放射能環境動態・影響評価 ネットワーク共同研究拠点 (ERAN)

# FY2024 Final Report 【海外/International 共同研究】

#### 海外共同研究 (外国機関所属研究者)

| 採択No.   | 種目 | 研究代表者名                 | 所属機関  | 職名・学年  | 課題名   | 受入研究者                                   | 受入機関  | 共同研究者   |
|---------|----|------------------------|---|--|---|---|-------|---|
| I-24-01 | 海外 | Haruko Wainwright      | MIT   | Assistant<br>professor   | Global environmental monitoring database<br>development   | 恩田 裕一                                   | CRIES |   |
| 1-24-02 | 海外 | Cooper Russell James   | University of Liverpool   | Faculty Director of<br>Postgraduate<br>Research /<br>Professor of<br>Hydrology | Impact of landscape decontamination on runoff and<br>erosion fluxes following the Fukushima nuclear<br>accident   | 恩田 裕一                                   | CRIES |   |
| I-24-03 | 海外 | Blake Henry William    | University of Plymouth  | Professor  | Utility of portable gamma sensors to support<br>agricultural land management decisions for soil and<br>contaminant management   | 恩田 裕一                                   | CRiES |   |
| 1-24-04 | 海外 | Smith Thompson James   | University of Portsmouth  | Professor of<br>Environmental<br>Science                                       | Radioactivity in aquatic systems in Europe and Japan  | 恩田 裕一                                   | CRIES |   |
| I-24-05 | 海外 | Feng Bin               | Technische Universität<br>Wien  | Junior researcher  | 霞ヶ浦湖畔の異なる土地利用が浮遊物質輸送と粒子状<br>137Csの排出に与える影響  | 恩田 裕一                                   | CRIES |   |
| I-24-06 | 海外 | Johnson Edward Thomas  | Colorado State<br>University  | Professor  | Radiocesium Migration and Nutrient Dynamics in<br>Fukushima   | 恩田 裕一<br>アンダーソン ドノヴァン                   | CRIES | Christian Grabowski   |
| 1-24-07 | 海外 | Feng-Yun J. Huang      | Central Taiwan<br>University and Science<br>and Technology  | Assistant<br>Professor   | Comparison of 99Tc concentration in seawater<br>between Japanese and Taiwanese coastal area   | 恩田 裕一<br>坂口 綾                           | CRIES |   |
| I-24-08 | 海外 | Wiederin Andreas       | University of Vienna  | Scientific project<br>staff and 4th year<br>Ph.D student                       | Characterization and first uses of an isotopic Np spike   | 坂口 綾                                    | CRIES |   |
| I-24-09 | 海外 | Shinkarev Sergey       | State Research Center -<br>Burnasyan Federal<br>Medical Biophysical<br>Center of Federal<br>Medical Biological<br>Agency                        | Head   | Assessment of the average external dose to air in a<br>group of settlements located around the<br>Semipalatinsk Nuclear Test Site on the basis of<br>thorough analysis of available input data useful for<br>retrospective dose estimations | 坂口 綾                                    | CRIES | 星 正治<br>Stepanenko Valeriy  |
| I-24-10 | 海外 | 岩花 剛                   | アラスカ大学フェアバン<br>クス校  | Research<br>Associate<br>Professor   | アラスカの永久凍土融解が環境中の放射性物質動態に与<br>える影響   | 五十嵐 康記                                  | CRIES |   |
| I-24-11 | 海外 | Lihoreau Mathieu       | National Center for<br>Scientific Research<br>(CNRS)  | Research Director  | Effects of environmental radiocontamination on<br>pollinators' behaviour and cognition  | 難波 謙二                                   | IER   | 水澤 玲子<br>Bonzom Jean-Marc<br>Armant Olivier<br>Gagnaire Béatrice<br>Goulefert Loïc<br>Abenis Kristine |
| I-24-12 | 海外 | Gilbert Franck         | French National Center<br>for Scientific Research<br>(CNRS)   | Research Director  | Soil biodiversity and functional processes in radio-<br>contaminated forests (Fukushima Prefecture, Japan)  | 難波 謙二<br>ヴァシル ヨシェンコ<br>和田 敏裕            | IER   | Bonzom Jean-Marc<br>Capowiez Yvan<br>Iribar-Pelozuelo Amaia<br>Hättenschwiler Stefan<br>金子 信博         |
| I-24-13 | 海外 | Bonzom Jean-Marc       | Institute for<br>Radioprotection and<br>Nuclear Safety (IRSN)   | Researcher   | Effect of radioactive contamination in Fukushima<br>Prefecture on wildlife: the case of the tree frog   | 難波 謙二<br>石庭 寛子<br>和田 敏裕                 | IER   | Dasque Léa<br>Frelon Sandrine<br>Armant Olivier<br>Lengagne Thierry<br>Mondy Nathalie                 |
| 1-24-14 | 海外 | Protsak Valentyn       | Ukrainian<br>Hydrometeorological<br>Institute of the State<br>Emergency Service of<br>Ukraine and National<br>Academy of Sciences of<br>Ukraine | Senior Researcher  | Parameterization of the long-term dynamics of cesium<br>distribution in the suspended sediment-water system<br>in water bodies of the Chornobyl Exclusion   | コノブリョフ アレクセイ                            | IER   |   |
| I-24-15 | 海外 | Kanivets Volodymyr     | Ukrainian<br>Hydrometeorological<br>Institute of the State<br>Emergency Service of<br>Ukraine and National<br>Academy of Sciences               | Researcher   | Influence of temperature and ammonium on<br>radiocesium seasonality in water bodies   | コノプリョフ アレクセイ<br>脇山 義史                   | IER   |   |
| I-24-16 | 海外 | Komissarov Mikhail     | Ufa Institute of Biology<br>UFRC RAS  | Senior researcher  | The temporal dynamics of radiocesium in water and<br>its distribution in bottom sediments of the Ogaki Dam<br>Reservoir   | コノプリョフ アレクセイ<br>脇山 義史<br>五十嵐 康記         | IER   |   |
| I-24-17 | 海外 | Chandrasekaran A.      | Sri Sivasubramaniya<br>Nadar College of<br>Engineering  | Assistant<br>Professor   | Determination of internal exposure due to natural<br>radioactivity in decorated ceramic building materials<br>used in India   | ラハマン モハマド モフィズ<br>ル イスマイル               | IER   |   |
| I-24-18 | 海外 | Musthafa M. Saiyad     | The New College<br>(Autonomous)   | Assistant<br>Professor   | Abundance and diversity of radiation resistant<br>zooplankton communities from Extreme regions of<br>Kayamkulam Estuary, Natural high background<br>radiation area (NHBRA), Kerala, South West Coast of<br>India                            | ラハマン モハマド モフィズ<br>ル イスマイル               | IER   |   |
| I-24-19 | 海外 | Islam Md. Atikul       | Hajee Mohammad<br>Danesh Science and<br>Technology University   | Associate<br>Professor   | Assessment of Naturally Occurring Radioactive<br>Materials in Soil and Foodstuffs from Barapukuria<br>Coal Fired Thermal Power Plant Area, Dinajpur,<br>Bangladesh  | ラハマン モハマド モフィズ<br>ル イスマイル               | IER   | Khan Rahat<br>Begum Zinnat Ara  |
| 1-24-20 | 海外 | Biswas Foni Bushon     | University of Chittagong  | Associate<br>Professor   | Synthesis and characterization of Ru(III) and Ru(IV)<br>complexes of C-chiral isomeric hexamethyl<br>tetraazamacrocyclic ligands and their applications in<br>the decontamination of radioactive waste                                      | ラハマン モハマド モフィズ<br>ル イスマイル               | IER   | Roy Tapashi Ghosh<br>Rabi Saswata<br>Begum Zinnat Ara   |
| I-24-21 | 海外 | Chowdhury Faisal Islam | University of Chittagong  | Professor  | Synthesis and characterization of nanocomposites for<br>separation of radiostrontium from wastewater  | ラ <mark>ハマン モハマド モフィズ</mark><br>ル イスマイル | IER   | Begum Zinnat Ara  |

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|---------|----|--|--|--|---|---|------|---|
| 1-24-22 | 海外 | Al Mamun Shamim                        | University of Canterbury   | Visiting Professor   | Unravelling Cadmium Fluxes in Native Plants of New<br>Zealand Using Synchrotron Technology and<br>radionuclide fractionation  | ラハマン モハマド モフィズ<br>ル イスマイル               | IER  | Robinson Brett<br>Begum Zinnat Ara  |
| I-24-23 | 海外 | Mahiuddin Md.                          | Khulna University  | Associate<br>Professor   | Development of graphene-based magnetic<br>nanocomposites for radioactive waste management   | ラハマン モハマド モフィズ<br>ル イスマイル               | IER  |   |
| 1-24-24 | 海外 | Alam Md. Ferdous                       | Bangladesh Atomic<br>Energy Commission   | Principal Scientific<br>Officer  | Evaluation of Isotopic and Chemical Characteristics in<br>Environmental Samples from the neighboring<br>locations of Rooppur Nuclear Power Plant,<br>Bangladesh   | ラハマン モハマド モフィズ<br>ル イスマイル               | IER  | Begum Zinnat Ara  |
| 1-24-25 | 海外 | Bezhenar Roman                         | Institute of Mathematical<br>Machines and System<br>Problems NAS of Ukraine                        | Senior Researcher  | Investigation of sedimentation areas in the Fukushima<br>coastal area for Cs-bearing microparlicles released<br>from rivers using Lagrangian particle tracking model  | 高田 兵衛<br>津旨 大輔                          | IER  | Maderich Vladimir   |
| 1-24-26 | 海外 | Tóth Piroska                           | University of Pannonia   | 4th grade  | Tritium measurement in hot springs in the Carpathian<br>basin (EU) and the Hamadori-Hakadori (Japan)<br>mountain ranges   | グシエフ マキシム                               | IER  |   |
| I-24-27 | 海外 | Morgenstern Gerd Uwe                   | Geological and Nuclear<br>Sciences   | Principal Scientist  | Tritium measurements in New Zealand and Japan<br>fresh and thermal water springs  | グシエフ マキシム                               | IER  |   |
| I-24-28 | 海外 | Burdo Olena                            | Institute for Nuclear<br>Research National<br>Academy of Sciences of<br>Ukraine                    | Researcher   | Establishment of FISH probes for dicentric analysis of<br>wild rodents in Chornobyl   | 石庭 寛子<br>三浦 富智<br>アンダーソン ドノヴァン<br>藤嶋 洋平 | IER  | 中田 章史   |
| 1-24-29 | 海外 | Kountchou Noube Michaux                | Institute of Geological<br>and Mining Research<br>(IRGM)   | Research Officer   | Development of a test bench for the electronics of<br>ionizing radiation detectors based on FPGA and<br>microcontrollers  | 床次 眞司<br>細田 正洋                          | IREM | Saïdou<br>Mbarndouka Taamté Jacob<br>Folifack Signing Vitrice Ruben<br>Omgba Abanda Zacharie Stève<br>Yerima Abba Hamadou |
| I-24-30 | 海外 | Mbarndouka Taamte Jacob                | Institute of Geological<br>and Mining Research   | RESEARCH<br>OFFICER  | Design and realization of a smart survey meter based<br>on low-cost electronic components for simultaneous<br>ambient equivalent dose rate and radon concentration<br>measurement: Calibration with a stable radon gas in<br>low, medium and high concentration | 床次 眞司<br>細田 正洋                          | IREM | Saîdou<br>Oumar Bobbo Modibo  |
| I-24-31 | 海外 | Prasad Ganesh                          | B.L.J. Govt. (P.G.)<br>College Purola,<br>Uttarkashi, Uttarakhand<br>India                         | Assistant<br>Professor   | Environmental Radioactivity, Radiation Physics  | 床次 眞司<br>大森 康孝<br>細田 正洋                 | IREM | Singh Deepak  |
| I-24-32 | 海外 | Ndjana Nkoulou li Joseph<br>Emmanuel   | INSTITUTE OF<br>GEOLOGICAL AND<br>MINING RESEARCH  | RESEARCHER   | Radiological characterization of local building<br>materials and environmental monitoring of the iron<br>bearing areas of Mbalam, Kribi and Bipindi, South-<br>Cameroon. (Continued)  | 床次 眞司<br>大森 康孝<br>クランロッド チュティマ          | IREM | Saīdou<br>Tchuente Siaka Yvette Flore<br>Oumar Bobbo Modibo   |
| 1-24-33 | 海外 | Yusuf Darlina                          | Technology Organization<br>of Nuclear Energy,<br>Research and Innovation<br>National Agency (BRIN) | Senior Researcher  | Risk and analysis base on stress oxidative and immune biomarker   | 三浦 富智                                   | IREM | Tetriana Devita<br>Lusiyanti Yanti<br>Purnami Sofiati<br>Utami Tyas Hayu  |
| 1-24-34 | 海外 | Kovács Tibor                           | University of Pannonia   | Associate<br>Professor, Head of<br>the Department of<br>Radiochemistry<br>and Radioecology | Comparison of strontium measurements in fishbone  | 三浦 富智<br>アンダーソン ドノヴァン                   | IREM | Tuvshinsaikhan Ganbaatar  |
| I-24-35 | 海外 | Winarni Dwi Ilma                       | The National Research<br>and Innovation Agency of<br>Indonesia (BRIN)                              | Junior Researcher  | Bacterial-assisted Environmental Phytoremediation of<br>Cs-137 Contaminated Soil  | 赤田 尚史<br>田副 博文                          | IREM | Nugraha Djatnika Eka  |
| I-24-36 | 海外 | Kim Hyuncheol                          | Korea Atomic Energy<br>Research Institute  | Principal<br>Researcher  | A Simple and Straightforward Technique for<br>determination of 90Sr and radiocesium in seawater   | 田副 博文                                   | IREM |   |
| I-24-37 | 海外 | Rahman Md Safiur                       | Bangladesh Atomic<br>Energy Commission   | Scientist  | Capacity building for development of nuclear<br>techniques for analysis of radionuclides and potential<br>toxic elements in environmental samples   | 田副 博文                                   | IREM | Choudhury Rabia Tasrina   |
| I-24-38 | 海外 | Mas José Luis                          | University of Seville<br>(Spain)   | Professor  | Precise and rapid determination of 238U in seawaters<br>from the Southern Ocean using ID-ICP-MS   | 田副 博文                                   | IREM | 篠永 妙子   |
| I-24-39 | 海外 | López-Lora Mercedes                    | University of Seville<br>(Spain)   | Postdoctoral<br>researcher   | 239Pu, 240Pu and 237Np in seawater from the<br>Southern Ocean   | 田副 博文                                   | IREM | 篠永 妙子<br>Chamizo Elena  |
| I-24-40 | 海外 | Perez Tribouillier Uematzin<br>Habacuc | Federal Institute of<br>Technology Zurich (ETH<br>Zürich)  | Postdoctoral<br>researcher   | Measurements of U-236 in seawater samples from the<br>Southern Ocean  | 田副 博文                                   | IREM | 篠永 妙子   |
| I-24-41 | 海外 | Csordás Anita                          | University of Pannonia   | assistant professor  | Evaluation of the transferrability of an AI driven radon<br>release prediction method based on machine learning   | 大森 康孝<br>床次 眞司                          | IREM | Homoki Zsolt  |
| I-24-42 | 海外 | Sola Phachirarat                       | Chulalongkorn University   | Ph.D student   | Intercomparison on passive radon measurement for<br>nation survey in Thailand caves.  | クランロッド チュティマ<br>床次 眞司                   | IREM | 田副博文  |
| I-24-43 | 海外 | Pojprapai Soodkhet                     | Suranaree University of<br>Technology  | Professor  | Portable cancer detector based on DNA probe   | クランロッド チュティマ<br>床次 眞司                   | IREM |   |
| 1-24-44 | 海外 | Rattanapongs Chanis                    | Kasetsart University   | Lecturer   | Proficiency test of passive radon measurement for<br>nation survey at Hin Dat hot spring in Kanchanaburi,<br>Thailand   | _<br>クランロッド チュティマ<br>床次 眞司              | IREM | Sola Phachirarat  |

