IAEA BULLETIN

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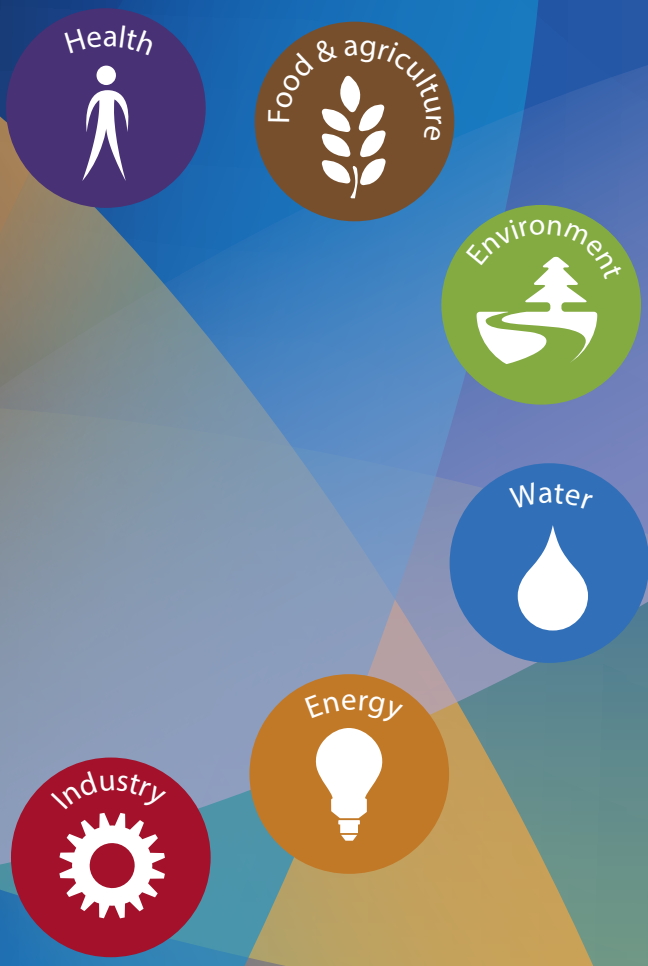
ATOMS FOR PEACE AND DEVELOPMENT



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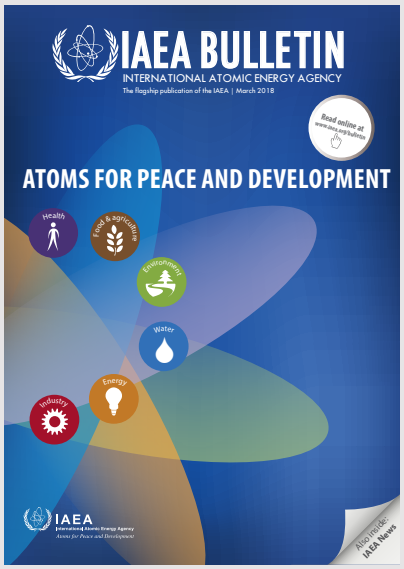

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IAEA

The International Atomic Energy Agency's mission is to prevent the spread of nuclear weapons and to help all countries — especially in the developing world — benefit from the peaceful, safe and secure use of nuclear science and technology.

Established as an autonomous organization under the United Nations in 1957, the IAEA is the only organization within the UN system with expertise in nuclear technologies. The IAEA's unique specialist laboratories help transfer knowledge and expertise to IAEA Member States in areas such as human health, food, water, industry and the environment.

The IAEA also serves as the global platform for strengthening nuclear security. The IAEA has established the Nuclear Security Series of international consensus guidance publications on nuclear security. The IAEA's work also focuses on helping to minimize the risk of nuclear and other radioactive material falling into the hands of terrorists and criminals, or of nuclear facilities being subjected to malicious acts.

The IAEA safety standards provide a system of fundamental safety principles and reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from the harmful effects of ionizing radiation. The IAEA safety standards have been developed for all types of nuclear facilities and activities that serve peaceful purposes, as well as for protective actions to reduce existing radiation risks.

The IAEA also verifies through its inspection system that Member States comply with their commitments under the Nuclear Non-Proliferation Treaty and other non-proliferation agreements to use nuclear material and facilities only for peaceful purposes.

The IAEA's work is multi-faceted and engages a wide variety of partners at the national, regional and international levels. IAEA programmes and budgets are set through decisions of its policymaking bodies — the 35-member Board of Governors and the General Conference of all Member States.

The IAEA is headquartered at the Vienna International Centre. Field and liaison offices are located in Geneva, New York, Tokyo and Toronto. The IAEA operates scientific laboratories in Monaco, Seibersdorf and Vienna. In addition, the IAEA supports and provides funding to the Abdus Salam International Centre for Theoretical Physics, in Trieste, Italy.

Atoms for Peace and Development: working towards the Sustainable Development Goals

By Yukiya Amano, Director General, IAEA

Technology and scientific innovation are essential for development. Nuclear applications offer enormous benefits in many areas of our lives, including health, agriculture, food production and energy generation, as well as in many sectors of industry. The IAEA is uniquely equipped to help Member States to use nuclear technology to achieve the Sustainable Development Goals.

Our Atoms for Peace and Development motto summarises our mission, which is to ensure that nuclear technology is used only for peaceful purposes and to help Member States use this remarkable technology to improve the well-being and prosperity of their people. Transferring nuclear technology to developing countries is core IAEA business and one of the most important areas of our work.

As IAEA Director General, I travel to many countries and meet people whose lives have been touched – and sometimes transformed – by the work of the Agency. These are very rewarding moments. This edition of the *IAEA Bulletin* features a selection of such stories.

You will learn of the rice farmers in Indonesia who have doubled their yield and income by growing a variety of rice, developed using radiation, which is resistant to some of the effects of climate change (page 4). You can read about how farmers in the Dominican Republic have been able to resume fruit and vegetable exports following the eradication of insect pests using nuclear techniques (page 6). Veterinarians in Lesotho tell us how they can, for the first time, test animals for animal and zoonotic diseases and keep livestock – and people – healthy (page 8).

Another article illustrates how nuclear techniques have contributed to recovery efforts in Nepal, Ecuador and Peru following devastating natural disasters (page 20). We feature a small business in Malaysia which has become more competitive and can sell internationally because it has improved the quality of its products using radiation (page 24).

Many countries believe that nuclear power can help them meet the twin challenges of securing enough energy to develop their economies while combatting climate change. We focus on the IAEA's cooperation with Bangladesh, which began building its first nuclear power plant last year (page 22).

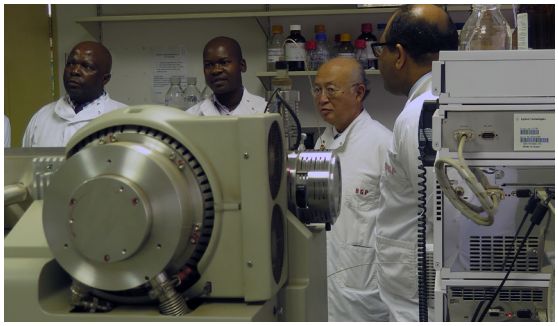
Membership of the IAEA has continued to expand and we now have 169 Member States. Requests for our assistance in all areas of nuclear science and applications are increasing steadily. The IAEA Peaceful Uses Initiative (PUI) has been instrumental in helping us to supplement our technical cooperation resources to meet this growing demand. The PUI has also given us more flexibility in responding quickly to new challenges and helped us to form new partnerships with the private sector.

I hope you will enjoy reading about the many ways in which the IAEA works to improve the lives of people throughout the world through the use of peaceful nuclear technology.

"Transferring nuclear technology to developing countries is core IAEA business and one of the most important areas of our work."

— Yukiya Amano, Director General, IAEA

(Photo: C. Brady/IAEA)

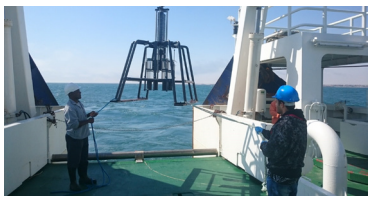


(Photo: C. Brady/IAEA)

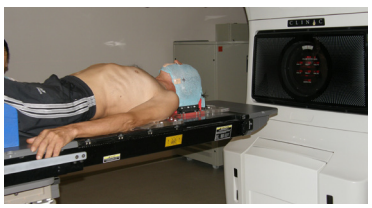
(Photo: Bureau for Legal, Public Relations and Cooperation, Badan Tenaga Nuklir Nasional (BATAN))

Food & agriculture

Water & Environment



Health



Energy

Industry

PUI

& development

Fighting climate change: Rice variety developed with nuclear techniques expands in Indonesia

By Miklos Gaspar

Workers at Indonesia's National Nuclear Energy Agency (BATAN) planting rice varieties developed using irradiation. (Photo: Yustantiana/BATAN).

"It is particularly important for us to have varieties that meet the new, more erratic weather conditions brought about by climate change,"

— Abdul Rasyid Afandi, Rice farmer, East Java, Indonesia

Stocky, strong and quick to ripen – that is how Indonesian farmers like their rice, and that is exactly what nuclear science has delivered to them. And higher income, to top it all.

Late 2017 was the second season that some 200 farmers in East Java used the variety Inpari Sidenuk ("nuclear dedication" in Indonesian), meeting the challenge posed by climate change while doubling their yields to 9 tons per hectare. Inpari Sidenuk is one of 22 rice varieties developed by scientists at the country's National Nuclear Energy Agency (BATAN) using irradiation, a process often used to generate new and useful traits in crops (see The Science box).

The IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), and partly financed through the Peaceful Uses Initiative (PUI), supports researchers in 70 countries, including Indonesia, in the use of radiation for agricultural research. The development of new, improved varieties helps increase the supply of food, and thereby food security.

"It is particularly important for us to have varieties that meet the new, more erratic weather conditions brought about by climate change," said Abdul Rasyid Afandi, a farmer in Mangaran, who has planted the new variety on over half of his 2-hectare plot.

Farmers here are able to plant rice three times a year, once in the dry and twice in the rainy season. The length of the seasons has varied more than usual in recent years, resulting in drier overall weather and the spread of new pests and diseases, he explained. As a result, farmers have seen yields with previously used varieties dip below 5 tons per hectare.

The introduction of Inpari Sidenuk has not only led to the recovery of previous yield levels, but at 9 tons per hectare has significantly surpassed earlier harvest rates. The plant is much shorter, making it less vulnerable to strong winds, which used to destroy around a tenth of the crop.

The only problem is the lack of seeds available to farmers, said A. Sidik Tanoyo, a Ministry of Agriculture official in East Java. "It's important that more seeds are produced to increase the area under cultivation, which will contribute to increased productivity and farmers' incomes," he said. It is now the task of the country's agriculture authorities to produce more seeds of the new variety. Such mass production no longer requires irradiation, only the conventional multiplication of seeds.

Seamless cooperation between BATAN and agriculture authorities is crucial in ensuring the distribution of any new variety to farmers, said Ita Dwimahyani, a plant breeder at BATAN's Centre for Isotope and Radiation Application. Inpari Sidenuk was developed from a local variety in 2007, and released by BATAN in 2011. However, difficulties with distribution have meant that it has taken a few years for it to get to farmers.

"We are very enthusiastic about this new variety," Afandi said. He added that the extra income he hopes to earn in coming years will contribute to the university education of his children and allow him to save more money for his old age.

Indonesia selects nuclear-bred soybean variety for mass production

Indonesia's Ministry of Agriculture has selected an improved soybean variety developed using nuclear techniques as the basis for its national self-sufficiency plan, which aims to increase food security in the country.

Tempeh, made of fermented soybeans, is a national staple, usually consumed with rice and broth. Due to an increase in population and living standards in the last couple of decades, however, consumption has grown considerably and Indonesia has gradually lost its self-sufficiency in tempeh production. It is now importing close to 60% of the 2.2 million tons of soybeans consumed each year. The Government would like to significantly increase domestic production. That, however, requires a variety suitable for the country's tropical climate, with high yields and resistance to local pests.

The Ministry of Agriculture has now selected a variety developed by the country's National Nuclear Energy Agency (BATAN) for mass seed production and distribution among farmers thanks to its favourable traits, said Lukman Hakim, the ministry official in charge of the project. The variety called Mutiara 1 was developed using irradiation. The syllable "ra" in its name stands for radiation.

Mutiara 1 has numerous advantages compared to the traditional soybean variety, said Gatot Gatot, one of 12 farmers in the heart of the country's soybean-growing area in East Java to already use the new variety. "The plants are shorter and stronger, tolerant to wind and resistant to disease," he said. Even more importantly, the yield — at above 3 tons per hectare — is 25% higher than that of local varieties. The seeds are larger and higher quality, fetching between 6500 and 7000 rupiah (40–44 euro cents) per kg, compared to under 6000 rupiah for the local variety.

The soybean variety grown by Indonesian farmer Gatot Gatot has been developed using irradiation. The Ministry of Agriculture has selected it for multiplication as part of its food security plan.
(Photo: M. Gaspar/IAEA)

Of the 200 farmers in this village, most would like to plant Mutiara 1, but for now there aren't enough seeds to go around, said A. Sidik Tanoyo, a Ministry of Agriculture official in the district. "This will now change as a result of the recent government decision."

