other radionuclides have been paid less attention. The aim is to get more information about other long-lived nuclides (^{90}Sr , Pu, Am) and about the most abundant discharge nuclides from the nuclear power plants (e.g. ^{60}Co). In addition, the usability of different organs or tissues of the organisms as indicators will be studied.

Exploitation:

The study yields data on the occurrence, transport and concentrations of certain radionuclides in potential candidates of indicator organisms. The candidates are based on literature concerning accumulation of radionuclides and stable elements in certain organisms.

Publication plan:

The results will be presented in an open Final Seminar and will be published in open literature.

Collaborators:

Lund University, E. Holm, S; Risø National Laboratory, H. Dahlgaard, DK; Norwegian Radiation Protection Authority, R. Gjelsvik and H. Stensrud, NO; Institute for Energy Technology, A. Raaum, NO; Agricultural University of Norway, L. Skipperud, NO; Icelandic Radiation Protection Institute, M.A. Sigurgeirsson, IS; University of Faroe Islands, H.P. Joensen, FO.

Timetable:

April 2002 – September 2005.

Responsible scientists:

Erkki Ilus, Tarja K. Ikäheimonen

3.1. Foodstuffs

Regional variation of ^{137}Cs and ^{90}Sr in dairy milk

Objectives:

The aim is to study regional differences in behaviour of long-lived radionuclides ^{137}Cs and ^{90}Sr in dairy milk. The factors affecting variation are studied.

Description of the work:

^{137}Cs and ^{90}Sr have been regularly analysed since 1960's in dairy milk in Finland. The data will be analysed and regional transfer factors are calculated from deposition to milk. Also halftimes are estimated regionally. Regional differences of radiation doses due to milk consumption are studied since 1960's. Consumption of milk products has changed during the study period and regionally.

Exploitation of results:

The results are utilised in calculation models to improve regional assessments. Long-term reviews give information to be applied as background in radiation emergencies. Doses calculated contribute in estimation of total ingestion doses regionally.

Publication plan:

The results will be published in 2003-2004.

Responsible scientists:

Eila Kostiainen, Aino Rantavaara

Radioactivity of wild food**Objectives:**

The aim is to predict internal radiation dose due to ingestion of wild foodstuffs, and contribution of different groups of wild foodstuffs to the dose. ^{137}Cs contents in wild foodstuffs originating from the same area will be compared. Variation of ^{137}Cs in mushrooms and wild berries will be studied both regionally and by species.

Description of the work:

A representative sampling of wild products is carried out in order to take into account regional differences. Doses due to wild foodstuffs are calculated, and doses to critical groups consuming large amounts of wild products are assessed. The results are used to assess average ingestion doses and variation of doses due to regional and dietary differences.

Exploitation of results:

The study will provide information on long-term changes in radioactivity of wild foodstuffs. The results are utilised in monitoring the levels given in EU recommendation (2003/120/EC). Ratios of ^{137}Cs contents of different species originating from same area can be utilised in emergency situations. When measurement capacity is limited, measuring of a couple of species can be used to estimate the ^{137}Cs contents of other species in the same area.

Publication plan:

The results will be published in STUK report series. The information on radioactivity of foodstuffs is reported in STUK www-pages.

Timetable:

A continuous programme. Annual updating of the information in STUK web site.

Responsible scientist:

Eila Kostiainen

^{137}Cs and ^{90}Sr in freshwater fish**Objectives:**

The main objective is to provide data on the contents of long-lived radionuclides in freshwater fishes for estimation of radiation doses both at present and in the long term. A special aim is to study factors for which levels of ^{137}Cs in fish stay high for an exceptionally long time after a deposition. Variation of ecological half times of ^{137}Cs in fishes and water in Finnish lakes will be studied. Based on changes of ^{137}Cs in fishes in individual lakes, regional transfer parameters are also assessed to get more generalized picture on ^{137}Cs in freshwater fishes. Besides ^{137}Cs , range of regional and temporal changes of ^{90}Sr in freshwater fishes in Finland will be studied.

Description of the work:

To find out temporal and regional differences in long-term behaviour of ^{137}Cs in freshwater fishes in Finnish lakes the results obtained since the accident at Chernobyl will be synthesised and assessed together with data on the water chemical parameters of the lakes and data on the catchment areas of the lakes. Transfer factors of ^{137}Cs from water to fishes and ecological halftimes of ^{137}Cs in water and in fishes are estimated. The dependence of them on lake specific parameters in a group of lakes analysed since 1987 to 2000 will be studied. A limited number of new fish samples during the fishing season are taken and analysed for ^{137}Cs for assessment of current radiation doses via freshwater fishes. The data for ^{90}Sr in fishes since 1986 will be assessed and radiation doses via ^{90}Sr estimated.

Exploitation of results:

The results of the project will improve the utilisation of dynamic transfer models, because the results can be used for the validation of the models (RODOS, DETRA). The results also help to find the most critical lakes and thus improve preparedness for an emergency situation.

Publication plan:

Publications on the subjects described above will be issued during 2003-2005.

Collaborators:

Finnish Game and Fisheries Research, J. Ruuhijärvi, P. Vuorinen

Timetable:

A continuous programme.

Responsible scientists:

Ritva Saxén, Aino Rantavaara

3.2. Forest and timber

Effect of fertilisation on the distribution of ^{137}Cs in forests

Objective:

Effect of several commonly used forest fertilisation treatments on the distribution of ^{137}Cs in forests is studied. Various types of forests have been chosen for field experiments established earlier by Forest Research Institute. Several types of forests with varying growth conditions and tree species (conifers and birch) are among the research subjects. Both industrial fertilisers and wood ash are used as fertilisers, and their effect on the root uptake of ^{137}Cs is analysed.

Description of the work:

Samples of trees, undervegetation and soil have been collected in 1999. Nutrient concentrations of soil and vegetation samples are determined at the laboratories of the Finnish Forest Research Institute. Gammasspectrometric measurements are carried out in 2003 – 2004. The transfer of ^{137}Cs in the long term, and the effect of fertilisation are analysed.

Exploitation of results:

The results will be used in providing information for the forestry sector, in assessing the consequences of the Chernobyl accident in wood energy industry, and in developing dose calculation models (RODOS Migration).

Publication plan:

The results will be published in scientific journals in 2004 - 2005.

Collaborators:

The Finnish Forest Research Institute

Timetable:

Main part of the current study will be published in 2003 - 2005

Responsible scientists:

Aino Rantavaara, Virve Vetikko

Radioactivity in wood fuels and ash, and implications for the use of ash

Objectives:

Project aims at improving assessment of wood ash radioactivity and facilitating safe handling and use of ash. There are safety requirements in Finland for the external gamma radiation from materials used for land filling, and for road and street construction etc. Wood ash in a material contributes to the overall dose caused by the material. The handling or use of ash may have to be modified, if the chosen key radionuclides in ash cause doses approaching intervention values for workers or the public.

Description of the work:

The origin and composition of wood fuel as sources of variation of radioactive caesium content in ash are examined. The radiation doses to workers handling ash are estimated in the project. The effect of ash fertilisation on radiation exposure from forests has also been assessed. The project is included in Wood Energy Technology Programme of Tekes (project PUUT23), and is funded by Tekes, STUK and Finnish energy and forest industries.

Exploitation of results:

The resulting information can be used by combustion plants which are responsible for safe handling of ash at the plant and deliver ash to customers for further utilisation.

Publication plan:

Final report is due in 2003. Scientific publications 2004.

Timetable:

The project was started in 2001 and will be finished in 2003.

Responsible scientists:

Virve Vetikko, Tuomas Valmari, Aino Rantavaara, Marko Oksanen, Seppo Kle-mola, Riitta Hänninen

3.3. Water ecosystems

Behaviour of long-lived radionuclides in lake ecosystems and their storage in the bottom sediments of the lakes

Objectives:

Lake ecosystems are a significant part of Finnish nature. After the Chernobyl accident the importance of lake radioecology was emphasized, because the highest radiation doses received by Finnish people were obtained by eating freshwater fish. Bottom sediments have an important role in lake radioecology, because the majority of the radionuclides deposited in or transferred into lakes are gradually sunk onto and finally stored in the bottom sediments. Fish use biota living in bottom sediment as their food. Therefore, it is important to obtain information on radioecological processes in bottom sediments to be able to estimate how long the radionuclides deposited in the bottom sediments will be in the biological cycle and available for biota and thus affecting radiation doses received by humans from consumption of fishes. Results obtained in our previous study on bottom sediments concerning the radionuclide content of the sediment correlate with eutrofication of the sediment.

The objectives of this project are 1) to follow the long-term gathering of the radionuclides and removal of the nuclides from the biological cycle, 2) to study the effect of eutrofication and humic substances on the sinking of the radionuclides to the bottom sediment and 3) to form a total picture of the distribution of radionuclides in the catchment, in water, in aquatic plants, in bottom animals, in bottom sediments and in fish.

Description of the work:

The project is a joint project of the laboratories for Ecology and Foodchains and NPP Environment, STUK. The lakes selected for the study include lakes for which numerous previous data on other compartments exist and lakes where the fish have exceptionally high contents of ^{137}Cs . Lake selection is also affected by limnological and hydrological background information available on the lakes. The effect of conventional contamination or eutrofication on the radionuclide contents of sediments is studied in areas where sampling both on the upper flow and on the lower flow of the contamination source is possible and where these stations are close to each other. After analysing of the samples, the data obtained will be synthesized and assessed.

Exploitation of results:

The results provide new information on differences in behaviour and sedimentation of radionuclides in various types of lakes. The results can be utilised in the validation and further development of environmental models used for estimation of the radionuclide contents of fish and water and for estimation of radiation doses.

Publication plan:

Calculations and data treatment 2004. Reporting 2005.

Responsible scientists:

Ritva Saxén, Erkki Ilus

Radiation surveillance and studies in the Baltic Sea

Objectives:

All of the Baltic Sea countries have ratified the Helsinki Convention, the Convention on the Protection of the Marine Environment of the Baltic Sea Area. The Helsinki Commission (HELCOM) co-ordinates the international co-operation, which focus on the implementation of the Convention. The objective of this project is to fulfil Finland's responsibility in the international HELCOM/MORS (Monitoring of Radioactive Substances) co-operation.

Description of the work:

Radiation surveillance in the Baltic Sea is carried out to the extent defined as Finland's contribution to the HELCOM monitoring programme of radioactive substances. The Finnish proportion consists of about 120 samples and radionuclide analysis annually from seawater, bottom sediments, fish and other biota. STUK maintains the HELCOM/MORS Discharge Register, in which the Contracting Parties report discharge data from all the nuclear facilities operating in the Baltic Sea area. This part is performed as a consultant service to the HELCOM.

The international HELCOM/MORS Project Group, which includes representatives from all the Contracting Parties, meets by turns in each Baltic Sea country. In 2003 the annual meeting will be held in Denmark. The Group is

preparing a joint report on Radioactivity in the Baltic Sea in 1992-1998. Specialists from the NPP Environmental Laboratory have been nominated Convenors of the Chapters "Monitoring network", "Sediments" and "Quality assurance".

Exploitation of results:

The study yields data on the occurrence, transport and concentrations of radionuclides in the Baltic Sea. The results are exploited in preparation of joint evaluation reports of the HELCOM/MORS Group at regular intervals.

Collaborators:

Risø National Laboratory, S.P. Nielsen, DK; National Institute of Radiation Hygiene, M. Oehlenschlaeger, DK; Estonian Radiation Protection Centre, E. Jakobson, EE; European Commission, G. Hunter; Federal Maritime and Hydrographic Agency, J. Herrmann, D; Federal Research Centre for Fisheries, G. Kanisch, D; Latvian Environment Agency, V. Graveris, LV; Ministry of Environment, S. Motiejunas, LT; Central Laboratory for Radiological Protection, M. Suplinska, PL; Institute of Meteorology and Water Management, T.Zalewska, PL; V.G. Khlopin Radium Institute, Yu. Panteleev, V. Tishkov and A. Stepanov, RU; Swedish Radiation Protection Institute, Maria Lüning, S; International Atomic Energy Agency, S. Mulsow; Finnish Environment Institute, P. Kotilainen, FI.

Publication plan:

Finnish results are published separately in the STUK-A report series. The results are reported annually to the HELCOM/MORS database.

Timetable:

A continuous programme.

Responsible scientists:

Erkki Ilus, Tarja K. Ikäheimonen, Vesa-Pekka Vartti, Jukka Mattila

Radionuclides in sewage sludge**Objectives:**

Radionuclides are highly concentrated in the sewage sludge formed during sewage water treatment processes. Small amounts of radioactive material

transported via different routes can be detected in sludge. Routine samples from output sludge are taken four times a year.

Description of the work:

Regularly sewage sludge samples are taken from:
Helsinki, Viikinmäki wastewater treatment plant and
Loviisa, Vårdö wastewater treatment plant.

In Helsinki, Viikinmäki routine samples will be taken from raw and digested dewatered sludge four times a year. In addition, in the municipal wastewater treatment plant in Loviisa (Vårdö) samples from output sludge will be taken during the maintenance period in the nearby nuclear power plant. About 10 samples will be taken during that period. The first samples will be taken before the maintenance, and the last ones about a month after the maintenance has been finished.

The amounts of gamma-emitting radionuclides and ^{90}Sr in the samples will be determined.

Exploitation of results:

Sewage sludge is a sensitive indicator of radioactive substances in the human environment.

Publication plan:

The results will be published in a scientific journal.

Timetable:

A continuous programme.

Responsible scientists:

Marketta Puhakainen, Tarja Heikkinen

3.4. Arctic and subarctic areas

Radioecological research in NW Russian Arctic Seas and in Kola Peninsula

Objectives:

The operational area of STUK's Regional Laboratory in Northern Finland is the northern half of Finland, comprising the two northernmost provinces of Lapland and Oulu. The goal of the Laboratory's research is to study the transfer and accumulation of radionuclides in Arctic and sub-Arctic food chains, and in locally produced foodstuffs. From 1993 to 1996 radioecological research was performed also on the Arctic Sea areas and shores of NW Russia.

After the end of the ARCTICMAR Project in 2001 STUK has continued to exploit the extensive sample material collected during scientific expeditions with the Murmansk Marine Biological Institute and stored in STUK's sample bank in Rovaniemi. The aim is to gain more information on levels and origin of caesium and plutonium in Russian Arctic areas.

Description of the work:

Radiochemical plutonium analyses are performed on benthic fauna samples collected in the Barents, Pechora, Kara Sea and White seas and in the Kola Bay. For concentration factor (CF) calculations the ^{137}Cs and $^{239,240}\text{Pu}$ concentrations in biota samples (fresh weight) are compared to seawater concentrations. For concentration ratio (CR) calculations the concentrations in biota (dry weight) are compared to concentrations in dry surface sediment.

Quantitatively collected terrestrial surface vegetation and soil plots collected on the shores and islands of NW Russia are analysed for plutonium isotopes and $^{239,240}\text{Pu}$ concentrations per square metre are calculated as well as Pu-isotope ratios. Soil plots from Northern Finland are also analysed as reference material.

Exploitation of results:

Benthic fauna plays an important role in the transport of radionuclides into arctic food chains. The results provide data on the state of Russian Arctic Sea areas. STUK's results on CF values have been used in FASSET Project.

The Bq/m² results forms background data on the occurrence of plutonium in Arctic terrestrial environment. $^{238}\text{Pu}/^{239,240}\text{Pu}$ -isotope ratio in the terrestrial plots shows if the plutonium originate from the global atmospheric fallout period or from some local source.

Publication plans:

To be submitted to a scientific journal.

Timetable:

2002 - 2005

Responsible scientist:

Kristina Rissanen, Tarja K. Ikäheimonen, Marko Junntila

Radiocaesium concentrations in humus layers in Finland and NW Russia in 2000-2001

Objectives:

The monitoring of anthropogenic radionuclides concentrations in the humus layer in Finland and Northwest Russia was carried out as a part of the Barents Ecogeochemistry Project, the aim of which is to provide the authorities and other involved parties with a basis for assessing the existing state of the environment. The NW part of Russia will be the focus of increased human activities in the near future e.g. as a result of the further exploitation of natural resources.