#### I-24-01

## Global environmental monitoring database development

研究代表者:Haruko Wainwright 受入研究者:恩田 裕一

#### 1. 成果

Environmental monitoring – the measurements of air, water and soil quality and associated attributes – plays a critical role in protecting the environment and public health. Such monitoring is often done as a part of regulatory requirements at or near industrial facilities which release hazardous substances routinely or may release in accident circumstances. In addition, monitoring is essential for existing soil and groundwater contamination sites during remediation and post-remediation institutional controls.

In this project, we explore how to modernize environmental monitoring activities for water/air/soil pollution, taking advantage of recent advances in sensing technologies, GIS and data science. We have reviewed different data management strategies at or adjacent to existing and historical nuclear facilities. Our particular focus this year is to evaluate the available database in terms of the potential to apply machine learning and AI techniques to datasets as well as perform meta-analyses across multiple sites, such as Wainwright et al. (2024).

In Japan, the Environmental Radioactivity Research Network Center (ERAN) database manages the datasets used in the published papers from the network, containing more than four million data points. Japan Atomic Energy Agency (JAEA)'s Database for Radioactive Substance Monitoring Data provides the monitoring datasets after the Fukushima Daiichi Nuclear Power Plant accident. The datasets are downloadable with the online map visualization function.

In the US, the US Nuclear Regulatory Commission (NRC) publishes a report on the radioactive effluent releases from all the nuclear power plants in the US, although the raw data values are not directly usable in a machine-readable format. One of the US Department of Energy (DOE) sites – the Hanford site – has a comprehensive online open database, PHOENIX, which allows users to view data on the site map and download datasets. In addition, the TRAC database (trac.pnnl.gov/) has compiled the types and footprints of the large plumes at the DOE Environmental Management sites, tracking the progress in the environmental restoration and closure status. In parallel, the DOE Office of Legacy Management (LM) has a publicly available open database – the Geospatial Environmental Mapping System (GEMS: https://gems.lm.doe.gov/) –

across over 100 sites. We find that GEMS allows users to download machine-readable datasets with two separate tables of station locations and concentrations in a unified format across the sites, which are easily ingestible for machine learning and data analytics software. In addition, GEMS provides well logs and photos that are important for understanding the nuanced information of each station and site. However, there are still challenges to accommodate the new types of datasets such as remote sensing images and data products (such as airborne LiDAR data).

In summary, there has been significant advances in environmental databases associated with radiological contamination. In particular, GEMS is a good example of uniform data formats across many sites. These advances follow the other databases – ECMWF's ERA5 weather database, the USGS National Water Data, and US EPA's Air Quality System (AQS)\* database – enabling large data science applications.

Reference: Wainwright, H.M. et al. (2024). The Iodine-129 Paradox in the Nuclear Fuel Cycle—Is Dilution a Solution? https://www.researchsquare.com/article/rs-4853533/v1 (pre-print)

## Impact of landscape decontamination on runoff and erosion fluxes following the Fukushima nuclear accident

研究代表者:Cooper Russell James 受入研究者:恩田 裕一

## 1. 成果

Introduction:

The project brought together the expertise of Onda's group in radiocesium migration and landscape change with the modelling tools of Cooper's group in runoff and erosion measurement to produce novel understanding of the impacts of decontamination within the Special Decontamination Zone on water and sediment fluxes.

Background & Importance:

Within the Special Decontamination Zone, topsoil was removed and replaced with a 5 cm layer of "clean" crushed granite. No study has quantified the impact of the substantial differences in physical properties of the granitic soil on runoff and erosion fluxes, and thus the potential for its use to enhance rates of Cs-137 wash-off elsewhere within the catchment.

Rainfall Simulation:

Rainfall events were simulated in the Large-scale Rainfall Simulator at NIED, Tsukuba, Japan over two soil-plots, one consisting of granitic sand and the other of Andisol from Fukushima, Japan. Three rainfall events of differing intensity and duration were simulated: (1) 45 mm/hr for 26.5 minutes; (2) 75 mm/hr for 26.5 minutes; (3) 105 mm/hr for 13.5 minutes. The water and sediment discharge, and the particle size of the transported sediment, was measured during and at the end of each of these events to quantify the effect of soil conditions, and rainfall intensity and duration on runoff and soil erosion.

At the downslope end of each of the plots, a gutter was installed to measure the water and sediment discharge, and the particle size of the transport sediment. The particle size was measured by taking samples of deposited sediment from the gutter for each rainfall event. The water level in a v-notch weir installed within the gutter, and the water volume and sediment mass was recorded during each rainfall event. In addition, numerous cameras wer installed along the length of the two plots to track the runoff velocity within the rills that developed during each rainfall.

Key Results:

1. The granitic soil had fundamentally different hydraulic and sediment characteristics to original soil in Fukushima. Namely the granitic soil had a higher infiltration rate and poorer

water storage capacity, and experienced enhanced rates of runoff in comparison to the original soil.

2. Granitic soil had high form drag leading to enhanced rill erosion and the transport of large particles sizes.

3. The topographic change in the grantic soil plot was greater than observed for the Andisol soil plot. This included the development of larger rills and more numerous microrills, and an overall soil loss. This change was more enhanced at higher rainfall intensities.

3. These differences have important consequences for agricultural productivity in decontaminated areas in Fukushima, making the landscape less resilient to erosion and landslides during the typhoon season, as well as having potential implications for the transport of soil-phase radiocesium.

## 2. 論文

Cooper, J.R. Onda Y. Sakai, N. (2004) Overland flow hydraulics during storm events. Proceedings of 12th International Conference on Fluvial Hydraulics, September 2024. Cooper, J.R. Onda Y. Sakai, N. (2004) Using surface image velocimetry to determine shallow, overland flow dynamics on eroded hillslopes. Proceedings of International Surface Velocimetry Workshop, October 2024.

## I-24-04

## Radioactivity in aquatic systems in Europe and Japan

研究代表者:Smith Thompson James 受入研究者:恩田 裕一

1. 成果

This project is a collaboration between The University of Portsmouth and The University of Tsukuba. The objective is to understand the factors controlling long term levels of radionuclides in rivers and lakes. The project has now collated data of radiocaesium and radiostrontium data from more than 30 rivers and lakes in Japan and Europe. Data analysis has begun with an investigation into how water chemistry is related to radiocaesium levels in surface water. Initial results indicate that some water quality parameters are associated with radiocaesium levels. Various models have been tested for prediction of radiocaesium activity concentrations. Current work is ongoing to evaluate catchment characteristics to investigate their relation to radiocaesium contamination.

2. 論文

None yet

## 霞ヶ浦湖畔の異なる土地利用が浮遊物質輸送と粒子状 137Cs の 排出に与える影響

研究代表者:Feng Bin 受入研究者:恩田 裕一

#### 1. 成果

Large amounts of 137Cs released from the Fukushima Daiichi nuclear power plant are continuously entering Lake Kasumigaura (Ibaraki Prefecture) from surrounding rivers, which could pose a potential radiation threat to drinking water safety and local fishing products. Given that more than 95% of 137Cs in rivers are tightly bound to suspended sediments (SS), understanding the dynamics of particulate 137Cs input/emission and the mechanisms behind controlling their transport is critical for the region. Land use is often considered a key factor affecting sediment yield and 137Cs inventory. Especially during the rainy season, its differences in soil erodibility can be greatly amplified, thus altering the supply of river sediment and the discharge of particulate 137Cs. Significant differences in land use composition have been identified in two sub-basins adjacent to Lake Kasumigaura (i.e., the Koise River basin and Sakura River basin), but due to the lack of long-term river monitoring data along the Kasumigaura Lake area, it remains difficult to evaluate the effect of such land use differences on sediment supply, river suspended sediment and particulate 137Cs fluxes.

To fill this knowledge gap, we conducted a six-year monitoring campaign in two sub-basins (i.e., Koise River basin and Sakura River basin) and combined hysteresis analysis and 137Cs tracing to specifically explore differences in sediment supply and transport across land-use basins. We found that sediment loads were more significantly correlated with discharge/rainfall in the Koise River (a higher proportion of forest fraction), and the dynamics of particulate 137Cs were more consistent over the same period. In contrast, the control of water flow/rainfall on sediment transport with 137Cs is relatively weaker in Sakura River (a higher PFU fraction). Hysteresis analysis shows that the frequency of clockwise event (CW) in the Koise exceeded 50%, while the figure of eight (F8) hysteresis occurred more frequently. We thus hypothesize that rainfall promotes sediment outflow from the forest edge in the Koise catchment, while the Sakura catchment has more paddy land, which leads to a more complex sediment composition due to its higher connectivity. To further study the location of sediment sources in two catchments, we propose a novel index to describe the spatial distribution of 137Cs loss using meteorological radar data, quantified land use, and 137Cs inventories. We found a significant positive correlation between this

metric and 137Cs dynamics in the Koise, rather than Sakura, which well-supports our explanation of highly 137Cs contaminated sediment in Koise mainly from the forest. Overall, our results suggest that forested areas in Kasumigaura lake may continue to discharge particulate 137Cs in the future. Moreover, the new index would be a useful tool to locate the potential sediment sources and benefit future catchment management.

## **Radiocesium Migration and Nutrient Dynamics in Fukushima**

研究代表者:Johnson Edward Thomas 受入研究者:恩田 裕一・アンダーソン ドノヴァン 共同研究者:Christian Grabowski

## 1. 成果

Many regions contaminated by the release of radionuclides following the 2011 Fukushima Daiichi Nuclear Power Plant disaster are still being investigated today. The mountainous forest areas surrounding Fukushima prefecture were most affected by fallout radionuclides, primarily radiocesium (Cs134 and Cs137), and remain a focus area for remediation and scientific research. Several models have been developed to estimate ambient dose equivalent rates (H\*(10)) using data on the depth distribution of fallout radiocesium in the forest soils.

Our hypothesis is that two different models will accurately predict radiation doses within 20% based on soil samples. The hypothesis was tested by applying the two models to a research plot in Kawauchi Village Japan, where forestry remediation such as clear-cutting and litter removal has been conducted. Using soil sampling data for radiocesium at the Kawauchi test site, these models were used to estimate  $H^*(10)$  and compared to measurements taken using handheld instrumentation. The distribution of radiocesium in soil for each sampling locations at the test site was determined using an exponential expression of vertical distribution. These distribution values were then used in two different models, one estimating  $H^*(10)$  using conversion coefficients from Bq/m2 to  $\mu$ Sv/hr, and the other model estimating  $H^*(10)$  measured at a central point within the test area. The results from this comparison provide a real-world test of computer model effectiveness. The conclusion was that both models could accurately predict radiation levels based on soil samples within 20% of measured values using field instrumentation but could improve if experimental conditions more closely matched those assumed in the model's design.

