

NUCLEAR TECHNOLOGY

**Nuclear Techniques
for Development
and Environmental Protection**



In 2023, nuclear sciences and applications continued to be essential tools for tackling critical development challenges. Under Rays of Hope, ZODIAC and NUTEC Plastics, nuclear sciences and applications helped bridge global gaps in cancer care, ramped up efforts to prevent new pandemics, and tackled plastic pollution. In the newly launched GloWAL Network, they will support effective water resource management, and in Atoms4Food, a new and exciting collaboration with FAO, they will help countries strengthen food and nutrition security.

Working at the cutting edge of nuclear sciences, the IAEA continues to accelerate innovation, through applied research and development, to advance sustainable development creating a better future.

Najat Mokhtar

Deputy Director General
and Head of the Department
of Nuclear Sciences and Applications

Nuclear Techniques for Development and Environmental Protection

active coordinated
research projects within the Department
of Nuclear Sciences and Applications

105

technical, consultancy and research
coordination meetings

149

active research contracts

1415

active Collaborating Centres
within the Department
of Nuclear Sciences and
Applications

54

databases

24



OA-ICC NEWS STREAM

almost **40 000** unique visitors
from **185** countries

938 posts

65 673 views

HUMAN HEALTH CAMPUS

79 446 users

365 771 page views



34

webinars

12

online courses

14

e-learning modules

186

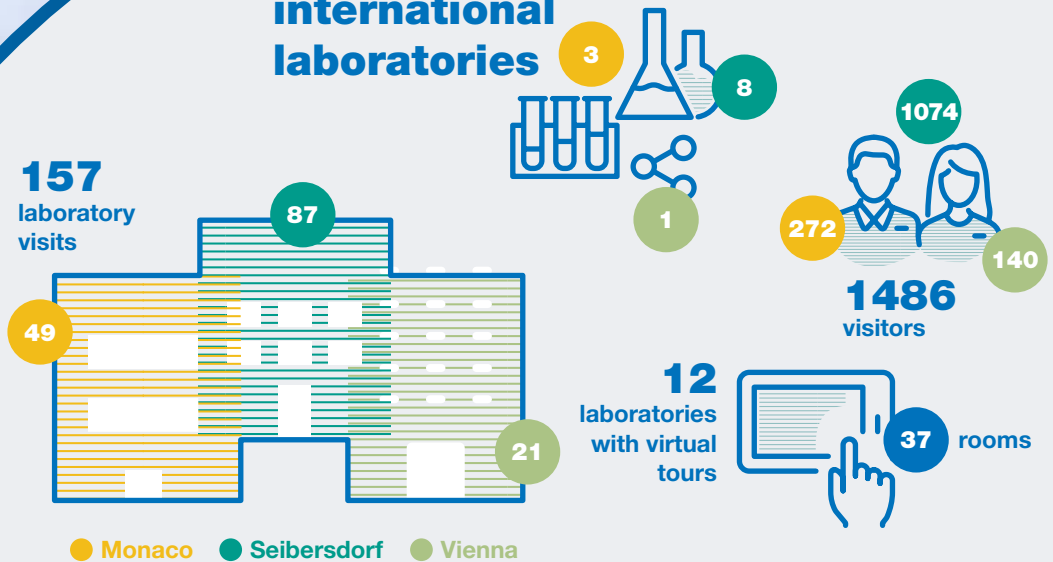
training courses and workshops

34

conferences
forums
symposiums
side events

12 international laboratories

157 laboratory visits



● Monaco ● Seibersdorf ● Vienna



FOOD AND AGRICULTURE

OBJECTIVE

To increase the sustainability and resilience of food and agriculture production and related livelihoods in Member States through climate-smart agriculture approaches, including meeting challenges from animal and zoonotic diseases, plant pests, food safety risks, climate change, biothreats, and nuclear or radiological emergencies.



Viet Nam has nurtured a long-standing partnership with the FAO/IAEA through the Joint FAO/IAEA Centre, focusing on the application of nuclear techniques in food and agriculture. This collaboration, alongside the utilization of nuclear techniques, has been instrumental in our efforts to combat food insecurity and malnutrition while making substantial contributions to nationwide food security.

Assoc. Prof. Huynh Thanh Dat

Minister of Science and Technology, Viet Nam



31

new varieties incorporated in the FAO/IAEA Mutant Variety Database



200

sequences submitted to GenBank; 31 new genomes produced



10

analytical methods developed to support food safety and authenticity



5

guidelines published on fruit fly pest management



5

SOPs and guidelines published on the use of stable isotope techniques to assess drought tolerance and water use efficiency in crops

KEY OUTPUTS

Combating Animal and Zoonotic Diseases through the Delineation of Pathogen Genomes

As part of the ZODIAC initiative, the Agency and FAO, through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, established and optimized next generation sequencing (NGS) and associated bioinformatics tools and transferred them to Member States to build capacity in addressing animal health challenges. NGS has the advantage of detecting unknown and unsuspected pathogens and their characteristics, providing key information to decision makers responsible for disease control.

