Contributing to great social challenges

04

“I could never have dreamed of becoming chairman”

Hans Vanmarcke at the helm of UNSCEAR

In 1996, he became a member of the Belgian delegation of scientists. He never missed a single meeting in Vienna. The Ministry of Foreign Affairs appointed him as head of the Belgian delegation in 2008. In 2015, he became vice-chairman. And in 2016, the 27 participating countries elected him as chairman. This was all at UNSCEAR, the United Nations Scientific Committee on the Effects of Atomic Radiation. His name? Hans Vanmarcke, radiation protection expert at SCK•CEN.

1955. At the height of the Cold War, the USA and the USSR were fully engaged in above-ground nuclear testing. Large quantities of radioactive material were released into the atmosphere and both superpowers were contaminating the world with radioactive waste. An organisation was needed to determine the consequences of the radioactive fallout in a neutral manner.

The General Assembly of the United Nations established UNSCEAR (the United Nations Scientific Committee on the Effects of Atomic Radiation) and gave it a mandate to assess the global levels of exposure to nuclear radiation and to investigate the resulting health effects. This exposure was the result of not only the arms race, but also the development of nuclear power, the extraction of raw materials, the growth of medical applications and natural exposure.

Elevated status

There is an important difference between how UNSCEAR operates and how organisations such as the IAEA (International Atomic Energy Agency) and the WHO (World Health Organisation) operate, Chairman of UNSCEAR Hans Vanmarcke explains: ‘Those organisations have a permanent base, where many staff members are employed. UNSCEAR is completely different. We just have a small secretariat in Vienna. The input comes from the countries that take part.’ But for every disadvantage there’s an advantage: ‘UNSCEAR has an important status because we report directly to the United Nations General Assembly.’

Reaching a consensus

The reports from UNSCEAR provide the United Nations and governments around the world with a scientific basis for evaluating radiation risks and taking safety precautions. Hans Vanmarcke emphasises UNSCEAR’s neutrality: ‘We try to reach a scientific consensus that serves as a basis for the legislation on protection against radiation across the globe. UNSCEAR’s task as a scientific committee is to process research results and to report on how things stand. An example? We are researching the presence of radon in homes: what are the concentrations and what is the likelihood that people develop lung cancer as a result?’

In addition, UNSCEAR also communicates directly with the public about exposure to ionising radiation and the effects of it: ‘One example is the accessible brochure “Radiation: effects and sources” that we have compiled and that is being published by UNEP (the United Nations Environment Programme). The work involved in translating this into many languages shouldn’t be underestimated.’

Belgium playing its part

Hans Vanmarcke has been a member of the Belgian delegation since 1996. ‘It’s a huge privilege and a real honour to chair this United Nations committee and to represent Belgium. I have invested a great deal of my time in UNSCEAR over the years and many colleagues from SCK•CEN have worked on UNSCEAR reports in that time. My chairmanship contributes to our renown and prestige. But this privilege does not only go to our research centre. That’s why I’m also involving other Belgian organisations.’

The chairmanship of Hans Vanmarcke also has consequences for the Belgian embassy in Austria: ‘Belgium now has to take the lead in UNSCEAR-related diplomatic activities at the United Nations. I am leading the scientific part, and the ambassador is taking charge of diplomacy.’

Currently, 27 countries are members of UNSCEAR: ‘One diplomatically sensitive subject in 2017 is the question of whether to expand the committee with new member states. It’s important to point out that becoming a member isn’t a gift, it’s a responsibility. As a country, you are given a task to make a difference to the world, and that’s only possible if you appoint motivated scientists.’

A dream come true

During Hans Vanmarcke’s term of office, UNSCEAR will focus specifically on producing various long-awaited reports: the health consequences of exposure to radon in the home, the biological mechanisms of exposure to low radiation doses, the epidemiological studies into the occurrence of radiation-related cancer and the occurrence of ‘secondary’ cancers following radiotherapy.

‘It is of fundamental importance for us to pursue our research into the effects of ionising radiation on human health, especially the consequences of low radiation doses. It’s essential that we provide the UN General Assembly, the scientific community and the general public with valid, scientific information.’

All this is tremendously hard work, as Hans Vanmarcke is all too aware. ‘But it’s also the icing on the cake as far as my career is concerned. After two years as chairman, I’ll be able to serve as past president for another two years. I never dreamed that I’d lead an international organisation like this.’