## Comparison of 99Tc concentration in seawater between Japanese and Taiwanese coastal area

研究代表者:Feng-Yun J. Huang 受入研究者:恩田 裕一・坂口 綾

#### 1. 成果

Technetium-99 is a long-lived (half-life of 2.11  $\times$  10<sup>5</sup> years) artificial radionuclide primarily produced in nuclear reactors, which can potentially impact the environment and human health. In this study, methods for the preconcentration and separation of 99Tc from seawater will be developed, followed by the determination of 99Tc using a liquid scintillation counter (LSC). Additionally, the recovery yield relationship between 99mTc and Re during the preconcentration and separation of 99Tc by various resins, including AG1-X8, TEVA, and TK-201, will be evaluated. The preconcentration and separation of 99Tc from 1L of seawater using different resins, such as AG1-X8/TEVA and AG1-X8/TK-201, will be investigated. Tracers, including 99mTc, 99Tc, and stable Re, will be employed to assess the chemical yield of 99Tc during these processes. Chemical yield evaluations during separation will be performed using gamma counting, LSC, and inductively coupled plasma optical emission spectrometry (ICP-OES). Decontamination factors (DF) for interfering nuclides, including Re, Mo, Ru, Co, Ni, Ag, Sb, V, Zn, and Pb, will be evaluated via ICP-OES during the preconcentration and separation of 99Tc. The minimum detectable activity (MDA) of 99Tc by LSC will be calculated based on literature equations. The preconcentration and separation methods for 99Tc in seawater, as well as experimental flowcharts for processing 1L of seawater, have been successfully established. The tracers 99mTc, 99Tc, and Re have been effectively utilized to monitor the chemical yield during the preconcentration and separation processes. The chemical yields, based on 99mTc, 99Tc, and Re tracers, for AG1-X8, AG1-X8/TEVA, and AG1-X8/TK-201 resins were determined to be  $96.9 \pm 1.5\%$ ,  $94.1 \pm 2.7\%$ , and  $96.9 \pm 3.9\%$ ;  $93.1 \pm 1.5\%$ , 95.9%, and  $97.7 \pm 4.8\%$ ; and  $89.9 \pm 0.6\%$ ,  $97.1 \pm 17.6\%$ , and  $100.4 \pm 2.9\%$ , respectively. For impurity removal during the preconcentration and separation processes, the results indicate that Mo, Ru, Co, Ni, Ag, Sb, V, Zn, and Pb can be effectively removed with DF values exceeding 1,000 during the separation of 99Tc using AG1-X8/TK-201 resin. Radiochemical determination of 99Tc in seawater via LSC has been successfully established. The MDA of 99Tc by LSC was calculated to be between 0.0342 and 0.0378 Bq/L. However, this MDA is significantly higher than the expected 99Tc concentration in seawater (~1 Bq/m<sup>3</sup>). As a result, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) will be employed to measure 99Tc postpreconcentration and separation in this project, as ICP-MS offers higher sensitivity and greater potential for detecting trace radionuclides in environmental samples.

## Characterization and first uses of an isotopic Np spike

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#### 1. 成果

In a recent collaboration between the University of Vienna and the University Tsukuba, a new isotopic Np spike has been developed. The Np spike material has been produced at the AVF Cyclotron at the RIKEN Nishina Center for Accelerator Based Science, and chemically purified at the University of Tsukuba. This material is intended to solve the problem of normalization in the measurement of 237Np by (advanced) mass spectrometric means such as Accelerator Mass Spectrometry or specialized QQQ-ICP-MS systems by measuring the environmental 237Np relative to a known quantity of the 236Np spike added to each sample before beginning the chemical processing and measurement.

The characterization and first application of this material faced steep challenges in both the low quantity produced, and the potential isobaric interference from both 236Pu and 236U on the desired 236Np spike isotope. A combination of three independent measurement techniques at the Vienna Environmental Research Accelerator – two of them developed for this purpose and one using a unique Ion Laser InterAction Mass Spectrometry (ILIAMS) setup were required to solve this problem. Extensive optimization of these methods allowed for a full characterization while leaving sufficient spike material for up to 70 environmental AMS samples.

With a small quantity of a prototype Np spike available, the final step was the application of this new spike material to a selection of environmental samples.

The ERAN grant I-24-08 was requested with the aim of funding the collection, transportation and measurement via Accelerator Mass Spectrometry of two 20L seawater samples from off the coast near Fukushima. Specifically, one sample was collected close to the outlet for treated water close to a scheduled release, and one at a larger distance. Due to it's long half life, significant quantities of 237Np have been released by reprocessing plants in past decades. The aim was to either verify the successful removal of Np from the Fukushima treated water, or to identify the releases as a new 237Np source term.

The two samples have been filtered to remove solids suspended during my stay at the University of Tsukuba in 2024, and after adding the new 236Np spike prepared for AMS measurement. This measurement was successfully performed at the Vienna

Environmental Research Accelerator, with no significant difference between the two sampling sites. The results are currently being prepared for publication alongside a validation of the new isotopic Np spike and a selection of other environmental 237Np samples. I can't provide a valid interpretation of the results or the exact values before completing the ongoing discussions on these points with the co-authors.

## 2. 論文

The manuscript is in preparation

## Assessment of the average external dose to air in a group of settlements located around the Semipalatinsk Nuclear Test Site on the basis of thorough analysis of available input data useful for retrospective dose estimations

研究代表者:Shinkarev Sergey 受入研究者:坂口 綾 共同研究者:星 正治・Stepanenko Valeriy

#### 1. 成果

Research on radiation exposure and its effects on human health around the Semipalatinsk nuclear test sites (SNTS) in Kazakhstan is in focus of many studies in order to derive the radiation risk. Reconstruction of external radiation dose to air in settlements located around the SNTS is the principal initial point for correct evaluating the radiation risk. There are following important steps on the way of external dose reconstruction: (1) to collect available input data useful for dose reconstruction, (2) to critically analyze them and (3) to use the most reliable input data for objective assessment of external exposure to the residents. Those input data are: (a) archival exposure rate measurements conducted soon after fallout in a vicinity of considered settlements, (b) available contemporary measurements of 137Cs deposition density inside and outside a given settlement; (c) TL/OSL measurements using quarts grains from quartz containing samples, which were "witnesses" of irradiation.

During this project the following research has been done:

(1) In order to collect all available data that might be useful for dose reconstruction, an intensive search of published materials has been conducted. All collected data were put together in the form of database for each settlement of interest.

(2) All input data collected together for each settlement have been thoroughly considered and critically analyzed taking into account published information on: parameters of considered tests, weathering conditions, locations of the settlements with respect to the trajectories of the traces related to the most significant tests.

(3) The most reliable input data were determined for further use. The up-to-date methodologies have been applied for external dose reconstruction of the settlement-average dose assessment.

Results: The estimates of the average-settlement dose for 18 settlements included in the project from 12 tests at the SNTS that affected those settlements have been carried out. The best estimates of the settlement-average dose to air are in the range (1-600) mGy.

## 2. 論文

Valeriy Stepanenko, Sergey Shinkarev, Andrey Kaprin, Kazbek Apsalikov, Sergey Ivanov, Peter Shegay, Evgenia Ostroumova, Ausrele Kesminiene, Alexandra Lipikhina, Viktoria Bogacheva, Kassym Zhumadilov, Masayoshi Yamamoto, Aya Sakaguchi, Satoru Endo, Nariaki Fujimoto, Bernd Grosche, Vladimir latsenko, Alla Androsova, Zukhra Apsalikova, Noriyuki Kawano, Masaharu Hoshi, Comparison of external dose estimates using different retrospective dosimetry methods in the settlements located near Semipalatinsk Nuclear Test Site, Republic of Kazakhstan, J. Radiat. Res., 65, January 2024, 36–46, https://doi.org/10.1093/jrr/rrad082.

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I-24-10

## アラスカの永久凍土融解が環境中の放射性物質動態に与える影響

研究代表者:岩花 剛

受入研究者:五十嵐 康記

1. 成果

北極域では急激な温暖化の影響により永久凍土の融解が進んでいる。その永久凍土には水 銀等の様々な重金属が含まれており、生態系に有害な物質の流出増加が懸念されている。 永久凍土上には、1950から60年代にかけて実施された大気核実験の降下物とそこに含ま れる放射性核種も堆積し、凍土に取り込まれている。凍土の存在によってこれまで安定し ていた土地が融解して流動化する一方、アラスカ各地で河川水が変色し、水質が変化する 事例が多発しているが、これらの大気核実験降下物とそこに含まれる放射性物質がどのよ う流出するかがわかっていない。本研究の目的は、アラスカの主要な河川を対象として、 河川中に存在する重金属および長半減期核種である 137Cs 濃度を明らかにすることであ る。

申請代表者の所属研究機関・アラスカ大学で実施中の永久凍土環境変化モニタリングを伴う複数の研究プロジェクトと連携し、アラスカ・北東ノーススロープ、北西ノーススロー プ、およびフェアバンクス近郊における近年の凍土動態の情報を取得し。それぞれの地域 を代表する河川において、河川水をサンプルした。河川水を濾過後、イオンクロマトグラ フィーにより溶存イオン、ICM-PS により微量元素濃度を測定した。また Cs-137 につい ては、水溶態・懸濁態の濃度を求めた。現地での採水の結果、河川中の溶存態 Cs-137 は 検出されなかった。懸濁態の濃度は最大で 0.86 Bq/kg となり、予想されていたよりも小 さい値であった。凍土の融解が進む地域において、大気核実験の降下物はまだ地表面に留 まっている可能性が示唆された。

2. 論文

なし

## Effects of environmental radiocontamination on pollinators' behaviour and cognition

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#### 1. 成果

Insect pollinators are vital to the maintenance of terrestrial ecosystems and global food security. Bees, wasps, flies, and butterflies heavily rely on learning and memory to forage on flowers. However, these cognitive abilities can be disrupted by environmental stressors, which can have dramatic consequences on populations if food supply is compromised. This approach has recently been successful in Europe to demonstrate the dramatic impact of neonicotinoid insecticides on pollinators and ban them even at non-lethal doses. Following this approach, our aim was to study the effects of radioactive contamination on the cognitive health of pollinators in the Fukushima Prefecture.

We massed phenotype the cognitive health of pollinators using a newly developed automated and non-invasive "flower", i.e., Y-maze device in which individual insects must learn to find a sucrose reward, that operate continuously without the need of experimenters. Our system uses on-board artificial intelligence, enabling recognition of individual insects. It is autonomous (on batteries), which means we can collect data over long periods of time without the need of human intervention in highly contaminated areas.

We ran two field campaigns in 2024. During the first field work session (Spring), we focused on population of domestic honey bees (Apis mellifera) that have been sat up in different sites characterized by contrasted levels of radio-contamination with the BEERAD project (2022-2024, PI: Bétrice Gagnaire). During the second field work session (Summer), we focused on wild pollinators in the same sites, giant hornets (Vespa mandarinia) naturally found in the study area. In both campaigns, we compared the cognitive health of insects in six sites carefully selected for their contrasted levels of radiocontamination (low, medium, high).

Our preliminary analyses indicate that both honey bees and hornets tested in the low contaminated sites showed higher learning performances than those tested in the high contaminated sites. Specifically, low radio-contamination levels had critical sublethal effects on domesticated honey bees after only six weeks of controlled exposure. Similar

effects were observed on wild giant hornets, for which exposure was uncontrolled. In the future, we plan to deploy a permanent monitoring of insect cognitive health across all sites. We also plan to study in the impact on key ecosystem services such as pollination and predation.

This is the first study to show that radio-contamination impairs animal cognition. Beyond advancing our fundamental understanding of the environmental impact of radio contamination, this research may help develop conservation procedures of and accelerate the return of agriculture in contaminated zones.

## Soil biodiversity and functional processes in radio-contaminated forests (Fukushima Prefecture, Japan)

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## 1. 成果

The RINSHŌ project aims to investigate the effects of radiocontamination on soil biodiversity and associated functional processes in forests of the Fukushima Prefecture. Our hypotheses are: (i) radiocontamination has an impact on soil biodiversity, (ii) radiocontamination has an impact of soil organisms and the processes they drive, (iii) the impact of radiocontamination is dose-dependent.

From November 2023 to November 2024 period, six Japanese cedar (Cryptomeria japonica) forest sites positioned along a radiocontamination gradient, were studied. Following the initial setup of in situ experimental units (5 units per site, n=30) and samplings, additional collections of experimental devices and samplings were conducted respectively after 6 and 12 months of experimentation (June and November 2024).

Very preliminary results suggest differences in soil and litter biodiversity (based on eDNA metabarcoding approach) and a reduction of functional processes (leaf litter decomposition and bioturbation) due to radiocontamination. So far, this impact does not appear to be dose-dependent. Others environmental parameters such a as temperature and humidity, may also have affected the observed results.

The complete set of results must now undergo in-depth analysis that includes all environmental parameters, particularly to determine whether there is a link between changes in biodiversity and functional processes, and to assess how different environmental factors (radiocontamination, temperature, humidity) account for the differences in soil functioning across studied forests.

Keywords: Fukushima Prefecture, ionizing radiation, forest, soil communities, functional processes.

## Effect of radioactive contamination in Fukushima Prefecture on wildlife: the case of the tree frog

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### 1. 成果

### Context & Objective

There are still many uncertainties about the long-term chronic effects of radioactive pollution on wildlife, which limits their use for implementation of environmental radioprotection criteria. This ERAN project is the third part of a study dealing with male tree-frogs (Dryophytes japonicus) living along a radioactive contamination gradient in Fukushima Prefecture. Since energetic metabolism plays a crucial role in the efficiency of the organism's major biological functions, we measured in a first step the activity of three enzymes involved in the energetic metabolism in the thoracic muscles of tree frogs (collected in 2022). Results shown that both aerobic and anaerobic metabolisms were positively correlated with the individual ionizing radiation absorbed dose rate that suggests a potential energy trade-off due to ionizing radiation exposure during the breeding season (data not yet published). Since the thoracic muscles play a crucial role in the calling behaviour of male tree frogs, as they are involved in the production of the vocal sounds used to attract conspecific females, the aim of this project was to investigate the relationship between calling effort (highly energetically costly), hormone levels, and sperm parameters. Understanding these trade-offs will help assess the reproductive costs of radiation exposure and its effects on population dynamics. Methodology

To achieve our objective, during the breeding season (i.e. May and June 2024), we measured tree frog calls along a contamination gradient in Fukushima Prefecture. We captured, individually caged and recorded the calls of 15 tree frogs at each of the 9 sampling sites. Environmental parameters (air and water temperature, sound ambiance, etc.) were also measured, as they can influence the individuals' calls. The calling parameters studied included: intra-bout speed, call ratio (i.e. the number of songs produced per hour), the total time spent calling throughout the night, and the dominant frequency. The following day, tree-frogs were killed and dissected out. The gonadosomatic index (gonad mass / individual mass), and the spermatozoa concentration, speed, and movement angle were measured. We also collected saliva

samples to measure testosterone concentration, a parameter that directly influences call production and sperm maturation. The femur bone of the tree frogs was collected to perform a skeletochronology procedure to determine the age of the calling individuals captured. Finally, the carcasses were mineralized, and their Cesium-137 activity was measured by liquid scintillation to obtain an internal dose rate. To estimate the external dose rate, we placed RPL dosimeters in the tree frogs' habitats.

