

Environmental Radioactivity Research
Network Center
(ERAN)

FY2022 FINAL REPORT
【International】

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海外	I-22-19	Purnami Sofiati	Research Organization for Nuclear Energy	Establishment of a protocol H2AX immunoassay for analysis of biological effects exposed to radiation and as a radiation biodosimetry assay.	Ramadhani Dwi Kurnia lin	IREM	三浦 富智
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海外	I-22-21	Swallow James Bruce Mathew	Mount Royal University	Radiocesium removal from soil		IREM	赤田 尚史 武田 晃 海野 佑介
海外	I-22-22	Sola Phachirarat	Chulalongkorn University	Study of NORM levels using high purity germanium (HPGe) gamma spectrometry and heavy metals analysis using ICP-MS in soil samples collected from Thailand.	Kranrod Chutima Kritsanawanuwat Rawiwan	IREM	田副 博文
海外	I-22-23	Rahman M Safiur	Bangladesh Atomic Energy Commission	Capacity building for development of nuclear techniques for analysis of radionuclides in environmental samples collected from Ruppur Nuclear Power Plant (RNPP), Bangladesh, Part-2		IREM	田副 博文
海外	I-22-24	Evrard Olivier	University Paris-Saclay	Novel environmental DNA – eDNA - analyses of sediment archives for the reconstruction of sediment and radiocesium source contributions in a lake draining the main Fukushima radioactive pollution plume		NIES	林 誠二 辻 英樹 脇山 義史

Long-term effects of thinning on canopy structure and interception processes in Japanese coniferous plantations

氏名 : Sun Xinchao
受入研究者 : 恩田 裕一
共同研究者 :

1. 成果

Forest thinning is among the most effective silvicultural treatments of forest management to increase water availability for humans. The forest thinning effects on the catchment hydrology would be primarily due to changes in evapotranspiration, induced by alterations to the forest canopy-atmosphere processes. Canopy interception is an important component of the water balance, and in coniferous forests it can represent around 25–45 % of gross rainfall. Canopy throughfall comprises the largest portion of net precipitation that is delivered to the forest floor. This water flux is highly variable across space and time and is influenced by species composition, canopy foliage, stand structure, and storm meteorological characteristics. Although numerous studies have been conducted on the thinning effect on canopy interception, few data are available for evaluating long term effects of thinning on interception processes. In addition, the post-thinning changes in vegetation structures are commonly expressed in terms of stocking density and basal area. However, the spatial distribution and vertical profile of vegetation structure may better capture the impact of various treatment types. This study investigated the temporal changes in vegetation structure using a LiDAR technology and canopy interception after thinning 10 years in a Japanese cypress plantation. Results showed that increasing of canopy interception after 7-9 years thinning was attributed to 90%-fully recovery of canopy cover. The results can provide strategies for hydrological observations, which are required for optimal water resource management in mountainous regions of Japan. Further research is required to determine which biotic and abiotic factors are most influential in their temporal patterns.

2. 論文

Chunyu Wang, Xinchao Sun, Chunbin Fan, Yixin Wei, Guangkai Jia, Yanhong Cao. Spatio-temporal variability and intra-event variation of throughfall ammonium and nitrate in a pine plantation. *Hydrological Processes*, 2023, in press.

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

氏名：Feng Bin

受入研究者：恩田 裕一

1. 成果

Large amounts of ^{137}Cs 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 ^{137}Cs in rivers are tightly bound to suspended sediments (SS), understanding the dynamics of particulate ^{137}Cs 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 ^{137}Cs 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 ^{137}Cs . 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 ^{137}Cs 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 ^{137}Cs 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 ^{137}Cs were more consistent over the same period. In contrast, the control of water flow/rainfall on sediment transport with ^{137}Cs 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 ^{137}Cs loss using meteorological radar data, quantified land use, and ^{137}Cs inventories. We found a significant positive correlation between this metric and ^{137}Cs dynamics in the Koise, rather than Sakura, which well-supports our explanation of highly ^{137}Cs contaminated sediment in Koise mainly from the forest. Overall, our results suggest that forested areas in Kasumigaura lake may continue to discharge particulate ^{137}Cs in the future. Moreover, the new index would be a useful tool to locate the potential sediment sources and benefit future catchment management.

2. 論文

**Thinning-induced migration of fine-grained sediment from the slope to the basin scales
in a forest plantation using Pb-210ex, Cs-137 and Cs-134**

氏名 : López-Vicente Manuel

受入研究者 : 恩田 裕一

共同研究者 :

1. 成果

In a previous study, López-Vicente et al. (2017; *Geomorphology* 292, 104–114) reported that the computer-based simulation results indicated that the work road is the main discharge route of sediment produced by thinning in the same watershed as in this study (basins K2 and K3 in FM Karasawa, Sano City, Tochigi Prefecture). The sediment transport process has been studied in various ways. There are various methods to study the sediment transport process, and in this study, radionuclides were used. The problem with the conventional method is that it does not take into account changes in the concentration of radionuclides in the production source over time because the end-member is not changed during the observation period. Therefore, the purpose of this study was to ESTIMATE THE SOURCE OF FINE SEDIMENT PRODUCTION from slope scale to watershed scale before and after thinning, and to estimate the source of production in more detail BY CHANGING THE END-MEMBERS OF THE SOURCE SEDIMENT IN EACH YEAR. In addition, there is no study that used Pb-210ex, Cs-137, and Cs-134 as tracers at the same time, and it is thought that the distinction of production sources can be made more clearly by using their ratios. For field observations, we set up SS samplers and turbidimeters in the river to observe the amount and concentration of sediment, and collected sediment in the forest to measure the concentration of radioisotopes using Ge semiconductor detectors.

As a result, in the watershed where row thinning was conducted, the amount of sediment increased rapidly in the year of thinning and one year later. On the other hand, in the watershed where point thinning was conducted, there was no significant increase in sediment discharge. In the production source estimation, we were able to clearly distinguish between work roads and river banks by using Cs-134/Cs-137 as the horizontal axis and Cs-134/Pb-210ex as the vertical axis. The TRACER ANALYSIS showed that the contribution of sediment production from the working road increased during the thinning period in the row-thinning basin, but no such trend was observed in the point-thinning basin.

In the row-thinning basin, the contribution rate from the work road increased from upstream to downstream. In addition, as the HC of the work road increased, the contribution rate from the work road in the row thinning basin tended to increase.

Main conclusions: For source estimation, the source contribution could be calculated by using

the ratio of Cs-137 and Cs-134 to Pb-210ex. When row thinning was conducted, the amount of sediment discharge from the forest to the river increased during thinning, and the contribution rate from the work road increased. After the thinning was completed, the amount of sediment discharge tended to decrease, and the contribution rate from the work road decreased accordingly. In the watershed where point thinning was conducted, there was no significant increase in the amount of sediment discharge before and after thinning, and there was no significant change in the contribution rate to river SS throughout the observation period. The above results suggest that row thinning increases the amount of sediment discharge from the work roads established in conjunction with the operation, and contributes to the increase in the amount of suspended sediment in the river. On the other hand, point thinning does not increase the amount of sediment discharge into the river because the number of work roads opened is small and there is little sediment disturbance in the forest. Further research: In order to analyze the change in sediment discharge in more detail, it is necessary to analyze the change in the time series of the canopy openness using LIDAR data by a drone, and to estimate the source of sediment supply from multiple aspects by estimating the production source based on the hysteresis between the flow rate and the amount of sediment.

