BULETIN

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EDITORIAL

Foreword: Shaping Malaysia's Energy Future

Welcome to the second edition of our bulletin.

After hard work by the editorial members, BNM 2026 Vol. 24, No. 2 is finally published. The editors would like to express their sincere thanks to all contributors and readers for their patience and loyal support to BNM. Congratulations MNS for its 37th anniversary. This effort is very much appreciated, and we hope this spirit will continue for all MNS activities and BNM, in particular. We know that the issuance of BNM needs very strong support and commitment from all members of MNS and readers in general. The editorial is very optimistic, with the good support and enough articles from the contributors the biannual issue of this bulletin will be published on schedule. We also observed that over the past few years there has been encouraging responses from contributors from a wide range of organizations and agencies. This can probably be improved in the future, as sharing and disseminating knowledge and information is one of the agendas of Malaysian Nuclear Society (MNS).

Malaysia's nuclear energy initiative designed to secure our long-term energy independence and fulfill our 2050 net-zero commitments. With an official decision targeted for 2031, the nation is actively building the foundation for a safe, modern nuclear framework. To ensure a structured transition, the government's latest developments are centred around five foundational pillars:

- **Feasibility & Readiness:** The Ministry of Energy Transition and Water Transformation's deep dive into policy, law, and human capital.
- **Structured Implementation:** MyPOWER Corporation's role as the IAEA-aligned nuclear energy programme implementing organization (NEPIO).
- **Tightened Regulations:** Recent legislative updates mandating strict permits for all radioactive materials.
- **Geographic Scouting:** Early site considerations in Peninsular Malaysia and Sabah.
- **Next-Gen Tech:** The exploration of flexible, inherently safer Small Modular Reactors (SMRs).

Learning from the past, the government is moving forward with eyes wide open—prioritizing public trust and flawless safety protocols over haste.

Spotlight: iNuSTEC 2026.

The highly anticipated annual event — the **International Nuclear Science Technology and Engineering Conference 2026 (iNuSTEC2026)** conference is fast approaching. This year, **Universiti Kebangsaan Malaysia (UKM)** has been selected to host the conference, scheduled to take place from October 26 to 29, 2026. Centred around the theme *"Nuclear Science and Technology for Socio-Economic Development,"* the conference will bring together global experts to discuss how nuclear innovation can drive both societal progress and economic growth.

We hope this edition provides you with valuable insights into the pivotal steps Malaysia is taking toward a cleaner, more sustainable tomorrow. Happy reading!

Chief Editor

Buletin Nuklear Malaysia, August 2026.

SECOND RESEARCH COORDINATION MEETING FOR THE COORDINATED RESEARCH PROJECT ON NUCLEAR FORENSICS SCIENCE TO BRIDGE THE RADIOLOGICAL CRIME SCENE TO THE NUCLEAR FORENSICS LABORATORY

Dr. Zalina Laili

Malaysian Nuclear Agency (Nuklear Malaysia)

Nuclear forensics plays a vital role in nuclear security by providing the technical expertise needed to trace radiological evidence back to its source and support legal investigations. To strengthen international capabilities in this area, the International Atomic Energy Agency (IAEA) hosted the Second Research Coordination Meeting (RCM) for the Coordinated Research Project (CRP) "Nuclear Forensics Science to Bridge the Radiological Crime Scene to the Nuclear Forensics Laboratory" (J02020). Held from February 16 to 20, 2026, at the IAEA Headquarters in Vienna, Austria, the event served as a follow-up to the first RCM held in 2025 at the same venue.

Group Photograph of Participants at the Second RCM on "Nuclear Forensics Science to Bridge the Radiological Crime Scene to the Nuclear Forensics Laboratory".

The meeting primarily aimed to facilitate the exchange of technical expertise and research findings among Chief Scientific Investigators (CSIs) representing the 19 participating countries under the CRP. These countries included Thailand, Malaysia, Tajikistan, Australia, China, Viet Nam, South Africa, Kenya, Ghana, Egypt, Greece, Poland, Latvia, Cuba, Indonesia, Hungary, Jordan, Serbia, and the European Commission JRC. In addition, the meeting was joined by international experts from the Netherlands, the United Kingdom, Germany, France, and Canada, who provided scientific feedback and supported the planning for the concluding year of J02020. During the meeting, participating countries presented their technical progress. The RCM also provided an opportunity to review progress and technical results, facilitate peer exchange and coordination among participating institutes, and agree on priorities and next steps.

