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HANDBOOK

SPERA CONFERENCE 2022

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Welcome TO THE SPERA CONFERENCE 2022

Tēnā koutou katoa,

Michael Lechermann

The South Pacific Environmental Radioactivity Association and the Royal Australian Chemical Institute are delighted to welcome you to Ōtautahi, Christchurch, for the 2022 SPERA conference and the RACI workshop. Who would have predicted the events of the past years and the scale at which they impacted our lives? The SPERA community has shown remarkable adaptability and resilience during challenging times.
Our committee has worked hard since the end of 2018 to plan and facilitate this conference and we are finally looking forward to gather together, learn, reflect and support each other.

The conference theme Connecting people, developing solutions for a changing environment highlights the importance of meaningful connections between researchers of diverse backgrounds to excel in an environment that is dominated by change. We aim to foster these connections by providing an environment for lively and fruitful discussions. An exciting programme with presentations on all aspects of environmental radioactivity and exceptional keynote speakers await you. Make the most of your conference and use the opportunity to share your research, re-connect to the community and create new networks.

We hope you can make some time to explore our ever-evolving city or perhaps even the beautiful nature of New Zealand. Christchurch has seen much change and development and has so much to offer to visitors. Head to the Riverside Market to eat and shop or to the Port Hills for magnificent views over our hometown and Lyttelton harbour. Thank you for joining us, have a great conference!

Nga mihi nui, kia pai te hui!

Michael Lechermann,
Conference Convenor | SPERA – Vice President

SPERA 2022 ORGANISING COMMITTEE

Michael Lechermann, Conference Convenor, ESR (Institute of Environmental Science and Research)
Sarah Guy, Tonkin + Taylor, Environmental Consultants
Maxie Christison, ESR (Institute of Environmental Science and Research)
Oksana Golovko, ESR (Institute of Environmental Science and Research)
Andrew Pearson, Tonkin + Taylor, Environmental Consultants
Peter Medley, Queensland Health
Vladimir Golovko, School of Physical and Chemical Sciences, University of Canterbury

General Information

CONFERENCE VENUE

The conference is being held at the Haere-roa, University of Canterbury Student's Association, 90 Ilam, Christchurch. See below about a regular bus from the city to Haere-roa.

Registration:	Haere-roa foyer open from 0800 Monday and open throughout conference
Plenary sessions:	Ti Kouka
Exhibition & Catering:	Central Street
Posters:	Central Street
Welcome reception:	Central Street
RACI Workshop:	Bentleys
RACI Social function:	The Foundry

Haere-roa's Health and Safety policies apply to all delegates. Delegates are asked to follow any instructions provided by the venue / event staff. Smoking is not permitted inside the venue.

ACCOMMODATION

If you are staying at The BreakFree Hotel, your deposit has been forwarded to the hotel. Please pay incidentals direct to the hotel, prior to departure. Address: 165 Cashel Street, Christchurch Central City, Christchurch 8011. Phone: 03 360 1064

PARKING

Visitors to campus are able to park in designated visitor parking areas. To park in these areas visitors will need to display an all-day parking coupon or pay by licence plate number at a pay-and-display unit. The carparking area immediately outside Haere-roa has just one park-and-display unit. Parking coupons can be purchased from the University Café or University Bookshop or Security (114 Ilam Road).

TAXIS / BUS

If you are staying in the city, a taxi fare to Haere-roa is approximately $30 one way or a bus around $5 one way. Bus to Haere-roa - Buses depart regularly from the Bus Interchange - a 5 minute walk from The Breakfree Hotel.

Taxis *Blue Star taxis* 0800 379 9799
Gold band taxis 03 379 5795
Corporate Cabs 03 379 5888

REGISTRATION AND INFORMATION

The registration desk will be open throughout the conference. Name badges can be collected from here on arrival and should be worn at all times. Please contact **Marg (0274 359 578)** or **Joanne (027 303 8703)** with any queries.

POSTERS

All posters will be on display throughout the three days Monday to Wednesday with a dedicated Poster Session on Monday.

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Emergency: Dial 111

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LIABILITY

In the event of any disruption or event leading to losses or added expenses being incurred in respect of the Conference, there shall be no liability attached to SPERA, the Organising Committee, University of Canterbury Student Association or The Conference Team. The programme is correct at time of printing; however, the Organising Committee reserves the right to amend any component as necessary.

CONFERENCE ORGANISERS

The Conference Team

P O Box 20 051, Christchurch 03 359 2600

e: marg@conferenceteam.co.nz

w: www.conferenceteam.co.nz

THE CONFERENCE TEAM

Programme

MONDAY 28 NOVEMBER

0800	Registration & exhibition open	
0830	Opening / Welcome	**Ti Kouka**
0845	Official Welcome from SPERA Vice President ***Michael Lechermann***	
0900	SPERA – Looking back and forward ***Murray Matthews***	

RADIOECOLOGY

0930	***KEYNOTE: Chornobyl radiation detector response during the Russian military invasion.*** ***Mike Wood*** Sponsored by arpansa	
1015	Radiological dose assessment for the actinium series (Ac-227 and Pa-231) from uranium mining. ***Peter Medley***	
1045	**Morning tea.** *Sponsored by* E/S/R Science for Communities He Pūtaiao, He Tāngata	**Central Street**
1130	An updated International Dataset of soil to fruit concentration ratios for Radiocaesium. ***Che Doering***	**Ti Kouka**
1155	Towards a holistic approach to protection of inhabitants of contaminated environments: the role of non-targeted effects. ***Carmel Mothersill***	
1220	Radionuclide Equilibrium Coefficients in decay chains in selected NORM materials. ***Ivan Hupka***	
1245	**Networking lunch.** *Sponsored by* Australian Government | ANSTO and ORTEC AMETEK	**Central Street**
1345	Activity concentrations of radiocaesium in self-consumed crops collected in Namie, Fukushima from 2019 to 2020 with associated internal radiation doses to humans. ***Hirofumi Tsukada***	**Ti Kouka**
1410	Recent studies of natural radionuclide uptake in non-human biota to inform radiological, environmental impact assessment for uranium mine rehabilitation in tropical northern Australia. ***Che Doering***	
1430	Anthropogenic radionuclides persist in marine sediment at the Montebello Islands nuclear legacy site in Western Australia. ***Madison Williams-Hoffman***	
1450	A geochemical journey in coastal groundwater exchange from Barter Island, Alaska to Roi Namur, Kwajalein RMI. ***Peter Swarzenski (pre-recorded)***	
1505	**Afternoon tea | Poster session.** *Sponsored by* E/S/R Science for Communities He Pūtaiao, He Tāngata	**Central Street**
1600	**SPERA Biennial General Meeting**	**Ti Kouka**
1700	Welcome Reception *Sponsored by* E/S/R Science for Communities He Pūtaiao, He Tāngata	**Central Street**

TUESDAY 29 NOVEMBER

0730 Registration open

INSTRUMENTS & METHOD DEVELOPMENT

0830 Welcome back **Ti Kouka**

0835 ***KEYNOTE: Noble Gas Sampling and Detection Systems for Monitoring the Nuclear Test Ban Treaty: System acceptance, calibration, and quality control.*** ***Nikolaus Hermanspahn***

0925 Portable, high sensitivity Rn-222 detector with an SI traceable calibration. ***Scott Chambers***

0950 A Pilot study of Radon and Thoron levels in workplaces cross New Zealand. ***James Eagle***

1015 Quality control sample design for measurement of Rn-222 in water. ***Ilonka Bokor***

1040 Morning tea. *Sponsored by* E/S/R Science for Communities He Pūtaiao, He Tāngata **Central Street**

1110 Investigating the lead-210 background in lead materials and chemical reagents. ***Michaela Froehlich*** **Ti Kouka**

1135 Sample preparation techniques for Alpha Spectrometry measurements in environmental samples. ***Oksana Golovko***

1200 Optimisation of neodymium hydroxide micro-precipitation of Polonium-210 for alpha spectrometry source preparation. ***Peter Medley***

1225 A new approach of the Compton-Suppression System (CSS) with the optimized performance for broader applications. ***David Pan***

1250 Networking lunch. *Sponsored by* Australian Government | ANSTO and ORTEC AMETEK **Central Street**

1350 Unexpected complications associated with using Mirion/Canberra LabSOCS with characterised detectors for the generation of efficiency curves - The Australian CTBTO laboratory (AUL02) experience. ***Emma Barnes*** **Ti Kouka**

1415 Validation against ISO 20042 “Generic test method using gamma-ray spectrometry”. ***Michael Lechermann***

1440 Analysis of the 2020 IAEA ALMERA intercomparison broken chain samples. ***Levi Bourke***

1510 Afternoon tea. *Sponsored by* E/S/R Science for Communities He Pūtaiao, He Tāngata **Central Street**

1540 Establishing a radioanalytical capability to support cyclotron decommissioning. ***Sangeeth Thiruvoth*** **Ti Kouka**

1605 Measurement of Terbium-161 via application of a portable environmental field monitoring gamma detector. ***Michelle Thomas***

1630 Close

FREE EVENING

Programme

WEDNESDAY 30 NOVEMBER

CONTAMINATION MONITORING & EMERGENCY PREPAREDNESS

0835	Welcome back	**Ti Kouka**
	KEYNOTE: Challenges for environment Radiation Monitoring in Australia. ***Stephen Marks***	
0925	Further measurements of Radon-222 exhalation from waste rock on a trial rehabilitated landform at the Ranger Uranium Mine, Northern Territory. ***Che Doering***	
0945	Migration of ^{239,240}Pu and ^{233}U from a low-level radioactive waste site. ***Jennifer Harrison***	
1010	Identifying radiological contamination risks for New Zealand site investigation. ***Andrew Pearson***	
1040	**Morning tea.** *Sponsored by* ESR Science for Communities Te Pūtaiao, Hā Tāngata	
1110	Determination of the specific vulnerability of groundwater sources using Ultrasensitive Analytical Procedures. ***Michal Fejgl***	**Ti Kouka**
1135	Contemporary radiological conditions at Koongarra, Northern Territory, Australia. ***John Pfitzner***	
1155	Passive monitoring of radiocaesium in seawaters using Chemcatcher. ***Alex Chapman***	
1220	Trinitite at the local market? ***Andrew Yule***	
1245	Radiation Protection in Australasia. ***Cameron Jefferies.***	
1300	**Networking lunch.** *Sponsored by* ANSTO and ORTEC AMETEK	**Central Street**

RADIOTRACERS IN ENVIRONMENTAL PROCESSES

1350	*KEYNOTE: Actinide trace amount measurements and the application of such measurements to environmental studies.* ***Aya Sakaguchi***	**Ti Kouka**
1438	Tritium as tracer for the hydrological cycle. ***Uwe Morgenstern***	
1501	Ultra low Tritium analysis: going bigger is better. ***Kellie-Anne Farrawell***	
152	Precise timing signals for the start of an Anthropocene era? ***Stephen Tims***	
1547	Radiokrypton dating in Australia with Australian Atom Trap Trace Analysis. ***Rohan Glover***	
1605	**Afternoon tea.** *Sponsored by* E/S/R Science for Communities He Pūtaiao, He Tāngata	
1630	**Awards**	
1650	Close	

The conference programme is current at the time of print however the committee reserves the right to amend any component as necessary. Every effort will be made to communicate any significant changes. In the event of any disruption or event leading to losses or added expenses being incurred by delegates, there will be no liability attached to SPERA, The Conference Team, The Organising Committee or Haere-roa.

RACI Workshop

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Bentleys

THURSDAY 1 DECEMBER

The RACI workshop continues the tradition of providing direct training and fostering collaboration in the region on the latest topics of interest in the field of environmental radioactivity. This year will see a leading international expert, Professor Mike Wood, provide advanced training in environmental dose assessment using the ERICA Assessment Tool. The training will focus on Tier 2 and 3 level assessments, considering some ways in which the tool can be tailored for specific needs and providing different perspectives on approaches relevant to the region.

Broader concepts that will be covered include modelling of wildlife exposure in heterogeneously contaminated environments and approaches to concentration ratio derivation from incomplete whole organism data. This interactive workshop will include discussions with participants regarding data gaps, regional assessment needs and global community perspectives on future research priorities in this growing area of interest.

The RACI Workshop commences at 0830 and is followed by a RACI Social Function from 1600 – 1700 at The Foundry Bar at Haere-roa.

