福島大学環境放射能研究所

第11回 成果報告会

The 11th Annual Symposium of the IER, Fukushima University

要旨集
Abstracts

日時 Date
2025年 3月10日(月) ～ 11日(火)
From Mon, March 10 to Tue, March 11, 2025

会場 Vanue
コラッセふくしま
CORASSE Fukushima

主催 国立大学法人 福島大学 Fukushima University
環境放射能研究所 INSTITUTE OF ENVIRONMENTAL RADIOACTIVITY

後援 福島県　筑波大学　広島大学　長崎大学　東京海洋大学
公立大学法人福島県立医科大学
国立研究開発法人量子科学技術研究開発機構　福島国際研究教育機構

はじめに

帰還困難区域を含む浜通りでの実験養蜂を2023年と2024年シーズンに行いました。フランスの研究者たちと共同です。６箇所に巣箱を６箱ずつ置いていろいろな方法でセイヨウミツバチを対象に環境放射能に関係する研究を行い、蜂蜜も収穫して分析しました。

2023年シーズンには巣箱ごとに蜂蜜を集めて放射性セシウム濃度を分析したところ、帰還困難区域ではたいてい食品基準値に近いか、ときにはそれを超える値が検出されました。ところが、同じ箇所の６箱で濃度が巣箱ごとに違うのです。１頭の働き蜂が１回に運ぶ花蜜は１種類の１箇所の花に由来するかもしれません。同じ巣の働き蜂も個体ごとに違う場所の花に行くでしょうから、１頭が運ぶ花蜜という単位で比べれば濃度には差があるでしょう。しかし、収穫した蜂蜜は百花蜜です。巣箱には何千もの働き蜂がいて色々な場所の色々な花から何回も蜜を集めてくるのですから、長期間巣箱を置いておけば平均化されるのではないでしょうか。そのような考えから、６つの巣箱で濃度差は大きくならないだろうと予想していましたが、結果はそうではなかったのです。もしかすると、巣箱(つまり同じ女王の群)ごとに蜜を集めに行く方向や花に好みや流行があるのかもしれません。濃度がかなり異なるという客観的事実を受けて、色々な可能性を考えながら次の段階の観察や実験に思いを巡らすことになりました。

ヤマメなどの淡水魚や、イノシシなどの野生哺乳類でも、放射性セシウム濃度に季節による変化だけでなく個体による違いが見られています。近い場所に居る個体間で食べ物に違いがあるのか、季節ごとに食べ物が変わるのか、など新たな課題設定があります。放射性セシウムの濃度の違いの理由が、同種の生き物の中で生じた行動や生態学的位置の違いに由来するかもしれないということで、生態学的な示唆を与えてもいるのです。

植物はどうでしょうか。植物は降雨に由来する水と大気中の二酸化炭素をもとに有機物を作ります。林の樹木は季節変化に応じた成長から年輪ができますが、その中に年ごとに異なる水の成分の痕跡を記録しています。年ごとに異なる日射、降雨、気温などの気象条件によって、植物が吸収する水の分子を構成する水素と酸素の同位体比が変動するのですが、その結果が有機物の形態として年輪に残っているのです。放射性ではない、自然に存在する安定同位体ですが、太陽の黒点周期やエルニーニョ等によっても変化する年ごとの気象条件も樹木から読み取る事ができる、つまり、樹木の同位体分析によって過去の気象条件を明らかにできるということでもあるのです。

生態系の理解は社会に何をもたらすのでしょうか。所与の条件の下、どのような食品にどれほどの放射性物質が含まれることになるかという推測の不確かさを生態系のより深い理解によって減じることができます。これによる安全性向上は環境放射能学が目指す社会実装です。さらに、放射能の動きの観察とそれを動機とした生態系理解は、生物資源の再生産や水の賦存量推定など環境の持続可能な利用とも関係する物質循環の解明にも道を開くものとなるでしょう。環境要素の背景となる気候変動やその結果の予測にすら同位体比研究など環境放射能学の守備範囲となりつつあるようにも思われます。シンポジウム「環境放射能から見えるエコシステム」はこのような考えから企画しました。被災からの復興はもちろん最重要ですが、復興の先あるいは被災の教訓のさらに向こうにあるものを皆様にご覧いただければ幸いです。

福島大学環境放射能研究所

所長　難波　謙二

FOREWORD

We conducted experimental beekeeping in Hamadori, including the difficult-to-return zone, during the 2023 and 2024 seasons in collaboration with researchers from France. Six beehives were placed at different locations to study the effects of environmental radiation on honeybees using various methods. Additionally, we harvested and analyzed honey as part of the research.

In the 2023 season, we collected honey from each beehive and analyzed its radiocesium concentration. In the difficult-to-return zone, detected radiation levels were generally close to or occasionally exceeded the food standard levels. However, the concentrations in six hives at the same location varied from hive to hive. The nectar carried by one worker bee at a time may come from flowers of a single species and a single location. The worker bees in the same hive may go to different flowers in different locations, so the concentration may vary when compared in terms of nectar carried by a single bee. However, the honey harvested is multi-flower honey; since there are thousands of worker bees in each hive and they collect nectar many times from various flowers in various locations, it was expected that the concentrations would be averaged out over a long period of time. Based on this idea, we expected that there would not be a significant difference in concentration among the six beehives, but this was not the case. Perhaps each hive (i.e., the same queen's colony) has its own preferences and trends in the direction and flowers from which it goes to collect nectar. Faced with the objective fact that the concentrations were quite different, we started to consider various possibilities and plan for the next stage of observation and experimentation.

In freshwater fish such as masu salmon, and wild boars and other wild mammals, differences in radiocesium concentrations have been observed not only between seasons but also between individuals. This raises new research questions to be addressed, such as whether there are differences in food among individuals in close proximity, or whether food changes with the seasons. It has ecological implications, as the reasons for differences in radiocesium concentrations may stem from differences in behavior and ecological position that occur within the same species of creature.

What about plants? Plants produce organic matter using water from rainfall and carbon dioxide from the atmosphere. Trees in the forest form annual rings during their growth in response to seasonal changes, which record traces of water components that vary from year to year. The stable isotope ratios of hydrogen and oxygen that make up the water molecules absorbed by plants fluctuate according to different solar radiation, rainfall, temperature, and other weather conditions from year to year, and the result is left in the annual rings as a form of organic matter. Although these isotopes are naturally occurring stable isotopes, not radioactive, and the annual weather conditions, which vary with the sunspot cycle and El Niño, can be read from the trees. In other words, isotope analysis of tree rings can reveal past climate conditions.

What does an understanding of ecosystems bring to society? A deeper understanding of ecosystems can reduce the uncertainty of estimating how much radioactive substances will be contained in a food item under any given condition. This improvement in safety is the social implementation that environmental radioactivity studies aim for. Furthermore, observation or monitoring of the movement of radioactivity and understanding of ecosystems motivated by it will pave the way for elucidating the material cycle, which is related to the sustainable use of the environment, including estimations of the reproduction of natural biological resources and the potentially available water. It seems that environmental radioactivity studies, including isotope ratio studies, are becoming a field of study for predicting climate change and its consequences, which are the background of environmental factors. The symposium, "Ecosystems from the Environmental Radioactivity Perspective" was planned with this in mind. While recovery from the disaster is of course of the utmost importance, we hope that everyone will be able to see what lies beyond recovery and beyond the lessons learned from the disaster.

NANBA Kenji
Director, Institute of Environmental Radioactivity, Fukushima University

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The 11th Annual Symposium of the IER, Fukushima University

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Ismail Md. Mofizur RAHMAN	(Professor)
WADA Toshihiro	(Professor)
TAKATA Hyoe	(Associate Professor)
Maksym GUSYEV	(Project Associate Professor)
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第11回成果報告会　ワーキンググループ

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和田　敏裕	教授
高田　兵衛	准教授
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Venue Guide Map / 会場案内

CORASSE Fukushima

1 -20 Mikawaminamimachi, Fukushima City, Fukushima Prefecture, Japan

コラッセふくしま

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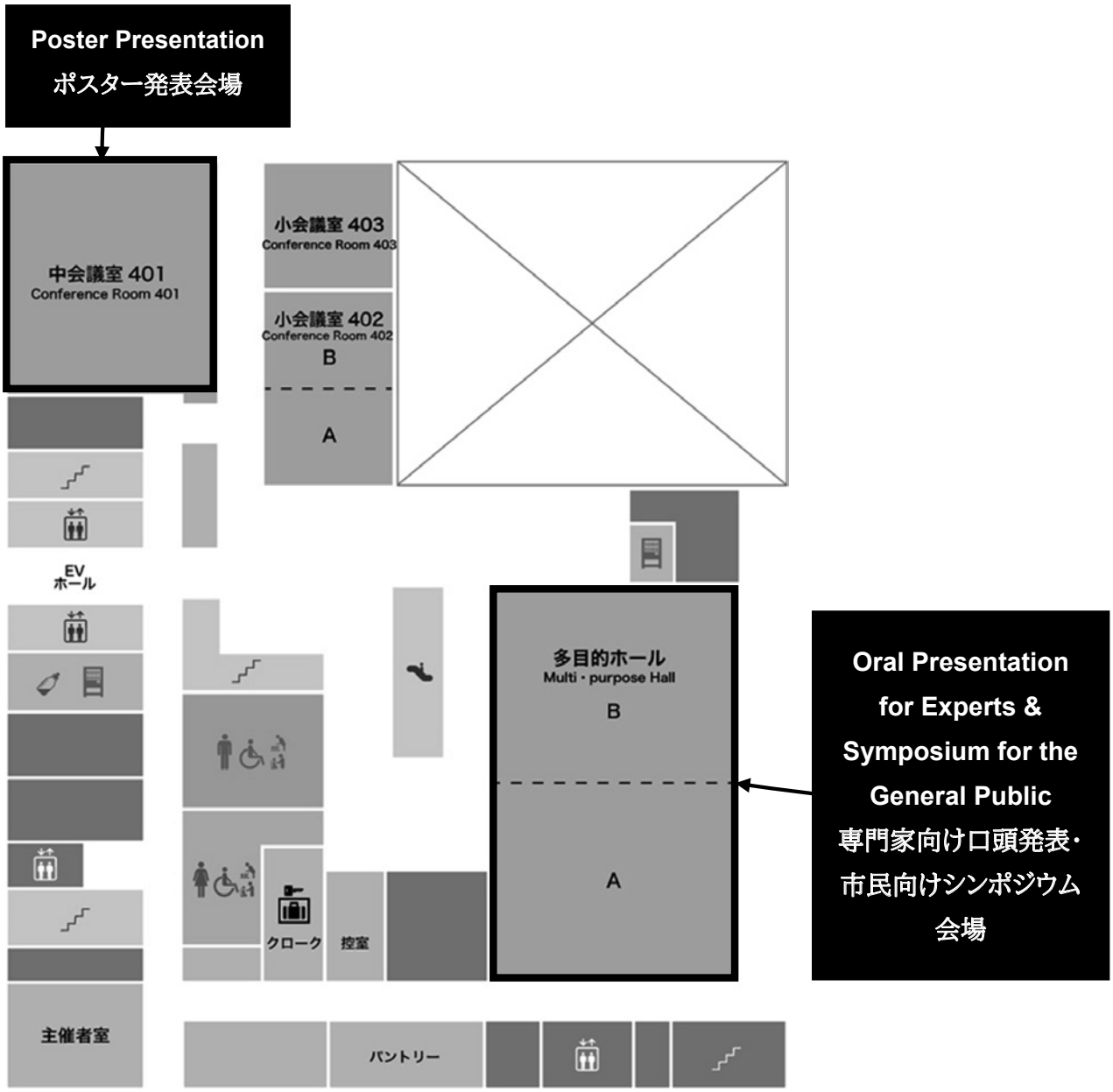
Floor Guide / フロアガイド



4th Floor / 4 階

3月11日 March 11, 2025

市民向けシンポジウム / Symposium for the General Public

13:00 **開会挨拶 / Opening Remarks**
福島大学　学長　三浦浩喜 / MIURA Hiroki, President, Fukushima University

13:05 **趣旨説明 / Overview**
福島大学環境放射能研究所　所長　難波謙二
NANBA Kenji, Director, Institute of Environmental Radioactivity, Fukushima University

13:10 **S-01** **年輪と古環境　－埋れ木の年代を決める－**
木村勝彦
Tree ring and past environment -Dating buried old woods-
KIMURA Katsuhiko …… 11

13:35 **S-02** **大気-植物-土壌系におけるHTO循環の解明**
平尾茂一
Elucidating of tritiated water cycle in atmosphere-plant-soil system
HIRAO Shigekazu …… 12

14:00 **休憩 / Break**

14:10 **S-03** **なぜ淡水魚の放射性セシウム濃度は低下しにくいのか？**
和田敏裕
Why does cesium radioactivity persist in freshwater fish?
WADA Toshihiro …… 13

14:35 **S-04** **ALPS処理水放出後の海のトリチウム**
高田兵衛、三浦輝、和田敏裕
Tritium in the marine environment after the ALPS treated water discharge
TAKATA Hyoe, MIURA Hikaru, WADA Toshihiro …… 14

15:00 **休憩 / Break**

15:10 **S-05** **Long-term changes in ecosystems radioactive contamination : legacy sites and Fukushima**
Aleksei KONOPLEV …… 15

15:35 **S-06** **なぜコメの放射性セシウム濃度は低いのか**
塚田祥文
Why are the radiocaesium activity concentrations in rice so low?
TSUKADA Hirofumi …… 16

16:00 **総合討論 / Discussion**

16:25 **閉会挨拶 / Closing Remarks**
福島大学環境放射能研究所　副所長/特任教授　アレクセイ・コノプリョフ
Aleksei KONOPLEV, Vice Director/Project Professor, Institute of Environmental Radioactivity, Fukushima University

16:30 **学生ポスター賞表彰**
Student poster awards ceremony

3月10日 March 10, 2025

専門家向け口頭発表 / Oral Presentation for Experts

13:30 **開会挨拶 / Opening Remarks**
福島大学環境放射能研究所　所長　難波謙二
NANBA Kenji, Director, Institute of Environmental Radioactivity, Fukushima University

13:35 **O-01** **Learning from tritium radioisotope in Fukushima waters**
Maksym GUSYEV, HIRAO Shigekazu, Aleksei KONOPLEV, WAKIYAMA Yoshifumi, Alexandre CAUQUOIN, AKATA Naofumi …… 19

14:00 **O-02** **Environmental modeling for radiocesium in watershed scale**
SAKUMA Kazuyuki, KURIKAMI Hiroshi
流域スケールにおける放射性セシウム動態モデリング
佐久間一幸、操上広志…… 20

14:25 **休憩 / Break**

14:35 **O-03** **The Fukushima paradox of plankton : hot zooplankton in clean waters**
NISHIKAWA Jun
福島プランクトンのパラドックス：きれいな水の中の高線量プランクトン
西川淳…… 21

15:00 **O-04** **Radial Distribution of ^{137}Cs in Japanese Cedar : Review and Ongoing Research**
Muyiwa Michael OROSUN, Vasyl YOSCHENKO, NANBA Kenji …… 22

15:25 **休憩 / Break**

15:35 **O-05** **Radioecology in agricultural systems: interception, weathering, translocation, and soil-to-crop transfer**
TAGAMI Keiko, UCHIDA Shigeo
農業環境における放射生態学：遮断、ウェザリング、転流および土壌-植物間移行係数
田上恵子、内田滋夫…… 23

16:00 **O-06** **Integrating Ecosystem Services in Radiological Protection**
Deborah OUGHTON …… 24

16:25 **総合討論 / Discussion**

16:55 **閉会挨拶 / Closing Remarks**
福島大学環境放射能研究所　副所長/特任教授　アレクセイ・コノプリョフ
Aleksei KONOPLEV, Vice Director/Project Professor, Institute of Environmental Radioactivity, Fukushima University

Poster Presentation for Experts / 専門家向けポスター発表

Rivers and Lakes/河川･湖沼

Measurement and Analysis/計測･分析

Ecosystem and Effects/生態系･影響

Speciation Radiochemistry/存在形態

Modeling/モデリング

市民向けシンポジウム

Symposium for the General Public

S-01

Tree ring and past environment -Dating buried old woods-

KIMURA Katsuhiko*[1]

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Tree ring analysis（dendrochronology）is the only tool for dating old woods excavated from archaeological sites and geological event deposits in annual resolution. Introduction of oxygen stable isotope dendrochronology enables to locate woods of various species on a single chronological scale. To create multi-millenial oxygen isotope chronology, tree rings of the vast old woods that I have collected were analyzed using TCEA-irms installed in IER. Constructed reference chronology was successfully applied to date timbers from Jomon Period archaeological sites.

