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Applied Research Using Biodosimetry Techniques

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Abstract:
Biodosimetry is the estimation of absorbed radiation dose by analyzing biological responses or reactions of the human body. Chromosome aberrations are known to be induced in radiation-induced response in exposed cells, occurring in a dose-dependent manner. In biodosimetry, dicentric chromosome frequencies are used as endpoints for acute dose estimation, while chromosome translocation frequencies are used for retrospective dose estimation. Biodosimetry using these chromosomal aberrations as endpoints has been used for over 70 years. Chromosome aberration analysis techniques in biodosimetry are used to evaluate DNA damage and genetic toxicity, assess the biological impact of radiation, and conduct risk assessments. The Fukushima Daiichi Nuclear Power Plant accident caused by the Great East Japan Earthquake in March 2011 has made it an international proposition to elucidate the biological impact of low-dose and low-dose-rate radiation exposure. Therefore, we have been analyzing chromosome aberration frequencies and using biodosimetry techniques in various populations exposed to low-dose radiation, including wild animals[1], CT scan patients[2], occupational exposures, and residents. The Hirosaki University Chromosome Research Group introduced the various applications of biodosimetry techniques and summarize the effects of low-dose radiation exposure through chromosome aberration analysis. In addition, the challenge of predicting treatment effects by monitoring chromosome aberrations in radiotherapy patients will be discussed. Furthermore, the potential of using chromosome aberration monitoring to predict treatment efficacy in these patients will also be presented.

Key words:
Chromosome aberration, Low-dose radiation, Biological impact, Medical exposure

References:

1. Fujishima Y, Nakata A, Ujiie R, Kasai K, Ariyoshi K, Goh VST, *et al*. Assessment of chromosome aberrations in large Japanese field mice (*Apodemus speciosus*) in Namie Town, Fukushima. Int J Radiat Biol. 2022;98(6):1159–67.
2. Abe Y, Miura T, Yoshida MA, Ujiie R, Kurosu Y, Kato N, *et al*. Increase in dicentric chromosome formation after a single CT scan in adults. Sci Rep. 2015;5:13882.

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Dose Estimation in Rapid Triage Based on the Quantification of Histone H2AX Phosphorylation in Whole Blood by Flow Cytometry and Foci Counting

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Abstract:
The biological assay that provides a quick, reliable, and reproducible result in the eve of large-scale radiological or nuclear incidents to distinguish individuals with potential health risks remains an ongoing research interest in biodosimetry. In this work, we investigated the use of γ-H2AX assay as a tool to estimate a dose received in individual based on a combination of flow cytometric and image analyses for rapid triage. Whole blood samples were collected from 11 donors and irradiated *ex vivo* inside a water phantom by gamma rays at 0.51 Gy/min. The white blood cells were isolated, immunofluorescently labeled for γ-H2AX, CD45, and nuclear stained for analyses by flow cytometry and confocal microscopy. Based on flow cytometric analysis, the dose-response curve constructed from relative γ-H2AX intensities of lymphocytes showed a linear increase over the absorbed doses from 0 to 6 Gy with a large inter-individual variation observed above 2 Gy. The assessment of relative γ-H2AX intensities of lymphocytes showed a high correlation (Intraclass Correction Coefficient = 0.99) between data obtained by two different cytometry setups. In terms of image analysis, γ-H2AX foci collected by confocal microscopy were observed to be in discrete shape inside the nuclei and increase proportionally with doses from 0 to 2 Gy. However, at higher doses of 4 and 6 Gy, the foci appeared to merge into large plagues. The foci counts showed a significant difference at 0 vs 1 and 2 vs 4 Gy doses. By performing blind tests to evaluate the use of γ-H2AX assay, the dose estimation at 0.5 Gy by both flow cytometry and foci counting showed a mean absolute difference of less than 0.5 Gy from the actual value. Our work demonstrated that while flow cytometry provided the quick quantitation of γ-H2AX, foci counting of microscopy images was required in parallel as a confirmation.

Key words:
γ-H2AX, Biodosimetry, Radiation triage, Flow cytometry, Confocal microscopy

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Serum Metabolomics for Early Detection of Lung Cancer Risk in High Radon Areas of Thailand: a Pilot Study

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Abstract:
Lung cancer (LC) is the leading cause of cancer-related death in Thailand, particularly in upper northern regions. After cigarette smoking, indoor radon is the main risk factor for LC. However, there is still no specific biomarkers for detecting LC caused by long-term indoor radon exposure. The study aimed to identify potential biomarkers for LC risk in high radon areas using a metabolomics approach. A passive radon-thoron discriminative monitor (RADUET) was used to assess indoor radon activity concentration in Mae Chaem district, Chiang Mai province from September 2022 to March 2023. The estimated indoor radon activity concentration ranged from 18.5–119 Bq/m^3 with an average value of 40.8 ± 22.6 Bq/m^3. Based on the indoor radon activity concentration measurements, serum samples from 15 LC patients and 30 matched healthy controls (low- and high-radon groups) were analyzed. Interestingly, a total of 139 differential metabolites were selected as promising biomarkers by the criteria of the variable importance in projection (VIP) ≥ 1 and a *P* value of ≤ 0.05. Consequently, the receiver operating characteristic curves indicate that 36 of these metabolites have the potential to serve as biomarkers of LC development caused by prolonged exposure to indoor radon. Among these, the fold change of 14 metabolites such as D-sphingosine, was considered significantly different in high radon groups compared to low radon groups. This study provides new insights into metabolic biomarkers for screening LC risk in areas with high residential radon exposure.

Key words:
Lung cancer, Indoor radon, Metabolomics, Biomarker

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How to Evaluate the Exhalation Rate of Radon and Thoron in Environmental Samples

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Abstract:
Radon and thoron come from soil, rocks, and building materials. The amount of radon gas exhaled from the soil into the atmosphere depends on the local ground surface and soil conditions. One of the indexes for exhaled radon from the materials is called the radon exhalation rate, often referred to as the radon flux. The radon exhalation rate is one of the most important factors that influences indoor and outdoor radon concentrations. Therefore, it is useful to measure the exhalation rates from the soil surface in order to identify a radon prone area. For this reason, we have carried out the in-situ measurements of radon exhalation rates using various techniques. In my presentation, I would like to show the various exhalation measurement techniques and the dependence of the environmental parameters on the exhalation rate from the soil surface. The typical methodology of radon exhalation rates requires an accumulation chamber and a radon monitor. These typical methods require a long time to allow for sufficient accumulation of radon gas in the accumulation chamber to determine the exhalation rate. Therefore, we have developed a new in-situ type radon exhalation rate monitor for small size and short time measurement periods. The details of our new monitor will also be presented in my talk. On the other hand, indoor thoron generally comes from the building materials in dwellings. Therefore, some key points of the methodology of thoron exhalation rates from building materials will also be mentioned.