Social Programme

SPERA WELCOME FUNCTION

When: Monday 28 November
Time: 1700 – 1800
Where: Haere-roa, Central Street
Includes: One drink and canapes – thereafter cash bar

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An opportunity to mix n' mingle at the end of day one

RACI SOCIAL FUNCTION

When: Thursday 1 December
Time: 1600 – 1700
Where: Haere-roa, Foundry
Includes: Light dinner & refreshments

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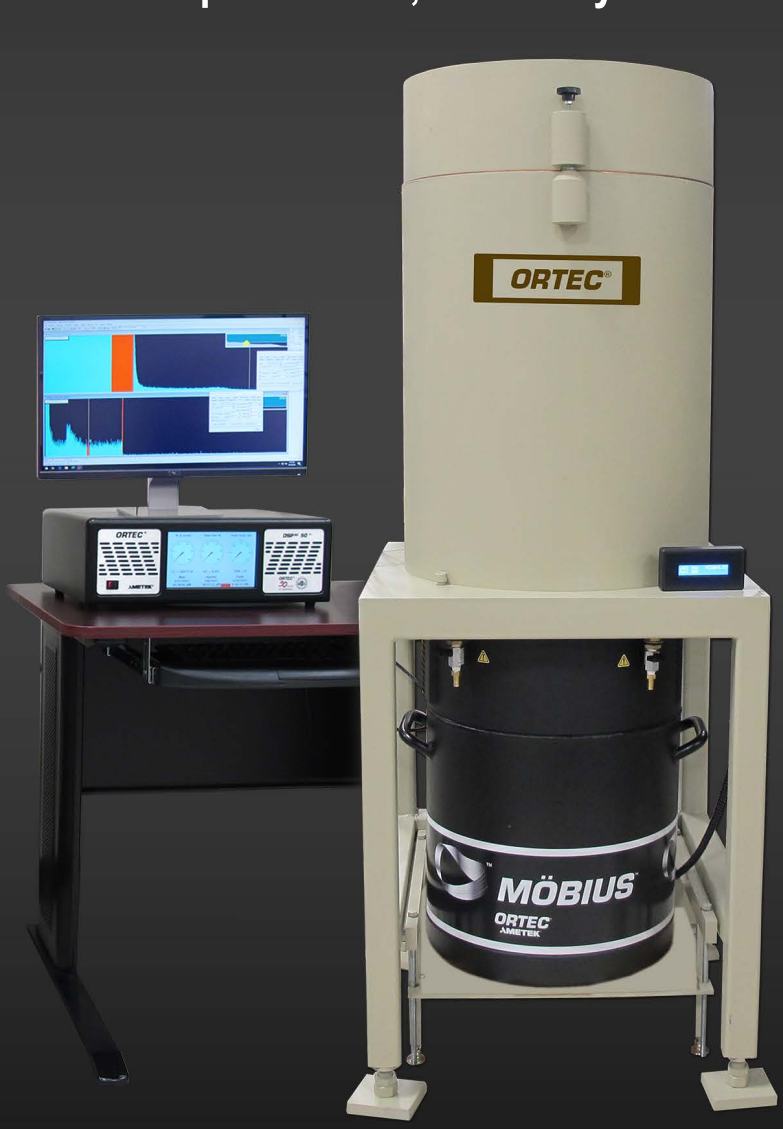

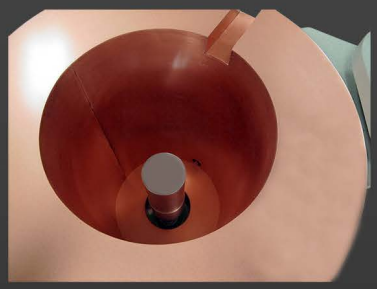

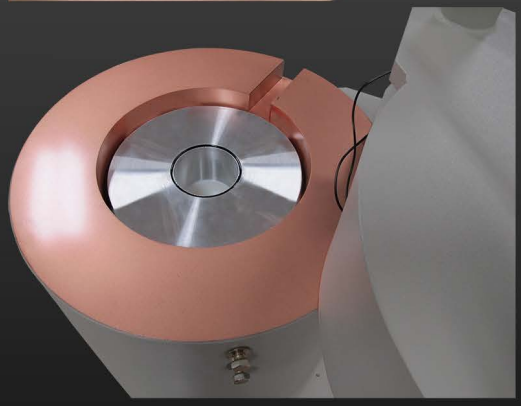

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Keynote Presenters

CHORNOBYL RADIATION DETECTOR RESPONSE DURING THE RUSSIAN MILITARY INVASION.

Mike Wood

Wood M.D.[1], Beresford N.A.[1,2], Barnett C.L.[2], Burgess P.H.[3], Mobbs S.[4]

[1]University of Salford, Salford, M5 4WT, United Kingdom
[2]UK Centre for Ecology & Hydrology, Lancaster Environment Centre, Bailrigg, Lancaster LA1 4AP, United Kingdom
[3]Radiation Metrology Ltd., 1A Highworth Rd., Faringdon, SN7 7EF, United Kingdom
[4]Eden Nuclear and Environment Ltd., Greenbank Road, Eden Business Park, Penrith, CA11 9FB,United Kingdom

In February 2022, increased gamma radiation dose rates (by up to 90 μSv/h) were reported within the Chornobyl Exclusion Zone (CEZ). This coincided with Russian military vehicles entering the Ukrainian part of the CEZ from neighbouring Belarus. Given the extensive nuclear waste legacy within the CEZ, the gamma dose rate monitoring network provides a crucial early warning system for releases of radioactivity to the environment and is part of the international safeguards for nuclear facilities. It was widely speculated that contaminated soil resuspension by vehicle movements or even a leak from the Chornobyl Nuclear Power Plant (ChNPP) complex may explain the dose rate increases. We evaluate the hypotheses suggested to explain the apparent gamma dose rate increases, demonstrating that neither military vehicle-induced soil resuspension nor a leak from the ChNPP can explain these increases. We also propose an alternative hypothesis, which our analyses suggest provides a more plausible explanation.

***Professor Mike Wood** holds the Chair in Applied Ecology at the University of Salford, UK. He is Head of Geography & Environmental Management at Salford and Director of the University's Environmental Research & Innovation Centre. Mike has spent the last two decades working on the development of the international environmental radiation protection system and conducting underpinning radioecological research. From work on the initial development of the ERICA Tool through to studies on radiation effects in Chornobyl, Mike's applied research plays a key role in informing regulation and policy. His Award-winning research in Chornobyl has received extensive media coverage. Mike is a Chartered Radiation Protection Professional, Associate Editor of Journal of Environmental Radioactivity, Editorial Board Member for Journal of Radiological Protection and appointed expert for various International Atomic Energy Agency activities. His scientific contributions have been recognised through prestigious awards, including the Times Higher Education Research Award and the Society for Radiological Protection's Founders' Medal.*

KEYNOTE PRESENTERS

NOBLE GAS SAMPLING AND DETECTION SYSTEMS FOR MONITORING THE NUCLEAR TEST BAN TREATY: SYSTEM ACCEPTANCE, CALIBRATION, AND QUALITY CONTROL.

Nikolaus Hermanspahn

Preparatory Commission for the CTBTO

The international monitoring network of radionuclide stations of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is designed to detect fission and activation products released by a nuclear test. It includes a sub-network of noble gas monitoring systems for the detection of xenon isotopes. These xenon measurement systems were specifically designed for Treaty monitoring purposes. Consequently, commissioning of these systems includes a period of extensive testing to ensure they meet requirements for use in the monitoring network. The presentation will present principles used for calibration of xenon detection systems and challenges with conducting quality assurance using short lived isotopes in a global network.

Nikolaus Hermanspahn started his career in the field of radioactivity measurements at the National Radiation Laboratory (Christchurch, NZ) – later Institute of Environmental Science and Research. The Environmental Radioactivity Laboratory provided a range of measurement and evaluation services to government agencies, research groups and private companies. Consequently, his main interests were focused on aspects of calibration, uncertainties in radioactivity measurements and quality assurance in a radiochemistry laboratory.

In his current role within the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) he is responsible for installation of new radionuclide monitoring stations within the Internal Monitoring System and for scheduling and implementing major upgrades to these stations. His section is undertaking acceptance testing for new equipment and new measurement systems and evaluates quality assurance processes for radionuclide stations and laboratories.

CHALLENGES FOR ENVIRONMENT RADIATION MONITORING IN AUSTRALIA.

Stephen Marks

The impending decisions on Australia's National Radioactive Waste Management Facility and acquisition of nuclear-propelled submarines pose a significant challenge to Australia's capacity to provide measurements of environmental radioactivity. As a non-nuclear-powered nation, Australia's environmental radioactivity measurement capability has primarily been focused on naturally occurring radionuclides near background levels. These new projects will require an increased focus on anthropogenic radionuclides, a broader monitoring network and an increased capacity to respond to a significant radiological incident.

Stephen Marks completed his degree in Physics (Applied Physics) at RMIT University in 2007 and has been Assistant Director of Personal Radiation Monitoring at ARPANSA for the past 3 years. Stephen maintains has over 10 years' experience in the detection and analysis of ionising radiation. Stephen's main areas of interest include radiation dosimetry and gamma spectrometry and their applications in planned and emergency exposure situations.

KEYNOTE PRESENTERS

ACTINIDE TRACE AMOUNT MEASUREMENTS AND THE APPLICATION OF SUCH MEASUREMENTS TO ENVIRONMENTAL STUDIES.

Aya Sakguchi

A variety of natural and anthropogenic actinides (An) are present in the environment, with each having a specific half-life and a behavior that changes in response to its surrounding environment as a result of differences in their physico-chemical properties. Further, some An have parent-child relationships, while some have different origins, leading to their having a wide range of abundances (concentrations) and different isotopic compositions depending on the sample and target environmental system. This makes detailed An observation and analysis important, not only from the perspective of radiation protection, but also for the possibility of using them as tools in the study of environmental dynamics.

Recent developments in mass spectrometry have made it possible to analyze nuclides that were not expected to exist in the environment, or that were expected to exist but had not been detected or quantified. However, analysis of anthropogenic radionuclides in the environment involves complicated/cumbersome chemical separations, and requires isotope spiking to correct for yield and instrumental efficiency, which can make it difficult to conduct An research in some countries and regions. The main aim of this presentation is to introduce, as time allows, the following environmental An research topics:

1. **Anthropogenic uranium as a geoscience research tool**
   The current geological age, known as the Holocene, is marked as the time from the last glacial period (about 10 Kyrs ago) to the present. However, the impact of human activities on global environmental change has become so marked that it cannot be ignored, resulting in the proposal of a new term; the 'Anthropocene', proposed as an acknowledgement of the 'age of humans'. Introduction of this new geological era classification is based on a clear signal found in a reference geological point known as the Global Boundary Stratotype Section and Point (GSSP). In this study, 'nuclear activity' is used as one of the indicators of human activity, and by reconstructing the uranium isotopic composition of sediments from Beppu Bay (Japan), the usefulness as a geological marker for the Anthropocene of the GSSP will be addressed.

2. **Challenges of measuring ^{237}Np in the hydrosphere**
   It is estimated that about 2000 kg of ^{237}Np, one of the most important nuclides in high-level radioactive waste, has already been released into the surface environment due to human nuclear activities. Since Np is mobile in the environment, it is essential to understand its concentration and distribution in order to understand its behavior and to facilitate its use as a tracer in the water cycle. However, no comprehensive studies have been carried out, especially in aqueous environments, because it is necessary to handle large volume of samples during complicated chemical treatments, and there are no appropriate isotope spikes in mass spectrometry.
   We have attempted, with the aim of establishing a simpler Np determination method for relatively large volume environmental water samples, to produce ^{236g}Np as an isotope-spike for ^{237}Np measurements and to construct a new pretreatment method for large volume environmental water samples.

Aya Sakaguchi is an associate professor of chemistry at the University of Tsukuba, Japan, where she works in the field of environmental radio-science. She specializes in the analysis of natural and artificial radionuclides in environmental samples. Samples are collected by field surveys, chemically processed and analysed for target radionuclides by radiometry and mass spectrometry. Resulting analyses are used in assessments of the environmental impact of contamination, such as at a uranium mining site in north Kazakhstan, and accident/test sites at Chernobyl, Fukushima and Semipalatinsk. Further, she researches environmental dynamics, such as seawater/airmass transport in the biosphere, by utilizing ultra-low levels of radionuclides as tools for clarification. Her recent work includes challenging topics such as laboratory tracer experiments to elucidate elemental cycling in surface environments, using accelerator produced short half-life radionuclides, and spike production for the measurement of long half-life actinides in the environment. Further, her work has been applied to the world's largest underground neutrino detector; SK-Gd.