In 2023, NGS confirmed the presence in West Africa of African swine fever virus (ASFV) genotype II, which caused severe outbreaks and contributed to the ongoing worldwide pandemic, and of four other ASFV genotypes co-circulating in Zambia, prompting informed research on the spread of ASFV and the required control strategies. In addition, pathogen genomes were sequenced in disease hotspots, providing a better understanding of pathogen diversity

and enhancing capacity to tackle outbreaks. The lumpy skin disease virus was further characterized, leading to the discovery of an ancient strain last seen in 1960 in Africa and currently circulating in South Asia. This data has been critical to inform vaccination and other control strategies.

Realizing the benefits of NGS in animal health, Member States have requested additional support to build local capacity. In 2023, the Agency and FAO provided training and standard operating procedures (SOPs) in NGS and bioinformatics to scientists from 15 African and Asian countries. The increased use of NGS led to enhanced diagnostics and strengthened surveillance programmes in 20 Member States, and is advancing research to combat infectious animal and zoonotic diseases worldwide.

Innovative Application of Radioisotopes/Stable Isotopes and Ionizing Radiation to Food Safety/Authenticity Testing and Standards Setting

To enhance food safety, promote food irradiation and combat food fraud, the Agency supported the development of analytical methods including X-ray fluorescence for metal-profiling in African and Asian millets, and immunosensors and supercritical fluid chromatography–mass spectrometry for mycotoxin testing in Belizean tortillas. Moreover, training and guidance on the detection of fraud in honey was provided to Moroccan stakeholders, while isotopic methods used for establishing vinegar and honey authenticity were adapted to monitor organic food and to trace the origins of mango, coffee and cocoa in the Philippines. Through a coordinated research project, the Agency produced the radioisotope Zinc-65 and used it to synthesize amoxicillin for fish-depletion studies. The use of positron emission tomography (PET) imaging for radiolabelled drugs in fish was also introduced. Additionally, an artificial intelligence-based tool was developed and

implemented in Colombia to interpret mass spectra and isotopic patterns in residue testing.

Worldwide, the Agency supported food safety laboratories to strengthen their capabilities. Thanks to this support, Zimbabwe’s Central Veterinary Laboratory obtained ISO/IEC 17025 accreditation — facilitating poultry exports and farmer awareness about antimicrobial use — and in Kyrgyzstan, a food safety laboratory improved service delivery and attained national reference status for testing antimicrobial residues and resistance.

With Agency support, the Commission on Phytosanitary Measures (CPM) for the International Plant Protection Convention revised and published *International Standard for Phytosanitary Measures No. 18*, which provides technical guidance on the application of irradiation as a phytosanitary measure for international trade agreements.

Pest Free Production Sites to Facilitate Fruit Trade

Pest free production sites (PFPSs) have been adopted by the CPM and are used as a pest risk mitigation scheme to facilitate fruit trade. Thanks to the Agency’s contribution, the number of PFPSs increased from 303 in 2018 to 1094 in 2023. Ecuador is among the countries that have benefited the most from the scheme’s extended use, exporting non-traditional fruits including pitahaya (dragon fruit), tree tomato

and uchuva (golden berries) to the United States of America and, more recently, to China and Peru. Bilateral workplans have been subscribed between Ecuador’s agency for regulation and control of plant and animal health, Agrocalidad, and recognized national plant protection organizations of importing countries. The workplans contain specific phytosanitary measures that must be applied by producers

▼
Scientists conduct experiments at the Agency’s Seibersdorf laboratories to delineate the complex genomes of pathogens to identify emerging and re-emerging animal and zoonotic pathogens.



and exporters for them to be eligible for participation in the export programme. Among the measures being used is the area-wide application of the sterile insect technique, which is supported by the Agency. Sterile flies are imported weekly from the mass-rearing and sterilization facility of the Moscamed programme located in El Pino, Guatemala, and are released over 855 hectares of commercial fruit crops and surrounding areas in Ecuador. Additionally, Agrocalidad staff received capacity development in surveillance, a key part of the PFPS scheme, suppression and, in particular, the handling and release of the sterile flies. A PFPS is achieved

when at least one year of surveillance demonstrates the absence of fruit flies of quarantine importance, specifically the Mediterranean fruit fly and the South American fruit fly.

The use of PFPS has increased the possibility of fruit exports in Ecuador, which has provided an incentive for the fruit industry to expand the production of these non-traditional crops. In the case of pitahaya, the production area has increased to over 1700 hectares and 34 000 tonnes of fruit are being exported. The value of these exports was more than US\$ 73 million as per September 2023.

Exploring Cosmic Radiation to Enhance Genetic Diversity for Climate-Resilient Crops

Scientists are looking to understand how cosmic radiation and microgravity impact induced genetic variation to develop crops that can withstand harsh growing conditions on Earth, particularly those imposed by climate change.

The Agency, through the Joint FAO/IAEA Centre, is leading a pioneering effort to conduct a feasibility study on seed irradiation in space for induced genetic diversity and expedited plant mutation breeding. Seeds of the model plant species *Arabidopsis thaliana* and sorghum (*Sorghum bicolor*) were sent to space for approximately five months to generate novel genetic diversity from exposure to harsh space environments. The seeds were exposed to different environments at the International Space Station; some seeds were kept inside and others were placed outside to

expose them not only to microgravity, but also to extreme temperatures and unshielded cosmic radiation.