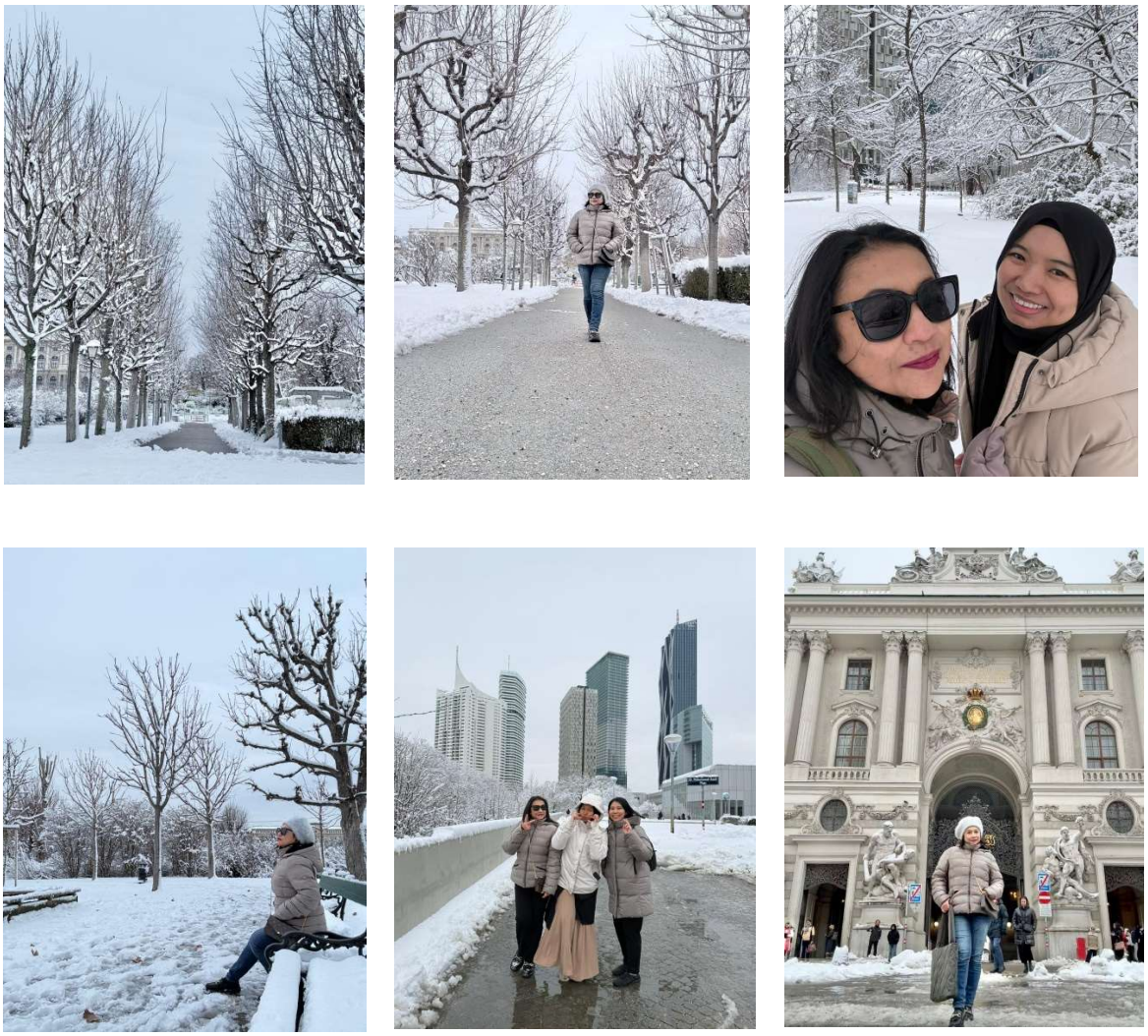
Dr. Zalina Laili as a Chief Scientific Investigator, representing Malaysia.

Dr Zalina Laili presented Malaysia's progress through a study titled "Development of Method for the Characterisation of Source Capsules and Containers of Nuclear Gauges for Nuclear Forensic Purposes," highlighting work conducted by five specialised groups focusing on visual inspection, material composition analysis, neutron imaging, X-ray imaging, and PGNAA / DGNAA. The presentation emphasised the application of advanced analytical techniques, including FESEM-EDX, XRD, and EDXRF, for the characterisation of radioactive source casings. In addition, non-destructive techniques, including X-ray and neutron imaging, were applied to support internal structural assessment. It also outlined the development of Standard Operating Procedures (SOPs) to ensure a systematic and reliable approach for maintaining data integrity from crime scene handling to laboratory analysis. The Malaysian work received positive feedback from the IAEA panel.

The meeting further underscored the importance of collaboration through the sharing of reference materials, spectral data, and technical expertise among participating laboratories. Discussions also focused on planning for the third year of the project, including key deliverables and improved coordination to ensure effective implementation. Future CRPs were also explored, particularly in the areas of morphological signatures and non-destructive analytical techniques.

Dr. Zalina Laili presented a study titled "Development of Method for the Characterisation of Source Capsules and Containers of Nuclear Gauges for Nuclear Forensic Purposes."

Overall, the meeting provided a valuable platform for knowledge exchange and strengthened collaboration among participating countries. Participation in this CRP enhances Malaysia's technical capabilities, international networking, and readiness in nuclear security and forensic response. It also supports the integration of nuclear forensic capabilities into national security frameworks, improving preparedness in handling radiological incidents and supporting law enforcement investigation



Taking a quick moment to enjoy the beautiful Vienna snowfall between sessions at the IAEA Second RCM.