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Abstracts - Oral Presentations

RADIOECOLOGY

RADIOLOGICAL DOSE ASSESSMENT FOR THE ACTINIUM SERIES (AC-227 AND PA-231) FROM URANIUM MINING

***Peter Medley*[1]**

***Stephen Tims*[2], *Michaela Froehlich*[3], *Keith Fifield*[2], *Andreas Bollhöfer*[4], *Dominik Koll*[2], *Zuzana Slavkovská*[3] *and Anton Wallner*[5]**

[1] *Environmental Research Institute of the Supervising Scientist; Australian National University; Queensland Health*
[2] *Australian National University*
[3] *Australian National University; ARC Centre of Excellence for Dark Matter Particle Physics*
[4] *Bundesamt für Strahlenschutz*
[5] *Helmholtz-Zentrum Dresden-Rossendorf*

The Ranger Uranium Mine (RUM) in the Alligator Rivers Region (ARR) of the Northern Territory of Australia ceased mining and milling operations in January 2021 and rehabilitation of the site is now taking place. Traditional indigenous land rights exist on the RUM site, and it is planned to be released to the Mirrar traditional owners once specified environmental requirements for rehabilitation have been met. These requirements apply to effects from operations at RUM both within and outside of the Ranger Project Area, during and following rehabilitation. The requirements relate to risks to the environment and to the health of Indigenous Australians and other members of the regional community. The Mirrar traditional owners also desire that residual radioactivity in the environment after rehabilitation will not make it unsafe to access or use the land (including water bodies) on or outside of the Ranger Project Area for activities, such as collecting and consuming bush foods, seasonal camping, recreation, land management and monitoring, rituals and ceremonies.

Detailed information on movement of naturally occurring radionuclides and accumulation in environmental media is therefore needed to assess compliance with the environmental requirements and aspirations of the traditional owners. Although information exists on radionuclides in the ^{238}U decay series, almost no information has been published for the actinium (^{235}U) decay series. Only three isotopes in the actinium series, ^{235}U, ^{231}Pa and ^{227}Ac, have half-lives longer than a month. The extent to which isotopes lower in the series are present in biological systems is therefore controlled both by the chemical properties of these three elements in the environment, and their biological uptake, particularly for species with life cycles in the order of years.

As the natural isotopic ratio ^{235}U:^{238}U is known, ^{238}U can be used as an analogue for the environmental behaviour of ^{235}U. The only radioactive isotopes of Ac and Pa in the ^{238}U decay series have half-lives of 6 hours or less and, as there are no stable isotopes, suitable analogues to model the environmental migration of ^{227}Ac and ^{231}Pa do not exist. While the activity concentrations of ^{235}U, at the head of the actinium series, are approximately 20 times smaller than those for ^{238}U, dose conversion coefficients for the actinium series isotopes can be 10 to 20 times higher than those for the ^{238}U series elements. If ^{231}Pa or ^{227}Ac are preferentially transported and/or taken up by biological organisms, then radiation doses to the organisms or to humans who eat those organisms from actinium series radionuclides may be significantly higher than from isotopes in the ^{238}U series. Consequently, the significance of the radiation dose received by plants and animals in the natural environment of the ARR, and to people that eat them remains uncertain. We report on measurements of biological materials and soils for ^{227}Ac and ^{231}Pa in traditional food items from the ARR. Implications for the development of radiological closure criteria for the Ranger Project area and potential doses from ionizing radiation to people and the environment from the actinium series.

AN UPDATED INTERNATIONAL DATASET OF SOIL TO FRUIT CONCENTRATION RATIOS FOR RADIOCAESIUM

***Che Doering*[1]**

***Franca Carini*[2], *Mamoru Sato*[3], *Brenda Howard*[4], *Andra-Rada Harbottle*[5], *Joanne Brown*[5], *John Twining*[6] and *Hugo Velasco*[7]**

[1] *Environmental Research Institute of the Supervising Scientist*
[2] *Università Cattolica del Sacro Cuore*
[3] *Fukushima University*
[4] *Centre for Ecology and Hydrology*
[5] *International Atomic Energy Agency*
[6] *Austral Radioecology*
[7] *Universidad Nacional de San Luis*

Caesium-137 with a half-life of approximately 30 years is one of the most important radionuclides with a long-term presence in the environment following a release of radioactivity from a nuclear facility. Root uptake of atmospherically deposited caesium-137 from soil is recognised as a key long-term transfer pathway leading to caesium-137 contamination of crops in the years and decades after a nuclear event. This long-term transfer pathway can be quantified using a parameter called 'concentration ratio', which relates the radionuclide activity concentration in the crop to that in the soil. The need for better information on soil to fruit concentration ratios for radiocaesium was highlighted by the Fukushima accident because fruit was a key agricultural product grown in Fukushima Prefecture.

The International Atomic Energy Agency (IAEA) Modelling and Data for Radiological Impact Assessments (MODARIA II) programme ran from 2016 to 2019 and included a working group on 'Transfer Processes and Data for Radiological Impact Assessment'. The activities of the working group included collating radionuclide transfer data from Japan following the Fukushima accident (IAEA-TECDOC-1927) and separately collating soil to crop concentration ratio data for non-temperate environments (IAEA-TECDOC-1979). The fruit radiocaesium data from these compilations were combined with those originally compiled for the Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments (IAEA Technical Reports Series No. 472) and additional data identified from the literature to form an updated international dataset of soil to fruit concentration ratios for radiocaesium.

This presentation will describe the process of finding, collating, classifying and analysing soil to fruit concentration ratio data for radiocaesium within the context of the IAEA MODARIA II programme. Differences in concentration ratio values between different climate classes, soil and plant types will be discussed. Comparisons with the original data from the IAEA Technical Reports Series No. 472 handbook will be presented.

TOWARDS A HOLISTIC APPROACH TO PROTECTION OF INHABITANTS OF CONTAMINATED ENVIRONMENTS: THE ROLE OF NON-TARGETED EFFECTS

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Recent moves within ICRP to develop an integrated approach to radiation protection of both humans and non-human biota are focused on regulating dose to exposed populations based on behaviour, size, lifestyle and "radiosensitivity". Currently man and 12 reference organisms are used covering various taxonomic groups, behaviours, and exposure scenarios - e.g. marine, terrestrial, sediment or airborne. However most biologists agree that particularly in low dose exposure legacy sites, the factors determining effects and outcomes are far more complex that this simple framework suggests. The issue is developing reliable predictors of system or ecosystem health rather than relying on biomarkers that give information about effects on individual cells, organs or organisms. Approaches to this include the Adverse Outcome Pathway (AOP) developed as part of the CERAD project in Norway, which looks at multiple levels of organisation from gene to ecosystem building a comprehensive picture of effects at multiple levels of organisation in multiple species including humans. Various camera drone based ecosystem evaluation techniques have been developed in other areas of environmental management. These could be applied at legacy sites where damage to for example tree canopies or river flow patterns can be used to assess ecosystem health much like a CAT or MRI scan reveals structural changes in individual organisms systems. Another more focused approach used by our group is to look at the role of non-targeted effects such as genomic instability (GI) and bystander effects (BE). These mechanisms involve transmission of information between different levels of organisation. In the case of BE signals from exposed to unexposed cells or organisms coordinate response at higher levels of organisation permitting population responses to radiation to be optimised. GI is more complex as it involves not only signalling but also trans-generational transmission of genetic or epigenetic changes and may lead to long-term adaptive evolution. GI may also be involved in memory or legacy effects, which contribute a further component to the dose effect measured in legacy sites. Our recent analysis of the contributions of memory and legacy effects to the total effect using data sets from Chernobyl and Fukushima (voles, birds and butterflies) suggest this type of analysis may help reduce uncertainties over lab to field extrapolations. Given the clear discrepancy between actual data measured in the field and dose effects generated using databases populated mainly with acute lab based experimental data, it is imperative that we strive to develop meaningful holistic systems for protection of those living in contaminated ecosystems.

RADIONUCLIDE EQUILIBRIUM COEFFICIENTS IN DECAY CHAINS IN SELECTED NORM MATERIALS

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Chemical or thermal procedures can disrupt the radioactive equilibrium in naturally occurring radioactive materials (NORM). This disruption can be caused by different solubility or volatility properties of radionuclides during separation steps. The assessment and measurement of activities of radionuclides contained in NORM materials in a workplace is considered as an important service from the radiation protection point of view. Activities of radionuclides in NORM materials are measured according to the Recommendation of State office for nuclear safety (SONS) in the Czech Republic [1]. This document describes the method of activity calculation of the radionuclides that are not measured directly but rather conservatively estimated. In this Recommendation, the activity of ^{234}U (and ^{230}Th) is expected to be twice the ^{238}U activity. On the other side, the ^{210}Pb and ^{210}Po are assumed to be in equilibrium. For the ^{232}Th radionuclide its activity is supposed to be the sum of ^{228}Th and ^{228}Ra activities. Therefore, the main motivation of this research was to determine the coefficients of potential disequilibrium between the ^{238}U-^{234}U, ^{238}U-^{230}Th and ^{210}Pb-^{210}Po nuclides in uranium decay series and ^{232}Th-^{228}Ra nuclides in thorium decay series in different matrices of NORM materials, regularly analysed at the NRPI institute.

Since 2019 the activity concentrations of mainly actinides comprised in the samples of sludge, filtration materials, sinters, sediments and fly ashes were measured as a part of a national monitoring system. Additionally, activities of ^{210}Pb and ^{210}Po in surface water and drinkable water from groundwater treatment station were assessed. Uranium, thorium and polonium activities were measured by alpha spectrometry using PIPS detector after ion exchange separation. A low background proportional counter was used to measure ^{210}Pb indirectly by its daughter nuclide (^{210}Bi) ingrowth. Activities of ^{238}U, ^{228}Ra, ^{228}Th and ^{210}Pb were measured by HPGe detector.

The partial results of the activities of the aforementioned radionuclides according to the matrix type will be presented in this contribution as well as the comparison of estimated activities according to the Recommendation and experimental results of radionuclide equilibrium coefficients.

[1] SONS Recommendation, DR-RO-5.3 (Rev. x.x), Measurement and evaluation of naturally occurring radionuclides in a radioactive matter released from a workplace with the possibility of elevated contamination from natural source of radiation.

ACTIVITY CONCENTRATIONS OF RADIOCAESIUM IN SELF-CONSUMED CROPS COLLECTED IN NAMIE, FUKUSHIMA FROM 2019 TO 2020 WITH ASSOCIATED INTERNAL RADIATION DOSES TO HUMANS

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In Namie Town, Fukushima Prefecture, decontamination was carried out after the Fukushima Daiichi Nuclear Power Station accident. After remediation, the restricted residential area and the area preparing for the lifting of evacuation orders in the eastern part of Namie Town were lifted, and residents started returning home beginning on March 31, 2017. Various self-consumed crops, including homegrown agricultural crops and edible wild plants, were collected from the decontaminated fields and surrounding areas in 2019 and 2020. Activity concentrations of radiocaesium were measured in 181 samples of grain, potatoes, beans, vegetables, and fruits. Internal radiation exposure to humans from ingestion of the crops were calculated. Activity concentrations of ^{137}Cs in the homegrown agricultural crops ranged from 0.18 to 46 Bq kg^{-1} fresh weight, which were all below the standard limit of 100 Bq kg^{-1}, while in the wild plants collected from around the fields ^{137}Cs ranged from 3.2 to 175 Bq kg^{-1} fresh weight. The additional internal radiocaesium radiation dose for adult males in 2020 from ingestion of the various self-consumed crops was 0.032 mSv, accounting for approximately 5% of the total additional internal and external radiation dose of 0.64 mSv due to the accident. The internal radiation dose from the intake of the homegrown agricultural crops, excluding wild plants, was 0.012 mSv, which was about 1/3 of that from the intake of both self-consumed crops and wild plants, and well below 1 mSv.

RECENT STUDIES OF NATURAL RADIONUCLIDE UPTAKE IN NON-HUMAN BIOTA TO INFORM RADIOLOGICAL ENVIRONMENTAL IMPACT ASSESSMENT FOR URANIUM MINE REHABILITATION IN TROPICAL NORTHERN AUSTRALIA

Che Doering[2]

Alexandra Stokes Hughes[1], Scott McMaster[2], John Pfitzner[2], Jefferson Chen[2]

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The need to consider and assess radiation dose rates to non-human biota from facilities and activities releasing radioactivity to the environment is now recognised as international best practice. A number of tools have been developed to facilitate dose rate assessments for non-human biota. These tools generally use an empirical parameter called 'concentration ratio' to predict radionuclide activity concentrations in an organism from those in the surrounding environmental medium such as soil or water (concentration ratio integrates radionuclide uptake from the environmental medium and trophic transfer into a single parameter). Databases of generic concentration ratio values for different types of non-human biota have been developed internationally and are available in some tools. However, these generic values may not be appropriate in situations where site-specific assessments are required.