The seeds are currently at the Agency's Plant Breeding and Genetics Laboratory in Seibersdorf and are undergoing rigorous evaluation for plant growth biology and DNA structural variation using cutting-edge technologies. Preliminary observations indicate normal morphology and reproductive behaviour in the plants arising from the seeds of both crops. The phenotypic and genetic variation within these mutant populations is being explored to identify useful traits for climate resilience and enhanced yields, with a view to developing new varieties that will contribute to global food security.

Synergizing Cosmic Ray Neutron Sensors and Remote Sensing for Water Saving Agriculture

Backed by a decade of comprehensive R&D conducted by the Joint FAO/IAEA Centre, cosmic ray neutron sensor technology experienced a significant increase in adoption rates in drought-prone regions in 2023, particularly in 23 African countries. Through different research and capacity-building mechanisms, the Agency has made concerted efforts to integrate cosmic ray neutron sensor technology with high-resolution remote sensing. The integration of these technologies promises a revolutionary shift in landscape-scale soil moisture monitoring by supporting climate-smart irrigation practices and providing crucial data on droughts and floods to decision makers and farmers. Under the US\$30 million 'Soil mapping for resilient agri-food systems in Central America and sub-Saharan Africa (SoilFER)' project, coordinated by FAO, the Agency, through the Joint FAO/IAEA Centre, developed an action plan for deploying 25 cosmic-ray neutron sensors in five countries across both regions, targeting

five representative agro-ecological zones per country. This strategic deployment will support better understanding of drought impacts on crop production and will provide data on effective mitigation strategies. Through the Joint FAO/IAEA Centre, the Agency supports SoilFER to enhance national soil fertility data through infrared spectroscopy and advanced mathematical modelling techniques, including artificial intelligence. This collaborative project underscores a concerted determination to fortify agricultural systems by offering comprehensive and innovative tools to adequately confront challenges posed by changing climatic conditions and ensuring more resilient agri-food systems. Soil mapping can improve efficiency in the use of fertilizers and help to boost food security and nutrition.



HUMAN HEALTH

OBJECTIVE

To support Member States in enhancing their capability to address needs relating to nutrition and the prevention, diagnosis and treatment of health problems through the development and application of nuclear and related techniques within a quality assurance framework.



There is a great opportunity and need to conduct randomized controlled trials in low and middle income countries (LMICs) to define evidence-based best practices within these settings. The IAEA HYPNO trial for head and neck cancer, a disease that disproportionately affects LMICs, is a good example. The IAEA played a crucial role facilitating the trial via the long term relationships they built with clinicians in cancer centres all over the world.

Søren M. Bentzen

Professor of Radiation Oncology and Director of the Division of Biostatistics and Bioinformatics at the University of Maryland School of Medicine, and principal investigator for the HYPNO trial



991

radiotherapy beams across **383 institutions** in **86 countries** measured by the IAEA/WHO TLD postal dose audit service



10

audits conducted
5 QUANUM
2 QUAADRIL
3 QUATRO



3

IAEA Nuclear Explained
podcast episodes on human health and nutrition



17

Agency publications produced and over 50 scientific publications featured in peer-reviewed journals

KEY OUTPUTS

Advancing Care Globally

A coordinated research project (CRP) that closed in 2023 resulted in the development and publication of groundbreaking infant body composition reference charts, allowing clinicians and researchers to better interpret related data. The use of the reference charts will help inform interventions that combat malnutrition and set up healthier childhood trajectories.

To strengthen the practice of nuclear medicine globally in a context-appropriate and safe manner, the Agency released *A Practical Guide for Pediatric Nuclear Medicine*. By presenting a hands-on approach, the guide enables physicians to use diagnostic nuclear medicine procedures successfully in children. Between its release in September 2023 and the end of the year, the publication was downloaded over 25 000 times — 13 000 in the first week alone.

The recently published results of the IAEA HYPNO trial, spanning 12 cancer centres in 10 LMICs, demonstrate the safety and effectiveness of a practice-changing, resource-sparing technique: hypofractionation. Through its use, radiation oncologists can treat head and neck cancer patients in four weeks — just over half the time that standard radiotherapy takes — by using fewer, but higher, radiation doses. For providers and patients alike, hypofractionation offers a cost-effective and convenient tool to make care more accessible and affordable, especially in LMICs.

The provision of codes of practice is highly valued by Member States, as they have a significant impact on the

quality and standardization of radiation globally. To improve the traceability, accuracy and consistency of clinical radiation dosimetry measurements in its Member States, the Agency issued *Dosimetry in Brachytherapy – An International Code of Practice for Secondary Standards Dosimetry Laboratories and Hospitals*. The publication meets the need for a systematic and internationally unified approach to brachytherapy dosimetry.