Key words:
Exhalation rate, Radon, Thoron, Soil, Building materials

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A Comparative Study of Cytogenetic Staining Methods for Dicentric Chromosome Detection in Biological Dosimetry

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Abstract:
In biological dosimetry, the scoring of metaphases and the frequency of chromosome aberrations, particularly dicentric chromosomes, are critical for estimating unknown absorbed radiation doses. Dicentric chromosomes are a key biomarker in acute radiation exposure. However, dose estimates can vary between laboratories due to inconsistency in scoring and process of metaphase analysis[1)]. To address these challenges, different cytogenetic staining techniques can be used to improve the accuracy and efficiency of dicentric detection. Alternative methods to Giemsa, such as PNA-FISH, though accurate, are costly and time-intensive for slide processing, and C-banding requires hazardous chemicals and prolonged slide aging. Here, we report on the development of a rapid C-banding method and compare it with other staining methods. The study compared techniques including Giemsa, PNA-FISH for centromere and telomere staining, and the improved C-banding. Preliminary results indicated that Giemsa staining required the longest time to score metaphases, while C-banding and PNA-FISH significantly reduced scoring time. The scorer tended to find more dicentrics in Giemsa-stained slides, which could indicate misclassification. The findings suggest that the rapid C-banding could offer a cost-effective solution for minimizing variability in dicentric frequency.

Key words:
Dicentric, C-banding, PNA-FISH, Staining

References:

1. Anderson A, Abe Y, Goh VST, Nakayama R, Takebayashi K, Thanh MT, *et al.* The dicentric chromosome and its role in biodosimetry. Radiat Emerg Med. 2023;12(2):121–39.

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Statistical-based Modeling Strategy for Entrance Skin Dose Estimation in Patient Undergoing Body Interventional Radiology

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Abstract:
Interventional radiology (IR) provides significant advancements in diagnostic and therapeutic procedures, yet concerns persist regarding radiological risks such as erythema, burns, and epilation. Direct dose measurements observed difficulties regarding the perturbation of the detector probe in X-ray images during fluoroscopy-guided procedures, high-cost expenses, and non-compliant patients. This study aims to develop a statistical-based model for estimating entrance skin dose (ESD) in body IR procedures using patient radiation-dose recording data. Models are categorized into vascular and non-vascular procedures. The study demonstrates that the simplified models are sufficient in estimating patient ESDs for both IR groups, with a 95% confidence interval. This user-friendly method enables radiologists to calculate doses without complex parameters such as the backscatter factor and mass-energy absorption coefficient, as required in conventional calculation methods. Not only does this support radiologists in effectively refining treatment protocols, but it also enables patients to monitor their received doses immediately after treatment ends.

Key words:
Body interventional radiology, Entrance skin dose assessment, Radiological hazard

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Quantifying Radon Exhalation Rates from Latex Pillows and Evaluating Potential User Exposure

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Abstract:
In 2018, relatively high radon isotopes (^{220}Rn and ^{222}Rn) were detected in latex pillows led to an increase in monitoring system of radon exhalation rates in Thai-manufactured latex pillow products. Radon analysis laboratory of Thailand Institute of Nuclear Technology (TINT) regularly provides services to examine radon exhalation rates from pillows and building materials. Accurate measurement is crucial to dispel customer concerns. The research aimed to develop test method and to compare between new and conventional one to control the quality of radon exhalation measurements from latex pillows and estimate potential user exposure rate. The new system is composed of two loops, the first loop is designed to trap radon and thoron background until levels are nearly zero, and the second loop is the measurement loop to detect radon and thoron exhalation rates from the pillow samples. The results showed that massive radon exhalation rates from both systems ranged from 0.18 Bq kg^{-1} h^{-1} to 0.78 Bq kg^{-1} h^{-1}, with an average of 0.36 ± 0.17 Bq kg^{-1} h^{-1} in 9 pillow samples, while massive thoron exhalation rates were found below the limit of detection (LOD) of AlphaGUARD, which is 2 Bq m^{-3}. The annual average effective dose to pillow users was estimated to be 15.51 ± 12.69 μSv by assuming two pillows were regularly used throughout the year. It was found that the new system can decrease the total measuring time by more than 24 hours when compared to the conventional one. The results clearly demonstrate that our new prototype can effectively measure very low radon exhalation rates in latex pillows. In addition, it is certain that the radon exhalation rates obtained from our chamber were no contamination of radon from other sources.

Key words:
Radon emanation, Latex pillow, Annual effective dose

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Assessment of Radon Concentrations and Health Effects in Water in the Surrounding Mine Areas of the Kanchanadit and Ban Na San Districts, Surat Thani Province, Southern Thailand

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Abstract:
In certain areas of Surat Thani Province, mining activities have been conducted. It is well known that mining sites may pose environmental risks related to radon gas concentrations. Therefore, this work aimed to measure radon concentrations in consumption water in the surrounding dolomite mine area of Tha Utae sub-district, Kanchanadit District, and in the vicinity of the abandoned gypsum mine of Phoem Phun Sap Sub-district, Ban Na San District, using a RAD7 radon detector. Additionally, the annual effective doses for water ingestion and inhalation were assessed. A total of 67 samples collected from consumption water sources were studied. The results showed that radon concentrations in water ranged from 7.81 to 162.35 Bq/L, with an average level of 46.84 ± 30.74 Bq/L, which was higher than the maximum contaminant level for drinking water (11.1 Bq/L) but lower than the alternative maximum contaminant level (148 Bq/L). When comparing the average radon concentrations in water from the mining area of Tha Utae Sub-district, Kanchanadit District (51.76 ± 17.26 Bq/L), with those from Phoem Phun Sap Sub-district, Ban Na San District (43.31 ± 37.40 Bq/L), no statistically significant difference was found at the 0.05 level. Furthermore, the total annual effective dose from water ingestion and radon inhalation was 127.88 ± 83.91 μSv/y, which exceeds the reference level (100 μSv/y). These findings indicate that the water sources in the study areas are not suitable for drinking without proper standard treatment.