In the meantime, BATAN scientists will continue to develop new varieties, further improving their traits. Mutiara 1 is less optimal in the wet season, when its bigger seeds acquire a brownish colour and are less viable, said Azri Kusuma Dewi, a plant breeder at BATAN's Centre for Isotope and Radiation Application in Jakarta. "We need to work on further optimizing Mutiara 1 by inducing mutations and breeding another variety for the rainy season," she said.

THE SCIENCE

Breeding new varieties using nuclear techniques

Twenty-two rice varieties have been developed by BATAN scientists through a process known as mutation breeding. Applied since the 1930s to accelerate the process of developing and selecting new, valuable agronomic traits, mutation breeding uses a plant's own genetic make-up, mimicking the natural process of spontaneous mutation. The mutation process generates random genetic variations, resulting in plants with new and useful traits.

BATAN scientists use gamma irradiation to induce mutations in seeds and considerably speed up the natural mutation process. After seed irradiation, they test the new mutant plants for various characteristics and select those displaying useful traits for further breeding and subsequent distribution to farmers.

Nuclear technique helps Dominican Republic eradicate insect pest and resume fruit and vegetable exports

By Luciana Viegas and Laura Gil

These Mediterranean fruit flies collected from the field are undergoing identification to confirm that they are sterile. Irradiation used to sterilize these insects in the Dominican Republic led to the eradication of the pest in July 2017.
(Photo: L. Gil/IAEA)

"For us, it became a trauma. I would go to sleep thinking of the fly, I would dream of the fly, and in the morning, I would wake up with the fly on my mind."

— Ángel Estévez, Agriculture Minister, Dominican Republic

In 2017, the Dominican Republic eradicated a major agricultural pest, the Mediterranean fruit fly, with the help of a nuclear technique and the support of the IAEA and the Food and Agriculture Organization of the United Nations (FAO). Two years after an outbreak led to considerable damage to its agricultural industry, the country declared in July 2017 that it was free of the insect.

Authorities used the sterile insect technique (SIT) to eradicate the fly (see The Science box).

The outbreak of the Mediterranean fruit fly in the Dominican Republic was first reported in March 2015 near the popular tourist city of Punta Cana, and rapidly spread to a 2000 square kilometre area in the east of the country. As soon as the Government announced the presence of the pest, the United States banned the import of 18 fruits and vegetables, severely affecting the country's exports.

Fruits and vegetables represent approximately 30% of food exports, earning the Dominican Republic around US $610 million per year, according to the country's Central Bank. The ban resulted in an estimated loss of US $42 million in fruit and vegetable exports in 2015 alone, putting thousands of jobs at risk. Thanks to successful eradication efforts, the ban has now been completely lifted.

"The Mediterranean fruit fly is one of the most damaging agricultural pests in the world," said Aldo Malavasi, IAEA Deputy Director General and Head of the Department of Nuclear Sciences and Applications. "The insect attacks several varieties of fruit and vegetable, and spreads very fast."

A female fly can lay up to 400 eggs in its lifetime, and in as little as six months a significant population can establish itself in a country the size of the Dominican Republic.

"It was disastrous," said Pablo Rodríguez, financial manager of Ocoa Avocados, the country's leading exporter of green king avocado. "Almost all we do is export, so you can imagine our loss. We had our products ready for export by March, when the ban started. We lost all that and our next cycle of production, too." Ocoa Avocados' losses amounted to US $8 million.

While most of the flies were discovered in non-commercial almond trees along the coast, there was a fear that they could also invade commercial fruit and vegetable farms. Any appearance of the fly is seen as high risk and often causes countries free of the pest to restrict imports of vulnerable fruit and vegetables.

Against the flies

When the Government detected the outbreak, it did not have the adequate institutional capacity to respond, said Agriculture Minister Ángel Estévez. “For us, it became a trauma. I would go to sleep thinking of the fly, I would dream of the fly, and in the morning, I would wake up with the fly on my mind.”

Upon the request of the Government, the IAEA provided assistance — through its technical cooperation programme — to adapt a facility in the town of Higüey to host sterile male flies brought in from Guatemala. Starting in October 2015, over 4 billion of these were released in the affected areas.

The IAEA, together with the FAO and the United States Department of Agriculture, also trained local personnel both in setting up surveillance systems throughout the country to trap and identify the fly and in using complementary pest-control methods such as pruning trees, destroying potential host fruits and using pesticides selectively.

Flies vs the Caribbean

The IAEA’s assistance, the coordinated emergency response and the Ministry’s containment of the outbreak have led to a number of knock-on benefits, not only for the Dominican Republic but also for the entire region.

“The project has also prevented the spread of the fly to other Caribbean and mainland countries, including Mexico and the USA, avoiding large economic losses,” said Walther Enkerlin, an entomologist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

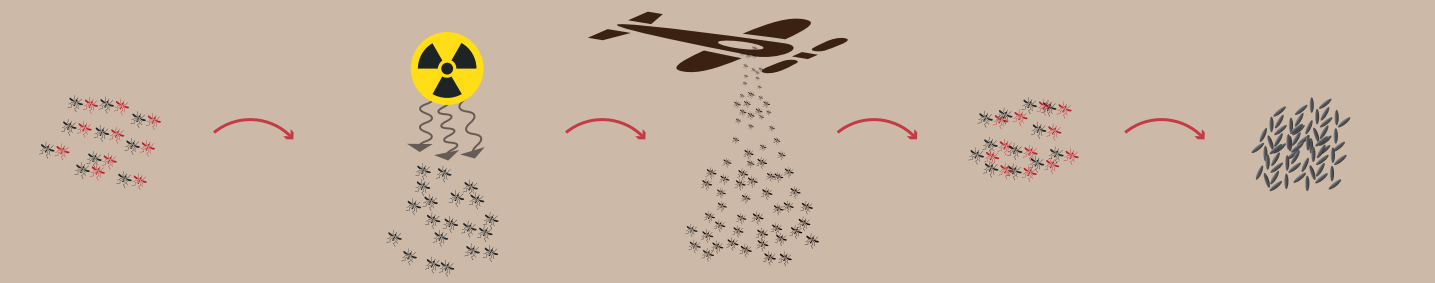
The Ministry of Agriculture now has the necessary technical and human capacity to tackle this and other outbreaks and to share lessons learned and know-how, said Frank Lam, representative of the Inter-American Institute for Cooperation on Agriculture in the Dominican Republic. “It has been a costly experience that we want to share, so that it doesn’t happen to other countries. We don’t want others to face this without being prepared,” Lam said.

THE SCIENCE

Birth control for flies

The sterile insect technique is a form of pest control that uses ionizing radiation to sterilize male flies that are mass-produced in special rearing facilities. Millions of sterile males are released systematically from the ground or by air on a regular basis. They mate with wild females, which do not produce offspring. As a result, this technique can eventually suppress or, in some cases, eradicate populations of various types of wild flies, such as fruit flies and tsetse flies. SIT is among the most environmentally friendly control tactics available, and is usually applied as the final component of an integrated campaign to remove insect populations.

The Joint FAO/IAEA Division supports about 40 such field projects delivered through the IAEA technical cooperation programme in parts of Africa, Asia, Europe and Latin America.



Mass-rearing of insects takes place in special facilities.

Male and female insects are separated. Ionizing radiation is used to sterilize the male insects.

The sterile male insects are released over towns or cities...

...where they compete with wild males to mate with females.

These females lay eggs that are infertile and bear no offspring, reducing the insect population.

Lesotho now better prepared to fight animal and zoonotic diseases

By Laura Gil

Diagnosing animal diseases early and rapidly is now possible in Lesotho, a country of two million people in southern Africa that until recently relied on foreign laboratories for analysis. Thanks to the support of the IAEA and the Food and Agriculture Organization of the United Nations (FAO), veterinary scientists in the capital Maseru have since mid-2017 been able to use nuclear-derived techniques to identify and characterize viruses that affect livestock and humans.

"To keep diseases under control and to respond rapidly to any possible outbreaks we need to be able to do our own diagnoses," said Gerard Mahloane, Director of Livestock Services at Lesotho's Ministry of Agriculture and Food Security.

These techniques enable the identification of viruses — including Ebola and avian influenza — within a few hours and with a high degree of accuracy. They are also cost effective. "What before would take weeks to discover, we now see immediately," Mahloane said. "This makes a great difference."

Early diagnosis helps curtail the spread of a disease by making it possible to rapidly isolate and treat infected animals and patients earlier. This enables authorities and farmers to respond quickly to any outbreaks and control them, and to maintain a level of surveillance that will prevent outbreaks.

With the help of these techniques, scientists at the Central Veterinary Laboratory have been able to confirm that Lesotho is free of foot-and-mouth disease, one of the most infectious diseases threatening livestock.

They are using equipment donated by the IAEA to verify whether the country is also free of the peste des petits ruminants (PPR),

The VETLAB Network: Building veterinary laboratory diagnostic capacity in Africa and Asia

To African countries facing the threat of animal disease outbreaks, the use of nuclear-derived techniques is critical for diagnosis and, in turn, containment and eradication.
(Photo: D. Calma/IAEA)

Veterinarians in Africa, working to stop the spread of transboundary animal diseases, including those that can spread to humans, using isotopic, nuclear and nuclear-derived diagnostic techniques, can share best practices, coordinate activities and develop joint disease control strategies through the Veterinary Diagnostic Laboratory (VETLAB) Network. The network was established by the IAEA in partnership with the Food and Agriculture Organization of the United Nations (FAO), and is partially supported through the Peaceful Uses Initiative (PUI).

These diseases can have a dramatic impact on public health and livelihoods. They also pose a major challenge to international trade in products of animal origin, potentially causing serious losses and substantial food safety and food security problems.

The early and rapid detection and characterization of disease pathogens is critical in implementing progressive control strategies, which contribute to containment and eventual eradication. Because such diseases, and the animals that carry them, know no borders, concerted measures are required. The members of the VETLAB Network share their diagnosis and control experience and know-how and promote national and regional animal and zoonotic disease prevention measures. The Network is supported with training courses, transfer of technologies and knowledge sharing, provision of guidance and standard operating procedures, expert services and the provision of equipment, reagents and consumables.

The VETLAB Network currently supports 44 countries in Africa and 19 countries in Asia.

a highly contagious animal disease that can kill thousands of sheep and goats per year. They have already collected all the necessary animal samples, some of which they are processing in the lab. Next, they are also planning to verify whether the country is free of avian influenza, detected in neighbouring South Africa in 2017.

In the past, Lesotho's authorities used to send more than 2000 blood samples of cattle and other animals to South Africa and Botswana for analysis each year to verify whether the country was free of these animal diseases — analyses that are expensive but mandated by the World Organisation for Animal Health (OIE). They now rely on foreign laboratories for confirmation or validation only.

To African countries facing the threat of animal disease outbreaks, the help of the IAEA, in cooperation with the FAO, has been critical in equipping their laboratories and training their scientists in the use of these techniques and the corresponding biosafety measures. Lesotho is the world's second largest producer of mohair, a material made from the country's many sheep and goats. Ensuring that their sheep and goats are healthy helps farmers, producers and exporters secure a steady income.

The IAEA, through its technical cooperation programme and in partnership with the FAO, has been assisting Lesotho in fighting infectious diseases since the country joined the Agency in 2009.

Nuclear-derived techniques have helped authorities demonstrate that Lesotho is free of foot-and-mouth disease.
(Photo: D. Calma/IAEA)

THE SCIENCE

Using nuclear techniques to detect animal diseases

Veterinarians at Lesotho's Livestock Services use various nuclear-derived techniques for the early and rapid diagnosis of animal and zoonotic diseases. Here is how these techniques work.

In serological assays, specific antibodies, unique to each pathogen, are detected using anti-immunoglobulins specific for each animal species tested.

In molecular assays, scientists replicate, or amplify, a specific region of DNA billion-fold in just a few hours. The detection of the amplification of the target DNA is then monitored by either radioisotopes or by fluorescent molecules. The polymerase chain reaction (PCR) is very specific, as it usually targets a specific marker on a given pathogen. It consists of repeated heating and cooling, causing separation of the two DNA-strands and then replication of the original DNA. This procedure gets repeated until enough copies of the targeted molecule are available. Scientists can then identify the presence of the pathogen's genome.

What makes these techniques nuclear-derived?

To visualize these reactions, the reactive molecules (antibodies in serological and genetic fragments in molecular techniques) are labelled with radioactive isotopes such as ^{32}P, ^{33}P, ^{35}S, ^{3}H, ^{14}C, so that the reactions can be measured using counters for radioactive rays or particles. However, where radioactivity is not an option due to the laboratory setup or the short half-life of radioisotopes or where the sensitivity of these techniques is not critically important, radioactive labelling can be replaced with colour-generating substances, such as enzymes or fluorescent dyes. These tags have simpler reading and evaluation processes, but become less reliable over time, decreasing the sensitivity of the techniques. Therefore, nuclear labelling is still used as a reference calibration standard in order to re-establish the accuracy of the visual labelling.

Costa Rica paves the way for climate-smart agriculture

By Laura Gil

"In our transformation towards a knowledge-based economy, we're making efforts to develop sustainable agriculture and industry, applying science and technology."