In 2023, the Agency maintained its commitment to advance cancer care globally through Rays of Hope, especially amid projections indicating that nearly three-quarters of all cancer-related deaths will occur in low and middle income countries by 2040. Under the initiative, the Agency has developed a clear and transparent process to review and select potential anchor centres, resulting in the establishment of the first five such centres in 2023. As part of the application process, institutions should comply with technical, logistical, governance and sustainability criteria, among others.

Under ZODIAC, the Agency signed a collaboration agreement with Amazon Web Services to leverage the latter's cloud-based service for the creation and development of the ZODIAC Respiratory Disease Phenotype Observatory — a secure medical imaging repository through which the Agency can foster global cooperation on the large-scale data analysis of disease patterns to enable the early detection of potential pandemics.

Ensuring Quality Care

In 2023, QUANUM, QUAADRIL and QUATRO audits helped to improve patient care through comprehensive, independent audits of clinical practices. The Agency expanded its pool of Spanish-speaking expert auditors by training complete QUATRO teams during a course at the Dosimetry Laboratory. These trained professionals from Latin America can now serve as a resource to train others in the region. In addition, the Agency published the guideline *National Networks for Radiotherapy Dosimetry Audits* to support countries in developing their own audit programmes.

To ensure the establishment and operation of quality health services within available resources, the Agency published *Basics of Quality Management for Nuclear Medicine Practices and Worldwide Implementation of Digital Mammography Imaging*.

The IAEA/WHO Network of Secondary Standards Dosimetry Laboratories (SSDLs) — which calibrates instruments for measuring radiation and is critical for accurate dose quantification by end-users — currently consists of 89 laboratories in 76 countries. In 2023, the Agency provided calibration services for 69 ionization chambers and 17 electrometers and issued 157 calibration certificates. In addition, the Agency held a technical meeting on SSDLs and quality management systems and published guidelines on establishing an SSDL for interested Member States and on the education of radiation metrologists for SSDLs.

Lastly, the Agency conducted an interlaboratory comparison study on analysis of deuterium oxide enriched water in 2023, among 50 laboratories that use Fourier transform infrared spectrometers to measure deuterium oxide in saliva samples for nutrition assessments to self-assess the quality of their measurements.

Catalysing Education and Training

To provide medical professionals with an in-depth understanding of radiotherapy set-ups, the Agency developed virtual reality models of three cancer treatment procedures. An innovative, cost-effective training tool, these models are especially advantageous when the necessary medical equipment is unavailable or has not yet been commissioned for clinical use — as was the case in Mozambique, where the Agency debuted its prototype during a training course. By enabling professionals in resource-challenged contexts to train in an immersive

learning environment, these models help close global knowledge gaps.

The Agency's Human Health Campus continued to serve as a critical resource for nuclear medicine, radiation oncology, medical physics and nutrition professionals, with new offerings ranging from a 3D realistically-rendered animation video on a nuclear technique for assessing body composition to four modules that aim to develop contouring skills for head and neck cancer radiotherapy planning.

▶ **Virtual reality goggles and the Agency's recently developed e-learning module 'Patient Setup and Positioning for Cervical Cancer External Beam Radiotherapy'.**



Leveraging Multilateralism for Global Coordinated Action

In 2023, the Agency worked with other UN agencies — including through the UN Interagency Task Force on the Prevention and Control of Non-communicable Diseases — to bring the full force of their tools and expertise directly to countries.

The Agency continued to serve on the steering committee of UN Nutrition, an interagency coordination mechanism that addresses malnutrition in all its forms. In doing so, the Agency raised awareness of the relevance of nuclear nutrition techniques for scientific and programming communities. Since November 2023, the Deputy Director General and Head of the Department of Nuclear Sciences and Applications, Ms Najat Mokhtar, has served as the UN Nutrition Chair.

To support the Global Breast Cancer Initiative, which aims

to reduce mortality from the most common form of cancer worldwide by 2.5% each year, the Agency and WHO created a common implementation framework with resource-appropriate strategies for countries in order to improve diagnosis and treatment. Both agencies also developed technical recommendations on the sustainable management of radiotherapy facilities and equipment, to help cancer departments ensure that all cancer patients can be treated safely and accurately with minimized care gaps.

The Agency also brought attention to an alarming trend. On the basis of data from its Directory of Radiotherapy Centres and from the International Agency for Research on Cancer, the WIPO Global Innovation Index 2023 revealed that cancer cases requiring radiotherapy were outpacing available technology.

Meeting the Challenges of the Present and the Demands of the Future

Theranostics — the combination of diagnostic imaging tools and therapeutic strategies — enhances diagnostic accuracy, treatment monitoring and therapeutic efficacy. By enabling medical professionals to tailor care to each patient's needs, it advances personalized medicine. To support countries in implementing emerging clinical applications in a safe and appropriate manner, the Agency organized a consultancy meeting on that topic and published four scientific peer-reviewed articles.

As the concentration and bioavailability of important nutrients are adversely impacted by changing climates and shifting food systems, nuclear techniques play an important role in generating much-needed data on how well certain food sources meet bodily needs. One such technique — the minimally invasive dual isotope tracer method, which was developed under a CRP that closed in 2023 — remains pivotal for understanding the absorption of essential amino acids

from various food sources. Data from this method continues to inform an ongoing initiative to establish a joint FAO/IAEA protein database. Supporting the new Atoms4Food initiative, the database will help to formulate evidence-based dietary guidelines and food-based interventions to ensure adequate and quality protein intake from balanced diets.