Key words:
Mining area, Radon in water, RAD7, Annual effective dose

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Evaluation of Activated Carbon Cartridges for Measuring Atmospheric Radon Concentration

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Abstract:
Internal exposure caused by the inhalation of radon is the second leading cause of lung cancer[1)]. Thus, radon concentration measurement is essential to minimize its effects on our health. A radioiodine sampler is used to monitor the environment around nuclear facilities today. The activated carbon stored in the sampler's cartridge can absorb not only radioiodine but also radon. In this study, we evaluated the activated carbon cartridges as passive radon collectors. Four cartridges were exposed to reference atmosphere of radon for 24, 48, 72, and 96 hours, respectively. Gamma rays from radon progenies trapped in the cartridge were then measured for 30 minutes using a high-purity germanium (HPGe) detector. As a result, the net counting rate of the cartridges exposed during the stable radon concentration showed consistent values, while those exposed during the lower radon concentration showed lower net counting rates. Therefore, fluctuation of the radon concentration influences the changes in the net counting rate. Our future work will aim to clarify how fluctuations in radon concentration affect the radon absorption ability of activated carbon cartridges.

Key words:
Activated carbon, Radon, Radioiodine sampler, HPGe detector

References:

1. World Health Organization. WHO Handbook on Indoor Radon: a Public Health Perspective. Geneva: WHO; 2009.

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Establishment of the Calibration Method for Passive-type Radon Progeny Monitor

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Abstract:
The passive-type radon progeny monitor (progeny monitor) can detect alpha emitters of radon and thoron progenies as tracks on the CR-39 at three channels with an energy discrimination function. These channels are called RnPI and RnPII for detecting radon progenies and TnP for detecting thoron progenies. The conversion factors (CFI and CFII) from the track density of the CR-39 to the Potential Alpha Energy Concentration (PAEC) for the progeny monitor were obtained in the radon exposure chamber and indoor environments, a hot spring facility, and a dwelling in Japan. The CFI and CFII were calculated based on the track density of ^{218}Po and ^{214}Po obtained from the RnPI and RnPII of the progeny monitors and the PAEC of 6.0 MeV and 7.7 MeV obtained from the Portable Environmental Radiation/Radioactivity Monitor, respectively. The CFI and CFII ranged from 2.3× 10^7 to 24 × 10^7 and 0.6 × 10^6 to 17 × 10^6 tracks mm^{-2} per J m^{-3} day, respectively, which were different by one order of magnitude. The CFI depended on the unattached fraction of radon progeny, which may be because most of the unattached fraction is ^{218}Po, and the deposition rate is faster than the attached fraction, increasing the number of ^{218}Po deposited on the progeny monitor. Nowadays measurements of environmental parameters in the indoor environment, such as unattached fraction, equilibrium factor, and attachment rate to aerosol, etc., are insufficient. Therefore, further data acquisition is necessary for a better understanding of their relationship with the CFI and CFII and for establishing a calibration method for the radon progeny monitor.

Key words:
PAEC, Track density, Conversion factor

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Influence of Soil Sample Thickness on the Evaluation of the Radon Emanation Coefficient

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Abstract:
A simple model for determining radon exhalation rate from soil was reported with the emanation coefficient as a critical parameter. Despite numerous estimates of radon emanation coefficients, conditions for experiments vary among researchers, and a standardized approach for laboratory experiments is lacking. In order to determine the suitable experimental conditions, this study evaluated the effect of soil sample thickness on the evaluation of emanation coefficients. An accumulation method was adopted in which soil samples. The samples were spread with the thickness of 1-7 cm on stainless steel trays and sealed in a 6.7 L accumulation chamber. Emanation coefficients were calculated from radon concentrations in the accumulation chamber and radium concentrations in the soil samples. The experiment was carried out with dried soil samples and a moisture saturation of 0.3 conditions. The emanation coefficient was examined at the thickness of 1 cm with the ratio of the volume of the gas phase in the accumulation chamber to the volume of the soil sample (volume ratio). The emanation coefficient for the dried soil samples condition showed an increasing up to the critical volume ratio of about 15 and then constant. In addition, the emanation coefficient did not depend on the sample thickness when the sample volume was constant. A similar trend was observed for the moisture saturation of 0.3 soil samples condition. These results suggest that the soil sample volume can be optimized in advance based on the accumulation chamber volume and critical volume ratio to determine the emanation coefficients without the effect of soil sample thickness.

Key words:
Radon, Emanation coefficient, Soil

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Development of Precise Chemical Analysis Techniques and Their Integration into Interdisciplinary Fields

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Abstract:
Chemical separation processes are adapted to increase the concentration of the analyte while removing interferences prior to instrumental analysis. In the case of radioactive strontium (Sr-90) analysis in environmental samples, chemical separation is crucial. Yttrium-90, the decay product of Sr-90, can be efficiently purified using solid phase extraction (SPE) with DGA extraction chromatography resin[1)]. This method was employed to analyze seawater samples collected near the Fukushima Daiichi Nuclear Power Plant in 2013. Elevated concentrations of Sr-90 in coastal seawater were observed, suggesting continuous leakage of contaminated water from the reactor building as of May 2013[2)]. The DGA SPE method is also applicable for all rare earth elements (REEs). We utilized this technique to analyze neodymium isotopic ratio ($^{143}Nd/^{144}Nd$ atomic ratio), which is useful chemical tracer in geochemistry and marine chemistry[3)]. In addition, we started exploring the application of Nd isotopic ratio to fisheries and archaeology. The Nd isotopic ratio in marine organisms reflects the geographic origin, enabling clear distinction between regions with different geological histories, such as Japan and China.