The Ranger uranium mine is located in the wet-dry tropics of Australia's Northern Territory and is surrounded by the World Heritage listed Kakadu National Park and its Ramsar listed wetlands of international importance. The mine operated from 1980 to 2021 and produced over 120,000 tonnes of uranium ore concentrate, making it one of the world's biggest producers of uranium. The mine is now being rehabilitated by the mining company in accordance with environmental requirements mandated by government. The standard to which the mine must be rehabilitated is to establish an environment similar to surrounds such that the site could be incorporated into Kakadu National Park.
The rehabilitation strategy for the mine includes disposal of tailings in the pit voids, removal of infrastructure, construction of a final landform covered by low uranium grade waste rock and revegetation using local native plant species.

The Ranger final landform will be a source of elevated radiation dose rates to terrestrial animals and plants that inhabit it. It may also be a source of elevated dose rates to freshwater organisms from surface runoff or groundwater transport of radionuclides to surrounding creek systems. Prospective assessments of dose rates to terrestrial and freshwater non-human biota from the final landform are being undertaken. Because of the very high environmental significance of Kakadu National Park, the preference is for the assessments to be site-specific. Sampling and analysis of various types of non-human biota to derive site-specific concentration ratios for uranium decay series radionuclides is ongoing. Recent studies have included algae, understorey vegetation and terrestrial invertebrates.

This presentation will discuss the recent studies. Sample collection and analysis methods will be described. Site-specific concentration ratios derived from the measurements will be presented and compared with the default values in the widely used ERICA Tool. Dose rate estimates for different scenarios of radionuclide activity concentration in final landform waste rock and in creek surface water will be presented and discussed in the context of international benchmark values for radiological protection of the environment.

ANTHROPOGENIC RADIONUCLIDES PERSIST IN MARINE SEDIMENT AT THE MONTEBELLO ISLANDS NUCLEAR LEGACY SITE IN WESTERN AUSTRALIA

***Madison Williams-Hoffman*[1]**

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In 1952 and 1956 the UK government conducted three atmospheric nuclear fission tests in the Montebello Islands, an archipelago approximately 100 km off the coast of northern Western Australia. Radioactive contamination from the tests was deposited locally across the archipelago in both terrestrial and marine environments but was investigated minimally in the decades that followed. This is particularly true for the marine environment which is composed of various distinct ecosystems – from mangroves to open marine channels and is home to a diverse trophic web of marine organisms. To understand the extent and persistence of anthropogenic radionuclides introduced by the tests into this region, we aim to establish the distribution of anthropogenic radionuclides in the marine surface sediments throughout the archipelago. Here we present the results on activity concentrations and distributions of ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239\&240}$Pu and ^{241}Am due to their long half lives and their potential to impart radiological dose to organisms existing at the sediment-water interface.

Quantification of anthropogenic and naturally occurring radionuclides in surface and core samples was completed by alpha spectrometry, Cherenkov counting and gamma spectrometry. Activity concentrations of ^{90}Sr, ^{137}Cs, ^{238} Pu, $^{239\&240}$Pu and ^{241}Am were highest around the detonation locations in the north of the archipelago in surface sediment samples. Observable activity concentrations also persist in the north-west of the detonation locations, reflecting the direction of the original fallout plumes from the weapons. One additional location showed higher activity concentrations of ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239\&240}$Pu and ^{241}Am in comparison to other locations within the archipelago (121 Bq/kg, 1.6 Bq/kg, 80 Bq/kg, 402 Bq/kg and 28 Bq/kg respectively). This sample was collected 26 km south of the nearest detonation site and was originally selected as an environmental control outside of the state marine park boundaries, suggesting migration of anthropogenic radionuclides has occurred in the 70 years since the detonations took place.

Sediment cores were also taken from different marine environments of the region, including at the bottom of the crater created by Operation Hurricane, which involved the detonation of a naval ship in shallow water in 1952. ^{210}Pb was analysed to assess the sedimentation rates over the last century across the cores. In most instances, mixing dominated throughout the sediment core profiles. This reflects the highly dynamic and turbulent nature of the region, subject to seasonal cyclones and fast-moving tides within the archipelago. The exception to this observed mixing was found in a single core, the 'Hurricane Core', taken in the bottom of the Operation Hurricane crater. ^{137}Cs and ^{241}Am activity concentrations of this core showed a clear peak in activity at 50 cm depth; an order of magnitude above those found in similar parts of the region within surface sediments. The maximum activity concentrations of 180 Bq/kg and 66 Bq/kg for ^{137}Cs and ^{241}Am respectively were established in the core at 50 cm depth, with the closest surface sediment activity concentrations established at 56 Bq/kg and 20 Bq/kg.

A GEOCHEMICAL JOURNEY IN COASTAL GROUNDWATER EXCHANGE FROM BARTER ISLAND, ALASKA TO ROI NAMUR, KWAJALEIN

Peter Swarzenski

Alexandra Stokes Hughes[1], Scott McMaster[2], John Pfitzner[2], Jefferson Chen[2]

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Coastal groundwater exchange connects upland watersheds to marine ecosystems but is still overlooked in many mass balance studies simply because this vector is much more difficult to quantify than riverine or atmospheric inputs. Indeed, looking only at nutrient delivery in a global review, Santos et al. Nat Rev Earth Environ 2, 307–323 (2021) observed that coastal groundwater-derived nutrient fluxes exceed river inputs in roughly 2/3 of all study sites world-wide. Naturally occurring U/Th series radionuclides, such as radium and radon, are ideally suited to identify, track, and quantify the saline, freshwater, and mixed components of coastal groundwater. Saline coastal groundwater is often a ubiquitous, large source of diffuse recycled nutrients to coastal waters, while fresh coastal groundwater can deliver a local source of new nutrients. This review presents a geochemical odyssey of sorts, where I summarize results from field studies in coastal groundwater exchange conducted across parts of the Pacific Basin. At some of these locations results directly have had an impact on water quality management plans.

PORTABLE, HIGH SENSITIVITY RN-222 DETECTOR WITH AN SI TRACEABLE CALIBRATION

***Scott Chambers*[1]**

***Stefan Röttger*[2], *Viacheslav Morosh*[2], *Florian Mertes*[2], *Ot Sisoutham*[1], *Alan D Griffiths*[1] *and Alastair Geraint Williams*[1]**

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Among the key limitations of "top-down" techniques such as the Radon Tracer Method to characterise local- to regional-scale emissions of greenhouse gases is reliable representation of the spatial and temporal variability in radon concentrations and fluxes (Röttger et al. 2021; Levin et al. 2021). Furthermore, the utility of complementary outdoor radon monitoring for the identification and characterisation of radon priority areas is also becoming more widely recognised. As such, the availability of reliable and accurate monitors of outdoor radon concentration ($1 \leq A_{Rn} < 100$ Bq.m^{-3}) is of significant interest to both the climate and radiation protection research communities. Until recently, however, calibrations traceable to the International System of Units (SI) were only available for concentrations ≥100 Bq.m^{-3}. Among the key objectives of the EMPIR 19ENV01 traceRadon Project[§] are the development low-activity radon sources to enable SI traceable calibrations between (1 – 100) Bq.m^{-3} and portable radon monitors capable of reliably measuring radon concentrations in this range and transferring an SI traceable calibration to other radon monitors. Here we present the fruits of a collaboration between ANSTO and Physikalisch-Technische Bundesanstalt (PTB) as part of traceRadon, namely, a portable two-filter dual-flow-loop radon detector with a detection limit of <0.2 Bq.m^{-3} and 30-minute temporal resolution. In conjunction with novel calibration sources developed by PTB, the compact size and low sampling flow rate of this monitor enable SI traceable calibration under laboratory and field conditions. The new detector (Chambers et al. 2022), sources (Mertes et al. 2022) and calibration method (Röttger et al. 2021) are introduced, measurement characteristics investigated, and an example provided of a calibration transfer from the portable monitor to a separate monitor operating under field conditions. The portability, reliability and sensitivity of this portable detector will facilitate the harmonization of radon monitoring being conducted in radiation protection and climate research station networks globally.

§ This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

A PILOT STUDY OF RADON AND THORON LEVELS IN WORKPLACES ACROSS NEW ZEALAND

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Radon 222, Radon 220 and their daughter products are known colloquially as Radon and Thoron. These gasses have been demonstrated to be a major cause of lung cancer (Pershagen, Goran, et al 1994). The World Health Organisation has recommended a residential action level of 100 Bq/m^3 and a limit of 300 Bq/m^3 which should never be surpassed. The IAEA recommends a workplace action level of 1000 Bq/m^3. From this the European Union established a conservative level of 300 Bq/m^3 for both workplaces and residential, which came into force 2018. In New Zealand, several small-scale radon surveys have previously been performed (Ardouin, Cris, et al 2016, Robertson, Murray Kenneth et al 1988). A median radon concentration of 19-23 Bq/m^3 was identified, the global average is approximately 40 Bq/m^3. The 2016 survey sampled 260 building, of these 19 were workplaces. From these results it has been assumed that Radon is not typically a concern for New Zealand homes and workplaces. However, a Recent measurement of a workplace basement in Dunedin produced a radon level of 850 Bq/m^3, in a low occupancy area and 180 Bq/m^3 in a high occupancy area. It should be noted that these measurements were only from an initial two-day test and are being followed up. This result highlighted the need for more workplace monitoring of radon levels in New Zealand. This pilot study aims to first identify which workplaces in New Zealand which could be at risk of elevated radon levels. From these higher risk workplaces an initial one-to-two-day measurement will be performed with digital active (Durridge RAD 7 Electronic radon detector) and passive radon air monitors (AirThings Corentium Pro). Sites with radon levels greater than 100 Bq/m^3 will be selected to have a follow up measurement, using a passive detector for a three-month period. The results from this pilot study will enable a potential comprehensive workplace radon survey in New Zealand and the development of national Radon reference levels.

QUALITY CONTROL SAMPLE DESIGN FOR MEASUREMENT OF RN-222 IN WATER

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The most common method for measuring Radon gas in water is by Liquid Scintillation Counting (LSC). Water samples need to be collected in ways that prevent de-gassing of the sample and are required to be tested close to the collection time to minimise any losses in Radon.

Quality control samples for ^{222}Radon are limited to sample duplicates, reagent blanks and the use of ^{226}Radium efficiency standards. These are not true Quality control samples and the ISO 13164-4 standard suggests the use of a certified reference material, however Radon in water is not available.

We will discuss the preparation and long term use of a ^{222}Radon quality control sample at ARPANSA. This technique utilises a resin impregnated with a standard solution of ^{226}Radium. These quality control samples are prepared and measured together with the unknown samples, therefore representative of the sample preparation at the time of measurement.

INVESTIGATING THE LEAD-210 BACKGROUND IN LEAD MATERIALS AND CHEMICAL REAGENTS

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SABRE (Sodium iodide with Active Background REjection) is a direct detection dark matter experiment based on ultra-pure NaI(Tl) crystals. This experiment is well-shielded against external radiation and thus its background rate is driven by radioactive contaminants in the detector material and in the materials used for the construction of the experimental setup. Such radioactive contamination may come from long-lived, naturally occurring radionuclides or from cosmogenic activation. Therefore, a careful selection and development of ultra-pure materials and equipment is required, as well as a detailed knowledge of the residual radioactivity.

Here, we focus on exploring the extraction of the radioisotope lead-210 (^{210}Pb) in analytical grade NaI prior to examining Astro-grade NaI(Tl), which will eventually serve in the SABRE-South experiment as a scintillator detector for dark matter studies based in the Southern Hemisphere. We aim to measure ^{210}Pb in NaI by accelerator mass spectrometry (a single atom counting technique), however this is challenging owing to the anticipated large mass of 1 kg. We will discuss two methods to extract Pb using different resins such as the Anion Exchange Resin (1-X8, 100-200 mesh Chloride form) and Sr® resin (100-150 mm).

Furthermore, it is essential that any material and reagents in use should contain as little ^{210}Pb as possible. For the chemical extraction of ^{210}Pb from NaI, a stable Pb carrier is being used, which may contain traces of ^{210}Pb as well. As ^{210}Pb has a half-life of 22.2 years, the “older” the material (i.e., age of manufacturing and processing) the better, as most, if not all, of the ^{210}Pb has decayed. However, ^{210}Pb is a decay product of U, which is omnipresent in the environment. Therefore, if uranium has not been completely removed from the Pb material during processing, ^{210}Pb will be continuously produced.