Over the next decade, clinically qualified medical physicists will play an essential role in facilitating the safe, effective and appropriate application of AI-based tools as their deployment within the medical uses of radiation grows. Against this backdrop, the Agency published *Artificial Intelligence in Medical Physics: Roles, Responsibilities, Education and Training of Clinically Qualified Medical Physicists* and trained 59 clinically qualified medical physicists during a joint workshop with the Abdus Salam International Centre for Theoretical Physics.



Workshop participants actively applying their new AI knowledge and skills in hands-on, group-based laboratory exercises.

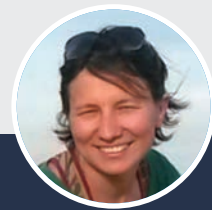




WATER RESOURCES

OBJECTIVE

To support Member States applying isotope hydrology techniques for assessment and management of their freshwater resources, including hydroclimatic change impacts on water resources distribution and availability.



Isotope hydrology is one of the tools that we use in Antarctica. In particular, we use stable water isotopes to understand the sources of moisture and its pathways and understand processes causing extreme events in Antarctica and their importance in melting of the ice-sheets.

Irina Gorodetskaya

Senior Researcher at the Interdisciplinary Centre of Marine and Environmental Research (CIIMAR), University of Porto, Portugal



443

**active GNIP
monitoring sites
in 98 Member
States at the end
of 2023**



2

**active isotope
monitoring
networks**



3

**active
Collaborating
Centres in
water resources**



33

**Agency
publications
produced**

KEY OUTPUTS

Sustainable Networks for Improved Isotope Data Generation

The Agency launched the Global Water Analysis Laboratory (GloWAL) Network at the UN 2023 Water Conference. This network will enable countries to generate and utilize isotopic water data to achieve SDG 6 on clean water and sanitation and the objectives of the UN Water Action Agenda. The network has four focus areas: the Grand Challenges related to water research; data management; capacity development; and innovation. These areas are crucial for managing freshwater resources amid climate change, population

growth and declining water quality worldwide. Australia, Switzerland and the United States of America have provided initial support to the Network and nine countries from three regions (Africa, Asia and the Pacific and Latin America and the Caribbean) have expressed interest in becoming nodes within the network. GloWAL data management will link to the Global Network of Isotopes in Precipitation (GNIP) and the Global Network of Isotopes in Rivers (GNIR) to enhance spatial and temporal data coverage in Member States.

Advancing Isotope Hydrology for Effective Water Resources Management

The 16th International Symposium on Isotope Hydrology, held in July 2023, identified the need for an Agency atom trap trace analysis facility, used to detect and measure low concentrations of certain atoms in samples, and additional mass spectrometry to expand the range of important isotope tracers for improving water management, as well as specific guidelines and specialized training activities to support the integration of these isotope tracers in water management practices. To meet these needs, the IAEA Isotope Hydrology

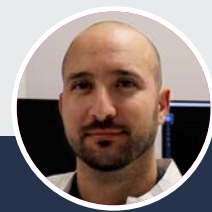
Laboratory is being expanded to accommodate the new equipment and improve training facilities. The Agency continues to promote the use of isotope hydrology for effective water management at international forums, including UN-Water activities and COP meetings. For the first time, the Agency conducted two training courses on modelling of isotope hydrology data in 2023, with all regions represented. The Agency also increased its focus on AI integration in hydrological modelling for better decision making.



MARINE ENVIRONMENT

OBJECTIVE

To support Member States to address and mitigate their most pressing marine challenges using nuclear and derived techniques while enhancing their expertise and capability to develop tailored science-based strategies for the sustainable management of marine ecosystems.



There is no human health without ocean health. Working with the IAEA to address marine contaminants and plastic pollution has been crucial in our work to advance knowledge and develop national action plans related to seafood safety.

Alejandro Garcia-Moya

Director of the Cienfuegos
Environmental Studies Centre, Cuba



26%

increase in ocean acidity since the industrial revolution



3 billion

people count seafood as their vital protein source



CRP

Evaluating the Impact of Ocean Acidification on Seafood — a Global Approach



11

countries performed experiments on 13 seafood species



3

scientific publications featured in peer-reviewed journals

KEY OUTPUTS

Our oceans and coastal seas provide unique benefits and resources to humans. Seafood, for example, is a vital protein source for over 3 billion people, contributing more than 17% of the world's animal protein supply, as well as micronutrients

and essential acids not easily found in land-based food. In 2023, the IAEA Marine Environment Laboratories continued supporting Member States in ensuring access to seafood that was safe to consume.

