

## Introduction

Radiation has existed everywhere in the environment since the Earth's formation--in rocks, soil, water, and plants. The mining and processing of naturally occurring radioactive materials for use in medicine, power generation, consumer products, and industry inevitably generate emissions and waste. Recognizing the potential hazards of these activities, radiation protection aims at protecting people and the environment from harmful and avoidable exposure to radiation.

As a federal research Centre, SCK•CEN has the statutory assignment to give priority to research related to safety, radioactive waste management, protection of man and environment, management of fissile and other strategic materials and social implications as part of the pursuit of sustainable development and to develop and gather the necessary knowledge and spread this knowledge through formation and communication.

At the Division of Radiation Protection at SCK•CEN we are therefore active to maintain and enhance knowledge and expertise in each aspect of radiation protection: we study the risk of exposure – the way that radioactive materials spread in the environment and the potential for human contact – and the risk from exposure – how radiation affects human health; we perform health physics measurements; we are involved in emergency planning and preparedness and support to risk governance and decision taking. These activities are supported by radiation specific analysis and measurement techniques. These activities are not performed in isolation but in context of national and international collaborations or demands.

## Health measurements and effects

At SCK•CEN several health measurement services are delivered. Dosimeters are provided and evaluated for workers who work with ionising radiation. At present more than 6000 persons are followed. Whole Body Counting is performed for 750 persons and 100 lung measurements are carried out.

Exposure following medical applications accounts for about 50 % of the average annual effective dose for the Belgian population. We are involved in studies and projects on the estimation and optimisation of doses to patients and medical personnel (e.g. EC CONRAD project) in interventional radiology.

The biological effects of the medical use of ionizing radiation and radioactive substances in radiotherapy and medical imaging is one of the principal fields of radiobiological research in radiation protection at SCK•CEN. Other important research areas are devoted to the influence of low doses of radiation on the development of embryos and female gametes, genetic risks after exposure to radiation and the influence of radiation on the nervous system under development. This research is carried out in national and international context. The Radiobiology group is involved in the European NOTES project, studying the non targeted effects of ionizing radiation. The European project GENRISK-T aims to better understand the genetic components of thyroid cancer induction after an irradiation at a low dose. SCK•CEN participates by virtue of its expertise in molecular and cellular biology. The radiosensitivity of the embryonic brain and the mechanisms of radiation-induced mental retardation, as observed amongst the survivors of Hiroshima and Nagasaki, is also a point of interest.



*Biology research: cell fluorimeter*

Since 2001 SCK•CEN has also been involved in biological research on the effects of radiation and weightlessness on man and micro-organisms within the framework of space flights. During these flights received dose can be up to 100 to 200 times the amount received on the ground. The space flights and the ground simulation experiments enable the study of short-term reactions and long-term adaptations of organisms in space. SCK•CEN researchers and their Belgian and international partners cultivate bacteria and human cells in the international space station (ISS) and study in detail the effects (on DNA and gene expression) on these cells at the time of their return to Earth.

During long-term missions, large food supplies will be necessary and tons of waste will be produced and will have to be processed. For this reason, ESA develops in collaboration with SCK•CEN a closed mini-ecosystem named MELiSSA. The MELiSSA system consists of a loop of biological reactors which make it possible to transform waste (carbon dioxide and organic material) and to produce oxygen and food. Micro-

organisms can cause infections and diseases, and pollute, and corrode structural materials. For this reason, SCK•CEN collaborates with European, Russian and American scientists to index and quantify the various kinds of bacteria and moulds present in these closed microcosms, in order to be able to develop new methods of prevention, detection and remediation. The extreme conditions in space have an effect on all living cells. We check the stability of DNA and the changes in gene expression following cosmic radiation and/or the microgravity conditions.

### Radioactivity in the environment: from monitoring to impact studies

Environmental contamination may result from the use of nuclear power for electricity production and for military and industrial applications, from the exploitation and treatment of ores and materials containing natural radionuclides (NORM) or from applications in medicine and research.

We have the in-house expertise, equipment and devices for monitoring environmental contamination and for sampling at contaminated sites. We are involved in the radiological surveillance programme under the authority of the FANC with a focus on monitoring routine releases by the nuclear industry.



*sampling in the Meuse*

To improve and facilitate our monitoring performance an airborne gamma counter (mounted on a helicopter) was connected with a GPS system, which allows for fast mapping and data processing, required for example in case of large-scale environmental contamination in case of emergencies. These airborne measurements can also be very useful for mapping inaccessible terrains.

To estimate the radiation exposure for man and the environment resulting from this environmental contamination and in order to propose appropriate countermeasures to reduce the resulting radiation exposure, in depth knowledge of the behaviour of radionuclides in the environment is

needed. Mechanisms and dynamics of radionuclide transfer are studied e.g. for making soil vulnerability classifications. We study and develop countermeasures and evaluate their feasibility and short and long-term efficiency. Models are developed to predict the evolution of the environmental contamination and the accidental discharges. Development of methods and guidelines for the evaluation of remediation options for contaminated sites is done in collaboration with the IAEA-EMRAS programme. Radiological impact assessments are also performed in the frame of the future deep disposal of medium and high level waste and the future surface disposal of low level waste at the Mol/Dessel site. These latter studies are performed in collaboration with NIRAS/ONDRAF and the group Performance Assessment at SCK•CEN.

There is an increasing concern about the protection of the environment and the paradigm 'if man is protected the environment is protected' is questioned. At SCK•CEN we contribute to the EC-ERICA project aiming at assessing and managing environmental risks from ionising contaminants and the IAEA EMRAS-BIOTA working group. Experiments are performed to analyse the biological effects induced following exposure of plants to gamma irradiation or uptake of uranium.