Results

Since the duration of the field campaign and the different analyses to perform, some results are still in progress.

However, the first key findings indicate that tree frogs do not differ significantly in age across all sampled sites, and the same holds true for testosterone concentration. These results suggest that individuals are of comparable age and reproductive status regardless of site. Furthermore, the gonadosomatic index, sperm concentration, and intra-bout speed—a parameter closely linked to the individual's energetic state—are all positively correlated with the external dose rate at the sampled sites. Two alternative hypotheses could explain these patterns: either males from contaminated sites invest more in sexual traits to enhance their reproductive success, or they are in better physiological condition due to the absence of other environmental stressors such as pesticides, which are more prevalent in the rice field environments of control sites.

The next step will be to compute individual total dose rates, once internal activities are available. This will allow us to link each individual's exposure to specific observed parameters, while accounting for other relevant variables such as temperature, individual mass, and more.

## Parameterization of the long-term dynamics of cesium distribution in the suspended sediment-water system in water bodies of the Chornobyl Exclusion

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#### 1. 成果

In the wake of the Chernobyl and Fukushima accidents, radiocesium has become a radionuclide of most environmental concern. The ease with which this radionuclide moves through the environment and is taken up by plants and animals is governed by its chemical forms and site-specific

environmental characteristics. Distinctions in climate and geomorphology, as well as Cs-137 speciation in the fallout, result in differences in the migration rates of Cs-137 in the environment and rates of its natural attenuation.

The goal of the project was to obtain the parameters of long-term dynamics of particulate and dissolved Cs-137 in the suspended sediment-water system for water bodies of the Chernobyl contaminated areas and compare with Fukushima data. Empirical multi-exponential model and semi-empirical "diffusional" model have been used (Konoplev et al., 2021).

Cs-137 activity concentrations in freshwater decreased with time after both accidents. In the case of Chernobyl, this decline in Cs-137 concentrations is well-predicted by a semiempirical "diffusional" model. However, the Cs-137 concentrations in Fukushima declined faster than predicted by the "diffusional" model. Two potential explanations of this difference in the behavior of Chernobyl- and Fukushima-derived radiocesium were suggested: (1) extensive remediation activity during the first several years after the Fukushima accident, which substantially reduced the Cs-137 content in the topsoil layer of the contaminated catchments; and (2) difference in surface runoff formation processes in Fukushima and Chernobyl due to higher intensity of precipitation and slopes in the Fukushima area.

Opposite to Chernobyl, the apparent distribution coefficient Kd(Cs-137) in the sediment-water system of Fukushima rivers and ponds was found to decrease with time after the accident. Proceeding on the assumption that the decrease in Kd is associated with the decomposition of glassy Cs-rich microparticles, the timescale of Cs-137 leaching from them was estimated to be in the range 6–20 years. The obtained estimates are consistent with the findings of laboratory experiments (Okumura et al.,

2019).

Higher mean annual precipitation and air temperature promote faster vertical and lateral radiocesium migration in Fukushima as compared with Chernobyl. Wash-off is the principal long-term process responsible for the radiocesium secondary contamination of surface waters in the contaminated areas for both accidents. Particulate and dissolved wash-off ratios in Chernobyl and Fukushima were found to decrease in the mid- and long term as a result of radiocesium depletion in the topsoil layer due to its vertical migration in catchment soils.

Particulate Cs-137 wash-off ratios from the catchments of the Fukushima area display only minor differences compared with those in the Chernobyl area, being at the lower limit of the Chernobyl values. Dissolved Cs-137 wash-off ratios for Fukushima catchments are at least an order-of-magnitude lower than those for Chernobyl, mainly due to an order-of-magnitude difference in the Cs-137 distribution coefficients for the Fukushima and Chernobyl rivers.

In summary, data from Chernobyl long-term studies can be further used to refine predictions of temporal changes in the radionuclide behavior for Fukushima areas.

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## Influence of temperature and ammonium on radiocesium seasonality in water bodies

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#### 1. 成果

Kyiv reservoir is the upper in the cascade of Dnieper reservoirs. Rivers flow into it, carrying cesium-137 from the areas heavily contaminated due the Chernobyl accident. Observation data on water temperature and cesium-137 activity concentrations in the lower dam part of the reservoir for the period 1987-2022 were collected, systematized and analyzed.

Data analysis showed that against the background of a long-term decrease in the activity of dissolved cesium-137 in river water, its regular seasonal fluctuations are observed (increase in summer and decrease in winter). The ratio of the highest to lowest concentrations of dissolved cesium-137 being mostly within range 1.5-3,5. It was found that seasonal fluctuations of dissolved cesium-137 in the water of the Kyiv Reservoir occurs synchronously with the seasonal course of water temperature.

Generally, there are two basic factors explaining seasonal variations of dissolved radiocesium in water bodies: seasonal changes of water temperature and ammonium concentration. An equation has been derived describing seasonal variations of dissolved radiocesium in water bodies considering two basic factors: water temperature and combined concentration of basic competitive cations.

Analysis of available hydro-chemical data at Kyiv Reservoir suggested that the predominant factor of dissolved cesium-137 seasonality is temperature dependence of cesium-137 desorption from sediments described by modified Arrhenius equation. Changes in ammonium concentration have comparable with water temperature contribution to seasonal fluctuations of dissolved cesium-137 activity concentration only in limited number of specific observations.

An empirical two-exponential and semi-empirical diffusional models of long-term dynamics of dissolved cesium-137 in rivers have been derived taking into account its seasonal fluctuations by combination with modified Arrhenius equation. Both models were tested against monitoring data for Kyiv reservoir and satisfactory agreement between modelling and experimental data was reached.

The calculated values of activation energy EA of cesium-137 desorption from sediments into solution in the Kiev Reservoir are close to the values obtained earlier in field studies

on rivers and lakes in the Fukushima-1 accident zone and in laboratory studies of the temperature dependence of radiocesium sorption-desorption on alluvial deposits of the Hanford site in the USA. This gives grounds to believe that the activation energy of cesium desorption from sediments into solution is a value that is more or less universal for a wide range of sediment properties in different geographic regions of the Earth.

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## The temporal dynamics of radiocesium in water and its distribution in bottom sediments of the Ogaki Dam Reservoir

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#### 1. 成果

A huge portion (about 6.4 PBq) of radiocesium (r-Cs) was deposited in NW of Japan after Fukushima Daiichi Nuclear Power Plant accident. The environment objects in Fukushima Prefecture were seriously subjected to ecological stress, for example the Ogaki – one of the biggest dam in Fukushima Prefecture. The initial contamination level of reservoir catchment area was considered as high (2.4 MBq/m2 as of March 2011). The dam represents an essential water resource for the local inhabitants and paddy field irrigation; therefore, the r-Cs concentration has important implications for the "health" of humans and biota. The lateral migration of r-Cs in most cases is associated with soil erosion. In particular, from sloped contaminated catchments, the RNs are transported with runoff. RNs are accumulated/redeposited at different parts of landscape, and some part delivered (with suspended sediments) to water bodies. This leads to a siltation, eutrophication, increase mortality of water fauna, and deterioration in water quality. Because of during natural events such as intensive rainfall and snowmelt, the turbidity and r-Cs concentration in water bodies usually is increase - the siltation rates, features of transport and redistribution of sediments, their texture and concentration of r-Cs (as well in water) is required a detail study.

The previous topic of research proposal was supported by ERAN in last years (I-22-08, I-23-11). The research was conducted for different parts (from source to mouth and elevation: floodplain, 1 and 2 terrace above the riverbed) of Abukuma River. All field and laboratory works were completed. In continuation of research, the Ogaki dam was selected as object of study. The following research objectives were set for 2024:

Task 1. Study of the bottom sediments. Results: the high r-Cs concentrations were found in sediments both of Abukuma River and Ogaki dam with domination of fine fractions. The sediments of Ogaki dam contain in average  $5 \times 104$  Bq/kg of 137Cs and ~70% of silt (0.05–0.002 mm) fraction, whereas in Abukuma River –  $2 \times 103$  Bq/kg of 137Cs and 50% of silt.

Task 2. Literary analysis related to the reconstruction of radiocesium dynamics in water bodies. The study is focused on the reconstruction of long-term dynamics of 137Cs concentration in water bodies contaminated as a result of Chernobyl and "Fukushima-1" NPP accidents. It was found that the vertical distribution of 137Cs in bottom sediments of deep-water sites could be a basis for reconstruction of the dynamics of radionuclide

concentration in suspension and in solution (Konoplev et al., 2024).

Task 3. Study of soil erosion and radiocesium distribution in the landscapes of Cis-Ural region. Despite the relative proximity to the East Ural Radioactive Trace and underground nuclear explosions conducted in the Republic of Bashkortostan, the soils are suitable for economic activity. The activity concentration of 137Cs in the surface soil layers ranges from 0.9 to 9.8 Bq•kg – 1, and inventories range from 1.8 to 5.1 kBq•m – 2, these quantities being higher within the forest (Komissarov et al., 2024).

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## Determination of internal exposure due to natural radioactivity in decorated ceramic building materials used in India

研究代表者:Chandrasekaran A. 受入研究者:ラハマン モハマド モフィズル イスマイル

#### 1. 成果

 $\boxtimes$ Experimental $\boxtimes$  In this work, a total number of 25 vitrified tiles were collected from various locations on building construction sites in Tamil Nadu. The collected tile samples are different sizes shapes, and colours. The samples were packed in polythene bags and labeled properly, and it was transferred into the laboratory for pre-treatment. At the initial stage, the samples are broken into small pieces (typically 5-10 cm in size) using a jaw crusher. Hereafter, the powder crusher instrument was utilized to pulverize and grind the tile samples to the fine powder (typically less than 0.16 mm). A finer, uniform powder is ideal for a gamma-ray spectrometer because it ensures that the sample is homogeneous and allows for more accurate measurements. Both the jaw and powder crusher help to ensure the homogeneity of vitrified tile samples .After that, the grained samples were dried in an oven at 105°C for 2hour completely removed the moisturizer constant, and packed in a 250 mL Marinelli beaker. At the top of the beaker, the screw caps were tightly sealed with Teflon tape and stored in an undisturbed place for four weeks to allow the natural radionuclides to attain secular equilibrium and their short-lived posterity. Finally, the samples are subjected to Nal (TI) gamma-ray spectroscopic to assess the activity concentration of primordial radionuclides of 238-U, 232-Th, and 40-K of the collected vitrified tiles samples.

⊠Observations⊠ The activity concentration of 226-Ra, 232-Th and 40-K was determined by Nal (TI) detector-based gamma ray spectrometer for vitrified tiles and slightly higher values were observed. A mean activity concentration of radionuclides was found in the order of 40K > 232Th > 226Ra. From normality results, the significance threshold 226-Ra and 40-K are both 0.200, which indicates that the distributions of 226Ra and 40K are log-normal. In contrast, the significance value for the frequency distribution of 232Th is less than 0.05, suggesting that this distribution is normal in the collected tile samples. The calculated radiological hazards DRin ELCRin shows the slightly higher whereas Raeq, AEDEinm Hin, and AGDE shows the less than the world permissible limit. Therefore, vitrified tiles do not possess much radioactivity however continuous monitoring is required for these samples.

## 2. 論文

Chandrasekaran, A., Rahman, I.M.M. Effect of natural radioactivity along the southern coastal area of Tamil Nadu with statistical approach. J Radioanal Nucl Chem 333, 6155–6165 (2024). https://doi.org/10.1007/s10967-024-09735-9

## Abundance and diversity of radiation resistant zooplankton communities from Extreme regions of Kayamkulam Estuary, Natural high background radiation area (NHBRA), Kerala, South West Coast of India

研究代表者:Musthafa M. Saiyad 受入研究者:ラハマン モハマド モフィズル イスマイル

## 1. 成果

The study documented 21 zooplankton species across 7 taxonomic groups, with Copepoda dominating (9 species; 64.3% of total abundance). Non-copepod groups such as Rotifera (3 species), Cladocera (3 species), and Dinoflagellata (1 species) showed seasonal peaks, particularly during monsoon and post-monsoon periods in Table 1. The zooplankton community inhabiting this estuarine ecosystem exhibits a diverse assemblage of species, reflecting the dynamic interplay of environmental factors and seasonal shifts that characterize such environments (Spilling et al., 2019). Copepods, known for their numerical dominance in many aquatic systems, are well-represented in this study, with species such as Acartia tropica, Pseudodiaptomus annandalei, Oithona plumifera, Calanoides carinatus, Paracalanus parvus, Centropages furcatus, Temora turbinata, and Euterpina acutifrons contributing significantly to the overall zooplankton abundance.

Conclusion

The study underscores the pivotal influence of seasonal monsoonal cycles on zooplankton community structure in tropical estuaries. Copepods dominated the assemblage, with Acartia tropica and Paracalanus parvus thriving in nutrient-rich monsoon conditions, while Oithona plumifera and Calanoides carinatus maintained year-round populations due to their broad environmental tolerance. Non-copepod taxa, such as rotifers and cladocerans, occupied specialized niches during post-monsoon clarity, ensuring trophic continuity. The seasonal surge in Noctiluca scintillans highlights the ecosystem's vulnerability to eutrophication, likely exacerbated by anthropogenic nutrient inputs. Climate-driven alterations in monsoon patterns could disrupt these dynamics, favoring smaller, fast-reproducing zooplankton over copepods, with cascading effects on fisheries and carbon cycling. This work provides a baseline for understanding zooplankton-driven ecological processes and abundance in estuaries of NHBRA.