— Carolina Vásquez Soto, Minister for Science, Technology and Telecommunications, Costa Rica

Costa Rica's Government is using nuclear techniques to reconcile two objectives: to become carbon neutral, while also remaining the world's number one producer of pineapples, which require a significant amount of fertilizer. With the help of the IAEA and the Food and Agriculture Organization of the United Nations (FAO), Costa Rican experts are exploring the use of nuclear technology to help producers grow fruit and other crops more efficiently and ecologically. They are testing how a new type of soil additive could help cut down the use of pesticides and fertilizers, as well as reduce greenhouse gas (GHG) emissions.

"Most producers apply more fertilizers and pesticides than the pineapples need, and a large part of these are lost to the atmosphere as greenhouse gases or pollute rivers and groundwater," said Cristina Chinchilla, agronomy scientist at the University of Costa Rica's Environmental Pollution Research Center (CICA).

CICA experts are working with the IAEA and the FAO to use biochar, a carbon-rich material produced from natural residues. In other parts of the world, biochar has been shown to improve soil fertility while helping to reduce the negative impact of chemicals on the environment.

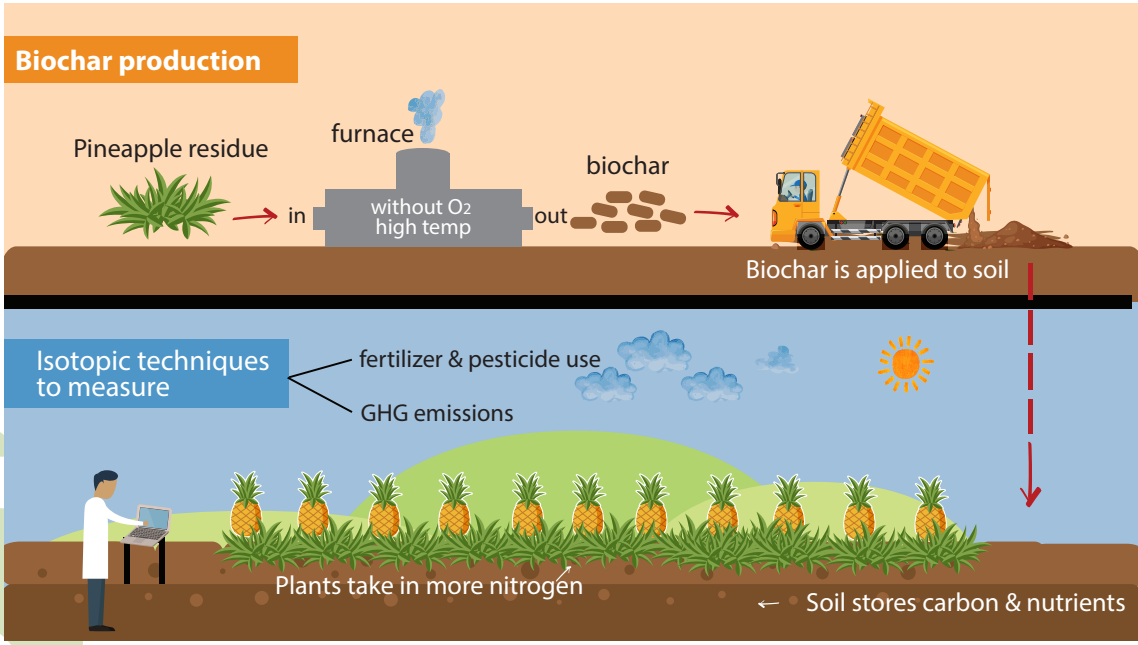
Pineapples and biochar

As Costa Rica generates more than 10 million tonnes of pineapple residues as a by-product per harvest every 18 months, the CICA team decided to use these residues to produce biochar.

Through an IAEA technical cooperation project, CICA experts are using nuclear-derived techniques to test the benefits of biochar. They crush the pineapple plant residue to produce biochar for farmers to use on their soil. They then apply pesticides labelled with a radioactive isotope — carbon-14 (^{14}C) — to plots of soil, which allows them to follow the behaviour of the pesticide molecules. With this technique they can also find out if biochar helps the soil store more carbon, reducing carbon dioxide (CO_2) emissions.

CICA experts also use fertilizer labelled with a stable isotope — nitrogen-15 (^{15}N) — to trace its pathway. Using this technique, they plan to see if pineapple plants can take up fertilizer in a more efficient way when planted into soil rich in biochar.

Reducing fertilizer and pesticides makes business sense. "Fertilizer and pesticides are expensive," said Donald González, a pineapple producer in Pital, northern Costa



Rica. “Sometimes we have to choose: either the plants eat or the family eats.”

Driven by growing environmental concerns, and stricter import regulations, the Costa Rican Government has established strong regulations for pineapple producers, banning certain chemicals and promoting sustainable practices.

The possibility of reducing fertilizer and pesticide use, while allowing farmers to continue earning a living and growing the crops the world demands, is the balance that all sides are looking for.

Reducing greenhouse gas emissions

In its plan to become a carbon-neutral country, Costa Rica is looking for ways to reduce its GHG emissions. Through the support of the IAEA and the FAO, experts are using nuclear techniques to measure the amount of GHG emitted from soil, including soil mixed with biochar, and to track where exactly these emissions come from.

“In our transformation towards a knowledge-based economy, we’re making efforts to develop sustainable agriculture and industry, applying science and technology,” said Carolina Vásquez Soto, Minister for Science, Technology and Telecommunications.

According to the Intergovernmental Panel on Climate Change (IPCC), agriculture and changes in land-use practices contribute to over 24% of the global release of GHG, and this continues to increase.

Donald González, pineapple producer in his field in Pital, northern Costa Rica, where scientists will test biochar.
(Photo: L. Gil/IAEA)

“Reducing greenhouse gas emissions related to agriculture is key to combating climate change,” said Ana Gabriela Pérez, coordinator of the University of Costa Rica’s National Reference Laboratory for Greenhouse Gases and Carbon Sequestration, which the IAEA equipped in 2014.

Isotopic techniques can provide essential information on the sources and amount of agriculturally derived greenhouse gases, said Mohammad Zaman, a soil scientist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. “This information provides policy makers with sufficient knowledge to make informed decisions on carbon policies.”

THE SCIENCE

Carbon sequestration in soil

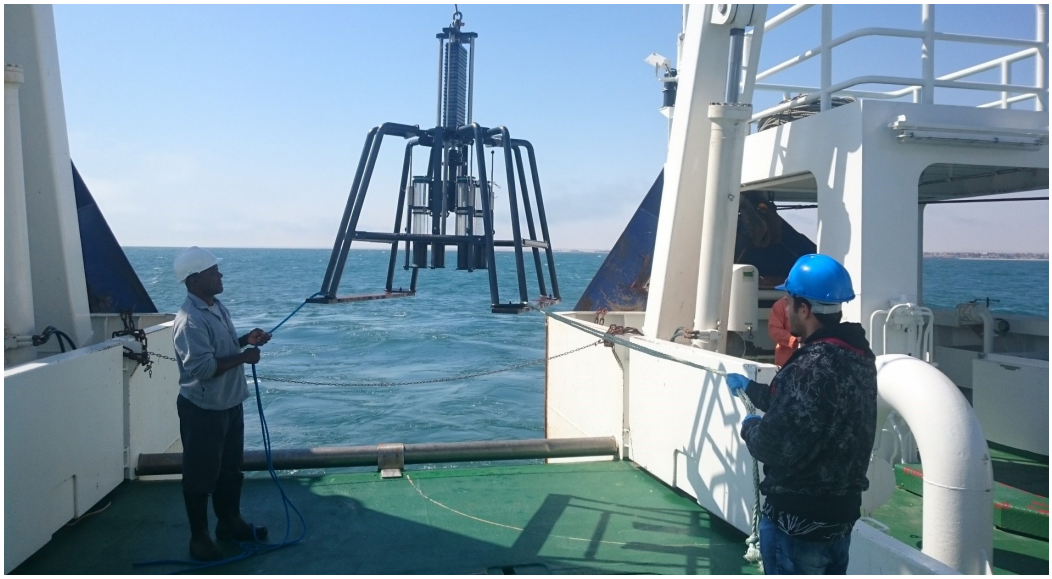
Soil is a mixture of minerals, organic matter, gases and water. Carbon is a key ingredient of soil and its health, but in a gaseous form as CO_2 it is a GHG. Plants capture carbon in the form of CO_2 from the air, transforming it into organic matter, which boosts soil productivity and resilience to harsh climate conditions.

The idea of soil capturing and storing atmospheric carbon dioxide, also known as carbon sequestration, can counterbalance the increase of GHG. Analysing the carbon-14 isotopes allows researchers to evaluate soil quality and sources of carbon sequestered in the soil. By measuring carbon sequestration, they can identify whether biochar is enhancing soil fertility and helping reduce CO_2 emissions.

Similarly, by using fertilizers in defined plots labelled with the nitrogen-15 stable isotope (^{15}N), scientists can track the amount of nitrogen taken up by plants or lost to the atmosphere as GHG or to surface and groundwater, and can determine how effectively the crops are taking up the fertilizer. This helps them optimize fertilizer use on farms.

Namibia enlists the IAEA to help study its marine ecosystem supporting key fisheries

By Lucas Small and Miklos Gaspar



Researchers gather sediment cores along the Namibian coast.
(Photo: D.C. Louw/Ministry of Fisheries and Marine Resources, Namibia)

"As marine resources contribute significantly to our national development, it is imperative that they be used sustainably."

— Axel Tibinyane, Director, National Radiation Protection Authority, Namibia

The first-ever comprehensive study on the concentration of radionuclides and trace elements in Namibia's coastal waters revealed that while radionuclide levels are very low, there is an indication of higher than usual concentration of certain trace elements. Further study is required to determine whether these are the result of human activity along the coast or are due to the underlying geology, according to a scientific report delivered by the IAEA to the Government of Namibia in late 2017, based on research carried out at the Government's request.

"The IAEA report provides excellent information about the current status and can be used as the basis for future monitoring activities," said Axel Tibinyane, Director of Namibia's National Radiation Protection Authority. "As marine resources contribute significantly to our national development, it is imperative that they be used sustainably. The report will help us do that."

Following this preliminary research, the IAEA will continue to provide support to the Government to gain better insight into the high trace element levels.

In addition to the country's increasing population, uranium, gold and diamond mining, as well as industrial activity, are on the rise and there is a growing interest in seabed mining for phosphates. Namibia is among the world's top five uranium producers. To assess any impact on the environment of this increased level of human activity, a baseline needs to be established, as some of these undertakings could result in increased levels of radionuclides and trace elements. The data in the report can provide such a baseline.

"This project is the first of its kind and has provided new information on the Namibian shelf," said Deon Louw, the marine scientist in charge of the study at Namibia's Ministry of Fisheries and Marine Resources. "We need this knowledge to monitor and protect our marine ecosystem as human activity continues to rise."

Increased coastal activities mean that new regulations are needed to monitor and manage natural and human-caused (or anthropogenic) radionuclides and trace elements that may contaminate the marine ecosystem, with potential impact on seafood, local populations and the economy.

Namibia's coastal waters support a rich biodiversity and stretch along the south Atlantic's turbulent Benguela current for over 1500 kilometres. Much of the coastline is a

marine protected area, which is considered unpolluted. It is part of the northern Benguela large marine ecosystem — one of the most productive coastal ecosystems in the world — and supports valuable fisheries and mariculture industries. It is a highly dynamic environment: strong winds, seething currents, and underwater sulphur eruptions surround rich stocks of fish, plankton, and other marine life, including the world's largest bacteria — visible to the naked eye.

Despite all this activity, little was known about Namibia's levels of marine radioactivity and trace elements until now.

The study

At the request of the Ministry of Fisheries and Marine Resources, in 2014 the IAEA began collecting a diverse range of marine samples off the coast. Over 500 samples were gathered, including sediment, seawater, fish, mussels and seaweed. Several thousand measurements were performed on the samples. More than 40 researchers from 11 institutions in six countries participated in the research project.

In addition to providing baseline measurements for ongoing pollution assessment and regulation, radionuclides and trace metal isotopes can serve as tracers to better understand oceanographic and pollution processes (see The Science box).

Namibia's coast is home to protected species like these African penguins on Mercury Island.

(Photo: D.C. Louw/Ministry of Fisheries and Marine Resources, Namibia)

The study of lead isotopes, for example, can help assess whether the lead is present naturally or as a result of human activities. Lead's isotopic signature can also provide information on the sources of pollutants.

"This research not only helps Namibia, but will also continue to add international scientific value by improving knowledge of global patterns of marine pollution," said Martina Rožmarić, a research scientist at the IAEA Environment Laboratories. "In studying the presence of natural and anthropogenic radionuclides and trace elements, such as lead, mercury, copper, and cadmium, off Namibia's seaboard, we are filling in a critical knowledge gap on the world map."

THE SCIENCE

Studying the oceans through isotopes

The concentration of radionuclides (natural and anthropogenic), trace elements and rare earth elements is difficult to measure. But measuring the levels of these substances and tracing them to their sources is central to understanding the state of the marine environment.

Several anthropogenic radionuclides can be detected at ultra-low levels; some, like the iodine isotope I-129 and the uranium isotope U-236, can be used as radiotracers to study oceanographic processes such as the movement of water masses or pollutants in the oceans and to improve the accuracy of marine dispersion models. Just like a colourful dye that can be observed in a water mass to see where it goes, these radionuclides have a unique signature that researchers can track to study different currents and see how fast it takes them to go from one part of the globe to another.