Keywords： dendrochronology, oxygen isotope, tree ring, Jomon Period

年輪と古環境　－埋れ木の年代を決める－

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樹木の年輪は樹木周辺の過去のさまざまな環境を１年毎に記録している。この年輪を使って考古遺跡や火山噴火などの年代決定や、年代の決まった古材の年輪を使って古気候などの環境復元をする学問を年輪年代学と呼ぶ。年輪年代学で最も重要な要素は年代決定で、年輪幅の年々変動が個体間で同調することを利用して年代決定がおこなわれてきたが、異なる樹種間では適用できないなどの制約があった。
これを解決したのが酸素同位体比年輪年代法で、１年輪ごとの「幅」の代わりに１年輪ごとの「酸素同位体比」を用いることで、多様な樹種を含む古い木材を１本の「年代の物差し」の上に配置することが可能になった。木村研究室では縄文時代を中心とした大量の木材を収集してきた。この木材の年輪を環境放射能研究所に設置された安定同位体比分析装置で分析することで5000年前までの年代の物差しがほぼ完成した。さらに、新たに収集した遺跡出土木材などの埋没材の年輪について分析を進めた結果を紹介する。

キーワード：酸素同位体比年輪年代、年輪、縄文時代

S -02

Elucidating of tritiated water cycle in atmosphere-plant-soil system

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There is a need for scientific knowledge to evaluate the environmental impact of releasing ALPS-treated water from the TEPCO FDNPP into the ocean and operating fusion facilities in the future. Therefore, it is crucial to understand tritium transfer to plants and organic matter synthesis through photosynthesis. However, observational data on tritiated water vapor migration under meteorological conditions in Japan are lacking. In this study, tritium concentrations in environmental media (air, soil, and plants) and tritium concentration variations in plants were characterized by analyzing tritium migration. Monthly atmospheric HTO concentrations were within past fluctuation ranges caused by nuclear tests, but ranged from below ND to slightly higher than the recent Japanese levels. The soil HTO concentrations were consistent when the atmospheric HTO was released. Tissue free water tritium concentrations in plant leaves varied greatly depending on observation timing, explained by diffusion uptake from the atmosphere through stomata, reflecting the instantaneous atmospheric HTO concentration at collection. The organically bound tritium concentrations were generally similar to monthly atmospheric HTO concentrations. This study revealed tritium concentration variations among air, soil, and plants through actual measurements, providing important basic information for assessing the environmental tritium impact near atmospheric release sources.

Keywords：tritiated water vapor, organically bound tritium, LSC

大気-植物-土壌系におけるHTO循環の解明

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大気放出されたトリチウムが植物に取り込まれる過程は被ばく線量評価で重要である。そのためトリチウムの植物への移行および光合成により有機生成物を合成するプロセスの理解が求められる。しかし、日本の気象条件での水蒸気状トリチウム(HTO)の移行過程の実験的な基礎データが不足している。本研究では環境媒体中(大気、土壌、植物)のトリチウム濃度を観測し、植物中のトリチウム濃度変動の特徴を明らかにした。月間大気中HTO濃度については、大気圏内の核実験に起因する過去の変動幅の範囲内ではあるが、ND以下から近年の日本の一般環境よりもやや高い濃度が得られた。土壌中HTO濃度については、大気中HTOを起源と仮定すると整合的な濃度レベルであった。植物葉中HTO濃度は、観測のタイミングにより大きく変動することが分かった。これは植物の葉の気孔を介して、大気から植物に拡散により取り込まれるプロセスで説明でき、採取時点の瞬間的な大気中HTO濃度を反映していると考えられる。一方で、有機結合型トリチウム濃度は、月間の大気中HTO濃度とおおむね同レベルであった。大気、土壌、植物間のトリチウム濃度変動を実測で明らかにした。これらの知見は大気放出源付近の環境トリチウム影響評価のための基本的な情報として重要である。

キーワード：大気水蒸気中トリチウム、有機結合型トリチウム、LSC

S -03

Why does cesium radioactivity persist in freshwater fish?

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This presentation will explain the reasons for the persistent ^{137}Cs contamination of freshwater fish compared to marine fish, based on a case study of masu salmon in the Ukedo River system that flows through the difficult-to-return zone (Wada et al., 2024). The ^{137}Cs concentrations of masu salmon ranged from 10.6 to 13,000 Bq/kg-wet, with large differences among sites. At all sites, "size effect" (a tendency for larger individuals to have higher ^{137}Cs concentrations) was observed and individuals exceeding the regulatory limit of 100 Bq/kg were also found. The ^{137}Cs concentrations of masu salmon at each site were found to be related to the air dose rates, dissolved-form ^{137}Cs concentrations, and ^{137}Cs concentrations of primary producers. Detailed analyses at the Ogaki Dam reservoir (an artificial lake) and two nearby river sites showed that the main prey of masu salmon were terrestrial insects with high ^{137}Cs concentrations in the river, and small fish with low ^{137}Cs concentrations in the lake. Based on the results of carbon and nitrogen stable isotope ratio analysis, it was considered that continuous ^{137}Cs uptake from terrestrial insects supplied from forest ecosystems and bioaccumulation within the water body strongly affected the ^{137}Cs concentration in the masu salmon in river and lake ecosystems, respectively. These different factors were thought to cause persistent ^{137}Cs contamination of freshwater fish inhabiting the upper reaches of rivers and dam reservoirs.

Keywords：Freshwater fish, ^{137}Cs, food-web transfer, river, dam reservoir

なぜ淡水魚の放射性セシウム濃度は低下しにくいのか？

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本講演では、帰還困難区域を流れる請戸川水系に生息するヤマメの研究事例(Wada et al., 2024)をもとに、海水魚に比べ、淡水魚の^{137}Cs汚染が長期化してしまう要因ついて説明する。2020年の夏季に請戸川水系の上流域５地点および大柿ダム貯水池で採集されたヤマメの^{137}Cs濃度は10.6～13,000 Bq/kg-wetであり、地点間で大きな違いが確認された。全ての地点でサイズ効果(サイズの大きな個体ほど^{137}Cs濃度が高い傾向)が認められるとともに、基準値100Bq/kgを超える個体が確認された。また、各地点のヤマメの^{137}Cs濃度は、空間線量率や溶存態^{137}Cs濃度、一次生産者の^{137}Cs濃度等との関係が認められた。大柿ダム貯水池および周辺河川２地点において詳しい分析を行った結果、ヤマメの主な餌生物は、河川では^{137}Cs濃度の高い陸生昆虫であり、ダム貯水池では^{137}Cs濃度の低い小型魚類であった。また、炭素窒素安定同位体比分析の結果から、河川では森林域に生息する陸生昆虫を介した取込が、ダム貯水池では水域内での生物濃縮が、各水域に生息するヤマメの^{137}Cs濃度に影響を及ぼしていると考えられた。これらの異なる要因により、河川上流域およびダム貯水域に生息する淡水魚のCs汚染が長期化していると考えられた。

キーワード：淡水魚、^{137}Cs、食物連鎖、河川、ダム貯水池

S -04

Tritium in the marine environment after the ALPS treated water discharge

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In this presentation, we will show the spatiotemporal distribution of tritium (H-3) in coastal seawater and marine organisms in the coastal waters near the Fukushima Daiichi Nuclear Power Plant (FDNPP) for one year after the release of ALPS treated water. Relatively high tritium was observed in the coastal water within 5 km from the plant on September 5, 2023 during the first discharge period (August 24-September 11). On the other hand, the results collected on October 11, 2023 during the second release period (October 5 - October 23) were not necessarily distributed in the same manner as the first release. A similar trend was observed thereafter, indicating that the distribution of tritium in the coastal area around FDNPP depends mainly on coastal currents and other factors. The results obtained approximately one year after the release will also be discussed and will be compared with results of coastal seawater and marine organisms before the release of ALPS treated water.

Keywords：coastal region, tritium level, seawater, marine organism

ALPS処理水放出後の海のトリチウム

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本成果報告会では、福島第一原子力発電所(FDNPP)近傍の沿岸海域においてALPS処理水放出後のおよそ１年間の沿岸海水および海洋生物中のトリチウム(H-3)の時空間分布について速報する。2023年の夏に最初のALPS処理水が放出され、放出期間中(８月24日～９月11日)の2023年９月５日に採取した結果、放出口から半径５km以内において、比較的高いトリチウムが観測された。一方、２回目の放出期間中(10月５日～10月23日)の10月11日に採取した結果は必ずしも１回目と同様の分布ではなかった。その後も同様な傾向が見られることから、FDNPP周辺の沿岸域におけるトリチウムの分布は、主に沿岸の海流などに依存していることが示唆される。本報告会では、放出後約１年間で得られた結果についてALPS処理水放出直前までの海水と海産生物濃度(約0.1Bq/L)の比較についても発表する。

キーワード：沿岸海域、トリチウムレベル、海水、海産生物

S -05

Long-term changes in ecosystems radioactive contamination : legacy sites and Fukushima

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The main radionuclides of environmental significance released due to the Fukushima accident were radioiodine (specifically ^{131}I) and radiocesium isotopes (^{137}Cs and ^{134}Cs). ^{131}I was posing a threat only during a few months after the accident since its half-life is very short (about 8 days). The initial ratio of $^{134}Cs/^{137}Cs$ isotopes in the Fukushima fallout was about one. The contribution of ^{134}Cs to the radioactivity of the environment, as compared to ^{137}Cs, was decreasing over time due to its more rapid decay. Today, 14 years after the Fukushima accident, with the short-term and mid-term phases already over, ^{137}Cs long-term fate and transport in the environment of the Fukushima Exclusion zone becomes an issue of significant relevance. The ease with which ^{137}Cs moves through the ecosystems and is taken up by plants and animals is determined by its chemical forms and site-specific environmental characteristics. The peculiarities in climate, geomorphology, and ^{137}Cs speciation in the fallout were demonstrated to lead to differences in migration rates of ^{137}Cs in the environment and rates of its natural attenuation as compared to Mayak in Russia and Chornobyl in Ukraine. It has been revealed that in the exclusion zone, the Fukushima-derived ^{137}Cs is strongly bound to soil and sediment particles, which reduces the potential bioavailability of this radionuclide. Up to 30% of the deposited ^{137}Cs on soil of the exclusion zone were found to be incorporated in hot glassy particles ("Cs balls") insoluble in water. Irrigation ponds in Okuma and Futaba towns demonstrated persistent behavior of ^{137}Cs, its concentrations not decreasing and showing regular seasonal variations: the ^{137}Cs concentrations tend to grow in the summer and decrease in the winter. Overall, higher precipitation, higher air temperatures and steep slopes in the Fukushima exclusion zone are conducive to higher wash-off of radiocesium and its faster self-purification as compared to the Mayak and Chornobyl cases.

Keywords : Fukushima, Chornobyl, Mayak, exclusion zone, radiocesium, fate, transport, self-purification

S-06

Why are the radiocaesium activity concentrations in rice so low?

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The absorption of radiocaesium (Cs) from roots to plants is strongly influenced by potassium (K), another alkali metal and an essential element, and plant uptake of Cs and K is competitive. Low K content increases the uptake of Cs by plants, while the presence of sufficient K inhibits Cs uptake. Therefore, the presence of a certain amount of K in the soil is necessary as an essential nutrient element for crops and to control the transfer of Cs to plants. Rice is the staple food of the Japanese and a major grain in Southeast Asia. Rice cultivation is irrigated with agricultural water and maintained under waterlogged conditions throughout the growing season. This creates a reducing environment in the soil below the water surface, generating ammonium ions (NH_4^+), and the Cs previously absorbed in the soil is exchanged with NH_4^+, resulting in a higher concentration of Cs in the pore water than in the flood water. In this study, flood water and pore water were collected throughout the cultivation period and investigated the changes in the ^{137}Cs and K concentrations. The ^{137}Cs concentration in pore water increased more than 10 times than that in flood water due to an increase in NH_4^+ in pore water, and that the K concentration in pore water also increased at the same time. As a result, the ^{137}Cs/K concentration ratio in pore water was relatively uniform, indicating no change in the competitive relationship between the two, which was similar to the ^{137}Cs/K concentration ratio in flood water. Therefore, it is clear that waterlogging increases the ^{137}Cs concentration in pore water, but at the same time increases K concentration, thereby suppressing ^{137}Cs uptake by rice.