Key words:
Chemical separation, Source identification, Sr-90, Neodymium

References:

1. Tazoe H, Obata H, Yamagata T, Karube Z, Nagai H, Yamada M. Determination of strontium-90 from direct separation of yttrium-90 by solid phase extraction using DGA Resin for seawater monitoring. Talanta. 2016;152:219–27.
2. Tazoe H, Yamagata T, Tsujita K, Nagai H, Obata H, Tsumune D, *et al*. Observation of Dispersion in the Japanese Coastal Area of Released ^{90}Sr, ^{134}Cs, and ^{137}Cs from the Fukushima Daiichi Nuclear Power Plant to the Sea in 2013 Int J Environ Res Public Health. 2019;16(21):4094.
3. Tazoe H, Amakawa H, Suzuki K, Nishioka J, Hara T, Obata H. Determination of Nd isotopic composition in seawater using newly developed solid phase extraction and MC-ICP-MS. Talanta. 2021;232:122435.

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Development of Semiconductors for Radiation Detection

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Abstract:
Radiation detection is one of the most fundamental fields in nuclear and radiation science and engineering. There are six basic radiation detection mechanisms, and these are (a) ionization, (b) scintillation, (c) luminescence, (d) heating, (e) chemical, and (f) biological. Among these mechanisms, ionization and scintillation are the most exploited principles in developing radiation detectors. Ionization detectors include gas-filled and semiconductor detectors. Semiconductor detectors are based on the measured electron-hole pair produced by the interaction of radiation with the detector. Semiconductors may either be an elemental or compound type. Elemental semiconductors are composed of a single element in Group IV, while the compound type includes the combination of elements in Groups III and V, or II and VI, metal halides, or multiple elements forming a crystal structure like perovskites. The most widely and commonly used elemental semiconductors for radiation detectors are Germanium for gamma radiation and Silicon for alpha particles. In the case of compound semiconductors, there is a growing interest in developing alternative materials for constructing PIN and P-N junction diodes to detect ionizing radiation, *e.g.* AlSb:Si/AlSb/AlSb:Cu on Si substrate[1)] and p-CsI/n-Si substrate[2)], respectively. In this study, we concentrate on developing cesium iodide and its ternary or quaternary compounds for use in radiation detectors. Emphasis shall be made on detecting alpha particles from NORM sources and exploring the potential integration with appropriate conversion screens for neutron detection in future investigations.

Keywords:
Semiconductor, Radiation detection, Cesium iodide, Alpha detector, Neutron detector

References:

1. Cheewajaroen K, Saengkaew P, Sanorpim S, Yordsri V, Thanachayanont C, Nuntawong N, *et al.* Characterization of N-type and P-type Aluminum Antimonides on Si substrates for room-temperature optoelectronic devices. Mater Sci Semicond Process. 2018;88:224–33.
2. Limthanameteekul P, Saengkaew P, Horprathum M, Lertvanithphol T, Dhanasiwawong K. Synthesis and characterization of cesium iodide thin film, grown by RF-magnetron. RMUTI Agric Technol J. 2024;5(2):59–68. (in Thai and English abstract)

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Development of a Fractal-shaped Radiation Detector Suitable for Use in High-dose Environments

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Abstract:
Over ten years have passed since the accident at the TEPCO's Fukushima Daiichi Nuclear Power Plant (FDNPP), and the urgent tasks of extracting fuel debris for decommissioning are underway. To facilitate efficient work planning and to reduce the radiation exposure of workers, it is essential to understand the three-dimensional distribution of radioactive material contamination in the buildings. Therefore, Torii *et al.* have developed a small and lightweight of omnidirectional radiation detector (Fractal Radiation Imaging Element: FRIE), which simulates fractal shape[1)]. This study focuses on the development and evaluation of a high-dose FRIE suitable for use at FDNPP. The developed FRIE has 16 $Gd_3Ga_3Al_2O_{12}$ crystals, arranged in a Sierpinski's tetrahedron pattern, with copper tungsten filling the spaces between the crystals to provide directional sensitivity. To assess its use in high-radiation environments, the measurable dose limit was examined using the Monte Carlo simulation. Field tests were also conducted to obtain three-dimensional contamination distribution by integrating the radiation images with a three-dimensional point cloud model of the measurement area. The maximum likelihood expectation maximization method was used to estimate contamination distribution. The field tests confirmed that the source location could be identified within a few minutes of measurement, and the approximate radioactivity intensity of the source could also be estimated. The authors plan to mount this detector on a quadruped robot and conduct measurements in FDNPP.

Key words:
Fukushima Daiichi Nuclear Power Plant accident, Radiation imaging, Fractal shape, Maximum likelihood expectation maximization

Reference:
Torii T, Sasaki M, Sanada Y. Development of an omnidirectional detector for beta and gamma-ray imaging with fractal geometry: IEEE Xplore, 2023.

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Rubber-leaf Extracted Cellulose and Its Reinforcing Effects in Recycled High-density Polyethylene Composites Containing Gadolinium Oxide

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Abstract:
The use of effective neutron shielding materials is essential for the safety of personnel and the public in all nuclear facilities, leading to a demand for better shielding materials that offer enhanced overall properties. Specifically, recent studies have shown that thermal neutron shielding materials made from recycled high-density polyethylene (R-HDPE) composites with 5 wt% of surface-treated gadolinium oxide (Gd_2O_3) exhibited higher mechanical strength, crystallinity, and neutron attenuation than those without Gd_2O_3. However, adding higher Gd_2O_3 reduced overall mechanical properties of the composites due to particle agglomeration of Gd_2O_3, that reduced the ability of the matrix to transfer and to withstand external forces. As a result, improvements in the materials' formulation must be developed to cope with such drawbacks. In this work, cellulose extracted from dried Para rubber leaves was incorporated into surface-treated Gd_2O_3/R-HDPE composites at varying cellulose contents of 0-6 wt% and relevant properties were then thoroughly investigated and analyzed. The results indicated that the addition of cellulose enhanced tensile modulus, hardness, and flexural properties of the composites, with those containing 6 wt% exhibiting higher overall neutron shielding and mechanical properties than those of commercial PE composites containing 5 wt% and 15 wt% of boron.