2. 論文

Under production

Expanded scoping study to establish a Fukushima 'Radioecological Observatory' site

linked to other worldwide sites

氏名 : Beresford Anthony Nicholas

受入研究者 : 恩田 裕一

共同研究者 : Wood D Michael

1. 成果

The contaminated areas following the Fukushima Dai-ichi Nuclear Power Plant accident in 2011 are some of the most radioactively contaminated sites in the world. The accident caused anthropogenically-derived radionuclide depositions across Fukushima Prefecture and resulted in large scale evacuations. The evacuation mandates in Fukushima Prefecture continue to be modified as governmental decontamination and natural radionuclide decay lower ionizing radiation exposures below the government set threshold for human occupancy in some areas. Our project's initial aim was to select an extensive area to establish a Radiological Observatory (RO) similar to that established in the Chernobyl Exclusion Zone (Lecomte- Pradines et al., 2020). The preliminary RO site is located in Namie Town (37°33'12.13"N, 140°50'05.5"E) of Fukushima Prefecture approximately 23 km northwest of the FDNPP and received about 4.7 MBq m⁻² of radiocesium (^{134,137}Cs) deposition in 2011. The preliminary RO contains forests, several streams, and has brown forest soils. Forest stands consist of Japanese Cedar approximately 3,300 trees ha⁻¹.

At the preliminary site, we initially deployed 6-8 wildlife monitoring surveillance systems, namely Browning game trail cameras. However, these were removed after one of the participant researchers changed institutions; unfortunately the cameras were not reinstalled. Additionally, international research participants involved in this study were unable to travel to the site due to the covid pandemic. The discussion of the selected Radiological Observatory in Fukushima will continue. All photographs or videos recorded by the camera traps have been viewed and the wild animal species/numbers recorded. All photographs and background information on the RO will be posted on a bespoke webpage shortly.

Reference:

Lecomte-Pradines C., Adam-Guillermin C., Gashchak S., Bradshaw C., Copplestone D., Beresford N.A., 2020. More than thirty years after the Chernobyl accident: What do we know about the effects of radiation on the environment?, *Journal of Environmental Radioactivity* 211, 106108. <https://doi.org/10.1016/j.jenvrad.2019.106108>

2. 論文

Assessment of the effects of ionizing radiation in bees

氏名 : Gagnaire Beatrice

受入研究者 : 難波 謙二・石庭 寛子

共同研究者 : Bonzom Jean-Marc・Belzunces Luc・Brunet Jean-Luc・Dubourg

Nicolas・Pelissier Michel

1. 成果

The risk assessment linked to the radiocontamination of the environment after a nuclear accident is a major ecological issue but is still surrounded by controversial results and conclusions on the real impact of such events on flora and fauna inhabiting the targeted zones. Moreover, the potential underlying mechanisms of the action of ionizing radiation are poorly known. Therefore, it is important to acquire data on the potential effects of ionizing radiation on ecosystems both in experimental and realistic conditions.

The objective of this project is, using a pluri-disciplinary approach, to increase the knowledge of effects and mechanisms of action of IR on physiology and populations of honeybees in the context of chronic exposure (i.e., exposure of a significant period of time relative to the lifespan of exposed organisms) and at low dose rates (sublethal ecotoxicity) in realistic conditions, i.e., on the field and in the laboratory. However, very few data exist on this subject, and it seems important to conduct studies which will serve as a basis to better evaluate the impacts of IR on animal health using honeybees.

Main results:

Work has started on the site search aspects for the field experimentation part. Several meetings have been held with the IER. GIS mapping work was carried out with an IRSN collaborator. Thanks to this work, different data have been cross-referenced (exposure, access by road, type of habitat, dose rate) and a gradient of sites going north of the plant seems to emerge. A field mission was performed from July 2 to 15, 2022 in order to observe the sites in person, to take photos, to characterize the flowering and sunshine of these different sites. Thanks to our colleagues from the IER and also with the help of a researcher from the NIES (National Institute for Environmental Studies), professional beekeepers were met during this mission to discuss the possibility of installing hives from March 2023 to October 2024. Six sites were finally selected: 2 in Okuma town (High dose), 1 in Namie town and 1 in Futaba town (Low dose) and 2 in Minamisoma town (controls). Our IER colleagues also took care of the identification of land owners and the obtention of written authorizations for deploying the hives on the six sites selected.

Concerning the laboratory experiments, two irradiation experiments of 14 days each were carried out between April and May 2022. The objective was to evaluate the toxicopathological interactions of ionizing radiation on the honeybee by combined approaches at the molecular

level, cell and tissue under controlled laboratory conditions. For this, newborn bees were infected to *Nosema ceranae*, an intestinal pathogen of bees, and then irradiated for 14 days in the laboratory at a high gamma irradiation dose rate (14 mGy/h). The bees were placed in cages (50 bees per cage) then arranged around a source of ¹³⁷Cs. Several modalities were tested: infected and irradiated bees, only irradiated bees, only infected bees and neither irradiated nor infected bees. The results demonstrated a higher mortality in the case where the bees were both irradiated and infected. In addition, irradiated bees presented a higher pathogen load than non-irradiated bees. This result expresses the sensitivity and the weakening of the bees due to the combination of the two modalities. No difference in food consumption was noted. Physiological analyses were carried out on the heads of bees and on the last day of exposure. Oxidative stress was observed with increased tissue activity of GST and SOD. A possible transient effect of AChE has been suggested. These data, supplemented by the analyses planned later on the other compartments and the other sampling times (and also on a lower dose rate of 14 µGy/h), will make it possible to better understand the combined effects of irradiation and infection on bees.

2. 論文

no published papers

From molecular ecology to evolutionary ecotoxicology: use of a tree frog for radio-contamination long-term impact assessment

氏名 : BozonJean-Marc

受入研究者 : 難波 謙二 · 石庭 寛子

共同研究者 : Car Clément · Gilles André · Armant Olivier · Frelon Sandrine · Miura Ikuko

1. 成果

The objective of this research project is to better understand and quantify the effects of environmental radiocontamination in the Fukushima Prefecture on wildlife. For this purpose, we have chosen a model species, the tree frog (*Dryophytes japonicus*). A vertebrate exposed to radionuclides through its terrestrial and aquatic lifestyle and its permeable skin. We study the effects of radio-contamination of the environment on the physiology and behavior of individuals but also on the evolutionary responses of populations through population genetics analysis. Our goal is to answer these two questions: what is the health status of individuals? After the nuclear accident, how have tree frog populations evolved? We have already started to conduct this type of research in the Chernobyl region (Ukraine), on another tree frog species (*Hyla orientalis*). We also conducted a first study on the species *D. japonicus* in 2012, and 2013 in the Fukushima region.

To achieve our objectives, in June 2022, we studied 11 tree frog populations (i.e., 11 sites) in contrasting radio-contaminated environments in Fukushima Prefecture. We collected about 20 male tree frogs per population. The mass and size of the frogs was measured and many organs (muscles, liver, blood...) have been dissected in order to perform many analyses such as enzymatic activities, population genetics, etc. We are also in the process of estimating the dose rate absorbed by each of the frogs, in particular via the determination of the level of Cs-137 activity measured in all frogs.