Seafood Safety and Associated Outputs: Marine Contaminants and Plastic Pollution

The consumption of contaminated seafood poses a direct threat to human health — a threat that is compounded by the escalating issue of plastic pollution and its effects. In 2023, within the framework of NUTEC Plastics, the Agency conducted experimental work on the fate of microplastic and nanoplastic pollution in seafood and tested the usefulness of a newly developed tool. Isotopically enriched plastics were synthesized and tested in experimental conditions to trace the transfer of microplastics along the seafood chain, with promising preliminary results. In addition, significant progress was made on the development of analytical methodologies for measuring microplastic-related contaminants in the marine environment, enabling a comprehensive survey of plastic additives and flame retardants. Additional research was conducted on the role of the biological film that naturally grows on microplastics (biofilm) in relation to the contaminant absorption capacities of microplastics and the leaching of microplastic additives, for a study assessing the fate of plasticizers on marine phytoplankton, the base of several aquatic food webs.

Regarding seafood safety, competent laboratories must monitor a comprehensive suite of contaminants. To build and maintain this competence, reliable data and reference materials

are necessary. In 2023, the Agency introduced a new certified reference fish material (IAEA-435A) with the aim of enhancing data quality assurance for the analysis of persistent organic pollutants (POPs) listed under the Stockholm Convention on Persistent Organic Pollutants, a critical aspect of identifying and addressing changing contamination patterns and trends resulting from human pollution and climate change. In addition, the Agency developed two protocols focusing on advancing the detection of marine biotoxins produced by harmful microalgae in seafood. At Monaco Ocean Week in 2023, the Agency presented the impacts of emerging chemicals on marine ecosystems and marine organisms to enhance knowledge sharing. In addition, it hosted two training courses underpinning the UNEP Mediterranean Action Plan's Programme for the Assessment and Control of Marine Pollution in the Mediterranean Region (MED POL) and trained scientists to assess and monitor the impacts of POPs. Further knowledge sharing with scientists in academia, industry, consultancies and governmental institutions took place at the International Conference on Chemistry in the Environment (ICCE 2023) through spotlight presentations that delved into leaching and sorption of microplastic-associated additives as transport vectors for organic pollutants.

Seafood Security Outputs: Advances in Research to Ensure Access to Seafood

Global access to seafood is threatened by human-driven climate pressures such as ocean warming, acidification and pollution. The Agency is actively monitoring these pressures and assessing their impact on seafood production and resources. Agency actions in this area primarily involve experimental research and capacity-building efforts, facilitated by partnerships with other stakeholders and UN agencies.

Addressing a variety of these impacts is the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), an independent group sponsored by ten UN agencies that acts in an advisory capacity on climate-related issues. To address specific marine issues, the Agency initiated GESAMP Working Group 45 on climate change- and greenhouse gas-related impacts on contaminants in the ocean to assess existing research, identify knowledge gaps and make recommendations to guide future research. Co-sponsored by the Agency, UNESCO's Intergovernmental Oceanographic Commission, the IMO, UNEP and the WMO, Working Group 45 held its final meeting in 2023 and continued drafting its report on the impacts of climate change on the fate, toxicity, speciation and bioaccumulation of contaminants in the ocean.

In 2023, the Ocean Acidification International Coordination Centre (OA-ICC), which aims to address impacts of ocean acidification on vulnerable coastal communities and their aquaculture industries, continued to host training events in order to build capacity, maintain an international presence to promote ocean acidification awareness and support

collaborative projects to advance research. OA-ICC resources, including the OA-ICC news stream, bibliographic database and biological response data portal, remain available to all Member States through the OA-ICC webpage, which is updated on the basis of daily searches of scientific literature. OA-ICC training events focused on using OA-ICC bibliographic resources to produce meta-analyses of ocean acidification impacts; understanding research methods for evaluating blue carbon and ocean change; and improving communication about ocean acidification to various audiences, including students and policymakers. In addition to capacity-building efforts, the OA-ICC hosted international experts from the Scientific Committee on Oceanic Research's 'Changing Ocean Biological Systems' working group; sponsored the first in-person meeting for the steering committee of the Global Ocean Acidification Observing Network (GOA-ON) Mediterranean regional hub; presented at the 2023 Aquatic Sciences meeting of the Association for the Sciences of Limnology and Oceanography; and participated in the annual GOA-ON Executive Council meeting.

Additionally, the OA-ICC completed a five-year coordinated research project to evaluate the impact of ocean acidification on various local seafood species with economic or cultural importance. Participating scientists from several Member States are now equipped with local and global perspectives on the impact of ocean acidification as tool to promote global mitigation measures, local investment and adaptation strategies, and best practices for ocean acidification research, including marine experimental biology.



As part of the activities of the IAEA Marine Environment Laboratories, Agency scientists partner with UNEP on the Mediterranean Action Plan's Programme for the Assessment and Control of Pollution in the Mediterranean Region. In this photo, Agency laboratory technicians train participating Member State scientists on sample preparation for trace element analysis using inductively coupled plasma mass spectrometry (ICP-MS).



Marine Radioactivity Monitoring

Data-based science is a matter of keen interest to the UN system and its global, regional and national partners and stakeholders. Environmental radioactivity monitoring laboratories across the world are responding to increasingly strict requirements from national authorities, including nuclear regulatory bodies as required by Agency safety standards, and public expectations to deliver timely and reliable data. The Agency actively supports marine environmental monitoring in Member State laboratories through long term, targeted and complementary activities to help improve and maintain data quality. These activities include interlaboratory comparisons (ILCs) and proficiency tests (PTs), which are standard methods for laboratories to assess the quality of their measurement results and to identify any necessary improvements.