> *“As a country, you are given a task to make a difference to the world, and that’s only possible if you appoint motivated scientists.”*

VALUABLE REPORTS

Since its foundation, UNSCEAR has published reports on twenty very important investigations. These reports are accepted as the standard all over the world and are used as a reference by the scientific community. Here are just a few examples:

- The effects of ionising radiation on animals and plants;
- Epidemiological studies into the link between cancer and exposure to radiation;
- Effects of exposure to radon in homes and workplaces;
- Health effects of exposure to radiation in children;
- Overview of global exposure to radiation (Fukushima, Chernobyl, health, etc.);
- Radiation exposure from electricity generation arising from different generating technologies.

More info: http://www.unscear.org

What impact does radiotherapy have on our health?

For better diagnostic and therapeutic treatments

Exposure to ionising radiation can have negative health effects. At SCK•CEN, researchers are investigating when these effects occur and how they can be prevented. This is important for the medical sector, which is increasingly making use of this useful and effective technology for diagnostic and therapeutic treatments.

In 1945, the Japanese cities of Hiroshima and Nagasaki were the targets of atomic bomb attacks. Children who were exposed to sufficiently high doses of radiation as foetuses between week 8 and 25 exhibited clear signs of delayed mental development at the age of 12. The size of their brains was also smaller.

Statistical data was collected, but no mechanistic studies were carried out. For that reason, scientists at SCK•CEN have, for a number of years, been studying the consequences of exposure to ionising radiation during the foetal or early post-natal stage. More specifically, they are investigating the effect of exposure on the development and later functionality of the brain, neurodegeneration and ageing processes, including the incidence of early onset Alzheimer's disease.

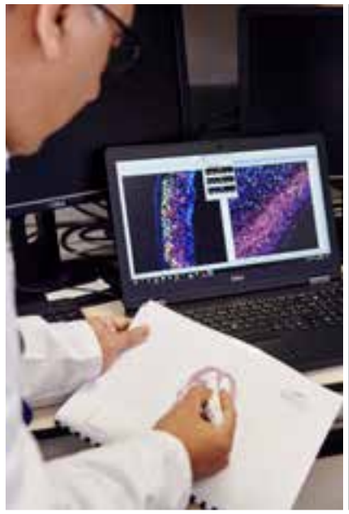
The researchers are also testing how it might be possible to protect children against the negative effects of radiation exposure, either before or immediately after birth.

The studies are making use of SCK•CEN's animal facility, where the researchers are looking at how ionising radiation influences the brains and behaviour of mice. The effects can be determined in a much shorter space of time than with people. Work is also being carried out on a genetic mouse model that is susceptible to the development of Alzheimer's disease.

Clarification of link between exposure of foetus to radiation and defects as an adult

The conclusions are clear: during the early stages when the organs are developing, sufficiently high doses of ionising radiation can lead to deformities, such as microphthalmus (disorder of the eye) and anencephaly (incomplete development of the skull). At the start of the period in which new nerve cells are being formed, radiation causes lasting developmental disorders and functional and structural changes in the brain, resulting in behavioural problems.

At the moment, the researchers are investigating the underlying mechanisms of these disorders and the related biomarkers. In the future, these could be used to identify



people who may be susceptible to certain diseases as a result of exposure to radiation. The intention is also to test ways of providing better protection of healthy tissue when exposed to radiation.

More sensitive methods

At the same time, research is also under way into the effects of prenatal exposure to radiation on the development of the brain of mouse embryos, specifically defects in the neural tube (precursor to the central nervous system) and the development of microcephaly (small size of the brain). The researchers are trying to identify the molecular mechanisms of these defects and are investigating whether administering folic acid or inhibitors of the p53 tumour suppressor gene can prevent the mechanisms.

They have found out that the p53 gene, which regulates the expression of many other genes, plays a key role in the mechanism of reduced growth of the brain after exposure to radiation, which is also seen in people infected with the Zika virus. Although p53 is the most widely studied gene in medical and biological

science due to its role in the development of many cancers, SCK•CEN has discovered a number of new target genes of p53, which may be important for a number of fields of research.