Here, we will present results for a series of Pb materials together with various reagents which were measured using the 1 MV Vega accelerator at ANSTO. Their ^{210}Pb/^{208}Pb isotopic ratios vary between (3-30) ´ 10^{-14} for the Pb carriers (0.38-173 mBq ^{210}Pb/g) and range from 1 ´ 10^{-14} to 3 ´ 10^{-11} for the reagents (4-194 mBq ^{210}Pb/g), respectively.

SAMPLE PREPARATION TECHNIQUES FOR ALPHA SPECTROMETRY MEASUREMENTS IN ENVIRONMENTAL SAMPLES

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ESR Environmental Radiochemistry Laboratory (ERL) offers testing for a range of alpha emitting isotopes. Most commonly, isotopes of actinide elements (Th, U, Pu, Am), Po-210, Ra-226 in variety of environmental matrices: food, water, plant and animal tissues, sediments, air filters.

The basic environmental radiochemistry procedure could easily be divided into four main parts: sample preparation (tracer addition, preconcentration or dissolution), radiochemical separation, source preparation (microprecipitation, electrodeposition) and counting.

This presentation is focused on commonly used sample preparation techniques and their practical application in ERL. Sample preparation is the first step in a basic environmental radiochemistry procedure and your first step to success or failure. Choice of techniques is primarily based on sample type and matrix, as well as the analyte to be measured. However other factors to be considered could be equipment availability, cost efficiency, safety concerns, waste generation.

OPTIMISATION OF NEODYMIUM HYDROXIDE MICRO-PRECIPITATION OF POLONIUM-210 FOR ALPHA SPECTROMETRY SOURCE PREPARATION

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Co-precipitation of actinides with lanthanide hydroxides is a suitable technique to prepare highresolution sources for alpha spectrometry. One such technique has been adapted and optimised for co-precipitation of ^{210}Po with $Nd(OH)_3$. Chemical recovery greater than 90%, with a resolution less than 40 keV at full-with-half-maximum (FWHM) was achieved. The method can be faster, less expensive and less labour intensive than routine techniques using auto-deposition of Po onto Ag. Owing to co-precipitation of several metals with $Nd(OH)_3$, including Fe and alpha emitting radionuclides, radiochemical separation of ^{210}Po from the sample matrix is required for this method to be effective. The technique, however, does effectively separate Po from Cu, and is thus highly suited to samples where complete radiochemical separation from Cu is difficult to achieve, such as copper concentrates. The method also achieves 94±2% separation of ^{210}Po from Pb. A common technique for measurement of ^{210}Pb uses an initial separation of ^{210}Pb from ^{210}Po and then allows time for ingrowth of ^{210}Po. A second radiochemical separation is then performed for ^{210}Po, measurement of which is used to infer the initial activity concentration of ^{210}Pb. Effective separation of ^{210}Po and ^{210}Pb using $Nd(OH)_3$ co-precipitation can therefore simultaneously radiochemically separate these two isotopes and prepare ^{210}Po for alpha spectrometry. Thus, reducing radiochemical processing for ^{210}Pb analysis when measured through ingrowth of ^{210}Po. As Bi is also co-precipitated with $Nd(OH)_3$ with this method, a correction factor for contribution from ^{210}Bi to the ^{210}Po activity measured may be required. Biological samples were processed using microwave-assisted digestion followed by radiochemical separation for ^{210}Pb and ^{210}Po. Co-precipitation of ^{210}Po with $Nd(OH)_3$ was done on the ^{210}Po fraction from both separated fractions, a delay after radiochemical separation for the ^{210}Pb fraction was allowed for ingrowth of ^{210}Po. Results from these measurements will be presented.

A NEW APPROACH OF THE COMPTON-SUPPRESSION SYSTEM (CSS) WITH THE OPTIMIZED PERFORMANCE FOR BROADER APPLICATIONS.

David Pan[1]

[1] *Ametek*

Compton Suppression Systems (CSS) are used to reduce the background continuum for low-background counting. This reduction improves the MDA and overall spectrum quality. However, there are some limitations on sample size, complications in setup, maintenance, and performance routine.

An application-centric redesign and implementation of the new CSS were completed recently with the following advantages:

- Improved Peak-to-Compton performance (1300:1 or greater).
- Increased sample height for sample volumes up to 500 cubic centimeters.
- Simplified single-step sample loading with the compact, cylindrical shield.
- Digital electronics using advanced digital programmable timing and gating.
- Turnkey application software for easy setup, ongoing performance optimization, and spectroscopy analysis.
- Optional cosmic veto rejection add-on.

UNEXPECTED COMPLICATIONS ASSOCIATED WITH USING MIRION/ CANBERRA LABSOCS WITH CHARACTERISED DETECTORS FOR THE GENERATION OF EFFICIENCY CURVES - THE AUSTRALIAN CTBTO LABORATORY (AUL02) EXPERIENCE.

Emma Barnes[1]

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Over recent years the Australian CTBTO Laboratory (AUL02) has transitioned from using empirical measurements of physical sources to utilising the Mirion/Canberra LabSOCS software in conjunction with characterisation of detectors to generate efficiency curve parameters for AUL02.

The process for developing a reliable LabSOCS model involves having the detector characterised by Mirion and using the resultant characterisation file to build a LabSOCS model of the detector and the sample geometry applicable for each efficiency required.

AUL02 pursued this process in 2021 on a detector returned from Mirion following repair, however when comparing the measured efficiency data with LabSOCS-generated efficiency data, the LabSOCS efficiencies were consistently ~10-15% lower than the measured data.

This presentation describes the troubleshooting required to understand the LabSOCS vs Measured data discrepancies and the steps taken to resolve the problem.

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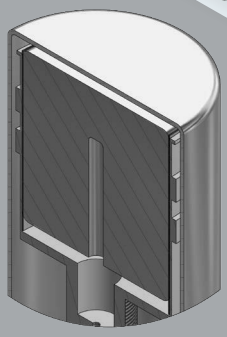

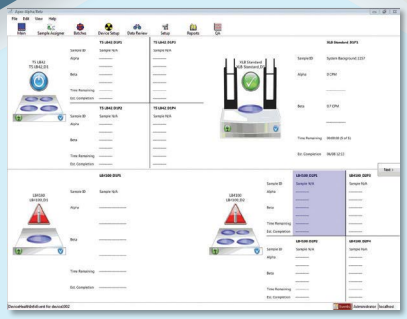

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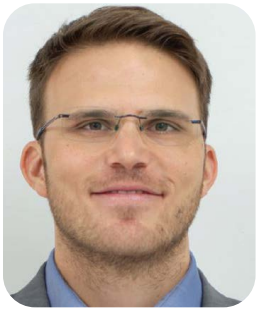
OPS-4818 – 10/2022

VALIDATION AGAINST ISO 20042 "GENERIC TEST METHOD USING GAMMA-RAY SPECTROMETRY"

Michael Lechermann[1]

[1] *ESR*



Gamma spectrometry offers the ability to quantify a wide range of analytes simultaneously for a variety of sample geometries and matrices. Accreditation under ISO 17025, however, is typically specific to sample matrix and analyte, and many accrediting bodies require explicit mention of both for each accredited test.

The chemical properties of the sample matrix and analytes are less critical for gamma spectrometry compared to radiometric analysis techniques that require chemical preparation. Physical characteristics, such as sample geometry and self-absorption coefficients can be modelled or calibrated reliably for different samples. While the sample preparation itself is generally more straightforward and uncomplicated, the analysis of gamma spectra, including the application of correct efficiency calibrations and correction factors, remains a challenging task even for experienced analysts.

ISO 20042 offers a path for laboratories to establish a quality regime that ensures competence in gamma spectrometry following a generic test method. ESR's environmental radioactivity laboratory aims to harmonize and validate its procedures against ISO 20042. In this presentation, we report the technical challenges and opportunities of such an undertaking.

ANALYSIS OF THE 2020 IAEA ALMERA INTERCOMPARISON BROKEN CHAIN SAMPLES

Levi Bourke[1]

[1] *ESR*

The 2020 IAEA ALMERA intercomparison contained two so called "broken chain" samples for gamma spectrometry. These samples proved challenging for a significant percentage of participants with only 17% reporting acceptable activities for Pb-212, and 57% not reporting a value at all. The Th-232 decay chain for these samples was not in equilibrium due to unsupported Ra-228. If this is not properly accounted for activity calculations to the reference time will be incorrect. In this presentation we demonstrate our approach for dealing with such samples, starting with a preliminary spectral analysis, discussion/ interpretation of the preliminary results, development of a solution and any assumptions made, and finally the results.

ESTABLISHING A RADIOANALYTICAL CAPABILITY TO SUPPORT CYCLOTRON DECOMMISSIONING

***Sangeeth Thiruvoth*[1]**

***Jennifer Harrison*[1], *Juniper Bedwell-Wilson*[1], *Trent Cunynghame*[1], *Julia Martiniello*[1], *Lida Mokhber Shahin*[1] *and Adella Silitonga*[1]**

[1] *ANSTO*

The 30 MeV cyclotron at the National Medical Cyclotron (NMC) ceased operations in October 2009 after producing medical isotopes for application in nuclear medicine for approximately 20 years.

Upon its closure a process of decommissioning commenced. Initially, internal components that make up the cyclotron were removed, leaving behind the vault. The vault is predominantly constructed of concrete and steel reinforcements. Neutron activation of these materials produced radioisotopes that will need to be accurately identified and quantified to support decision making around storage and disposal options of these materials. This is a critical aspect of any cyclotron decommissioning project and has safety, environmental and economic implications.

A capability to quantify typical radionuclides found in cyclotron materials is being developed at ANSTO. Cyclotron vault materials that may require assessment are concrete, steel and waters. Radionuclides of interest are typically beta- and gamma-emitting neutron activation products.

Non-destructive, high resolution gamma spectrometry will be applied to quantify gamma emitting radionuclides such as ^{152}Eu, ^{154}Eu, ^{134}Cs and ^{60}Co. The complex matrix of some reactor materials will cause attenuation of gamma photons and empirical and/or theoretical corrections will be applied.

Beta-emitting radionuclides will require a suite of destructive radioanalytical techniques designed to isolate and quantify beta-emitting radionuclides such as ^{59}Fe and ^{55}Fe. Gross beta counting will assist in identifying which samples will require destructive beta analysis.

This presentation will outline the approach taken in identifying a sampling strategy and in the method development for non-destructive and destructive analysis and how this can support future cyclotron decommissioning needs of Australia and our region.

MEASUREMENT OF TERBIUM-161 VIA APPLICATION OF A PORTABLE ENVIRONMENTAL FIELD MONITORING GAMMA DETECTOR

Michelle Thomas[1]

[1] *ARPANSA*

It is essential to be able to measure the correct activity of radiopharmaceuticals to ensure that nuclear medicine patients receive the correct dose. Measuring the activity of a radiopharmaceutical is normally a straightforward process, but the use of novel isotopes can make this challenging. Terbium-161 (^{161}Tb) is one such isotope and it shows promise for use in the treatment of various kinds of cancer. It is challenging to measure as there is limited nuclear data on ^{161}Tb, and many of the key gamma and x-ray emission lines of ^{161}Tb being of low intensity and low energy. Most nuclear medicine dose calibrators are not set up to measure ^{161}Tb, and certified ^{161}Tb standards to confirm activity are difficult to manufacture and obtain making it challenging to ensure dose activity measurements are accurate. To assist in obtaining an accurate dose measurement, in-field gamma spectroscopy measurement techniques normally used for environmental radioactivity monitoring were applied in a hospital setting. The measurements generated data to further the understanding and characterisation of ^{161}Tb and will allow for optimise dose measurement protocols through assurance of the activity measured by a dose calibrator.

CONTAMINATION MONITORING & EMERGENCY PREPAREDNESS

FURTHER MEASUREMENTS OF RADON-222 EXHALATION FROM WASTE ROCK ON A TRIAL REHABILITATED LANDFORM AT THE RANGER URANIUM MINE, NORTHERN TERRITORY,

Che Doering [1]

Scott McMaster [1], ***John Pfitzner1, Alex Stokes Hughes*** [1] ***and Jefferson Chen*** [1]

[1] *Environmental Research Institute of the Supervising Scientist*

Radon-222 is a radioactive noble gas produced from the decay of radium-226 in the uranium decay series. It is released from soils and rocks to the surrounding pore space in a process called emanation and from the ground to the atmosphere in a process called exhalation. Once in the atmosphere, radon-222 is transported by wind and turbulent mixing. The decay of radon-222 produces several short-lived progeny radionuclides which give a radiation dose to the lungs when inhaled.