INTERNATIONAL WORKSHOP ON EXPOSURE DUE TO RADIONUCLIDES IN FOOD IN NON-EMERGENCY SITUATIONS

Siti Aminah Omar

Malaysian Nuclear Agency

The International Atomic Energy Agency (IAEA) has conducted a training workshop on Exposure Due to Radionuclides in Food in Non-Emergency Situations from 21 to 23 October 2025 at the IAEA's Laboratories in Seibersdorf, Vienna, Austria. The workshop was attended by 31 participants from Austria, Argentina, the Central African Republic, Colombia, Cote d'Ivoire, Germany, India, Ireland, Italy, Japan, Latvia, Malaysia, Norway, Poland, Portugal, Qatar, Sri Lanka, Sudan, Sweden, Thailand, Togo, Tunisia, the UAE, the USA, and Zimbabwe. The three-day workshops cover lectures and classroom presentations as well as a tour of the Terrestrial Environmental Radiochemistry Laboratory.

The purpose of the event is to introduce the newly developed international guidance on radiation safety in food for non-emergency situations. For the record, the international guidance suggested the use of 'about 1 mSv' of total radionuclides in food. It also aims to facilitate discussions on the potential national and international impacts of the guidance. Furthermore, this workshop also provides a platform for exchanging insights on the opportunities and challenges associated with its application. During this training workshop, participants were given lectures on radioactivity in food in non-emergency situations and an overview of the Codex standard, as well as other international standards' requirements regarding radioactivity in food, including the IAEA, WHO, and UNSCEAR. This is followed by a sharing session by Mr. Kevin Kelleher, an IAEA expert, on Ireland's experiences in establishing the baseline data for exposure due to radionuclides in food, including the diet surveys and measurement and laboratory techniques.

The experts and participants of the training workshop (left) and Member State's presentation (right).

In addition, selected participants were also given chances to present their member state's experiences in assessing radionuclide doses from total diet and individual foods, total diet studies, and measurement techniques of radionuclides, including those of natural origin in food. From Malaysia's perspective, the country has yet to establish legislation / guidelines in place for radionuclides in food or the diet in the country. The legislation is important as it helps to establish safe limits to minimize human exposure and health risks while adhering to international standards. Furthermore, it helps to ensure food safety and consumer confidence. The current food dietary survey conducted by the Ministry of Health (MOH) is a good start to set a radioactivity baseline in food in Malaysia.

One of the key findings of the workshop is the recommendation to apply the reference level of 'about 1 mSv' when managing radionuclides in food. To do so, it is advised to characterize the levels of radionuclides in food before any legislation is put through. Countries are also advised to choose independently which radionuclides are important to screen in foods. Some of the challenges were also identified, such as the misinterpretation of the 95th percentile of the radionuclide dose that could hinder international trade. Other than that, it is also important to have a protection strategy when designing the legislation / guideline in the country with regard to radionuclides in food so as to protect cultural habits and the local economy.

Visit to the Terrestrial Environmental Radiochemistry Laboratory.

Walking around Seibersdorf and Vienna.

MISI PAKAR DI JAEA TOKAI DAN EVOLUSI NTC *ENVIRONMENTAL RADIOACTIVITY MONITORING*

Muhammad Azfar Azman

Pegawai Penyelidik,

Bahagian Teknologi Sisa dan Alam Sekitar, Agensi Nuklear Malaysia

Penulis telah memenuhi jemputan sebagai penceramah bagi *Instructor Training Course* (ITC) dalam bidang *Environmental Radioactivity Monitoring* (ERM) di JAEA, Tokai, Jepun pada 8 hingga 12 September 2025. Kursus ini merupakan sebahagian daripada *Instructor Training Program* (ITP), iaitu inisiatif JAEA sejak tahun 1998 yang bertujuan memupuk pembangunan tenaga nuklear dalam kalangan negara Asia.

Penulis diperuntukan masa selama satu jam untuk menyampaikan ceramah. Ceramah dimulakan dengan pengenalan tentang Malaysia agar para peserta ITC dari pelbagai negara Asia dapat mengenali negara ini dengan lebih dekat. Seterusnya, ceramah diteruskan dengan pengenalan mengenai Agensi Nuklear Malaysia (Nuklear Malaysia), termasuk sejarah penubuhannya dan peranan Reaktor TRIGA PUSPATI. Sesi ini turut mengetengahkan Kumpulan Aplikasi Kimia Analisis di bawah Bahagian Teknologi Sisa dan Alam Sekitar sebagai makmal analisis pelbagai unsur di agensi tersebut.

Inti pati utama ceramah ini memfokuskan kepada pengalaman mengkoordinasikan *National Training Course* (NTC) ERM (2019 – 2026), yang bermula sebagai *Follow-up Training Course* (FTC) ERM selepas penyertaan penulis dalam ITC di Jepun pada 2019. Selepas ditukarkan nama kepada NTC ERM pada 2023, program tahunan ini konsisten dilaksanakan sehingga siri terbaharu pada 9 – 13 Februari 2026. Sepanjang tempoh tersebut, pengurusan program telah berdepan dengan beberapa cabaran, antaranya termasuklah:

- **Ketidakkonsistenan kehadiran** dalam kalangan peserta.
- **Kekangan komunikasi**, terutamanya dalam penyampaian maklumat kepada peserta serta penyelarasan dengan pihak makmal dan reaktor.
- **Isu logistik**, seperti kesilapan pengangkutan bas ke lokasi persampelan.
- **Masalah teknikal kecil** semasa pengendalian aktiviti di lapangan.