Description of the work:

The project area encompasses the whole of Finland, as well as that part of Russia running from St. Petersburg to the coast of the Barents and Pechora Seas, and from the Russian / Finnish / Norwegian border to the Ural Mountains. The uppermost 3 cm of the O horizon (humus layer) were collected at ca. 1550 sampling sites in 2000 – 2001 by Russian field teams. The humus layer represented the organic material immediately below the living vegetation, and included the litter layer. All living vegetation was removed. The samples were randomly divided into two parts and 750 samples delivered for gamma nuclide analyses to STUK. The other half was analysed by a Russian laboratory.

The most contaminated region was South Finland, followed by Leningrad Region. The humus layer in the Arctic areas had low ^{137}Cs concentrations. Because of the long physical half-life (30 years), the humus layer still contained about 72 per cent of the original ^{137}Cs isotope levels in 1986, but only about 0.7 of the 1986 level of the short half-life (2 years) ^{134}Cs isotope. Part of the ^{137}Cs

concentrations originate from the global fallout period, but the ^{134}Cs isotope is Chernobyl specific. After passing over Finland along a corridor running from Kokkola to Kajaani, the first Chernobyl plume (28-29.4.1986) seems to have proceeded to the northeast into Russia and eastwards as far as the Ural Mountains.

Exploitation of results:

It is important to document current radioactivity levels in NW Russia owing to the considerable concern that arose in Russia following the Chernobyl nuclear power plant accident in 1986. The humus layer plays an important part for the radionuclide accumulation in ground vegetation and in mushrooms.

Publication plans:

Results of the ^{137}Cs and ^{134}Cs concentrations were presented as poster in 2002 at the 2nd AMAP Symposium in Rovaniemi and at the International Conference "Oil and Gas of Arctic Shelf 2002" in Murmansk. Joint publication exploiting also the ^{60}Co , ^{125}Sb and ^{154}Eu isotopes detected in the samples taken in South Finland in 2000 and during the pilot phase in 1999 will be published with the Finnish and Russian partners in a scientific journal.

Collaborators:

Geological Survey of Finland, Reijo Salminen; S/C Mineral, St. Petersburg, Russia, Victor Chekushin.

Timetable:

1999 - 2004

Responsible scientist:

Kristina Rissanen, Eila Kostiainen, Jarkko Ylipieti

Arctic monitoring and assessment programme (AMAP)

Objectives:

The Arctic Monitoring and Assessment Programme (AMAP) is a group working under the Arctic Council (AC). The Arctic Council Ministers have requested AMAP to: produce assessment reports on the status and trends of the conditions of the Arctic ecosystems; identify possible causes for the changing conditions; detect emergency problems and the potential risk to Arctic ecosystems including indigenous peoples and other Arctic residents; and to recommend actions to reduce risks to Arctic ecosystems. One of the key pollutants in the AMAP programme is radioactivity.

Description of the work:

The report Arctic Pollution 2002; Persistent Organic Pollutants, Heavy metals, radioactivity, Human Health, Changing Pathways, was published during the 2nd AMAP International Symposium on Environmental Pollution of the Arctic in 2002.

The 2nd AMAP Radioactivity Report of the Radioactivity Expert Group deals with issues relating to the presence and effects of radioactive contaminants in the Arctic. It is successor to the 1st AMAP assessment published in 1997. The purpose of this second assessment is to provide an update in cases where new information has become available that either warrants revised assessment or relate to activities and sources that were not previously considered. Such new information has come to light through the provision of information and data by arctic countries as a result of further research or as a consequence of AMAP monitoring activities. The report deals with sources, contamination levels and trends, human exposures, protection of the environment, vulnerability, potential accidents and risk management.

AMAP is developing a new Strategic Plan for the years to come. The priority for the monitoring work is under discussion among the experts.

According to the Report of Senior Arctic Officials (SAO) to the Arctic Council Ministers (October 2002): Risk and impact assessments programs should be performed prior to implementation of actions to handle radioactive materials and wastes, and to reduce risk. These assessments, including accident scenarios, should be performed with regard to the transport of nuclear waste and fuel within the Arctic and nearby areas and with regard to planned storage and reprocessing within the Arctic and nearby area.

The SAOs recommend to the Ministers

- to encourage AMAP to continue the ongoing and long-term monitoring activities, including temporal and spatial trends and human health and biological effect studies,
- to support a more detailed study on the remobilization of radionuclides from sediment and its potential effect on the arctic
- to further investigate how climate change and variability may influence the ways in which chemical pollutants and radionuclides move with respect to the Arctic environment and accumulate in and affect biota
- to request AMAP to continue contributing to specific ACAP projects.

STUK is responsible for the radioactivity data in the Finnish National Implementation Plan.

- continuous monitoring of external radiation and the analysis of aerosol and precipitation samples
- analysis of radioactivity concentrations in samples from the areas where the other Finnish participants are analysing POPs, heavy metals, acidity etc. The monitoring is being performed in the terrestrial environment (permanent lichen and vascular plant sampling plots, reindeer, ptarmigan, wild mushrooms, milk), in the fresh water environment (surface water, lake and river fish), and in the marine environment (Arctic and Baltic Sea salmon)
- wholebody counting of the Sami reindeer herders, including food consumption data.

Exploitation of results:

Long term data series are the basic prerequisite in studying changes and trends in radioactivity levels in our Arctic environment. Owing to the over-grazing of the lichen carpet, the accumulation and transport of radionuclides in the most important foodchain, lichen – reindeer – man, is not the same as after the global fallout period. The models, as well as the vulnerability aspects have to be re-evaluated.

Publication plans:

2nd AMAP Radioactivity Report in 2003.

Collaborators:

Norwegian Radiation protection Authority, Per Strand, Tone Bergan, Morten Sickel; Risø National Laboratory, Denmark, Henning Dahlgaard; FOI, National Defence Research Establishment, Sweden, Ronny Bergman; Islandic Radiation Protection Institute, Sigurdur Emil Pallsson; University of the Faroe Islands, Hans Pauli Joensen; Roshydromet, Federal Service of Russia for Hydrometeorology and Environmental monitoring, Yuri S. Tsaturov; Scientific Production Association "Typhoon", Obninsk, Alexander Nikitin, V.V. Boulgakov; US Department of Energy, Washington, Vincent J. McClelland, Ann Heinrich; Alaska Department of Environmental Conservation, Fairbanks, Douglas Dasher; Bureau of Indian affairs, Canada, Mike J. Bewers; Institute of Terrestrial Ecology, Cumbria, UK, Brenda Howard; Lapland Regional Environment Centre, Finland, Outi Mähönen.

Timetable:

2004-

Responsible scientist:

Kristina Rissanen, Jarkko Ylipieti

Radioactivity inventory of ¹³⁷Cs levels in reindeer summer fodder in the Finnish reindeer management area**Objectives:**

Samples taken by the Reindeer Research Station of the Finnish Game and Fisheries Research Institute during the 1997–1998 summer pasture inventories, and covering the whole the reindeer management area, were delivered in 2002 to STUK for the determination of ¹³⁷Cs concentration. The aim of STUK's analyses is to determine which plant species accumulate the highest radiocesium concentrations, and which reindeer herding co-operatives would be most vulnerable to heavy radioactive fallout owing to the type of soil and vegetation. The Chernobyl fallout was low enough, even in most parts of the Finnish reindeer management area, to allow this kind of assessment.

Description of the work:

Before gammaspectrometric measurement, all the samples of the same plant species collected from the same reindeer co-operation were pooled to form one sample. The analysed material covers more than 20 plant species, and all of the

56 Finnish reindeer-herding co-operations. The plant species included birch (*Betula*), dwarf birch (*Betula nana*), willow (*Salix*), blueberry (*Vaccinium myrtillus*), bog bilberry (*Vaccinium uliginosum*), cloudberry (*Rubus chamaemorus*), forest wiregrass (*Dechampsia flexuosa*), cow-wheat (*Melampyrum*), willow-herb (*Epilobium*), horsetail (*Equisetum*), bogbean (*Menyanthes trifoliata*), sedge (*Carex*), and species *Eriophorum*, *Eleocharis*, *Scheuchzeria* etc.

Exploitation of results:

To assess the spatial vulnerability of Finnish reindeer management area during vegetation period. Because of the decreasing availability of lichen pasture, the importance of summer fodder is also having an increasing effect on the concentrations measured in reindeer meat during winter. The delivery of biomass data allows some quantitative calculations on the importance of different plant species.

Publication plans:

Poster presentation of preliminary results at the 11th Ungulate Conference, August 2003. To be submitted to a scientific journal.

Collaborators:

Finnish Game and Fisheries Research Institute, reindeer research station, Mauri Nieminen, Jouko Kumpula; University of Oulu, Department of geography, Alfred Colpaert.

Timetable:

2002 - 2005

Responsible scientist:

Kristina Rissanen, Jarkko Ylipieti

Ecological half-life of ¹³⁷Cs in mushrooms collected at different forest stands in Kivalo experimental area after the Chernobyl accident**Objectives:**

Although the Chernobyl ¹³⁷Cs fallout in 1986 was low in Finnish Lapland, averaging only 1000 Bq/m², measurable concentrations are still found in nature. The sharp, additional radiocaesium labelling with a ¹³⁷Cs/¹³⁴Cs isotope

ratio of 1.6:1, due to the accident has made it possible to determine ecological half-lives and to estimate how much of the ^{137}Cs in the Arctic environment still originates from the global fallout period. The aim of this project is to determine ecological half-life of ^{137}Cs in the fruiting bodies of different mycorrhizal mushrooms in Finnish Lapland after the Chernobyl accident. Concentrations before and after the accident will be compared and accumulation rate of caesium from soil to mushroom calculated.

Description of the work:

Fruit-bodies of mycorrhizal macrofungi species *Lactarius*, *Russula*, *Suillus*, *Leccinum*, *Cortinarius* and *Rozites* have been collected since 1989 in the birch, spruce, mixed forest and pine stands at the Kivalo research area of the Finnish Forest Research Institute (Metla), located 70 km SE from Rovaniemi. Analogous dry mushroom samples from 1981-1984 have been obtained from Metla's archive and are used as reference material for situation before the Chernobyl nuclear power plant accident in 1986. In 1993, 1999 and 2001 quantitative samples were taken at the same forest stands from the surface vegetation, humus and underlying mineral soil layer down to the depth of 5-6 cm.

Exploitation of results:

After a nuclear accident people are able to avoid mushroom consumption, but reindeer will continue to collect as many mushrooms as available, because the mushrooms are their most important autumn fodder. Because radiocaesium is effectively accumulating in mushrooms and the rate of decrease is slow, mushrooms will contribute significantly, for a long period of time, to the intake of reindeer following a severe nuclear accident.

The high accumulation of ^{137}Cs in mushrooms and their importance to the radiocaesium intake of humans, reindeer, deer, lam and other mushroom consuming species was not fully understood before the Chernobyl accident. During the atmospheric nuclear test period hardly any attention was paid to the radioactivity concentrations in mushrooms.

Publication plans:

To be submitted to a scientific journal.

Collaborators:

The Finnish Forest Research Institute (Metla), Rovaniemi Research Station, Yrjö Norokorpi

Timetable:

2003 - 2005

Responsible scientist:

Kristina Rissanen, Jarkko Ylipieti

Regional differences in ^{137}Cs effective ecological half-lives in domestic and wild reindeer in Finland**Objectives:**

The aim of the project is to determine ecological half-life of ^{137}Cs in reindeer at different reindeer management areas in Finland with variable environmental conditions. Domestic reindeer are compared to the two wild reindeer populations living in Suomenselkä and in Kuhmo. The winter diet of domestic reindeer has changed from the global fallout period due to overgrazing, fallout of Chernobyl was low. The wild reindeer graze on thick lichen carpet with considerably high Chernobyl fallout.

Description of the work:

The ^{137}Cs concentration in reindeer meat produced in the Saami reindeer co-operatives at the northernmost municipalities Inari and Utsjoki and in the east border reindeer co-operatives Kemin-Sompio and Pohjois-Salla are surveyed annually, for the whole reindeer management area every 5th year. Wild reindeer samples from Suomenselkä are analysed annually, from Kuhmo every 3rd or 5th year.

Exploitation of results:

The results are exploited to assess the effects of heavy radiocaesium fallout on reindeer meat contamination and on long term behaviour at different parts of Finnish reindeer management area. Ecological half-lives are required to better understand the regional differences in transfer of caesium in foodchain lichen – reindeer – man. The results have been used in LAPPI-2003 emergency exercise and will be used in NKS ECODOSES – Improving regional assessment for doses to man from terrestrial ecosystems.

The new EU-recommendation states that wild game placed on the market should not contain more than 600 Bq/kg of cesium-134 and cesium-137.

Publication plans:

To be submitted to *Rangifer* in 2004.

Collaborators:

Reindeer co-operatives, Reindeer Management Association, Game Management Districts of Pohjanmaa and Kainuu.

Timetable:

2003 - 2005

Responsible scientists:

Kristina Rissanen, Pertti Niskala, Jarkko Ylipieti

3.5. Decision support systems for nuclear emergency management

Information requirements and countermeasure evaluation techniques in nuclear emergency management (EVATECH)

Objectives:

EVATECH is aiming for enhancement of quality and coherence of response to nuclear and radiological emergencies in Europe. The project is carried out within the key action "Nuclear Fission" in the fifth Euratom Framework Programme (FP5). EVATECH is one of the eleven projects in the FP5 dealing with off-site management of nuclear emergencies and restoration of contaminated environments. The objective of EVATECH is to improve the decision support methods, models and processes in ways that take into account the expectations and concerns of different stakeholders participating in decision making of protection of members of the public and workers in a nuclear emergency situation.

Description of work:

The project is divided into four work packages dealing with; (1) development of evaluation tool(s) for the decision support systems (RODOS and ARGOS) that enable

to find out the most practicable countermeasures or protective actions in a quick and reliable way, (2) description of emergency management processes in few European countries by a modern process modelling technique to clarify the decision making processes and to find out the best practices, (3) development of methodologies to conduct scenario-focused decision making workshops with participation of relevant stakeholders, and (4) arranging of national decision making workshops in seven participating countries to identify feasible countermeasures to clean-up contaminated urban environments after a nuclear accident. The project has ten partners from seven European countries. In the first year, several technical alternatives to develop evaluation tools for the decision support systems were discussed, modelling of emergency management processes was started in UK, and a preliminary programme and accident scenario for the training seminar on scenario-focused workshops and for the national decision making workshops were fixed. During the first year the project faced with technical problems related to evaluation tools. During the first months of the second year the project partners have to decide how to resolve the problems related to development of the evaluation subsystem of RODOS, developed during the earlier framework programmes, and/or utilisation of commercially available tools of decision analysis. A seminar on process modelling was arranged to the project partners in November 2002, and a draft emergency management process in UK was introduced. The project selected a tool and decided the method on how the emergency management processes in Germany, Belgium and Slovak republic will be modelled. Evaluation tools for RODOS and ARGOS decision support systems were selected and will be modified for the systems. Training on use of this kind of evaluation tools in facilitated workshops will be arranged in 2003 and the tools will be tested in practice in the national workshops in late 2003 and early 2004.

Exploitation of results:

The project will produce 21 deliverables in forms of reports (public and restricted), seminars and training courses.

Timetable:

The project started in December 2002 and will end by the end of 2004.

Responsible scientists:

Raimo Mustonen, Kari Sinkko

European approach to nuclear and radiological emergency management (EURANOS)

STUK is actively participating in a wide European research and development project EURANOS which deals with off-site management of nuclear and radiological emergency situations. Below is a brief description of the whole project, co-ordinated by the Research Centre of Karlsruhe (FZK), and descriptions of the 23 sub-projects with which STUK is involved. The project has an external Advisory Committee where STUK is also represented.

Summary of EURANOS project:

The Integrated Project EURANOS, through the commitment of fifty-one operational emergency management organisations, ‘stakeholder panels” and competent RTD institutes of many European countries will build a fully interactive framework for initiating and promoting practical improvements of emergency management and rehabilitation strategies in Europe never reached before. The Integrated Project will actively contribute to the following objectives:

- (A) Creating better communication links between those responsible for nuclear and radiological emergency management in European countries with the perspective of fast notifications, information exchange and interaction through more direct channels.
- (B) Providing better coherence and transparency in decision processes on local, national and border crossing interventions as one input to improving public understanding and acceptance of off-site measures;
- (C) Supporting decisions on effective and timely emergency actions and countermeasures in case of nuclear or radiological emergencies by access to reliable, consistent and comprehensive information, and in this way mitigating radiological and economic consequences;
- (D) Developing a coherent framework for the sustainable rehabilitation of living conditions in contaminated areas by implementing integrated and decentralised approaches involving key stakeholders and the public.