Ranger mine in the seasonal wet-dry tropics of the Northern Territory of Australia has been one of the world's biggest producers of uranium over its 40 year operational life. The mine ceased operating in 2021 and is now being rehabilitated by the mining company in accordance with environmental requirements mandated by government. The mine is situated on Aboriginal land which is to be returned to traditional owners when rehabilitation is complete. Low uranium grade waste rock is planned to be used for the surface cover on the yet-to-be-built ~800 ha final landform of the rehabilitated Ranger mine. This will make the final landform a source of potentially elevated radon-222 exposure to traditional owners and other members of the public in its vicinity.

In late 2008, a waste rock covered trial rehabilitated landform of ~8 ha was constructed at Ranger mine to study surface erosion characteristics and revegetation strategies. Wet and dry season measurements of radon-222 exhalation were also made on the trial landform in 2009–2014 to characterise the relationship between flux density and waste rock radium-226 activity concentration. The work was presented at SPERA 2014. The results showed that dry season radon-222 exhalation flux density normalised to waste rock radium-226 activity concentration increased over the 5 year measurement period and that a distinct wet-dry seasonal pattern in radon-222 exhalation did not establish until at least four years after construction of the trial landform. The results were subsequently used to inform radon-222 dispersion modelling for the final landform, which was presented at SPERA 2018.

Between 2019 and 2021, further wet and dry season measurements of radon-222 exhalation from the trial landform were conducted. The purpose of these measurements was to check whether there was a stable wet-dry seasonal pattern in radon-222 exhalation and whether radon-222 dispersion modelling for the final landform might need to be updated. This presentation will describe the 2019–2021 measurements, how they compare with those from 2009–2014 and implications for the radon-222 dispersion modelling.

ABSTRACTS - CONTAMINATION MONITORING & EMERGENCY PREPAREDNESS

MIGRATION OF $^{239, 240}$PU AND ^{233}U FROM A LOW-LEVEL RADIOACTIVE WASTE SITE

Jennifer Harrison[1]

Timothy Payne[1]***, David Child***[1]***, Mike Hotchkis***[1]***, Mat Johansen***[1]***, Sangeeth Thiruvoth***[1] ***and Atun Zawadzki***[1]

[1] *ANSTO*

Low-level measurements of ^{240}Pu/^{239}Pu and ^{233}U have been used to investigate the migration pathways of these radionuclides in the vicinity of a legacy waste site near Sydney, Australia. Between the years of 1960 to 1968 mixed wastes, including laboratory waste, were disposed at the site in shallow, unlined trenches, and disposal records indicate that the waste contained small masses of plutonium (several grams) and other long-lived radionuclides, including ^{233}U.

Measurements of ^{240}Pu/^{239}Pu and ^{233}U in environmental matrices of soil, sediment, water, and vegetation have been made using a combination of accelerator mass spectrometry and alpha spectrometry techniques. Both ^{240}Pu/^{239}Pu and ^{233}U concentrations and ^{240}Pu/^{239}Pu atom ratios have been used to assess the migration of these actinides.

A site specific 240/239Pu atom ratio has been established (0.084) which is distinctly different from the ratio found elsewhere in the Sydney Basin due to nuclear weapons testing fallout thereby providing an indicator of plutonium originating from the site. ^{233}U has very low abundance in nuclear weapons test fallout therefore the only plausible source of elevated ^{233}U in the environment at and around this site is uranium migration from the disposal site.

The concentrations of ^{240}Pu/^{239}Pu and ^{233}U typically decrease with distance from the disposal trenches. The ^{240}Pu/^{239}Pu concentrations in soils and sediments at distance are within the range seen elsewhere in Australia due to atmospheric nuclear weapons fallout. However, the presence of ^{233}U and the influence of the site specific ^{240}Pu/^{239}Pu atom ratio on the local plutonium isotopic signature indicates that these actinides are persistent in soils, sediments and waters hundreds of metres away and vegetation tens of metres away from the disposal trenches.

Multiple migration mechanisms have been considered for actinides derived from the site, including surface water flow from the disposal trenches, particulate transport during heavy rainfall events, vegetation uptake, contamination which may have occurred during disposal operations and airborne particulate transport.

IDENTIFYING RADIOLOGICAL CONTAMINATION RISKS FOR NEW ZEALAND SITE INVESTIGATIONS

Andrew Pearson[1]

[1] *Tonkin + Taylor*

Investigation and remediation of contaminated sites is an important process in managing legacy issues and protecting the health of future users and the environment. Legacy radiological contamination can present a significant risk to health of future site users and there are overseas examples of extensive remediation being necessary to mitigate these risks. Through its nuclear free status and geographical isolation from nuclear infrastructure New Zealand is insulated from many of the risk factors that drive radiological contamination of sediments, soils and water seen overseas. However, this does not mean that investigation of contaminated sites in New Zealand should by default discount the risk of radiological contamination.

Historical activities involving radioactive material, such as painting with luminescent paints, or use of research tracers, were undertaken in New Zealand, often with limited mitigations to prevent contamination. Determining the fate of radiologically contaminated material from these operations is often reliant on poor records or even anecdotes, however there are examples of this material being disposed into historic landfills, while some disposal to sea also occurred.

There has also been widespread and continued use of naturally occurring radioactive materials in the primary and secondary sectors. Most widespread is the use of phosphate ores as fertilisers to sustain New Zealand pastoral and horticultural sectors. With activity concentrations of 1-2 kBq/Kg reported in commercially available fertilisers, sites associated with fertiliser activities, such as manufacturing, storage sheds and top-dressing airstrips have the potential to accumulate significant soil activity.

Through current and historical examples of potential contributors to non-nuclear radiological contamination in New Zealand and overseas this presentation will discuss risk factors to trigger consideration of radiological aspects in a New Zealand contamination investigation. The regulatory aspects of identifying and assessing radiological contamination in New Zealand will also be considered.

DETERMINATION OF THE SPECIFIC VULNERABILITY OF GROUNDWATER SOURCES USING ULTRASENSITIVE ANALYTICAL PROCEDURES

***Michal Fejgl*[1]**

[1] *SURO*

This contribution concerns a research project on the safety of groundwater sources.In occasion of nuclear accident safety of the water sources is one of the most important tasks of the governmental emergency preparedness system of the Czech Republic. More than 50% of drinking water consumption in the Czech Republic comes from surface sources. In case of nuclear accident, such sources are prone to radioactive contamination and, despite the sophisticated system of radioactive contamination monitoring of these waters in the Czech Republic, are expected to be temporarily decommissioned.

Under such circumstances, bulk of the drinking water consumption would be substituted by underground sources. The major aim of this research project is to characterise each of 152 main hydrogeological districts in the Czech Republic by their vulnerabilility by radioactive contamination.

It was completed by combination of these particular steps:

1) Study of hydrogeological parameters of the aquifers and their over layers
2) Research of ^{90}Sr and ^{137}Cs residual contamination and its vertical distribution in soil horizons. Residual contamination remaining from nuclear weapon tests and Chernobyl accident is concerned.
3) Research of residual contamination from nuclear weapon tests and Chernobyl accident in underground water samples. Activity concentrations of ^{3}H, ^{90}Sr and ^{137}Cs were analysed. Two ultrasensitive methods were developed to enable steps 2 and 3 fulfil. For determination of ^{137}Cs activity concentration, a method based on Caesium concentration from high volume water sample using KNiFC-PAN resin and consequent measurements using Gama automat, a newly constructed effectively shielded gamma spectrometer with automatic sample exchange conveyor, was employed.

For determination of ^{90}Sr activity concentration a method proposed for determination of large volume groundwater samples, in which a high concentration of sodium, calcium and magnesium can be expected, was developed. Strontium is separated in five steps with the aim to get rid of every interfering radionuclide and cation affecting geometry of the final measuring target. An unique pixel detector technique is employed for ^{90}Sr in the measuring target determination, measurements are performed inside a shielded chamber.

On bases of the data yielded within research project, 152 hydrogeological districts were characterised by the specific vulnerability by radioactive contamination. Tools, maps and software, enabling classification of these regions due to its vulnerability were developed. These tools can in emergency situation help to the governmental decision makers to perform rapid estimation, for how long time can be each of the water sources safe from radioactive contamination defined by a specific source term.

Description of two developed analytical methods, determination of underground water source vulnerability and presentation of developed tools form the main focus of the conference presentation.
This study is supported by the institutional funding of the Czech Ministry of the Interior of the Czech Republic (project VI20192022142).

CONTEMPORARY RADIOLOGICAL CONDITIONS AT KOONGARRA, NORTHERN TERRITORY, AUSTRALIA

John Pfitzner[1]

Alexandra Stokes Hughes[1] ***and Che Doering***[2]

[1] *SSB/Dept. Ag. Water & Environment*
[2] *Environmental Research Institute of the Supervising Scientist*

The Koongarra uranium deposit is located in the Alligator Rivers Region of Northern Territory, Australia. The deposit was discovered in 1970 and subject to exploration drilling over subsequent years to characterise its size and uranium grade. Despite the mining company gaining approval from government in the early 1980s, the deposit was never mined. In 2013, the mining lease over the Koongarra uranium deposit was revoked and the site was incorporated into the World Heritage listed Kakadu National Park with consent from the senior traditional owner.

Relics of past uranium exploration activities are still present at Koongarra. These include sheds, bores, other infrastructure and several shipping containers of drill core with naturally elevated uranium concentrations. Options to remediate the site to restore its environmental aesthetic values are currently being explored.

Information on radiological conditions at Koongarra is scarce. To support any future remediation effort, an environmental radiation survey was recently conducted to establish the contemporary radiological conditions of the site. The survey included measurement of gamma dose rate, radon-222 exhalation flux density from the ground and soil radionuclide activity concentrations. The survey showed that much of the site has radiation levels typical of normal environmental background. Elevated radiation levels were only found in the immediate vicinity of the shipping containers and above a small section of the uranium deposit.

This presentation will discuss the methods and results of the environmental radiation survey of Koongarra and the benefit of antecedent knowledge of site radiological conditions when planning for remediation.

PASSIVE MONITORING OF RADIOCAESIUM IN SEAWATERS USING CHEMCATCHER

Alex Chapman[1]

[1] *NZ Institute for Environmental Science & Research*

Radiocaesium contamination of seawater is associated with accidental and routine releases from nuclear power plants and fuel facilities, in addition to fallout from legacy testing of nuclear weapons.

From a human perspective, ^{137}Cs is of particular radiological concern owing to its relatively long half-life (30.05 years). Exposure occurs primarily through consumption of marine biota, which readily assimilate Cs due to its biochemical similarity to potassium, with subsequent transfer and bioaccumulation through the marine food chain.

Conventional methods for measuring the activity concentration of ^{137}Cs in seawater are based on selective ion exchange for the concentration and separation of Cs ions. Caesium-137 activity concentrations in seawaters are typically in the range of 0.5-5 Bq/m^3. Such low activity concentrations require preconcentration of large sample volumes, on the order of 100 L or more, for subsequent gamma spectrometric analysis. This complicates sampling and transportation, which is followed by labour-intensive laboratory processing.

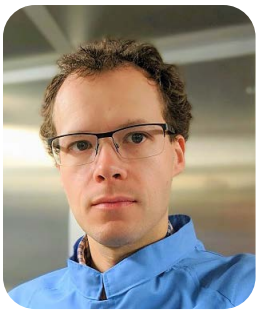
Chemcatcher is a passive sampling technique used for measuring time-weighted average concentrations of a range of analytes through diffusional uptake over an extended in situ deployment period of several days or more. A range of analyte-specific receiving phases for the Chemcatcher sampler have been developed; in this study, a Cs selective solid phase extraction disk (Rad/Empore, manufactured by CDS) is utilised. Direct gamma analysis of the passive sampler means that many of the limitations of conventional sampling described above are avoided.

Here we present experimental work on the calibration of Chemcatcher passive monitors for radiocaesium uptake in a laboratory environment. We discuss further validation steps to determine the feasibility of Chemcatcher as a viable tool for monitoring radiocaesium in seawater.

TRINITITE AT THE LOCAL MARKET?

Andrew Yule[1]

[1] *ARPANSA*



Nuclear weapons produce intense heat when they explode. In the right conditions, this can melt the surface of the ground in surrounding areas, which then fuses into a glass like material as it cools. This substance is named trinitite as it was first seen after the Trinity test in New Mexico in 1945. Due to the unusual production method and potentially interesting appearance, trinitite is of interest to scientist and mineral collectors and small samples are common throughout the world.