Thanks to more sensitive methods of measuring both the size of the brain and cognitive functions, the scientists were able to demonstrate that prenatal exposure to nuclear radiation can have negative effects at lower doses than previously suspected. However, these doses can still be deemed relatively high in the context of medical diagnostics.

“The intention is to better protect healthy tissue during radiotherapy, thereby contributing to an improved quality of life for the patients.”

Identification of biomarkers

Ionising radiation also has an effect on the cardiovascular system, often only after one or two decades. This has also been observed in the survivors of the Japanese atomic bomb explosions in WWII. Problems related to cardiovascular diseases can also occur as a result of radiotherapy treatment for breast cancer. When the symptoms present themselves, the disease is often already at an advanced stage. For that reason, it is necessary on the one hand to identify biomarkers that indicate an issue at an early stage, and on the other hand to intervene in order to prevent the problems developing further.

Based on research into the underlying cellular and molecular mechanisms of radiation-induced cardiovascular conditions, SCK•CEN scientists are gaining a better understanding of the potential health risks for people who are exposed to ionising radiation. Specific attention is being devoted to the development of atherosclerosis. The researchers are attempting to contribute to the formulation of improved guidelines for cardiovascular radioprotection. They also want to identify the agents that are able to limit the harmful effects of ionising radiation if they are administered just before, during or after the treatment.

The research is being carried out with in-vitro cell cultures from endothelial cells, the cells that line blood vessels and are in direct contact with the blood. Endothelial cells are important in order for the vascular system to function normally. If they become damaged, cardiovascular diseases may result. In this experiment, mice are also exposed to ionising radiation and blood samples from cancer patients who have been treated with radiotherapy are analysed.

The researchers have now discovered that a low acute dose of X-ray radiation can cause DNA damage and cell death. The results of the DNA damage indicated a non-linear relationship with relatively more DNA damage at lower doses.

Chronic exposure to radiation at a low dose rate can lead to a profile of cell stress and infection in the first instance, which further results in premature cell ageing. The researchers are also revealing the mechanisms behind the delayed-onset effects of ionising radiation. Furthermore, they now want to study intercellular communication: how do cells in a radiation area communicate with other cells, and how can this intercellular communication be prevented?

Expertise

Social relevance is key to us

SCK•CEN is using its scientific and technical expertise to find solutions and answers to social issues. Is our drinking water safe? What are the potential risks of using ionising radiation for diagnostic and therapeutic purposes? SCK•CEN builds bridges. We ask people for more information about their values and expectations and then start a dialogue on the risks of using ionising radiation. We offer our expertise to developing countries. We are strongly engaged with society.

Hildegarde Vandenhove

Environment, Health and Safety
Institute Director

Key role in radioactivity measurements for Drinking Water Directive

New measurement techniques refined and validated

Over the next few years, a large number of water sources will be subject to radioactivity monitoring. This comes in the wake of a recent European Directive. But how do you determine the various radionuclides and parameters in drinking water? To this end, researchers from SCK•CEN have selected, refined and validated nuclear measurement techniques.

Michel Bruggeman and **Freddy Verrezen**

Radiological monitoring of drinking water is nothing new. The Low-level Radioactivity Measurements (LRM) expert group has been analysing drinking water for many years, primarily via gross alpha and beta measurements. They do this for a number of major soft drink producers.

New recommended values

The research has gained great momentum in recent years as a result of the implementation of new European legislation in Belgium. LRM researcher Michel Bruggeman explains: ‘In 2013, the new European Directive 2013/51/EURATOM laid down recommended values for the monitoring of radioactivity in both drinking water and water that is used for the preparation of food or that comes into contact with food. The new legislation also defined the nuclide-specific recommended values that you need to bear in mind in detailed monitoring.’

What is the result of all of this? Michel goes on: ‘Both drinking water producers and food companies that make use of water that comes into contact with food need to have their various sources of water monitored. Of course, everything depends on how each individual member state interprets the Directive. For us, the differences in national legislation present an additional challenge.’

His colleague Freddy Verrezen considers the scope of the monitoring: ‘It’s not just about water that may be contaminated by radioactivity as a result of human activities; it’s mainly about the concentrations of radioactivity that are the result of natural radioactivity. Groundwater comes into contact with rocks underground that are naturally radioactive to some extent. As a result, it always contains radionuclides from the natural series of uranium, thorium and potassium.’