Bagi memastikan penambahbaikan berterusan, beberapa langkah strategik telah diambil termasuklah memendekkan sesi ceramah daripada dua jam kepada satu jam demi meningkatkan fokus, serta mengemas kini kandungan silibus. Sebagai contoh, FTC ERM 2020 yang mengehadkan 25 peserta menawarkan 10 ceramah dan 4 eksperimen praktikal seperti persampelan tanah / air serta analisis menggunakan *Liquid Scintillation Counter* dan *Gamma Spectrometry*. Manakala bagi NTC ERM 2026, had peserta dikurangkan kepada maksimum 12 orang setelah mengambil kira faktor keluasan makmal yang kecil bagi mengelakkan ada peserta yang terpaksa berdiri di luar. Struktur NTC ERM 2026 juga diperkukuh dengan pengenalan modul baharu iaitu *Neutron Activation Analysis*, Spektrometer Alfa, dan Isotop Hidrologi bagi Pengurusan Sumber Air.

Penulis mengakhiri ceramah dengan menitikberatkan bagaimana pengalaman mengendalikan program ini boleh dimanfaatkan oleh peserta ITC di tanah air masing-masing, sama ada dalam kapasiti sebagai pengajar atau pengurus program yang menyeluruh. Penulis juga menegaskan kunci utama kepada keberkesanan program seperti NTC / FTC terletak pada aspek persediaan yang rapi, komunikasi yang jelas, serta kesediaan untuk sentiasa belajar daripada setiap kesilapan.

Selain ceramah, aktiviti program turut merangkumi demonstrasi dan lawatan ke fasiliti pemantauan radioaktiviti alam sekitar. Pada petang 10 September, satu sesi demonstrasi persediaan sampel (*sample*

preparation) telah dijalankan, yang meliputi teknik pemotongan, pengisaran, dan pengabuan sampel bagi pengiraan NORM (*Naturally Occurring Radioactive Materials*). Sesi pada hari tersebut diakhiri dengan jamuan makan malam sushi di Mito atas jemputan Encik Ohkura dan Encik Yokoyama.

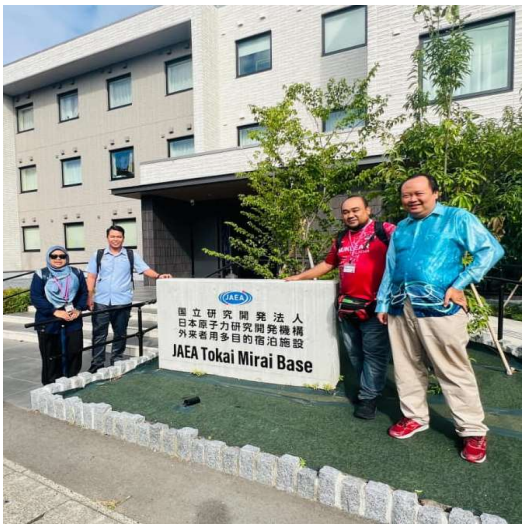
Pada 11 September, program diteruskan dengan lawatan ke fasiliti JAEA Tokai bagi meninjau *monitoring post* dan *monitoring station* di sekitar kompleks. Fasiliti ini berfungsi menjalankan pemantauan dos radiasi serta kepekatan radioaktiviti udara secara berterusan. Selain itu, peserta melawat makmal alam sekitar untuk melihat proses persediaan sampel dan penggunaan tolok hujan (*rain water sampler*) bagi pemantauan air hujan. Sistem pemantauan alam sekitar JAEA ini secara menyeluruh melibatkan pengumpulan dan analisis sampel tanah, air, serta udara untuk menilai kesan radioaktiviti daripada kemudahan nuklear.

Pada 12 September, sesi ITC diteruskan dengan pembentangan daripada para peserta mengenai aktiviti Persediaan Kecemasan Radiologi Kebangsaan (*National Radiological Emergency Preparedness* - NREP) dan ERM dari negara masing-masing. Sesi tersebut turut diserikan dengan maklum balas, komen, dan pandangan membina daripada penceramah jemputan. Selepas sesi bergambar berkumpulan, Encik Ohkura menghantar para peserta ke Stesen Katsuta. Memandangkan terdapat masa lapang sebelum waktu penerbangan, slot tersebut dimanfaatkan dengan lawatan ringkas ke beberapa tempat menarik di Tokyo seperti Asakusa, Tokyo Skytree, dan Odaiba (bagi melihat patung Gundam Unicorn). Penerbangan pulang berlepas dari Lapangan Terbang Haneda sekitar jam 11.00 malam.

Secara keseluruhannya, pengalaman ini berjaya memperkukuh rangkaian kerjasama strategik antara Malaysia dan Jepun dalam bidang pemantauan radioaktiviti alam sekitar. Program seperti ITP, ITC, FTC, dan NTC terbukti memainkan peranan penting dalam membina kapasiti serantau, khususnya menerusi perkongsian pengajaran berharga daripada insiden Fukushima. Antara manfaat utama yang diperoleh termasuklah peningkatan kemahiran pengurusan program serta pemantapan pengetahuan teknikal dalam kalangan pegawai Nuklear Malaysia, di samping peluang menyebarkan amalan terbaik kepada peserta ITC dari negara Asia yang lain. Sekalung penghargaan dan terima kasih diucapkan kepada pihak JAEA, terutamanya Encik Ohkura, Puan Yoko, serta seluruh pasukan atas penganjuran ini. Diharapkan jalinan kerjasama yang erat ini akan terus berkekalan demi kemajuan masa hadapan.