In 2022, a stall in a market in suburban Melbourne was selling piece of glassy rock with the claim that it was trinitite from the original Trinity test. This sample was purchased by a member of the public and offered to ARPANSA for analysis. The sample was analysed using high resolution gamma spectroscopy to identify and quantify the radionuclides present. These results were compared with measurements of trinitite from the Breakaway test at Maralinga and with the published radionuclide content of trinitite from other tests. All results were consistent with the sample being trinitite from the Trinity test.

RADIATION PROTECTION IN AUSTRALASIA

Cameron Jeffries [1]

Jim Hondros [2], ***Alice Jagger*** [3], ***Brent Rogers*** [4]

[1] *South Australia Medical Imaging, SA Dept of Health and Wellbeing*
[2] *JRHC Enterprises*
[3] *SA Radiation*
[4] *South East Sydney Local Health Network*

The Australasian Radiation Protection Society (ARPS) is the professional body representing radiation protection practitioners. ARPS members are from government, the regulatory authority, industry and academia. They are responsible for ensuring radiation safety across the medical, nuclear, mining industrial, research, defence and emergency management sectors throughout Australia, New Zealand and surrounding Oceania nations. ARPS sponsors the Australasian Radiation Protection Accreditation Board (ARPAB), which provides a certification process for professionals with demonstrated proficiency and knowledge in radiation safety. Internationally, ARPS jointly established the Journal of Radiation Protection and Research (JRPR), an emerging international journal for the Asia and Oceanic region.
This presentation will provide an overview of ARPS including the aim to support and benefit everyone working in radiation protection. The benefits for all people involved in radiation safety for people and the environment via ARPAB, JRPR and representation at an international level will be presented.

ABSTRACTS - RADIOTRACERS IN ENVIRONMENTAL PROCESSES

TRITIUM AS TRACER FOR THE HYDROLOGICAL CYCLE THEME: RADIOTRACERS IN ENVIRONMENTAL PROCESSES

Uwe Morgenstern[1]

[1]*GNS Science*

Tritium is an excellent tracer for understanding water transit times through the hydrologic cycle. As a hydrogen isotope and therefore part of the water molecule it is an ideal tracer for the water cycle, and with its half-life of 12.3 years it enables dating of water up to hundred years, the most important age range for renewable water resources.

Environmental tritium concentrations are, however, very low, especially in the southern hemisphere, and require enrichment prior to tritium detection. After the bomb-tritium from the atmospheric thermonuclear weapons testing in the early 1960s had been washed out from the atmosphere and decayed to insignificant levels, tritium concentrations in rain returned to natural levels about three decades ago, with typical concentrations in New Zealand and Australian rain of about 2TU (H^3/H^1 ratio $2x10^{-18}$).

I will show examples where tritium, if measured with high sensitivity and accuracy to 0.02 TU, proved extremely useful for understanding of groundwater flow dynamics, glacier flow, ocean circulation, and young water ingression into geothermal resources. Tritium dating is now an established technique for groundwater resource management.

ULTRA LOW TRITIUM ANALYSIS: GOING BIGGER IS BETTER

Kellie-Anne Farrawell[1]

Robert Chisari[1]

[1] *ANSTO*

Since the commencement of nuclear weapons testing in 1945, the tritium (H^3) signature of the bomb pulse has been used as a tool for groundwater dating and understanding the groundwater recharge process through studying the interaction between rainfall, surface water and subsurface water. Tritium exists in the environment due to natural production by cosmic radiation and residue fallout from atmospheric nuclear weapons testing and nuclear reactors. The bomb pulse tritium has now decayed to almost undetectable limits within the southern hemisphere atmospheric and terrestrial water bodies. Ultra-low tritium analysis is therefore required for accurate groundwater dating studies. This very sensitive tritium data is extremely valuable for making sustainable management decisions that affect our most precious resource, water.

Ultra-low tritium analysis is achieved through the use of electrolytic concentration using electrolysis cells which both concentrates tritium and removes ^{1}H & ^{2}H. Glass cells have historically been used as the chosen material for these cells, however to continue to measure ever-decaying tritium levels, electrolysis cells of higher capacity and durability needed to be developed to increase concentration folds and lower detection limits. Glass proved to be a challenging material at increased cell sizes, therefore stainless steel cells were developed which were more robust and easily accessible. Moving towards stainless steel components during the electrolytic concentration phase has presented different challenges to glass and the approach, challenges and outcomes of the investigation will be outlined in this presentation.

PRECISE TIMING SIGNALS FOR THE START OF AN ANTHROPOCENE ERA?

Stephen Tims[1]

Yusuke Yokoyama[2], Michaela Froehlich[3], Shoka Hirabayashi[2], Takahiro Aze [2], L. Keith Fifield[3], Dominik Koll[3], Yosuke Miyairi[2], Stefan Pavetich[3] and Michinobu Kuwae[4]

[1] Australian National University
[2] Atmosphere and Ocean Research Institute, The University of Tokyo
[3] Research School of Physics, The Australian National University
[4] Center for Marine Environmental Studies, Ehime University

Plutonium (Pu) has been used as a mid-twentieth century time-marker in various geological archives as a result of atmospheric nuclear tests mainly conducted in 1950s. Advancement of analytical techniques has allowed us to reconstruct the Pu signal that originated from the former Pacific Proving Grounds (PPG) in the Marshall Islands. We have developed a novel method that couples annual banded reef building corals and nearshore anoxic marine sediments to provide a marker to precisely determine the start of the nuclear era. Sedimentary records from Beppu Bay, Japan, show a clear Pu increase from 1950, peaking during the 1960s, and then showing a sharp decline during the 1970s. However, a constantly higher isotope ratio between ^{239}Pu and ^{240}Pu suggests a contribution other than global fallout. Furthermore, single elevations in $^{240}Pu/^{239}Pu$ provide supportive evidence of close-in-fallout similar to previous studies. A coral from Ishigaki Island, Japan shows skeletal radiocarbon which displays a clear timing with the signatures supporting the reliability of the Beppu Bay sediments as archives and demonstrates the strength of this method to capture potential Anthropocene signatures.

RADIOKRYPTON DATING IN AUSTRALIA WITH AUSTRALIAN ATOM TRAP TRACE ANALYSIS

***Rohan Glover*[1]**

***Thomas Chambers*[1], *Alec Deslandes*[2], *Christoph Gerber*[2], *Axel Suckow*[2], *Dirk Mallants*[2] *and Andre Luiten*[1]**

[1] *University of Adelaide*
[2] *CSIRO*

Advances in measuring the concentration of radioactive noble gas isotopes though Atom Trap Trace Analysis (ATTA) over the last decade has seen enormous growth in the interest of these isotopes within the earth sciences. In the past, the use of these tracers has been limited due to their low natural abundance (typically below parts per trillion). However, ATTA has made measurement of these tracers feasible for exciting new applications. For example, independent dating of glacier ice [1], putting constraints on processes in physical oceanography [2], determining groundwater residence times of ancient aquifers [3], and determining anthropogenic impacts on groundwater in regions of intensive agriculture [4].

Environmental tritium concentrations are, however, very low, especially in the southern hemisphere, and require enrichment prior to tritium detection. After the bomb-tritium from the atmospheric thermonuclear weapons testing in the early 1960s had been washed out from the atmosphere and decayed to insignificant levels, tritium concentrations in rain returned to natural levels about three decades ago, with typical concentrations in New Zealand and Australian rain of about 2TU (H^3/H^1 ratio $2x10^{-18}$).

I will show examples where tritium, if measured with high sensitivity and accuracy to 0.02 TU, proved extremely useful for understanding of groundwater flow dynamics, glacier flow, ocean circulation, and young water ingression into geothermal resources. Tritium dating is now an established technique for groundwater resource management

Posters

Posters will be on display throughout the conference in Central Street with a dedicated Poster Session during an extended afternoon tea on Monday.

1 THE POTENTIAL OF URANIUM-236 AS AN ENVIRONMENTAL TRACER

M.B. Froehlich[1], S.J. Fallon[2], L.K. Fifield[1], S.G. Tims[1], A. Wallner[1]

[1]Department of Nuclear Physics and Accelerator Applications, Research School of Physics, The Australian National University, Canberra, ACT 2601, Australia
[2]Radiocarbon Laboratory, Research School of Earth Sciences, The Australian National University, Canberra, ACT 2601, Australia

Uranium is naturally omnipresent in our environment and the isotopes ^{238}U, ^{235}U and ^{234}U are widely known. However, the underrepresented uranium-236 (^{236}U), with a half-life of 23 million years, has become of major interest in the recent years. It is naturally produced via thermal neutron capture on ^{235}U in ultra-trace amounts. However, a very much larger quantity has been produced in nuclear power plants and during nuclear weapons tests via the same neutron capture reaction. The $^{236}U/^{238}U$ isotopic ratio varies between 10^{-12} and 10^{-10} in uranium ores but can be as high as 10^{-2} in spent nuclear fuel. Thus, ^{236}U is useful as a fingerprint for anthropogenic sources in the environment. Additionally, if an anthropogenic contribution can be excluded, the natural signal can be used for nuclear forensic and geological applications.

This extremely broad range presents a significant challenge to the researcher. I will present our investigations about the natural as well as anthropogenic occurrence of ^{236}U in the environment, measured by the 14UD heavy ion accelerator at the Australian National University during the last years.\

2 TRACE DETECTION OF LONG-LIVED NOBLE GAS ISOTOPES WITH ATOM TRAP TRACE ANALYSIS

Rohan Glover[1]

Thomas Chambers[1], Alec Deslandes[2], Christoph Gerber[2], Axel Suckow[2], Dirk Mallants[2] and Andre Luiten[1]

[1] University of Adelaide
[2] CSIRO

Advances in measuring the concentration of radioactive noble gas isotopes though Atom Trap Trace Analysis (ATTA) over the last decade has seen enormous growth in the interest of these isotopes within the earth sciences. In the past, the use of these tracers has been limited due to their low natural abundance (typically below parts per trillion). However, ATTA has made measurement of these tracers feasible for exciting new applications. For example, independent dating of glacier ice [1], putting constraints on processes in physical oceanography [2], determining groundwater residence times of ancient aquifers [3], and determining anthropogenic impacts on groundwater in regions of intensive agriculture [4].

We are building a new ATTA facility for measuring ^{85}Kr, ^{81}Kr and ^{39}Ar that is located at the University of Adelaide, South Australia. In Australia, water security including groundwater access and management is a major and growing issue. For two thirds of Australia, groundwater is the only source of fresh water, and communities and industry rely on this water to sustain life and economy. The noble gas radioisotopes, ^{85}Kr and ^{81}Kr, are the most reliable tracers available to provide insight into the age, origin, and interconnectivity of groundwater systems, improving conceptualisation of groundwater systems, enabling the quantification of recharge, and testing of the accuracy of groundwater models. Furthermore, the extensive study of groundwater sources is of particular interest due to our changing climate, and the Australian continent provides valuable climate archives in its groundwater. Tapping into these archives will provide new information for understanding the underlying environmental dynamics.

The ATTA system in Adelaide was first used to detect the krypton isotopes ^{85}Kr and ^{81}Kr in 2021, which are, with half-lives of 11 years and 229,000 years, suitable to date samples of very young or very old groundwater. We report on the progress that has been made towards detection of ^{39}Ar that has a natural atmospheric abundance ^{39}Ar/Ar of $8x10^{-16}$ and a half-life of 269 years making it ideal for dating on an anthropogenic timescale.

[1] C. Buizert, D. Baggenstos, W. Jiang, R. Purtschert, V. V. Petrenko, Z.-T. Lu, P. Muller, T. Kuhl, J. Lee, J. P. Severinghaus, and E. J. Brook, "Radiometric ^{81}Kr dating identifies 120,000-year-old ice at Taylor Glacier, Antarctica," PNAS, 111, 6876-6881 (2014).
[2] S. Ebser, A. Kersting, T. Stoven, Z. Feng, L. Ringena, M. Schmidt, T. Tanhua, W. Aeschbach, and M. K. Oberthaler "^{39}Ar dating with small ocean samples provides new key constraints on ocean ventilation," Nature Communications, 9, 5046 (2018).
[3] C. Gerber, R. Vaikmae, W. Aeschbach, Alise Babre, W. Jiang, M. Leuenberger, Z.-T. Lu, R. Mokrik, P. Muller, V. Raidla, T. Saks, H. N. Waber, T. Weissbach, J. C. Zappala, and R. Purtschert, "Using 81Kr and noble gases to characterize and date groundwater and brines in the Baltic Artesian Basin on the one-million-year timescale," Geochimica et Cosmochimica Acta, 205, 187-210 (2017).
[4] A. M. Seltzer, D. V. Bekaert, P. H. Barry, K. E. Durkin, E. K. Mace, C. E. Aalseth, J. C. Zappala, P. Mueller, B. Jurgens, and J. T. Kulongoski, "Groundwater residence time estimates obscured by anthropogenic carbonate," Science Advances, 7, 3503 (2021).