Quick, sensitive and affordable

‘The Federal Agency for Nuclear Control (FANC) organises the monitoring of drinking water on the basis of a decision tree: first of all, screening is carried out (overall measurements and the quantification of two key nuclides) and – depending on the results of this screening – more detailed analyses are then performed in order to determine the presence of more radionuclides. For the basic screening for radioactivity, we’ve purchased additional proportional meters that we use to measure the gross alpha and beta activity.’

Radionuclides of importance can be divided into two groups. One group is characterised by natural radioactivity, whereas the other is the result of human activity. Michel Bruggeman: ‘We’ve mainly focused on the first group and have established new measurement techniques for Ra-226, Ra-228, Rn-222 and Pb-210.’

The LRM researchers therefore faced the challenge of developing new measurement techniques for nuclide-specific analyses of water that would produce results relatively quickly and cost-effectively. But it is not just the speed of the technique that is important, as Freddy Verrezen explains: ‘It also needs to be reliable and comply with the sensitivity requirements of the Directive.’

> *“Sometimes the success of a method is found in the small things that you need to discover during your research.”*

Not the best, but the most suitable

Researcher Mirela Vasile coordinated the development of the measurement techniques for monitoring purposes. Use was made, for instance, of filter membranes in order to filter certain elements out of the water and then measure them selectively. This type of membrane technology provides a quick way of removing certain elements from the water, but the full method must also be balanced: ‘It took us several months to be able to guarantee the stability of the measurement with a RAD disk™. This is selective for radium and can therefore be used to determine Ra-226 and Ra-228. After filtering the water, you can simply measure the membrane using liquid scintillation spectroscopy or gamma spectroscopy. You do need to know the appropriate after-treatments of the membrane and the start time of the measurement in order to be able to carry out reliable measurements.’

A team fit for the future

There are not many laboratories in Belgium that can perform all necessary analyses of the radioactivity of drinking water samples. The number of samples which will have to be analysed in the next few years is still hard to predict but the LRM expert group prepared to undertake a large number of these tests over the coming years. ‘We anticipated the demand by expanding the measurement capacity of the screening. We’ve bought additional meters and developed techniques with short throughput times. We’ve been working hard in the field of client acquisition too. Together with our business department, we’ve been seeking partnerships with other water analysis laboratories that are only able to carry out chemical or biological testing. We’re waiting with bated breath...’

You do science with and for people

PISA builds a bridge between science and society

In the 1990s, SCK•CEN launched the ‘Programme for Integration of Social Aspects into nuclear research’ (PISA). In the nuclear sector, this programme has expanded to become the driving force for addressing social science and humanities issues in the nuclear debate at a European level. SCK•CEN is playing a leading role in this integration, now more so than ever. Interview with Catrinel Turcanu and Tanja Perko from the Nuclear Science & Technology Studies Group.

Why do social science and humanities need to find a place in a field that is primarily about exact sciences?

Catrinel Turcanu: ‘These days, you can no longer work in the field of nuclear science without engaging with society. You do science with and for people. This means that you take account of the standards, values and opinions of all stakeholders – and not just researchers, industry and the government, but everyone in our society. SCK•CEN’s PISA programme certainly enjoys an international reputation for its pioneering role in this. We have acquired a great deal of expertise on the integration of social science and humanities, specifically with regard to the research into the risks of ionising radiation.’

Are exact scientists happy about this?

Tanja Perko: ‘We’re taking exact scientists out of their comfort zone. But we aren’t being disruptive; we’re generating new solutions. Because only together can we practise effective and complete science. More interaction is required; you need to cross the boundaries between different disciplines: social and technical aspects cannot be separated from each other.’

> *“It’s infectious, because there are now a growing number of initiatives to integrate social and ethical aspects into nuclear research at an international level.”*

‘The fact that we hold a mirror up to scientists can be annoying... but this can also be useful. At SCK•CEN, we’d built up the necessary support within fifteen years and were able to go public. It’s infectious, because there are now a growing number of initiatives to integrate social and ethical aspects into nuclear research at an international level.’

After the nuclear accident at Fukushima in 2011, the European Commission concluded that action needed to be taken with regard to communication about ionising radiation. The result was the EAGLE project...