Our initial results show that regardless of the sites where the tree frogs were captured (i.e. radiocontaminated or non-radiocontaminated), the mass of tree frogs captured in ponds or abandoned rice fields is significantly greater than that of frogs captured in cultivated rice fields. In addition, from the thoracic muscle of tree frogs, we measured two enzymes (citrate synthase: CS, lactate dehydrogenase: LDH) involved in mitochondrial function. The LDH/CS activity ratios allow to evaluate the relative capacities of anaerobic metabolism (or glycolytic activity) compared to aerobic metabolism (oxidative activity). Overall, the LDH/CS ratio of tree frogs captured in ponds was significantly higher than that of tree frogs from rice fields (Anova, $F= 15.039$, $p < 0.001$). This difference in ratio is mainly explained by the increase in LDH activity values. Pond-dwelling tree frogs maintain a relatively stable aerobic

metabolism but implement a higher metabolism via glycolysis, thus they produce more energy. Their thoracic muscles therefore appear to be more efficient.

These first results show that the type of habitat (pond or rice field) would have an effect on the energy metabolism of tree frogs. This variable (i.e., habitat type) must therefore be taken into account in our future analyses to assess the impact of radiation on tree frogs.

Concerning the population genetics analyses, our first results show that mitochondrial genetic diversity is higher in radiocontaminated sites than non-radiocontaminated sites in 2013, but not in 2012 nor 2022. This higher mitochondrial genetic diversity in 2013 could be the result of mutations resulting from the high dose exposure at the first times of the 2011 accident, not already visible in 2012 and not fixed in 2022. But the analysis of tree frogs age shows that this unusual diversity is mostly coming from individuals born before the accident, mutations being probably not the only explanation for this diversity. Future analysis of nuclear DNA will help us to investigate the origin of this high diversity, and its decrease in 2022.

In addition, the analysis of mitochondrial DNA highlights the existence of three historically differentiated mitochondrial genetic clades coexisting in the Fukushima prefecture, which could present different response to ionizing radiation and thus should be included in our future analysis of phenotypic traits.

2. 論文

The analyzes of the biological samples are still in progress. The 1st publications will be submitted during the year 2023.

small ponds radioecology

氏名：Linnik Grigorievich Vitaly

受入研究者：Konoplev Aleksei・脇山 義史・五十嵐 康記

共同研究者：

1. 成果

Spatial variability of radiocesium contamination in the bottom sediments of the small size ponds in the vicinity of Fukushima Dai-ichi nuclear power plant (FDNPP)

Linnik Vitaly and Ivanitsky Oleg (Vernadsky Institute), Konoplev Aleksei, Wakiyama Yoshifumi and Igarashi Yasunori (Institute of Environmental Radioactivity)

To find out the changes in the nature of the distribution of radioactive contamination caused by the Fukushima Dai-ichi nuclear power plant (FDNPP) accident as a result of typhoons, the rainy season, as well as other man-made and environmental causes, it is necessary to conduct regular observations at specially selected monitoring sites located in different landscape conditions at diverse levels of radioactive contamination.

Closed and semi-closed water bodies of small size are most suitable for radiological monitoring. Our analyses revealed spatial variability of the radiocesium (r-Cs) inventory measured in bottom sediment cores and soils taken in Inkyozaka (isolated pond), Suzuuchi (irrigation pond), and Funasawa (recreational urban pond) contaminated by the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident in 2011.

Bottom sediment samples were taken in each pond in triplicate in June 2016. The selected ponds are characterized by the following statistical parameters of r-Cs inventory (minimal, maximal and mean value, MBq/m²): 1) Inkyozaka – min= 1.0, max = 2.3, mean = 1.58; 2)Suzuuchi - min= 5.8, max = 14.1, mean=11.0; 3)Funasawa – min= 3.85, max= 6.77, mean = 1.52. The ratio of the average r-Cs inventory in bottom sediments and soil samples taken from the watersheds (at three points) for Inkyozaka, Suzuuchi and Funasawa was 0.7, 1.63 and 1.52, respectively. Thus, r-Cs accumulations due to erosion are observed only in Suzuuchi and Funasawa, while Inkyozaka, a completely isolated pond, was contaminated due to atmospheric precipitation on the water surface in March 2011.

One task of ERAN Project I-22-07 “Small ponds radioecology” is to study variations of r-Cs flows in the near zone of FDNPP in different types of landscapes using simple erosion models constrained in GIS software like SAGA. These DEM data were used for the calculation of the LS factor, which implemented in the RUSLE erosion model. The topographic wetness index (TWI) expresses the relief-driven water balance and local drainage of the catchment and marks predominant r-Cs transport patterns. Creating Google Image Overlay for TWI provide effective identifying places where surface runoff enters and outlets ponds, as well as potential r-Cs transfer on slopes.

ERAN Project I-22-07 Results:

1. Compilation of digital elevation model (DEM) based on data from the Geospatial Information Authority of Japan for the study area around the FDNPP (approximately 6-8 km).
2. Radioecological GIS of the area including digital elevation level (DEM) to draw the maps of potential radionuclide flow path in the basins of the three ponds (Inkyozaka, Suzuuchi and Funasawa).
3. Maps of the r-Cs surface flow paths and flow accumulation (contributing areas) obtained from GIS-modeling (LS-factor, wetness index, slope, flow accumulation, and others).
4. Database of r-Cs inventories in the water and bottom sediments for the three ponds since FDNPP accident.
5. Estimation of r-Cs vertical migration rate (distribution) in the soils closed the ponds.
6. Variability of r-Cs accumulation rates in bottom sediments depending on the type of ponds (closed, low-flow)
7. The manuscript of the research article has been drafted and prepared for submission.

Developing a maps of various parameters of surface flows towards the selected ponds corroborated the contribution of erosion to bottom sediments contamination: although radiocesium wash-off can be observed during the rainy season, the main flux of radiocesium comes mainly from temporary streams.

2. 論文

Linnik Vitaly, Konoplev Alexei, Wakiyama Yoshifumi, Ivanitsky Oleg, Byrnes Ian Spatial variability of radiocesium contamination in the bottom sediments of the small size ponds in the vicinity of Fukushima Dai-ichi nuclear power plant (FDNPP) // The 9th Annual Symposium of the IER, Fukushima University, February 14, 2023, p.44.

**Behavior of radiocesium in fluvial systems of contaminated areas under development of
erosional processes**

氏名：Komissarov Mikhail

受入研究者：Konoplev Aleksei・脇山 義史・五十嵐 康記

共同研究者：

1. 成果

The Fukushima Daiichi Nuclear Power Plant (FDNPP) accident leads to releasing of vast amount radionuclides into environment. Meteorological conditions in the accident period favored radionuclides' fallout in the northwest from the FDNPP, with a trace of 50–70 km long and 20 km wide. Ultimately, a huge portion only of ^{137}Cs (about 7–20 PBq) was deposited on the land surface in Honshu island, predominantly in Fukushima Prefecture. Owing to the long half-life of ^{137}Cs ($T_{1/2} = 30.17$ years), its negative ecological impact remains in the region, and is a concern. Meanwhile, to minimize the radiological health risks of the FDNPP accident, intensive clean-up efforts have been conducted in contaminated areas. Mostly such works were did only for urban areas, while decontamination activities in forest districts are much more difficult to carry out, and ^{137}Cs will remain there for a long time.