3 CONTINUOUS DETERMINATION OF BETA AND GAMMA ACTIVITY IN SURFACE WATERS

Ivan Hupka[1], Michal Fejgl[1], Petra Valdezova[1], Alena Kelnarova[1] and Petr Rulik[1]

[1]National Radiation Protection Institute, Czech Republic

This contribution covers a research project aiming to develop a concept of a new system for modelling the dissipation of the artificial radioactive contamination in the hydrosphere of the Czech Republic. The concept includes data assimilation for the needs of the state during routine operation of the NPP and as well as its accident in occasion of accident and its impact on the surrounding area. The conference poster will be focused on the project chapter concerning introduction of the innovative monitoring systems enabling continuous in situ measurements of surface water radioactive contamination. There are three different groups of such devices:

1) Autonomous monitoring station for gamma activity determination employing sophisticated software. This kind of monitoring station was launched in the Czech Republic in previous years and is successfully in operation.The other two groups are in stage of developing concepts based on rapid development of technological components occurring in recent years, namely solid scintillators and silicon diodes (SiPM) under some conditions capable to replace traditional solid scintillators and photomultiplier tubes (PMT).
2) Device for continuous measurements of beta activity using device utilising scintillation crystals YaG:Ce and SiPM diodes.
3) Device for continuous measurements of gamma activity by a low-budget probe based alternatively either on GAGG+ or CsI:Tl detector assembled with SiPM.
The capabilities of previously mentioned concepts in the environment of surface waters will be described for the purpose of gamma and beta activity determination. Their measurement skills will be put in the context of current requirements of nuclear legislation in the Czech Republic.

This study is supported by the institutional funding of the Technology Agency of the Czech Republic (project TK02010064).

4 IMPROVING THE RECOVERY OF POLONIUM ANALYSIS IN SEDIMENT SAMPLES BY ALPHA PARTICLE SPECTROMETRY

***Sabika Maizma*[1], Atun Zawadzki[1]**

[1] *ANSTO*

At the ANSTO low level radioanalytical facility, sediment samples for lead-210 dating are analysed for polonium-210 and radium-226 activities by alpha particle spectrometry. To improve the efficiency of sample digestion, a block digester was acquired for digesting sediment and other environmental samples. A new hot plate stirrer was also acquired and used in the isolation of polonium via auto-deposition onto silvers disks. The change in the digestion
and auto-deposition steps resulted in improved polonium recoveries from 50-60% to 80-90%.

The ability to control the acid digestion temperature at 90°C and between 70°C to 80°C during auto-deposition improved the polonium recoveries.

5 PLUTONIUM AND AMERICIUM MIGRATION AT MARALINGA - ARPANSA MONITORING AND EMERGENCY RESPONSE SECTION

***Callum Watson*[1] *and Michelle Thomas*[1]**

[1] *ARPANSA*

Between 1953 and 1963 the British armed forces conducted 7 major nuclear weapon test and hundreds of minor trials at Maralinga in South Australia. These activities dispersed Uranium, Plutonium and various short lived isotopes over an expansive area in South Australia. Initial clean-up efforts made by the British in the 70s and 80s were ineffective at remediating the site and the Australian government established a technical assessment group to undertake a rehabilitation project, which finished in 2002 and is detailed in the MARTAC report.

Subsequently ARPANSA has undertaken radiation surveys at Maralinga since 2002 to ensure the radiological safety of the site and ensuring that specific areas were fit for intended use.

The Taranaki area was used for multiple major trials and was subject to the most intense clean up effort. The NE plume area at Taranaki spreads over several large sand hills and ARPANSA measures at the centre of this area during each survey. Over the past 20 years the Am-241 activity concentration at this site has dropped off significantly compared to decay and other measurement sites, so the activity depth profile of the first 10 cm was investigated to determine the occurrence of any vertical migration. Samples were taken every 1 cm and analysed using in-situ gamma spectroscopy to determine the Am-241 activity at each depth, which will indicate the migration of Pu-239 below the surface. The depth profile showed a clear increase in the Am-241 concentration with depth and confirmed the vertical migration was likely responsible for the decrease in the surface activity measured by In-situ gamma spectroscopy. This provided confidence that Pu-239 was not migrating horizontally into other areas around Taranaki and the safety precautions and requirements at the site did not need to change.

6 DECODING AN UNEXPECTED MYSTERY AT THE MONTEBELLO ISLANDS

Madison Williams-Hoffman[1], Mathew P. Johansen[2], Paul L. Lavery[1], Sangeeth Thiruvoth[2], Oscar Serrano[1,3], Pere Masqué[1,4]

[1] Centre for Marine Ecosystem Research, Edith Cowan University
[2] Australian Nuclear Science and Technology Organisation
[3]Centro de Estudios Avanzados de Blanes
[4] International Atomic Energy Agency

During the 1950's three nuclear tests were conducted in the Montebello Islands in Western Australia by the UK government. The tests introduced a radioactive legacy into the surrounding marine environment but were investigated minimally immediately after and in the decades that followed.

Work is currently underway to quantify the persistence and migration of anthropogenic radionuclides within the island archipelago's marine sediments. Activity concentrations of studied radionuclides (^{137}Cs, ^{238}Pu, $^{239\&240}$Pu and ^{241}Am) in surface sediments so far have concentrated within a 5 km radius of the three ground zero locations and in the north-west of the islands inline with the original fallout plume trajectories. However, one sampling location does not fit within this originally hypothesised pattern of distribution. This single site, called the Lowendal Islands site, was 26 km south of the detonation ground zero locations and originally sampled as an environmental background. Activity concentrations of studied radionuclides were the second highest of all surface sediments collected (1.6 Bq kg^{-1}, 80 Bq kg^{-1}, 402 Bq kg^{-1} and 28 Bq kg^{-1} respectively). Four initial theories are proposed to explain this mystery: currents, air movement, rafting or human involvement. Current analysis indicates that either rafting or human involvement are most likely, based on reviews of historical data, knowledge of regional water movement and ^{241}Am/^{240}Pu/^{239}Pu ratios.

7 TEMPORAL VARIATION OF RADON AND RADON PROGENY IN TOURIST CAVES

Andrew Yule[1]

[1] *ARPANSA*

Radon gas and radon progeny can reach high concentrations within caves. This has the potential to cause significant radiation doses to people spending large amounts of time in caves, such as workers in tourist caves. There are several important factors affecting the dose received, especially the concentration of radon gas, the concentration of radon progeny and the associated activity size distribution of the progeny. It is important to have accurate data on all three factors to enable accurate dose calculations for these workers.

Radon gas concentration is the easiest of these factors to measure, and many measurements have been taken in caves. Most measurements have been long-term, integrated over several months without any temporal data, although there have been a much smaller number of studies that have collected detailed information on the temporal variation of radon gas concentration. Far fewer radon progeny measurements have ever been taken in caves, and these have all been limited to short-term spot measurements. An even smaller number of caves have had the radon progeny activity size distribution measured in detail, and no studies have provided temporal data to assess how this may change with time. This leaves a significant gap in our knowledge of the behaviour of radon progeny in caves.

New equipment developed at the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has allowed us to take measurements to begin to fill this gap. In addition to the measurement of radon and radon progeny concentrations, these measurements include detailed information on the activity size distribution of the radon progeny. This provides new insight into cave dynamics and important information when considering the potential radiation doses received by cave workers.

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- encourage publications in the field of radiation protection

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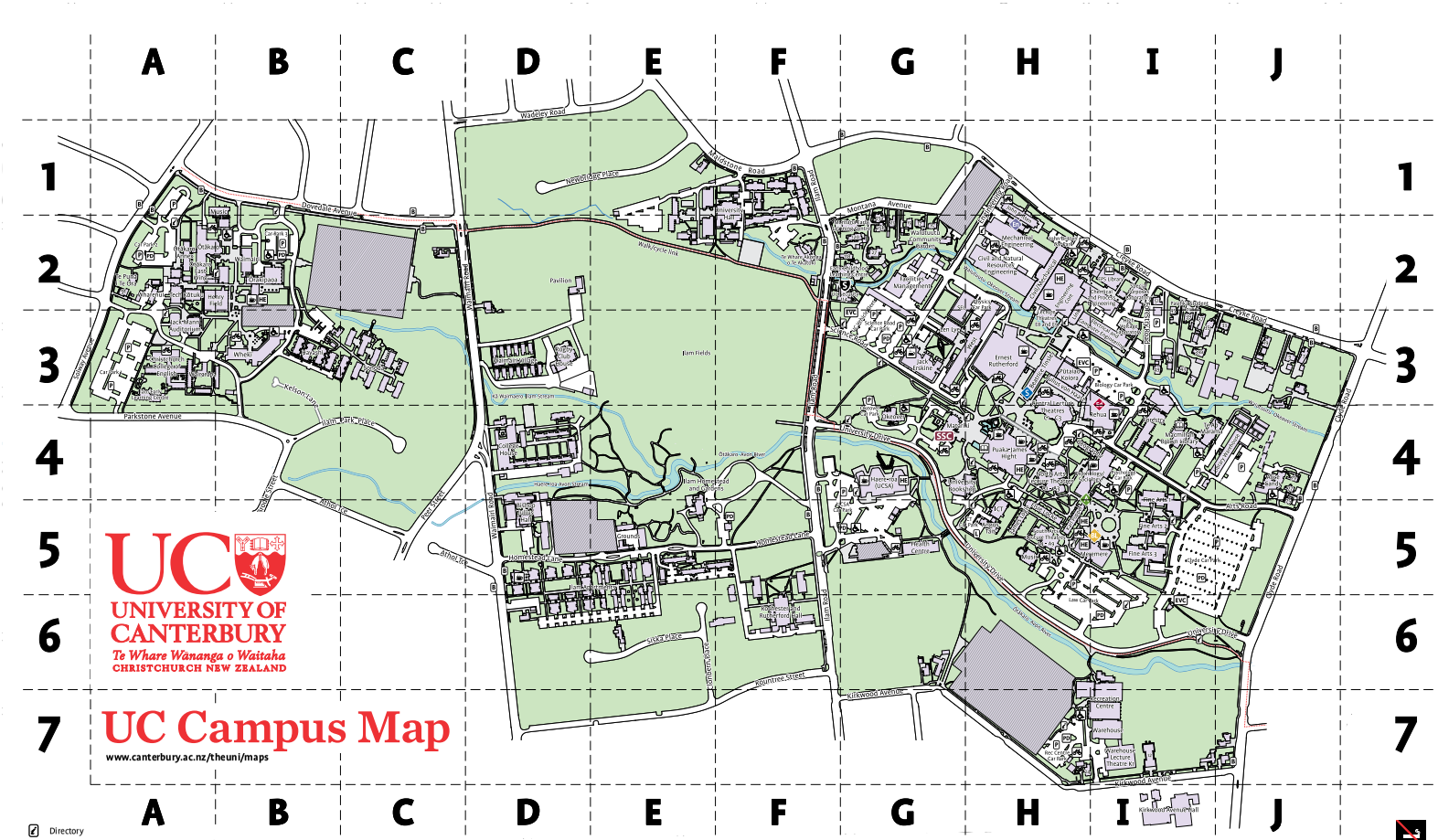

Attendees

Current as at 9 November. This does not include attendees who have asked for their name not to be published.

LAST NAME	FIRST NAME	COMPANY
Ardouin	Cris	ESR
Barnes	Emma	Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)
Bokor	Ilonka	ARPANSA
Bourke	Levi	ESR
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Chapman	Alex	ESR
Christison	Maxie	ESR
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Douglas	Peter	DTect Innovation Pty Limited
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Fejgl	Michal	National Radiation Protection Institute
Froehlich	Michaela	The Australian National University
Gao	Vicky	ESR
Glover	Rohan	University of Adelaide
Golovko	Oksana	ESR
Green	Liesel	ARPANSA
Guy	Sarah	Tonkin + Taylor
Harrison	Jen	ANSTO
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Hoffman	Madison	Edith Cowan University
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Morgenstern	Uwe	GNS Science
Mothersill	Carmel	McMaster University
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Pearson	Andrew	Tonkin + Taylor
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Tsukada	Hirofumi	Institute of Environmental Radioactivity, Fukushima University
Vimalasiri	Titus	ALS
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