Tanja Perko: ‘How do you enlighten people about the risks and advantages of ionising radiation? How can they be in a position to make informed decisions? What should they do in the event of an incident? In EAGLE, we systematically documented national and international data, instruments and methods, looked into education, information and communication requirements and identified the potential for coordination at European level. EAGLE was also a step towards a communication ideal: to bring everyone together so they can learn from each other – the nuclear sector, the users of ionising radiation, the government, mass and social media, informed citizens, and so on.’

What is the tangible end result of EAGLE?

Tanja Perko: ‘A series of recommendations about how to achieve a communication process in which the citizen plays a central role – always in the context of the risks of ionising radiation. From nuclear producers to journalists, everyone can use the recommendations. They are being published in a booklet for RICOMET 2017.’

Catrinel Turcanu: ‘RICOMET is an international conference about risk perception, communication and ethics of exposure to ionising radiation. It’s yet another initiative from SCK•CEN! In 2015 and 2016, RICOMET was the number one place to exchange views about scientific research, communication, risk perception and ethics – always at an international level and in the field of nuclear applications, natural radioactivity and radiological protection. One study for example dealt with citizen science in Japan after the accident at Fukushima. Immediately after the disaster, citizens in Japan took control by measuring radioactivity in the environment with Geiger counters and publishing the collected data online. This type of citizen science is a response to a public need to share reliable information about nuclear radiation. We can learn lessons from this for the future.’

Organising a conference is one thing, but how do you keep interest and the debate alive?

Tanja Perko: ‘First of all, there’s our network. We keep that active via a European platform for social science and humanities in research into ionising radiation. Besides that, we want to develop an environment for responsible research and innovation in the field of ionising radiation. It is important that we continue to encourage self-reflection among technical communities. We want to be a source of inspirational ideas for social science research in various areas. Of course, we will always align our research with social values, requirements and expectations. We would also like to create a public science centre in order to enhance media relations and to communicate intensively with the public.’

It all started off with PISA. How do you want to give your efforts more impact in the future?

Catrinel Turcanu: ‘Greater integration is necessary for that. The impact of social science and humanities was addressed in the European OPERRA and CONCERT projects. But that process is too fragmented. That’s why, in collaboration with our international partners in Europe, we’ve proposed developing a strategic agenda for social science and humanities in radiological protection research, within the CONCERT HORIZON 2020 project. We want to break down the barriers between the various disciplines that are involved with ionising radiation, but also the barriers between academic science and society. The aim of all this is to be able to better respond to the demands of the general public and to involve the policy-makers in the process. It’s not only communication that needs to be addressed; other social and ethical aspects are extremely important too. You can’t isolate these issues. As a pioneer in the integration of all of these aspects, SCK•CEN continues to play its part, now more than ever.’

Inspiration fuels space research in Congo

Combating malnutrition with Spirulina, the green protein source

In Congo, around 43% of all children under the age of 5 suffer from chronic malnutrition. The result is a high infant mortality rate. This prompted researchers from SCK•CEN to start working in Congo on the cultivation of spirulina, a type of algae rich in vitamins and minerals that are essential for combating chronic malnutrition in children. This Inspiration project is the first in a series and signals our research centre's ambition to contribute towards a balanced and sustainable world.

'Traditionally, SCK•CEN has supported a range of small projects. Each organisation received a small amount of money from us. More and more often, however, we found ourselves wondering: what are we actually supporting, what is the result of it, what is our aim?' Eric van Walle, Director-General of SCK•CEN, outlines how the Inspiration project came about: 'We had the idea of focusing on one social project and getting our own staff involved in it. This is how we first came into contact with Entrepreneurs for Entrepreneurs, an organisation that motivates companies in developed countries to enter into sustainable partnerships with developing countries. We felt the concept was an interesting one, so we made an appeal to our employees.'

Researcher Felice Mastroleo stepped up: 'Management asked if we had an idea that could be applied in Africa. Together with a few colleagues, we presented "Inspiration", or INtroduction of SPIRulina in equatorial Africa To Improve lOcal Nutrition. Our aim was to start growing spirulina algae in Congo in order to combat chronic malnutrition in children.'

Out of all the proposals, SCK•CEN's management chose the Inspiration project. But the researchers were not given carte blanche, as Eric explains: 'The first task was to establish good contacts in Africa. We didn't simply want to send people over there. We also entered into a commitment with them: they would be able to work on the project for a number of working hours, but would have to spend just as much free time on it.'