A common approach and an European perspective of a more harmonised emergency management and rehabilitation strategy on the local, national and supra-national levels will be created and promoted through common

emergency exercises and their thorough evaluation together with all stakeholders involved and through “stakeholder panels” on the key issues of rehabilitation. The common views on improved technical tools, methods, strategies and guidance will also create initiatives on the administrative and political levels to improve the efficacy of European emergency management and rehabilitation strategies.

Research projects of EURANOS in which STUK is participating:

Extension of countermeasure compendium for food production systems in agricultural and semi-natural areas

Objectives:

This sub-project aims at building up and expanding the existing countermeasure compendium for agriculture and semi-natural areas in a case of a nuclear accident. Another objective is to complement the corresponding work being carried out for inhabited areas.

Description of work:

Countermeasures applicable to the early post accident phase will be identified and new datasheets compiled. Existing datasheets will be extended to consider radionuclides of importance during the early phase (e.g. ^{131}I). Furthermore, in consultation with other research projects of EURANOS, radionuclides relevant to nuclear emergencies other than those potentially occurring at nuclear power plants (e.g. terrorist use of dirty bombs) will be identified and countermeasure datasheets adapted, or generated, as appropriate. Social and ethical input to the datasheets will be important for these new types of radiological incident. Countermeasures appropriate to important European food production systems currently poorly addressed within the datasheets will be identified and evaluated, and new datasheets will be compiled where appropriate. The existing countermeasure compendium contains detailed information on the incremental doses incurred by those involved in implementing the countermeasures. For completeness, incremental doses for all the new nuclide-countermeasure combinations identified will also be derived, including waste disposal options.

All additions and amendments to the compendium will be circulated widely for peer review. A draft version will be made available to the national stakeholder panels set up to assist in the production of the generic handbook

being developed for food production systems in another EURANOS project. The compendium will also support the enhanced countermeasure modelling capability for agriculture being developed elsewhere in the EURANOS project.

Exploitation of results:

The project will produce the following deliverables which can be utilized in national emergency planning in Finland.

- New/updated datasheets for early phase countermeasures
- New/updated datasheets for additional production systems
- Report on incremental doses for new countermeasure-nuclide combinations
- Draft countermeasure compendium for food production systems in agricultural and semi-natural areas - restricted dissemination level
- Countermeasure compendium for food production systems in agricultural and semi-natural areas

Collaborators:

Natural Environment Research Council, NERC-CEH, UK; National Radiological Protection Board, NRPB, UK; University of Ioannina, UOI, Greece ; Institute de Protection et de Surété Nucléaire, IRSN, France ; Agricultural University of Norway, NLH, Norway.

Timetable:

The project will start in the spring 2004 and will last 18 months.

Responsible scientists:

Aino Rantavaara, Kristina Rissanen, Riitta Hänninen, Eila Kostianen, Ritva Saxén

Production of a generic handbook for the management of contaminated food production systems in Europe

Objectives:

One way to guide decision-makers in their choice of options for the management of contaminated food production systems is through a handbook. Such a handbook is being developed specifically for use in the UK and will be available in January 2005. This project aims at expanding this British handbook for a generic handbook for use in Europe.

Description of work:

Pre-existing stakeholder panel in Finland will convene to determine the requirements of such a handbook with regard to its scope, format and content: its findings will be summarised in an individual report of the panel. The report will be discussed at a meeting of the national co-ordinators of different countries (Finland, Belgium, France, Greece and UK) and the final scope, format and content agreed. After a period of preparation, national co-ordinators will spend an intensive week collectively drafting the text, including annexes on how to customise the handbook for northern, western and southern regions of Europe. A specialist in ethics will provide input on the ethical issues that should be considered by decision-makers and this information will also be included in the handbook.

In the later phase of the project, stakeholder panel in Finland (and in other participating countries) will then convene to provide feedback on the overall applicability of the handbook for use in Europe. The handbook will be revised through several iterative consultations with the stakeholders. The final version of the generic handbook will be produced in 2007, following a meeting of the national co-ordinators.

Exploitation of results:

The project will produce a generic handbook for management of contaminated food production systems in Europe. In addition, the work done in Finland will give useful information which should be taken into consideration in nuclear emergency management in Finland. The deliverables of the project are:

- A report from the Finnish stakeholder panel on scope, format and content of the generic handbook
- Draft generic handbook with annexes on customisation
- Final generic handbook with annexes on customisation

Collaborators:

National Radiological Protection Board, NRPB, UK; Belgian Nuclear Research Centre, SCK-CEN, Belgium; Institute National Agronomique Paris-Grignon – Institute de Stratégies Patrimoniales, INAPG, France ; University of Ioannina, UOI, Greece; Agricultural University of Norway, NLH, Norway.

Timetable:

The project will start in the spring 2004 and will last to 2007.

Responsible scientists:

Riitta Hänninen, Aino Rantavaara, Eila Kostianen

Production of a generic handbook for the management of contaminated inhabited areas in Europe

Objectives:

One way to guide decision-makers in their choice of options for the management of inhabited areas is through the use of a handbook. Such a handbook is being developed specifically for use in the UK and will be available in January 2005. Other material used for the management of recovery in inhabited areas has been developed in Denmark/Sweden. The objective is to use these materials in conjunction with the countermeasure compendium to produce a draft prototype handbook for use in Europe.

Description of work:

Stakeholder panel will be convened in Finland to determine the suitability of such a handbook with regard to its scope, format and content: their findings will be summarised in an individual report of the panel. Input from stakeholder group that has met under the EC sponsored EVATECH project will also be used where appropriate. A meeting of national co-ordinators from participating countries (Finland, France, Germany, Slovak Republic, Denmark and UK) will then be convened to agree on final scope, format and content of generic handbook, which will be revised accordingly. The national co-ordinators will then spend an intensive 2-3 days collectively drafting annexes on how to customise the handbook for different regions of Europe.

In the later phase of the project, stakeholder panel in Finland (and also in France, Germany and the Slovak Republic) will reconvene to provide feedback on the overall applicability of the handbook, including the annexes for use in Europe. The handbook will be revised through several iterative consultations with the stakeholders. The final version of the generic handbook will be produced in 2007, following a meeting of the national co-ordinators.

Exploitation of results:

The project will produce the deliverables shown below. These deliverables can be utilised in nuclear emergency planning for inhabited areas in Finland.

- Translated Danish/Swedish handbook
- Handbook section on interpretation of measurements and calculation of doses
- Draft handbook for input to stakeholder panels
- A report from Finnish stakeholder panel on scope, format and content of

generic handbook

- Draft generic handbook with annexes on customisation
- Final generic handbook with annexes on customisation

Collaborators:

National Radiological Protection Board, NRPB, UK; RISOE National Laboratory, RISO, Denmark; Engineering, Design and Research Organisation, VUJE, Slovak Republic; Institute de Protection et de Surété Nucléaire, IRSN, France ; Federal Office for Radiation Protection, BfS, Germany

Timetable:

The project will start in the spring 2004 and will last to 2007.

Responsible scientists:

Tarja K. Ikäheimonen, Kari Sinkko, Riitta Hänninen

Radiation monitoring strategies and their optimisation

Objectives:

The purpose of the work is to produce a monitoring strategy handbook for facilitating the practical management and optimisation of radiation measurements in an emergency.

Description of work:

Main tasks of the work include:

- Defining the different general factors affecting monitoring strategies and measurements.
- Defining the objectives of radiation monitoring in different emergency situations (scenario, surroundings, time phase).
- Studying and comparing the quantities received from measurements with those produced by prediction models such as RODOS and ARGOS (with the emphasis on data assimilation and use of model output to guide measurement activities).
- Preparing recommendations concerning harmonisation of measurement units, data formats and quality control of measurement results (in order

to facilitate international data exchange).

- Analysing a few scenarios from the point of view of monitoring strategies and their optimisation.
- Producing a European monitoring strategy handbook including recommendations and analysed example scenarios.

STUK is the co-ordinating organisation.

Exploitation of results:

The information and data in the handbook can be directly utilised in the Finnish nuclear and radiological emergency plans.

Publication plan:

The results and conclusions will be published in a monitoring strategy handbook. In addition, there will be project reports and possibly a few papers published in scientific journals.

Collaborators:

SCK-CEN, Belgium; Bundesamt für Strahlenschutz (BfS), Germany; Danish Emergency Management Agency, Denmark; Norwegian Radiation Protection Authority (NRPA), Norway.

Timetable:

The project will start in spring 2006 and end in 2008 (or early 2009).

Responsible scientists:

Juhani Lahtinen, Harri Toivonen

Foodchain and agricultural countermeasures

Objectives:

This work packages aims at improving the information necessary for decision making in agricultural and seminatural areas.

Description of work:

To harmonise predictions and measurements, data assimilation tools were developed in the recent years and prototype version of two modules to update

the deposited activity (DeMM) and feed and food contamination (FoMM) were implemented into RODOS. With the application of the data assimilation features, it will be also possible to run specific scenarios and provide guidance for the monitoring strategies to be developed in the previous project. From the experiences up to now it is to be expected that an enhancement of the data assimilation modules towards operational application remains an important task for FP6. Improvement of the robustness of data assimilation modules is considered to be an urgent task since without its realisation it will hardly be possible to convince users of the usefulness of data assimilation in a demonstration sub-project of EURANOS. Also the development of a well working connection to the real time data base in collaboration with the users is a pre-requisite for a successful demonstration project.

The development of the ERMIN model to estimate the radionuclide contamination and potential countermeasures in inhabited areas requires the restructuring of the foodchain and countermeasure modules currently implemented in RODOS versions PV5 and PV6. Therefore, the functionality of the agricultural countermeasure module will be added to the food and dose module for terrestrial pathways (FDMT module of RODOS). Provisions will be made to accommodate countermeasures recommended in the handbook for the agricultural areas and the later phases of an accident (to be developed in another EURANOS project). To harmonise ARGOS and RODOS, it is proposed to integrate the updated data assimilation tools and foodchain and dose modules in both decision support systems.

Exploitation of results:

The project will produce a lot of software improvements to RODOS and ARGOS systems (listed below). As RODOS is used also at STUK, these improvements will enhance STUK's capability to handle off-site consequences of nuclear accidents. The deliverables of this sub-project of EURANOS are:

- Functional specification and software design document for the revised food and countermeasure routines
- FPROC implemented into ARGOS
- FPROC implemented into RODOS PV 7
- Updated model descriptions and user guides
- Formal guidance to Monitoring Strategies (another EURANOS project) providing information on monitoring requirements in agricultural areas
- Updated software modules of the RODOS data assimilation modules for deposition (DeMM) and food contamination (FoMM) with data input from the real-time data base

- Enhanced software modules of the RODOS data assimilation modules for deposition (DeMM) and food contamination (FoMM)
- Formal guidance to Monitoring Strategies (another EURANOS project) providing information on monitoring requirements in agricultural areas
- Updated agricultural food countermeasures in RODOS PV 8
- Updated semi-natural food countermeasures in RODOS PV 8
- Enhanced software modules of the data assimilation modules for deposition (DeMM) and food contamination (FoMM)
- Data assimilation modules integrated into ARGOS

Collaborators:

National Radiological Protection Board, NRPB, UK; Federal Office for Radiation Protection, BfS, Germany; Danish Emergency Management Agency, DEMA, Denmark; Prolog Development Center A/S, PDC, Denmark; Forschungszentrum Karlsruhe GmbH, FZK, Germany; Forschungszentrum für Umwelt und Gesundheit, GSF, Germany

Timetable:

The project will start in the spring 2004 and will last up to the spring 2008.

Responsible scientists:

Aino Rantavaara, Michael Ammann, Riitta Hänninen

Extension of the portability and operability of the RODOS system

Objectives:

This sub-project has several technical objectives regarding development of the RODOS system:

- Migration of RODOS from UNIX to the LINUX operation system
- Extension and modification of the RODOS WebServer applications and RODOS applications to enable operation through firewall computers
- Conversion of grid results into administrative units
- Improvement of the wind field modelling in RODOS including data assimilation features
- Improvements of the long-range module MATCH
- Preparation and test of two new versions of RODOS

Description of work:

Currently, the operation of RODOS is limited to the HP UNIX platform. Some of its functions, such as the WebServer, are only possible under HP-UX 11. With the increasing computational power of personal computers and the extended functions of their operating systems, it is now possible to move to one of the most advanced operating system running on personal computers, the LINUX operating system. The possibility to use powerful PCs and LINUX servers would greatly reduce the installation and maintenance costs. In that way, the dependence from one company (Hewlett Packard) would vanish and platform independent installations of RODOS would become possible.

The RODOS WebServer operates/hosts several applications running on web browsers, such as the B- and C-user interfaces, the visualisation tool for the real-time data base and in future also the XML tools for international data exchange. At present, it is assumed that RODOS and the RODOS WebServer are running in the same segment of a local area network and not separated by firewalls. Firewalls however, become much more common in public organisations, in particular in emergency centres which need the secure operation of networks. Therefore connection to the INTERNET will be protected by firewalls. In this case, the RODOS server with access to all data providers of the emergency centre has to be operated inside the firewall, whereas the RODOS WebServer with its direct connection to the INTERNET has to be run outside the firewall. Under this activity, software tools will be developed enabling the communication between the RODOS system and the RODOS WebServer via this firewall.

At present, RODOS calculations are performed on a variable grid of 2520 grid points. Decisions on long term countermeasures, however, are in a number of European countries introduced on the level of administrative units only (e.g. in Finland). Therefore, software tools have to be developed which enable the grid results to be converted into areas defined by administrative borderlines. In addition, the graphics functions and evaluation programmes of the RODOS system have to be adapted to this new form of presentation.

The MPP of the RODOS system acts as interface between the Atmospheric Dispersion Models (ADMs) and the incoming meteorological data, which can be measurements from stations in the area of interest or prognostic data from Numerical Weather Prediction (NWP) models. The analysis time of the NWP data is usually several hours in the past. So in the cases that NWP data are used as input to the ADM, the information from measurements available between the NWP analysis time and present time is lost. As a consequence, relatively large differences can be observed between results of

the ADMs calculated with locally measured meteorological data and those obtained with the forecasts of the NWP models. Such deviations have actually been observed in practical applications of the RODOS system. The implementation of Data Assimilation (DA) procedures in the MPP of RODOS enables the simultaneous use of meteorological measurements, such as wind velocity, cloud cover, net radiation, and precipitation, with Numerical Weather Prediction (NWP) data and improves in this way, the prognostic meteorological fields used by the ADMs. In the second phase of the project the calculation and propagation of the uncertainties to the system will be implemented.

The MATCH model is an integrated part of the RODOS system with the objective to describe the long-range dispersion and fallout from a nuclear release. The MATCH model is a 3-dimensional transport model that covers a major part of the atmosphere on the European scale. As such the model is rather demanding in terms of computer resources and input of weather data. The MATCH module has connections both to the local dispersion model chain and counter measure modules. The MATCH module has to be adapted to F90 in order to enable a more dynamic selection of number of nuclides handled, than the present system allows, and consequently connections to the RODOS nuclide data bases. Development will also be undertaken to directly connect MATCH to the RODOS source term data base. The interactions between MATCH and countermeasure modules will be further refined to make the full use of long-range deposition estimates for counter measure decision support. The usability will be enhanced by accounting for additional sets of numerical weather prediction data, as input drivers of the MATCH model, and consequently adaptations to these. European scale land-use mapping will be incorporated for improved estimates primarily of nuclide specific dry deposition fluxes.