In addition, since 2014, the IAEA Marine Environment Laboratories, through regular ILCs and PTs, have been assisting the Government of Japan to improve the reliability and transparency of the post-Fukushima-accident marine environmental radioactivity monitoring carried out under its Comprehensive Radiation Monitoring Plan. Eleven ILCs and eight PTs have been conducted so far and the initiative is ongoing. These exercises have helped to ensure that the data produced by Japan's marine monitoring are of high quality and demonstrate a continued high level of accuracy and competence on the part of the Japanese laboratories involved. Similar assistance in marine monitoring is available to all Agency Member States.

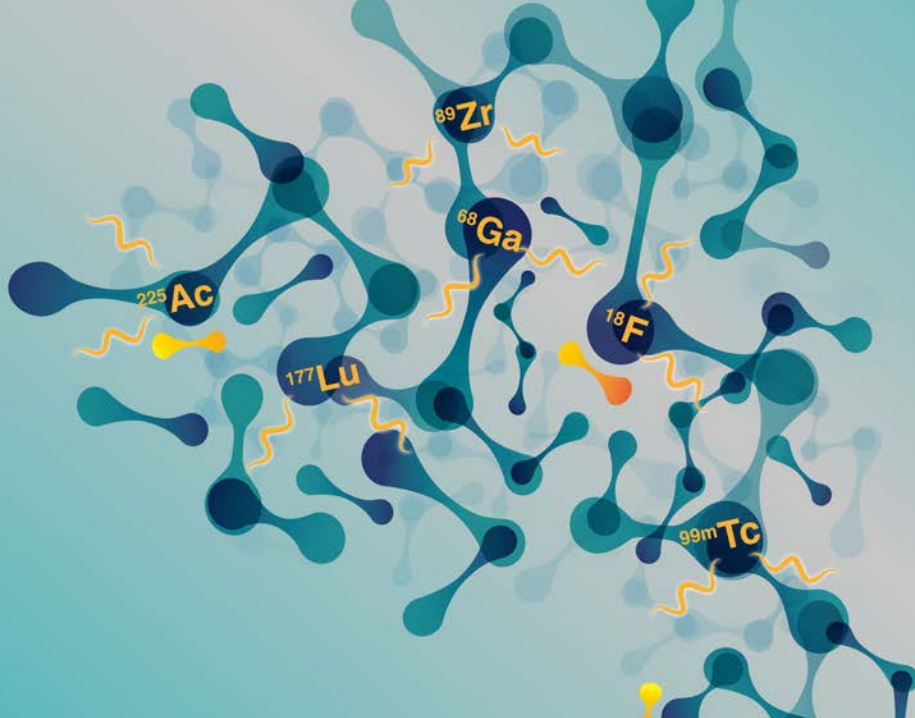
In 2023, for the most recent ILC, Agency staff and independent experts from the Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) network participated in a mission in Japan to observe the sampling of seawater, marine sediment and fish from the sea around Fukushima Daiichi NPP. The samples were sent to Japanese, IAEA and ALMERA laboratories for analysis.

Reference materials produced by the IAEA Marine Environment Laboratories' Radiometrics Laboratory, in the context of a quality management system accredited to the ISO 17034 standard, are used ubiquitously in Member States for maintaining quality assurance and for verifying their analytical methods. The Agency's reference materials are accessible to scientists worldwide who are engaged in monitoring and research on pollution and on environmental and climate change. In 2023, the focus was on the characterization of new reference materials relevant to marine radioactivity monitoring in routine and emergency situations: seawater, which is the primary medium for the dispersion and transfer of radionuclides that have reached the marine environment, regardless of their origin; and shrimp powder, which is relevant to seafood safety.

Reference materials, ILCs and PTs — which are relevant to international and regional networks of laboratories (such as ALMERA and technical cooperation project networks) and regional marine conventions (such as the Convention on the Protection of the Marine Environment of the Baltic Sea Area and the Convention for the Protection of the Marine Environment of the North-East Atlantic) — aid in monitoring data reliability and comparability. This is critical for the IAEA-curated Marine Radioactivity Information System (MARIS), which offers online access to over 800 000 items of marine radioactivity data. MARIS facilitates various applications related to marine monitoring, including investigating radioactivity levels in different time periods and geographic areas, quantifying climate change impacts, validating marine models, assessing radiation doses and providing public information. Recent upgrades to MARIS include comprehensive mapping of radionuclide levels; mapping of sampling locations; dynamic mapping allowing users to zoom in to individual data points or to produce averages across datasets; and enhanced accessibility for mobile devices.



Plankton nets being used to take samples for analysis.



RADIOCHEMISTRY AND RADIATION TECHNOLOGY

OBJECTIVE

To support Member States in strengthening their capability to produce radioisotopes and radiopharmaceuticals.