Future recommendations

Future research should prioritize the collection of zooplankton species exhibiting high abundance within the NHBRA (Northern High Background Radiation Area) to assess the

specificity of genes associated with radiation resistance. By integrating whole-genome sequencing approaches, these studies could precisely identify candidate genetic markers linked to radioprotective mechanisms. Such insights would advance our understanding of adaptive traits in high-radiation environments and inform applications in radiation protection research, including biomimetic strategies for mitigating radiation-induced damage in biological systems.

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## Assessment of Naturally Occurring Radioactive Materials in Soil and Foodstuffs from Barapukuria Coal Fired Thermal Power Plant Area, Dinajpur, Bangladesh

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### 1. 成果

Assessment of Naturally Occurring Radioactive Materials in Soil and Foodstuffs from Barapukuria Coal Fired Thermal Power Plant Area, Dinajpur, Bangladesh

Introduction: The presence of naturally occurring radioactive materials (NORMs) in the environment can pose potential health risks due to their radiological impact. This study focuses on assessing the concentration of NORMs, specifically Radium-226 (Ra-226), Thorium-232 (Th-232), and Potassium-40 (K-40), in soil and commonly consumed foodstuffs within the vicinity of the Barapukuria Coal-Fired Thermal Power Plant (BCFTP) located in Dinajpur, Bangladesh. The BCFTP has a capacity of 525 MW. Coal-fired power plants are known to potentially release NORMs into the surrounding environment through fly ash and other byproducts. Therefore, understanding the distribution and transfer of these radionuclides is crucial for assessing potential environmental and public health implications in the region.

Objectives: The objectives of this research are as follows. (a) Determine the levels of NORMs (Ra-226, Th-232, and K-40) in soil, plants, and various food items (rice, wheat, fruits, and vegetables) collected from the area surrounding the BCFTP. (b) Evaluate the transfer factors of these radionuclides from soil to plants and food items within the BCFTP area to understand potential pathways of human exposure and associated health impacts. (c) Contribute to a better understanding of environmental radioactivity in coal-fired power plant regions and its implications for public health and food safety. Materials and Methods: This study involves the collection of soil samples at depths of 0-5 cm and 5–10 cm, as well as 22 different types of food samples (including rice, wheat, fruits, and vegetables) from 22 sampling points around the BCFTP area. The sampling points were strategically selected considering the average wind direction of the area. All collected samples are prepared for analysis, which includes drying, weighing, and, in the case of food samples, making pellets. The activity concentrations of Ra-226, Th-232, and K-40 in the prepared soil and food samples will be determined using gamma-ray spectrometry.

Expected Outcomes and Significance: The findings of this study will provide valuable

data on the levels of NORMs in the soil and commonly consumed foodstuffs in the vicinity of the BCFTP. Understanding the transfer of these radioactive materials from soil to the food chain is crucial for assessing potential radiological risks to the local population.

Progress: Sample collection and preparation have been completed, and the samples are now prepared for analysis. Data analysis and scientific manuscript preparation will follow the analysis phase.

## 2. 論文

S.R.T. Parija, J. Alam, H. Roy, M. Bhuiyan, M.S. Khan, M.R.A. Rifat, M.S. Ahammed, M. Rahman, M.N. Uddin, I.M.M. Rahman and M.A. Islam (2025) Development of a rapid qualitative and quantitative method for the detection of palm oil adulteration in cow milk from Bangladesh by using ATR-FTIR spectroscopy with chemometric analysis, Food Analytical Methods, (Article In-Press). https://doi.org/10.1007/s12161-025-02770-6

## Synthesis and characterization of Ru(III) and Ru(IV) complexes of C-chiral isomeric hexamethyl tetraazamacrocyclic ligands and their applications in the decontamination of radioactive waste

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### 1. 成果

Ruthenium (Ru), a rare transition metal, is used in catalysis, electronics, the nuclear industry, and medicine. However, its compounds pose chemical and radiological toxicity risks. The radioisotopes 106Ru and 103Ru are highly volatile and hazardous, especially RuO4. Nuclear power operations and radioactive waste disposal may release these isotopes, making their removal essential. Adsorption-based extraction is a cost-effective solution. Understanding the complexation of Ru(III) and Ru(IV) with chelators is crucial for developing efficient chelator-modified adsorbents.

Synthesis of the ligand 5,7,7,12,14,14-hexamethyl-1,4,8,11-tetraazacyclotetradeca-4,11-dienedihydroperchlorate (L.2HCIO4) and isolation of isomers of its saturated analog ('tet-a' and 'tet-b') was carried out according to the procedure adopted in literature (Busch, et al., 1971). The prepared isomeric macrocyclic ligands contain nitrogen as the donor atom. The methanolic solutions of these ligands were treated separately with methanolic solutions of RuCl3 · 3H2O and Rul3, producing four corresponding complexes: [Ru(tet-a)Cl2]Cl, [Ru(tet-a)I2]I, [Ru(tet-b)Cl2]Cl, and [Ru(tet-b)I2]I. Characterization of the ligands and complexes was conducted using FTIR ( $\nu$ N-H, 3262 s;  $\nu$ C-H, 2945 s;  $\nu$ CH3, 1381 w;  $\nu$ C-C, 1194 s;  $\nu$ NH2, 3311 w;  $\nu$ C=O, 1686 s; and  $\nu$ Ru-N, 422 s), molar conductivity (32 to 66 ohm-1 cm2 mol-1), magnetochemical (1.28 to 1.32 B.M.), and electronic spectral (d-d band at 406 nm) analyses. The data suggest that all the complexes are 1:1 electrolyte and octahedral in shape.

The spontaneous formation of Ru(III) complexes with the N-donor ligands 'tet-a' and 'tet-b' indicates that developing stable and cost-effective N-bearing functional groupcontaining adsorbents could be efficient for the removal of radioactive Ru from nuclear wastes.

2. 論文

N/A

## Synthesis and characterization of nanocomposites for separation of radiostrontium from wastewater

研究代表者: Chowdhury Faisal Islam 受入研究者: ラハマン モハマド モフィズル イスマイル 共同研究者: Begum Zinnat Ara

#### 1. 成果

Introduction: Zeolitic imidazolate frameworks (ZIFs) are highly porous and stable, making them ideal for treating wastewater. Combining the rigidity of zeolites with the tunability of MOFs, ZIFs offer high surface area and adjustable pore sizes, enabling effective degradation of toxic contaminants in the water matrix. This study focuses on the role of ZIF-8 in sustainable water purification through advanced dye removal techniques.

Experimental: This study explores the synthesis, characterization, and photocatalytic performance of ZIF-8 nanoparticles. The samples of ZIF-8 were synthesized using (a) 2.978 g (0.01 mol) for J-1 and (b) 4.476 g (0.015 mol) for J-2 of Zn(NO3)2·6H2O via a simple precipitation method. The synthesized nanoparticles were characterized using XRD, SEM, EDS, and FT-IR. Photocatalytic tests showed effective degradation of eosin yellow dye under simulated solar irradiation. The unique porous structure and stability of ZIF-8 highlight its potential for environmental remediation, particularly in wastewater treatment and pollution control.

Key Findings: FT-IR analysis of ZIF confirmed the vibrational frequencies of Zn-N at 421 cm-1 and C=N bond at 1527-1589 cm-1, consistent with the literature. XRD analysis confirmed the ZIF-8 phase, with Miller indices matching the body-centered cubic structure. SEM analysis revealed cubic, irregular, and porous morphology of ZIF-8 nanoparticles. The photocatalytic degradation rates of Eosin Yellow for J-1 and J-2 were observed at 91.29% and 83.21%, respectively.

Conclusion: The study shows that ZIF-8 nanoparticles synthesized through an ecofriendly method display notable photocatalytic activity, with the lower Zn-containing ZIF demonstrating superior performance compared to the higher Zn-containing sample. Note: the report is based on the preliminary findings, and more work is underway.

## 2. 論文

M.A. Hasan, I.M.M. Rahman, M.R. Hossain and F.I. Chowdhury (2025) Quantum chemical investigations into the structural and spectroscopic properties of choline chloride-based deep eutectic solvents, Chemical Physics Impact, 10, 100777. https://doi.org/10.1016/j.chphi.2024.100777

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## Unravelling Cadmium Fluxes in Native Plants of New Zealand Using Synchrotron Technology and radionuclide fractionation

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### 1. 成果

Abstract: This report summarizes a study assessing cadmium (Cd) levels in rice and vegetables, as well as their potential health implications, in Bangladesh. The findings indicate that Cd concentrations in certain regions exceed the limits set by the FAO/WHO, posing potential long-term health risks to both children and adults.

Key Findings: (a) The average Cd concentration in the studied area of Bangladesh (Jamalpur) was found to be 1.93 mg/kg, surpassing the FAO/WHO limits. (b) While the Target Hazard Quotient (THQ) and Hazard Index (HI) did not indicate immediate non-carcinogenic risks, the Target Carcinogenic Risk (TCR) exceeded the acceptable threshold for both children and adults. The data suggest a potential for long-term cancer risks associated with Cd exposure through rice and vegetable consumption. (c) The Estimated Daily Intake (EDI) for Cd, along with Nickel (Ni) and Lead (Pb), exceeded the Maximum Tolerable Daily Intake (MTDI), highlighting significant potential health risks in the studied population.

Conclusion and Recommendations: The study concludes that cadmium levels in rice and vegetables in some areas of Bangladesh and India exceed recommended limits, indicating potential health hazards, particularly concerning long-term carcinogenic risks. The findings emphasize the urgent need for consistent monitoring and the implementation of effective regulations to ensure food safety and protect public health. Further research is recommended to gain a deeper understanding of the biogeochemistry of cadmium in the soil and its accumulation in these essential food crops.

Note: This report is based on preliminary findings, and additional research is underway.

### 2. 論文

S.A. Mamun, M.A. Islam, S.B. Quraishi, M.M. Hosen, B.H. Robinson and I.M.M. Rahman (2024) Assessment of potentially toxic element contents in chickens and poultry feeds from Bangladesh markets: Implications for human health risk, Toxicology Reports, 13, 101706. https://doi.org/10.1016/j.toxrep.2024.101706

## Development of graphene-based magnetic nanocomposites for radioactive waste management

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受入研究者: ラハマン モハマド モフィズル イスマイル

#### 1. 成果

Global and regional contamination by anthropogenic radionuclides has occurred due to nuclear testing and accidents, such as those at Kyshtym, Chornobyl, and Fukushima Daiichi. Radionuclides can enter the food chain, posing health risks. Developing costeffective methods for managing radioactive waste is crucial (Romanchuk et al., 2016). Nanoadsorbents, particularly graphene oxide (GO) combined with iron oxide nanoparticles, show promise for removing radionuclides from wastewater due to their high surface area and magnetic properties (Minitha et al., 2018; Xia et al., 2022). A proposed study aims to create a novel magnetic GO nanocomposite to remove radionuclides from contaminated water efficiently.

Magnetic reduced graphene oxide (M-rGO) is an innovative composite material that is synthesized by effectively combining D-glucose or soluble starch with a mixture of iron salts, specifically Fe(II) and Fe(III), under precisely controlled conditions. This process successfully integrates iron oxide nanoparticles (IONPs) into reduced graphene oxide (rGO), resulting in a material that boasts exceptional magnetic and functional properties. These unique characteristics, including significantly enhanced adsorption capabilities, stem from the dynamic chemical interactions between the components. The fabrication of M-rGO is firstly verified through visual observation of magnetic separation by an external magnet and conclusively verified through a variety of robust analytical techniques, such as ultraviolet-visible (UV-Vis) and Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM). The UV-Vis and FTIR analyses unmistakably demonstrate the transformation of Dglucose/starch to rGO through characteristic peaks. The XRD results reveal distinct peaks for M-rGO instead of rGO, confirming the integration of iron oxide nanoparticles within the composite. Furthermore, the SEM images illustrate a porous structure, which is crucial for adsorption applications due to its high surface area and remarkable ability to trap contaminants effectively.

The resultant M-rGO can remove radionuclides, specifically Sr(II), from contaminated water. The process involves the adsorption of Sr(II) ions onto the surface of M-rGO (Li et al., 2018; Minitha et al., 2018). The inherent magnetic properties allow for efficient solid-liquid separation using an external magnetic field, eliminating the need for filtration or centrifugation. This feature significantly simplifies the separation process while ensuring high removal efficiency.

## 2. 論文

One paper has been submitted, and another one has been drafted

## Evaluation of Isotopic and Chemical Characteristics in Environmental Samples from the neighboring locations of Rooppur Nuclear Power Plant, Bangladesh

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### 1. 成果

The baseline radioactivity levels and physicochemical properties of environmental samples collected in the vicinity of the under-construction Rooppur Nuclear Power Plant (RNPP) in Bangladesh have been investigated. The RNPP, comprising two units of 1200 MW each, is anticipated to commence commercial operation in 2027. Recognizing the potential for radionuclide release during operational emergencies and the generation of radioactive waste, this research underscores the importance of isotopic and chemical assessments of environmental samples for ensuring ecological and public safety. Tracking radioactivity levels in environmental matrices, such as soil, sediment, and water bodies, is crucial both before and after a nuclear power plant becomes operational.

The study area was geographically defined by northern longitudes 24.024306 to 24.102518 and eastern longitudes 88.963637 to 89.108499. A total of 20 samples were collected, consisting of 10 soil samples (S1–S10) and 10 water samples (W1–W10), with an approximate inter-sample distance of 1 km. Soil and water samples were obtained from depths of 5 cm and 80–120 feet relative to the surface, respectively.