The results of the various RTD activities, in particular new or modified software components, will be integrated in within the RODOS system to build new releases with extended functions. The corresponding user interfaces will be extended or modified according to the needs of the software and the users. Tests will be performed to check the functionality of the overall system containing the new software. The RODOS documentation will be updated by extending or modifying the user guide and the test procedures and by adding the model descriptions and the functional specification documents provided by the developers. Two versions of RODOS are foreseen within the working period tentatively at the end of 2005 / Beginning of 2006 (RODOS PV7.0) and at the end of 2007 / Beginning of 2008 (RODOS PV8.0). About 2 months after the release of each version, the corresponding LINUX version will be ready for distribution (RODOS LX7.0 and RODOS 8.0, respectively). If need be, patches will be prepared by FZK for each existing version of RODOS, which may contain

corrections and minor modifications of models and system components.

Removing bugs in computer software is an ongoing process and will continue as long as a tool is used. Therefore manpower has also to be foreseen to cure severe problems immediately and distribute corresponding patches to the users community; minor bugs can be corrected in the next version.

Exploitation of results:

The project will produce a remarkable amount of technical deliverables which will be included in the RODOS system. They will make RODOS more user-friendly and more reliable in operational use. The defined deliverables of this project are:

- LINUX version of RODOS PV6.0
- Software patch for the LINUX version of RODOS PV6.0 enabling the remote operation of the Graphics Servers
- Software enabling the interaction of the RODOS WebServer and the RODOS system through firewall computers integrated in the LINUX version of RODOS PV6.0 at month 12 and the HP-UX version of RODOS PV 7.0
- Grid conversion tools integrated in the LINUX version of RODOS PV6.0 at month 12 and HP UX version of RODOS PV7.0
- Meteorological pre-processor extended with a mass-consistent wind-field model and data assimilation features, integrated in RODOS PV7.0
- Long-range module MATCH that facilitates enhanced usability and database connections at month 12
- Updated MATCH model integrated into RODOS PV7.0
- Updated MATCH model integrated into RODOS
- Meteorological pre-processor extended with uncertainty propagation, integrated in RODOS PV8.0
- HP-UX version of RODOS PV 7
- Linux version of RODOS PV 7
- HP-UX version of RODOS PV 8
- Linux version of RODOS PV 8

Collaborators:

University of Karlsruhe – Institute for Industrial Production, UniKarl, Germany; Forschungszentrum für Umwelt und Gesundheit, GSF, Germany; RISOE National Laboratory, RISO, Denmark; Forschungszentrum Karlsruhe GmbH, FZK, Germany; National Centre for Scientific Research DEMOKRITOS, NCSR, Greece; University of Thessaloniki, AUTH, Greece; Swedish Meteorological and Hydrological Institute, SMHI, Sweden.

Timetable:

Spring 2004 - spring 2007

Responsible scientists:

Michael Ammann

Further enhancements of evaluation tools in decision support systems for operational applicability

Objectives:

In order to improve the operational applicability of the decision support systems, further developments of the evaluation tools (tools for ranking different countermeasures) within RODOS are necessary. This sub-project aims to include more background information, explanation and methodological enhancements for the decision makers.

Description of work:

The integration of an explanation module in WebHipre is an enhancement contributing to the direct involvement of the decision makers. Furthermore results of the EVATECH project can be used to improve the explanation subsystem of RODOS, e.g. the automated import of limited decision trees with a direct linkage of the LCMT with WebHipre. In the later phase further methodological enhancements can be implemented (uncertainties modelling or sequential decision making support).

Exploitation of results:

Integration of modified commercial evaluation tool WebHipre into RODOS will make for decision makers possibly to easily rank different countermeasures and select the most suitable for implementation. The project will produce the following deliverables to be integrated to RODOS system:

- WebHipre with integrated generic Explanation Module
- Enhancements of the Integration of WebHipre into the RODOS System by generating a direct linkage between the LCMT and WebHipre and implementing a default list of demanded attribute values to be passed automated from the LCMT to WebHipre
- WebHipre with integrated templates with background information
- Concept for the implementation of uncertainty modelling and sequential decision making for post accident management into RODOS

- WebHipre extended either with the chosen concept for uncertainty modelling or sequential decision making for post accident management

Collaborators:

University of Karlsruhe – Institute for Industrial Production, UniKarl, Germany.

Timetable:

Spring 2004 - spring 2008

Responsible scientists:

Kari Sinkko, Michael Ammann, Raimo Mustonen

User driven development of the RODOS user interface and graphics system**Objectives:**

Objective of this project is to develop an improved graphical user interface and a new graphical presentation software for RODOS system.

Description of work:

The present graphical user interface emerged mainly from the requirements of the R&D community involved in the development of the RODOS system and its various modules. This has led to structures and functional specifications which are well defined from the point of the information technology, but lacks the interaction and feedback with the end user. As the operational use of the RODOS systems depends strongly on the easy use of the modules and input possibilities, the graphical user interface has to be as user friendly as possible. This goal could not be fully achieved in the past as the operational use of the system was limited. Within the demonstration projects, however, the system will be used by more and more participants in an operational way, thus feedback is expected in much more quality and quantity as during FP5. The improved graphical user interface will guide the user in a more sensible way through all the potential input models to obtain exactly those results he/she is interested in.

When RODOS was designed, the graphical presentation system was mainly limited to display results in the near range around a nuclear installation. With the increasing functionality of the RODOS system, the

amount of data to be processed increases continuously. As a consequence, the European map data set of background information comprises about 1 GB of data. Such an amount of information cannot be treated effectively with the present graphical system due to the implemented ASCII format of the map data. In addition, the present graphical system does not provide native language support, which is important for the implementation in national emergency centres. As the present graphical system is not modular, modifications or extensions may require more effort than a completely new redesign. Therefore, it is necessary to change the design and layout in such a way that state of the art GIS functionalities provide a fast and easy operation of the new graphical presentation system.

Main objective of the RODOS software redesign is to enable the RODOS system to be operated under all commonly used operation systems (such as MicroSoft, Unix, Linux, MacIntosh). In that way, sustainability of the RODOS software will be achieved for the time period after the end of the EURANOS project. In particular, this will allow to provide a more powerful and user-friendly Graphical Presentation System, which enables the realisation of distributed graphics applications on centrally installed servers and remote desktops. The current software technology of RODOS is based on the client-server application architecture with *centrally* organised data management. It focuses on the retrieval and display of data. The RODOS software redesign will make use of Web-Services with *distributed* architecture, the current state-of-the-art software technology.

Exploitation of results:

The new graphics system will be installed to RODOS making it more user friendly. The outputs of this project are:

- Accepted design document
- RODOS version 8.0 with new user interface and graphics system

Collaborators:

Forschungszentrum Karlsruhe GmbH, FZK, Germany; Institute of Math. Mash. and System Problems of National Academy of Sciences, IMMSP, Ukraine

Timetable:

The project will start in 2006 and end in 2008.

Responsible scientist:

Michael Ammann

Improvement, extension and integration of operational decision support for nuclear emergency management (DSSNET)**Objectives:**

RODOS is currently being installed for (pre-) operational use in emergency centres of eight Eastern and Western European countries with the perspective of an increasing number of users during the 5th Framework programme. Therefore, it is timely and opportune to initiate a broader discussion and interaction, both to provide essential feedback to the developers and to familiarise the users (and decision makers) with the nature and level of support they can expect in practice. The overall objective of this proposal aims at establishing an effective and accepted framework for better communication and understanding between the operational community and the many and diverse disciplines involved in R&D for making well informed and consistent judgements with respect to practical improvements of emergency response in Europe.

Description of the work:

Participants in the network will be primarily nuclear off-site emergency centres with (pre-) operational installation of RODOS and end users of the information provided by RODOS; interested institutes operating other support tools, in particular, monitoring systems, will be integrated. As a counterpart, the leading R&D institutes involved in developing, customising and/or maintaining RODOS - and other decision support tools - will become partners in the network.

The structured evaluation of the experience gained with decision support systems and the information exchange between them will be performed by Working Groups. Each Working Group addresses one of four work packages, which cover areas identified by the partners of the network as relevant with respect to improving the practical applicability of decision support systems: user interfaces, results and interaction with decision-makers; exchange of data and information relevant for decision-making; system functions and networks; and processing of on-line data. In this way, all interfaces between the users and the systems developed by the R&D community will be covered.

To stimulate these activities and to facilitate the communication between the users and the R&D community, problem-oriented emergency exercises will be prepared, which cover the various time phases of an accident, extending from near range to greater distances with frontier-crossing transport of radionuclides. They will help to understand the strengths and weaknesses of decision-support systems, their interaction within data-exchange networks,

and their administrative arrangements on the local, regional, national and international levels.

To support interaction between all partners of the proposal and co-ordination within the network, a secretariat will be established for supporting co-ordination and management. A Steering Committee is proposed for keeping track of network activities.

Exploitation of results:

Four emergency exercises will be prepared, conducted and evaluated. Each of the five working groups under the lead of working group convenors will deliver reports as input to five network meetings; they summarise the experience gained with RODOS and its networking during the past reporting period, in particular, the emergency exercises, and formulate proposals for further improving decision support systems and emergency management more generally.

Collaborators:

Forschungszentrum Karlsruhe GmbH, J. Ehrhardt (co-ordinator) FZK, D; Joint Research Centre, JRC Ispra, I; and 30 other institutes from the Middle and Eastern Europe.

Publication plan:

The work will be promoted in RODOS reports, seminars and in scientific publications produced by each working groups. Reports will also be written to facilitate the communication between RODOS users and the R&D community. Especially reports describing the findings of exercises.

Timetable:

2000-2004 (EC Concerted Action), Exercises at months 8, 20, 32, 44 .

Responsible scientist:

Kari Sinkko

RODOS Migration, forest modelling for RODOS

Objectives:

The development of the RODOS forest model continues in the 5th Framework Programme of the EU. The first operative version of the model was a result of

co-operation of STUK, Finland, and IPSN, France, and it was integrated in the RODOS system in 1999. Currently, the forest model is being extended for assessment of countermeasures related with dose pathways from contaminated forests to man.

Description of the work:

As in the first version, radiation doses are assessed for consumption of wild foodstuffs and staying in forests either for work or for recreation. Contamination of barked timber will be explicitly calculated for quantification of the effect of remedial measures.

In 2003 the new version of the forest model will be completed and tested. The description of the model content will be finalised, and a guide for users and those who adapt the model in new geographical regions will be prepared.

Exploitation of the results:

The reports on the new version of the forest model, as well as the model software will be made available by the general coordinator and main user of RODOS, the FZK, Germany.

Collaborators:

Forschungszentrum Karlsruhe GmbH, J. Ehrhardt, W. Raskob, Germany; National Radiological Protection Board, J. Brown, UK; National Centre for Scientific Research DEMOKRITOS, J. Bartzis, EL; GSF-Forschungszentrum für Umwelt und Gesundheit, H. Müller, Germany;

Timetable:

The RODOS Migration project, lasting three years in all, was activated on October 1, 2000. Contribution of STUK will be finished by the end of September 2003.

Responsible scientists:

Aino Rantavaara, Michael Ammann

Improving regional impact assessments and improving radiological assessments of doses to man from terrestrial ecosystems (ECODOSES/NKS)**Objectives:**

The aim of the project is to improve the accuracy of radioecological modelling via gathering of available Nordic regional data and the exploitation of results from ongoing and new studies. The focus is on finding the appropriate parameters for different regions to be incorporated in the food chain and dose models. Regional differences in long-term behaviour of radionuclides are studied, including the nuclear weapons tests period and the period after the Chernobyl accident. Results obtained for deposited radionuclides ^{137}Cs and ^{90}Sr in various Nordic regions are used for the validation of a model developed for the estimation of deposited radionuclides based on the amounts of precipitation. Concerning radionuclide transfer in food-chains, the focus of the study is milk, which is a foodstuff of main concern in case of a nuclear accident. Regional differences of ^{137}Cs in reindeer meat are also studied, because the food-chain lichen-reindeer-man is the most vulnerable in case of deposition, causing radiation doses to Nordic people.

Description of the work:

The Laboratory for Ecology and Foodchains and the Regional Laboratory in Northern Finland will produce regional data on ^{137}Cs and ^{90}Sr in deposition and in milk, and ^{137}Cs in reindeer meat since 1960's. The regional data from Finland, Sweden, Norway, Denmark, Iceland and Faroe Islands are gathered, synthesized, assessed and reported in 2003. A workshop on the utilization of a transfer model is also organised in connection with a small seminar on radioecology in 2003.

Exploitation of results:

Long-term reviews are useful for information packages to be applied as background information in radiation emergencies. The incorporation of region specific parameters in environmental models will enhance their usefulness in case of a nuclear accident. The project will thus lead to a better emergency planning, a faster decision in case of an accident and a more appropriate choice.

Publication plan:

Reports on the three topics (deposition, milk, reindeer) together with the proceedings of the work-shop form the report of the project.

Collaborators:

Risø National Laboratory, S.-P. Nielsen; Icelandic Radiation Protection Institute, S.E. Pálsson; Norwegian Radiation Protection Institute, T. Bergan, A. Liland, L. Skuterud H. Thorrying; Göteborg University, M. Isaksson; University of the Faroe Islands, H. P. Joensen.

Timetable:

Reporting by the end of 2003.

Responsible scientists:

Eila Kostianen, Ritva Saxén, Kristina Rissanen

Thematic network project in the 5th Framework Programme of the EU (FARMING)**Objectives:**

'FARMING' refers to Food and Agriculture Restoration Management Involving Networked Groups. The project has several objectives for all five participating countries:

The main objective of the project is 'to create a European network of stakeholder groups initially in five member states, to assist in the development of robust and practicable strategies for restoring and managing rural areas contaminated by radioactivity' (ref.: www.ec-farming.net).

Description of the work:

The Finnish group is called 'The Finnish Expert Group on Food and Agricultural Industry's Preparedness for Nuclear Emergencies and Reduction Of Radiation Harms'. The group has formulated its terms of reference, it surveys how they are followed, and, in the contractual work for FARMING, the group will participate in the third national seminar in 2003. Additional effort in 2003 is the project workshop WISDOM in September. The workshop has been planned to facilitate further extension of the network to new participants in Europe. Participants will present the key results of the project achieved by the year 2003. STUK is responsible for coordination of FARMING work in Finland, and thereby sends representatives to the annual steering group meetings of the project. National coordinator is also responsible for reports of the stakeholder seminars and for providing updated information on the achievements of the stakeholder group to the project web-site.

Exploitation of results:

The results are made available through the project web-site www.ec-farming.net. After publishing the evaluation results of national seminars will be useful material for further analyses when stakeholders are involved in planning of emergency preparedness of the food branch.

Publication plan:

Stakeholder seminar results will be published either as STUK reports or in the WISDOM workshop in 2003.

Timetable:

The project was activated in November 1, 2000, and contributions of Finland will be finished by the end of June 2004.

Responsible scientists:

Aino Rantavaara, Riitta Hänninen

Emergency management and radiation monitoring in nuclear and radiological accidents (EMARAD)

Objectives:

EMARAD is an NKS project co-ordinated by STUK. The basic goal of the project is to create a web-based library that includes several pre-calculated radiological situations representing consequences of nuclear power plant accidents, nuclear submarine accidents, explosions of 'dirty' bombs etc. The library can be accessed by all Nordic radiation monitoring authorities who can use the stored results to plan and test radiation monitoring strategies.

Description of work:

A www server has been set up at STUK's headquarters. The server will contain a number of different scenarios and a selection of appropriate background material concerning radiation monitoring and monitoring strategies. The user interface will be designed with the intention of making the system suitable for planning and testing strategies. In addition, a report describing factors affecting radiation monitoring strategies in the Nordic countries will be produced.

Exploitation of results:

The results of the project provide emergency authorities with a reference library of consequence calculations and a tool that aids general planning of radiation monitoring strategies.

Publication plan:

The results will be published in the NKS report series. If appropriate, some of the main results may be published in scientific journals, too.

Collaborators:

The Technical Research Centre of Finland (VTT); Swedish Radiation Protection Authority (SSI); Lund University; Risö National Laboratory; Norwegian Radiation Protection Authority (NRPA); Icelandic Radiation Protection Institute.

Timetable:

The project was started in 2002 and is foreseen to end in 2004. However, decisions on the continuation of the project and on the work to be done are made separately every year.

Responsible scientists:

Juhani Lahtinen, Eila Kostiainen, Tarja Ilander, Kaj Vesterbacka, Riitta Hänninen

Testing of radiation surveillance equipment in aerial vehicles**Objectives:**

To install and test a prototype radiation surveillance equipment in aerial vehicles.