Peserta ITC 2025 di bilik kuliah.


Menikmati hidangan sushi bersama koordinator ITC, Mr. Ohkura dan Mr. Yokoyama di Mito (kiri) dan bersama koordinator ERM, Ms. Yoko: berdekatan JAEA.



Peserta Malaysia di hadapan JAEA Tokai Mirai Base.

FROM CRIME SCENE TO LABORATORY: MANAGING NUCLEAR FORENSIC SAMPLES

Dr. Zalina Laili, Suzilawati Muhd Sarowi and Muhammad Azfar Azman

Malaysian Nuclear Agency, Bangi

Introduction

Investigating a radiological crime scene is uniquely challenging because of the hazards posed by radioactive materials. Evidence from these scenes can be dangerous to handle, yet it carries the critical forensic signatures needed to solve the case. Safely managing these samples from the crime scene all the way to the lab is essential to protect personnel, preserve evidence, and ensure the integrity of the entire investigation.

Laboratories follow standardised protocols for receiving, assessing, handling, storing, and preparing samples collected from radiological crime scenes, based on established nuclear forensic best practices, including international guidelines, regional frameworks, and established local operational procedures. These protocols support analyses aimed at determining the nature, origin, history, and possible intended use of nuclear or other radioactive materials, while ensuring that scientific findings are reliable and suitable for use as evidence in a court of law (IAEA 2014; Keegan, 2015).

Types of Evidence at Radiological Crime Scenes

Radiological crime scenes may involve a complex mixture of radioactive materials and conventional forensic evidence. In many cases, traditional forensic evidence may be contaminated with radioactive substances, requiring specialised handling throughout the forensic process.
Examples of evidence that may be encountered include:

- Biological evidence such as body fluids (DNA), hair, and fibres
- Impression evidence including fingerprints and shoe or tyre impressions
- Chemical and toxicological evidence
- Environmental indicators such as pollen (for geolocation), soil, dust, and debris
- Toolmarks and mechanical traces
- Digital evidence and electronic devices
- Questioned documents
- Materials evidence such as metal alloys and components
- Design or fabrication residues associated with radioactive material

These diverse evidence types highlight the need for close coordination between radiological protection and forensic examination activities. The wide range of evidence types present at radiological crime scenes underscores the complexity of sampling strategies and subsequent forensic interpretation. Determining sample representativeness remains a major challenge in nuclear forensics, as analytical results must support specific investigative objectives, such as source attribution, with defined confidence levels (IAEA 2015). Given that nuclear and radiological materials are frequently heterogeneous, reliance on bulk analytical approaches alone may fail to capture critical variations within the material. The chemical composition and structural characteristics of a material are essential for uncovering its origin and historical background (Dunn et al. 2025). Consequently, careful sample selection and coordinated radiological and forensic examination are essential to ensure that both radiological signatures and conventional forensic evidence are preserved and interpreted reliably.

Figure 1. Forensic personnel collecting evidence containing radioactive and conventional materials, illustrating integrated procedures for radiological safety and evidence preservation.

Receiving and Verifying Samples

All incoming samples are treated as potentially radioactive and contaminated until proven otherwise. Upon receipt, documentation such as transport records and chain-of-custody forms are verified. Containers are inspected for integrity without opening, and details of the receipt are logged. Samples are only opened under the authorization of a Radiation Protection Officer (RPO), ensuring safe handling at all times.

Initial Radiological Assessment

An initial radiological assessment is performed to determine external dose rates and surface contamination. Ambient radiation levels are recorded to guide handling and storage requirements. This assessment ensures that samples are managed according to their radiological hazard, minimising risks to personnel and maintaining safety within the laboratory.

Figure 2. Radiation detection instruments are used to assess external dose rates and surface contamination before samples are opened or processed.

Maintaining Chain of Custody

Continuous documentation of sample movement is essential to maintain accountability and traceability. Chain of custody documentation and laboratory handling procedures for nuclear forensic evidence are detailed in international guidance (IAEA 2015). Any discrepancies, damage to containers, or deviations in documentation are reported immediately. This process safeguards the integrity of the forensic evidence and supports admissibility in legal proceedings.

Sample Handling and Contamination Control

Samples are processed in controlled laboratory areas. Unknown or potentially dispersible materials are handled within glove bags, glove boxes, or equivalent containment systems. Non-destructive techniques are prioritized to preserve physical, chemical, and radiological characteristics of the samples. Strict contamination control prevents cross-contamination and ensures that forensic signatures remain intact.