The physicochemical properties (pH, electrical conductivity, total dissolved solids, total hardness, total alkalinity, and silica), cations (Mg and Ca), anions (Cl–, SO42–, NO3–, PO43–), trace metal concentrations (Cu, Zn, Fe, Mn, Pb, and Cd), and the activity of radionuclides (226Ra, 232Th, 40K, and 137Cs) were measured in the water samples. The results indicated that the physicochemical parameters, except silica, were within the safety limits established by the World Health Organization, the Department of Environment, and the Bangladesh Standards and Testing Institution. The average concentrations of the investigated trace metals were below the recommended levels, except for Mg, Pb, Cd, and Mn. Elevated Mg levels in the groundwater may be attributed to seawater intrusion. The increased concentration of other metals could originate from natural sources, such as the dissolution of manganese oxide, carbonates, and silicates, or from anthropogenic activities, including industrial discharge and landfill leachate. The study identified Mg, Fe, and Pb as the predominant metals in the study area. The

activity concentrations of radionuclides 226Ra, 232Th, 40K, and 137Cs in the water samples were below the detection limit.

The pH and electrical conductivity levels in the soil samples were within acceptable ranges. The estimated activity concentrations ranged from  $31.84 \pm 1.62$  to  $37.53 \pm 2.17$  Bq/kg for 226Ra,  $40.74 \pm 2.39$  to  $52.13 \pm 3.15$  Bq/kg for 232Th,  $472.06 \pm 28.46$  to  $685.23 \pm 44.13$  Bq/kg for 40K, and  $1.15 \pm 0.42$  to  $1.25 \pm 0.30$  Bq/kg for 137Cs. Notably, all these values were significantly higher than the reported world average values for 226Ra (30 Bq/kg), 232Th (35 Bq/kg), 40K (400 Bq/kg), and 137Cs (4 Bq/kg).

The findings of this research will be beneficial for monitoring and comparing environmental data before and after the operational phase of the RNPP.

## 2. 論文

N/A

## Investigation of sedimentation areas in the Fukushima coastal area for Cs-bearing microparlicles released from rivers using Lagrangian particle tracking model

研究代表者:Bezhenar Roman 受入研究者:高田 兵衛・津旨 大輔 共同研究者:Maderich Vladimir

### 1. 成果

13 years since the Fukushima nuclear accident, the coastal area in front of the Fukushima Dai-ichi Nuclear Power Plant remains contaminated. First of all, it is related to the bottom sediments, which were contaminated with Cs-137 during the accidental and post-accidental releases. Additional contamination of bottom sediments could be caused by river runoff of Cs-bearing microparticles, which were formed in the initial phase of the accident, dispersed in the atmosphere and fell into the watershed of nearby rivers. Cesium may be preserved in such particles for a long time due to its insoluble characteristics. River runoff carries suspended particles along with Cs-bearing microparticles to the coastal areas of the ocean, especially during heavy rains. In the study we applied the Lagrangian particle tracking model Parcels to identify places of potential deposition of such Cs-bearing microparticles in the Fukushima coastal area. As input data we used

- 3D circulation data from the detailed ROMS-based ocean circulation model customized to the Fukushima coast for the period 2013-2016;

- Estimates of released Cs-bearing microparticles from rivers during heavy rains in the selected period;

- Estimates of microparticles' sizes defining vertical velocity of their falling down in the ocean.

The maximum water discharge from the Abakuma River in the period of available ocean circulation took place in early September 2015 and corresponded to the Tropical Storm Etau. In the considered period, the flowrate of the Abakuma River changed from 600 m3/s to 6000 m3/s and back to 600 m3/s. We suggested to release 1 Lagrangian particle per hour at the time of 600 m3/s flow rate and 100 Lagrangian particles per hour at the time of 600 m3/s flow rate that agrees with Takata et al. (2021), where increasing of flow rate by 10 times led to increasing of suspended particle discharge by approximately 100 times. Microparticles of 3 sizes (average – 23.4 um, minimal – 11.6 um, and maximal – 32.7 um) were considered, according to measurement data by Taniguchi et al. (2020). Stokes settling velocity was applied to each particle size.

As a result, areas of initial distribution of microparticles on the seabed near the Abakuma River mouth after the Tropical Storm Etau in early September 2015 are identified. It is shown that the sedimentation area for microparticles with size 11.6 um is much larger than that for microparticles with size 23.4 um and 32.7 um. Later, under the influence of tides, waves and extreme currents, microparticles can be resuspended and settled in other places. They can also migrate to deeper areas due to bedload. Results of the study were submitted to the EGU-25 conference (Abstract 8294: Sedimentation areas along the Fukushima coast for Cs-bearing microparticles from the Lagrangian particle tracking).

## Tritium measurement in hot springs in the Carpathian basin (EU) and the Hamadori-Hakadori (Japan) mountain ranges

研究代表者:Tóth Piroska 受入研究者:グシエフ マキシム 共同研究者:Hegedűs Miklós

#### 1. 成果

The Carpathian basin, similar to Japan, is the home of a large number of natural and thermal springs, which offer a potential interest for tritium measurements. However, tritium data are sparse in mountainous ranges' water resources and could provide valuable insights to the hydrodynamics of the area. In Japan, Fukushima Prefecture has recently receiving more international attention due to the Fukushima Daiichi Nuclear Power Plant (FDNPP) discharge into the ocean, however data are still relatively sparse in natural and thermal springs created by three mountain ranges. In our study, we collected fresh water and geothermal water samples of natural fresh and thermal springs in Tsuchiyu onsen of Fukushima, Japan and Carpathian basin, EU in summer 2023. For the Tsuchiyu onsen sites, fresh and geothermal water samples were distilled at IER and enriched from 300 mL and 500 mL to 50 mL by TRIPURE at Hirosaki University. The 50 mL enriched sample was mixed with 50 mL scintillator (Ultima Gold uLLT, PerkinElmer) in a 100 mL Teflon vial, and were measured by ALOKA Liquid Scintillation Counter Low Background 8 (LSC-LB8) for 1000 min. For Hungarian study sites, freshwater and thermal water spring samples were collected, distilled and are schedule for the enrichment in the next phase of this study. In the Tsuchiyu onsen six sites, the H-3 values of Shimonoyu spring and Lake 1 spring are similar with  $0.32(\pm 0.02)$  Bq/L and  $0.31(\pm 0.02)$  Bq/L, respectively indicating similar groundwater circulation. The River 2 site has higher H-3 of  $-0.39(\pm 0.02)$  Bq/L confirming rain water H-3 contribution to the sampling point. Following these results, we sampled three freshwater and Shinomoyu geothermal water on 4th March 2025 for tritium measurements. For two geothermal bores, both H-3 values are below the detection limit of 0.06 Bq/L suggesting that higher enrichment factor and needs to be applied in the next phase of our joint study.

## Tritium measurements in New Zealand and Japan fresh and thermal water springs

研究代表者:Morgenstern Gerd Uwe 受入研究者:グシエフ マキシム

#### 1. 成果

Japan and New Zealand (NZ) have many natural freshwater and thermal springs making them valuable water resource. For sustainable management, their water dynamics need to be understood. Environmental H-3 radioisotope with a half-life of 12.32 years is a useful tracer to study water circulation. In the thermal springs, H-3 levels are expected to be minimal requiring large water volume for the ultra-low level tritium analysis, which is only provided by a few H-3 laboratories, such as GNS Science, NZ and International Atomic Energy Agency (IAEA) HQ, Vienna.

To understand water dynamics, we collected fresh water and geothermal water samples of natural fresh and thermal springs of NZ and Japan, in Tsuchiyu onsen of Fukushima, Japan and Rachel Hot Springs, NZ. In Tsuchiyu onsen, 2L of fresh water samples were collected at Shimonoyu spring, Lake spring and River and of 3 geothermal water at Shimonoyu onsen, and Thermal Well No. 1 & 2. The H-3 values of Shimonoyu spring and Lake 1 spring are similar with  $2.70(\pm 0.15)$  TU and  $2.65(\pm 0.15)$  TU, respectively, indicating similar groundwater circulation. The River 2 has higher H-3 of  $3.30(\pm 0.15)$  TU confirming rain water contribution to the sample. For two thermal bores in Tsuchiyu, H-3 values are below the 0.51 TU detection limit suggesting that the better detection limit and higher enrichment factor are necessary to identify small fractions of young water. In NZ study sites, hot spring samples were collected, distilled and electrolytically enriched with EF=90 while the ultralow level LSC with Detection Limit=0.015 TU (or 0.002 Bq/L) is on-going at GNS Science. As a result, the comparison would benefit the international collaboration between the NZ and Japan to provide tritium measurements in natural and hot water springs to general public.

## Establishment of FISH probes for dicentric analysis of wild rodents in Chornobyl

研究代表者:Burdo Olena 受入研究者:石庭 寛子・三浦 富智・アンダーソン ドノヴァン・藤嶋 洋平 共同研究者:中田 章史

#### 1. 成果

Dicentric chromosomes, which are radiation induced chromosome aberrations, are difficult to analyze in rodents because majority of the chromosomes are acrocentric and the short arms are not visible. The purpose of this study is to establish fluorescence in situ hybridization (FISH) method for the bank vole, Myodes glareolus (2n = 56), which is a common rodent species in Chornobyl, in order to simplify and shorten the dicentric assessment by visualizing the centromere of chromosomes. However, conducting research in Ukraine has become difficult and unsafe due to the on-going war. To progress our research, we decided to establish FISH probes for a closely related rodent species in Japan.

Using extracted DNA from liver of bank vole (previous study: I-21-11) as a template, the candidate centromere-specific tandem repeat region, Msat-160, was amplified by PCR (referenced by Jernfors et al., 2021) and a novel sequence of 260 bp without homologous was cloned. Then, using designed primer pair based on Msat-160 motifs extracted from whole genome sequence data of bank vole, PCR was conducted for three species, bank vole, grey red-backed vole (M. rufocanus), and northern red-backed vole (M. rutilus) (previous study: I-23-19). Non-consensual sequence was cloned from an amplified band from northern red-backed vole. These two new sequences were labeled with a fluorescent dye to create probes and hybridize to bank vole chromosomal DNA . Probes from bank vole stained most of chromosomes but not all. Comparing the two types of probes, probes from northern red-backed vole merged whole probes from bank vole and stained additional 4 centromeres. As a next step, we will clone another candidate sequence amplified from related species, the northern red-backed vole, and try for FISH analysis.

## Development of a test bench for the electronics of ionizing radiation detectors based on FPGA and microcontrollers

研究代表者: Kountchou Noube Michaux 受入研究者:床次 眞司・細田 正洋 共同研究者:Saïdou・Mbarndouka Taamté Jacob・Folifack Signing Vitrice Ruben・ Omgba Abanda Zacharie Stève・Yerima Abba Hamadou

#### 1. 成果

The primary objective of this project is to develop an efficient, low-cost local test bench for verifying the accuracy of electronic circuits in ionizing radiation detection equipment. Additionally, the project aims to reduce maintenance costs, minimize breakdowns, refurbish existing equipment, improve staff performance, and enhance laboratory capabilities. The test bench will also facilitate pole-zero cancellation adjustments and the study of the pile-up effect.

As part of this initiative, our team has been dedicated to developing a cutting-edge test bench specifically designed for the electronics of ionizing radiation detectors. Our goal is to create a solution that not only ensures the reliability of electronic circuits but also addresses key objectives such as cost reduction, equipment longevity, and the overall enhancement of CRSTN and IREM laboratory capabilities.

The project began with a thorough analysis of requirements, involving extensive discussions with stakeholders to gain a comprehensive understanding of their needs and expectations. Based on these insights, we carefully selected appropriate hardware components, including FPGAs and microcontrollers, ensuring they met stringent criteria for performance, flexibility, and cost-effectiveness. Particular attention was given to selecting analog components such as ADCs, DACs, and operational amplifiers, essential for signal conditioning and data acquisition.

With clearly defined requirements and carefully chosen hardware, we proceeded to design the system architecture. This phase involved outlining the interconnections between the FPGA and microcontrollers, defining communication protocols, and assigning specific roles to each component.

Beyond development and validation, a strong emphasis will be placed on documentation and training. Comprehensive documentation will be compiled, detailing design specifications, implementation methodologies, and testing procedures. Training sessions will be conducted to equip laboratory personnel and maintenance staff with the necessary skills to effectively operate and maintain the test bench.

Looking ahead, we will focus on further validation tests, gathering user feedback for

continuous improvement, exploring collaboration opportunities with other research institutions, and closely monitoring the test bench's performance in real-world conditions. We are confident that this test bench will play a pivotal role in advancing ionizing radiation detection technology, fostering innovation, and driving excellence in scientific research.

## 2. 論文

Taamté, Jacob Mbarndouka, Michaux Kountchou Noube, Vitrice Ruben Folifack Signing, Yerima Abba Hamadou, Hosoda Masahiro, and Shinji Tokonami. "Real-time air quality monitoring based on locally developed unmanned aerial vehicle and low-cost smart electronic device." Journal of Instrumentation 19, no. 05 (2024): P05036, DOI 10.1088/1748-0221/19/05/P05036 (IOP).