The Abukuma River was selected as object of the study. The Abukuma is the second longest (length 234 km) river in the Tohoku region and largest in Fukushima Prefecture. The catchment of Abukuma River encompasses an area of about 5400 km² and its mean ^{137}Cs initial inventory was 88.3 kBq/m². The river represents an essential water resource for the local inhabitants. There is general concern that the ^{137}Cs deposited in mountain forests will be transported to decontaminated downstream areas via water discharge with soil particles. This transport of ^{137}Cs could potentially cause an increased radiation dose and contamination of water resources in the downstream regions. Beside of ^{137}Cs water bodies contamination, the other ecological problems associated with soil erosion could occur: siltation and eutrophication. During extreme natural erosional events: intensive snowmelt, rainfalls or typhoons (eg. Etau, Hagibis) the turbidity and ^{137}Cs concentration in river's water could increase noticeably. Hagibis was (6–13 October 2019) the strongest typhoon in the last several decades in Japan and caused widespread destruction and high-floods. The rainfall at the Abukuma River basin was nearly 600 mm in 24 h (mean annual precipitation is 1200 mm).

A total of 6 locations (from the source to mouth) at Abukuma River were studied. At each location, artificial plastic lawn-grass mats and metal rules for determination of sedimentation rates on floodplain terrace (with different elevation: low, middle and top) were installed. From

the same points, the sediment cores (up to 50 cm) were sampled, as well the water from river. In laboratory, the core samples were sliced (into 3 cm layers) and prepared (dried, crushed, sieved and etc.) for further analyzing. The contaminated water was filtered through a multilayer cascade to separate the ^{137}Cs particles and then through a sorbent in order to determine the amount of dissolved cesium. The texture of bottom sediments (as well suspended material from water samples) was determined using a laser diffraction particle size analyzer Mastersizer 3000; the ^{137}Cs activity concentrations – by γ -spectrometry using a high purity germanium detector (HPGe) MIRION Technologies.

The result showed that the max ^{137}Cs inventory at upstream of Abukuma River valley floor in 2018 was $\sim 950 \text{ kBq/m}^2$ (~ 600 in 2019), is indicated a high migration of r-Cs from upstream to downstream. It interesting to note, Japanese researchers found that during the 4-day period (12–15 October 2019) of typhoon Hagibis the particulate ^{137}Cs export flux from the Abukuma River into Pacific Ocean was $1.1 \times 10^{12} \text{ Bq}$ and equaled $2/3$ of the annual flux during 2012–2015 (the period of high ^{137}Cs levels following the FDNPP accident). The thickness of “fresh” sediment deposited on the floodplain in the case of the ordinary flood is in the range 1–5 cm, while up to 40–50 cm during the extreme flood associated with typhoon. The high radiocesium concentrations were found in sediments with domination of silt and clay fractions.

2. 論文

Komissarov M., Konoplev A., Wakiyama Y., Golosov V., Ivanov M., Igarashi Y. Peculiarities in distribution of sediments and radiocesium on Abukuma River floodplains caused by typhoon Hagibis // The 9th Annual Symposium of the IER, Fukushima University, Japan, Fukushima, 14 February, 2023, p. 45.

**Effect of torrential rain on the naturally occurring radiative material content in soils that
exposed to open-beach ship recycling activities in Bangladesh**

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共同研究者 : Begum Zinnat Ara

1. 成果

Introduction

Commercial vessels reach their end-of-life (EoL) stage after an average economic lifespan of 20 to 30 years and are then usually dismantled. It refreshes the global shipping fleet from occupational and environmental safety perspectives. About 2% of the global inventory of approximately 45,000 ocean-going ships is processed annually by the ship-breaking industry (SBI). Ship owners receive freight revenue during the ship's life and positive cash inflow from selling EoL ships to the SBI for demolition. A vessel becomes scrap when the expected revenue from selling the ship to the SBI outweighs its future earning potential over its operating cost. Other deciding factors for sending a ship for scrapping include an existing fleet's age profile, fleet size, accidents, and regulatory issues. SBIs in South Asia (Bangladesh, India, and Pakistan) have become popular destinations for EoL vessels over the last two decades due to their profitability, which stems from saved costs on labor, safety, and environmental compliance.

Coastal contamination due to ship-breaking activity at open beaches has been an actively debated issue. Making any objective comment on this issue requires a health risk assessment of the ship-breaking activities. The question of the current work is as follows:

“Is there any effect of a torrential downpour on the naturally occurring radiative material (NORM: U-238, Th-232, and K-40) content in soils of the SBI areas in Bangladesh?”

Experimental

Sample collected from five ship-breaking yards (Y1 to Y5) and one control location from January to December. Each yard was divided into three specific segments based on the activity: beaching, cutting, and storage. Cutting and storage segments receive the maximum exposure during the ship-breaking activity. Samples collected from cutting and storage segments were mixed to prepare composite samples, air-dried, and stored. The stored samples were later analyzed following standard protocols.

Results and discussions

U-238: The U-238 activity concentrations in SBz range from 25.59 ± 5.25 to 45.58 ± 8.19 Bq/Kg. The U-238 activity concentrations (Bq/Kg) varied among the pre-monsoon (Pre-M), monsoon (M), and post-monsoon (post-M) seasons, showing lower or comparable values

($p < 0.05$) at Post-M than in Pre-M (except for U-238 at Y5).

Th-232: The Th-232 activity concentrations in SBz range from 33.88 ± 1.69 to 56.40 ± 5.09 Bq/Kg. The Th-232 activity concentrations (Bq/Kg) varied among the pre-monsoon (Pre-M), monsoon (M), and post-monsoon (post-M) seasons, showing lower or comparable values ($p < 0.05$) at Post-M than in Pre-M.

K-40: The K-40 activity concentrations in SBz range from 365.1 ± 30.7 to 594.9 ± 58.3 Bq/Kg. The K-40 activity concentrations (Bq/Kg) varied among the pre-monsoon (Pre-M), monsoon (M), and post-monsoon (post-M) seasons, showing lower or comparable values ($p < 0.05$) at Post-M than in Pre-M.

2. 論文

S. Barua, S. Miah, M.N. Mahmud and I.M.M. Rahman, Isolation and identification of naturally occurring textile effluent-degrading bacteria and evaluation of their ability to inhibit potentially toxic elements, *Results in Engineering*, 17: 100967, 2023. [doi: 10.1016/j.rineng.2023.100967]

**Synthesis and characterization of some complexes of molybdenum,
an important fission product**

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共同研究者 : Biswas Bhusan Foni · Begum AraZinnat

1. 成果

The sources of high-specific activity molybdenum-99 (^{99}Mo) are research reactors as produced by neutron-induced fission of ^{235}U . Alternatively, low-specific activity ^{99}Mo can be obtained by using the (n, γ) nuclear reaction with ^{98}Mo (natural Mo or enriched ^{98}Mo). Generally, the specific activity of ^{99}Mo produced by fission is more than 1000 times higher than that obtained by the (n, γ) process. The universal means by which technetium- $^{99\text{m}}$ is made available for clinical applications is from the elution of generators containing high-specific activity fission-based ^{99}Mo . Nonetheless, we find the fission products as a mixture of different radionuclides. So, it is essential to separate them, which can be done by various means. The complexation of molybdenum (Mo) by ligands can be used to separate ^{99}Mo from the fission product mixture.

The ligands were prepared in two steps. S-methyldithiocarbamate was first condensed with amino benzaldehyde, and the resulting compound was condensed again with salicylaldehyde, 3-methoxy salicylaldehyde, 5-bromo salicylaldehyde, 5-nitro salicylaldehyde, and 4-diethylamino salicylaldehyde, to get five different ligands. The alcoholic solution of the ligands was then allowed to react with molybdenum acetylacetonate to form molybdenum complexes.