Keywords： ^{137}Cs/K concentration ratio, NH_4^+, waterlogging period, competitive absorption

なぜコメの放射性セシウム濃度は低いのか

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根から植物へ吸収される放射性セシウム(Cs)は、同族のアルカリ金属であり必須元素でもあるカリウム(K)に強い影響を受け、CsとKの植物吸収は競合的な関係にある。Kが少なければ多くのCsが植物に吸収され、十分なKが存在すればCsの吸収は抑制される。Kは作物の必須栄養元素として、また、Csの植物移行抑制としても土壌に一定量の存在が必要となる。コメは日本人の主食であり、また、広く東南アジアの主要穀物である。コメの栽培は、農業用水を灌漑し、生育期間中湛水(水田に水を張ってため続ける)状態を維持する。そのため、水面下の土壌は還元的な環境となり、アンモニウムイオン(NH_4^+)が発生し、それまで土壌に吸着していたCsがNH_4^+と交換され間隙水にCsが溶出するため、田面水に比べ高い濃度となる。そこで本研究では、栽培期間を通して田面水と間隙水を採取し、^{137}CsとKの濃度変化を調査した。間隙水の^{137}Cs濃度はNH_4^+の増加によって田面水^{137}Cs濃度の10倍以上に増加したが、同時にK濃度も増加した。その結果、間隙水中^{137}Cs/K濃度比は比較的一様にあり、両者の競合的な関係に変化は見られず、また、田面水の^{137}Cs/K濃度比とも同様であった。したがって、湛水によって間隙水中^{137}Cs濃度は上昇するが、同時にK濃度も増加することで、イネへの^{137}Cs吸収を抑制していることが明らかになった。

キーワード： ^{137}Cs/K濃度比、NH_4^+、湛水、競合的な吸収

Oral Presentation for Experts

専門家向け口頭発表

O-01

Learning from tritium radioisotope in Fukushima waters

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Tritium radioisotope (H-3 or T) with a half-life of 12.32 years was released to the atmosphere in the 2011 Fukushima Daiichi Nuclear Power Plant (FDNPP) accident making it a complimentary tool to the established cesium-137 dynamics in Fukushima waters. While environmental tritium is a cosmogenic radionuclide traced as a water molecule (HTO) to understand terrestrial water circulation, tritium monitoring is required to quantify the influence of the FDNPP tritium release and ongoing activities such as the FDNPP decommissioning. In the recent study, the atmospheric simulation with both the FDNPP anthropogenic and natural tritium in precipitation was required to interpret water transit times from tritium measurements at coastal sites between 2012 and 2014. For monthly precipitation, tritium has been measured in Namie Town from 2012 and at the Institute of Environmental Radioactivity (IER) from 2023 as a part of the Global Network of Isotopes in Precipitation (GNIP) under the International Atomic Energy Agency. In 2023, tritium measurements in summer precipitation and surface waters indicated non-typical seasonality pattern indicating a complex water circulation.

Keywords：tritium radioisotope, precipitation, pond water, stream water, mean transit times

O-02

Environmental modeling for radiocesium in watershed scale

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It is important to investigate radiocesium behavior through rivers based on the characteristics of migration of each land use when we consider the radiocesium behavior in terrestrial areas. Many universities and institutes have been conducting long-term monitoring to investigate the radiocesium discharge through rivers and the mechanism of its sources and discharges. In this study, we report simulation studies by watershed modeling coupled with a forest compartment model which describes radiocesium leaches from forest litter upstream of Ohta River in the forested catchment in Fukushima Prefecture. Regarding the dissolved radiocesium concentration in river water, our model can reproduce the observed phenomena such as the temporal variation under base flow conditions and high concentration under storm flow conditions. Furthermore, we also report the importance of thinking about the radiocesium behavior on a watershed scale and the role of environmental modeling based on the previous reports.

Keywords： physically-based watershed modeling, radiocesium, river

流域スケールにおける放射性セシウム動態モデリング

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陸上に降下した放射性セシウムの動態を考える際、土地利用ごとの移行特性を踏まえた上で、河川を経由した移行挙動を把握することが重要である。各大学・研究機関によって精力的に現地調査に基づく流出評価や流出メカニズムの解明への取り組みが実施されてきている。本発表では、福島県太田川上流の森林流域を対象に、溶存態セシウムの発生源として考えられる森林リターからの溶出をモデル化・カップリングした水循環モデルのシミュレーション結果を報告する。河川水中の溶存態セシウム濃度に関して、観測から得られている平水時の季節変動や出水時の上昇を再現することが可能となった。さらに、河川水中の放射性セシウムを考える際には流域スケールでの事象を考えることが重要であることを概括し、モデリング研究が果たす役割について、実際の研究成果を踏まえて考察する。

キーワード：流域物理モデル、放射性セシウム、河川

O-03

The Fukushima paradox of plankton：hot zooplankton in clean waters

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The March 2011 Tohoku earthquake and subsequent tsunami resulted in the release of a large amount of radionuclides from the TEPCO Fukushima Daiichi Nuclear Power Plant (Fukushima NPP), and was contaminated into the ocean. Immediately after the accident, we have conducted research cruises to examine Cs concentrations in marine plankton and seawater in the areas around the Fukushima NPP (Buesseler et al. 2012, Baumann et al. 2015, Vives i Batlle et al. 2018, Tateda et al. 2024). The results from ours and other studies indicated that the rate of decrease in Cs concentrations in zooplankton (bulk) is lower than those in seawater. In particular, in offshore areas, Cs concentrations in zooplankton were high and fluctuated, even though Cs concentrations in seawater showed pre-accident levels. And, the reasons for these mismatch in Cs concentrations in zooplankton and their surrounding waters are still unclear. When measuring zooplankton Cs concentrations, samples collected by the plankton nets are measured as "bulk" zooplankton values. Because these plankton samples contain a variety of animal taxa, the differences in their community structures as well as trophic structure may affect the Cs concentrations. Furthermore, it has recently been suggested that plankton samples may be contaminated by the cesium-bearing microparticles suspended in the water. In this talk, I will discuss the possible reasons to explain "why zooplankton living in 'clean' seawater show high and fluctuating Cs values" focusing on the relationships between ^{137}Cs concentrations in zooplankton and the community/trophic-level structures of them from recent cruises.

Keywords：radiocesium, zooplankton

福島プランクトンのパラドックス：きれいな水の中の高線量プランクトン

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2011年３月に発生した東北地方太平洋沖地震とそれに伴う津波の影響により、TEPCO 福島第一原子力発電所(以下、福島原発)から大量の放射性核種が放出され、北西太平洋をはじめとする海洋に拡散された。我々は、事故直後から福島原発周辺海域において、水圏生物、特に低次食段階生物のCs濃度に関する経時的な調査を実施してきた(Buesseler et al. 2012, Baumann et al. 2015, Vives i Batlle et al. 2018, Tateda et al. 2024)。その結果、動物プランクトン(バルク)のCs濃度の減少率は海水に比べて低いことが明らかになってきた。特に、沖合域では海水のCs濃度は事故以前のレベルまで下がっているにも関わらず、そこに生息する動物プランクトンのCs濃度は高くかつ変動が激しく、その理由は明らかになっていない。動物プランクトンCs濃度を測定する際には、大型のプランクトンネットで採集を行いこれらをまとめて測定するが、試料には様々な分類群が含まれるため、動物プランクトンの群集構造の違いや食段階構造の違いが値の変動に関係している可能性がある。さらに、近年、プランクトン試料に含まれる高線量Cs微粒子が影響を与えている可能性も示唆されている。本講演では、近年の調査結果から、「低いCs濃度の海水に生息する動物プランクトンがなぜ高く変動するCs濃度を示すのか？」について、動物プランクトン^{137}Cs濃度と群集構造および栄養段階構造の関係に着目して、現在までにわかっていることについて紹介したい。

キーワード：放射性セシウム、動物プランクトン

O-04

Radial Distribution of ^{137}Cs in Japanese Cedar：Review and Ongoing Research

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Radiocesium (^{137}Cs), with a half-life of 30.04 years, remains the primary contributor to long-lasting contamination in Fukushima Prefecture and neighboring areas following the nuclear accident. The forests, covering up to 70 % of the affected areas, are a concern due to their valuable ecosystem services (timber, food, recreation, etc.). The potential resumption of commercial forestry activities in areas with high contamination levels is contingent upon compliance with national radiocesium standards for forest products, primarily focusing on wood. Japanese cedar, which is the dominant coniferous plant in Japan, is significant due to its usefulness in timber production making it a crucial area for study and management to mitigate ongoing radiological risks. The radial distribution of radiocesium in Japanese cedar tree trunks has shown unexpected patterns, with higher concentrations in the heartwood than the sapwood, which deviates from the typical distribution patterns observed in other tree species. This apparent conundrum is a serious concern requiring a rigorous study to unravel the complex interplay of biochemical and environmental factors and mechanisms responsible for radiocesium uptake, transport, and accumulation in the Japanese cedar. Hence, this review explores factors driving observed trends, identifies knowledge gaps, and outlines future research directions to deepen our understanding of the radial distribution of radiocesium in Japanese cedar.

Keywords：radiocesium, forest ecosystems, Japanese cedar, Fukushima

O-05

Radioecology in agricultural systems: interception, weathering, translocation, and soil-to-crop transfer

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Ingestion of agricultural crops is one of the important pathways of radionuclides to humans like essential elements. Therefore, the behaviour of radionuclides in agricultural ecosystems are of great interest. When releases of radionuclides to the atmosphere occur due to nuclear accidents, crop surfaces are contaminated due to the direct deposition before radionuclides reach to the soil surface, which is known as interception. Then the radionuclides attached to the crop surfaces are gradually removed by weathering, that is by wind and rain. During that time some portion of the attached radionuclides can be fixed on the plant surfaces or taken up to the inside of the plant and then translocated to other plant tissues. The degree of fixation or translocation depends on the characteristics of the radionuclides. For instance, some radiocaesium are taken up by plant and translocated to other tissues especially growing parts because it is a surrogate of potassium, an essential element for plants. Compared to radiocaesium, radioiodine and radiostrontium are less translocate from the attached parts.
After the period of atmospheric releases, radionuclides deposited on the soil surface remains in there thus soil-to-crop transfer of radionuclides through roots are observed in paddy field, upland field, and so on. The transfer factor of radionuclide is defined as the concentration ratio in crop and soil. The factor is affected by the radionuclide mobility in soil and also necessity of the elements to crop.

Keywords： paddy field, upland field, radiocaesium, radioiodine, radiostrontium

農業環境における放射生態学：遮断、ウェザリング、転流および土壌-植物間移行係数

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農作物を摂取することは、必須元素がヒトに移行する重要な経路であるが、放射性核種にとっても同様のことが言える。そのため、農業生態系における放射性核種の挙動が注目される。原子力災害によって放射性核種の大気放出が起こると、放射性核種が土壌表面に降下する前に植物に直接沈着し、農作物表面が汚染される。その後、作物表面に付着した放射性核種は雨や風による風化によって徐々に除去される。また植物表面に付着した放射性核種の一部は固定されるか、植物内部に取り込まれて他の組織に転流する。固定や転流の程度は、放射性核種の特性によって異なる。例えば、放射性セシウムの場合、植物にとって必須元素であるカリウムと同族のため、一部は植物に取り込まれて特に成長部分に転流する。放射性ヨウ素と放射性ストロンチウムは、放射性セシウムに比べ、付着部からの転流は少ない。
大気放出が無くなった後、土壌表面に沈着した放射性核種は土壌中に留まっているため、水田や畑では土壌から作物への放射性核種の経根吸収が観察される。放射性核種の移行係数は、作物と土壌の濃度比として定義され、土壌中の放射性核種の移動の程度や、作物の元素の必要度に影響される。

キーワード： 水田、畑、放射性セシウム、放射性ヨウ素、放射性ストロンチウム

O-06

Integrating Ecosystem Services in Radiological Protection

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The ICRP has proposed that ecosystem services could be applied as a relevant framework for environmental protection and related policy. The approach could be used to support the integrated approach of risk assessment and management, including research on quantification of effects of ionizing radiation on ecosystem functions and the integration of ecosystem services in post-accident management and remediation. As the ecosystem services concept highlights the biophysical, economic and socio-cultural dimensions of the impacts of radiological contamination, encompassing both the radiation protection of human and ecosystems, it could contribute to future research in radioecology.
However, the ecosystem services concept is not without controversy. There is a need to address the different ways in which radioactive contamination could affect ecosystem services, and to articulate cause and effect relationships between the state of an ecosystem, its level or radiological contamination and provision of services. In addition, the concept is also accompanied by debates about the status of humans in ecosystems, and the reduction of environmental goods to monetary values. To solve these knowledge gaps and uncertainties, it is still necessary to acquire robust data on the impacts of radiation on ecosystems both under experimental and realistic conditions, and to integrate all potential consequences, ecotoxicological but also economic and sociocultural into decision making processes involved in radiological contamination situations or post accidental contexts. The presentation will use ongoing projects to illustrate both how the approach could be applied and highlight some of the challenges with integrating ecosystem services in environmental radiological protection.

Keywords：ecosystem services, radioecology, ethics, radiation.

Poster Presentation for Experts

専門家向けポスター発表

P-01

Spatio-temporal variations in ^{137}Cs concentrations in water bodies of an urban area

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It has been reported that the rate of decrease in ^{137}Cs concentrations in suspended solids (SS) and dissolved form in urban areas is faster than in forests and agricultural lands. On the other hand, high concentrations of ^{137}Cs in concentrations in water and sediment in urban areas were also reported. There are still uncertainties of ^{137}Cs dynamics in urban areas because of relatively small numbers of research focusing on urban areas. In this study, water samples of 40 L each were collected 5 times at 17 locations in Koriyama from August 2023 to August 2024. The water samples were filtered to measure the ^{137}Cs concentration of SS and dissolved ^{137}Cs concentration. In addition, stable isotope ratios, δ^{15}N and δ^{13}C and heavy metals contents were measured. The dissolved ^{137}Cs concentration ranged from 0.002 to 0.03 Bq/L and there was no bias in its spatial distributions. The ^{137}Cs concentration of SS ranged from 0.7 to 6.9 kBq/kg and tended to increase toward downstream direction. The difference in spatial pattern between the concentrations suggests that the inflow of the no-dissolved ^{137}Cs increased the ^{137}Cs concentration. The ^{137}Cs concentration in SS showed a positive correlation with δ^{15}N. This result suggests that any of anthropogenic substances may be a factor in increasing the ^{137}Cs concentration. Updated analysis will be presented after completion of planned analyses.