## Design and realization of a smart survey meter based on low-cost electronic components for simultaneous ambient equivalent dose rate and radon concentration measurement: Calibration with a stable radon gas in low, medium and high concentration

研究代表者:Mbarndouka Taamte Jacob 受入研究者:床次 眞司・細田 正洋 共同研究者:Saïdou・Oumar Bobbo Modibo

### 1. 成果

In our current context the prevalence of respiratory diseases is very high and the major cause after smoking is exposure to residential radon, thoron and its descendants. Real-time monitoring of radon and thoron in homes should be a priority in all countries around the world. In African countries, the process of measuring radon and thoron is supported by international laboratories, as there is no calibration system for radon and thoron detectors installed on the continent. This delays decision-making for the protection of populations against radioactive gases. The project on the Generation of stable gases of radon and thoron at low, medium and high concentration and application to the calibration system aims to :

Locally master the technique of generation of a stable concentration (low, medium and high) of radon and thoron gases for the calibration system of radon and thoron detectors. Many commercial devices are used for the measurement of radon (Rn-222) and thoron (Rn220). These devices must be regularly calibrated. The principle of calibration consists of enclosing the instruments in a known volume, injecting a primary radon standard at a time, and calibrating the devices considering the radioactive decay of radon. One or more measuring instruments can be placed inside the sealed volume of the calibration chamber. The radon standard is circulated in this volume using a closed cycle pump and a fan which ensures the homogeneity of the radon activity concentration in the chamber. To implement our calibration project, we proceed by several working methods, such:

Development and calibration of electronic devices for measuring ambient equivalent dose rate and radon concentration based on new technologies in order to master locally nuclear instrumentations

## 2. 論文

1- Vitrice Ruben Folifack Signing, Jacob Mbarndouka Taamté, Michaux Kountchou Noube, Zacharie Stève Omgba Abanda, Hamadou Yerima Abba, Saïdou "Real-time environmental radiation monitoring based on locally developed low-cost device and unmanned aerial vehicle", Journal of Instrumentation, 18 P05031, https://doi.org/10.1088/1748-0221/18/05/P05031, 2023, (IOPscience).

2- Jacob Mbarndouka Taamté, Michaux Kountchou Noube, Vitrice Ruben Folifack Signing, Yerima Abba Hamadou, Hosoda Masahiro, Saïdou, and Shinji Tokonami, "Real-time air quality monitoring based on locally developed unmanned aerial vehicle and low-cost smart electronic device", Journal of Instrumentation, 2024, https://doi.org/10.1088/1748-0221/19/05/P05036, JINST 19 P05036 (IOP).

3- Jacob Mbarndouka Taamté, Vitrice Ruben Folifack Signing, Modibo Oumar Bobbo, Kountchou Noubé Michaux, Yerima Abba Hamadou, Saïdou, "Air Quality Assessment Based on a Smart Locally CO2 Monitoring System With Validation by a Reference Instrument", Sustainable Chemical Engineering, DOI: https://doi.org/10.37256/sce.5120244286, SCE 2024, 5, 259-278.

4- Jacob Mbarndouka Taamté, Koyang François, Gondji Dieu Souffit, Oumar Bobbo Modibo, Hamadou Yerima Abba, Kountchou Noubé Michaux, Saïdou, Shinji Tokonami, "Low-cost radon monitoring with validation by a reference instrument", Instrumentation Science and Technology, 2022, https://doi.org/10.1080/10739149.2022.2095401, (Taylor and Francis).

## **Environmental Radioactivity, Radiation Physics**

研究代表者: Prasad Ganesh 受入研究者:床次 眞司・大森 康孝・細田 正洋 共同研究者: Singh Deepak

1. 成果

The potable groundwater samples is collected from 100 different locations in Yamuna and Tons Valleys. The universally accepted protocols of the American Public Health Association (APHA) is be followed for sample collection, preservation, transportation and analysis. This study investigates the concentrations of different heavy metals 52Cr, 55Mn, 56Fe, 60Ni, 63Cu, 66Zn, 75As, 78Se, 95Mo, 111Cd, 121Sb, 137Ba, 208Pb and 238U in the water samples is measured using an Agilent 8900 Triple quad Inductively Coupled Plasma Mass Spectrometer (ICP-MS). Groundwater samples obtained from Yamuna and Tons valley of western Himalayan. The average concentrations of Cr, Cd, TDS, Mo, and Pb have been found to surpass yet fall below the WHO drinking water standard threshold. Heavy metals from both natural and man-made sources affect the groundwater at the test locations. Using a number of indicators, the study conducted a thorough assessment of the overall pollution situation. The levels of Zn, Pb, and Cd pollution range from low to high, from pristine to badly contaminated, and from negligible to seriously affected. The groundwater in the study area appears to be fit for human consumption based on the water quality indices. Therefore, it can be concluded that the inhabitants of the study area have no significant health concerns (both carcinogenic and non-carcinogenic) from the exposure to uranium in the collected water samples. Beyond health risk assessment, uranium levels in groundwater can contribute to geochemical exploration, generation of baseline data and offer insights into geochemical processes in the Himalayan region. Next, we will collect additional samples from the designated region and analyze them for all the heavy metals mentioned above. Subsequently, we will prepare a manuscript and submit it to a suitable journal for publication.

Attended the "5th National Conference on Radiation Awareness & Detection in the Natural Environment (RADNET-V)" from October 7-9, 2024, organized by the Department of Physics, Graphic Era University in association with RADNET India.

Presented two posters at the conference titled:

1. Occurrence, correlation and health implications of uranium and other PTEs in Himalayan Springs.

2. A systematic study of uranium toxicity in drinking water of the Tons valley, Garhwal Himalaya, India.

2. 論文

Nil

## Radiological characterization of local building materials and environmental monitoring of the iron bearing areas of Mbalam, Kribi and Bipindi, South-Cameroon. (Continued)

研究代表者:Ndjana Nkoulou li Joseph Emmanuel 受入研究者:床次 眞司・大森 康孝・クランロッド チュティマ 共同研究者:Saïdou・Tchuente Siaka Yvette Flore・Oumar Bobbo Modibo

## 1. 成果

 Determination of the radioactivity level in the environment and in local building materials;

 Determination of the indoor and soil activity concentrations of radon and thoron gases;

 Determination of the contribution of exhaled radon and thoron from local building materials;

□ Establishment of the radiological risk mapping of the area.

## I-24-33

## Risk and analysis base on stress oxidative and immune biomarker

研究代表者:Yusuf Darlina 受入研究者:三浦 富智

共同研究者: Tetriana Devita · Lusiyanti Yanti · Purnami Sofiati · Utami Tyas Hayu

### 1. 成果

The Long-term exposure to ionizing radiation (IR) can cause health consequences, even below the dose limit IR exposure in radiation workers, alters the redox environment by increasing the amount of ROS. Increased levels of reactive oxygen species (ROS) can cause oxidative DNA damage. The chronic oxidative stress is involved in many pathological conditions such as inflammation, fibrosis, necrosis, DNA damage, and cancer. Understanding the potential health effects of IR exposure, especially among radiation workers, is essential for further tailoring targeted preventive interviews to reduce harmful IR exposure. Therefore, in this study, we aimed to investigate the association between IR exposure and changes in 8 OHdG and interleukin-6 (IL-6). The samples used in this research were the plasma from 10 radiation workers and 10 controls group. Blood was collected using EDTA tubes. divided into 2 tubes, one tube was irradiated using cobalt60 with a dose of 2 Gy. Plasma was isolated using centrifugation. Concentrations of 8-OHdG and IL 6 were measured using the ELISA method.

The concentration of 8 OHdG was almost the same in all groups. The concentration of 8-OHdG in the samples after irradiation also did not appear to be different. The concentration of IL6 in the blood samples of the worker group was higher than the control but not significantly different. The concentration of IL6 in the blood samples of the irradiated worker group was the highest. There was no significant difference between the blood of workers before and after irradiation. The concentration of IL6 in the samples exposed to 2 Gy radiation, the worker group was significantly higher than the control.

The conclusion that there was no significant difference in both parameters of oxidative stress or inflammation between the two groups. In other words, in our study exposure to ionizing radiation had no adverse effects on both parameters

## Bacterial-assisted Environmental Phytoremediation of Cs-137 Contaminated Soil

研究代表者:Winarni Dwi Ilma 受入研究者:赤田 尚史・田副 博文 共同研究者:Nugraha Djatnika Eka

#### 1. 成果

This study aimed to develop an environmentally friendly and sustainable remediation strategy for <sup>137</sup>Cs-contaminated land. This study establishes a framework for remediating soil contaminated with <sup>137</sup>Cs using bacterial-assisted environmental phytoremediation techniques. A key aspect is the selection of plant species suitable for phytoremediation combined with compatible microbes. Plant-based technology has been proposed as a costeffective, operationally simple, and eco-friendly strategy for remediating radiocesiumcontaminated soil. Numerous studies have been conducted to identify plants or varieties that can effectively accumulate <sup>137</sup>Cs. To investigate suitable phytoremediation plants, this study estimates the soil-to-banana transfer factor of radionuclides in southern Lampung, Indonesia, a region influenced by a large coal-fired power plant (CFPP) and other heavy industrial activities. Coal combustion in CFPPs concentrates natural radionuclides from the uranium and thorium series within the resulting ash. Soil and banana samples from Srengsem, Mataram, and Rangai Tri Tunggal villages were analyzed for <sup>226</sup>Ra, <sup>232</sup>Th, and <sup>40</sup>K using a calibrated P-type High-Purity Germanium (HPGe) detector. The study found average activity concentrations in soil were 26  $\pm$  1 Bq kg<sup>-1</sup> for <sup>226</sup>Ra, 28  $\pm$  1 Bq kg<sup>-1</sup> for <sup>232</sup>Th, and 368  $\pm$  12 Bq kg<sup>-1</sup> for <sup>40</sup>K. In the banana, <sup>226</sup>Ra at 6  $\pm$  1 Bq kg<sup>-1</sup> and <sup>40</sup>K at 288  $\pm$ 10 Bq kg<sup>-1</sup> were detected, while <sup>232</sup>Th was below the detection limit. The transfer factors for  $^{226}$ Ra and  $^{40}$ K were calculated at 0.3  $\pm$  0.2 and 1.6  $\pm$  1.3, respectively, indicating medium to high radionuclide uptake by the banana.

## Capacity building for development of nuclear techniques for analysis of radionuclides and potential toxic elements in environmental samples

研究代表者:Rahman Md Safiur 受入研究者:田副 博文 共同研究者:Choudhury Rabia Tasrina

### 1. 成果

Research Result

During the project period, we had not done any research dealing with the radionuclides in environmental samples but we have done research on potential toxic elements in surface water and the research work has been published with the following title in Heliyon Journal.

Potential toxic elements in surface water of Mokosh Beel, Gazipur, Bangladesh: Ecological and human health risk assessment for recreational users

Heliyon 11 (2025) e42421

https://doi.org/10.1016/j.heliyon.2025.e42421

Mokosh Beel, a significant wetland in Bangladesh, is increasingly impacted by industrial effluents, leading to potential ecological and human health risks. This study evaluates the surface water quality of Mokosh Beel by analyzing both physicochemical parameters (pH, DO, EC, TDS, and salinity) and the concentrations of potential toxic elements (PTEs) (i.e., Mn, Cu, Ni, Pb, As, Cd, Co, Cr, Sb, and Zn). The findings reveal that most water quality parameters, except pH, exceeded local and international guidelines, indicating poor water quality. Among the PTEs, Mn (269.13  $\mu$  g/L), Cr (33.20  $\mu$  g/L), and Pb (71.47  $\mu$  g/L) surpassed recommended safety limits. The spatial distribution analysis identified Mn and Pb as the primary pollutants based on the singlefactor pollution index. The Nemerow pollution index indicated mild to moderate pollution, while the heavy metal pollution index (HPI) and heavy metal evaluation index (HEI) suggested a low degree of pollution at most sampling sites. Principal component analysis (PCA) and hierarchical cluster analysis (HCA) linked the majority of PTEs to industrial sources, particularly from tannery, leather, and paint industries. The potential ecological risk index (PERI) showed minimal ecological risk, but the hazard index (HI) indicated non-carcinogenic risks for children, although adults were not significantly affected. Carcinogenic risk assessments highlighted Pb and Cd as key contributors, with risks exceeding the critical threshold for both children and adults. This study underscores the urgency of addressing industrial pollution to safeguard both ecological

health and human well-being, particularly for vulnerable populations like children. Policymakers must implement sustainable water management strategies to mitigate the ongoing contamination of Mokosh Beel.

## Precise and rapid determination of 238U in seawaters from the Southern Ocean using ID-ICP-MS

研究代表者: Mas José Luis 受入研究者:田副 博文 共同研究者: 篠永 妙子

#### 1. 成果

Objectives.

To determine the concentration of 236U (aU-236) in seawater using the result of isotope ratio 236U/238U (AMS), we quantify 238U concentration (c238) in the seawaters using ID-ICP-MS. A rapid and precise analytical method was developed and applied. The method developed could be applicable for the analysis of 236U in emergency case, e.g., Fukushima Daiichi Nuclear Power Plant incident.

Methods.

Seawater and seawater ice fragments were collected at the Southern Ocean following a transect covering 51°S-67°S. The seawater samples were diluted  $\boxtimes$  1:15 m:m in 1% HNO3 and spiked with approximately 20 pg of 233U. Then the 238U concentration was calculated after measuring the 233U/238U isotope ratio (ID-ICP-MS) with an ICP-MS/MS (Agilent 8800) coupled to a CETAC ARIDUS II desolvation system at the Servicio de radioisótopos laboratory, CITIUS, University of Sevilla, Spain. This approach allows a precise determination of low 238U concentrations without the need to apply a previous radiochemical separation.

Results.

The calculated concentrations ranged from very low values (0.131  $\boxtimes$ g/kg) to the expected concentrations range in open seawater (3.1-3.4  $\boxtimes$ g/kg). The relative uncertainties ranged 4-14%. They were calculated for a significance  $\boxtimes$  = 0.05 (i.e., k =2) after quadratic propagation as required by GUM.

The lower values reflect the result of mixing processes between seawater and melted ice, because dissolved salts such as UO22+ ion are extruded during ice formation. The extrusion process also affects the dissolved uranium, leading to a decrease of its concentration regarding the seawater.