Description of the work:

The study is performed in cooperation between STUK and the Finnish Defence Forces. A prototype radiation surveillance equipment has been constructed earlier by STUK. The feasibility of different (radiation) detectors as well as the entire equipment are studied in Ranger unmanned aerial vehicle (UAV) and in Piper Chieftain aeroplane. In 2003 special emphasis is placed on the calculation of detection limits of different radionuclides, the control of thermal gradients in

the equipment and real time data transmission. Hereafter, test flights will be carried out.

Exploitation of results:

The tested equipment is a design basis for an operative radiation monitoring equipment intended to be equipped in Ranger UAV or other platforms in the near future.

Publication plan:

The final report for the Scientific Advisory Board for Defense will be ready on 31.12.2003. Several internal technical reports will also be prepared. Scientific publications will be issued later.

Timetable:

2002 - 2003

Responsible scientists:

Petri Smolander, Roy Pöllänen

3.6. Internal contamination, measuring methods and dosimetry

Estimation of human exposure to natural radionuclides, ^{nat}U and ²¹⁰Pb by using direct and indirect methods

Objectives:

The aim of this study is to develop a method to estimate the retrospective internal dose from natural radionuclides. Exposure to natural radionuclides in drinking water and indoor air is usually chronic. It is usually difficult to assess individual cumulative exposures of afflicted persons with biokinetic models because of several problems: activity concentrations in water and air may show great temporal variations, assumptions on individual water consumption rates have to be made and many biokinetic parameters are uncertain. Due to these difficulties with biokinetic models it would be useful to have a biological indicator in the human body itself. This would provide more direct information on the cumulative exposure.

Description of the work:

The instrumentation constructed at STUK for the *in vivo* measurements consists of four high purity broad energy Ge-detectors. Two measurement geometries can be used: the detectors can be placed either near the head or the knee of the studied person. The persons to be measured are selected in cooperation with the laboratory for Natural Radiation. The requirements are that the persons are volunteers, have a long history of exposure to natural uranium or radon and its daughter products either by using water from drilled wells with high concentrations of the natural radionuclides or living in a house with high indoor air radon concentration. In these cases it is possible that measurable amounts of ^{210}Pb or $^{\text{nat}}\text{U}$ have been concentrated in the skeleton as has already been demonstrated by the measurements taken.

The study persons are also asked to collect hair and nail samples and 24-h urine samples for the determination of ^{210}Pb and $^{\text{nat}}\text{U}$ concentrations. Analysing methods of ^{210}Pb and $^{\text{nat}}\text{U}$ in human samples will be further developed. For the possible variations in the intake of ^{210}Pb and $^{\text{nat}}\text{U}$ the concentration of radioactive substances in drinking water and indoor air radon concentrations are determined. A questionnaire is made to collect information on residential history, usage of drilled well water, daily beverage consumption (well water and other beverages) as well as smoking history and dietary habits.

Exploitation of results:

The results are used for the retrospective determination of radiation doses from natural radionuclides.

Publication plan:

The results will be presented at international meetings and published in scientific journals.

Timetable:

2000 - 2005

Responsible scientists:

Maarit Muikku, Marketta Puhakainen, Laina Salonen, Ilona Mäkeläinen

¹³⁷Cs body content and internal radiation doses to the population**Objectives:**

The objectives are to study the changes in internal radiation doses for the population and especially for population groups receiving more ¹³⁷Cs from the diet than the population in general. Such a diet includes much fresh water fish, game, wild mushrooms and wild berries from the areas with high ¹³⁷Cs deposition and in the reindeer-herding area, reindeer meat. By annually performed measurements of the population groups the changes in amounts of ¹³⁷Cs are monitored.

Description of the work:

The whole-body counting measurements are done either with a stationary system at STUK in Helsinki or with a mobile system installed in a truck. Two different types of population groups are followed. One type represents the population in general and the other people with special diets including much produce from nature. Population groups are measured in Southern, Central and Northern Finland and special dietary groups in Central and Northern Finland. The reference group from the Helsinki region with low ¹³⁷Cs deposition represents the mean of the population as has been shown earlier.

Exploitation of results:

The results are used for the estimation of radiation doses from caesium. The results also give information on the variation of and the highest radiation doses to Finns due to the Chernobyl accident.

Publication plan:

The results of the study will be presented at international meetings and published in international journals.

Timetable:

A continuous programme.

Responsible scientists:

Tua Rahola, Maarit Muikku, Sauli Pusa

The dependence of the biological half-life of caesium on age**Objectives:**

The possible changes of the biological excretion rate of caesium with age or other body parameters will be studied. The biological half-lives of the persons studied were previously determined about 30 years ago. The information is important when estimating radiation doses to individuals.

Description of the work:

Four of the persons studied earlier were able to take part in the study. Caesium-137 solution was administered orally to the persons studied. The study required many whole-body counting measurements to determine also the long component of the retention function. The amount of caesium excreted in urine was determined in parallel to the whole body measurements and the excretion rate at different points in time will be assessed.

The participants of the study were radiation protection professionals. The ethical approval was given by the Advisory Board for Radiation Safety.

Exploitation of results:

The results will be used for estimating the influence of biological half-life on the radiation doses received by Finns.

Publication plan:

The results will be presented at an international conference and published in a scientific journal.

Timetable:

1996 - 2004

Responsible scientists:

Tua Rahola, Marketta Puhakainen, Sauli Pusa

Indirect methods of analyses for internal contamination and dose assessment

Objectives:

The objective is to improve the methods to assess the amounts of radioactive material in the body. The doses from these materials are estimated by analysing the activities of radionuclides in human samples using indirect methods.

Description of the work:

Radiochemical analysis methods for determination of beta- and alpha-active materials in human samples are developed. When testing the methods urine, nail and hair samples are collected from the groups of people exposed to higher concentrations of both man-made and natural radionuclides than population in general.

Exploitation of results:

The results will be used for dose assessment and, if possible, in comparison of internal doses derived with other methods. The developed methods will later be used when estimating the mean levels and variation of concentrations of radionuclides in Finnish population.

Timetable:

2001- 2005

Responsible scientists:

Marketta Puhakainen, Tarja Heikkinen

Optimisation of monitoring for internal exposure (OMINEX)**Objectives:**

A worker in the nuclear industry may receive radiation doses either from external exposure or from internal exposure (eg from inhaled radionuclides). The costs of monitoring and control of internal exposure in the workplace are usually significantly greater than the equivalent costs for external exposures, and there is therefore a need to ensure that resources are employed with maximum effectiveness. This project aims to develop practical methods that could be used to optimise the design and implementation of internal exposure monitoring programmes for specified exposure situations.

Description of the work:

The project is divided into five work packages. In the first, headed by Tua Rahola, the current internal dose monitoring programmes in EC nuclear industries will be surveyed. Even after the implementation of the Basic Safety Standards there will be differences between national regulations. For optimisation information on these is needed. A questionnaire will be designed for gathering the information. The former experience and personal contacts of the consortium members will be used.

Exploitation of results:

The outcome of the project should be a common approach to the design and implementation of internal dose monitoring programmes throughout the EC.

Collaborators:

NRPB, G. Etherington, (co-ordinator) UK; IRSN, J-R. Jourdan, F; CEA, P. Berard, F; SCK-CEN, C. Hurtgen, B; EdF, B. Le-Guen, F; TVONS, R. Sundell, FI.

Publication plan:

The results will be published in international journals and in EC-reports.

Timetable:

The project will end in 2004.

Responsible scientists:

Tua Rahola, Maarit Muikku, Sauli Pusa

Annual effective dose to population in Finland

Objectives:

The aim of this study is to present a review of annual effective doses to population in Finland due to all sources of ionising radiation, both natural and artificial. The average annual effective dose to Finns as well as the regional variation in doses will be determined. Especially the population groups receiving doses higher than the average will be considered.

Description of the work:

In the first part of the study, the methods used in 1996 to determine the average annual effective dose to Finns will be reviewed. Second task is to update dose estimates by taking into account the present radiation situation in Finland. Finally, a plan for the continuous follow-up program will be contrived.

Exploitation of results:

The results will be used for determination and follow-up of annual radiation doses of population in Finland.

Timetable:

2003 -

A continuous program

Publication plan:

The results of the study will be presented in the series STUK-A.

Responsible scientists:

Maarit Muikku, Hannu Arvela, Kaj Vesterbacka, Kristina Rissanen, Eila Kostinen, Eija Vartiainen, Hannu Järvinen

Transfer of radionuclides in different radiation situations and decontamination of people, surfaces and objects

Objectives:

The objective is to demonstrate how radioactive substances are transferred, for example carried along with radiation workers, from work to home and to show how to decontaminate people, objects and indoor surfaces.

The activities can be determined either by surface contamination measurements or by more precise gamma measurements of clothes and other articles (like watches, keys and glasses) of the workers. A preliminary study at a nuclear power plant was carried out in 1986. The results were presented at a Nordic meeting in Maarianhamina, 1987. Now previous results will be documented and the project will continue.

Description of the work:

The results of the previous study made to find out the effectiveness of shower and sauna as decontamination methods will be used. In the study, the radiation workers were measured using the whole body counter before having shower, after shower and finally after sauna. Their towels were also measured. Another short project was to estimate the amounts of radioactive substances carried along from work to home with the civil clothes and other articles of the workers. Workers, who came to for whole body measurements, were asked to have also their clothes and other belongings measured.

Radionuclides are also transferred via the workers further on to the communal wastewater treatment plants. The aim is to determine the amounts of radionuclides in the urine of the workers and in the sewage sludge of nearby wastewater treatment plants and to compare the results to those of the whole body measurements. Data on radionuclide discharges reported by the power plant are used to estimate the amounts of radionuclides ending up to sewage sludge directly via air or via rainwater. As the project goes along valuable information about contamination and decontamination will be gained. A literature search will be done to obtain knowledge of the present developments in decontamination and decorporation of radionuclides.

Exploitation of results:

Using these results the amounts of radionuclides transported via the radiation workers from the nuclear power plant to home and to the wastewater treatment plant will be estimated and internal doses assessed. Collected data

will also be used in emergency preparedness planning giving instructions on decontamination and reducing radiation doses as well as possibilities of decorporation.

Publication plan:

The results will be published in the series STUK-A and in an international journal.

Timetable:

2003-2005

Responsible scientists:

Marketta Puhakainen, Eero Illukka

Fast method for detecting airborne artificial alpha-active substances

Objectives:

Rapid method for detecting artificial alpha-emitting nuclides present in the air will be developed.

Description of the work:

An aerosol sample is collected on the membrane filter which is measured directly without any chemical separation. A computer code will be developed for simulating alpha-particle spectra from aerosol samples. Different factors that affect the quality of the alpha spectra can be quickly studied. Measurements and simulations are carried out for validating the computer code, and before the filter type and material is chosen. Test measurements in varying environmental conditions (dust, high radon concentration etc.) are also needed. Measurement geometry has to be optimised.

Exploitation of results:

The results are used for planning of the measurement strategies. The resulting system can be used for measurements in the field as well as in the laboratory. The method will be employed in the programme of environmental radiation surveillance.

Publication plan:

The results will be published in STUK report series, conference proceedings and in scientific journals.

Timetable:

2003 - 2004

Responsible scientists:

Teemu Siiskonen, Roy Pöllänen

Improvement of the analysis chain for aerosol samples**Objectives:**

An automated gamma spectrum analysis pipeline, combined with a relational database, for aerosol sample measurements will be developed. Standardised interface for all data communications with the database will be defined. At the same time, precisely defined but flexible gamma-measurement geometry will be developed for aerosol samples from the nation-wide monitoring network.

Description of the work:

The structure and the data flow in the database and in the analysis chain as a whole will be defined, including documentation and definition of the messages with the database. Reporting and data entry programmes will be developed. The aerosol filter will be cut to equal-sized pieces which have round active areas. They will be measured without any pre-treatment. This way further analyses, like autoradiography, are possible. Efficiency calibration of the gamma detectors must be determined for samples which have the same diameter but varying height. Efficiency calibration will be based on the naturally-occurring radionuclides. This method has not been used before in STUK. Method will be tested and documented.

Exploitation of results:

The database will provide a standardised platform for airborne radioactivity data. New measurement geometry enables easy sample division and further analyses. At the same time, the geometry is precisely defined.

Publication plan:

The results will be published in STUK report series and in scientific journals.

Timetable:

2003 - 2004

Responsible scientists:

Teemu Siiskonen, Harri Toivonen

Neutron-induced background in gamma spectrometry

Objectives:

Secondary and tertiary neutrons which are produced by the cosmic radiation generate interfering background in the gamma spectroscopy. The background induced by the neutrons will be modelled.

Description of the work:

Important sources for the neutrons include the lead shield around the detector and the detector itself. The multiplicity and the energy spectrum of the liberated neutrons will be calculated using a microscopic nuclear-structure model. Obtained neutron spectrum is then used for modelling the detector background. Precise knowledge of this background is important when gamma peaks close to the detection limit are analysed.

Exploitation of results:

Accuracy of the activity calculation is improved for gamma peaks close to the detection limit.

Publication plan:

The results will be published in scientific journals.

Collaborators:

University of Jyväskylä, Department of Physics: J. Suhonen and M. Kortelainen.

Timetable:

2003 - 2005

Responsible scientist:

Teemu Siiskonen

4 Protection of the environment from the effects of ionizing radiation

Framework for Assessment of Environmental Impact (FASSET), (EU, 5th framework programme)

Objectives:

Radiation protection is generally based on the principles of the ICRP, according to which plants and animals are sufficiently protected when man, the most sensitive organism, is protected. During recent years it has been widely recognised that this principle is not sufficient on all occasions to protect other living organisms than humans from the harmful effects of radiation. In the legislation of many countries concerning nuclear energy it has been mentioned that radiation protection of the environment must be taken care of properly, but internationally accepted criteria or national frameworks do not yet exist.

The objective of this project is to create a framework for the protection of the environment. This is achieved by combining sources, exposure, dosimetry and environmental effects. Exposure pathways of various organisms, radiation doses and their effects will be considered in various discharge scenarios in typical European environmental conditions.

Description of the work:

STUK participates mainly in two work packages of the project, the exposure pathways and creating the framework. On the basis of the results from the various work packages and by taking into account the criteria for the protection of the environment against other harmful subjects in the environment, for instance chemicals, a systematic framework for radiation protection of the environment will be created.

The project is a shared cost EU project, which has eight partners. The coordinator of the project is SSI from Sweden. Three units from STUK in addition to Ecology and Foodchains will participate in the project. These are the NPP Environment, Nuclear Waste Management and the Regional Laboratory in Northern Finland. The Laboratory for Ecology and Foodchains contributes to the exposure pathways work package providing data on transfer factors of various radionuclides to biota in freshwater environment and the NPP Environment Laboratory respective factors in the Baltic Sea. Distribution

patterns of radionuclides in freshwater and terrestrial biota will be produced by the Laboratory for Ecology and Foodchains and the Regional Laboratory in Northern Finland. The contribution of the NPP Environment is based on the biota and special characteristics of the Baltic Sea. The project is finished in October 2003.

Exploitation of results:

A systematic framework for radiation protection of plants and animals and development of methods for estimating radiation doses received by organisms will create a basis for radiation protection of the environment. Simultaneously, the principle of maintaining biological diversity and durable use of natural resources will be considered. Results produced in the project are useful for decision-makers, for instance in connection with final disposal of nuclear waste.

Publication plan:

Results are published in scientific journals and presented at international meetings. Published reports can be found in the www.fasset.org.

Collaborators:

Swedish Radiation Protection Institute (SSI), C-M Larsson (co-ordinator), Sweden; Kemaka Konsult AB (Kemaka), Sweden; Swedish Nuclear Fuel and Waste Management Co. (SKB), Sweden; Stockholm University (SU), Sweden; UK Environment Agency (EA), UK; Centre for Ecology and Hydrology (CEH), UK; Westlakes Scientific Consulting Ltd (WSC), UK; Centre for Environment, Fisheries and Aquaculture Science (CEFAS), UK; German Federal Office for Radiation Protection (BfS), Germany; German National Centre for Environment and Health (GSF), Germany; Spanish Research Centre in Energy, Environment and Technology (CIEMAT), Spain; Norwegian Radiation Protection Authority (NRPA, Norway); University of Reading (UR), UK.