Keywords： urban area, suspended solids, ^{137}Cs concentration

都市の水域における^{137}Cs濃度の時空間変動

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都市域における懸濁態と溶存態^{137}Cs濃度の減少率は、森林や農地より早いという報告がある。一方、都市域では池の水や底質の中の^{137}Cs濃度が高いという報告もある。都市域に焦点を当てた研究が少ないため、都市域の^{137}Cs挙動は不確かである。本研究では、郡山において2023年８月から2024年８月にかけ５回、17か所で各40Lの採水を行った。サンプリング水はろ過し、懸濁態と溶存態^{137}Cs濃度を測定した。加えて安定同位体δ^{15}Nとδ^{13}C、及び重金属濃度を測定した。溶存態^{137}Cs濃度は0.002-0.03Bq/Lであり、溶存態^{137}Cs濃度の空間分布に偏りは見られなかった。懸濁態^{137}Csは0.7-6.9kBq/kgの濃度範囲で、下流に行くに従い増加傾向であった。このことは溶存態ではない^{137}Csの流入が^{137}Cs濃度を上昇させていることを示唆している。更に^{137}Cs濃度とδ^{15}Nが正の相関を示すことから、人間活動に由来する物質が^{137}Cs濃度の上昇の原因となっていることを示唆する結果となっている。計画している分析を終了し、最新結果を報告する予定である。

キーワード：都市域、懸濁物質、^{137}Cs濃度

P-02

Water quality change associated with decontamination in an urban pond

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Ponds affected by the Fukushima Daiichi Nuclear Power Plant accident have been decontaminated through measures such as bottom sediment removal to mitigate risks associated with radionuclides. Bottom sediment removal has been widely implemented with the aim of improving water quality by preventing the leaching of nutrients. On the other hand, if the purpose is not to improve water quality, the water quality may deteriorate. The objective of this study was to clarify the effects of decontamination on the pond water quality and the long-term changes in water quality after decontamination. The study site is an urban pond in center of Koriyama City, Fukushima Prefecture, and it was decontaminated by bottom sediment removal in 2017. Pond water was collected in 2015 and 2018 - 2022, inflow and outflow water in 2020 - 2022 was also collected and analyzed for ^{137}Cs concentration, nutrients, major cations, and C and N stable isotope ratios. Comparing 2015 and 2018, only $\delta^{13}C$ significantly increased ($p < 0.05$); comparing 2018 and 2019 - 2022, K^+ and NO_2^--N concentrations significantly decreased ($p < 0.05$). It was suggested that water quality did not change dramatically due to decontamination. The concentrations of major cations and nutrients in the inflow water were higher than in the pond and outflow water, and the concentrations of chlorophyll a in the pond and outflow water were higher than in the inflow water. It was suggested that water with high concentration of nutrients and major cations flows into the pond and is used for phytoplankton growth in the pond.

Keywords：bottom sediment removal, nutrients, C and N stable isotope ratio

都市域ため池における除染にともなう水質の変化

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福島第一原子力発電所事故の影響を受けたため池では、放射性物質によるリスクを軽減することを目的として底質除去等の除染が実施された。底質除去は栄養塩類の溶出を防ぐ水質改善を目的として広く実施されてきた。一方で、水質改善が目的ではない場合、水質悪化の可能性が指摘されている。本研究では、除染による池水の水質への影響，除染後の長期的な水質の変化を明らかにすることを目的とした。郡山市の市街地にある、2017年度に底質除去による除染が行われたため池にて調査した。2015年、2018–2022年に池水、2020–2022年に流入水、流出水も採集し、栄養塩類、主要陽イオン、炭素窒素安定同位体比等を分析した。2015年、2018年を比較すると、$\delta^{13}C$のみが有意に上昇していた($p < 0.05$)。2018年と2019–2022年を比較すると，K^+濃度、NO_2^-–N濃度が有意に低下していた($p < 0.05$)。有意差が認められた項目が少なかったことから、除染による水質の変化は大きくなかったと言える。流入水の主要陽イオン濃度、栄養塩類濃度は池水、流出水よりも高く、池水、流出水のクロロフィルa濃度は流入水よりも高かった。栄養塩類、主要陽イオンが多く含まれた水がため池に流入し、ため池の植物プランクトンの生育に使われることが示唆された。

キーワード：底質除去、栄養塩類、炭素窒素安定同位体比

P-03

Variations in ^{137}Cs concentrations in river water and coastal seawater in a high-flow event on Abukuma river catchment

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A substantial exportation of ^{137}Cs through rivers during high-flow reportedly resulted in a temporary increase in ^{137}Cs concentration in coastal seawater. Our previous observation on the Ukedo river system showed that the190 GBq of ^{137}Cs exportation increased ^{137}Cs concentration in seawater at the seashore to 50 times the level of normal condition September 2023. Accumulation of such observation cases could contribute to a better understanding of the ^{137}Cs dynamics and to improve predictability. In this context, we present the results of observations of the Abukuma river. Water samples were collected for five times at the Iwanuma site downstream the Abukuma river and at the beach on river mouth from August 11 to 23, 2024. During this period, a catchment mean rainfall totaled 217 mm with a peak on August 16, as Typhoon *Ampil* approached. The ^{137}Cs concentration of suspended solids in river averaged 1120 Bq/kg and showed a decreasing trend during the period. Dissolved ^{137}Cs concentrations averaged 20 mBq/L and were lowest on August 17, the peak flow day. The total ^{137}Cs exportation during this period was estimated to be 82 GBq. The ^{137}Cs concentration in suspended sediment in coastal seawater averaged 380 Bq/kg and the dissolved ^{137}Cs concentration averaged 43 mBq/L. No significant increase in ^{137}Cs concentrations was observed during ^{137}Cs exportation peak. Comparing with the results on the Ukedo river, it is suggested that response in coastal seawater to ^{137}Cs exportation depends not only on magnitude of the exportation, but also on various factors of catchment and seawater conditions.

Keywords：^{137}Cs, Sediment transport system, typhoon

阿武隈川における降雨流出時の河川・沿岸海水の^{137}Cs濃度の変動

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出水時には、河川を通じ多量の^{137}Csが流出し、沿岸海水の^{137}Cs濃度が一時的に上昇させることが報告されている。筆者らは、請戸川を対象とした2023年９月の観測により、約190GBqの^{137}Cs流出によって沿岸海水の^{137}Cs濃度が平水時の50倍程度に上昇することを示した。こうした観測事例の蓄積は、陸域と海域における^{137}Cs動態に関する理解深化・予測精度向上に資すると考えられる。本研究では、阿武隈川を対象とする観測結果を報告する。2024年８月11日から23日にかけて、阿武隈川下流の岩沼地点および河口の荒浜海水浴場において各５回ずつ水試料を採取・分析した。この期間には、台風７号接近にともなって８月16日をピークとして流域平均217mmの降雨が観測された。岩沼地点における河川水の懸濁物質の^{137}Cs濃度は平均1120Bq/kgであり、低下傾向を示した。溶存態^{137}Cs濃度は平均20mBq/Lであり、流量ピークの８月17日に最低値を示した。この期間の^{137}Cs総流出量は82GBqと推定された。沿岸海水の懸濁物質の^{137}Cs濃度は平均380Bq/kg、溶存態^{137}Cs濃度は平均43mBq/Lであったが、河川からの^{137}Cs流出ピーク時にも顕著な濃度上昇は見られなかった。請戸川での結果との対比から、^{137}Cs流出に対する沿岸海域での応答は、その流出量のみではなく、様々な流域および海域の条件に左右されることが示唆される。

キーワード：^{137}Cs、流砂系、台風

P-04

Accumulation of plutonium-242 by the pondweed. Model experiments

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Plutonium isotopes dissolved in surface water bodies accumulate in aquatic plants. In the present research, we studied the accumulation of plutonium-242 by a submerged aquatic plant, pondweed, during model experiments. Water and aquatic plants were collected in the Yenisei River. The plutonium isotope content was determined by the ICP-SM method. To compare the results, we used the alpha spectrometry method after radiochemical extraction of the isotope. After the end of the experiment on plutonium accumulation, the isotope distribution was studied in plant fragments. As a result, the following was obtained: 10 to 15% of the total accumulated plutonium was detected on the leaf surface in the exchange-adsorption layer while 45 to 55% was directly associated with the leaf biomass, among these up to 40-50% was associated with solid fragments of the plant cells, and ~5% with the cell cytoplasm (intracellular fluid). With citrate ions added to the water of the model environment, the portion of plutonium on the surface of the leaves decreased to 5-7%, while the portion of the radionuclide in the cytoplasm increased to 10-12%. This is probably due to the physicochemical properties of the compound formed between citrates and plutonium.

Keywords：plutonium, pondweed, accumulation, distribution, model experiments

P-05

Effects of large-scale wildfires on the redistribution of radionuclides in the Chornobyl River system

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Wildfires in radiologically contaminated areas raise significant concerns due to potential radionuclides redistribution and increased public radiation exposure. This study examined the impact of the 2020 Chornobyl wildfire on the redistribution of radionuclides, specifically ^{137}Cs and ^{90}Sr, in the Chornobyl River system. Our findings indicate that the inventories of ^{137}Cs and ^{90}Sr in the charred residues and soil decreased with increasing distance from the nuclear power plant, which is consistent with the initial deposition patterns. Speciation analysis revealed that the water-soluble fractions of ^{137}Cs and ^{90}Sr in the charred residues were significantly higher than those in the soil, implying increased mobility. Following the wildfires, no significant increase in ^{137}Cs concentration was observed in a river catchment in Chornobyl. However, ^{90}Sr concentrations showed a significant increase, exceeding the permissible levels in drinking water (2 Bq/L) in Ukraine. This increase is attributed to hydrologically driven mobilization processes: (1) during snowmelt in spring and (2) the transport of soluble ^{90}Sr from charred residues and surface soil into the river during high suspended solid concentration events.

Keywords： wildfire, radionuclide redistribution, Chornobyl River system, radioactive contamination

大規模森林火災がチョルノービリ河川システムの放射性物質再拡散に与える影響

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放射能汚染地域における森林火災は、放射性物質の再拡散や住民の被ばくといった重大な懸念を引き起こす。本研究では、2020年４月にウクライナのチョルノービリ規制区域内で発生した大規模な森林火災が、河川中の^{137}Csおよび^{90}Srの再拡散に与えた影響を調査した。火災後に現地で採取された炭化残留物や土壌に含まれる^{137}Csおよび^{90}Srの存在画分を特定し、河川中の^{137}Csおよび^{90}Sr濃度の長期的なモニタリングデータを解析した。解析の結果、炭化残留物や土壌に含まれる^{137}Csおよび^{90}Srの存在量は、チョルノービリ原子力発電所からの距離が増すにつれて減少しており、これはチョルノービリ原発事故後の初期の沈着パターンと一致した。また溶出試験により、炭化残留物に含まれる水溶性の^{137}Csおよび^{90}Srの存在量は、土壌のそれよりも有意に高くなっており、火災は河川を介して^{137}Csおよび^{90}Srの再拡散を促進することが明らかとなった。火災の前後で、チョルノービリの河川流域における^{137}Csの濃度に顕著な増加は見られなかったが、^{90}Sr濃度は有意に増加してウクライナの飲料水基準（２Bq/L）を超える値を示しており、これは、炭化残留物や土壌から溶出した^{90}Srが河川に流入したことが原因だと考えられる。

キーワード：山火事、放射性核種の再分布、チョルノービリの河川、放射能汚染

P-06

Study on pretreatment methods of seawater for determination of ultra-trace radionuclide ^{135}Cs

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Cs-135 (^{135}Cs, $T_{1/2}$ = 2.3M years) is an anthropogenic radionuclide released into the environment as a result of nuclear testing and leaks from nuclear facilities. This nuclide can be used as an alternative to ^{137}Cs as a tracer of seawater circulation. In addition, the monitoring of the concentrations of ^{135}Cs associated with releases/dispersal from nuclear facilities is required from a radiation protection point of view. It is therefore essential to establish the measurement method for this nuclide. However, the concentration of ^{135}Cs in seawater in general is extremely low (estimated at 1.6 fg/kg), and mass spectrometry requires the concentration of Cs from a large amount of seawater. To overcome this problem, we focused on insoluble cobalt ferrocyanide (Co-FC) adsorbents. First, the conditions of radiation-induced graft polymerization for the synthesis of Co-FC adsorbents were investigated, and the optimum conditions were determined. The optimum conditions for the adsorption and desorption of Cs in seawater by the synthesized Co-FC were also investigated. As a result, simple concentration method for Cs from seawater was established.

Keywords： anthropogenic radionuclide, ^{135}Cs, insoluble cobalt ferrocyanide, graft polymerization, mass spectrometry

極微量放射性核種^{135}Csの定量を目指した海水の前処理法検討

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セシウム-135(^{135}Cs, $T_{1/2}$ = 230万年)は核実験や核関連施設からの漏洩により環境中に放出された人工放射性核種であり、^{137}Csに代わる海水循環トレーサーとしての利用と、核関連施設からの放出に関連した濃度定量、長期的な環境影響評価の必要性から測定法の確立が求められている。しかし、一般的な海水中の^{135}Csは極微量(推定1.6fg/kg)であり、質量測定には大量の海水からCsを濃集する必要がある。この課題を解決すべく、本研究では不溶性フェロシアン化コバルト(Co-FC)吸着剤に着目した研究を行ってきた。まず、放射線グラフト重合によりCo-FC吸着材を合成する条件について検討を行い、最適条件を決定した。また合成したCo-FCによる海水中Csの吸着条件や、脱離条件等に関する検討も行い、効率良いCs濃集条件を求めた。結果として、海水から簡便にCsを濃集することが可能となった。

キーワード：人工放射性核種、^{135}Cs、不溶性フェロシアン化コバルト、グラフト重合、質量分析

P -07

Gravitational separation of contaminated soil and quantification of cesium-rich micro-particles

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The Fukushima Daiichi Nuclear Power Plant accident resulted in the large-scale release of radioactive cesium. It has been revealed that, in addition to natural minerals, cesium-rich micro-particles (CsMP) serve as a medium for radioactive cesium in surface soils. Despite their small size (~a few micrometers), CsMPs possess high radioactivity per particle, making them of particular concern from the perspective of biological effects and other related issues. However, there is currently no method available for the selective separation of CsMPs. In this study, a method for selectively separating CsMPs was developed, focusing on particle density. Contaminated soil was treated using gravitational liquid separation, and the mass of each fraction was measured. Subsequently, γ-ray analysis using a Ge semiconductor detector was conducted on each fraction, and a quantitative method (QCP method) was applied to determine the amount of CsMPs and their radioactivity. The density of CsMPs was then discussed. As a result, it was found that most of CsMPs were obtained from the fractions with lower densities. Differences in the number and radioactivity of CsMPs at various sampling locations are also reported.