These isotopes are decaying slowly, which makes them a reliable tracer of natural processes, such as the circulation and mixing of water masses. But U-236 concentrations in the oceans are extremely low and can only be measured using highly sensitive accelerator mass spectrometry, which enables monitoring of ratios between U-236 and U-238, a more abundant natural isotope. In the Namibian project, these measurements were carried out at an IAEA collaborating centre, Spain's National Centre of Accelerators in Seville.

How to win the fight against soil erosion: saving fertile land and preserving water quality with the help of nuclear techniques

By Nicole Jawerth and Miklos Gaspar

Erosion eats away at fertile land, threatening food production and farmers' income alike. The top layer of the soil, which is the first to go, is the most nutritious. Often this nutritious soil ends up in rivers and lakes where it encourages algae to grow, causing the amount of oxygen in the water to decrease. This in turn compromises water quality and harms fish populations.

Nuclear techniques can help scientists and farmers find erosion hot spots and identify the right soil conservation technique to save both farmland and fresh water sources (see The Science box on page 17). The IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), provides support to 70 countries on erosion research. This article profiles two of them: Morocco, where the focus is on saving agricultural land, and Myanmar, where they are fighting off an algae boom in the country's second largest lake.

Saving farmland in Morocco

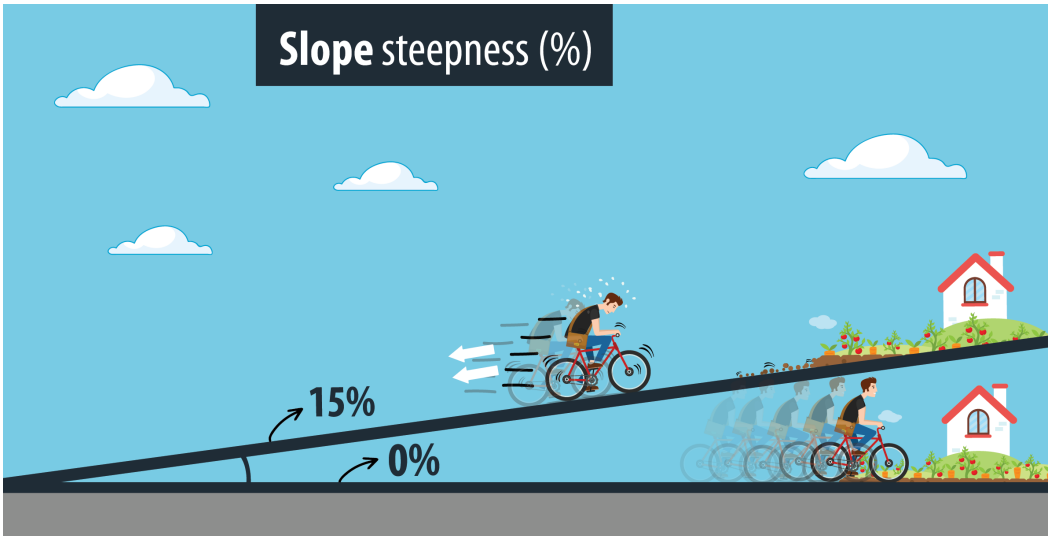
Farmer El Haj Abdeslam's son drives a tractor to help with the farm work while scientists take soil samples from the fields.
(Photo: R. Moussadek/INRA)

Farmer El Haj Abdeslam and his three helpers spent years fighting soil erosion that swept away their crops' fertile ground, taking their incomes with it.

"Year after year, soil erosion was making the quality of my land worse and that made my farm less productive," said Abdeslam, whose 5-hectare chickpea and cereal farm feeds his family of seven and is his sole source of income. "Since the scientists helped me conserve my soil, my farm has been producing 20 to 30% more with less input, and my income has gone up."

The scientists used fallout radionuclides and compound-specific stable isotope techniques (see The Science box on page 17) to pinpoint erosion-prone areas and evaluate the effectiveness of various conservation methods. The technique was introduced in response to Morocco's more than 100 million tonnes of soil losses each year.

"Once we knew where the erosion hotspots were, we tested several soil-conservation methods using nuclear techniques to see how we could improve the situation. We adapted and combined different conservation methods



On a 15% slope, the soil has to withstand a much greater source of gravity.
(Graphic: F. Nassif/IAEA)

already in use worldwide to see what worked best under Morocco's environmental and agricultural conditions," said Moncef Benmansour, Head of the Division of Water, Soil and Climate at the National Centre for Nuclear Energy, Science and Techniques (CNESTEN).

Over 40% of Morocco's total land area suffers from soil erosion owing to deforestation, overgrazing by animals and poor planting techniques. This is compounded by harsh climate conditions such as long periods of drought and short periods of intense rain. The steep ridges carved into the country's landscape make the situation worse for the land and the farmers.

Abdeslam's farm, for example, is on a sharp 10–15% slope. This means, the soil can be more easily washed away by rainfall, especially the fertile top soil (see infographic).

The new conservation method combines growing cereal crops using no-till land management with growing fruit trees and shrub strips. No-till helps to leave the soil undisturbed instead of the digging or stirring of the soil associated with tilling. The roots and leftover parts such as stems and leaves from the selected plants improve the soil structure and overall soil health, which helps hold the soil in place on steep hills.

"We have now reduced soil loss in the Tangier-Tétouan region by 40% and by around 60% in the Casablanca-Settat region," Benmansour said. "The Ministry of Agriculture and the High Commission for Water and Forests and the Fight against Desertification are using the project results and methods to expand soil-conservation efforts to more farmers throughout the country."

Scientists taking a soil sample during the study of erosion hot spots, using nuclear techniques.
(Photo: INRA)

Preserving Myanmar's Inle Lake

The water quality of beautiful Inle Lake in central Myanmar is under threat as a result of erosion on the neighbouring hillsides.
(Photo: M. Gaspar/IAEA)

Tens of thousands of people depend on Inle Lake in central Myanmar for their drinking water and livelihood, but erosion on neighbouring hillsides is causing soil accumulation in the lake, threatening its water quality and fragile ecosystem. A study using nuclear techniques has identified the exact sources of the soil erosion in the valley of the Kalaw river that feeds the lake, which has seen a lot of deforestation in the last few decades. This study has enabled local forestry officials to target their conservation efforts in the areas most susceptible to erosion.

Conservation methods and the use of the new data to educate local people about the consequences of illegal logging and the increased use of the lake as a floating vegetable garden will help save Inle, said U Sein Tun, park warden at the Forest Department in Nyaungshwe, the biggest town on the lake.

The erosion site in the Kalaw watershed. Much of the soil missing from the hillside ended up in Inle Lake.
(Photo: M. Gaspar/IAEA)

The erosion research, which was completed in 2017, was carried out by Myanmar's Forest Research Institute and supported by the IAEA, in cooperation with the FAO. The project was partly funded through the Peaceful Uses Initiative.

The research uses two nuclear techniques to characterize how the soil accumulates and moves as well as to identify its origin and areas prone to soil degradation (see The Science box). The results revealed how, in the Kalaw watershed, each hectare of land that lost its forest cover 15 years ago has also lost 26 tonnes of soil every year since, said Cho Cho Win, the research officer who headed the study. For land that was deforested and cultivated 40 years ago, the soil loss has been 40 tonnes per hectare per year. "By contrast,

on comparable areas where the forest cover was left intact, there has been no erosion whatsoever," she said.

Significant soil losses on the upper slopes and soil accumulation at lower locations, closer to the lake, were noted. This indicates that significant sediment discharges into the lake continue to occur, Cho Win said.

Reversing the environmental degradation of Inle Lake brought about by soil erosion is a key objective not only of the local forestry office but also of the regional Government of Shan State, Sein Tun said. Chief Minister of Shan State Government, Linn Htut, has agreed to head the commission that is tasked with improving the condition of the lake. "The research by Ms Cho Cho Win is an important contribution to our efforts," Tun said.

These efforts will also help to protect the lake's diverse and unique habitat, which was internationally recognized in 2015 when the United Nations Educational, Scientific and Cultural Organization (UNESCO) declared the lake a World Biosphere Reserve. "This title gives us additional responsibilities: the lake is part not only of our heritage, but also of world heritage now," Tun said.

Erosion researcher Cho Cho Win and a local forestry official looking at erosion sites around Inle Lake. (Photo: M. Gaspar/IAEA)

THE SCIENCE

Fallout radionuclides and the compound-specific stable isotope technique

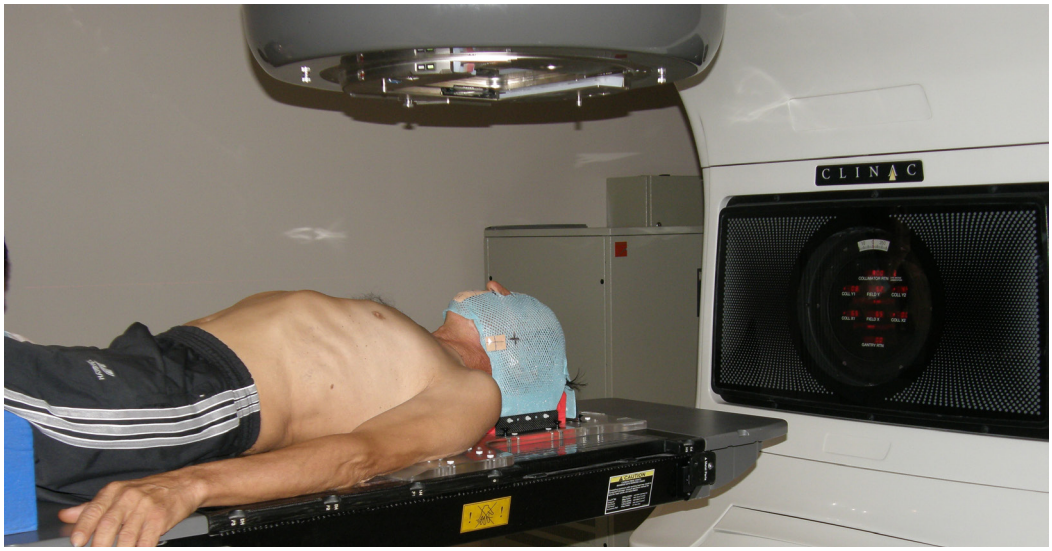
Fallout radionuclides (FRNs) are present in the atmosphere and are deposited on the soil surface through rain.

They bind with soil particles and are concentrated mainly in the top soil layer. They are strongly fixed to soil particles and are not taken up by plants. During erosion and deposition processes, they move with the soil particles and can be used to trace soil redistribution over large areas and extended periods of time. When the top soil layer is eroded, the concentration of FRNs goes down, which scientists can track and measure using gamma spectrometry. Their analysis can help identify changes in soil-redistribution patterns and rates in large catchment areas. They can also evaluate the efficiency of soil-conservation measures in controlling soil erosion. The three commonly used fallout radionuclides for soil erosion tracking are caesium-137, lead-210 and beryllium-7, with caesium-137 being the most common.

Compound-specific stable isotope techniques involve measuring stable isotopes like carbon-13 found in specific, soil-bound organic compounds such as fatty acids. The fatty acids originate from plant roots, animal waste and other remains found in natural ecosystems, which break down and become part of the soil's organic matter. These compounds have unique stable isotope signatures, almost like fingerprints. As the composition of carbon-13 is unique for each compound, a carbon-13 analysis reveals the origin of the eroded soil. By linking carbon-13 fingerprints of land use to the sediment in deposition zones, the technique is useful in determining the sources of eroded soil and in identifying areas prone to soil degradation, enabling authorities to prioritize soil conservation in areas most prone to erosion.

Upgrading radiotherapy services in Moldova

By Aabha Dixit



A patient with head and neck cancer being treated on a LINAC radiotherapy machine at the Institute of Oncology in Moldova.
(Photo: Institute of Oncology, Moldova)

Moldova, with the support of the IAEA, is dealing with over 11 000 new cancer cases a year — often reported at a late stage, when chances of getting cured are lower. Nearly half of these patients now undergo radiotherapy at the newly equipped Institute of Oncology and the Republican Clinical Hospital, in Chisinau, the capital.

"Under the National Cancer Control Programme for 2016–2025, the aim is to reduce cancer mortality by 7%," said Rodica Mindruta-Stratan, a senior oncology surgeon at the Institute of Oncology and Head of the National Cancer Control Programme at the country's Ministry of Health. "Despite recent improvements in early diagnosis, tumours still accounted for over 6000 cases of death in 2016, representing the second highest cause of mortality."

"The Government's goal is to increase stage I and stage II cancer diagnosis by 25% and ensure access of at least 80% of cancer patients to quality diagnosis, treatment and continuous care by 2025."

— Rodica Mindruta-Stratan, Head, National Cancer Control Programme, Moldova

The National Cancer Control Programme sets out to increase access to services for early diagnosis, screening, prevention and treatment. "The Government's goal is to increase stage I and stage II cancer diagnosis by 25% and ensure access of at least 80% of cancer patients to quality diagnosis, treatment and continuous care by 2025," she said.

Since the mid-2000s, the IAEA has worked closely with Moldova's authorities to improve radiotherapy and nuclear medicine services. Moldova faces immense challenges in the health care sector, including cancer diagnosis and treatment, said Ludmila Wiszczor, the IAEA programme management officer working with Moldova.