From the structure of the ligands, one can see several donor atoms in the ligands. But all of them can not donate to the metal atom due to the steric hindrance of the other atoms in the ligand. The IR spectrum of the Schiff bases shows the ν (NH) modes at ca. 3110 cm^{-1} . The C=N stretching mode is observed as a strong absorption at $1580\text{-}1630\text{ cm}^{-1}$. The $^1\text{H-NMR}$ spectrum of the Schiff bases in CDCl_3 also does not show resonance of the thiol proton at around 4.2 ppm, corroborating the IR evidence that the thiol tautomer is not present. Therefore, they can act as a bivalent tetradentate ligand by forming bonds with metal ions through the phenolic oxygen atom, the two azomethine nitrogen atoms, and the thiol or thioether sulfur atoms.

$[\text{MoO}_2(\text{acac})_2]$ has been used as a precursor to prepare dioxomolybdenum(VI) complexes of the ligands described above by ligand exchange reactions. When the ligands and $[\text{MoO}_2(\text{acac})_2]$ were refluxed in ethanol, solid, non-hygroscopic complexes were found. The IR spectra of the complexes show two bands at $902\text{ to }997\text{ cm}^{-1}$ and at $752\text{ to }883\text{ cm}^{-1}$ due

to $\nu \text{ sym}(\text{O}=\text{Mo}=\text{O})$ and $\nu \text{ asym}(\text{O}=\text{Mo}=\text{O})$ stretches, respectively. Dioxomolybdenum(VI) complexes possessing a cis O=Mo=O moiety exhibit two strong bands at this region. This is strong evidence of the formation of molybdenum complexes due to the reaction between the ligands and the molybdenum complexes.

Considering the spectral and analytical data, a regular octahedral structure of the molybdenum complexes is suggested, where two azomethine nitrogen, one thiol sulfur, and a phenolic oxygen act as donor atoms from the ligand and two oxygen atoms from molybdenum dioxo moiety.

2. 論文

1. R. Das, P. Sarker, S. Rabi, T. R. Majumder, A.M. M. A. Chowdhury, D. Palit and T. G. Roy, "Syntheses, characterization and antibacterial studies of manganese(II) complexes of hexamethyl tetraazacyclotetradecadiene ligand and isomers of its reduced form", 6(10), 10-15 (2022).
2. S. Rabi, P. Paul, S. K. S. Hazari, B. K. Dey, D. Palit, I. M. M. Rahman, T. G. Roy, "Rhodium(III) and Platinum(II) Complexes of an Azamacrocyclic: Synthesis, Characterization, and Antimicrobial Evaluation". Asian J. Chem., 34(9), 2444-2450 (2022).
3. A. Chakraborty, S. Rabi, L. Dey, D. Palit, B. K. Dey, E. R. T. Tiekink and T. G. Roy, "Cadmium(II) compounds of the bis-cyanoethyl derivative (LCX) of Me8[14]aneC (LC): Characterization and antibacterial studies", Heliyon, 8, e09678 (2022)

Nickel(II) complexes of a tetraethylphenyl tetraazamacrocyclic chelator: Synthesis, characterization, biological investigations and applications in radioactive waste decontamination.

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1. 成果

Introduction

Radioisotopes of nickel (r-Ni: Ni-59, Ni-63) are produced in the structural steels of nuclear reactor vessels and internal components from neutron activation of corresponding naturally occurring stable isotopes. The shape-persistent macrocycles can be used to isolate r-Ni from the waste matrix selectively. The objectives of the current work are as follows: (a) Preparation and characterization of a new tetraethylphenyl tetraazamacrocyclic chelator; (b) Preparation and characterization of its Ni(II) complexes; (c) Carrying out a study on their biological activities; (d) Study of the new macrocycle as an absorbent of radioisotopes of Ni.

Experimental

The chelators and corresponding metal complexes have been synthesized following standard protocols. Later, the same was characterized by some physical methods (color, melting point, solubility, etc.), microanalysis (C, H, N, and S), spectroscopic techniques (IR, UV-VIS, NMR, and Mass), and X-ray crystallography. Antimicrobial activities of the chelator and corresponding metal complexes have been studied against some bacteria. Antioxidant activities of the prepared compounds are also investigated.

Summary of findings

The summary of findings is as follows: (a) A new tetraethylphenyl tetraazamacrocyclic chelator and its Ni(II) complexes have been synthesized and characterized; (b) X-ray crystallographic study of the Ni(II) complex were conducted; (c) Remarkable biological activities of the prepared compounds were observed; (d) The new macrocycle acts as an excellent absorbent of Ni(II) during complex formation.

2. 論文

S. Rabi, P. Paul, S.K.S. Hazari, B.K. Dey, D. Palit, I.M.M. Rahman and T.G. Roy, Rhodium(III) and platinum(II) complexes of azamacrocycle: Synthesis, characterization and antimicrobial evaluation, Asian Journal of Chemistry, Vol. 34, No. 9, pp. 2444-2450, 2022.

[doi: 10.14233/ajchem.2022.23893]

M.A. Sayed, S. Rabi, P. Paul, L. Dey, B.K. Dey, Z.A. Begum, I.M.M. Rahman and T.G. Roy, Studies on cobalt(III) complexes of a cyanoethyl derivative of an isomeric hexamethyl tetraazamacrocyclic ligand, *Journal of Inclusion Phenomena and Macrocyclic Chemistry*, Vol. 102, No. 3-4, pp. 251-259, 2022. [doi: 10.1007/s10847-021-01110-5]

R. Amin, S. Rabi, L. Barua, M.N. Uddin, M.I. Morshed, I.M.M. Rahman and T.G. Roy, Nickel(II) complexes of an octamethyl tetraazamacrocyclic ligand and its N-pendent derivative: Syntheses, characterization, electrolytic behavior, and antimicrobial activities, *Asian Journal of Chemistry*, Vol. 35, No. 2, pp. 447-454, 2023. [doi: 10.14233/ajchem.2023.26929]

Development of the numerical model for simulation of the transfer of radionuclides and their uptake by marine biota due to planned release of the Fukushima storage water

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1. 成果

The 3D model THREETOX was applied for the long-term simulation of the planned release of radioactively contaminated water from Fukushima storage tanks to marine environment. Two radionuclides were considered: ^3H that has the largest activity in tanks and ^{129}I that can caused the largest dose of radiation to human. The constant release rate of ^3H equal to 22 TBq/y according to TEPCO estimations and the constant release rate of ^{129}I equal to 361 MBq/y according to estimations from the current study were used in the simulations.

The THREETOX model used monthly averaged currents from the KIOST-MOM model. A dynamic food web model was included in the THREETOX model. In the model, organisms uptake the activity directly from water and through the food chain. The food chain consists of phytoplankton, zooplankton, non-piscivorous (prey) fish, and piscivorous (predatory) fish. In case of ^{129}I , macro-algae was also considered. The modelling area covers Fukushima coastal waters and extends for 1600 km from the coast to the East. From North to South this area extends for 1300 km.