Keywords：cesium-rich micro-particles, particle density, QCP method

汚染土壌の重液分離及び放射性セシウム含有粒子の定量

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福島第一原子力発電所の事故により、放射性セシウムが大量に放出された。表層土壌における放射性セシウムの媒体として、天然鉱物のほかセシウム含有粒子(Cesium-rich micro-particles, CsMP)の存在が明らかとなっている。CsMPは数マイクロメートル程度の大きさにも関わらず、１粒子の放射能が大きいため生体影響などの観点から重要である。しかし、CsMPを選択的に分離する手法は現状存在しない。そこで本研究では、CsMPを選択的に分離するための手法を構築するために、粒子の密度に着目した。重液分離により汚染土壌を処理し、それぞれの画分の質量を測定した。その後、それぞれの画分についてGe半導体検出器を用いたγ線分析を行った後、CsMPの量を定量するための定量法(QCP法)を適用し、CsMPの密度について考察を行った。結果として、多くの粒子が密度の小さな画分に得られることが分かった。また、採取地点ごとのCsMPの数や放射能の違いなどについても報告する。

キーワード：CsMP、密度、QCP法

P-08

A study on a method for obtaining radiation source intensity and location from multiple viewpoints using swarm intelligence

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To monitor a wide area, it is necessary to do so using a large number of measuring instruments and to integrate their data. The objective of this study is to create radiation distributions from multiple viewpoints using multiple robots with swarm intelligence as an artificial life simulation. Here we report on the objectives, methods, and progress of this study.

Keywords： radiation monitoring, swarm intelligence, swarm robotics

群知能を用いた多視点からの放射線源強度と場所の把握手法に関する研究

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広いエリアをモニタリングするには、多数の測定器を用いて行い、それらのデータを統合させることが必要となる。本研究は、人工生命シミュレーションとしての群知能を用いた複数のロボットを用いて多視点からの放射線分布を作成することを目的としている。ここでは、緒についたばかりではあるが、この研究の目的、手法、及びその進展について報告する。

キーワード： 放射線モニタリング、群知能、群ロボット

P -09

Characteristics of Cs-137 activity concentrations in aquatic insects

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Due to the Fukushima Daiichi Nuclear Power Plant accident, some headwater streams in central and eastern Fukushima are still heavily contaminated by radiocesium, and the shipment of mountain stream fish continues to be restricted. Radiocesium has also been detected in aquatic insects eaten by stream fish in the food webs of stream ecosystems. Because aquatic insects differ in their habitat and food sources among species, it is expected that the activity concentration of radiocesium will also differ, and the difference may affect the difference of radiocesium activity concentration among the fish. Therefore, we compared the Cs-137 activity concentrations in aquatic insects with similar habitats but different food sources. In previous studies, the whole body was used for radiocesium measurement because many species of aquatic insects are small. However, the aquatic insects do not absorb all the radiocesium contained in the food sources, and some of radiocesium is excreted without being absorbed. Radiocesium in forms that are not absorbed by aquatic insects may also not be absorbed by stream fish that prey on aquatic insects. Therefore, we collected relatively large larvae of Ephemeridae, which had a high density of individuals and were easy to collect, to compare the Cs-137 activity concentrations between their gut content, legs, and body.

Keywords：headwater stream ecosystem, Trichoptera, Ephemeridae, gut contents

水生昆虫のセシウム137濃度特性

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福島第一原発事故により、福島県中・東部の渓流の中には、未だに放射性セシウム汚染の影響が強く、渓流魚の出荷制限が続いている。渓流生態系の食物網において、渓流魚の餌となる水生昆虫からもまた放射性セシウムが検出されている。水生昆虫は種によって生息場所及び食性が異なるため、放射性セシウム濃度も異なることが予想され、この違いが渓流魚の個体間における放射性セシウム濃度の違いに影響する可能性がある。そのため、生息場所が似ているが食性が異なる水生昆虫のセシウム137濃度を比較した。また、既存研究では、水生昆虫はサイズの小さい種が多いため、放射性セシウム測定には全身を用いてきた。しかし、水生昆虫が摂食した餌資源に含まれる放射性セシウムをすべて吸収しておらず、一部は吸収されずに排泄されている。水生昆虫に吸収されない化学形態の放射性セシウムは、水生昆虫を捕食した渓流魚にも吸収されない可能性がある。そのため、個体密度が高く、採取が容易で比較的大型のモンカゲロウ科幼虫を採取し、消化管内容物を取り出し、消化管の無い個体とセシウム137濃度を比較した。さらに、脚部を胴体から分離し、セシウム137濃度を比較した。

キーワード：渓流生態系、トビケラ、モンカゲロウ、消化管内容物

P-10

Comparison of the amounts of radiocesium uptake by Polychaete (*Perinereis aibuhitensis*) reared in seawater with different radiocesium concentrations

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Polychaete (*Perinereis aibuhitensis*) were reared in seawater with different concentrations of radiocesium (1 Bq/L and 5 Bq/L) and the amounts of radiocesium absorbed were compared. Approximately 500g of polychaetes were kept in a 60 cm glass tank (45L water volume) at a water temperature of 12 ° C, a salinity of 25‰ , and the experiment was conducted without feeding. Polychaetes were collected at 7, 14, and 28 days after the start of the rearing experiment and measured for radiocesium concentrations.
The radiocesium concentrations of polychaetes reared in rearing seawater with a radiocesium concentration of 1 Bq/L were 6.6-9.6 Bq/kg-wet, 10.1-12.4 Bq/kg-wet, 10.2-15.8 Bq/kg-wet at 7, 14, and 28 days, respectively. The radiocesium concentrations of polychaetes reared in rearing seawater with a radiocesium concentration of 5 Bq/L were 21.3-25.6 Bq/kg-wet, 30.5.-43.8 Bq/kg-wet, and 75.4 Bq/kg-wet at 7, 14, and 28 days, respectively.
The radiocesium concentration in the polychaetes was non-detectable (ND) at the beginning of the experiment. Polychaete accumulated radiocesium by about 15 times in both rearing seawaters at the end of the experiments.

Keywords： radiocesium, polychaete (*Perinereis aibuhitensis*), prey organisms

放射性Cs濃度が異なる海水で飼育したアオゴカイの取り込み量比較

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放射性Csの濃度が異なる海水（１Bq/Lと５Bq/L）でアオゴカイを飼育し、放射性Csの取り込み量を比較した。アオゴカイ500gを60cm水槽（水量45L）に収容し、水温12℃、塩分濃度25‰、無給餌で飼育試験を行った。アオゴカイは実験開始から７日後、14日後、28日後に取り上げ、放射性Cs濃度を測定した。
放射性Cs濃度１Bq/Lの海水で飼育したアオゴカイの放射性Cs濃度は７日後が6.6～9.6Bq/kg-wet、14日後が10.1～12.4Bq/kg-wet、28日後が10.2～15.8Bq/kg-wetであった。放射性Cs濃度５Bq/Lの海水で飼育したアオゴカイの放射性Cs濃度は７日後が21.3～25.6Bq/kg-wet、14日後が30.5～43.8Bq/kg-wet、28日後が75.4Bq/kg-wetであった。
試験開始時におけるアオゴカイの放射性Cs濃度はNDであったことから、アオゴカイはいずれの飼育海水においても15倍程度まで放射性Csを濃縮していた。

キーワード：放射性Cs、アオゴカイ、餌生物

P-11

Microbial analysis of the bryophyte symbiotic ecosystem in Fukushima Prefecture

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The bryophytes are one of the most widely used organisms for biomonitoring including radioactive contamination due to their small bodies in direct contact with soil. Various types of microorganisms grow inside the bryophyte tissue, forming a symbiotic ecosystem. The composition of these microorganisms, which are mainly cyanobacteria and fungi, is not well understood in terms of genetic information. Biomonitoring using the microbiome as an indicator is often faced the challenges of the vast and complex composition of the soil microbiome, and the fact that it can fluctuate even in a very small range due to subtle differences in environmental conditions. We considered that by focusing on the composition and genetic diversity of the symbiotic microbiome within the single bryophyte species, we might be able to evaluate the fluctuations in the soil ecosystem according to the environment of each survey site under unified conditions. In this study, we collected a bryophyte species, *Anthoceros agrestis*, which grows widely in rice paddies and around houses, from five localities in Fukushima Prefecture, including the Hamadori region, and five localities in Hiroshima Prefecture. In addition to microscopic observation of the inside of the plant body, we performed amplicon analysis of the 16SrRNA V3/V4 region of the bacteria and the ITS1 region of the fungus to analyze the symbiotic microbial community. We report the results of comparative analyses of the microbiota within and between the bryophyte populations and discuss the effectiveness of biomonitoring using bryophyte-symbiotic microbiota.

Keywords：bryophytes, hornworts, biomonitoring, radiation effect, 16S rRNA, ITS, microbiome analysis

福島県をフィールドとしたコケ植物共生生態系の微生物叢解析

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分布域が広く、地面を覆うように生育し、植物体が小さいコケ植物は放射能汚染を含む生態系のバイオモニタリングに適した生物として知られている。コケ植物の植物体内部には、さまざまなタイプの微生物も生育し共生生態系を構成している。主に、シアノバクテリアと真菌類からなるこれらの微生物について、遺伝情報の視点での組成についての理解は進んでいない。微生物叢を指標としたバイオモニタリングには、土中の微生物叢の組成が膨大かつ複雑であること、さらに微細な環境条件の違いによってごく狭い範囲でも変動しうるという課題がある。我々は、同一種の植物体内の共生微生物叢に研究対象を絞って組成や遺伝的多様性を調べることで、各調査地の環境に応じた土壌生態系システムの変動を統一的な条件で評価できるかもしれないと考えた。今回福島県内の浜通り地域を含む５ヶ所、広島県内の５ヶ所で、水田や人家周辺に広く生育するナガサキツノゴケ（*Anthoceros agrestis*）を採集し、植物体内の顕微鏡観察に加え、細菌の16SrRNA V3/V4領域、真菌のITS1領域のアンプリコン解析を行い、細菌と真菌を含む微生物叢解析を行った。各集団内と集団間での微生物叢の比較解析の結果について報告し、コケ植物共生微生物叢を用いたバイオモニタリングの有効性について考察する。

キーワード：コケ植物、ツノゴケ、生物モニタリング、放射線、16S rRNA、ITS、細菌／真菌叢解析

P-12

Effect of different Prussian Blue compounds in feed on ^{137}Cs uptake and excretion by silver Prussian carp

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This paper documents that adding the different Prussian Blue (PB) compounds in feed is an effective and inexpensive countermeasure to reduce the ^{137}Cs contamination of fish. Laboratory aquarium experiments were conducted to investigate the effects of feed containing either 0.1 % or 1 % of ammonium ferric hexacyanoferrate (AFCF, $NH_4Fe[Fe(CN)_6]$), potassium ferric hexacyanoferrate (KFCF, $KFe[Fe(CN)_6]$), or Ferrocyn (mixture of 95% ferric hexacyanoferrate (FCF, $Fe_4[Fe(CN)_6]_3$) and 5% KFCF) on ^{137}Cs uptake and excretion by silver Prussian carp (Carassius gibelio (Bloch, 1782)). The experiments lasted for 2 months at a constant water temperature of 24 ± 1 ℃. In each aquarium, at 9 a.m., fish received 0.2 g of feed per day (about 0.2% of fish weight) containing 19 ± 2 Bq of ^{137}Cs. In addition, at 3-4 p.m., fish in different aquariums received 0.8-1.0 g of feed per day (about 1% of fish weight) containing 0%, 0.1% or 1% of different PB compounds. The use of feed with 0.1% and 1% of PB compounds resulted in 2-3 and 3-4 times lower accumulation of ^{137}Cs in the fish body at the end of the experiments, respectively, compared to control fish receiving feed without PB compounds. The reduction factors when using PB compounds were 5-10. The method of feed granulation did not affect the effectiveness of PB, and no statistically significant difference was found between the effectiveness of the studied PB compounds. The obtained results, along with the results of our previous studies, demonstrate that the use of PB compounds in feed does not significantly reduce the rate of ^{137}Cs uptake by fish (by 1.4-1.8 times), but substantially reduces the half-life of ^{137}Cs activity in fish (from 100 to 15-30 days).

Keywords： ^{137}Cs, ferric hexacyanoferrate, Prussian Blue, freshwater fish, reduction factor

P-13

Frequency of novel mutations in populations of large Japanese field mouse inhabiting radiation-contaminated areas

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DNA mutation is one of the biological effects of radiation. In this study, we investigated the frequency of novel mutations occurring within a population of large Japanese field mouse (*Apodemus speciosus*) living in a contaminated area by radioactive substances following the Fukushima Daiichi Nuclear Power Plant accident. Mice were captured from 2012 to 2013 in the difficult-to-return zone in Fukushima Prefecture and Aomori and Toyama Prefectures as control areas. Age estimation for collected mice was carried out and divided into three groups: summer 2011, spring 2012, and summer 2012 after the disaster. SNPs information was obtained for each individual by GRAS-Di analysis and analyzed between groups in each area. No differences in frequency of novel mutations and also basic genetic indices such as nucleotide diversity and population differentiation were found between difficult-to-return zone and control areas. Although the present study couldn't describe the effects of radiation on mutation before and after the Nuclear Power Plant accident occurred, the incidence of mutations in population of large Japanese field mouse living in the exposure doses studied is not expected to be different from the natural incidence rate.

Keywords： Radiation, large Japanese field mouse, *Apodemus speciosus*, mutation, biological effect, GRAS-Di, SNPs

放射線汚染域に生息するアカネズミ個体群の新規突然変異の発生頻度

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放射線による生物影響の一つに、DNAの突然変異が挙げられる。本研究では福島第一原子力発電所事故後、放射性物質に汚染された環境下で生息する小型齧歯類アカネズミの個体群内で発生する新規突然変異の発生頻度を調査した。2012年から2013年の間に福島県の帰還困難区域、および対照区として青森県と富山県で捕獲されたアカネズミの齢推定を行い震災後の2011年夏、2012年春、2012年夏の３つのグループ分けを行った。GRAS-Di解析によって各個体のSNPs情報を取得し、各区域のグループ間で解析した。新規突然変異の発生頻度、また塩基多様度や遺伝的分化を表す基礎的な遺伝的指数には帰還困難区域内と対照区域の集団間の解析で違いは見られなかった。本解析では、放射性物質による汚染が発生した前後の個体群への影響に言及できないが、調査を実施した被ばく線量下に生息するアカネズミ個体群の突然変異の発生率は自然発生率と変わらないと考えられる。

キーワード：放射線、アカネズミ、*Apodemus speciosus*、突然変異、生物影響、GRAS-Di、SNPs

P-14

Effects of the line thinning on the soil environment and ^{137}Cs dynamics in the cedar forests

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Most of the cedar plantations in the difficult-to-return and former evacuation zones remain untouched. It is known that the risk of soil erosion increases due to the overcrowding of the forest and the decline of the understory vegetation, so appropriate forest management is necessary. Thinning improves the light conditions in the forest, and it will affect the dynamics of ^{137}Cs by increasing the soil temperature and activating microbial activity. Therefore, in order to evaluate the dynamics of ^{137}Cs when thinning is resumed, litter bag experiments and monitoring of soil temperature and moisture were conducted from July to November 2024 in thinned areas and adjacent control areas in cedar forests located in the former evacuation zone. The study site is located in Iitate Village, and 3-cut and 6-leave line thinning was carried out in October and November 2022. As a result, the mean soil temperature at a soil depth of 5 cm was 16.9° C in the control site, while it was 18.1° C in the thinned area and 17.8° C in the remaining area in the thinning site, showing a tendency to be higher. On the other hand, the soil moisture content at a depth of 5 cm was approximately 40.6% in the control area, but was higher in the thinned rows in the thinned area at 44.6%, and tended to be lower in the remaining rows at 35.2%. In the litter bag experiment, the decrease in litter weight was almost the same in the control area and the thinned area, but it was confirmed that the ^{137}Cs concentration increased significantly in the control area.