Key words:
R-HDPE, Gd_2O_3, Cellulose, Neutron shielding, Reinforcement

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Rearing Insects for Animal Feed Using By-products from a Sugar Factory

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Abstract:
Insects are a nutritional source rich in protein and fat. In Japan, edible insects have attracted much attention as a potential solution to the protein crisis and as a way to contribute to achieving the Sustainable Developmental Goals (SDGs) in the future. However, efforts to promote social acceptance have largely failed, and many people in Japanese society reject entomophagy. In contrast, using insects as animal feed remains a promising approach to ensure food security and address rising fishmeal prices in Japan. Sugar factories generate enormous amounts of by-products during the process of extracting and purifying sugar. In subtropical areas of Japan, most of the by-products are stored in outdoor yards where wild insects can freely access them. Rhinoceros beetles (*Oryctes rhinoceros*) can easily be found in these yards. Accordingly, we hypothesized that rearing *O. rhinoceros* using these by-products would be beneficial for producing large quantities of animal feed.

To produce large numbers of beetles effectively under controlled conditions, we evaluated the effects of different diets on insect growth in our laboratory. Three types of diets were provided from hatching to the last (3rd) instar larvae of *O. rhinoceros*. The duration of the first and second instars, as well as larval weights during growth, were recorded. The control diet was collected from the yard where *O. rhinoceros* larvae naturally occur. The Type 1 diet consisted of a single sugar by-product, whereas the Type 2 diet was a mixture of two sugar by-products. The duration of the first instar larvae fed the Type 2 and control diets was approximately 10-20 days, whereas that of the first instar larvae fed the Type 1 diet lasted approximately 30 days. The durations of the second instar were comparable among the three groups. The larvae fed the Type 2 diet gained weight more quickly than those fed the Type 1 and control diets. Therefore, the Type 2 diet is preferable for the mass cultivation of *O. rhinoceros* larvae.
In Thailand, a sugar factory in collaboration with Mitsui DM Sugar Co., Ltd. produces enormous amounts of these by-products. We plan to carry out this insect-rearing project in Thailand.

Key words:
Rhinoceros beetle, Larvae, *Oryctes rhinoceros*

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Laser Isotope Separation (LIS) of ^{48}Ca for the Study of Neutrinoless Double Beta Decay by CANDLES

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Abstract:
Neutrinoless double beta decay ($0\nu\beta\beta$) is a powerful method for exploring the universe mysteries, such as the matter-dominated universe, the lepton number violation, and the neutrino mass. CANDLES investigated this phenomenon using ^{48}Ca, which has the highest Q-value at 4.23 MeV among the double beta decay nuclides, allowing the near background-free measurement above the natural radioactive background. A large amount of double beta decay nuclides is one of the crucial elements for the search for $0\nu\beta\beta$. Nevertheless, ^{48}Ca has a natural abundance of only 0.187%, and the enrichment is difficult because calcium does not have a gaseous compound. A large-scale system was developed to produce ^{48}Ca using laser isotope separation (LIS). The spatial distribution of the calcium atomic beam was measured using time-of-flight (TOF) analysis. The displacement of ^{48}Ca was found to be 3.84 ± 0.83 mm, while no displacement was observed for other isotopes, including ^{40}Ca and ^{44}Ca. This presentation will also outline the status, strategies, and requirements for mass production using single-frequency and high-power laser diodes, aiming at 300 kg/year production rates.

Key words:
Laser isotope separation, Calcium-48, Neutrinoless double beta decay, CANDLES

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Assessment of Radiological Risk of Monazite Content in Mortar Cement as Building Materials

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Abstract:
Monazite contains natural radionuclides associated with the natural radioactive series of uranium and thorium. The objective of this study is to ascertain the effect of monazite concentration on radioactivity concentration of mortar cement as a building material. Six ratio of cement–monazite was analyzed for radioactivity concentration using an HPGe gamma spectrometer. The radiological parameters such as radium equivalent, hazard indices, gamma index, and annual effective dose were calculated. The radium equivalent in the samples ranged from 34.34 Bq/kg to 796.81 Bq/kg, while the external hazard index varied from 0.09 to 2.14, and the internal hazard index ranged from 0.15 to 2.83. The gamma index exceeded unity in samples containing monazite concentrations of 0.016% or lower when mixed with sand in mortar cement. The average annual effective dose rate varied between 0.07 and 1.76 mSv/year. The results of this study demonstrated that as the monazite concentration increased, the concentration radioactivity increased for all practical purposes. The obtained information data will be used to design and develop the radiation shielding materials and compounds in the further study.

Key words:
Monazite, Natural radionuclides, Building materials, Radiation hazards, Portland cement

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Radiat Environ Med

Safety Management and Radiation Protection During TRR-1/M1 Reactor Pool Refurbishment

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Abstract:
The integrated safety management program is improved through the implementation of the best practices and lessons learned into a TRR-1/M1 safety management system during reactor pool refurbishment. Effective radiation protection during the maintenance of a research reactor requires a systematic approach. Radiation protection during the maintenance of a research reactor is a comprehensive strategy that ensures the safety of personnel, the public, and the environment from potential radiation hazards[1)]. It involves a combination of personal protective equipment (PPE), area classification, regulatory compliance, and operational procedures that are designed to minimize radiation exposure and effectively manage radioactive materials[2)]. The key elements of a comprehensive safety management and radiation protection program during reactor pool refurbishment are used based on a thorough assessment of the potential radiation hazards present[3)]. Calibration and testing of radiation protection equipment are regularly checked to ensure that radiation protection equipment remains functional and effective. Radioactive wastes generated during pool refurbishment are carefully monitored and managed to prevent contamination and ensure compliance with regulatory standards. The proper placement of shielding is particularly important during maintenance activities in areas with high radiation levels to prevent direct exposure to workers. Adhering to IAEA safety guidelines[1)] guarantees that reactor maintenance operations are conducted in a manner that minimizes radiation hazards to the environment, the public, and workers while also aligning to international best practices.

Key words:
Pool refurbishment, Integrated safety management, Radiation protection

References:

1. IAEA. Safety of Research Reactors. IAEA Safety Standards Series No. SSR-3. Vienna: IAEA; 2016.
2. IAEA. Maintenance, Periodic Testing and Inspection of Research Reactors. IAEA Safety Standards Series No. SSG-81. Vienna: IAEA; 2023.
3. IAEA. Safety Analysis for Research Reactors. IAEA Safety Reports Series No. 55. Vienna: IAEA; 2008.