From model results, we can see how contamination will spread along the coast in different seasons. For example, in summer time the currents near the coast are directed to the North that leads to contamination of the Sendai Bay. This means that at different points along the coast, the concentration of radionuclides can periodically change according to currents that change during the year. Calculated concentrations of activity at several points along the coast of Japan, which correspond to largest cities in the area of interest, were extracted from model results. For example, calculated concentration of ^3H in water in Tomioka point, which is quite close to FDNPP, sometimes can exceed 200 Bq/m³. In Soma point, the concentration will exceed 50 Bq/m³, while in point Iwaki-Onahama – 20 Bq/m³ at some moments of time. In other points, the calculated concentration of ^3H in water will not exceed 10 Bq/m³ that is less than background concentration 50 Bq/m³. Concerning ^{129}I , its maximum concentration in water will be around 10^{-3} – 10^{-2} Bq/m³ in points close to FDNPP and around 10^{-4} Bq/m³ in points further from the NPP that is around 100 000 times less than the calculated concentrations of ^3H .

Calculated concentrations of OBT (organically bounded tritium) in predatory and prey fish are less than 0.01 Bq/kg in all points except FDNPP point where it is around 0.02 Bq/kg.

This value is 10 times less than measured concentration of OBT in fish (0.2 Bq/kg) that was made in 2014 in the coastal area near the damaged NPP. Calculated concentrations of ¹²⁹I in predatory and prey fish are in the range 10⁻⁶ – 10⁻⁴ Bq/kg in all considered points. Concentrations of ¹²⁹I in macro-algae are about 100 times higher due to ability of iodine to accumulate in macro-algae.

2. 論文

Bezhenar, R., Takata, H., and Maderich, V.: Transport of H-3 and I-129 in water and their uptake by marine organisms due to the planned release of Fukushima storage water, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-6019, <https://doi.org/10.5194/egusphere-egu23-6019>, 2023.

Establishment of FISH probes for dicentric analysis of wild rodents in Chernobyl

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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 Chernobyl, 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.

We collected two vole species, Grey red-backed vole (*M. rufocanus*) and Northern red-backed vole (*M. rutilus*) inhabiting Hokkaido, Japan. Leukocytes from bone marrow were cultured and chromosome spreads of cultured bone marrow cells were prepared for all samples. Then, using extracted DNA from liver of bank vole (previous study: I-21-11) as a template, the candidate centromere-specific tandem repeat region was amplified by PCR (referenced by Jernfors et al., 2021) and mounted fluorescent dye to create a probe. Finally, each chromosome plate was stained by the newly created probe and DAPI. Furthermore, we were able to transport cultured leukocytes of bank vole from Ukraine to Japan, so we centromere labeling was performed with newly prepared FISH-probes on bank vole chromosomes.

For both Japanese vole species, all of chromosomes with the exception of the Y chromosome were successfully stained. However, for bank vole, some chromosomes were not stained. As for the next step, we will try to identify the cause of failed labeling on these bank vole chromosomes and establish a new probe.

Acknowledgement: We thank Dr. NAKATA Akifumi, Hokkaido University of Science and Dr. Donovan ANDERSON, Hirosaki University for their great contribution about collecting voles and probe establishment.

2. 論文

Synthesis of Nano Charcoal as a Passive Radon Monitor

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受入研究者：床次 眞司・Kranrod Chutima・大森 康孝

1. 成果

INTRODUCTION

Radon is one of the naturally occurring radionuclides, which is well known as the second leading risk factor for lung cancer after tobacco smoking. According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2008 report on the sources and effects of ionizing radiation, the world mean value of annual effective dose by natural radiation sources is 2.4 mSv. Half of this dose is attributed to radon. To estimate the health effects of radon in natural gas, it is essential to determine the radon concentration in natural gas. There are many available methods to measure radon, including film badges, solid-state nuclear track detectors (SSNTD), active monitor, and charcoal adsorption. However, the detector and other components of the commercially available automated radon-in-air analyzer are sensitive to the hydrocarbons found in natural gas. Many radon detectors are measured using passive-type monitors by SSNTD to record long-term measurements. However, radon measurement needs a short-term measurement for screening purposes to get a quick result. Thus, we will develop a passive radon monitor base on the activated charcoal with nano technology.

METHOD

In the early stages of the research, the synthesis of nano charcoal was carried out. The activated charcoal were coconut shell-based combined with silica as a desiccant, put into the nano ball mill and magnetic stirrer. The next stage is quality control and validation. To obtain the counting efficiency and calibration factor to radon concentration, this monitor (nano charcoal that has been put into the canister) were placed in the radon calibration chamber at the Institute of Radiation Emergency Medicine (IREM), Hirosaki University in various conditions. Then measure by HPGe.

After exposure in radon chamber, the charcoal were measure with high purity germanium detector to analyze radon progeny (^{214}Pb and ^{214}Bi)

RESULTS

The results of this study has good counting efficiency against radon and can be used in all environment conditions. The radon monitor that will be developed is handy for screening measurements of radon concentrations both in public and work areas. The cost for this detector is not expensive and the quick analyses.

2. 論文

submitted to international journal, this year will be updated

**Quantification of radioactive-mineral deposition in various types of fossils from
excavation sites containing high levels of natural background radiation in Korat Plateau,**

Thailand

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受入研究者：床次 眞司

1. 成果

Project summary

The project “Quantification of radioactive-mineral deposition in various types of fossils from excavation sites containing high levels of natural background radiation in Korat Plateau, Thailand,” received a great opportunity supported by the ERAN 2022. This project was launched to quantify the radioactive mineral transition into fossil structures. The gamma dose rates released from fossil bones and petrified woods discovered from the Phu Wiang site (Khon Kaen), Nong Bua Lumpu site (Nong Bua Lamphu), Petchabun site (Petchabun), Sra Kaew site (Sra Kaew), Korat site (Nakorn Rachasima), Ubon Ratchathani site (Ubon Ratchathani), Tak site (Tak), Phu Noi site (Kalasin), and Phu Por site (Kalasin) were compared between the USB-Inspector survey meter and the OSLDs, as presented in Table 2. Although the long-term dose measurements using the OSLDs under the secular equilibrium of ^{222}Rn (> 38 days) were found to be higher than the short-time dose measurement (30 seconds) using the USB-Inspector survey meter, these values were found to be consistent for each fossil specimen. The study observed high gamma doses released from fossil bones discovered from the Petchabun and the Korat sites, which were found to be higher than the permissible level of radiation exposure to the public of $0.1 \mu\text{Sv} \cdot \text{h}^{-1}$ (corresponding to $1 \text{mSv} \cdot \text{y}^{-1}$). Contrastingly, radioactive minerals incorporated into the petrified woods were found to be lower than in the fossil bones, even though they were collected from the same excavation site. A possible assumption is due to the different compositions between bone and wood. In general, bones are composed of calcium phosphate, hydroxyapatite, and other organic components. During the fossilization process, an atom-by-atom of original organisms is replaced by radioactive minerals, especially for Ra-Ca ion substitution to concentrate in bone structure. Therefore, an action plan for radiation safety during fossil preparation and collection should be taken into account.