Keywords：forest decontamination, forest management, litter bag experiment

スギ林の列状間伐による土壌環境と^{137}Cs動態への影響

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帰還困難区域や旧避難区域のスギ人工林の大部分は依然として手付かずであるが、林分の過密化による下層植生の衰退等によって土砂侵食のリスクが高まることも知られており、適切な森林管理が必要である。間伐を行うと林内の光環境が改善し、地温の上昇や微生物活動の活性化など、^{137}Cs動態にも影響すると考えられる。そこで、本研究では間伐を再開したときの^{137}Cs動態を評価するため、旧避難区域内に位置するスギ林の間伐地および隣接する対照地において、2024年7月から2024年11月にかけてリターバック実験を実施するとともに、地温計、土壌水分計を設置した。調査地は飯舘村にあり、2022年10から11月に3伐6残の列状間伐が実施されている。モニタリングの結果、土壌5 cm深の地温は対照地で平均16.9℃であったのに対し、間伐地の間伐列で平均18.1℃、残存列で17.8℃と高い傾向にあった。一方、5 cm深の土壌水分量は対照地で約40.6%であったのに対し、間伐地の間伐列では44.6%と対照地よりも高く、残存列では35.2%と低い傾向にあった。リターバック実験では、対照地と間伐地でリター重量の減少量はほぼ同じであったが、対照地では^{137}Cs濃度が大きく増加していることが確認された。

キーワード：森林除染、森林管理、リターバック実験

P-15

Transfer of radiocesium by hydrological processes within the forest following Fukushima Daiichi Nuclear Power Plant accident

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Cesium-137 released during the Fukushima Daiichi Nuclear Power Plant accident was deposited in forested areas and circulated within these ecosystems. In Japan, extensive field data on the distribution and migration of radiocesium in forests have been collected, spanning the initial post-accident dynamics to over a decade of observations. This study reports on the long-term migration mechanisms of radiocesium in Japanese forests, focusing on hydrological processes involving atmospheric, canopy, and soil interactions, as well as the export of dissolved ^{137}Cs from hillslope soils to aquatic systems via groundwater in headwater catchments. Field monitoring was conducted in experimental forest stands and catchments in Kawamata and Namie towns, Fukushima Prefecture. The presentation also examines the temporal changes (hysteresis) in dissolved ^{137}Cs, dissolved organic carbon (DOC), and K^+ concentrations in surface water during storm events. Using dissolved ^{137}Cs as a tracer, we evaluate the influence of soil infiltration water and groundwater from various depths on surface water dynamics, providing insights into the pathways and processes governing ^{137}Cs migration into aquatic systems.

Keywords：Fukushima Dai-ichi NPP accident, radiocesium, forest, distribution, transfer mechanisms

福島第一原子力発電所事故後の森林内における水文学的過程による放射性セシウムの移行

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福島第一原子力発電所事故で放出された^{137}Csの多くは森林に沈着し、現在も森林内で循環している。我が国の森林においては、福島第一原子力発電所の事故により沈着した放射性セシウムの初期の動態から10年以上に及ぶ林内分布・移行状況のフィールドデータが精力的に取得されている。本発表では、我が国の森林における放射性セシウムの移行メカニズムのうち、水文素過程にともなう大気-樹冠-土壌間での移行や、森林源頭部流域における斜面土壌から地下水を通じた水系への溶存態^{137}Csの流出について、福島県川俣町及び浪江町に設定した試験林分・流域でのフィールドモニタリングの成果をもとに、長期的な移行メカニズムについて報告する。また、出水時の表流水中の溶存態^{137}Cs、DOC、K^+濃度の時系列変化(ヒステリシス)にもとづいて、溶存態^{137}Cs濃度をトレーサーとして、表流水への土壌浸透水や深度の異なる地下水の流入の影響を評価する手法について検討した。

キーワード：福島第一原子力発電所事故、放射性セシウム、森林、分布、移行メカニズム

P-16

Intrinsic and extrinsic factors influence wild boar gut microbiome dynamics in the Difficult-to-Return Zone and surrounding landscape

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A decade after the 9.0 magnitude Tohoku earthquake off the east coast of Japan and subsequent nuclear accident, wildlife occupy an environment with varying levels of radionuclide contamination that may profoundly affect wildlife behavior, physiology, reproduction, health, survival and ultimately evolution. By sampling longitudinally across the gastrointestinal tracts of wild boar (*Sus scrofa*) captured in the Difficult-to-Return Zone and surrounding landscape, we show how both intrinsic and extrinsic factors influence wild boar gut microbiomes (GMBs) relative to robust radiation dosimetry on individual animals, as well as the impact of radiation dose on the GMB of wild boar at different life stages. Location within the wild boar gut was the main selective driver of bacterial alpha and beta diversity (i.e., membership within versus differences among bacterial communities, respectively), while bacterial membership within the lower gut (i.e., cecum, colon, and distal colon) differed relative to radiation dose, landscape elevation, social distance among wild boar, and life stage suggesting chronic low-dose radiation may alter the host immune system. These discoveries reveal wild boar may serve as excellent sentinels for monitoring the long-term effects of low-dose radionuclide exposure on wildlife.

Keywords：radionuclide exposure, mammalian gut microbiomes

P-17

^{90}Sr and ^{137}Cs distribution in Chornobyl forests：30 years after the nuclear accident

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The aim of this study was to quantify patterns in the distribution of ^{90}Sr and ^{137}Cs activity in pine (*Pinus sylvestris* L.：18 sites) and birch (*Betula pendula Roth.*：2 sites) forests within the Chornobyl exclusion zone, 30 years after the Chornobyl Nuclear Power Plant accident in 1986. From our results, the geometric mean of the ^{90}Sr aggregated transfer factor (T_{ag}) from mineral soil to the trunk wood for Scots pines was 24 x 10^{-3} m^2 kg^{-1}, which is an order of magnitude higher than the ^{90}Sr T_{ag} value of 1.6 x 10^{-3} m^2 kg^{-1} reported by the IAEA (2010) "Handbook of parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments". The observations suggest that the above-ground biomass such as soil organic layers, green forest floor, and trees may contribute more to the ^{90}Sr inventory than the mineral soil at the stand level. In contrast, the ^{137}Cs T_{ag} values for pine and birch stands were consistent with those reported in the literature. Both results align with the known bioavailability of radionuclides from previous studies：low for ^{137}Cs, leading to limited soil depth migration (less than 30 cm in the mineral horizon), and higher for ^{90}Sr, resulting in greater soil migration (up to 1.0 m in the mineral horizon). This study highlighted significant correlations between the ^{90}Sr and ^{137}Cs radionuclide activity concentrations in the litter layers and their content in the trunk wood of pine trees.

Keywords：^{90}Sr; ^{137}Cs; aggregated transfer factors; Chornobyl accident; forest; radioactive contamination; radionuclide distribution.

P-18

RINSHO：Soil biodiversity and functional processes in radio-contaminated forests (Fukushima Prefecture, Japan). Preliminary results.

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

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

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

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

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

P-19

Assessment of the effects of ionizing radiation in bees – BEERAD

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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 essential to acquire data on the likely effects of ionizing radiation on ecosystems in experimental and realistic conditions. The objective of the BEERAD 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 crucial to conduct studies that will serve as a basis to better evaluate the impacts of IR on animal health using honeybees. In 2023 and 2024, honeybee colonies were installed in April on six sites around the Fukushima Daiichi Nuclear Power Plant：2 in Okuma (high dose), 1 in Namie, 1 in Futaba (low dose), and 2 in Minamisoma (controls). Hives were sampled at different time points for ^{137}Cs measurement, biomarker analyses, and colony development assessment. Honey was also collected to measure ^{137}Cs, pollen diversity, and pesticide content. In July 2024, queens were also sampled for biomarkers and fertility analyses. Concerning the laboratory experiments, a queen irradiation experiment was carried out in 2024 for 14 days. Queens were then divided into two groups, one for biomarkers and fertility analysis, and the other for introduction into queenless colonies to monitor their survival and development. The poster will present the main results obtained from field and laboratory experiments.

Keywords：ionizing radiation, honeybee (*Apis mellifera*), physiology, biomarkers, Fukushima NPP.

P-20

Radiation effects in Japanese red pine：A review of recent research

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Since the first few years after the Fukushima Daiichi Nuclear Power Plant accident, we observed an increased frequency of morphological abnormalities in natural young populations of Japanese red pine that began to grow on abandoned lands in the evacuation areas of Fukushima Prefecture. As a result of our research, the frequency of such abnormalities (cancellation of apical dominance) was formulated as a function of the dose rate of chronic irradiation for young trees. Subsequently, in the course of joint projects with RIRAE, SCK-CEN, and NIRS-QST, the effects of red pine irradiation on morphological, cellular, and molecular levels in natural and artificial populations were studied to establish their relationship. In this review, we summarize the main results obtained, present previously unpublished data on the morphological effects in the artificial pine population and suggest an interpretation of the results of cytological and molecular studies.

Keywords：Fukushima, radiation effects, Japanese red pine

P-21

Estimating radiation exposure to Fukushima wild boars through chromosomal damage assessment

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Radioactive contamination of large mammals has been monitored in Japan following the significant release of radioactive substances from the Fukushima Daiichi Nuclear Power Plant accident in 2011. Previous studies have shown a decreasing trend in radiocesium concentrations in wildlife, including game animals; however, internal contamination in some areas of Fukushima remains well above the Japanese government's standard limit for radionuclides in food (100 Bq kg^{-1}). Among these, wild boar has been the focus of several studies investigating the effects of chronic low-dose radiation exposure. While no adverse effects have been observed, the total radiation dose received by these animals remains uncertain. In this study, radiation exposure was assessed in 307 wild boars from radioactively contaminated areas (50 to 8,000 kBq m^{-2} in soil) of Fukushima Prefecture between 2016 and 2019. Radiocesium concentrations in boar meat remained high near the power plant, with a maximum value of 50 kBq kg^{-1} recorded in 2019. Estimated total dose rates ranged from 0.02 to 36 μGy h^{-1}, primarily due to external exposure, with dose rates exceeding the generic no-effects benchmark (10 μGy h^{-1}) in some cases. External and internal dosimetry were used to estimate these dose rates. Additionally, chromosomal aberrations were evaluated to assess potential biological effects; however, no aberrations were detected in the boar examined. It is likely that the low-dose, low-dose-rate exposure was insufficient to induce detectable aberrations at the number of cells scored or that effective DNA repair mechanisms mitigated damage. Future studies will require scoring a larger number of cells to improve sensitivity and detect potential effects.

Keywords：wild boar, Fukushima, chromosomal aberration, radiocesium

P -22

Study of the effects of environmental radiocontamination on the ecophysiology of an amphibian, the tree frog

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The Fukushima nuclear accident in 2011 led to significant radioactive releases into the environment, resulting in chronic exposure to ionizing radiation (IR) for local wildlife. This prolonged exposure has raised critical questions about its effects on biodiversity and the physiological mechanisms essential for species survival and reproduction.
This study examines the effects of IR on male Japanese tree frogs (*Dryophytes japonicus*), a sentinel species for ecosystem health. We analyzed the impact of IR during reproductive period, focusing on reproductive traits and energy metabolism on two key tissues : thoracic muscles, essential for calling, and the liver, a detoxification organ. The results revealed adjustments in aerobic and anaerobic metabolism, suggesting changes in energy allocation in response to the costs of radiation exposures. Building on these findings, we are investigating potential effects on reproductive traits and by measuring male vocal performance, an energetically costly critical factor in mate attraction, and sperm quality (e.g., transcriptomic analysis, count, morphology, and motility). This study explores how ionizing radiation influences energy allocation and intensifies trade-offs between reproductive traits, potentially compromising reproductive success in wildlife, with long-term implications for ecosystems in radiocontaminated environments. This study adds to the understanding of nuclear accidents' impacts on biodiversity by integrating findings from Fukushima with those observed in Chornobyl, highlighting shared patterns and mechanisms underlying the ecological consequences of ionizing radiation.

Keywords : physiology, treefrog, Fukushima nuclear accident

P -23

Changes in ^{137}Cs concentration in food organisms of marine fish in Fukushima Prefecture waters

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It has been revealed that the main uptake routes for radioactive cesium in fish and shellfish are through feed and water, and investigating the concentration of radioactive cesium in feeding organisms is important in order to elucidate the mechanism by which radioactive cesium are transferred to fish and shellfish is important. In the waters of Fukushima Prefecture, ^{137}Cs concentrations in marine fish feed were determined from 2011 to 2013, immediately after the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant accident. In order to confirm changes in ^{137}Cs concentration in prey organisms, samples were collected using bottom trawling nets by Fukushima prefecture research vessels and fishing boats between 2023 and 2024 was measured and corrected to the date of specimen collection. We calculated the 3-month average ^{137}Cs concentration in mysids and shrimps along the coast of Iwaki City, where large quantities were collected. The ^{137}Cs concentration in mysids was 4.59-36.0 Bq/kg-wet in 2011-2013, but it was 0.17-0.81 Bq/kg-wet in 2023-2024. The ^{137}Cs concentration in shrimp was 2.35-23.7 Bq/kg-wet in 2011-2013, but 0.19-0.24 Bq/kg-wet in 2023-2024. From these results, it is thought that the influence of mysids and shrimps on the ^{137}Cs concentration in marine fish has decreased.