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Surface Exposure Age Deduced from ^{10}Be: a Case Study of Northeastern Japan

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Abstract:
Land surface ages are often estimated using the concentration of in situ cosmogenic nuclides. These nuclides are produced by the reaction between cosmic rays and surface materials. The amount of these nuclides increases as cosmic rays reach the Earth's surface, while radioactive nuclides decrease over time due to their half-lives. Various scaling methods and studies have been conducted worldwide to model the production rate of these nuclides. By applying these production processes and rates, land surface ages can be estimated, such as the exposure age of the surface, erosion rates, or burial rates. This study introduces an example of determining surface exposure ages using ^{10}Be, one of the in situ cosmogenic nuclides.

Key words:
^{10}Be, Exposure age, In situ cosmogenic radionuclide

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Establishment of a Nuclear Plant Simulator Facility in the Philippines for R&D and Workforce Development: Strengthening Nuclear Safety and Competency

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Abstract:
To meet growing energy demands, the Philippines plans to integrate nuclear power into its energy mix, aiming to commission its first nuclear power plant (NPP) by 2032 under Executive Order No. 164[1]. However, the country faces a shortage of trained nuclear engineers, radiation workers, and regulators, making workforce development a critical priority. Following International Atomic Energy Agency recommendations, training should start at least nine years before plant operations begin[2]. A local NPP simulator, based on a Generation III two-loop pressurized water reactor (PWR), is being established by the Philippine Nuclear Research Institute (PNRI) to address this need. This high-fidelity simulator, located at the Philippine Research Reactor-1 facility, enables training in key operations, safety protocols, and emergency response, reducing dependency on expensive overseas training while enhancing consistency and mitigating human error. The simulator features 10 student workstations and an instructor station displayed on six large screens, integrated with nuclear safety software such as RELAP5/MOD/3D and NNKM within the 3KEYMASTER environment. Beyond supporting PNRI's research and operational capabilities, the facility will aid utilities, regulatory bodies, and academic institutions by strengthening safety culture, meeting statutory requirements, and providing a resource for education, research, and decision-making. As a cost-effective tool, it will play a vital role in workforce development, advancing the Philippine Energy Plan 2020-2040, and ensuring safe, reliable nuclear plant operations.

Key words:
Nuclear plant simulator, Nuclear safety, Nuclear power plant, Manpower development

References:

1. Official Gazette. Executive Order No. 164 s. 2022. Manila, Philippines; 2022
2. IAEA. Human Resource Development for Introducing and Expanding Nuclear Power Programmes. Vienna: IAEA; 2012.

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Radiat Environ Med

Effect of Insole Therapy for Chronic Ankle Instability on the Hindfoot-lower Leg Kinetic Chain

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Abstract:
Ankle sprains are the most common lower extremity injury in sports situations. In addition, a high recurrence rate and residual aftereffects are problematic. The residual condition is called chronic ankle instability, and it causes a decrease in performance due to instability. One of the treatment methods for (CAI) is insole therapy. Insole therapy is a treatment method in which an uneven insole is inserted into the shoe to change the physical motion. The use of insoles has been shown to increase the strength of the toe muscles and arch height ratio, as well as alter lower limb dynamics during walking. The hindfoot and lower leg in particular are said to be involved in a kinetic chain, and this assessment is important; however, kinetic chain assessment with the use of insoles in CAI cases is inadequate. The presenter used the MVCT method to evaluate the kinetic chain, and classified the type of motion between the lower leg and hindfoot during gait using insoles in CAI cases. The results showed that the use of insoles changed the coordinated kinematic patterns, suggesting that the insoles may be effective for the CAI cases.

Key words:
Ankle sprains, Chronic ankle instability, Insole, Kinetic chain

References:

1. Ishikawa T, Oda A, Narita H, Takahashi N, Akahira T. Effects of ankle sprains on the lower limb alignment and physical performances in female high school volleyball players. J Aomori SOC Sports Med. 2010;19:13–7.

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Radiat Environ Med

Examination for Origin of Tsunami Boulders Based on Landform Development around Pakarang Cape, Southwestern Thailand

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Abstract:
Numerous tsunami boulders were washed up on the coast of Pakarang Cape in southwest Thailand during the 2004 Indian Ocean tsunami. These tsunami boulders are thought to be micro-atolls at the reef edge that were destroyed by the tsunami and transported to the coast. Numerical analysis using these boulders in this area has been used to reconstruct the tsunami velocities of the Indian Ocean Tsunami[1]. On the other hand, the tsunamis boulders are dated to the middle Holocene age, suggesting that they were produced by past earthquakes, subsequently covered by sediments and newly exposed by the 2004 Indian Ocean tsunami[2]. Micro-atolls basically develop in shallow waters with small waves behind reef ridges, and in the area around Cape Pakarang micro-atolls, which are fossilised and dated to about 5,000 years ago, are widely distributed. The area is estimated to have been in the high sea level period about 5000 years ago[3]. During this period, a set of lagoon and ridge landforms existed, and the subsequent relative decline in sea level is thought to have resulted in the fossilisation of the micro-atolls and the destruction of these topography. From a geomorphic and developmental perspective, the old dated tsunami boulders at Pakarang Cape would not have been brought about by past tsunamis, but by the destruction and transport of fossilised micro-atolls in the mid-Holocene by the 2004 Indian Ocean tsunami.

Key words:
Tsunami boulders, Micro-atolls, C-14 dating, 2004 Indian Ocean tsunami

References:

1. Goto K, Okada K, Imamura F. Numerical analysis of boulder transport by the 2004 Indian Ocean tsunami at Pakarang Cape, Thailand. Mar Geol. 2010;268:97–105.
2. Neubauer N, Brill D, Brückner H, Kelletat D, Scheffers S,Vött A. 5000 Jahre Tsunami-Geschichte am Kap Pakarang (Thailand). Coast Rpts. 2011;17:81–98.
3. Scheffers A, Brill D, Kelletat D, Brückner H, Scheffers S, Fox K. Holocene sea levels along the Andaman Sea coast of Thailand. Holocene. 2012;22(10):1169–80.