2. 論文

Manuscript

Changes of 8-OHdG in the Residents Living in High Radon Area of Mamuju, Indonesia

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1. 成果

The continuous exposure to low radiation doses, such as highly radon gas concentration, may induces oxidative base damage of guanine resulting in telomere fragility [1]. Radon is a radioactive gaseous element that emits α particles and have high linear energy transfer [2]. Alpha particle exposure can generate free radicals. When these free radicals interact with biological molecules, they may cause cellular lipid peroxidation and DNA damage [3]. These radioactive elements are found in abnormal concentration in area with high natural radiation exposure such as Mamuju in Indonesia [4,5]. Active oxygen radicals attack the eighth carbon atom of the guanine base in the DNA molecule to produce 8-hydroxydeoxyguanosine (8-OHdG) (its structure is illustrated in Figure 1) which is believed to be one of the predominant DNA lesions, resulting from free radical-induced oxidative stress in nuclear and mitochondrial DNA, and is widely used as a sensitive biomarker of DNA oxidative damage [6,7]. Thus, (8-OHdG) representing the oxidation levels. Beside that levels of 8-Oxo-dG in urine and blood serum can also be used to monitor oxidative responses to radiation therapy and chemotherapy in patients with cancer [8], such as gastrointestinal tumor [9]. So far, 8-OHdG levels in Mamuju have never been determined. This study will explore the effects of long-term staying in highly radon area on oxidative damage and antioxidation function in humans.

In this study, blood was collected from around 65 residents (both sex and age range from 20 to 60 y.o.) in the Mamuju, Sulawesi Barat with elevated radon area (40 person) and nearby control area (38 person). It was known that Tande-Tande sub-village in Botteng Utara, Mamuju has the highest annual radioactivity that reached up to 32 mSv/year (Figure 2). 8-Hydroxydeoxyguanosine (8-OHdG) was analyzed in serum/plasma isolated from these residents with standard procedure of the enzyme-linked micro method immunosorbent assay (ELISA). Statistical analysis will be implemented to know the significantly difference between exposed and control group. One-Way Analysis of Variance test was also used to determine the effect of radiation to the marker. The selected residents should have lived in the villages for more than 15 years, and no hospital X-ray examination within 6 months. The blood sampling for this research was conducted in 2020 with ethical approval from Ethical Committee of Health Research.

Results on the measurement of radon in 40 houses in study area of Tande-tande sub village showed that average radon concentration was 889.325 Bq/m³, whereas its mean

concentration from 38 houses in control area of Topoyo Village was 28.289 Bq/m³. From this study we also found that mean 8-OHdG in lymphocyte of Tande-Tande sub-village inhabitants was 15.69 ng/mL, whereas in samples from control area it was 25.73 ng/mL, and statistical analysis revealed that 8-OHdG in study area was significantly lower compared to those of control ($p < 0.0001$) (Figure 3). No positive correlation was found between radon concentration and its corresponding 8-OHdG. However, it is concluded that 8-Oxo-dG may be a suitable parameter for evaluating the degree of ionizing radiation-induced DNA damage. Further studies are needed for determining the underlying mechanism of their elevation. There is no difference found in the concentration of 8-OHdG between male and female respondents either in study area (15.51 vs. 15.92) or in control area (25.90 vs. 25.47) (Figure 4). This finding is similar with research by Kondkar et al. [10] that stated that there was no significant correlation between 8-OHdG and sex. Other experiment by Matsumoto et al. [11] also support these findings that this biomarker of oxidative stress in urine is not significantly influenced by sex or gender.

2. 論文

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The preliminary Study of Thioredoxin (Trx) Level in Residents Living in High Radon

Concentrations.

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共同研究者 : Purnami Sofiati

1. 成果

In Indonesia, Tande-Tande sub-village in Botteng Utara (Northern Botteng) village, Mamuju, West Sulawesi, is known to have a high indoor radon concentration. The indoor radon concentrations in this location can exceed 1,644 Bq/m³ (1). People in this area are exposed chronically to high levels of radon. Radon is an odorless and colorless noble gas derived from the uranium decay chain (U-238), which results directly from the decay of radium (Ra-226). Alpha (α) and beta (β) radioactive isotopes are among the radon decay products. Alpha particles, which are made up of two protons and two neutrons, have the capability to ionize and damage the DNA contained in living cells (2,3). Ionizing radiation in the form of alpha particles can cause DNA damage from chromosomal aberrations (CA), double strand DNA breaks and generate reactive oxygen species (ROS) (4,5). As a form of free radical, ROS includes molecules such as singlet oxygen ¹O₂, superoxide anion O₂^{•-}, hydrogen peroxide H₂O₂, and a hydroxide radical OH[•]. Several mechanisms exist in the human body for controlling and inhibiting ROS generation. An antioxidant is a chemical that scavenges free radicals and protects the organism from oxidative damage. As a result, adequate amounts of antioxidants may minimize the harm caused by free radicals and protect against alpha radiation damage. The thioredoxin (Trx) system is a key component in ROS removal. Thioredoxin reductase (TrxR), and nicotinamide adenine dinucleotide phosphate are components of an oxidative stress response system. Thioredoxin reductase is the sole enzyme known to catalyze Trx reduction and is a key role in irradiation resistance. Thus, in this study we will evaluate the TrxR level in the sera of Tande-Tande sub-village inhabitants and find out whether the levels are higher compare to control subjects. From this study we expected to reveal the antioxidant enzyme status particularly TrxR in Tande-Tande sub-village inhabitants. Until now study to evaluate the activity of TrxR in population living at high radon concentration never be conducted in Indonesia. This study will be considered as the first study in Indonesia that evaluate the activity of TrxR in population exposed to high levels of radon concentrations.

Methods

Fifty healthy adult subjects from Tande-Tande sub-village, Mamuju and fifty healthy adult

subjects from normal background radiation areas (NBRAs) will be enrolled in this study. Blood samples then will be obtained from the antecubital vein. Sera then will be collected by centrifugation at 3600 r.p.m for 15 min and keep at 4 degree celcius. The TrxR in serum samples then will be measured using TrxR ELISA Kit in our study.

Results

The measurement of Trx levels in the sera of Tande-Tande sub-village inhabitants already performed and showed a lower but non-significant compared to Topoyo village inhabitants.

2. 論文

Ramadhani, D., Purnami, S., Tetriana, D., Sugoro, I., Suvifan, V. A., Rahadjeng, N., Wanandi, S. I., Wibowo, H., Kashiwakura, I., Miura, T., & Syaifudin, M. (2022). Chromosome aberrations, micronucleus frequency, and catalase concentration in a population chronically exposed to high levels of radon. *International journal of radiation biology*, 1–16. Advance online publication. <https://doi.org/10.1080/09553002.2022.2110314>

Establishment of a protocol H2AX immunoassay for analysis of biological effects exposed to radiation and as a radiation biodosimetry assay.

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受入研究者：三浦 富智

共同研究者：Ramadhani Dwi・Kurnia Iin

1. 成果

Introduction

The basic principle of biodosimetry is to utilize the biologic changes induced by ionizing radiation to predict the radiation dose received by radiological accident victims. The acute cellular reaction as a biological effect to ionizing radiation can be used for quantitative biodosimetry. Phosphorylation occurs in histone H2AX after ionizing radiation exposure. Radiation-induced changes in the phosphorylation status of histone H2AX could be quantified using a whole-cell immunocytofluorescence technique. Another technique that could be used for evaluating the phosphorylation status of histone H2AX is the enzyme-linked immunosorbent assay (ELISA). In this study, we aim to establish the gamma H2AX analysis using an ELISA assay.

Methodology

Human blood from three healthy donors of similar age (38 years) will be collected in HEPARIN-containing vacutainer tubes. Blood samples will then be irradiated with a radiation dose 0, 2 and 6 Gy. Peripheral blood mononuclear cell lysates were prepared after two-hour incubation at 37 °C following irradiation or sham treatment using radioimmunoprecipitation (RIPA) buffer. The ELISA assay will then be performed using a commercial gamma H2AX ELISA Kit.