Keywords：Fukushima Prefecture waters, marine fish, food organism, radioactive cesium

福島県海域における海産魚類の餌料生物の^{137}Cs濃度の推移

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魚介類の放射性セシウムの主要な取込経路は餌と水であることが明らかになっており、餌料生物の放射性セシウム濃度を調査することは、放射性セシウムの魚介類への移行メカニズムを解明するために重要である。福島県海域においては、東京電力㈱福島第一原子力発電所の事故直後の2011～2013年に、海産魚類の餌料生物の^{137}Cs濃度が把握されている。餌料生物の^{137}Cs濃度の変化を確認するために、2023年６月～2024年１月に、福島県の調査船及び漁船により底びき網を用いて検体を採集し、ゲルマニウム半導体検出器で^{137}Cs濃度を測定した。採集量が多かったいわき市沿岸のアミ類、エビ類の^{137}Cs濃度について、過去のデータと同様に３ヶ月平均値を求めた。アミ類の^{137}Cs濃度は、2011～2013年は4.59～36.0Bq/kg-wetであったが、2023～2024年は0.17～0.81Bq/kg-wetであった。エビ類の^{137}Cs濃度は、2011～2013年は2.35～23.7Bq/kg-wetであったが、2023～2024年は0.19～0.24Bq/kg-wetであった。これらの結果から、アミ類、エビ類が海産魚類の^{137}Cs濃度に与える影響は低下したと考えられる。

キーワード：福島県海域、海産魚類、餌料生物、放射性セシウム

P-24

Impact assessment of radiation dosage on helminth diversity and infectious load in rodents in the Chornobyl Exclusion Zone

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Helminths regulate host populations, having a significant effect on the functioning and health of ecosystems. Helminth fauna in rodents is also a bioindicator of radioactive contamination. To assess the effect of radioactive contamination on ecosystem functioning, we analyzed parasitic groups in rodents (*Apodemus, Myodes, Microtus*) found in the Chornobyl Exclusion Zone (CEZ), a highly contaminated area after the Chornobyl accident. The main aspects include: 1) measurement of background radiation at rodent capture sites to assess the level radioactive contamination of the environment. The content of ^{137}Cs was measured in rodent tissue samples to predict bioaccumulation from diet, behavior and seasonal changes; 2) study of helminth diversity in rodents in the CEZ by conducting helminthological dissections, parasite identification and molecular studies. 3) assessment of the rodent helminth infectious load at sites with different levels of radiation background.

Preliminary results show that the species composition and infectious load of helminths in rodents vary depending on the level of radiation contamination. We collected 69 samples at eight sites with different levels of contamination, ranging from 0.09 to 41.5 μSv/h, and revealed 9 helminth species. All sites demonstrate different intensities of helminth infection, which may be due to different dose rates.

Keywords：Chornobyl Exclusion Zone, rodents, helminth fauna, radioactive contamination, radionuclides.

P-25

Impacts of Fukushima Daiichi Nuclear accident, explored with the data of land transaction in Fukushima prefecture

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The Fukushima Daiichi Nuclear Power Plant accident triggered by the tsunami caused by the Great East Japan Earthquake in 2011 gave significant impacts on socio-economical condition of Fukushima Prefecture. In order to explore the impacts, we analyze trends of land transactions in Fukushima prefecture. The data in all municipalities in Fukushima Prefecture during 2007-2021 were obtained from the Real Estate Library published by the Ministry of Land, Infrastructure, Transport and Tourism. In Fukushima, Koriyama, and Iwaki, the annual average of transaction prices (yen/m^2) per unit area of land (residential land) increased after 2011, reaching 1.8 to 2.3 times the 2011 level in 2016 or 2017, and then leveling off. In contrast, the annual average of public land prices in each city reached a low in 2013 and then showed an upward trend, reaching about 1.2 times the 2011 level as of 2021. In addition, transaction prices of land (residential land) and agricultural land at various locations did not show any significant correlation with air dose rates based on aircraft monitoring. These results suggest that demand for housing increased immediately after the accident in a manner that outweighed concerns about radiation. We will present other datasets, including results of farmland transaction analysis and interviews with real estate agents etc., at the annual symposium.

Keywords： Real Estate Library, land transaction price, official land price

福島県の土地取引データからみた原発事故の影響

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2011年の東日本大震災の津波による福島第一原子力発電所事故は福島県の地域社会に大きな影響を与えた。本研究では土地価格の変動から原発事故による社会的な影響を評価することを試みた。国土交通省による不動産ライブラリから、福島県全市町村の2007年～2021年における土地(宅地)・土地(宅地)＋建物・農地・林地の取引価格を取得した。福島市、郡山市、いわき市のいずれにおいても、土地(宅地)の単位面積当たりの取引価格(円／㎡)の年平均値が2011年以降上昇し、2016年または2017年に2011年比で1.8～2.3倍に達し、その後横ばいとなった。これに対して、各都市の公示地価の年平均値は2013年に最低となった後、上昇傾向を示し、2021年時点で2011年比1.2倍程度であった。また、土地(宅地)・農地の各地点の取引価格は、航空機モニタリングによる空間線量率との間に有意な相関を示さなかった。以上のことから、原発事故直後から放射線に対する懸念を上回る形で住宅の需要が増加したことが考えられた。成果報告会時には、農地取引の動向に関する解析や不動産業者等へのインタビューの結果を含めて報告を行う予定である。

キーワード：不動産ライブラリ、土地取引価格、公示地価

P-26

Seasonal variations in the diets and ^{137}Cs concentrations of masu salmon in the Ukedo River system

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The Fukushima Dai-ichi Nuclear Power Plant accident in 2011 released a huge amount of radioactive materials into surrounding environments including freshwater ecosystems. As a result, high concentrations of ^{137}Cs continue to be detected in salmonid species, particularly masu salmon, inhabiting the Ukedo River system. The aims of this study are to elucidate seasonal variations in the diets and ^{137}Cs concentrations of masu salmon. From June 2023 to June 2024, masu salmon were sampled seasonally using electrofishing in the two river sites (Kodeya and Ogaki-shita) of the Ukedo River system. Analyses were conducted on their bodies and stomach contents. The stomach contents were identified to the taxonomic order levels, and ^{137}Cs concentrations in the body and prey items were measured using Ge semiconductor detectors. The results revealed that, in Kodeya river, masu salmon predominantly fed on Hymenoptera insects (ants) during the summer and shifted to Diptera insects (fly larvae and adults) in the autumn. Conversely, in Ogaki-shita river, masu salmon primarily consumed Hymenoptera insects (ants) in both seasons. Additionally, ^{137}Cs concentrations showed a marked increase during autumn, particularly in one-year-old individuals, where concentrations rose approximately 4–6 times compared to summer levels (Kodeya: mean 971 and 3,700 Bq/kg, Ogaki-shita: mean 2,150 and 13,600 Bq/kg in summer and autumn, respectively). These findings suggest that seasonal changes in prey composition significantly influence the ^{137}Cs concentrations in masu salmon.

Keywords：freshwater fish, river, diet, ^{137}Cs, Seasonal changes

請戸川水系におけるヤマメの食性と^{137}Cs濃度の季節変化

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2011年に発生した福島第一原子力発電所事故により、大量の放射性物質が周辺の陸水域へ拡散した。その影響として、請戸川水系に生息するサケ科魚類、特にヤマメにおいて、高濃度の^{137}Csが検出され続けている。本研究では、ヤマメの食性および^{137}Cs濃度が季節によってどのように変化するのかを明らかにすることを目的として調査を行った。2023年６月から2024年６月まで、季節ごとに請戸川水系の小出谷川と大柿下において電気ショッカーを用いてヤマメを採捕し、魚体および胃内容物の分析を実施した。胃内容物は摘出後、分類群ごとに同定した。Ge半導体検出器を用いて魚体および胃内容物の^{137}Cs濃度を測定した。その結果、小出谷川では、ヤマメは夏季に主にハチ目昆虫(アリ)を摂食し、秋季にはハエ目昆虫(幼虫および成虫)を中心に摂食していることが分かった。一方、大柿下では、両季節ともにハチ目昆虫(アリ)を主な餌とする傾向が見られた。また、^{137}Cs濃度は秋季に顕著な上昇を示し、特に１歳個体のヤマメでは、夏季に比べて約４～６倍の増加が確認された(夏季および秋季の平均値：小出谷川　各971、3,700Bq/kg，大柿下　各2,150、13,600 Bq/kg)。これらの結果は、季節ごとの餌生物の変化がヤマメの^{137}Cs濃度に大きく影響を与えていることを示唆している。

キーワード：淡水魚、河川、食性、^{137}Cs、季節変化

P -27

Seasonal variations in ^{137}Cs concentrations and habitat conditions of fish in the Ukedo River system

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Ukedo River system has been heavily contaminated by radiocesium (^{137}Cs) after the Fukushima Daiichi Nuclear Power Plant accident. High ^{137}Cs concentrations in fish were identified. In order to lift future restrictions on the shipment of fish in the Ukedo River system and to resume fishing activities, it is necessary to know more about the ^{137}Cs contamination situation.
Field investigation was carried out at Ogaki Dam reservoir, and at nearby rivers (Kodeya, Ogaki-sita) about every three months from June 2023 to June 2024. In the investigation, environmental samples such as fish, water, bottom sediment were collected, and environmental parameters such as water temperature and dissolved oxygen (DO) were measured. Comparison of ^{137}Cs concentration of masu salmon in Kodeya river and Ogaki Dam reservoir revealed that ^{137}Cs concentrations in salmon from the rivers were significantly higher than from the dam reservoir, although the size of salmon from the dam reservoir was significantly larger than that from the river. These results suggested the existence of different routes of ^{137}Cs uptake in masu salmon in each environment. Also, masu salmon in Kodeya river, ^{137}Cs concentrations increased significantly from summer to autumn (Average: 784 Bq/kg and 1,720 Bq/kg, respectively). The dissolved ^{137}Cs concentration of Ogaki Dam reservoir was higher than that of Kodeya river (an inflow river in Ogaki Dam reservoir) in all seasons. In the dam reservoir, the higher dissolved ^{137}Cs concentrations in the bottom layer, and extremely high ^{137}Cs concentrations in bottom sediments were observed, suggesting that bottom sediment is the source of ^{137}Cs in the dam reservoir.

Keywords：freshwater fish, dam reservoir, river, ^{137}Cs, seasonal changes

請戸川水系における魚類の^{137}Cs濃度と生息環境の季節変化

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請戸川水系は福島第一原子力発電所事故により特に放射性セシウム(^{137}Cs)で汚染された水系であり、現在も高濃度の^{137}Csを含む魚類が確認されている。将来的な請戸川水系における魚類の出荷制限解除や漁業活動の再開に向け、放射性セシウムの汚染状況を詳しく把握する必要がある。
2023年６月から翌年の６月まで、約３ヶ月ごとに福島県浪江町の大柿ダム、その周辺の河川(小出谷川、大柿下)で季節ごとの調査を行った。調査ではヤマメを中心とした魚類の採捕、環境水や底質等の環境試料の採取、水温、溶存酸素(DO)等環境データの測定を行った。小出谷川とダムに生息するヤマメを比較すると、サイズはダムで有意に大きいものの、^{137}Cs濃度は河川のヤマメが有意に高かった。この要因として、それぞれの環境における^{137}Csの取込経路が異なることが考えられる。また、小出谷川で採捕したヤマメの^{137}Cs濃度について比較すると、夏季に比べ秋季に採捕された個体の^{137}Cs濃度が有意に高かった（平均値：夏季784 Bq/kg，秋季1,720Bq/kg)。環境水の溶存態^{137}Cs濃度を見ると、ダムの流入河川である小出谷川に比べ大柿ダム表層の濃度が高かった。また、ダムでは表層よりも底層の濃度が高く、底泥が高濃度だった。これは、底泥が大柿ダムの^{137}Csの供給源であることを示唆している。

キーワード：淡水魚、ダム、河川、^{137}Cs、季節変化

P-28

Estimation of ^{137}Cs uptake pathway of Japanese eel by rearing experiment and river survey near the FDNPP

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As a result of the FDNPP accident, radioactive materials were dispersed and deposited over a wide area in Fukushima Prefecture. The transfer of ^{137}Cs to aquatic organisms occurs through environmental water or prey organisms and varies greatly depending on environmental conditions. The Japanese eel, an euryhaline fish, could be an indicator species for clarifying the transfer of ^{137}Cs to aquatic organisms in various water bodies from freshwater to seawater. In this study, the pathway of ^{137}Cs uptake was estimated by rearing experiment under different salinity conditions and river surveys near the FDNPP. From May to October 2024, a rearing experiment without feeding was conducted in freshwater and seawater (salinity 0.1 and 32 psu, respectively). First, the eels were reared in water containing ^{137}Cs, and then kept in tap water with low ^{137}Cs concentration to evaluate the uptake and excretion. In addition, wild eels were collected in the river (salinity 0.2–31.1 psu) in August and September, and ^{137}Cs concentrations in the water and muscle parts were measured. In the analyses, the water-to-body concentration ratio (CR) of ^{137}Cs was determined. The CRs in the experiments were estimated to increase up to 9.79 L/kg in the seawater and 2.30 L/kg in the freshwater, and the uptake of ^{137}Cs from the water was clearly higher in the seawater. In addition, the CRs of wild individuals (943 L/kg) were significantly higher than the predicted values obtained in the experiment. These results suggest that the ^{137}Cs uptake by eels is affected by salinity conditions and that prey items are the main uptake pathway of ^{137}Cs.

Keywords：eel, rearing experiment, ^{137}Cs, indicator species

飼育試験及び原発近傍河川調査によるニホンウナギの^{137}Cs取込経路の推定

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福島第一原子力発電所事故により、放射性物質が福島県の広域に拡散・沈着した。^{137}Csの水生生物への移行は環境水あるいは餌生物を介して生じ、環境条件によって大きく変化する。広塩性のウナギは、淡水域～海域の様々な水域に生息しており、各水域での^{137}Csの水生生物への移行を明らかにするうえで指標種となり得る。本研究では、本種の^{137}Csの取込経路を異なる塩分条件下での飼育試験と原発近傍河川調査のデータ解析により推定した。2024年５月から10月にかけて、淡水区と海水区（塩分濃度0.1、32psu）での無給餌の飼育試験を実施した。^{137}Cs含有水で飼育し、その後、^{137}Cs濃度の低い水道水で飼育することで^{137}Csの取込・排出を評価した。また、８・９月にウナギの天然個体と河川水（塩分濃度0.2–31.1psu）を採取し、水と筋肉部の^{137}Cs濃度を測定した。また、これらの水に対する魚体の^{137}Csの濃度比（CR値）を求めた。飼育試験では、CR値の極限値は海水区で9.79L/kg、淡水区で2.30L/kgと計算され、飼育水からの^{137}Csの取込みは海水区で明確に高かった。また、天然個体のCR値（943L/kg）は、飼育試験で得られた予測値よりも著しく高かった。以上の結果から、ウナギの^{137}Csの取込みは塩分の条件に影響を受けること、また、餌生物が^{137}Csの主な取込経路であることが示唆された。

キーワード：ウナギ、飼育試験、^{137}Cs、指標種

P-29

Assessment of ^{137}Cs accumulation in wild animals using road-killed individuals

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The Fukushima Daiichi Nuclear Power Plant accident occurred in March 2011 released a large amount of radioactive materials into the environment. Among the released radionuclides, radioactive cesium-137 (^{137}Cs) is of greatest concern for its long-term impacts because it accumulates in living organisms and has a long half-life of about 30 years. Monitoring surveys conducted after the accident on wild animals and plants have reported high concentrations of ^{137}Cs in a variety of species. However, regarding large and medium-sized mammals, there have been few reports on the species other than game animals. The aim of this study is to evaluate the accumulation of ^{137}Cs in mammals and birds, for which there are few reported cases, living in Fukushima Prefecture. We focused on accidental death (especially road-kill), which are relatively easy to collect for large and medium-sized mammals and individuals that died in accidents in Fukushima were collected and analyzed accumulation of ^{137}Cs.
Forty-seven accidentally killed animals of 14 species including six bird species were collected from April 2024 to January 2025. A comparison of ^{137}Cs concentration in muscles among species, including game species referred from the Fukushima radiation monitoring survey of wild birds and animals conducted in 2024, showed higher ^{137}Cs concentration in *Mustelidae* species such as Japanese badger, Japanese weasel, and Japanese marten.