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Performance Tests of Membrane Filters for Collection of Ambient Radioactive Aerosols

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Abstract:
Artificial alpha-emitting radionuclides that may be released from nuclear facilities are typically collected on a filter and measured using a Si semiconductor detector. Since alpha particles have a self-absorption effect, their energies may not be properly measured when they are collected within the filter matrix. Therefore, the surface collection efficiency (SCE) of filters is crucial for their selection. It is well known that membrane filters have a high SCE. In fact, they are recommended for the collection of atmospheric alpha emitters in the monitoring guideline in Japan. However, the filter types and its pore sizes are not specified. Pressure drop of filters is also important for filter selection. In this study, we have examined the SCE and pressure drop for membrane filters to find suitable filters for alpha spectrometry. Radon progeny aerosols in a radon exposure chamber were collected on filters and the energy spectra of alpha particles emitted from filters were measured using a passivated implanted planar silicon semiconductor detector (CAM–490AM, CANBERRA) under vacuum conditions. Then, the SCE was evaluated using the method analyzing the energy peak and its tailings of ^{214}Po with approximation of spectral shapes using a Gaussian function. Considering the upper limit of the pump, pressure drops were measured using a manometer under the face velocity ranging from 2.38 to 23.8 cm/s. As a result, it was found that SCE and pressure drop tended to be higher with smaller pore sizes. However, there were several filters for which there were no differences in SCE, even as the pore size increased to a few micrometers. Filters made from polytetrafluoroethylene resulted in high SCE, even with larger pore sizes. It was suggested that these filters would be suitable for alpha spectrometry.

Key words:
Alpha spectrometry, Membrane filters, Surface collection efficiency, Pressure drop

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Novel Transparent X-ray Shielding Solutions with Various Metal Ions

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Abstract:
We fabricated transparent, Pb-free X-ray shielding materials using solvated ions in a polar solvent. Previous materials have been based on dispersions of metal-containing particles such as barium sulfate ($BaSO_4$) in a matrix. Comparisons of suspensions of metal-based particles and solutions of metal ions in a solvent enable better understanding of interactions such as reflection, scattering, and absorption between X-rays and substances. The X-ray shielding properties of a solution of solvated metal ions were similar to or better than those of suspensions of metal-containing particles. In addition, the metal-ion solutions exhibited high transparency. The most effective material among those investigated for X-ray shielding was barium bromide ($BaBr_2$), which exhibits high solubility in polar solvents. X-ray shielding of 92% was confirmed at a tube voltage of 120 kV, along with ~90% UV transmittance at a visible-light wavelength of 400 nm. Thus, both high X-ray shielding performance and high transparency were achieved.

Key words:
X-ray shielding, Transparent, Metal ions, Dissolution

References:

1. Tokonami R, Osanai M, Hosoda M, Tokonami S, Takahashi T. Simple surface modification of barium sulfate for improving the interface of polymer composites and its X-ray shielding properties. Polym Compos. 2024;45:1–11.
2. Tokonami R, Osanai M, Hosoda M, Tokonami S, Takahashi T. Flexible composites of barium sulfate modified by tannic acid using glycerol/starch for X-ray shielding applications. Macromol Chem Phys. 2025;226(4):2400273.
3. Tokonami R, Osanai M, Hosoda M, Tokonami S, Takahashi T. Transparent X-ray shielding solutions with various metal ions. ACS Omega. 2024;9(44):44770–7.

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Tritium in the Environment and Its Analytical Method

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Abstract:
Tritium (^{3}H; $T_{1/2}$ = 12.3 y) is the radioisotope of hydrogen that decays to ^{3}He; the majority of sources of environmental tritium are natural, and some parts originate from artificial sources[1)]. The 99% of naturally occurring tritium is present in atmospheric water vapor, rainwater, land water, and seawater in the chemical form of HTO, and migrates through the earth surface as part of the water cycle. Furthermore, the data on tritium concentration is used for evaluation of the residence time of groundwater and as the tracers for air masses containing water vapor along with hydrogen and oxygen stable isotope ratios. More than 10 years have passed since the accident at the Fukushima Daiichi Nuclear Power Plant (FDNPP). "ALPS (Advanced Liquid Processing System) treated water" is the water which has been purified from contaminated water and in which the radioactive materials are removed by ALPS to meet the regulatory standards with an exception of tritium at FDNPP. Concentrations of the radioactive materials will be far below the regulatory standard values by purifying/re-purifying the radionuclides other than tritium; and diluting by sea water, and is released to the ocean through outlet pipe. In addition, spent nuclear fuel reprocessing plant also plan to release much amount of tritium to the surrounding environment. In future, fusion energy and its activity is one of the sources of tritium in the environment. In this presentation, tritium dynamics in the environment and its analytical technique are reported.

Key words:
Tritium, Environmental dynamics, Analytical method

References:
1. Momoshima, N. Tritium in the environment. Radiat Prot Dosim. 2022;198: 896–903.

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Modeling and Simulation of the Phase Inversion from Fresh Cream via Whipped Cream to Butter by Coupled Map Lattice

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Abstract:
Fresh cream is a multi-component, multi-phase and multi-scale emulsion[1]. Thus, there are high technical barriers to modeling and simulating the phase inversion from fresh cream via whipped cream to butter, such as consistent approximation in macroscopic equations and massive computation in microscopic simulations. These barriers are overcome by using a well-established complex systems approach, coupled map lattice[2] (CML). CML has successfully reproduced various complex phenomena such as nucleate to film boiling[3], soft to hard turbulence[4], stratus to cumulonimbus cloud formation[5], and spiral arm to stellar gas clump formation[6, 7]. We shall present in detail the modeling and simulation of the CML for the phase inversion of fresh cream[8]. The modeling follows the general method of CML construction[2]: the introduction of a lattice, the assignment of field variables, and the formulation of procedures. (1) Consider a relatively flat container filled with an emulsion. Introduce a two-dimensional square lattice as we view the emulsion from above. (2) Consider the physical and chemical state of the emulsion. Assign to each lattice point the surface energy, cohesive energy, and velocity (flow) of the emulsion. (3) Consider only important elementary processes of physical and chemical changes of the emulsion in the phase inversion. Formulate the whipping, coalescence, and flocculation procedures. In the simulations, two well-known and different phase inversion processes are reproduced at high and low whipping temperatures (WTs). The overrun and viscosity changes in these processes are consistent with those in experiments. The two processes give rise to distinctive spatial patterns of overrun (surface energy) and viscosity (cohesive energy), and are characterized on the viscosity-overrun plane which is one of the state diagrams, as the viscosity dominance at high WT and the overrun dominance at low WT, respectively. The butters in the two processes have different textures.