### Decision support and social aspects

The most important aspects of societal concern are the consequences of nuclear accidents, the disposal of high level waste and the uncontrolled use of fissile material with a potentially malign intention. SCK•CEN has the in house competence to model atmospheric dispersions following a nuclear accident, we assist the government in the off-site nuclear emergency planning and response in particular through stakeholder involvement. Under the EC EURANOS project a 'Generic handbook for countermeasures in the food chain' was produced. Decision support systems for crisis management with remote access at government instances (FANC, Federal Agency for Food Safety) are under continuous development.

'Emergency flow scheme of zo iets' als picture

In the frame of the Belgian support programme to the IAEA, we contribute to the IAEA Safeguards programme in the framework of the United Nations Non-Proliferation treaty.

Under the PISA programme, we deal with the societal dimension of mentioned concern, assessing nuclear technology in relation to sustainable development covering amongst others the themes energy policy, waste, legal aspects, risk perception.

## Measurement facilities

In order to be able to perform research or monitoring in radiation protection, adequate support by measurement facilities is required.

The low level radioactivity measurements service performs measurement of alpha and beta emitters on various types of low-radioactivity samples both for internal and external clients. Every year thousands of biological (urine, faeces and nose blow) and environmental samples (airborne dust, rainwater, surface water, sediments, soil, vegetation and foodstuffs) are collected for analysis of radioactivity content.

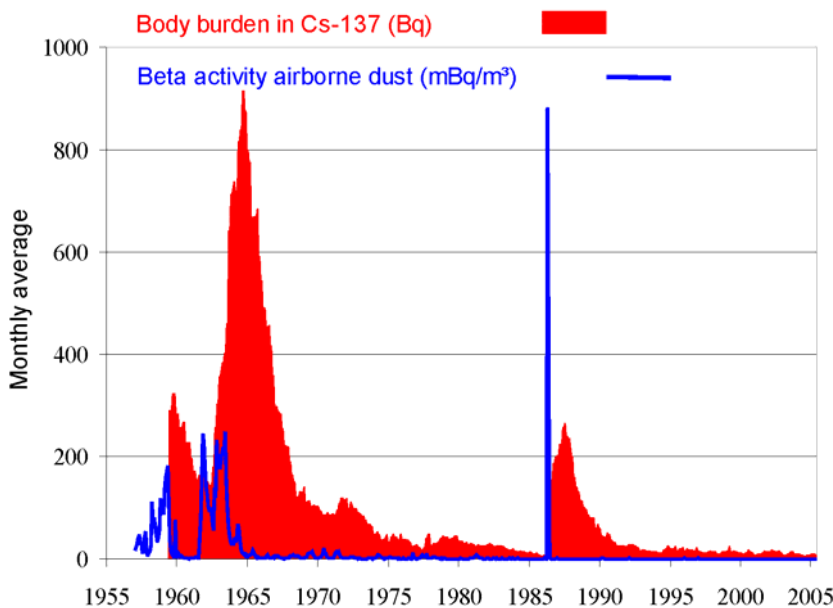
The high-resolution gamma-ray spectrometry laboratory is engaged with measurements of amounts of gamma or X-ray emitting substances intermixed with non-radioactive material in solid and liquid samples. They perform around 1600 analysis per year on environmental samples, foodstuff, samples collected in decommissioning process, BRA effluents, ... The laboratory is also engaged in development of techniques. For example in collaboration with the SCK•CEN's BR1 team, neutron-activation analyses are performed and improved, relying on the  $K_0$  method.

At the expertise group of radiation protection dosimetry and calibrations, services are delivered in the domain of dosimetry, anthropogammametry, nuclear calibrations and non-nuclear calibrations, both for internal and external clients.

The laboratories are accredited (Beltest accreditation for the ISO17025 standard) and most measurements are performed according to the quality assurance program:

## Chernobyl, 20 years later:

2006 was marked by the 20<sup>th</sup> anniversary of the Chernobyl accident. On April 26, 1986 reactor number 4 in Chernobyl exploded. It is regarded as the worst accident in the history of peaceful use of nuclear energy. Locally the accident has caused great human sorrow. A few days after the accident the radioactive cloud reached Belgium. SCK•CEN as well as other institutes followed the evolution of the radioactivity increase in Belgium very accurately. This has never caused alarming doses in Belgium and today, the residual radioactivity is negligible.



*Cs body burden following Chernobyl accident.*

The main consequence of the accident was undoubtedly the impact on the public opinion. The population was rightly concerned in consequence of the accident and the safety of nuclear energy production for civil uses was strongly questioned. The Radiation Protection Department amongst other SCK•CEN groups, conducts or conducted a lot of research directly related with the accident or its consequences in co-operation with national or international organisations. SCK•CEN largely contributed to the measurements of contamination of the territory

and of the food chain and of the human body burden. In the aftermath of the accident, the Belgian surveillance programme around the nuclear installations as well as the Belgian emergency planning organisation was updated. SCK•CEN performs the major part of this surveillance programme and is one of the main partners of the government to refine and look after the emergency organisation, for example by adapting European research results and information to the Belgian situation. SCK•CEN is and was largely involved in the research on the influence of weather patterns on the spread of the radioactive plume. In the Chernobyl contaminated area of Belarus and Ukraine, SCK•CEN coordinated radioecological research projects studying the feasibility of cultivating energy crops. Today, the radioecology group is still actively participating in a project assessing the contribution of forests established on the 'red forest' disposal site (the heavily contaminated forest neighbouring the Chernobyl reactor was buried and a forest was established on it) to the secondary dispersion of radionuclides. SCK•CEN has produced a brochure 'Chernobyl, 20 years later' to which several radiation protection researchers contributed. This brochure is available on the SCK•CEN web site.