Expanding radiotherapy services

Over the past 15 years, Moldova has received IAEA assistance to build capacity to implement new technologies and improve quality assurance in nuclear medicine, radio-diagnostics and radiotherapy. Support to upgrade nuclear medicine units at the Institute of Oncology and the Republican Clinical Hospital were identified as priorities by the country's Government, Wiszczor said. The situation was critical, as lack of funds for refurbishment and upgrades had meant that both hospitals had shut down their nuclear medicine diagnostics units, which were obsolete and not functioning. The IAEA support led to their reopening.

Close collaboration with the IAEA led to the installation of a computed tomography (CT) machine in the Republican Clinical Hospital, which radiologists use to more easily diagnose cancer and other serious diseases. A second machine at the Institute of Oncology is scheduled to be installed later this year.

CT uses special X-ray equipment to obtain image data from different angles around the body. It then uses computer processing of the information to show a cross-section of body tissues and organs.

IAEA support also led to the installation of the first modern radiotherapy equipment — a linear accelerator — at the Institute of Oncology. The linear accelerator has improved the country's radiotherapy services and helped expand access, Mindruta-Stratan said.

The IAEA also helped with the installation of a single-photon emission computed tomography (SPECT) machine at the Institute of Oncology in 2011, resulting in increased patient access to modern nuclear diagnostic investigation. The installation of SPECT/CT equipment at the Republican Clinical Hospital in 2013 resulted in the reopening of its nuclear medicine unit, enabling more precise and complex examination of a variety of cancers.

The upgraded radiotherapy units are saving lives. According to World Health Organization (WHO) reports, the six years between 2010 and 2016 saw a dramatic fall in the number of patients being diagnosed with stage III and stage IV cancer — when the chances of recovery are lower — dropping from 70% to 55%. This was in part thanks to the new equipment and training provided by the IAEA, Mindruta-Stratan said.

Training and skill development

Limited access to training and education for medical practitioners working in nuclear medicine and radiotherapy in Moldova resulted in a huge medical gap in cancer care.

"Working with the IAEA to have precise training and skill development has helped us have a pool of professionals such as trained radiation oncologists, medical physicists and radiation therapy technologists to meet our health care requirements," Mindruta-Stratan said.

The country's ongoing engagement in IAEA technical cooperation activities aims to ensure that staff receive appropriate training to make the best use of the new, state-of-the-art equipment. Medical staff's participation in fellowships and scientific visits to build capacity and to update their skills in diagnostic investigation techniques in radiation medicine are key to the national programme for cancer care, she added.

Partnering with the International Agency for Research in Cancer (IARC), a specialized agency of the WHO, has also been key to meeting the country's cancer control challenge. An important achievement has been the introduction of an online cancer registry at the Institute of Oncology, with IAEA, WHO and IARC support. This tool helps track the doses received by patients during treatment at the Institute of Oncology.

The Ministry of Health, Labour and Social Protection organizes anti-cancer campaigns to help raise public awareness of the disease — including the important role of radiotherapy in fighting cancer. The campaigns also promote healthy lifestyle habits, and free medical check-ups are offered.

In order to enhance the quality of health services in cancer control, it is vital to improve the working conditions and implement new technologies based on cost-effectiveness, as well as greater monitoring of health risk factors, Mindruta-Stratan said.

THE SCIENCE

Radiotherapy

Radiotherapy is one of the main types of cancer treatment. It uses ionizing radiation to destroy cancer cells and limit cell growth. It is applied by a team of experts with many years of experience in radiation oncology, medical physics and radiation-therapy technology.

Radiotherapy can be delivered externally or internally. In external beam radiotherapy, radiation beams originating externally to the patient are directed towards the treatment site. These beams are usually created through the use of a linear accelerator or a cobalt unit.

Linear accelerator and cobalt-60 (Co-60) machines are two of the most commonly used pieces of equipment for external beam radiation therapy, a procedure that uses high-energy beams to kill tumour cells. Co-60 machines and linear accelerators have both been used for cancer treatment since the 1950s.

After a natural disaster, nuclear technology helps with recovery

By Laura Gil

A nurse uses new portable X-ray equipment at a health centre in Quito, Ecuador, after the earthquake.
(Photo: M. Melo)

Following recent devastating natural disasters in Ecuador, Nepal, Peru and — just last year — the Caribbean and Mexico, the IAEA was quick to provide medical and other forms of assistance using nuclear technology to help countries maintain essential services in the aftermath. From mobile X-ray units and Zika-detection kits to non-destructive testing (NDT) for infrastructure, the support helped these countries' road to recovery.

"When you go through an earthquake, all your basic, strategic infrastructure is affected: your electricity, your water, your health services," said Rodrigo Salas Ponce, Under-Secretary of Control, Research and Nuclear Applications at Ecuador's Ministry of Electricity and Renewable Energy. "The IAEA's response to our call came at that critical moment — when we needed it the most."

In April 2016, a 7.8-magnitude earthquake hit Ecuador's Pacific coast, rupturing buildings, rendering roads impassable and causing flooding and mudslides. More than 600 lives were lost, and over 28 000 people hospitalized. In addition to other public infrastructure damaged by the earthquake, around ten hospitals and a hundred clinics — whose role in emergency response is pivotal — became inoperable.

Responding to the Government's request for emergency assistance, the IAEA immediately sent X-ray equipment to the affected areas. Through its technical cooperation programme and with the support of the Peaceful Uses Initiative (PUI), the IAEA provided mobile digital X-ray systems, including their complementary power generators and personal detectors. The portable X-ray units allowed medical staff to diagnose around 10 000 patients.

"Basic health care often requires diagnostic imaging with X-rays, particularly in the aftermath of an accident," said Enrique Estrada, a nuclear medicine physician at the IAEA. "And if you have a mobile, portable X-ray unit, even better, because it allows doctors to go to remote places, all the way to the patient's bed, and see what's going on inside their body. This is crucial in a situation like an earthquake, where many are affected by collisions and cannot move."

The IAEA also delivered detectors to test for Zika in response to a small outbreak of *Aedes Aegypti* mosquitoes — the vectors that carry the virus — that the earthquake caused in Guayaquil, on the country's southwestern

coast. "When your water pipes and sewage systems are damaged, mosquitoes that live in them escape, so you have a higher risk of disease," Estrada said.

With the donated equipment, which uses nuclear-derived technology, medical staff detected over 200 Zika cases, in addition to over 60 dengue cases and almost 15 of chikungunya, all viruses transmitted by this type of mosquito.

Assistance to Peru and the Caribbean

The same type of assistance has been delivered to Peru, the north of which was largely affected by floods and landslides caused by a rise in sea levels in 2017. Up to 22 deaths were reported, alongside a rise in viruses transmitted by the *Aedes Aegypti* mosquito, in particular dengue.

Similarly, the IAEA is providing hurricane-hit Dominica, Antigua and Barbuda, and Barbados with portable X-ray units to cover basic medical needs after hospitals on these islands were destroyed by the Irma and Maria hurricanes in September 2017.

"We are helping with what falls under our area of expertise: basic diagnostics through nuclear imaging," Estrada said.

Finding the tiniest crack: using non-destructive testing to test infrastructure

After an earthquake, even the tiniest crack inside a building can become dangerous— it can also reveal to an expert if that building is safe to live in, can be repaired or needs to be demolished. To find this crack, experts rely on non-destructive testing.

These inspection techniques are extremely handy when evaluating the physical integrity of buildings, bridges and other free-standing structures. They are non-invasive — that is, they can literally look through materials without altering them and find cracks, buried objects or leakages. The methods include applying nuclear techniques such as radiography using X-rays, visual inspection, and ultrasonic and magnetic testing.

"These techniques provide professionals with key information to evaluate the structural safety of a building, so that they can, if necessary, initiate repair," said Sebastián Lápida, a civil engineer at the IAEA. Lápida and his peers travelled to Mexico after the September 2017 earthquake, in which hundreds of buildings had collapsed, killing around 300 people. They trained and helped national experts evaluate the integrity of critical buildings.

NDT also helped Ecuadorian authorities test the safety of the country's most damaged buildings after the 2016 earthquake. Today, experts are building the first regional NDT centre in Quito, the capital, to provide expertise for the entire Latin America.

The first time the IAEA offered NDT to help a country recover from a natural disaster was when it supported Nepalese authorities after a 7.8-magnitude earthquake hit the country in April 2015, killing nearly 9000 people and injuring almost 20 000. Five hundred buildings collapsed, with almost 300 000 suffering partial damage.

Immediately after the earthquake, an IAEA-led team of experts went to the mountainous country to help the locals evaluate their key infrastructure such as hospitals and bridges using NDT. The local experts used the results to take key decisions — which buildings to knock down; which to repair.

"Whilst critical public civil infrastructure remained standing after the earthquake, we could not have known if there were hidden flaws that could pose a risk without NDT," said Mani Ram Gelal, Deputy Director General at the Department of Urban Development and Building Construction in the Ministry of Urban Development. "For a country like us, located in between two tectonic plates, there is always a high risk of an earthquake and, in addition, we are a hotspot for other natural disasters."

Besides providing equipment in health care and NDT for critical infrastructure, the IAEA has also helped strengthen regional capacity in Latin America and Asia to respond to natural disasters.

In 2017 the IAEA, through a project funded under the PUI, organized training courses in Japan to bolster NDT capabilities for Member States in Asia. A similar project is under way in Latin America.

"Whilst critical public civil infrastructure remained standing after the earthquake, we could not have known if there were hidden flaws that could pose a risk without NDT."

— Mani Ram Gelal, Deputy Director General, Department of Urban Development and Building Construction, Ministry of Urban Development, Nepal

Introduction of nuclear power in Bangladesh underway with IAEA assistance

By Matt Fisher

Construction of Bangladesh's first nuclear power plant began on 30 November 2017.
(Photo: Arkady Sukhonin/Rosatom)

"Bangladesh is introducing nuclear energy as a safe, environmentally friendly and economically viable source of electricity generation."

— Mohammad Shawkat Akbar, Managing Director, Nuclear Power Plant Company Bangladesh Limited

The beginning of construction at Bangladesh's first nuclear power reactor on 30 November 2017 marked a significant milestone in the decade-long process to bring the benefits of nuclear energy to the world's eighth most populous country. The IAEA has been supporting Bangladesh on its way to becoming the third 'newcomer' country to nuclear power in 30 years, following the United Arab Emirates in 2012 and Belarus in 2013.

Bangladesh is in the process of implementing an ambitious, multifaceted development programme to become a middle-income country by 2021 and a developed country by 2041. Vastly increased electricity production, with the goal of connecting 2.7 million more homes to the grid by 2021, is a cornerstone of this push for development, and nuclear energy will play a key role in this area, said Mohammad Shawkat Akbar, Managing Director of Nuclear Power Plant Company Bangladesh Limited. Bangladesh is also working to diversify its energy supply to enhance energy security, reduce its dependence on imports and on its limited domestic resources, he added.

"Bangladesh is introducing nuclear energy as a safe, environmentally friendly and economically viable source of electricity generation," said Akbar. The plant in Rooppur, 160 kilometres north-west of Dhaka, will consist of two units, with a combined power capacity of 2400 MW(e). It is being built by a subsidiary of Russia's State Atomic Energy Corporation ROSATOM. The first unit is scheduled to come online in 2023 and the second in 2024. "This project will enhance the development of the social, economic, scientific and technological potential of the country," Akbar said.

The country's goal of increased electricity production via nuclear energy will soon be a reality, Akbar said. "For 60 years, Bangladesh has had a dream of building its own nuclear power plant. The Rooppur Nuclear Power Plant will provide not only a stable baseload of electricity, but it will enhance our knowledge and allow us to increase our economic efficiency."

Milestones for nuclear

Bangladesh is among around 30 countries that are considering, planning or starting the introduction of nuclear power. The IAEA assists them in developing their programmes through the Milestones Approach — a methodology that provides guidance on working towards the establishment of

When completed, the two units of the Rooppur Nuclear Power Plant will have a combined power capacity of 2400 MW(e).
(Photo: Arkady Sukhonin/Rosatom)

nuclear power in a newcomer country, including the associated infrastructure. It focuses on pointing out gaps, if any, in countries' progress towards the introduction of nuclear power.

The IAEA has been supporting Bangladesh in developing its nuclear power infrastructure, including in establishing a regulatory framework and developing a radioactive waste-management system. This support has been delivered under the IAEA technical cooperation programme and is partially funded through the Peaceful Uses Initiative.

Nuclear infrastructure is multifaceted, containing governmental, legal, regulatory and managerial components, in addition to the physical infrastructure. The Milestones Approach consists of three phases, with a milestone to be reached at the end of each.

The first phase involves considerations before a decision is taken to start a nuclear power programme and concludes with the official commitment to the programme. The second phase entails preparatory work for the contracting and construction of a nuclear power plant, ending with the commencement of bids or contract negotiations for the construction. The final phase includes activities to implement the nuclear power plant, such as the final investment decision, contracting and construction. The duration of these phases varies by country, but they typically take between 10 and 15 years.

"The IAEA Milestones Approach is a guiding document and the Integrated Work Plan (IWP) is the important means of bringing all of the stakeholders in Bangladesh together to ensure the fulfilment of all safety, security, and safeguards requirements of the Rooppur NPP project," said Akbar. "This IWP enabled Bangladesh to develop a holistic approach to implementing IAEA guidance as well as cooperating with national stakeholders and other bilateral partners towards the development of a national nuclear power programme."