To support Member States in applications of radiotracers and radiation technology for industrial and other uses, and in application of nuclear analytical techniques to address environmental challenges.



This event is unique since, for the first time, all professional societies from the EU, North America as well as worldwide Member States are gathering under the same roof to discuss and exchange the same interesting topic: radiopharmaceuticals.

Suzanne E. Lapi

Vice Chair of Translational Research in the Department of Radiology, University of Alabama at Birmingham, commenting on the International Symposium on Trends in Radiopharmaceuticals (ISTR-2023)



345

laboratories from 83 countries participated in a global proficiency test



107

laboratories from 58 countries participated in the ALMERA network proficiency test



1

major conference ISTR-2023



15

active Collaborating Centres

KEY OUTPUTS

Radioisotopes and Radiopharmaceuticals

In 2023, the Agency held the International Symposium on Trends in Radiopharmaceuticals (ISTR-2023), which provided scientists and other professionals working in the production of radioisotopes and radiopharmaceuticals with the largest international forum to discuss the most recent developments and challenges in the field.

In addition, numerous papers, reports, standards and relevant guidance documents were produced during the year, including in relation to accelerating the availability of improved radiopharmaceuticals. Among them were: *Guidance for Preclinical Studies with Radiopharmaceuticals, providing a route for the approval of new radiopharmaceuticals*;

Copper-64 Radiopharmaceuticals: Production, Quality Control and Clinical Applications; and guidance documents for good manufacturing practice production and regulatory oversight for radiopharmaceuticals, produced together with WHO.

In addition, two new coordinated research projects (CRPs) were launched for diagnostic and therapeutic radiopharmaceuticals ('Development of Potential Lutetium-177 Radiopharmaceuticals: Design, Radiolabelling and Nonclinical Evaluation' and 'Development of new generation of Tc-99m kits') to transfer knowledge on production and preclinical studies based on the latest targeting agents.

Applications of Radiotracers and Radiation Technology

The Agency actively supported the publication of a new ISO standard, 'Measurement of fluid flow rate in closed conduits — Radioactive tracer methods' (ISO 24460:2023), to facilitate radiotracer applications in industrial processes.

Under NUTEC Plastics, a new CRP was launched to generate sustainable alternatives to petrol-based plastics. Using radiation-mediated conversion, biomass feedstocks from

renewable waste sources can potentially be transformed into new biobased and biodegradable plastic solutions.

In addition, the Agency's Terrestrial Environmental Radiochemistry Laboratory implemented recurring global and ALMERA network proficiency tests for radioactive environmental monitoring, with a record 452 participating laboratories in 2023.

26 publications in 2023



3 Environment

13 Human Health

3 Radioisotope Production
and Radiation Technology

7 Nuclear Science



www.iaea.org/publications

250 664 online views
of NA publications in 2023

MOST POPULAR PUBLICATION



Handbook of Basic Quality Control
Tests for Diagnostic Radiology

14 792 online views

Nuclear Techniques for Development and Environmental Protection



Joint ICTP-IAEA Workshop on Artificial Intelligence in Ionizing Radiation for Medical Physicists

November 2023, Trieste

Participants: **59** in person, from **50** Member States

This event equipped early and mid-career clinically qualified medical physicists with the knowledge and skills to facilitate the safe, effective, and appropriate application of artificial intelligence-based tools in the medical uses of radiation.



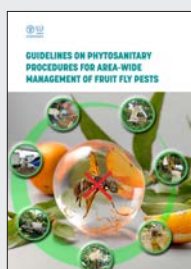
Ministerial Roundtable on Climate Change and Food Security: The Role of Nuclear Science and Technology

December 2023, Dubai

Participants: **40** in person, plus online participants

This Agency-FAO joint side event at COP28 showcased the invaluable contribution of nuclear techniques to increasing the resilience of global agri-food systems against climate change and raised awareness about Atoms4Food, launched in 2023.

This guideline describes the most widely used phytosanitary procedures for the management of fruit flies that infest fruits and vegetables and are of quarantine and economic importance.



The most downloaded Agency publication of 2023, this handbook helps radiology departments around the world to ensure safety and quality when using X-rays.



Recognizing the importance of adaptation to the climate change impact on water resources, the Agency has developed guidelines and recommendations on the selection and application of isotope-enabled hydrological models.



This publication summarizes the results of an interlaboratory comparison on the determination of trace elements and methylmercury in a fish sample, organized in 2021 to support Member States in the area of seafood safety monitoring.



IAEA PUBLICATIONS AND CONFERENCES IN 2023



Workshop on Ocean Change and Blue Carbon

August–September 2023, Monaco
Participants: **18** in person, from **14** Member States

This two-week workshop, combining practical and theoretical sessions, was organized by the Agency to empower Member States to conduct pertinent research on blue carbon and develop optimal evidence-based solutions.



International Symposium on Isotope Hydrology: Sustainable Water Resources in a Changing World

July 2023, Vienna
Participants: **358** in person, from **71** Member States

This event brought together scientists, managers, policymakers and stakeholders in the field of water resources management to discuss the latest scientific advances in isotope hydrology tools and techniques and how these developments can support global water security at a variety of scales.