From space to Congo

Where does the knowledge about spirulina come from? 'From our work for the ESA space project', Felice explains. 'As part of that, MELiSSA was developed, a recycling system for long-term space missions. The aim is to produce drinking water, food and oxygen for the astronauts. In that system, plants and bacteria carry out the recycling process. One of the bacteria is spirulina, which is actually a cyanobacterium that can be seen as something between a bacterium and a plant. Spirulina grows as quickly as a plant and produces oxygen. In our research, we're investigating whether spirulina is resistant to the effect of outer space – and especially ionising radiation – and to the effect of micro-gravity.'

> *"Inspiration highlights what the DNA of our research centre consists of. In at least half of our activities, we try to develop solutions to major societal challenges."*

Felice set about establishing contacts: 'First of all with Louvain Coopération, an organisation of the Université catholique de Louvain (UCL) in Louvain-la-Neuve, where a project was under way for Burundi. But due to the civil war, we were forced to find an alternative. That's how we ended up at the NGO Congodorpen, an organisation that focuses on various aspects of agriculture and medicine in Congo. They have set up an agricultural centre in the Congolese village of Mooto. The people there produce palm oil, coffee and cocoa and also farm fish.'

From Mol to Mooto

The leap from research in molecular biology to the large-scale cultivation of spirulina is a considerable one. With his colleagues, Felice built an open basin with a capacity of 1,000 litres of water: 'We did that in our research building in Mol. In order to simulate the tropical climate, the temperature was a constant 30°C. The light was as natural as possible. The test with the basin lasted eight months. My thanks go to the many colleagues that volunteered their time to regularly stir the spirulina basin. They also helped raise money at an event where people were able to try waffles, pasta and chervil soup that had been fortified with spirulina.'

In summer 2016, Felice and his colleague Ben Vos left for the village of Mooto in Congo: ‘First of all, we started the preculture of the spirulina and built the basin. The challenge in growing spirulina was getting the composition of the nutrients right, although spirulina doesn’t need many. We’d brought nutrients with us from our lab, except for nitrates, which you’re not allowed to transport by air. Once we were there, we went on the hunt for a good source of nitrates to add.’

Pure water, healthy spirulina

The biggest challenge was finding pure water: ‘Analysis of various sources found large quantities of nitrites and heavy metals. The least contaminated source was the furthest from the village. But we made the people use that water. Spirulina is very nutritious, but acts like a sponge for heavy metals. Pure water is needed for healthy spirulina.’

The spirulina grew according to plan. The residents of Mooto were able to eat it immediately: ‘You pour the crop through a filter. This collects the spirulina cells. You can then eat the spirulina straight away with a spoon. Unfortunately, however, you can’t store it in that state, which is why we’ve developed a method to dry it. This means that the local population can add it to their food. Spirulina has a neutral taste, but is high in protein compared with cassava, their daily staple.’

In Mooto, Felice did even more than setting up the cultivation of spirulina: ‘We demonstrated how people can incorporate spirulina into the cultivation of pondu, a spinach-like vegetable. We introduced spirulina to researchers from colleges and universities, so that they can pass this knowledge on in their courses. And we showed a doctor from the local hospital the things he needs to pay attention to if he wants to give spirulina to patients.’

Proven commitment

The Inspiration project attracted the attention of the press and had the honour of being nominated for the Entrepreneurs for Entrepreneurs award. ‘This project highlights what the DNA of our research centre consists of. In at least half of our activities, we try to develop solutions to major societal challenges. This clearly shows what we are doing at a social level. Sustainability is also crucial to us, hence why we want to send our researchers on the field to pass on their knowledge and enable local people to assume responsibility for their own health. How could it have been done better than with a public health project?’

TROPHY FOR MOST SUSTAINABLE ENTREPRENEUR

Our project “Inspiration” was one of the finalists for the Trophy Most Sustainable Entrepreneur, awarded by the organisation Entrepreneurs for Entrepreneurs. The event rewards the work of Belgian companies that stimulate sustainable entrepreneurship and economic growth in developing countries. SCK•CEN was praised for its work in the Congo by Alexander de Croo, Deputy Prime Minister and Minister of Development Co-operation.