Date of report: 2025-03-01

#### I-24-39

## 239Pu, 240Pu and 237Np in seawater from the Southern Ocean

研究代表者:López-Lora Mercedes 受入研究者:田副 博文 共同研究者:篠永 妙子・Chamizo Elena

#### 1. 成果

#### Objectives:

This project aims to analyze 239Pu, 240Pu and 237Np in sea ice fragments from the Southern Ocean, following up on our previous ERAN-2023 project which focused on seawater samples. The 1 MV Accelerator Mass Spectrometry (AMS) system at the CNA (Seville, Spain) was used for the analysis. The data could be helpful for a better understanding of the sources and pathways of 239Pu, 240Pu and 237Np into the Southern Ocean, including a possible impact from the Fukushima Daiichi Nuclear Power Plant incident on the region of interest.

#### Methods:

239,240Pu and 237Np samples were processed and analyzed at the CNA (Seville, Spain) following the methods in (López-Lora et al., 2019; López-Lora and Chamizo, 2019). Pu and Np were extracted as monoxide anions (e.g. 239Pu160) from the Cs sputter ion source; analyzed on a first 90° sector magnet; stripped to 3+ charge state (e.g. 239Pu3+) in He gas at 670 kV in the accelerator terminal; analyzed on a sector magnet and on an electrostatic deflector; and finally, counted from the total energy signal provided by a gas ionisation chamber. The CNA Pu+Np in-house standard was used for normalisation. Targets containing only iron oxide and Nb were inserted to keep track of the instrumental background. The laboratory background during chemical separation processes was controlled through procedural blank analysis. The masses of interest (i.e. 237Np, 239Pu, 240Pu and 242Pu, the yield tracer) were counted in a 5-20 s pulses using the ARGUS software machine. Background levels for 237Np, 239Pu and 240Pu were below 0.1, 2 and 0.4 fg, respectively.

Results:

The results indicate higher 239Pu concentrations in certain sea ice fragments than in seawater. The 237Np concentrations in the sea ice fragments, in contrast, decrease compared to the seawater. The 240Pu/239Pu isotope ratio in some seawater and sea ice samples is below the global fallout level for the 30-53° South latitude, 0.185  $\pm$ 0.047 (Kelley et al., 1999). However, the variations in this ratio across samples indicate a need for additional data to interpret those values properly. The findings from this project, along with any future related data, may serve as valuable information for understanding the marine dynamics in the area studied. No effects from the Fukushima Daiichi Nuclear Power Plant incident were found in the samples analyzed.

References:

Kelley, J.M., Bond, L.A., Beasley, T.M., 1999. Sci. Total Environ. 237–238, 483–500.

López-Lora, M., Chamizo, E., 2019. Nucl. Instruments Methods Phys. Res. Sect. B Beam Interact. with Mater. Atoms 455, 39–51.

López-Lora, M., Levy, I., Chamizo, E., 2019. Talanta 200, 22–30.

## Measurements of U-236 in seawater samples from the Southern Ocean

研究代表者: Perez Tribouillier Uematzin Habacuc 受入研究者:田副 博文 共同研究者: 篠永 妙子

#### 1. 成果

#### Objectives:

This project aims to analyze 236U in seawater samples from the Southern Ocean using Accelerator Mass Spectrometry (AMS)-MILEA system at ETH Zurich, collaborating with the CNA, Spain and IREM, Hirosaki University. The data could be helpful for a better understanding of the sources and pathways of 236U fallout into the Southern Ocean, including a possible impact from the Fukushima Daiichi Nuclear Power Plant incident on the region of interest.

#### Methods:

236U and 238U source for AMS measurements were prepared at the CNA (Seville, Spain) and subsequently analyzed at the Laboratory of Ion Beam Physics, ETH Zürich using the 300 kV Multi-Isotope-Low-Energy-Accelerator Mass Spectrometer (MILEA). The U as oxide, was introduced into the ionizing source in matrix of iron oxide and Nb. They were bracketed with the ETH in-house standard Zuttri and with the targets containing only iron oxide and Nb to keep track of the instrumental background. The laboratory background during chemical separation processes was controlled through procedural blank analysis. The standard setup for U measurements at the ETH MILEA system consists of a combination of three slow sequential cycling sequences, with fast cycling of the abundant 238U isotope with 236U, 233U and 235U. Background levels for the measurements were below  $2 \times 10^{-14}$  for 236U/238U and the 236U/238U precision of the measurements was typically below 5%.

#### Results:

The concentrations of 236U in seawater  $(1.6-2.7)\cdot10^{5}$  (atom/kg) (n=3) were found to be 1-2 orders of magnitude lower than that found in the Atlantic Ocean (Christl, 2012). The 236U/238U atom ratios in surface waters were  $(2.0-3.3)\cdot10^{-11}$  (n=3), while in the sea ice fragments ratio were  $(2.2-48)\cdot10^{-11}$  (n=2) The higher amount of 236U in the sea ice fragments may be due to atmospheric deposition of global fallout. However, the variations in this ratio across two sea ice samples and high uncertainty indicate a need for additional data to interpret those values properly. Similar to this result for U, some sea ice samples showed higher concentrations of 239Pu and 240Pu, and lower 240Pu/239Pu atom ratios than seawater (ERAN I-24-39). The impact of the Fukushima DNPP incident could not be confirmed by the samples analyzed. Reference: Christl, et al., Geochim. Cosmochim. Ac. 77 (2012) 98.

## Evaluation of the transferrability of an AI driven radon release prediction method based on machine learning

研究代表者:Csordás Anita 受入研究者:大森 康孝・床次 眞司 共同研究者:Homoki Zsolt

#### 1. 成果

Radon isotopes are responsible for approximately 50-70% of natural radiation exposure to humans, and pose the second highest lung-cancer risk after smoking, so identifying radon-prone areas would help focusing resources to achieve an efficient use of resources for maximum public benefit. The two main sources of indoor radon concentration are the underlaying soil and the building materials. The radionuclide content of modern building materials is being controlled by the screening of building material based on gamma spectrometry, however old building material, and novel building material incorporating NORM may pose challenges, as does the underlying geology. Modern building practices, such as higher energy efficiency, and more insulated buildings equipped with air conditioning may increase previously measured radon concentrations due to changes in ventillation, and restricting air-exchange. ANN based machine learning is a powerful predictive tool for predicting radon risk, and it has been previously used for predicting radon prevalence for a Vietnamese copper ore mine with good results.

Datasets of the sampling location, radionuclide concentrations, soil gas radon concentration, permeability, geogenic radon potential, soil type, measured gamma dose rate, and calculated gamma dose rate of Transdanubian region of Hungary were used to train, validate and test an ANN based algorythm for geogenic radon prediction using 80% of the dataset for training and 20% for prediction. The predictive capacity of the model was evaluated using the test dataset and various standard metrics (RMSE, MAPE, MABE, R and R squared). The ANN was also tested on Japanese datasets to check the transferability of the method and predictive capability.

Compared to the relatively homogeneous region in the vicinity of the Vietnamese copper mine, the heterogeneous nature of the Transdanubian Region reguires the inclusion of further parameters. The gamma dose rate or soil Ra-226 concentration, while connected to GRP and radon gas concentration in soil and air, were not reliable predictors of Rn concentrations on their own. Th-232 does not seem to interfere significantly with the GRP measurement method. The current ANN based approach might still prove valuable on a smaller scale in more homogeneous regions after retraining. Japanese datasets can have similar issues as the Transdanubian region on a national scale due to the heterogeneity of the data, however regional or local scale evaluation might be worth pursuing.

In the future in addition to increasing the input requirement of the current model, the use of different machine learning approaches, such as autoencoder neural network hybridized to the Extra Trees model (AENN-ExT), multi-layer perceptron neural network (MLP), support vector regression (SVR), stochastic gradient descent (SGD), k-nearest neighbors (KNN), and hist gradient boosting regression (HGBR) might be considered and compared to the current ANN based approach.

## 2. 論文

Due to the short grant period and the difficulties during data analysis no joint paper was published by the research group between April 2024 and March 2025.

## Intercomparison on passive radon measurement for nation survey in Thailand caves.

研究代表者:Sola Phachirarat 受入研究者:クランロッド チュティマ・床次 眞司 共同研究者:田副 博文

1. 成果

Cave tourism in Thailand has grown increasingly popular due to its natural beauty, cultural significance, and local legends. However, caves are enclosed environments with limited ventilation, making them prone to the accumulation of radon gas (<sup>222</sup>Rn), a naturally occurring radioactive nuclide that poses health risks, particularly lung cancer after long-term exposure. This research project aims to conduct an intercomparison of passive radon measurement methods at IREM, Hirosaki University, Japan, as part of a national survey of radon levels in Thai caves. The calibration result was use to assess radon concentrations in tourist caves across Thailand and estimate the radiation dose received by visitors and staff. The goal is to establish a foundation for future safety measures and regulatory guidelines.

Since the project commenced in October 2024, the research team has reviewed literature on cave radon studies worldwide and conducted fieldwork at two pilot sites: Tham Chiang Dao in Chiang Mai and Tham Ta Lor in Khon Kaen. The field survey at Tham Chiang Dao was conducted between January 13–31, 2025, using an AlphaGUARD DF 2000 device for active radon measurements and Raduet detectors were put in the caves for 90 days for passive measurements. Soil and water samples were also collected for elemental analysis. The survey at Tham Ta Lor took place between February 17 and March 7, 2025, employing the same methodology. Preliminary results showed that the average radon concentration in Tham Chiang Dao was approximately 500 Bq/m³, while Tham Ta Lor had a higher average of around 1200 Bq/m³. Radon levels in the workplace should not exceed 1000 Bg/m<sup>3</sup>, as recommended by the International Commission on Radiological Protection (ICRP). These levels may pose health risks with prolonged exposure, particularly for cave staff or tour guides. Data from passive detectors are currently being processed and will be compared with active measurement results for validation. Despite steady progress, the project has faced some limitations. The one-year duration necessitates careful selection of caves to represent diverse conditions across the country. Seasonal challenges such as heavy rainfall, especially in southern Thailand, prompted a shift to survey caves in the northeast during the early stages. Additionally, obtaining permission to access tourist caves required coordination

with multiple agencies and was time-consuming.

On the academic front, the team has begun drafting the first research article to present preliminary findings in an international journal, such as "Toxics", by the end of 2025. This study is expected to contribute to the body of knowledge on radiation safety in Thai caves and support policy development in environmental and tourism management.

## 2. 論文

The results of this research study will be published in the TOXIC or Atmosphere journals by this year.

## Portable cancer detector based on DNA probe

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## 1. 成果

### Overview

Prostate cancer remains one of the most common cancers in men worldwide and is often diagnosed at late stages, resulting in high mortality rates. Prostate cancer antigen 3 (PCA3) has emerged as a promising biomarker, offering greater specificity than traditional prostate-specific antigens (PSAs) for early-stage diagnosis. In this study, we introduce a portable, quartz-crystal microbalance (QCM)-based biosensor enhanced with graphene oxide (GO) nanomaterials for the rapid, sensitive detection of PCA3, offering a viable solution for point-of-care diagnostics.

Methodology

The biosensor was developed using a layer-by-layer assembly of L-cysteine and graphene oxide, enhancing the surface area and increasing the density of binding sites for biomolecules. The GO-modified QCM electrode was thoroughly characterized using XRD, SEM, AFM, and FTIR, confirming the successful deposition of GO with carboxylic moieties, ideal for biomolecular immobilization. Optimization studies included EDC-NHS activation time, capture probe concentration, and incubation conditions.

Results and Performance

The GO-enhanced sensor exhibited excellent performance, detecting PCA3 targets across a wide concentration range (1.00 fM – 1.00  $\mu$  M), with a limit of detection (LOD) of 0.93 nM achieved within 20 minutes. SEM and AFM images confirmed a large surface area for GO particle deposition, while FTIR spectra validated the chemical functionality of the modified surface. Selectivity tests demonstrated exceptional discrimination of PCA3 from unrelated analytes including COVID-19, DLX1, and EGFR, all of which showed significantly lower responses—even at higher concentrations—than PCA3 at the lowest tested level.

Conclusion and Implications

The QCM-based biosensor incorporating GO nanomaterials enables rapid, accurate, and selective detection of the PCA3 biomarker, with promising implications for early prostate cancer screening. Its high reproducibility, selectivity, and stability highlight the potential for integration into clinical practice, particularly in urine-based diagnostics. This platform also sets the stage for broader biomedical applications, offering a flexible foundation for

detecting other disease-specific biomarkers in future point-of-care testing systems.

2. 論文

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## Proficiency test of passive radon measurement for nation survey at Hin Dat hot spring in Kanchanaburi, Thailand

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#### 1. 成果

This research aimed to test the proficiency of passive radon measurement analysis for outdoor radon measurement in high background radiation areas. Initially, six samples of Hin Dat hot springs were analyzed, consisting of two hot springs for the public, one hot spring for children, one drinking water well, one hot spring for monks, and a natural waterfall area to examine the amount of radon in the water using a RAD7 radon detector. The results showed that the radon values in the water ranged from 770 to 25,300 Bq L-1, with the lowest values found in the natural waterfall area adjacent to the hot springs and the highest values found in the hot spring for monks, which had relatively high levels compared to many other regions. The radon concentration in the air at three points around the area was measured with a radon detector (AlphaGuard), the values obtained ranged from 13 to 50 Bq m-3, approximately 500 times lower than the measured radon concentration in water and exceeded the average outdoor radon level mentioned by the World Health Organization: WHO (average of roughly 10 Bq m-3). Therefore, to test the ability of outdoor radon measurement with a passive measuring device, RADUET was installed in the hot spring area with a total of 10 installation points (23 samples) for 3 months. After completion, all RADUETs were sent to the Institute of Radiation Emergency Medicine, Hirosaki University, Japan, for etching and analysis using the RadoMeter system. The experimental results showed that the values ranged from 2 - 67 Bq m-3, and all samples had radon concentration values higher than the lower limit of detection (LLD). In conclusion, it is possible to use passive radon measurements to analyze outdoor radon concentrations in high background radiation areas. However, this method still has limitations for measurements in outdoor low background radiation areas.