Key words:
Coupled map lattice, Dairy products, Phase inversion, Overrun, Viscosity, Food texture

References:

1. Fujita S. Shokuhin no Nyuka [Food Emulsions]. Tokyo: Saiwaishobo; 2006. (in Japanese)
2. Kaneko K, Tsuda I. Complex Systems: Chaos and beyond. Berlin: Springer; 2001.
3. Yanagita T. Coupled map lattice model for boiling. Phys Lett A. 1992;165:405–8.
4. Yanagita T, Kaneko K. Coupled map lattice model for convection. Phys Lett A. 1993;175:415–20.
5. Yanagita T, Kaneko K. Modeling and characterization of cloud dynamics. Phys Rev Lett. 1997;78:4297–300.
6. Nozawa E. Coupled map lattice for the spiral pattern formation in astronomical objects. Physica D. 2020;405:132377.
7. Nozawa E. Jammed Keplerian gas leads to the formation and disappearance of spiral arms in a coupled map lattice for astronomical objects. Prog Theor Exp Phys. 2023;2023(6):063A02.
8. Nozawa E, Deguchi T. Simulating phase inversion processes by coupled map lattice: Toward the theoretical design of food texture and quality in dairy processing from fresh cream to butter via whipped cream. J Chem Phys. 2025;162(6):064902.

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Preliminary Assessment of Tritium Levels in Imported Seafood Products by TINT

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Abstract:
Following 2023, treated radioactive water was released from the Fukushima Daiichi nuclear power plant into the Pacific Ocean in Japan. Although monitoring data indicated that marine radioactivity levels remained within regulatory limits. Thailand, a major importer of Japanese seafood products, is concerned regarding potential radiological impacts on marine food products. The assessment of potential radionuclide accumulation in the food chain and subsequent consumer health implications was initiated. Isotope Hydrology Laboratory at Thailand Institute of Nuclear Technology (TINT), specialized in low-level tritium analysis in hydrological research, conducted tritium measurements in imported seafood products at the request of regulatory authorities. A total of 64 samples were processed using vacuum distillation for water extraction, followed by Liquid Scintillation Counter (LSC) for analysis. The samples were prepared by mixing the extracted water samples with Ultima Gold LLT scintillation cocktail in a ratio 8:12. Measurements were conducted alongside the diluted NIST 4926E Standard Reference Material and tritium-free water (dead water). Calculations were performed in accordance with the U.S. Food and Drug Administration (FDA) analytical protocol WEAC-RN-METHOD.8.0 for determination of Free Water Tritium (FWT). The results showed that tritium activities in these samples ranged from 0.10 to 1.75 Bq/kg, which is below the Minimum Detection Concentration of 1.05–3.51 Bq/kg and well under the World Health Organization's maximum permissible limit for tritium, set at 10,000 Bq/kg. However, Thailand currently lacks standardized methods for analyzing radioactive nuclides in food, particularly Organic Bound Tritium (OBT). The development of such standards is essential to ensure consumer confidence and maintain food safety assurance.

Key words:
Tritium, Imported seafood products, FWT, OBT, LSC

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Depleted Uranium (^{235}U) Analysis in Some Food Samples Using Inductively Coupled Plasma Spectrometry

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Abstract:
After Fukushima Daiichi nuclear power plants (NPP) accident, there has been significant radioactive contamination, raising concerns about the health of local populations. Radioactive particles can be inhaled and may also settle on the ground, where they can be disturbed by wind, spreading to agricultural areas and contaminating food and water sources. To address the need for quick screening methods to detect radioactive contaminants in food, especially given the limitations in analytical capabilities, researchers have turned to inductively Coupled plasma mass spectrometry (ICP-MS). This technique is favored for its high sensitivity and precision and can analyze a wide range of elements without being limited by ionization potential. As a result, ICP-MS is increasingly replacing thermal ionization mass spectrometry (TIMS) for accurate isotope ratio measurements of long-lived radionuclides. Other analytical methods, such as neutron activation analysis (NAA) and alpha/gamma-ray spectroscopy, are less effective for routine use. NAA does not allow for isotopic ratio analysis, while spectroscopic techniques often lack sufficient sensitivity. This study focus on the sample pretreatment methods and digestion techniques for determination of ^{235}U in food samples using ICP-MS. An acceptable calibration curve of ^{235}U with high linearity was obtained. The mixed fish (IAEA-414) certified reference material was used in this study. The measured value of ^{235}U showed reasonable agreement with the that certified value with the difference below 30% when the sample was dried at 105°C for 12 hrs. and digested with nitric acid using microwave-assistant digestion procedure.

Key words:
Food samples, Analytical methods, Inductively coupled plasma spectrometry, Isotope

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Study of Soil Properties in Relation to Radionuclides in Coffee Samples from Thailand and Japan

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Abstract:
Coffee is widely popular and essential to economic growth[1)]. This study evaluates radionuclide levels in soil from Agricultural Innovation Research, Integration, Demonstration, and Training Center (AIRID), Chiang Mai, Thailand, and The Okinawa Orchid Society (OOS), Okinawa, Japan, as well as commercial coffee beans, using an XRF spectrometer and an HPGe gamma spectrometer. Exchangeable K and extractable P were determined via the ammonium acetate and Bray methods. In AIRID soil samples, ^{40}K activity ranged from 316.3-937.1 Bq kg^{-1} before and 403.4-851.3 Bq kg^{-1} after fertilization. For OOS soil, average concentrations were 570.7 Bq kg^{-1} and 508.9 Bq kg^{-1}, respectively. The average of ^{40}K concentration in the soil samples is higher than the global average of 420 Bq kg^{-1} [2)]. The coffee beans samples show the average concentrations of natural radionuclides such as ^{226}Ra less than 1 Bq kg^{-1} and ^{40}K slightly higher than the global average.

Key words:
Soil properties, Coffee, Chiang Mai, Okinawa

References:

1. Roselli C, Desideri D, Rongoni A, Saetta D, Feduzi L. Radioactivity in coffee. J Radioanal Nucl Chem. 2013;295(3):1813–18.
2. UNSCEAR 2008 Report. Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2008 Report. Vol. I, United Nation. 2008.

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