Timetable:

2000-2003

Responsible scientists:

Ritva Saxén, Riitta Hänninen, Erkki Ilus, Kristina Rissanen, Kirsti-Liisa Sjöblom

Environmental risks from ionizing contaminants: assessment and management (ERICA), (EU, 6th framework programme)**Objectives:**

The objective of ERICA is to provide and apply an integrated approach to scientific, managerial and societal issues concerned with the environmental effects of ionising contamination, with emphasis on biota and ecosystems. The final outcome of the project will be the ERICA integrated approach to assessment and management of environmental risks. The project will partly build on the achievements of the FASSET project, which provided a basic framework for the assessment of environmental impact of radionuclides. The FASSET project has also identified gaps in our basic knowledge about the effects from chronic exposure in different non-human organisms and problems associated with estimating the exposure of these organisms. Guidance is also lacking about how to characterise risks to the environment and to provide a firm scientific basis for managerial decisions and bring stakeholder views into decision making.

Description of the work:

The scientific objectives of ERICA will be achieved by carrying out experimental, theoretical and desk-studies to provide new data to cover the knowledge gaps in the following areas: source and hazard analysis, exposure analysis, dosimetry and dose-effect relationships at low dose rates and in the presence of other contaminants. Development of risk characterisation methodologies is also included. The assessment framework developed in FASSET will be applied to a number of case studies. A number of meetings with a group of end users will be organised to develop the managerial guidance.

Collaborators:

Swedish Radiation Protection Authority (SSI) C-M Larsson (co-ordinator), Swedish Nuclear Fuel and waste Management Company (SKB), Kemakta Konsult AB, Facilia, Södertörn University Campus, Stockholm University, Norwegian Radiation Protection Authority (NRPA), Spanish Research Centre in Energy, Environment and Technology (CIEMAT), Environment Agency of England and Wales (EA), Environmental Research Institute, Liverpool University (ERIC), Centre for Environment and Hydrology (CEH), Centre for Environment, Fisheries and Aquaculture Sciences (CEFAS), Westlakes Scientific Consulting Ltd (WSC), British Nuclear Fuel Ltd (BNFL), Institut de

Protection et de Sûreté Nucleaire (IRSN), Compagnie Generale de Matiere Nucleaires (COGEMA), St. Luke's Institute for Cancer Research (SLICR), German National Centre for Environmental and Health (GSF), Belgian Nuclear Research Centre (SCK-CEN), Agricultural University of Norway (AUN), Electricite de France (EDF).

Responsible scientists:

Ritva Saxén, Riitta Hänninen, Erkki Ilus, Kristina Rissanen, Kirsti-Liisa Sjöblom

Timetable:

2003 - 2006

5 Health effects of ionizing radiation

5.1 Epidemiology

A pooled analysis of European case-control studies on indoor radon and lung cancer

Objectives:

The aim of the study is to obtain a precise estimate of lung cancer risk due to indoor radon.

Description of the work:

Results of 13 European case-control studies will be pooled in a combined analysis. In addition, a glass-based measurement of cumulative radon exposure will be validated and risk estimate obtained for this alternative exposure assessment method.

Exploitation of results:

Radon risk assessment.

Collaborators:

Cancer Research UK/University of Oxford, National Radiological Protection Board (UK), Karolinska Institutet/Sweden, Statens Strålskyddsinstitut/Sweden, Finnish Cancer Registry, GSF/Germany, Tierärztliche Hochschule Hannover/Germany, Istituto Superiore dell Sanita and Associazione per la Ricerca di Epidemiologia/Italia, Universiteit Gent/Belgium, Insitut de Protection et de Surete Nucleaire/France, University College Dublin/Ireland, Tiroler Landkrankenanstalten Gesellschaft/Austria and National Radiological Protection Institute/Czechia.

Publication plan:

The results will be published in international journals.

Timetable:

The data collection has been completed and the results will be available in 2004.

Responsible scientists:

Anssi Auvinen, Ilona Mäkeläinen

Cancer incidence among workers in nuclear power plants

Objectives:

To obtain a precise cancer risk estimate for protracted exposure to ionising radiation.

Description of the work:

An international collaborative study coordinated by IARC is aimed at obtaining precise risk estimate for occupational exposure to repeated, low doses of ionising radiation in a combined analysis of cancer mortality of nuclear workers from 13 countries.

Exploitation of results:

Cancer risk assessment of ionising radiation.

Collaborators:

Finnish Cancer Registry, International Agency for Research on Cancer/WHO, National Radiological Protection Board (UK), Sweden, Germany, Belgium, Switzerland, France, Consejo de Seguridad Nuclear/Spain, USA, Canada, Japan

Publication plan:

The results will be published in international journals.

Timetable:

The data collection has been completed and the results will be available in 2004.

Responsible scientist:

Anssi Auvinen

Leukaemia in the vicinity of nuclear power plants**Objectives:**

To study the cancer incidence around Finnish nuclear power plants.

Description of the work:

Incidence of leukaemia in the vicinity of Finnish nuclear power plants is analysed by municipality and by distance from the plants. Furthermore, a case-control analysis is conducted to explore the distance at various time intervals prior to leukaemia diagnosis.

Exploitation of results:

The information is needed by the decision makers and citizens.

Collaborator:

Finnish Cancer Registry, National Public Health Institute

Publication plan:

The results will be published in international journals.

Timetable:

The data collection has been completed and the results will be available in 2004.

Responsible scientist:

Anssi Auvinen

Cancer incidence among x-ray workers**Objectives:**

To determine the cancer incidence among X-ray workers in Finland.

Description of the work:

All physicians occupationally exposed to ionising radiation are identified from the dose register maintained by STUK. A reference cohort of unexposed physicians is formed through the Statistics Finland. Information on cancer incidence is obtained from the cancer registry. A similar analysis will be carried out for other health care professions.

Exploitation of results:

The study will provide information for occupational risk assessment.

Collaborators:

University of Tampere, Finnish Cancer Registry.

Publication plan:

The results will be published in international journals.

Timetable:

Data collection is on-going and first results will be obtained in 2005.

Responsible scientist:

Anssi Auvinen

Cancer incidence among Baltic Chernobyl clean-up workers

Objectives:

To estimate cancer risk due to exposure to Chernobyl fallout.

Description of the work:

All approximately 15,000 persons sent to the Chernobyl area from the Baltic countries in the aftermath of the 1986 nuclear power plant accident are identified from dose registers, military lists and other sources. Information on cancer incidence is obtained from the national cancer registers. Incidence of leukaemia, thyroid cancer and other malignancies is compared with the national rates to evaluate possible effect of radiation on cancer risk.

Exploitation of results:

The study will provide information on the low dose cancer risk.

Collaborators:

Estonian Institute of Experimental and Clinical Medicine; Finnish Cancer Registry; National Cancer Institute of USA.

Publication plan:

The results will be published in international journals.

Timetable:

Data collection has been completed and results are expected in 2004.

Responsible scientist:

Anssi Auvinen

Fallout from Chernobyl and thyroid cancer

Objectives:

To estimate the thyroid doses of Finns received after the Chernobyl accident and study the incidence of thyroid cancer among children and adolescent.

Project description:

Level and geographical distribution of radioiodine and external radiation from the Chernobyl fallout are estimated at STUK. A case-control analysis of all thyroid cancer cases among persons less than 20 years of age at the time of the accident is conducted, comparing exposure levels among persons with thyroid cancer and the referents identified from the Population Registry.

Exploitation of results:

Results will be used for public health surveillance of the Chernobyl fallout.

Collaborator:

Finnish Cancer Registry

Publication plan:

The findings will be published in an international, peer-reviewed journal.

Timetable:

Data collection has been completed and the results will be available in 2004.

Responsible scientist:

Anssi Auvinen, Päivi Kurttio

Cancer incidence among airline crew

Objectives:

To obtain information on cancer risk due to cosmic radiation.

Description of the work:

Airline crews are occupationally exposed to low doses of cosmic radiation and an increased risk of breast cancer has been reported among Finnish cabin attendants. To evaluate possible effect on cancer risk, a Nordic collaborative study evaluates cancer incidence among cockpit and cabin crew and European joint analysis cancer mortality in airline personnel relative to the national rates. A Finnish case-control study compares the contribution of occupational and non-occupational factors on breast cancer risk among cabin attendants.

Exploitation of results:

Risk assessment of health effects of cosmic radiation.

Collaborators:

Finnish Cancer Registry; University of Tampere; Karolinska Institutet/Sweden; Norwegian Radiation Protection Authority; Danish Cancer Society; Istituto Superiore di Sanita/Italy; British Airways/UK; University of Athens/Greece

Publication plan:

Results will be published in international journals.

Timetable:

Data collection and analyses have been completed. First results were published in 2002 and further results are due in 2003 and 2004.

Responsible scientists:

Anssi Auvinen, Katja Kojo

Cancer risks from radioisotopes in drinking water**Objectives:**

To assess the health effects of ingested radon, uranium and other natural radionuclides occurring in high concentration in water from wells drilled in bedrock.

Description of the work:

Finland has exceptionally high concentrations of natural radioisotopes including uranium, radon and radium in groundwater. Some wells drilled in bedrock contain these radioisotopes in substantial concentrations. A cohort of Finns without municipal tap water supply is formed and occurrence leukaemia, stomach cancer, as well as kidney and bladder cancer are evaluated in relation to ingestion of various radioisotopes.

Exploitation of results:

Assessment of cancer risk from internally deposited radionuclides.

Collaborators:

Finnish Cancer Registry; Geological Survey of Finland; National Public Health Institute

Publication plan:

Results will be published in international journals.

Timetable:

First results were published in 2002 and further results will be available in 2003-2004.

Responsible scientists:

Anssi Auvinen, Päivi Kurttio, Laina Salonen

Health effects of uranium in drinking water

Objectives:

Evaluation of toxic effects of ingested uranium on kidney and other target organs.

Description of the work:

Finland has exceptionally high concentrations of natural uranium in groundwater and consequently, a proportion of the Finnish population is exposed to relatively high levels of uranium through ingestion of drinking water. Several thousand water samples have been analysed at STUK and persons with high levels of exposure are asked to participate in studies of health effects of uranium. Nephrotoxic effects of uranium are evaluated by measuring kidney function from blood and urine samples. Furthermore, possible effect on bone metabolism is assessed.

Exploitation of results:

Assessment of chemical toxicity of uranium.

Collaborators:

National Public Health Institute, Tampere University Hospital

Publication plan:

Results will be published in international journals.

Timetable:

First results were published in 2002 and further results are expected in 2004-2005.

Responsible scientists:

Päivi Kurttio, Laina Salonen, Anssi Auvinen

Risk factors for brain tumours**Objectives:**

Risk assessment of mobile phone use and diagnostic radiography in intracranial tumours.

Description of the work:

An international collaborative study on the effect of mobile phone use on brain tumour risk is conducted with coordination of IARC. A Nordic collaborative study evaluates the effects of medical irradiation, hormones and hereditary factors on brain tumour risk. All approximately 700 brain tumour and acoustic neurinoma cases diagnosed between November 2000 and September 2002 are interviewed by study nurses at the neurosurgery departments of the five Finnish university hospitals. A similar number of controls are identified from the population registry and interviewed. The diagnoses are evaluated in independent review and tumour microarrays are prepared. Blood samples are collected from a sample of cases and controls. Incidence trends of different brain tumour types are analysed in a Nordic collaborative study. Polymorphisms in various genes related to genomic integrity and xenobiotic detoxification are analysed in relation to brain tumour risk.

Exploitation of results:

The study provides risk estimates for mobile phone use in relation to intracranial tumours.

Collaborators:

Tampere, Helsinki, Turku, Kuopio and Oulu University Hospitals; Finnish Cancer Registry; International Agency for Research on Cancer/WHO; Karolinska Institutet/Sweden; Norwegian radiation Protection Authority; Danish Cancer Society; Cancer Research UK; Germany; France; Israel; Australia; New Zealand; Canada

Publication plan:

Results will be published in international journals.

Timetable:

First results will be available by 2004 and further results from 2005.

Responsible scientists:

Anssi Auvinen, Anna Lahkola, Päivi Kurttio

Cancer incidence among reindeer-herding Saami

Objectives:

Surveillance of possible health effects among people most heavily affected by the atmospheric nuclear bomb testing.

Project description:

Due to the lichen-reindeer-man pathway, Saami population was more heavily exposed than any other group to the fallout from atomic bomb testing in the 1950's and 1960's. A Nordic collaborative study evaluates cancer incidence among reindeer-herding Saami relative to other population of the northern Scandinavia to explore possible effect of radiation.

Exploitation of results:

Risk assessment of internal exposure to caesium and other internally deposited radionuclides.

Collaborators:

Finnish Cancer Registry; Södra Lapplands Forskningsenhet/Sweden; Cancer Registry of Norway; Norwegian Radiation Protection Authority

Publication plan:

Results will be published in international journals.

Timetable:

Data collection is completed and results will be available in 2004.

Responsible scientists:

Anssi Auvinen, Päivi Kurttio

5.2 Biological dosimetry

The use of FISH techniques for retrospective biodosimetry (COD)

Objectives:

To further investigate the achievements and limitations of using FISH techniques (translocation analysis) for biological dosimetry in cases of past exposures.

Description of the work:

More information is collected concerning the control levels of stable chromosome aberrations in individuals exposed to normal background levels of radiation. Data are needed to identify other possibly confounding factors than age which cause individual variations in control levels. The victims of recent radiation accidents are monitored with respect to their aberration frequencies in order to gain more knowledge on the stability of translocations with time. The project involves laboratories in seven countries with specialists in biological dosimetry.

Exploitation of results:

The results are exploited to achieve a pan-European consensus and recommendations on the usability of the FISH technique for retrospective dosimetry.

Collaborators:

National Radiological Protection Board, UK, Alan Edwards (Coordinator); Westlakes Research Institute, UK, Janet Tawn; Institute de radioprotection et de sûreté nucléaire, France, Philippe Voisin; Bundesamt für Strahlenschutz, Germany, Günther Stephan; University of Barcelona, Spain, Francesco Barquinero; University of Leiden, The Netherlands, Firouz Darroudi.

Publication plan:

One paper already published: Lindholm C, Romm H, Stephan G, Schmidts E, Moquet J, Edwards A. Intercomparison of translocation and dicentric frequencies between laboratories in a follow-up of the radiological accident in Estonia. *International Journal of Radiation Biology* 2002, 78 (10); 883-890.

Recommendations and other joint papers will be published in international journals.

Timetable:

The project has been completed in 2003.

Responsible scientist:

Carita Lindholm

Cytogenetic follow-up of the radiological accident in Estonia

Objectives:

The aim of the study is to assess the long-term persistency of translocations in peripheral lymphocytes.

Description of the work:

The yield of translocations will be followed in accident victims of the radiological accident in Estonia using FISH chromosome painting. Chromosome analysis is performed on samples taken once a year.

Exploitation of the results:

The long-term stability of translocations plays a major role in the assessment of the FISH technique as retrospective biodosimeter. The follow-up of the Estonia accident victims is especially important in order to achieve an international consensus, since a prospective study of accidentally exposed persons is practically the only means to clarify the persistency of translocations. There are indications that non-homogeneous irradiation reduces the stability of translocations with time. However, recent findings have implied that counting the yield of translocations only from stable cells improves their long-term persistency.

Collaborators:

Estonian Institute of Experimental and Clinical Medicine, Mare Tekkel, Toomas Veidebaum

Publication plan:

The results will be published in international journals.

Timetable:

Samples are collected once a year during undetermined time in the future.

Responsible scientist:

Carita Lindholm

5.3. Individual susceptibility

Cytogenetic biomarkers and human cancer risk (CancerRiskBiomarkers)**Objectives:**

To investigate the role of individual susceptibility factors in explaining the findings of high chromosomal aberration levels generally predicting increased cancer risk.

Description of the work:

An existing European cohort provides an exceptional opportunity to characterise susceptibility factors (genetic polymorphisms) by a molecular epidemiological approach, since archived cell specimens are available on most of the subjects - in addition to the cytogenetic results, exposure information, and cancer status already included in the database.