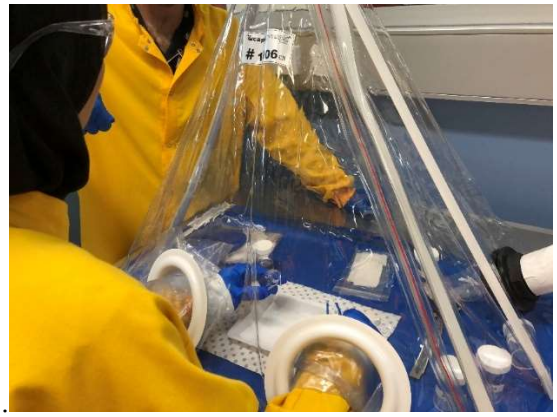


Figure 3 Nuclear analysts carefully handle nuclear forensic samples within glove bags or glove boxes, preserving forensic integrity while minimising radiation and contamination risks.

Storage and Preparation for Analysis

Samples are stored in shielded, secure, and access-controlled facilities. Uncharacterised or high-risk samples are quarantined until radiological clearance is granted by the RPO. Preparation for analysis follows method-specific procedures while maintaining forensic integrity. This ensures that analytical results are accurate and can reliably support investigative outcomes.

Figure 4. Samples are stored in shielded, access-controlled facilities to ensure safety, security, and evidence integrity.

Safety and Personnel Competency

Personnel are trained in radiation protection, contamination control, and nuclear forensic principles. ALARA (As Low As Reasonably Achievable) principles of time, distance, and shielding are applied in all activities. Personal protective equipment (PPE) and dosimeters are worn at all times, and controlled laboratory areas strictly prohibit eating, drinking, or smoking. Procedures for incident management and non-conformance address abnormal radiation readings, damaged containers, or any deviation from standard protocols.

Key Equipment

- Radiation Detection and Identification Devices – Instruments such as Geiger-Müller counters, scintillation detectors, and gamma spectrometers for detecting and identifying radioactive materials.
- Dosimetry Devices – Thermoluminescent Dosimeters (TLDs), Optically Stimulated Luminescence (OSL) rings, or electronic personal dosimeters to monitor personnel radiation exposure.
- Sample Handling and Containment – Glove bags, glove boxes, and remote handling tools (tongs, forceps) for safe manipulation of unknown or potentially dispersible samples.
- Radiation Shielding and Storage – Shielded boxes, lead bricks, shielded containers, and secure storage cabinets to protect personnel and preserve sample integrity.
- Contamination Control and Monitoring – Surface contamination monitors, portable survey meters, wipe test kits, and work surface mats for contamination prevention.
- Personal Protective Equipment (PPE) – Gloves, lab coats, shoe covers, safety goggles, and respirators where required.
- Sample Transport and Packaging – Tamper-evident, shielded transport containers compliant with safety regulations.
- Waste Management Equipment – Designated containers for radioactive or contaminated waste, both solid and liquid.
- Documentation and Security Tools – Chain-of-custody forms, evidence labels, barcoding systems, and secure logbooks or storage.
- Auxiliary Laboratory Tools – Fume hoods, small analytical balances, and sample preparation tools for safe, precise sample handling.

Regulatory and Legal Context

In many jurisdictions, handling and analysis of nuclear and radiological materials are regulated under national law and licensing frameworks. For example, the Atomic Energy Licensing Act 1984 establishes requirements for the possession, transport, and management of radioactive materials to ensure safety and compliance with regulatory obligations (Malaysia,2011).

Figure 5. Radiation survey meters commonly used in nuclear forensic laboratories to assess dose rates and surface contamination.

Conclusion

From collection at a radiological crime scene to analysis in the laboratory, standardised procedures are essential for the safe and effective management of nuclear forensic samples. Following these protocols ensures the protection of personnel, preservation of forensic evidence, and reliability of analytical results. By drawing on internationally recognised guidance, regional frameworks, and established local practices, laboratories can maintain high standards of nuclear forensic investigation worldwide.

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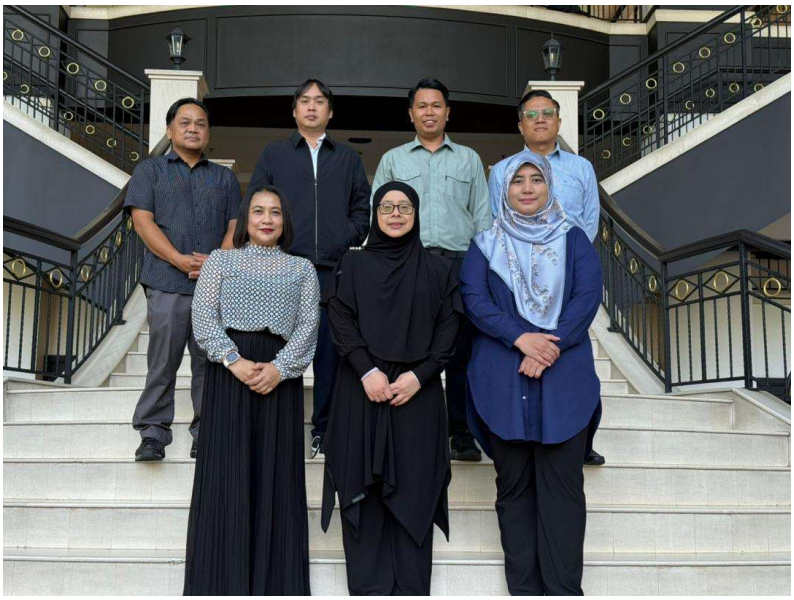
CLIMATE CHANGE CHALLENGES TO THE SAFETY OF NUCLEAR INSTALLATIONS