INIR Mission

The Integrated Nuclear Infrastructure Review (INIR) is a holistic peer review to assist Member States in assessing the status of their national infrastructure for introducing nuclear power. The IAEA completed its first INIR mission to Bangladesh in November 2011, making recommendations on how to develop a plan to establish the nuclear infrastructure. Nearly five years later, in May 2016, a follow-up mission was conducted, which noted the progress made — Bangladesh had established a nuclear regulatory body, had chosen a site for the power plant and had completed site characterization and environmental impact assessment.

"The IAEA and other bodies, including those from experienced countries, can and do provide support, but the responsibility for safety and security will lie with the Government," said Dohee Hahn, Director of the IAEA's Division of Nuclear Power, at the ceremony for the pouring of the first nuclear safety-related concrete at Rooppur on 30 November 2017. "The IAEA stands ready to continue supporting Bangladesh in developing a safe, secure, peaceful and sustainable nuclear power programme."

Radiation processing enables small businesses to enter global value chains in Malaysia

By Miklos Gaspar

Cables such as these produced at Wonderful Ebeam Cable will be used in the engine compartment of cars. They are made heat resistant and fire retardant using irradiation.
(Photo: M. Gaspar/IAEA)

"By using radiation technology, we have been able to improve our product line and meet the requirements of the car manufacturers."

— Ir Chan Chang Choy, Managing Director, Wonderful Ebeam Cable Sdn Bhd, Malaysia

To maximize the benefits of globalization and increase their revenues, many small and medium-sized businesses (SMEs) would like to join a global supply chain. Meeting the quality requirements set by the multinationals that head these value chains is often tough for SMEs operating on shoestring budgets. The country's nuclear agency, Nuklear Malaysia, is doing its bit to help.

Thanks to the support of Nuklear Malaysia, Wonderful Ebeam Cable Sdn Bhd has become the first SME in the country to supply cables to Malaysia's booming automotive sector. "By using radiation technology, we have been able to improve our product line and meet the requirements of the car manufacturers," said Managing Director Ir Chan Chang Choy. "This has allowed me to grow my business and increase the workforce."

Owing to the high temperature in engines, cables that are used in the engine compartment of cars need to be heat and flame resistant to make sure they, and the car, do not catch fire. To improve the heat resistance and flame retardance of the insulation of copper wires, their polymers need to be cross-linked, forming an extremely tightly packed network of interconnected polymer chains (see The Science box). Cross-linked insulation material increases the service temperature of the cables; for instance, from 75°C in the case of normal polyvinyl chloride (or PVC) to 100°C for cross-linked PVC.

Although cross-linking can be achieved using chemicals, the process requires high temperatures. The alternative, the irradiation of polymers, leads to the formation of permanent bonds between the polymer chains at room temperature — which requires lower operating costs.

No SME in Malaysia has the technology in place to carry out such irradiation, and banks are reluctant to provide loans for the purchase of irradiation equipment, Chang

Choy said. “These machines are expensive, and the banks do not accept the equipment itself as collateral because, as there is no second-hand market for irradiation equipment, they cannot sell it if my company were to go bankrupt.”

Nuklear Malaysia, however, irradiates the products of small businesses like Chang Choy’s for a small fee.

“The automotive industry has long been recognized as one of the key sectors towards the realization of Malaysia’s aspiration to become an industrialized nation by 2020,” said Zulkafli Ghazali, Director of Radiation Processing Technology at Nuklear Malaysia. “This requires domestic capacity in cable manufacturing.” Through this support, the nuclear agency is doing its part to support the Government’s SME Masterplan to accelerate the growth of SMEs and increase their contribution to the economy from 32% of GDP in 2010 to 41% by 2020.

Wonderful Ebeam Cable ships its products to Nuklear Malaysia’s irradiation facility three times a week. After a few days, the cables are returned, ready for the car companies.

Nuklear Malaysia is working with several SMEs in different areas of radiation processing — using ionizing radiation such as gamma radiation and electron beam to change the physical, chemical or biological characteristics of materials to increase their usefulness and value or to reduce their impact on the environment. It is most widely used to modify plastic and rubber materials, sterilize medical devices and consumer items, preserve food and reduce environmental pollution.

Nuklear Malaysia’s scientists have benefitted from various IAEA technical cooperation and collaborative research projects, through which they were able to perfect the technologies used in radiation processing by working with experts from around the world. “The IAEA helps turn global expertise into local expertise,” Ghazali said.

The IAEA helps Member States strengthen capacities in adopting radiation-based techniques that support cleaner and safer industrial processes. Nuklear Malaysia has participated in several such projects and has been recognized, since 2006, as an IAEA Collaborating Centre for radiation processing of natural polymers and nano-materials.

THE SCIENCE

Radiation Processing

Radiation technology can be used to modify diverse materials. It brings about certain changes in their properties, many of which can be used in a wide variety of commercial applications.

Various radiation sources are used to modify materials, such as high-intensity radioisotope sources, electron accelerators of various energies, and the X-rays they produce. Radiation is also used for the grafting.

The main commercial application of the technology is the cross-linking of polymer chains, used in producing wire and cable insulations, car tyres or natural rubber latex for medical items, such as gloves. This method achieves superior material properties without the need to use toxic chemicals.

A cross link is a bond that links one polymer chain to another, resulting in changes in the polymers’ physical characteristics. For instance, when cross links are added to long rubber molecules, the flexibility decreases, the hardness increases, and the melting point increases as well.

Other worldwide commercial applications are heat-shrinkable tubing, food wraps and self-regulating heaters. Cross-linked water-soluble polymers, also known as hydrogels, are commercialized for wound dressing, specifically for burn wounds and diabetic ulcers.

Inside the SESAME International Research Centre

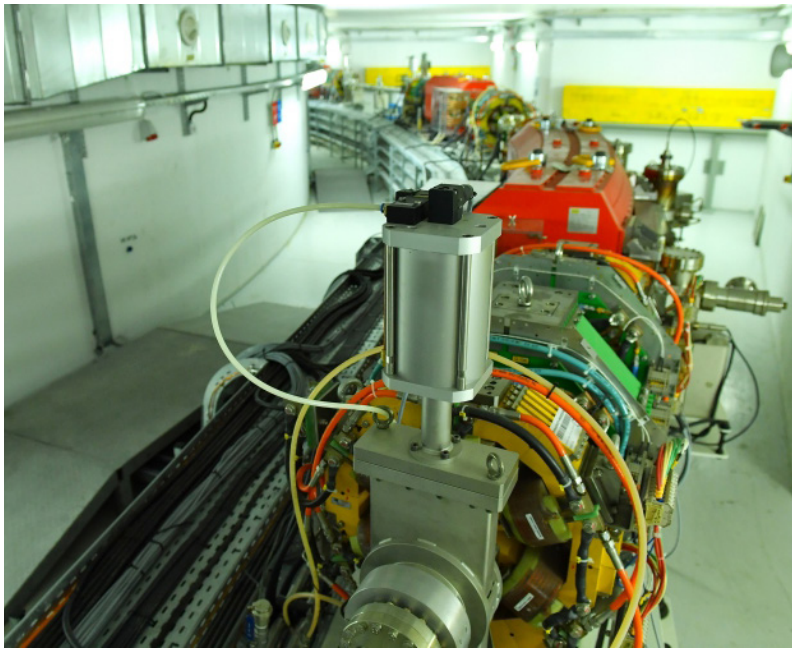
By Aabha Dixit (text) and Dean Calma (photos)

1 The Synchrotron-Light for Experimental Science and Applications in the Middle East — or SESAME — Centre, a nuclear research facility inaugurated in May 2017, is a regional initiative, developed with the help of the United Nations Educational, Scientific and Cultural Organization (UNESCO). The IAEA provided advice and technical support during the development of the facility through its Technical Cooperation programme.

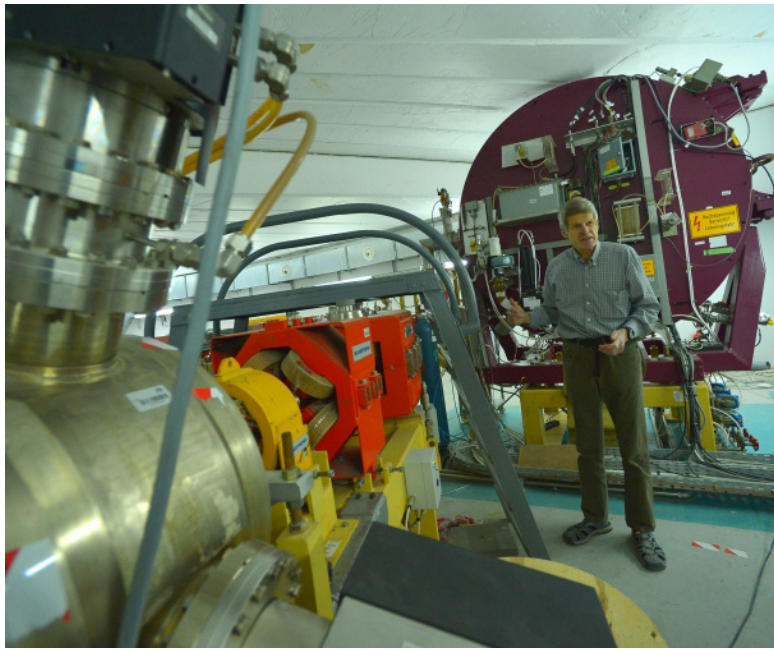
2 "SESAME is an achievement both in terms of science and international relations and its success is due to the interest and confidence of all involved," says Khaled Toukan, Chairman of the Jordan Atomic Energy Commission. SESAME lists as members: Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey.

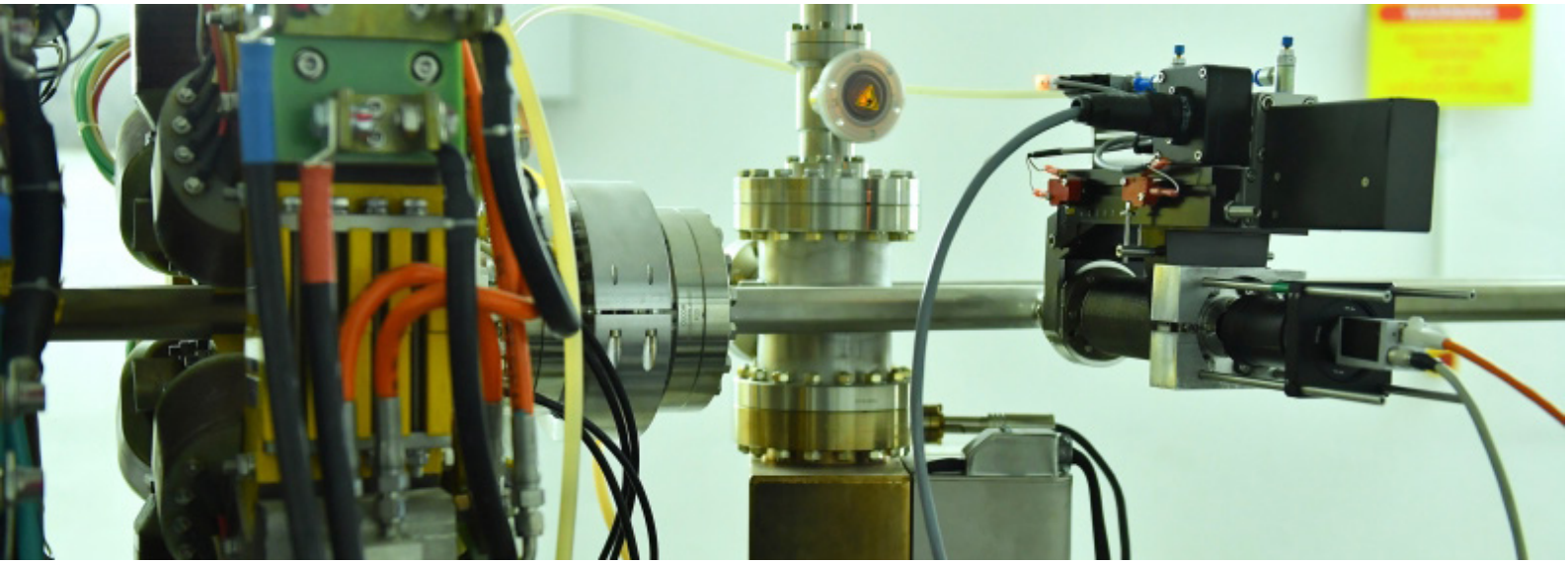
3 This is the inner storage ring of the facility, where electrons start to circulate to build up the required energy of 2.5 GeV. The inner storage ring, or booster, with deflection and focused magnets, will enable the electron beams to circulate as they accelerate. The precise beams of light produced include microwave, infrared, visible, ultraviolet, X-ray and gamma-ray light.

4 The IAEA has helped in the successful commissioning of the SESAME magnets, offering training in areas such as beamline technology, as well as in installation, mounting and testing of the equipment.



5 SESAME's Technical Director Erhard Huttel explains the process of how pre-accelerated electron beams are injected into the synchrotron. Synchrotrons are sources of electromagnetic radiation generated by electrons moving almost at the speed of light.