Result

The γ -H2AX/total H2AX ratio increased as the radiation dose increased in samples from two subjects. When the data from all subjects were pooled, a similar trend was observed. Interestingly, for one subject, an opposite trend was observed, i.e., a higher basal level of γ -H2AX/total H2AX ratio compared to the levels in blood samples irradiated with 2 and 6 Gy. The linear equation obtained using the pooled data was: $Y = 0.1247D + 0.9009$, ($R = 0.92$) Since the increased of γ -H2AX/total H2AX ratio with the radiation dose was found when all data were pooled, thus our study support the applicability of the ELISA-based quantification of γ -H2AX/total H2AX ratio in biodosimetry

2. 論文

Paper being submitted to the radiation protection dosimetry journal

Development method on Determination of Rare Earth Elements Analysis on Nuclear

Minerals from Monazite samples

氏名：Rosianna Ilsa

受入研究者：赤田 尚史・田副 博文

共同研究者：

1. 成果

The needs of Rare Earth Elements (REE) has recently increased tremendously. Significantly, the presence of REE commodities can contribute to the improvement of modern technology around us, such as cellular phones, computers, rechargeable batteries, magnets, fluorescent lamps, and other electronic equipment for civil and military purposes. Indonesia is an REE-producing country, primarily the result of processing tin mines in the form of monazite. Besides REE, there are also natural radionuclides in this monazite rock, namely Uranium and thorium. Therefore, qualified human resources are needed to analyze REE accurately and quickly.

in this research we separating the REE with U and Th from monazite using extraction chromatography technique and its successful with recovery around 85-105%. This research is method are quickly and accurately analyze Rare Earth Elements (REE) on various mineral and concentrate rocks, especially monazite from the Bangka Belitung Islands and Kalan with type of samples arerirang, so that the supply of REE for advanced materials. can be met both international and national demands

2. 論文

none

Radiocesium removal from soil

氏名：Swallow James Bruce Mathew

受入研究者：赤田 尚史・武田 晃・海野 佑介

共同研究者：

1. 成果

This proposed work was to develop a novel means of radiocesium removal from soil affected by the FDNPP accident while attempting to maintain the soil as a functioning entity. We planned to test a novel method to remove radiocesium from soil while limiting the impacts on soil properties. The new method may have reduced subsequent volumes of contaminated water and reduced further treatment and storage. Also, the radiocesium removed from the soil was hoped to be immobilized as it will be concentrated and stored within prussian blue (PB).

The experiment plan was to be done at the Institute for Environmental Sciences at Rokkasho with support from IREM and Mount Royal University. ERAN support was used to purchase the startup equipment needed to conduct the experiment. The basic setup was completed at Rokkasho with the aim of Dr. Swallow travelling to Japan in the summer of 2022 to assist. Regrettably, due to difficulties caused by the prolonged border closures due to the COVID-19 pandemic the work had to be indefinitely suspended.

2. 論文

N/A

Capacity building for development of nuclear techniques for analysis of radionuclides in environmental samples collected from Ruppur Nuclear Power Plant (RNPP), Bangladesh,

Part-2

氏名 : Rahman M Safiur

受入研究者 : 田副 博文

共同研究者 :

1. 成果

Capacity building for development of nuclear techniques for analysis of radionuclides in environmental samples collected from Ruppur Nuclear Power Plant (RNPP), Bangladesh
Bangladesh has a huge power (electricity) crisis and it is now prime goal of this country to enhance power generation. As a consequence, our government has started a project for establishing a 2400 MWe nuclear power plant, which will be commissioned in 2023. Therefore, development of manpower on the managements of radioactive materials is very important for the management of radiation safety, environmental contamination and their remediation. Interest in the uptake kinetics of radionuclides and toxic elements in natural system has recently been increased in order to understand the dispersion of radioactive waste and toxic elements in environment. Therefore, monitoring of radionuclides and toxic elements in vegetables, soil, sediment, rock and water samples in Bangladesh may provide important information for the management of radioactive materials and trace elements in the environment. However, the following manuscript has been published during the fascial of the project in 2022.

Choudhury, T.R., Ferdous, J., Haque, M.M., Rahman, M., Quraishi, S.B., Rahman, M.S. (2022). Assessment of heavy metals and radionuclides in groundwater and associated human health risk appraisal in the vicinity of Rooppur nuclear power plant, Bangladesh. *Journal of Contaminant Hydrology* 251 (2022) 104072. <https://doi.org/10.1016/j.jconhyd.2022.104072> [Impact Factor: 4.184]

2. 論文

1

Novel environmental DNA – eDNA - analyses of sediment archives for the reconstruction of sediment and radiocesium source contributions in a lake draining the main Fukushima radioactive pollution plume

氏名：Evrard Olivier

受入研究者：林 誠二・辻 英樹・脇山 義史

共同研究者：

1. 成果

High-resolution reconstruction of sediment and radiocesium source contributions in a lake draining the main Fukushima radioactive pollution plume.

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(a) Laboratoire des Sciences du Climat et de l'Environnement (LSCE/IPSL), Unité Mixte de Recherche 8212 (CEA/CNRS/UVSQ), Université Paris-Saclay, Gif-sur-Yvette, France

(b) National Institute for Environmental Science (NIES), Fukushima Branch, 10-2 Fukasaku, Miharu, Tamura, Fukushima, 963-7700 Japan

(c) Institute of Environmental Radioactivity (IER), University of Fukushima, Fukushima, Japan

Fallout radionuclides including a majority of ^{137}Cs have been deposited on Fukushima landscapes following the accident in March 2011. Ten years after the accident, questions remain regarding the fate of particle-bound ^{137}Cs across terrestrial environments in response to heavy rainfall events and the associated erosion events. In particular, there is a need to identify and quantify the sources delivering sediment and associated ^{137}Cs to the water bodies. Two sediment cores were collected in the Mano Dam reservoir, also referred to as Hayama lake, at midstream and downstream locations in June 2021 by the NIES team. Elemental geochemistry, organic matter and stable isotopes, visible colorimetry, particle size, and radiocesium isotope spectrometry analyses were carried out at very high resolution, with depth increments of 1 cm, on both sediment cores. In addition, 17 samples were collected for environmental DNA (eDNA) analyses on the midstream core. A total of three DNA extraction methods with three replicates, which mean 9 replicates per samples, were done to ensure more robust measurements. The extracted DNA was then amplified by PCR/NGS and then sequenced using various primers targeting vertebrates, plants and fungus DNA. Sequenced DNA was compared with Japan and worldwide DNA banks to identify taxa and species. These various analyses were used to provide multiple lines of evidence to define and interpret the flood event sequence recorded by the sediment deposits, and rainfall records were used for

relative dating. The sediment tracing approach highlighted changes in sediment sources, with variable contributions from forest, cropland, and subsoil (i.e. channel bank collapse and landslides) since the Fukushima accident and following decontamination works. Following the Fukushima accident, during the abandonment period (2011 - 2014), there was a sharp decrease in cropland contribution. However, as soon as the decontamination work began (2014 - 2016), cropland contribution started increasing until it returned again to the pre-accident level during the remediation phase (2018-2019). Finally, we are investigating the added value of eDNA measurements to study the temporal evolution of biological communities in response to these changes.

2. 論文