Exploitation of results:

The project will provide definite information about the effect of major known polymorphisms on the frequency of chromosome damage. This information can directly be utilised in design, method selection, and interpretation of genotoxicity surveys of exposure to occupational and environmental carcinogens, including biological dosimetry of radiation exposure. The project will also thoroughly characterise the cancer predictivity of chromosome damage and the possible modifying effect of genetic polymorphisms, thus providing valuable tools for policy makers and regulatory bodies in assessing various factors contributing to cancer risk.

Collaborators:

Finnish Institute of Occupational Health, Hannu Norppa (Coordinator) and 13 other European laboratories

Publication plan:

The results will be published in international journals.

Timetable:

The project will be completed in 2004

Responsible scientist:

Carita Lindholm

Susceptibility factors and biomarkers of effect in humans exposed to low dose radiation

Objectives:

The aim is to study a well-defined bio-sample database of Estonian Chernobyl clean-up workers for the association of individual susceptibility factors (genotypes) to chromosome aberrations.

Description of work:

The first aim is to collect data on chromosomal aberrations obtained using the FISH technique from cohorts of Estonian males exposed to radiation during clean-up work after the Chernobyl accident. A total of 300 exposed men, with preference to those in the highest doses, as well as 150 control persons will be studied. Isolated lymphocytes are available for cell culturing. The chromosome aberration yields, especially translocation yield, will be compared with individual recorded doses. Genotyping will be performed on a set of genes that are well-characterised and relevant for DNA-repair, e.g. XRCCT, XRCC3, hOGG1 and XPD, using PCR. The role of genotypes to the frequency of chromosomal aberrations will be determined using multivariate regression analysis. Confounding factors such as radiation exposure, smoking and age will be accounted for. The results on control individuals will be used to determine the baseline of the genotype-biomarker relationship.

Exploitation of results:

The results provide information on the effect of genotypes on individual responses to chronic low dose radiation as measured by chromosomal aberrations. The data also help in the evaluation of risk at low radiation dose.

Collaborators:

Estonian Institute of Experimental and Clinical Medicine, Toomas Veidebaum, Mare Tekkel, Mati Rahu

Publication plan:

The results will be published in international journals.

Timetable:

The project is commenced in 2003 and extends over several years

Responsible scientists:

Carita Lindholm, Anne Kiuru

Inter-individual differences in the yield of radiation-induced chromosomal aberrations and DNA-damage repair**Objectives:**

Aim of the project is to determine inter-individual differences in the sensitivity to ionising radiation by studying the amount of chromosomal aberrations and kinetics of DNA-damage repair.

Description of the work:

Blood samples have been collected from 10 persons who have not been exposed to radiation in their work. Blood samples have been irradiated *in vitro* using different doses of gamma radiation. The amount of translocations and other chromosomal aberrations are studied from these blood samples by using FISH chromosome painting method. The amount of chromosomal aberrations is compared between different persons and individual dose response curves are prepared. Individual differences in the amount of radiation-induced DNA-damage and damage repair in lymphocytes are studied by using the Comet

assay –method (single cell gel electrophoresis). Possible association between chromosomal aberrations and DNA-damage repair are determined.

Exploitation of results:

The results provide knowledge on inter-individual differences in the chromosomal aberration-DNA damage repair relationship. The project constitutes a part of a doctoral thesis.

Publication plan:

The results will be published in international journals in 2005.

Timetable:

Analyses will be completed during year 2004.

Responsible scientists:

Carita Lindholm, Anne Kiuru

Individual sensitivity in the aetiology of brain tumours

Objectives:

The aim of the project is to study the effect of individual sensitivity determining genes on the aetiology of brain cancer. This project is a part of the INTERPHONE study.

Description of the work:

This study is a Nordic collaboration project. In the INTERPHONE study blood samples have been drawn from Swedish, Danish and Finnish brain cancer patients. From these samples, xenobiotic- and cancer related genes will be studied in Sweden and DNA-repair genes in Finland. Finnish INTERPHONE material consists of brain cancer cases diagnosed in the age of 20 – 69 years and their controls collected during 3 years. Blood samples have been collected from altogether 180 cases (90 gliomas and 90 meningeomas) and 100 controls. Genotypes of DNA-repair genes (e.g. XRCC1, XRCC3, and hOGG1) are determined from DNA extracted from the blood samples in STUK. Genotypes of cancer related genes (preliminary list: p53, ATM, BRCA1, MSH6, CHJ2, P53R2) are analysed from the same DNA samples in the University of Umeå.

Genotypes of the xenobiotic genes (preliminary list: GSTT1, GSTM1, GSTM3, GSTP1, NQO1, CYP1A1) will be determined in the Karolinska Institutet. The relationship of all the studied genotypes with brain cancer risk is examined. In addition, the possible significance of radiation exposure will be determined.

Exploitation of results:

Results will give new information on the aetiology of brain cancer.

Collaborators:

Karolinska Institutet, Institut för Miljömedicin, Sweden, Anders Ahlbom, Maria Feyhting; University of Umeå, Sweden, Beatrice Malmer.

Publication plan:

The results will be published in international journals.

Timetable:

The project will last three years 2003 – 2005.

Responsible scientists:

Anssi Auvinen, Anne Kiuru, Carita Lindholm

The significance of individual radiation sensitivity to secondary cancer**Objectives:**

The aim of the project is to study individual radiation sensitivity related factors affecting induction of secondary sarcomas in patients who receive radiotherapy for treatment of cancer.

Description of the work:

In this project, genotypes of DNA-repair genes (e.g. MTHFR, ERCC1, ERCC2, XRCC1, XRCC3, hOGG1) and cancer related genes (e.g. p53, ATM, BRCA1, MSH6, CHJ2, P53R2) will be determined. Genotypes (SNPs = single nucleotide polymorphisms) are studied from DNA extracted from blood lymphocytes or paraffin embedded tissue blocks using a PCR-based method. Genotypes are determined from sarcoma patients who have a secondary tumour grown in the field of radiotherapy several years after the irradiation. These genotypes are

compared with the genotypes of sarcoma patients without preceding radiotherapy. Genotypes of DNA- repair genes are studied in STUK and genotypes related to cancer are determined in the University of Umeå. The same DNA samples will be studied in both institutes. At the moment there are about 10 living secondary sarcoma patients in Finland. Paraffin blocks are available from patients already dead (about 30). Corresponding samples are collected in Sweden. Blood samples of the patients can be used also for further analyses (e.g. Comet assay).

Exploitation of results:

Results of the projects concerning genotypes of DNA-repair genes and cancer related genes will give new information on secondary sarcomas. Received information can possibly be exploited when individual radiation therapy doses and prognosis of the patient are determined.

Collaborators:

The Helsinki University Central Hospital, Clinic for Radiotherapy and Oncology, M. Tarkkanen, R. Huuhtanen; Finnish Cancer Registry, T. Hakulinen.

Publication plan:

The results will be published in international journals.

Timetable:

The project will last three years (2003 – 2005).

Responsible scientists:

Anssi Auvinen, Anne Kiuru, Carita Lindholm

The effect of genotypes on stable chromosome aberrations in radon-exposed persons

Objectives:

The project aims to clarify the correlation of different genetic polymorphism of DNA repair and carcinogen metabolism to chromosome damage in persons exposed to radon.

Description of work:

A group of 84 persons with residential radon exposure have been previously studied by the FISH technique. The same material will be used for analysis of genotypes in different DNA repair genes as well as in genes involved in xenobiotic metabolism. Multivariate analysis will be performed in order to investigate the role of different genotypes to the yield of stable chromosome aberrations.

Exploitation of results:

The results will help to clarify the influence of different genotypes into the individual variation in the translocation yields.

Collaborators:

Finnish Institute of Occupational Health, Ari Hirvonen

Publication plan:

The results will be published in international journals in 2004.

Timetable:

The analyses have been completed in 2003.

Responsible scientist:

Carita Lindholm

5.4. Non-targeted effects

Mechanisms of radiation-induced genomic instability and bystander effect

Objectives:

The aim of the present project is to study mechanisms, a possible relationship and a biological purpose of the bystander effect and genomic instability in normal human epithelial and fibroblast cell lines.

Description of the work:

The radiation-induced bystander effect is a phenomenon whereby cellular effects are expressed in unirradiated neighbouring cells near to an irradiated cell or cells. Radiation-induced genomic instability is defined as a persistent elevation in the rate of *de novo* appearance of genetic changes within a clonal population. Recent research demonstrates that bystander effects and genomic instability are related. In the present study we will use human fibroblast and epithelial cell lines. Experiments will employ medium transfer technique, conventional broad field and microbeam irradiations. A variety of endpoints related to intercellular signalling (connexins expression, changes in Gap Junction Intercellular Communication) and cellular response (apoptosis, chromosomal damage, p21Waf, TP53 and cyclins expression) will be used.

Exploitation of results:

Bystander effects and genomic instability are important in several areas related to radiation. These phenomena might contribute to the estimation of cancer risk from domestic radon exposure and uranium in drinking water, the effects of space radiation, high energy radiotherapy outcome, health effects of air crew and nuclear power station personnel. In particular, bystander effect and genomic instability are potentiality significant for radiation protection issues and may have implications for the applicability of the Linear-No-Threshold (LNT) model in extrapolating radiation risk data into the low-dose region.

Collaborators:

Gray Cancer Institute, Northwood, UK, K.M. Prise.

Publication plan:

We plan to present data obtained during the present study at two scientific meetings and publish two articles in international journals with referee practice.

Timetable:

Project begins in 2003 and ends in 2005. Project is supported by Marie Curie Individual Fellowship under EU sponsored Euratom Specific Programme on Nuclear Energy Research.

Responsible scientists:

Oleg V. Belyakov, Sisko Salomaa, Dariusz Leszczynski

Mechanisms of radiation-induced bystander effects and genomic instability in artificial human skin tissue systems and skin explants (RISC-RAD)**Objectives:**

The objective of the project is to study mechanisms of induction and perpetuation of radiation induced bystander effects and genomic instability in human three-dimensional (3D) tissue skin system. The final goal is to develop a hypothesis for the role of these non-targeted phenomena in radiation-induced tissue response and, ultimately, carcinogenesis.

Description of the work:

Our rationale is that bystander effect and genomic instability are likely to be natural phenomena which should be studied in an *in vivo* like multi-cellular system with preserved 3D tissue micro-architecture and microenvironment. Our project employs 3D artificial human skin models that will be exposed to non-targeted (narrow and broad field α -particle) and targeted (microbeam proton and $^3\text{He}^{2+}$) irradiations. Three different approaches for post-irradiation tissue processing will be implemented: preparation of serial histological sections, disaggregation of a tissue sample for subsequent cultivation or flow cytometry and studying endpoints of interest *in situ* with confocal microscope. Mechanisms of radiation induced bystander effects and genomic instability under *in vivo* like 3D tissue conditions will be studied with a panel of endpoints: *in situ* apoptosis assay and bystander-induced differentiation, proliferative pattern assessment, cell cycle analysis and intercellular communication.

Exploitation of results:

The study of radiation induced non-targeted effects is important for understanding the dose response mechanisms relevant to low dose natural and man-made radiation. Regrettably, the current state of understanding of the underlying mechanistic basis of radiation induced effects and genomic instability *in vivo* does not allow a firm conclusion to be expressed on the validity of an association with a reduction or increase of cancer risk in human populations. Expected results of the present project will contribute to the current discussion about health effects of low dose irradiation.

Collaborators:

This work is a part of an EU funded RISC-RAD integrated project coordinated by Dr. L. Sabatier, Radiobiology and Oncology Unit, the French Atomic Energy Commission (CEA), Fontenay-aux-Roses, France. 29 research groups from

different European countries are involved in this project. A major collaboration is planned with Dr. K.M. Prise, Gray Cancer Institute, Northwood, UK.

Publication plan:

We plan to present data obtained during the present study at two scientific meetings and publish two articles in international journals with referee practice.

Timetable:

First stage of the project will begin in 2004 and end in 2006.

Responsible scientists:

Sisko Salomaa, Oleg V. Belyakov, Dariusz Leszczynski

6 Non-ionizing radiation

6.1 Radiation metrology and dosimetry

The combined effects of electromagnetic fields with environmental carcinogenes (CEMFEC)

Objective:

This is an EC project belonging to the 5th framework programme. The project is coordinated by the University of Kuopio. The objective is to study the combined effects of the MX carcinogen in drinking water and 900 MHz GSM mobile phone radiation. STUK's task is to develop the exposure system which enables an accurately known and uniform simultaneous exposure for a large group of rats. The system will consist of large exposure chambers with 25 rats placed in each chamber where they can freely move in their cages.

Description of the work:

The exposure system was designed and constructed at the beginning of 2001 and it was mounted in Kuopio in May 2001. The exposure of the animals was started at the end of May 2001. The system consists of nine exposure chambers. Each chamber is made of two parallel circular parallel aluminium plates short-circuited at the edges. The diameter of the plates is approx. 1.5 m and the separation distance is 15 cm. Radiofrequency power is fed into chamber through a monopole antenna mounted in the centre of the chamber. Most of the power of the radial TEM wave radiated by the antenna is absorbed by the rats placed near the edge of the chamber. The average Specific Absorption Rate (SAR) of the rats per input power of the chamber was determined with computations and calorimetric measurements. The input power and the power reflected from the chambers are continuously monitored during exposures by using RF power meters. STUK has calibrated the RF power meters at least once a year. STUK has studied by stability of the chambers by return loss measurements carried out twice a year. The exposures will end at the end of May 2003.

Exploitation of results:

The University of Kuopio is using the exposure system for exposing rats to 900 MHz GSM mobile phone radiation.

Publication plan:

A report has been written on the development of the exposure system and the initial RF dosimetry. The accuracy of the dosimetry will be followed and studied during the animal exposures. The final report on the dosimetry will be prepared by the end of November 2003. The results will also be published in the series of international scientific publications.

Collaborators:

University of Kuopio, J. Juutilainen (coordinator) FI; Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung, Munchen, Germany, H. Ernst, D; VITO-Vlaamse Instelling voor Technologisch Onderzoek NV, L. Verschaeve, B; Università degli Studi di Genova (UGOA), M.-R. Scarfi, I.

Responsible scientist:

Lauri Puranen

Antenna design, measurement techniques and standardization (AMEST)

Objective:

This is a large multi-centre study funded partly by TEKES. The objective is to improve the performance of base station and mobile handset antennas. The main objective of STUK's research is to develop a transfer standard for SAR probe calibrations and numerical methods for assessing the low-frequency current density induced in the head of a mobile phone user due to the battery currents of the phone.

Description of the work:

Different possibilities to implement a transfer standard for SAR probes were studied with analytical and numerical methods in 2002. According to the results obtained from the calculations a transfer standard operating at 900 MHz and at 1800 Mhz was designed and it will be constructed and tested by the end of June 2003. The development of a computation software for assessing the low-frequency current density induced in the head was started and a numerical head model was created in 2002. The software based on the impedance method will be validated and induced current densities will be computed for popular GSM phone models in 2003.

Exploitation of results:

The developed transfer standard will be used for on-site calibration of SAR probes in Finnish SAR laboratories.

Publication plan:

A report has been written on the design of the transfer standard in 2002. Reports will be prepared on the testing of the transfer standard and on the development of the numerical method for the assessment of the current density by the end of 2003. The results will also be published in the series of international scientific publications.

laborators:

Helsinki University of Technology, P. Vainikainen; Technical Research Centre of Finland; K Laukkanen, Nokia Research Center, K. Kiesi, Filtronic LK, P. Annamaa

Responsible scientist:

Lauri Puranen

Development of broad-band weighted magnetic field meter**Objective:**

In the frequency range up to 100 kHz there are a number of sources of non-sinusoidal magnetic fields with the potential to exceed the exposure guidelines. Mos 50 Hz magnetic fields, for example, are distorted by harmonic components, which sybstantially influence the exposure. Biologically, it is usually more important to restrict peak value than the rms-value of pulsed or complex non-sinusoidal field.