Zalina Laili and Mazleha Maskin

Malaysian Nuclear Agency, Malaysia

The first Technical Meeting for the IAEA Coordinated Research Project (CRP) No. 28266, "Climate Change Challenges to the Safety of Nuclear Installations," was convened at the Bangi Resort Hotel from 8 to 10 April 2026. Organised by the Malaysian CRP team, the session focused on the technical coordination and harmonization of national research inputs concerning the impact of climate change on nuclear safety. Although the project initially used Pakistan's Chasma nuclear power plant as a benchmark, this phase of the project focused on incorporating local Malaysian data to strengthen national risk assessment capabilities. This initiative reinforces Malaysia's strategic commitment to international nuclear safety frameworks. It also served as the primary preparation phase for the country's technical submission to the upcoming IAEA meeting in South Korea, scheduled for June 22–26, 2026.

The project involves a multinational consortium including Malaysia, Canada, China, France, the United States, and the Republic of Korea, with Dr. Mark Dennis Usang serving as the designated national representative. Within the CRP framework, which is bifurcated into Riverine and Coastal focus groups, the Malaysian team is integrated into the Riverine cohort due to the inland location of the national research reactor.

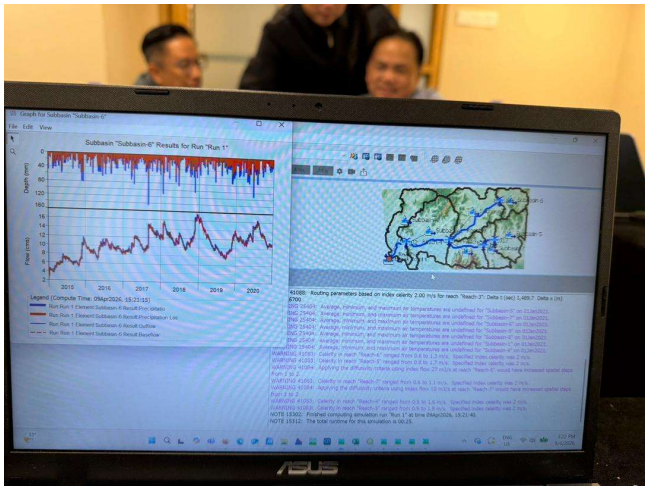


Project Leader Dr. Mazleha Maskin (centre) alongside members of the IAEA Coordinated Research Project (CRP No. 28266).

During the sessions, Dr. Mark Dennis conducted a dedicated technical training session to standardise hydrological and geospatial methodologies. This involved the integration of HEC-HMS (Hydrologic Modeling System) and QGIS (Quantum Geographic Information System) for advanced geospatial analysis.

Throughout the meeting, participants actively engaged in real-time document preparation and review to ensure the quality, consistency, and reliability of scientific outputs. Team members were tasked with developing flood simulations tailored to specific geographical variables, specifically focusing on

hydrological profiles for Sungai Semenyih and Sungai Langat.



A training session on data analysis and modelling using HEC-HMS and QGIS software, conducted by Dr. Mark Dennis.

Moving forward, the Malaysian CRP team will further analyse these scenarios using RCP 2.6 and RCP 8.5 climate change pathways applied to the existing terrain models. This initiative reflects Malaysia's continued commitment to supporting IAEA coordinated research while strengthening national expertise in nuclear safety and climate change impact assessment at an international level.

ALMERA TRAINING WORKSHOP ON ENVIRONMENTAL SAMPLING FOR RADIONUCLIDE ANALYSES (EVT2504181), SWITZERLAND

Dr. Nurrul Assyikeen Md. Jaffary

Malaysian Nuclear Agency, Bangi.

INTRODUCTION

The ALMERA Training Workshop on Environmental Sampling for Radionuclide Analyses (EVT2504181) was held from 1 to 5 June 2026 at the Federal Training Centre Schwarzenburg (FTCS) and Spiez Laboratory, Switzerland. The workshop was organised by the International Atomic Energy Agency (IAEA) under the Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) network in collaboration with Spiez Laboratory, Switzerland.

The programme brought together participants from ALMERA member laboratories representing various countries to strengthen competencies in environmental sampling for radionuclide analyses. Through lectures, practical exercises, group discussions and field activities, participants gained practical knowledge of representative sampling and its importance in supporting reliable environmental radioactivity measurements.

Figure 1. Group photo of participants and facilitators of the *ALMERA Sampling Workshop*.

REPRESENTATIVE SAMPLING AS THE FOUNDATION OF RELIABLE RESULTS

One of the key lessons from the workshop was that reliable analytical results depend on collecting representative samples. While laboratories often focus on the accuracy of measurements, the workshop highlighted those errors introduced during sampling can have a greater impact on the final result than the analytical process itself.

To address this issue, participants were introduced to the Theory of Sampling (TOS), developed by Pierre Gy. The concept explains how sampling errors can occur and provides guidance on how to minimise them. The training emphasised that even when laboratory measurements are accurate, the results may still be misleading if the samples collected do not adequately represent the area or population being studied.