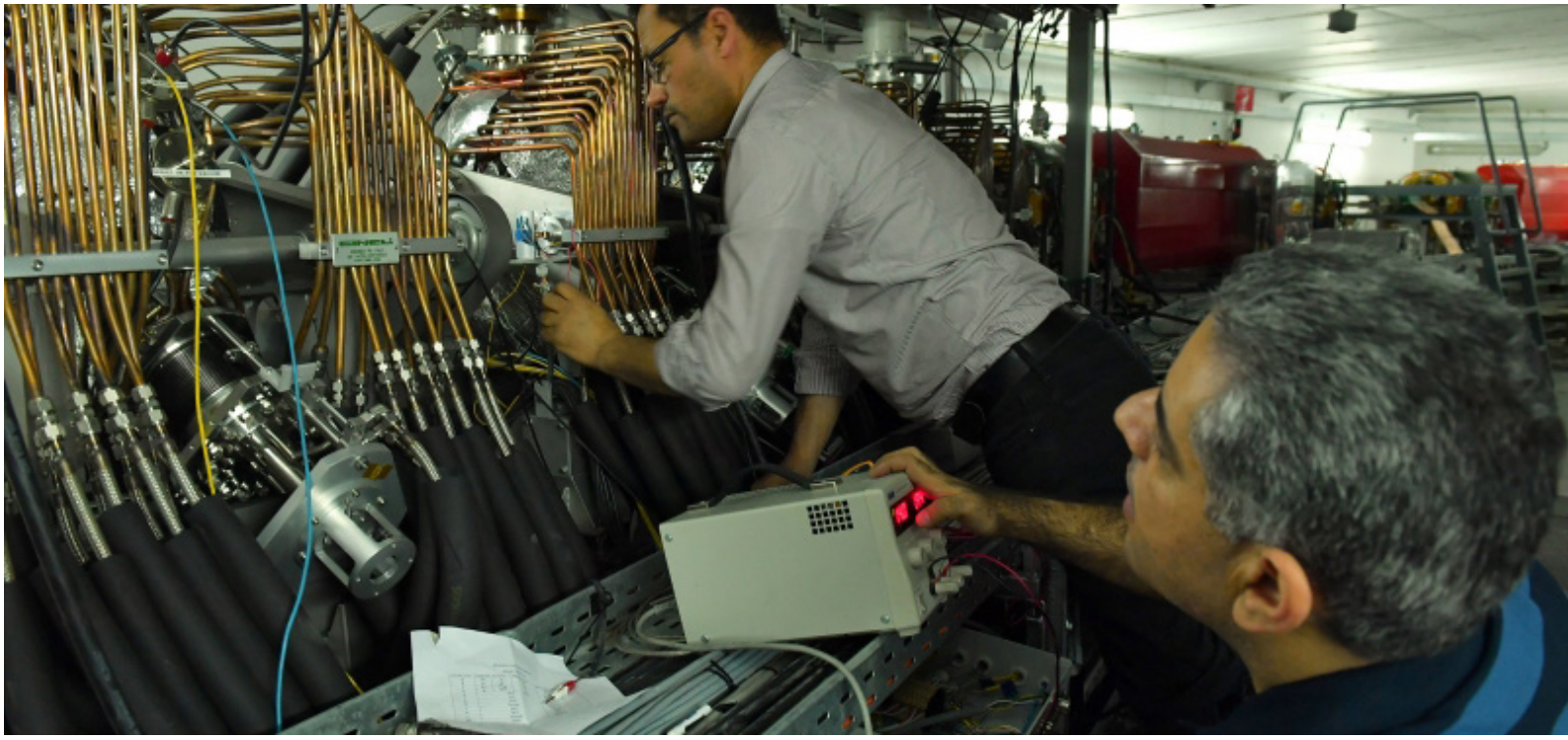




6 These are sealed vacuum pipes through which the electromagnetic beams pass to reach the experimental hubs.

7 The SESAME Centre enables visiting scientists, including university students and researchers, to participate in experiments with synchrotron radiation and analyse the data obtained in a diverse set of disciplines, such as biology, archaeology, physics, chemistry and medical sciences, as well as in research concerning the basic properties of materials.

8 To ensure safety, the specially designed roof shield provides radiation protection and protects the storage rings through which the electromagnetic beamlines circulate.



9 Staff checking the power supplies in the outer storage ring of the facility.

10 Messaoud Harfouche, XRF/XAFS beamline scientist, checking the reactor's XRF equipment. The XRF beamline hub uses the synchrotron light for research and training in a wide range of applications.

11 Gihan Kamel, an infrared beamline scientist from Egypt, working in the infrared beam laboratory. The research and training on the infrared beamline at the SESAME Centre is helping the scientific community in the region to gain a better understanding of its use and applications.

What is the Peaceful Uses Initiative?

The Peaceful Uses Initiative (PUI), which was launched in 2010, has become instrumental in mobilizing extra-budgetary contributions that supplement the Technical Cooperation Fund to support various technical cooperation projects and other unfunded projects of the IAEA in the peaceful application of nuclear technology.

Additional resources through PUI have been used to support a wide variety of IAEA activities aimed at promoting broad development goals in Member States in areas such as food security, water resource management, human and animal health, including the establishment of a network of veterinary diagnostic laboratories in Africa and Asia, nuclear power infrastructure development and nuclear safety, many of which would have remained unfunded without PUI.

PUI has also allowed the IAEA to respond faster and more flexibly to the evolving priorities of Member States, as well as to unexpected needs or unforeseen emergency events. This was demonstrated by the IAEA's response to the Ebola virus disease in West Africa, to the Zika virus disease in Latin America and the Caribbean, as well as to natural disasters in Asia and Latin America.

As of February 2018, PUI has helped mobilize over 100 million euros — from 24 Member States, the European Commission and the private sector — in support of more than 250 projects that benefit over 150 Member States.

The IAEA will continue its work to further promote the benefits of the peaceful uses of nuclear science and technology, contributing to 'Atoms for Peace and Development' and the attainment by Member States of their Sustainable Development Goals.

Nuclear and nuclear-derived techniques can help improve livestock heath and production and fight animal diseases.
(Photo: N. Jawerth/IAEA)

Vets in Bangui, Central African Republic, use nuclear-derived techniques to detect diseases that are transmitted from animals to humans, including Ebola. The IAEA helps equip laboratories and trains scientists in the use of these techniques.
(Photo: L. Gil/IAEA)

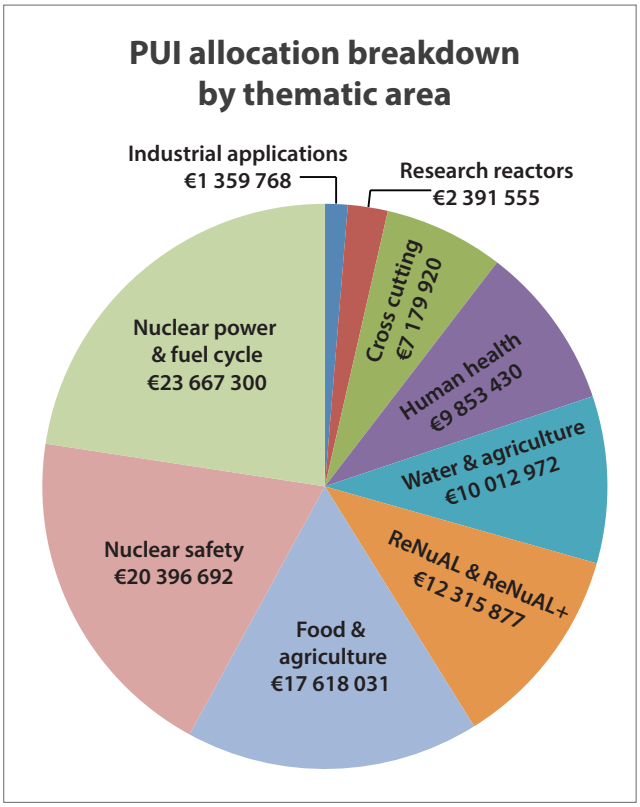
How to make an extra-budgetary contribution through the Peaceful Uses Initiative

Member States initiate the process by sending a pledge letter to the IAEA, including the amount of the contribution, specific project to fund, if already identified, and an indication that the contribution is made through PUI. Member States are encouraged to closely consult with the Secretariat before they make their official pledge.

The IAEA will initiate the formal acceptance process for the contribution and respond to the pledge letter.

Private donors interested in contributing through the PUI are encouraged to contact the Secretariat to identify the appropriate modality.

For further information on PUI, please access https://www.iaea.org/services/key-programmes/peaceful-uses-initiative



Construction of a bunker for a linear accelerator at the IAEA's campus in Seibersdorf, Austria.
(Photo: D. Calma/IAEA)

IAEA laboratory modernization efforts continue to progress

By Matt Fisher

Modernization of the IAEA's nuclear applications laboratories in Seibersdorf, Austria, is well under way as the IAEA works to bolster its capacity to better support Member States' needs through applied research, capacity-building and technical services in the applications of nuclear sciences. The initiative is partly financed through the Peaceful Uses Initiative (PUI).

The modernization initiative includes the construction of two new laboratory buildings. One of these, the Insect Pest Control Laboratory (IPCL), was inaugurated on 25 September 2017 and is planned to become operational at the beginning of 2019. This laboratory will augment the IAEA's ability to provide assistance to Member States in using the sterile insect technique to combat insect pests.

"With new and modern facilities, the IPCL will in the future be able to do even more to help Member States control insect pests that endanger our crops, our livestock and our health," said IAEA Director General Yukiya Amano during the inauguration.

The new Flexible Modular Laboratory building, to be inaugurated by the end of 2018, will house three laboratories — the Food and Environmental Protection Laboratory, the Soil and Water Management and Crop Nutrition Laboratory and the Animal Production and Health Laboratory.

Member State contributions to the modernization have amounted to more than €32 million in extrabudgetary funding, including over €12 million via PUI. As of February 2018, 33 Member States have provided financial or in-kind contributions. Donors are being recognized with a place on the donor wall, located in the lobby of the new IPCL. The next funding targets will focus on the remaining infrastructure needs, equipment and start-up activities, as well as enhancement of the other laboratories.

Efforts aimed at extending the IAEA's resource mobilization base beyond its traditional donors resulted in a partnership with Varian Medical Systems for a ten-year loan of a linear accelerator (linac) to the Dosimetry Laboratory. Preparatory work for the construction of the bunker to house the linac started in August 2017.

The IAEA has also received a High-Speed Liquid Chromatograph Mass Spectrometer, based on an agreement with Shimadzu Corporation for its donation through the Peaceful Uses Initiative. It will enable the IAEA to better support Member States in research and training on food safety.

Inauguration of the Insect Pest Control Laboratory in Seibersdorf, Austria on 25 September 2017 (from left to right): Assistant Director General of the Food and Agriculture Organization of the United Nations Ren Wang, Resident Representative of Germany to the IAEA Friedrich Däuble, Permanent Representative of Austria to the United Nations Christine Stix-Hackl, IAEA Director General Yukiya Amano, Permanent Representative of Indonesia to the United Nations Darmansjah Djumala and Permanent Representative of South Africa to the United Nations Tebogo Seokolo. (Photo: D. Calma/IAEA)

Experts emphasise importance of multidisciplinary approaches involving nuclear techniques at World Cancer Day event

At a panel discussion on World Cancer Day, world-renowned experts highlighted the importance of facilitating synergy between various nuclear techniques to prevent, diagnose and treat cancer.

"We will strive to continuously improve the services we offer our Member States so they can provide better care — and hope — for their people," said IAEA Director General Yukiya Amano. "IAEA experts from all technical departments, and from many scientific disciplines, put together packages of services that help countries improve access to modern cancer treatment."

Panellists examined the various ways in which nuclear techniques can support the prevention, diagnosis and treatment of cancer and help countries worldwide to achieve better disease management for their patients. The discussion centred on four main areas: nutrition, diagnosis and follow-up, radiation oncology and radiotherapy, and quality assurance.

"Millions of people are counting on us to keep pushing the cancer agenda forward," said Princess Dina Mired of Jordan, President-elect of the Union for International Cancer Control. She emphasised the importance of political will and proper management in the fight against cancer.

The IAEA is heavily involved in the fight against cancer through the application of nuclear techniques including radiotherapy, brachytherapy and diagnostic radiopharmaceuticals. These efforts contribute to the achievement of United Nations Sustainable Development Goal 3 (ensure healthy lives and promote well-being for all at all ages).

"Cancer care should be carried out comprehensively…we have incorporated a cancer control program into our national health system," said keynote speaker Nila F. Moeloek, Indonesia's Minister of Health. Sustainable collaboration and coordination with all stakeholders is key, she added.

Alan Jackson, Chair of the Continuous Update Panel on Nutrition and Cancer & Professor of Human Nutrition at the University of Southampton, United Kingdom talked about the role of nutrition and physical activity in the prevention and management of cancer.

"There are a range of opportunities that are being developed and promoted involving isotopic techniques in the prevention and treatment of cancer," Jackson said. "There is an emerging international collaboration involving the link between nutrition and cancer."

Joanna Kasznia-Brown, a UK radiologist and member of the International Committee of the Royal College of Radiologists, discussed the role of medical imaging in cancer management, including diagnosis and the development of the treatment plan. "If we catch the cancer in its early stages, we can treat patients with much better results," she said.

Mack Roach III, Professor of Radiation Oncology and Urology, Director, Particle Therapy Research Program & Outreach, Department of Radiation Oncology at the University of California-San Francisco, emphasized the importance of the multidisciplinary management of cancer, and in particular the role of radiotherapy.