What makes the exposure assessment even more complicated is that the reference levels vary with frequency. There is a method first proposed by Kari Jokela (Jokela 2000) and then accepted by ICNIRP (ICNIRP statement 2003) that recognizes these characteristics of non-sinusoidal waveforms and the nature of biological interactions as well. The method is called weighted peak restriction, and it is exploited in this meter wich is under development at STUK. At the moment, there are no such instruments commercially available. In the first phase, the objective is to build a small series of hand-held instruments for the collaborators of this project, the next phase involves a technology transfer to a Finnish manufacturer.

Description of the work:

The first prototype of the magnetic field meter has been constructed and tested in 2002, and a more sophisticated second prototype is under work. This prototype will be ready by the end of 2003. A small series of these instruments will be manufactured for the collaborators of this project during 2004.

Exploitation of the results:

The meter can be utilized to verify the compliance of broad band magnetic field exposure with the decree (294/2002) of the Ministry of Social Affairs and Health. Sources to be measured include overhead power lines, indoor distribution substations, electronic surveillance equipment (EAS), metal detectors, induction furnaces and arc furnaces.

Publication plan:

The design and testing results of this measurement system will be published in the series of international scientific publications.

Collaborators:

Ministry of Social Affairs and Health, Ministry of Trade and Industry, Helsinki Energy, Metorex Security Products Oy, Fingrid Oyj, Tampere University of Technology, Stadia.

Timetable:

2002 - 2004

Responsible scientist:

Kari Jokela

The improvement of practical methods for quality assurance of UV treatments

Objectives:

The research is a continuation study of a study made in 1996-1997 in collaboration with STUK and National Agency of Medicine. In this project the data of medical lamps will be updated and the measurement data will be harmonised. The current status of quality assurance (QA) in phototherapy clinics will be surveyed. Detailed practical instructions for quality assurance

will be made. A fast and easily transportable spectral measurement system for dose measurement of phototherapy devices and solariums will be developed.

Description of the work:

The UV-therapy lamps currently available in the market will be investigated and lamp-types missing from STUK's inventory will be purchased. All the lamps will be measured with a similar method.

The current quality assurance practices in phototherapy clinics will be investigated by a questionnaire. Also the effect of the previous study on QA-practices will be investigated.

Detailed and practical instructions for defining the patient's dose, for measuring the dose rate of the equipment and for monitoring the dose rate of the equipment.

The cosine-response, stability, temperature response and other things influencing the measurement accuracy and reliability of Ocean Optics S2000 spectroradiometer will be measured in the laboratory, the measurement uncertainty estimation based on these measurements will be made and correction algorithms will be developed. To verify the new measurement system comparison measurements will be done with current Optronic 742 spectroradiometer.

Exploitation of results:

The lamp-data is updated and consisted. The measurements of spectral irradiance in tanning saloons and phototherapy clinics are easier to make.

Publication plan:

The results will be published in the project report and in international scientific publications.

Responsible scientist:

Lasse Ylianttila

6.2 Biological effects

Development of *In Vitro* Dosimetry and Bio-Markers (LaVita)

Objectives:

The issue of the potential health hazards of mobile telephones remains unclear. The objective of STUK is to study whether changes in expression of heat-shock proteins could be used as a marker of the severity of cellular exposure and/or response to radiofrequency-modulated electromagnetic fields.

Description of the work:

The proposed project will consist of *in vitro* dosimetry and biological studies. In particular there will be development of dosimetry for a variety of cell culture set-ups and biological markers of cell exposure to RF-ELF of varying SAR.

Exploitation of results:

The results will be used in the development of new health safety standards for portable phones.

Publication plan:

Leszczynski D, Joenväärä S, Reivinen J, Kuokka R. Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: Molecular mechanism for cancer- and blood-brain barrier-related effects. *Differentiation*, vol. 70, 2002, pp 120-129. Leszczynski D, Nylund R, Joenväärä S, Reivinen J. Applicability of discovery science approach to determine biological effects of mobile phone radiation. *Proteomics*, vol. 4 issue 2 (February) 2004, in press.

Collaborators:

The project is part of the LaVita consortium project that is funded by the National Technology Agency. Kuopio University, J. Juutilainen (coordinator). The consortium consists of 9 research groups from Kuopio University, Turku University, Tampere University, the Finnish Institute of Occupational Health and VTT-Information Technology, Finland.

Timetable:

Project will end in 2003.

Responsible scientist:

Dariusz Leszczynski

Potential health hazards of mobile telephones (REFLEX)**Objectives:**

The issue of the potential health risks of mobile telephones remains unclear. The objective of STUK is to study whether radiofrequency-modulated electromagnetic fields have effect in expression of genes or protein and on cell cycle kinetics in vitro.

Description of the work:

This research project is part of an EU-funded (Quality of Life) consortium. STUK will investigate the effects of radiofrequency-modulated electromagnetic fields (RF-ELF, 900MHz GSM signal) on the pattern of expression of genes and their protein products and on cell cycle kinetics (proliferation, cell cycle and cell death).

Exploitation of results:

The results obtained in the execution of this project, together with the results of the ongoing study of the RF-ELF effects on protein phosphorylation and receptor function (ongoing since 1998 the National Technology Agency funded project) and the future LaVita/National Technology Agency project, will determine whether there is any potential risk of hazardous effects of cell exposure to radiation emitted by portable telephones. This issue is still uncertain and requires clarification in order to address the public's health concerns.

Publication plan:

Leszczynski D, Joenväärä S, Reivinen J, Kuokka R. Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: Molecular mechanism for cancer- and blood-brain barrier-related effects. *Differentiation*, vol. 70, 2002, pp 120-129. Leszczynski D, Nylund R, Joenväärä S, Reivinen J. Applicability of discovery science approach to determine biological effects of mobile phone radiation. *Proteomics*, vol. 4 issue 2 (February) 2004, in press.

Collaborators:

VerUm Foundation for Behaviour and Environment, Munich, Germany, F. Adlkofer (coordinator); Universitätsklinikum Benjamin Franklin, Berlin, Germany, R. Tauber; Institut fuer Pflanzengenetik und Kulturpflanzenforschung, Germany, A.M. Wobus; Universität Hannover, Germany, H.A. Kolb; Universitätsklinik fuer Innere Medizin IV, Vienna, Austria, O. Jahn; Hospital Ramon y Cajal, Madrid, Spain, J. Leal; University of Bologna, Italy, F. Bersani; University of Milan, Italy, F. Clementi; Ecole Nationale Supérieure de Chimie et de Physique, Bordeaux, France B. Veyret and I. Lagroye; Swiss Federal Institute of Technology, Zurich, Switzerland, N. Kuster.

Timetable:

The project started in 2003 and final report will be published in 2004.

Responsible scientist:

Dariusz Leszczynski

Transcriptomics and proteomics approach to study cellular responses to mobile phone radiation

Objectives:

The issue of the potential health risks of mobile telephones remains unclear. The objective of STUK is to study whether radiofrequency modulated electromagnetic fields have effect on cellular signal transduction.

Description of the work:

This research project investigates the effects of radiofrequency-modulated electro-magnetic fields emitted by 900 GSM and 1800 GSM phones on:

- blood-brain barrier permeability using in vitro model
- activity of protein kinases located upstream of hsp27 stress response protein
- changes in expression of genes (cDNA Expression Arrays) by analysing up to 85.000 genes and their fragments (German Genome Center in Heidelberg)
- changes in expression of proteins
- identification of differentially expressed proteins by Maldi-ToF mass spectrometry

Exploitation of results:

The results obtained in the execution of this project, together with the results obtained from the REFLEX project and LaVita-project will provide information that will help to estimate the potential risk of hazardous effects of the exposure to radiation emitted by portable telephones. This issue is still uncertain and requires clarification in order to address the public's health concerns. Project will be funded by STUK. Applications for supplementary funding from the Academy of Finland, TEKES and EU are in progress.

Publication plan:

The results will be published in international journals.

Collaborators:

German Genome Center, Heidelberg, Germany, Ch. Maercker; Sydney Technical University, Sydney Australia, Donald Martin; University of Pretoria, Pretoria, South Africa, C. Huyser; University Laval, Quebec City, Quebec, Canada, Jacques Landry; Bureau of Standards, Pretoria, South Africa, Francois le Roux Fourie; Swiss Federal Institute of Technology, Zurich, Switzerland, N. Kuster.

Timetable:

The project will be executed from 2003 onwards.

Responsible scientist:

Dariusz Leszczynski, Reetta Kuokka

UVA effects on melanoma metastasis (SYTYKE)**Objectives:**

The study examines effect of long-wave ultraviolet radiation (UVA) on metastatic potential of melanoma.

Description of the work:

Project consists of in vitro experiments, using human and mice cell cultures, and of animal experiments.

Using mice B16-F1 and B16-F10 melanoma cell lines and endothelial cell line MS1 are examined effects of UVA radiation on:

- adhesion between melanoma cell themselves and adhesion with

endothelial cells,

- expression of cadherins (flow cytometry),
- changes in expression of adhesion molecules encoding genes (cDNA Expression Arrays).

Effect of UVA on formation of lung metastases by i.v. injected melanoma cells is examined using UVA-exposed and non-exposed C57BL/6 mice.

Exploitation of results:

The results obtained at STUK will provide information concerning the potential health risks of exposure to long-wave UV radiation (UVA) that is present in solar UV radiation and is a major part of the UV-spectrum emitted by solaria. This issue is still uncertain and requires clarification in order to address the public's health concerns. The project is part of the Postgraduate School on Environment and Health (SYTYKE) of the Academy of Finland. A PhD thesis of a researcher will be based on this work.

Publication plan:

The results will be published in international journals. A PhD thesis will be prepared within this project (expected in 2005).

Timetable:

Project ends in 2004 and extension for 2005 is being applied.

Responsible scientists:

Dariusz Leszczynski, Riikka Pastila

Mechanism of mobile phone radiation-induced bioeffects (HERMO/Mechanisms)

Objectives:

The issue of the potential health hazards of mobile telephones remains unclear. Research project will search for the biophysical mechanism behind the observed in some studies non-thermal biological effects of mobile phone radiation.

Description of the work:

Project will determine whether exposure of cells to mobile phone radiation causes broad-range activation of cellular stress response and whether it causes abnormal protein conformation. In particular the following will be examined in

two specific aims:

- Expression of Hsp27, Hsp60, Hsp70 and Hsp90 in SY5Y and EA.hy926 cells,
- Expression, phosphorylation and cellular localization of Hsp27 protein in SY5Y cells,
- Changes in protein conformation induced in SY5Y and EA.hy926 cells,
- Changes in expression of genes and proteins involved in degradation of misfolded/aggregated proteins.

Exploitation of results:

Execution of this project will provide information whether mobile phone radiation is able to cause abnormal protein aggregation in cells, like the one occurring in neurodegenerative diseases. Claims of such possible effects have been put forward by some research groups. However, there is missing proof of mobile phone radiation being able to cause misfolding of proteins or their pathological aggregation. Clarification of this issue is important. Results of this study will either support or dismiss claims of potential neurodegenerative impact of mobile phone radiation.

Collaborators:

The project is part of the LaVita-2 consortium project that is funded by the National Technology Agency. Kuopio University, J. Juutilainen (coordinator). The consortium consists of 9 research groups from Kuopio University, Turku University, Tampere University, the Finnish Institute of Occupational Health and VTT-Information Technology, Finland. LaVita-2 Mechanisms projects involves collaboration with foreign researchers: Prof. Niels Kuster, IT'IS ETH, Zurich, Switzerland; Dr. Christian Maercker, DKFZ, Heidelberg, Germany; Prof. Tim Griffin, Univ. Minnesota, MN, USA; Prof. James Weaver, MIT, Cambridge, MA, USA.

Timetable:

Project will take 2 years, 2004-2006.

Responsible scientists:

Dariusz Leszczynski, Reetta Nylund

UVA effects on melanoma cells

Objectives:

The study examines effect of long-wave ultraviolet radiation (UVA) on melanoma.

Description of work:

Project consists of in vitro experiments, using human and mice cell cultures, and of animal experiments. Using mice B16-F1 and B16-F10 melanoma cell lines and endothelial cell line MS1 are examined effects of UVA radiation on:

- adhesion between melanoma cell themselves and adhesion with endothelial cells,
- expression of cadherins (flow cytometry),
- changes in expression of adhesion molecules encoding genes (cDNA Expression Arrays).

Effect of UVA on formation of lung metastases by i.v. injected melanoma cells is examined using UVA-exposed and non-exposed C57BL/6 mice.

Exploitation of results:

The results obtained at STUK will provide information concerning the potential health risks of exposure to long-wave UV radiation (UVA) that is present in solar UV radiation and is a major part of the UV-spectrum emitted by solaria. This issue is still uncertain and requires clarification in order to address the public's health concerns. The project is continuation of the project executed as part of the Postgraduate School on Environment and Health (SYTYKE) of the Academy of Finland. A PhD thesis of a researcher will be based on this work.

Collaborators:

Prof. R. Rox Anderson and Prof. Charles Lin, Harvard University, Boston, USA.

Publication plan

Results will be published in peer-review journals.

Timetable:

Project will last for ca. 2 years (2004-2005).

Responsible scientist:

Dariusz Leszczynski, Riikka Pastila

6.3. Epidemiology

Case-control study on mobile phone use and brain tumours (INTERPHONE)

Objectives:

To determine whether exposure to mobile phone radiation might increase number of brain cancer cases among the users.

Description of the work:

The aim of the study is to assess the possible risk of brain tumours (meningioma and glioma) related to use of mobile phones. All incident brain tumour cases have been interviewed at neurosurgery clinics of all the five university hospitals in Finland between November 2000 and September 2002. The interview covered issues related to mobile phone use such as number and duration of calls, laterality of use, hands-free devices, use while moving/stationary, urban/rural, type of phone and network. A similar interview has been performed for controls identified from the Population Register Centre.

Exploitation of results:

Results will be used in estimation of the potential health risk of mobile phone radiation.

Collaborators:

The material has been collected in collaboration with neurosurgery clinics in Finland. International collaboration coordinated by the International Agency for Research on Cancer enables analysis of up to 5000 tumour cases and a similar number of controls, which will provide much more precise risk estimates than available from any single study. The international study group includes collaborators from Sweden, Denmark, Norway, Germany, Great Britain, France, Italy, Israel, Australia, New Zealand, Canada and United States. Support for the study has also been obtained from the academy of Finland for hiring a post-doctoral scientist.

Publication plan:

Results will be published in peer-review journals.

Timetable:

The data collection has been completed and editing is on-going. The results of the international collaborative analysis will be available in 2006.

Responsible scientist:

Anssi Auvinen, Päivi Kurttio, Anna Lahkola

Mobile phone use and brain tumour risk: assessment of uncertainty and sources of error (HERMO/Epidemiology)

Objectives:

The aim of the project is to identify and quantify the sources of error in an epidemiological study.

Description of the work:

Project will identify and quantify the sources of error in an epidemiological study including selection bias, information bias and measurement error (misclassification). This allows a sensitivity analysis for determination of potential impact on the results and correction of the results already at the analysis stage. This assessment has not been included in the INTERPHONE study and therefore a separate effort is needed for data collection.

Exploitation of results:

Results will be used in evaluation of the validity of results generated by the INTERPHONE project.

Collaborators:

Finnish Cancer Registry, University of Tampere

Publication plan:

Results will be published in peer-review journals.

Timetable:

Project will take 2 years; 2004-2006.

Responsible scientist:

Anssi Auvinen

Ultraviolet radiation and skin cancer**Objectives:**

To determine the possible correlation between UV skin exposure and incidence of skin cancer.

Description of the work:

Information on incidence of cutaneous malignant melanoma is obtained from the cancer registry and evaluated in relation to UVR exposure. Effect of UVR on skin can be evaluated by measuring the changes in bioimpedance (dielectric constant). The reliability and validity of the biophysical measurement is assessed. Early detection of skin cancer is sought in cancer society campaigns. Detection rates and sensitivity of the campaign is evaluated by obtaining information on cancer incidence among attendees of Pirkanmaa Cancer Society campaign clinic.

Exploitation of results:

Results will be used to advice population at large about the risks of UV exposure.

Collaborators:

Finnish Cancer Registry, University of Turku; University of Oulu; Pirkanmaa Cancer Society; Delfin Technologies

Publication plan:

Results will be published in peer-review journals.

Timetable:

First results will be available in 2004 and further results in 2005.

Responsible scientists:

Katja Kojo, Anssi Auvinen.

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