The workshop also introduced the concept of Data Quality Objectives (DQO), a systematic approach for planning sampling activities. Participants learned that before any sampling campaign begins, it is important to define the purpose of the study, identify the Decision Unit (DU) to be evaluated and

determine the level of confidence required for decision-making. This approach helps ensure that sampling plans are fit for purpose and meet the requirements of quality management systems such as ISO/IEC 17025.

Figure 2. Group discussion on environmental sampling design using TOS and DQO.

FIELD EXERCISES AND GLOBAL ESTIMATION ERROR

The workshop included several field exercises based on simulated radionuclide contamination scenarios. Participants were divided into international teams and asked to develop sampling plans for hypothetical contaminated sites.

During the exercises, participants identified the Decision Unit (DU), designed sampling grids and determined the number of samples needed to obtain representative results. The activities demonstrated how environmental variability can influence sampling outcomes and data quality.

Participants were also introduced to the concept of Global Estimation Error (GEE), which considers uncertainties arising from both sampling and laboratory analysis. Through group discussions and practical exercises, participants evaluated whether the collected data were sufficient to support decision-making with the required level of confidence.

A key lesson from the exercise was that accurate laboratory measurements alone are not enough to ensure reliable results. Proper sampling design is equally important in obtaining representative data for environmental radioactivity monitoring.

Figure 3. Group members participating in a field sampling exercise.

SUBSAMPLING AND SAMPLE REPRESENTATIVENESS

Another important component of the workshop focused on subsampling techniques and their role in ensuring reliable analytical results. Participants were introduced to practical methods for reducing the size of bulk samples while maintaining their representativeness.

Through hands-on exercises involving sample mixing, homogenisation and sample division, participants learned how improper subsampling can introduce bias and affect the quality of analytical results. The training highlighted that obtaining a representative field sample is only the first step; proper sample preparation is equally important to ensure that the portion analysed in the laboratory accurately reflects the original sample.

The session also demonstrated how subsampling errors contribute to overall measurement uncertainty and emphasised the importance of applying appropriate sample preparation procedures, particularly for heterogeneous matrices such as soil and sediment.

Figure 4. Practical exercise on sample mixing, homogenisation and subsampling techniques.

WATER SAMPLING AND ENVIRONMENTAL MONITORING

The workshop also included sessions dedicated to water sampling strategies and the challenges associated with obtaining representative samples from aquatic environments. Participants were introduced to approaches for defining Decision Units within rivers and water bodies, selecting representative sampling locations and understanding the influence of environmental variability on analytical results.

The discussions highlighted the importance of integrating field observations, sampling objectives and statistical considerations when designing monitoring programmes. These concepts are directly applicable to environmental radioactivity monitoring activities involving surface water, groundwater and marine environments.

Figure 5. Demonstration of water sampling techniques during the *Water Sampling* module.

TECHNICAL VISIT TO SPIEZ LABORATORY

A major highlight of the workshop was a technical visit to Spiez Laboratory, one of Switzerland's leading institutions in environmental radioactivity monitoring, radiological protection, nuclear forensics and CBRN (Chemical, Biological, Radiological and Nuclear) preparedness.

Participants also gained insight into the role of Spiez Laboratory in supporting radiological preparedness, environmental monitoring and international technical cooperation. The visit provided valuable insight into how environmental sampling, laboratory measurements and scientific interpretation are integrated within a national radiological protection framework.

INTERNATIONAL NETWORKING AND KNOWLEDGE EXCHANGE

Beyond the technical sessions, the workshop provided valuable opportunities for professional networking and knowledge exchange among participants from ALMERA member laboratories worldwide. Informal discussions during group activities and social events enabled participants to share experiences related to radionuclide analyses, quality assurance practices and emergency preparedness programmes implemented in their respective countries.

These interactions fostered stronger professional relationships within the ALMERA network and created opportunities for future technical collaboration, exchange of expertise and participation in international capacity-building initiatives coordinated by the IAEA.

Figure 6. Networking dinner with participants and experts from ALMERA member laboratories.

RELEVANCE TO MALAYSIA

The knowledge and experience gained from the workshop are directly applicable to environmental sampling activities conducted by the Malaysian Nuclear Agency, particularly those involving soil, sediment, water and biota monitoring programmes.

The training also provided exposure to international best practices that can support ongoing efforts to strengthen sampling protocols, improve data quality and enhance compliance with ISO/IEC 17025 requirements. Furthermore, participation in the workshop expanded professional networks with ALMERA member laboratories and international experts, creating opportunities for future technical collaboration and knowledge exchange in the field of environmental radioactivity monitoring.

CONCLUSION

The ALMERA Training Workshop on Environmental Sampling for Radionuclide Analyses (EVT2504181) provided valuable exposure to the principles and practices of environmental sampling for radionuclide investigations. The workshop reinforced the importance of systematic sampling design, uncertainty management and fit-for-purpose data collection in supporting reliable radionuclide analyses and informed

decision-making.

The knowledge acquired during the programme will support ongoing efforts by the Malaysian Nuclear Agency to strengthen environmental radioactivity monitoring activities and enhance compliance with international best practices and ISO/IEC 17025 requirements.