"Radiotherapy continues to be one of the oldest, most effective and cost-effective treatments for cancer available today," Roach said. Improvements in computers, imaging and material sciences have resulted in major advances in the accuracy and safety of radiotherapy, he added.

Jake Van Dyk, President of Medical Physics for World Benefit & Professor Emeritus of Oncology and Medical Biophysics, Western University, London, Ontario, Canada discussed the use of medical physics as an integral part of the path towards a cancer-free world.

"Medical physicists are important members of a radiotherapy team," Van Dyk said. "They are critical for positive patient outcomes, and training of the next generation of medical physicists, radiation oncologists and radiation therapists is critical."

Ntokozo Ndlovu, Radiation Oncologist & Senior Lecturer at the University of Zimbabwe discussed the role of nuclear techniques for cancer treatment in Africa.

"The IAEA has been instrumental in building capacity in radiotherapy in Africa," Ndolovu said. "This project led to the creation of the African Radiation Oncology Network (AFRONET), a telemedicine initiative to improve the quality of clinical decisions and radiotherapy treatment, strengthen the education of medical residents and improve treatment outcomes."

"The IAEA World Cancer Day event highlighted the importance of advances in radiation medicine in fighting cancer as well as nutrition for prevention and served as a bridge between science and policy," said May Abdel-Wahab, Director of the IAEA's Division of Human Health.

— By Matt Fisher

$600k OPEC-fund grant to promote use of nuclear techniques for improved food security and sustainable agriculture

Improved farming practices, healthier animals and – ultimately – increased food security will be the outcomes of projects supported by a US$ 600 000 grant by the Organization of Petroleum Exporting Countries (OPEC) Fund for International Development (OFID) under a partnership with the IAEA signed last December.

The work will promote the use of nuclear techniques towards best agricultural practices, and will benefit many people, including poor farmers, in developing countries in Asia.

The projects tie in with Sustainable Development Goal 2 "Zero Hunger", emphasized OFID Director-General Suleiman J Al-Herbish at the signature of the agreement at OFID headquarters in Vienna.

"The two projects will improve food security, and ultimately social and economic growth – two essential elements of the United Nations Agenda 2030 for Sustainable Development, which OFID has committed to wholeheartedly," Al-Herbish said. "We are pleased to be working with the IAEA in support of agriculture in Asia."

Producing more rice

US$ 400 000 will be used to help farmers grow rice that can cope with the effects of climate change in Bangladesh, Cambodia, Lao PDR and Nepal. Countries in Asia, which produce 90% of the world's rice, have seen fluctuating yields in recent years due to rising temperatures that bring plant diseases and insect pests, extreme floods and droughts as well as a rise in sea levels leading to increased soil salinity and lower soil fertility in coastal areas. By using nuclear and isotopic techniques, scientists can help farmers improve water management practices and optimize the use of fertilizer for best yields at the lowest cost.

The increased productivity from these improved practices is expected to lead to higher volumes of high-quality, affordable rice, increasing the food security of the rural population in target countries. The improved technologies will also help reduce greenhouse gas emissions from rice production.

Fighting animal diseases

The other US$ 200 000 will go towards the application of nuclear-related techniques for the diagnosis of foot-and-mouth disease and other diseases impacting cattle in Cambodia, Lao PDR, Myanmar and Vietnam. Many animal diseases are highly contagious and can spread extremely quickly within a country and across borders, hindering trade and, in some cases, affecting public health. Early and rapid detection of the pathogen is key to halting the spread of these diseases. Nuclear-related techniques are used in the development of testing kits for the diagnosis of such diseases. While conventional methods can detect the viruses, they take a long time and cannot determine their behaviour or genetic character – which is required for a rapid response.

Under the grant, the IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), will train veterinarians from the four countries in the diagnosis and control of the diseases. The project will ultimately benefit livestock farmers and increase cattle production.

Since 1989, OFID has extended 12 grants totalling US$ 2.4 million to the IAEA in support of health and agricultural projects in Africa, Asia and Latin America.

— By Miklos Gaspar

Strategic management of new and expanding nuclear power programmes discussed at annual meeting

Challenges that countries face when introducing or expanding a nuclear power programme were discussed at an IAEA meeting in Vienna earlier this year. Among them are developing a regulatory and legal framework, establishing an effective owner/operator organization, involving all stakeholders to build public confidence in nuclear power, and training a well-qualified workforce.

The annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure, held from 31 January to 2 February 2018, attracted some 100 representatives from both embarking and operating countries and international organizations. Senior officials from national government organizations, regulatory bodies and owner/operator organizations presented updates on their activities, shared good practices and lessons learned as they embark on, or consider introducing or expanding nuclear power.

"In 2017, we saw considerable progress in the area of nuclear power programme development," said Milko Kovachev, Head of the IAEA Nuclear Infrastructure Development Section. "Two countries new to nuclear power, the United Arab Emirates (UAE) and Belarus, are about to complete their first nuclear power plants. The UAE will be the first newcomer country to start commissioning in years." He added that a key for success is that the relevant nuclear infrastructure is developed at the same pace as the nuclear power plant project.

Bangladesh began constructing its first unit in November 2017. Turkey is expected to start construction of its first plant soon, subject to regulatory approval. Egypt has signed contracts for its first nuclear power plant, while other newcomer countries are at different stages of making preparatory steps for their nuclear power programme.

There were also significant developments in operating countries expanding their programmes last year. "We expect that advanced, first-of-a-kind designs are scheduled to be commissioned in a number of countries this year, such as the AP1000 in China and the EPR1600 in China and France," Kovachev pointed out. Both designs are advanced pressurized water reactors.

Participants discussed a number of key areas that are also part of the IAEA Milestones Approach, a three-phase process for developing the necessary infrastructure for a safe, secure and sustainable nuclear power programme.

Involving different groups of stakeholders at various stages of programme development is a crucial aspect in successful programme implementation, participants heard. IAEA Member States are using a combination of common tools and approaches to meet stakeholder needs, including social media, and aim at creating positive and open relationships with local communities.

The IAEA offers a wide range of guidance materials and training activities for national experts and policymakers and is developing new services including a training course in stakeholder involvement.

Modelling human resource needs plays an important role in preparing plans for adequate staffing of national organizations at different stages of programme development, participants agreed. The IAEA offers a nuclear power human resource model and has already trained many national experts in its application.

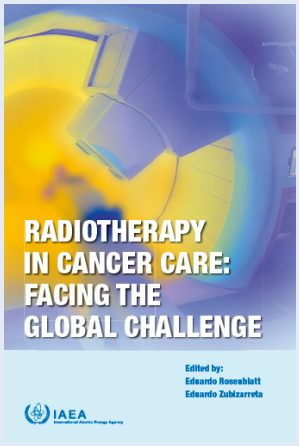
The owner/operator organization for the nuclear power plant project needs to be planned from the very beginning and established during the project development phase (Phase 2 of the IAEA Milestones Approach), participants heard. They agreed that the owner/operator organization must be a 'knowledgeable customer' with sufficient capabilities to hire services from contractors and oversee them.

Building capabilities for regulatory oversight must start early on, during the project development phase, to be expanded during construction. A sufficient number of qualified staff is crucial for national regulators to perform their functions effectively. The IAEA offers support and guidance in this area. "Having a transparent, open and trusted regulatory body is one of the most important aspects of a nuclear power programme," stressed Stewart Magruder of the IAEA's Regulatory Activities Section.

Several countries are considering small modular reactor technology for their nuclear power programmes. These advanced reactors that produce electricity up to 300 MW(e) per module are better suited for smaller electricity grids and for remote or isolated locations. Also, they have shorter construction times and may require less initial investment. However, participants also recognized that licensing would include first-of-a-kind features, so the regulatory processes would be complex. Although there are about 50 small and medium-sized or modular reactor designs and concepts, three of which are in advanced stages of construction, they are lacking operating experience. The IAEA offers a forum for exchange of the most recent research and development results in this technology.

Representatives from many countries highlighted their cooperation with the IAEA and emphasized the importance of an Integrated Nuclear Infrastructure Review (INIR) missions. "The pathway for us to move forward has become much clearer after an INIR mission in 2017," said Nii Kwashi Allotey, Director of the Nuclear Power Institute in Ghana. "We are now working on the mission's recommendation and have a better understanding of where we need to commit more resources." To date, the IAEA has conducted 22 INIR missions in 16 countries.

— By Elisabeth Dyck



Radiotherapy in Cancer Care: Facing the Global Challenge

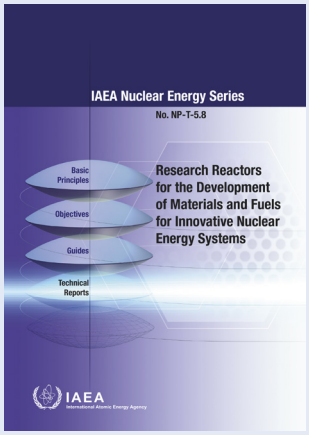
This publication presents a comprehensive overview of the major topics and issues to be taken into consideration when planning a strategy to address cancer diagnosis and treatment, particularly in low- and middle-income countries. Cancer treatment is complex and calls for a diverse set of services. Radiotherapy is recognized as an essential tool in the treatment and palliation of cancer.

Access to radiation treatment is limited in many countries and non-existent in some. The lack of radiotherapy-treatment resources exacerbates the burden of disease and underscores the continuing health care disparity among countries. Closing this gap represents an essential measure in addressing this global health equity problem.

With contributions from leaders in the field, the publication provides an introduction to the achievements and issues related to the use of radiation therapy as a cancer treatment modality around the world. Dedicated chapters focus on proton therapy, carbon ion radiotherapy, intraoperative radiotherapy, radiotherapy for children, HIV/AIDS-related malignancies, and costing and quality management issues.

Non-serial publications; ISBN: 978-92-0-115013-4; English edition; 62.00 euros; 2017

www-pub.iaea.org/books/IAEABooks/10627/Cancer



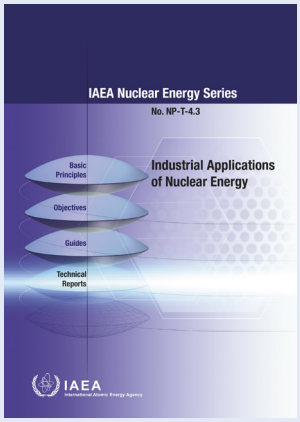
Research Reactors for the Development of Materials and Fuels for Innovative Nuclear Energy Systems

This publication presents an overview of research reactor capabilities and capacities in the development of fuels and materials for innovative nuclear reactors, such as GenIV reactors. It provides comprehensive information on the potential for materials- and fuel-testing research of 30 research reactors, both operational and in development. The information includes their power levels, mode of operation, current status, availability and a historical overview of their utilization. A summary of these capabilities and capacities is also presented.

Papers providing a technical description of the research reactors, including their specific features for utilization, are collected as profiles on a CD-ROM and represent an integral part of the publication. The publication is intended to foster wider access to information on existing research reactors with capacity for advanced material-testing research and thus ensure their increased utilization in this particular domain.

IAEA Nuclear Energy Series No. NP-T-5.8; ISBN: 978-92-0-100816-9; English Edition; 32.00 euros; 2017

www-pub.iaea.org/books/IAEABooks/10984/Research-Reactors



Industrial Applications of Nuclear Energy

This publication provides a detailed overview of the potential use of nuclear energy for industrial systems or processes that have a strong demand for process heat steam and power and information on the mapping of nuclear power reactors proposed for various industrial applications. It describes the technical concepts for combined nuclear-industrial complexes that are being pursued in various countries and presents the concepts that were developed in the past to be applied in connection with some major industries. It also provides an analysis of the energy demand in various industries and outlines the potential that nuclear energy may have in major industrial applications such as process steam for oil recovery and refineries, hydrogen generation and steel and aluminium production.

IAEA Nuclear Energy Series No. NP-T-4.3; ISBN: 978-92-0-101417-7; English Edition; 59.00 euros; 2017

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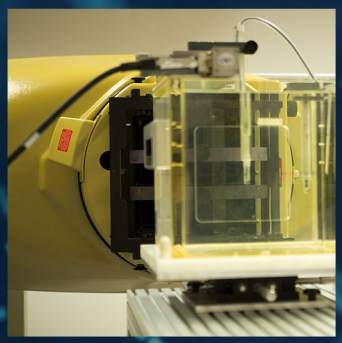
Nuclear Security

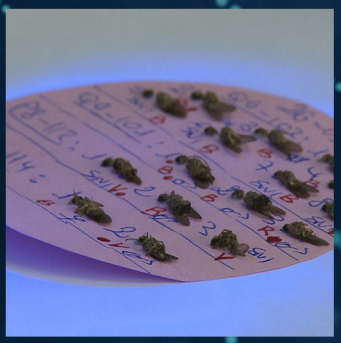


Nuclear Safety

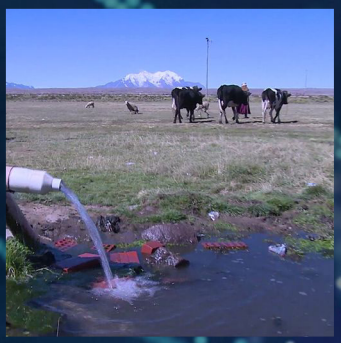
Energy

Health

Plant Breeding



Pest Control



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