Keywords： ^{137}Cs, mammal, bird, road-kill

ロードキル個体を用いた哺乳類・鳥類の^{137}Csの広域的蓄積評価

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2011年３月に発生した福島第一原発事故では、大量の放射性物質が大気中に放出され、広範囲の陸域や水系に降下・沈着した。放出された核種の中でも放射性セシウム137(以下、^{137}Cs)は生物へ蓄積し、また半減期は約30年と長期にわたり影響を与えることが懸念されている。これまでに行われた野生動植物へのモニタリング調査では、実際に多様な生物種から高濃度の放射性物質の蓄積が報告されているが、大型・中型哺乳類に関しては狩猟鳥獣以外の種についての報告例は少ない。そこで本研究では、大・中型哺乳類の収集が比較的容易である事故死(特にロードキル)に着目し、福島県内で事故死した個体を収集・分析することで、哺乳類や鳥類の^{137}Csの蓄積を広域的に評価することを試みた。
2024年４月から2025年１月の間に14種47個体の野生動物の事故死個体が回収された。これらの中には鳥類も６種含まれていた。同時期に実施された福島県の野生鳥獣放射線モニタリング調査結果の狩猟鳥獣種を含め、筋肉中の^{137}Cs濃度を比較したところ、アナグマやイタチ、テンなどのイタチ科で^{137}Cs濃度が高い傾向が見られた。

キーワード： ^{137}Cs、哺乳類、鳥類、ロードキル

P-30

Summer-autumn changes in ^{137}Cs concentrations and diets of masu salmon in the river and dam reservoir of the Ota River system

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Radiocesium contamination of freshwater fish due to the FDNPP accident continues to this day. Freshwater fish mainly take up ^{137}Cs from their prey, and because salmonids change their diets with the seasons, ^{137}Cs concentrations may also change with the seasons. In addition, salmonids have different uptake pathways of ^{137}Cs between rivers and lakes. In this study, we determined changes in ^{137}Cs concentrations and diets of masu salmon in the Ota River and Yokokawa Dam reservoir according to season, life history type, and age. Surveys were conducted in August (summer) and October (autumn) 2017. Concentrations of ^{137}Cs in masu salmon in the Ota River increased from summer to autumn (summer: mean 920 Bq/kg; autumn: 2,430 Bq/kg). This trend was more pronounced in age-1 fish. No significant change was observed in masu salmon in the Yokokawa Dam reservoir. In the Ota River, aquatic insects were the main prey of age-0 fish, while terrestrial insects were the main prey of age-1 fish (80% each). In Yokokawa Dam reservoir, only small fish (pond smelt) were observed in the stomachs in both seasons. In the Ota River, only terrestrial insects in the autumn had higher ^{137}Cs concentrations (2,840 Bq/kg) than others. Pond smelt showed no significant change between the summer and autumn seasons (280 Bq/kg). In conclusion, ^{137}Cs concentrations in masu salmon in the Ota River system are likely to be affected by life history type and age as well as seasonal changes in diet and prey ^{137}Cs concentrations.

Keywords：masu salmon, ^{137}Cs, diets, season, life history type, age

太田川水系の河川とダム貯水池に生息するヤマメの^{137}Cs濃度と食性の夏季・秋季間の変化

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FDNPP事故による淡水魚の^{137}Cs汚染は現在も続いている。淡水魚は主に餌から^{137}Csを取り込み、サケ科魚類は季節により食性が変化するため、^{137}Cs濃度も季節によって変化する可能性がある。また、サケ科魚類は河川と湖で^{137}Csの取り込み経路が異なる。本研究では、太田川と横川ダム貯水池に生息するヤマメの季節、生活型、年齢による^{137}Cs濃度と食性の変化について明らかにした。調査は2017年８月(夏季)、10月(秋季)に行った。太田川のヤマメの^{137}Cs濃度は夏季から秋季にかけて有意に上昇していた(夏季：平均920Bq/kg、秋季：2,430Bq/kg)。また、その傾向は１歳魚において顕著であった。横川ダム貯水池のヤマメの^{137}Cs濃度はほとんど変化していなかった。太田川では０歳魚の主な餌生物は水生昆虫であったが、１歳魚は陸生昆虫であった(各80%)。横川ダム貯水池では両季節ともワカサギのみが確認された。太田川では秋季の陸生昆虫のみ他と比べ^{137}Cs濃度が有意に高かった(2,840Bq/kg)。ワカサギは夏季と秋季で大きな変化はみられなかった(280Bq/kg)。以上のことから、太田川水系のヤマメの^{137}Cs濃度は、季節と生活型、さらには年齢による食性と餌生物の^{137}Cs濃度の変化に影響を受けていると考えられる。

キーワード：ヤマメ、^{137}Cs、食性、季節、生活型、年齢

P-31

Comparisons of ^{137}Cs concentrations and feeding habits of masu salmon and white-spotted charr in the Ota River, Fukushima Prefecture, Japan

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The Fukushima Dai-ichi Nuclear Power Plant accident has negatively affected inland water fisheries due to contamination by ^{137}Cs. In June, September, and December 2023, masu salmon and white-spotted charr were sampled at the upper reaches of Ota River (St.4). The stomach contents were identified to the order level, and the Index of Relative Importance (IRI) of each species was calculated. The ^{137}Cs concentrations in their bodies were also measured. The highest mean ^{137}Cs concentrations of masu salmon and white-spotted charr at St.4 were found in the autumn (3,360 Bq-kg-FW) and winter (2,540 Bq-kg-FW) seasons, respectively. The ^{137}Cs concentrations in salmonid fish could be mainly affected by the prey species one season earlier, because it takes a few months for the increase of ^{137}Cs concentrations in salmonids. In summer, the main prey of masu salmon was Coleoptera (beetles) (44%, %IRI), while that of white-spotted charr was Hymenoptera (ants) (41%). In autumn, the main prey of masu salmon were Hymenoptera (ants) (46%), and Orthoptera (grasshopper) (31%) for white-spotted charr. Although the main prey items of masu salmon and white-spotted charr were terrestrial insects in both seasons, large differences were observed at the order level, suggesting that more detailed comparisons between prey taxa are needed to compare the seasonal changes of ^{137}Cs concentrations in both species.

Keywords： ^{137}Cs concentrations, stomach contents, masu salmon, white-spotted charr

福島県太田川におけるヤマメとイワナの^{137}Cs濃度と食性の比較

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福島第一原子力発電所事故が発生し、137Csによる汚染が内水面漁業に影響を与えている。本研究では、2023年６月、９月、12月に太田川上流(St. ４)においてヤマメとイワナを採捕し、胃内容物を目レベルまで同定した。胃内容物については胃内容物重要度指数(Index of Relative Importance、以下IRI)を求めた。また、魚体の^{137}Cs濃度を測定した。St. ４においてヤマメは秋季(3,360Bq-kg-FW)、イワナは冬季(2,540Bq-kg-FW)に^{137}Cs濃度が最も上昇した。サケ科魚類の^{137}Cs濃度の上昇には数か月かかるため、魚体の^{137}Cs濃度は一季節前の餌生物が影響する可能性がある。夏季のヤマメの主な餌生物はコウチュウ目(44%，%IRI)、イワナはハチ目(41%，%IRI)であった。秋季のヤマメの主な餌生物はハチ目(46%，%IRI)、イワナはバッタ目(31%，%IRI)であった。ヤマメ、イワナともに両季節で主な餌生物は陸生昆虫であったが、目レベルで大きな違いが確認された。両種の^{137}Cs濃度の季節変化の比較には、より詳細な餌生物の分類群ごとの比較が必要であることが示唆された。

キーワード： ^{137}Cs濃度、胃内容物、ヤマメ、イワナ

P-32

Transfer of Cs-137 to giant hornet (*Vespa mandarinia japonica*) and assessment of variation factors through analysis of stable carbon and nitrogen isotope in the difficult to return zone

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Larvae of giant hornet (*Vespa mandarinia japonica*) feed on meat balls made from insects, spiders, and other hornets captured by worker hornets. The worker hornets cannot ingest solid food; instead, they consume tree sap, nectar, and amino acid-rich nutritional fluid secreted by the larvae. The foraging range of workers is typically reported to be 1-2 km. In the 2023 season, a total of about 300 individual workers were captured at six experimental beekeeping sites in Hamadori, including the difficult-to-return zone. The average aggregated transfer factor for giant hornet were two orders of magnitude higher than for honey. Different carbon and nitrogen stable isotope ratios were observed for individuals collected at the same location on different dates, which may be due to individuals of different colony coming to hunt in the same site. However, even among individuals considered to be from the same colony, there was a range of several tenfold in Cs-137 concentrations, and no correlation was observed between Cs-137 concentrations and stable isotope ratios. The range of Cs-137 concentrations can be influenced by the fact that deposition varies by a factor of several even within a 2 km radius of each site.

Keywords：Cs-137, *Vespa mandarinia japonica*, stable carbon and nitrogen isotope ratios

帰還困難区域におけるオオスズメバチへのCs-137の移行とその変動要因の炭素・窒素安定同位体比による推定

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オオスズメバチの幼虫は働きバチが捕ってきた昆虫やクモ・スズメバチ類でできた肉団子を食べる。働きバチは固形物を摂取できず、樹液や花蜜、幼虫から分泌されるアミノ酸栄養液を摂取する。働きバチの採餌距離は通常１～２kmといわれている。2023年シーズンには帰還困難区域を含む浜通り６箇所の実験養蜂サイトでオオスズメバチ合計約300個体を捕獲した。オオスズメバチ個体への面移行係数は蜂蜜と比較すると２桁高い値となった。同じ場所で採集した個体でも、採集日の違いで炭素・窒素安定同位体比が異なることが観察され、異なる群れが同じ養蜂場に狩りにきているためと考えられる。しかし、同群と考えられる複数個体でもCs-137濃度には数倍程度の幅があり、Cs-137濃度と安定同位体比とには相関が見られなかった。各養蜂場から２kmの範囲内でも沈着量が数倍程度異なることがCs-137濃度の幅に影響していると考えられる。

キーワード：放射性セシウム、オオスズメバチ、炭素・窒素安定同位体比

P-33

Observation of radiocesium distribution and biotic disturbance in forest soil by preparing sliced carbowax embedding samples

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A large amount of radioactive material was released into the environment due to the accident at the Fukushima Daiichi Nuclear Power Plant in March 2011. Even now, large amounts of radionuclide remain in forest soil, making it necessary to continuously monitor the distribution and dynamics of ^{137}Cs. In particular, the influence of soil animals, which significantly alter the soil physical environment, cannot be ignored when considering the downward migration of ^{137}Cs. However, the details of this influence have not yet been fully clarified. This study aims to evaluate the extent to which soil animals contribute to the downward migration of ^{137}Cs in the forest soil of Fukushima. To investigate the relationship between the distribution of ^{137}Cs in the soil and biological traces, the method of preparing sliced carbowax embedding samples was implemented and examined on its usefulness. By solidifying soil samples with resin and creating thin sections, biological traces within the soil could be observed without destruction. Additionally, autoradiographic analysis was conducted on the soil thin sections to quantitatively evaluate the distribution of radionuclide. As a result, while the distribution of ^{137}Cs was concentrated near the surface layer, radioactive cesium-rich microparticles were transferred to deeper layers.

Keywords： ^{137}Cs, radioactive cesium-rich microparticles, biotic disturbance, forest soil, downward migration

土壌薄片の作成による森林土壌中の放射性セシウム分布と生物撹乱の観察

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2011年３月に発生した福島第一原子力発電所の事故により、多量の放射性物質が環境中に放出された。森林土壌には現在も多量の放射性物質が蓄積されており、^{137}Csの分布・動態を継続的に把握する必要がある。土壌中の^{137}Csの下方移動において、土壌の物理環境を改変する土壌動物の影響は無視できないと考えられるが、その詳細についてはこれまで明らかにされていない。本研究は、福島の森林土壌において、土壌動物が^{137}Csの下方移動にどのように関与しているのかを明らかにすることを目的とする。土壌中の^{137}Cs分布と生物の活動痕の関係を調べる手法として、土壌薄片の作成を実施、有用性を検討した。土壌試料を樹脂で固め、薄片を作成することで、土壌中の生物の活動痕を破壊することなく観察することができた。また、土壌薄片に対してオートラジオグラフィ解析を実施し、放射性物質の分布を定量評価した。その結果、表層付近に^{137}Cs分布が集中している一方、深層に高濃度放射性セシウム粒子が移送されていることが確認された。

キーワード：^{137}Cs、高濃度放射性セシウム含有粒子、生物撹乱、森林土壌、下方移動

P-34

Distribution of radioactive cesium and effects of radioactive cesium-rich microparticles in insect communities in Fukushima

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Since the accident at the Fukushima Daiichi Nuclear Power Plant, it has been confirmed that radiocesium has been transferred to insects living around Fukushima. The radiocesium taken in by insects has the potential to be transferred to higher organisms such as fish and reptiles via the food web, and it is essential to understand the concentration of this radiocesium to assess the risk to the ecosystem. This study aimed to understand the variation in radiocesium concentration at the individual level in insect communities and the distribution of radiocesium about the habitat. We collected ground, flying, and aquatic insects by pitfall traps, flight interception traps, and nets. We determined whether each individual contained radioactive cesium-rich microparticles in its body using the autoradiography method. In addition, the radioactivity of the entire sample was measured, and the distribution of radiocesium in the insect community was analyzed. As a result, a case where a terrestrial insect had taken in a radioactive cesium-rich microparticle through feeding was confirmed. It was thought that the characteristics of each individual's diet affected the distribution of radiocesium in the insect community.

Keywords： radiocesium, radioactive cesium-rich microparticles, forest ecosystem, insect

福島の昆虫群集における放射性セシウムの分布と高濃度放射性セシウム含有粒子が及ぼす影響

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福島第一原子力発電所事故以降、福島周辺地域に生息する昆虫類に放射性セシウムが移行していることが確認されている。昆虫類に取り込まれた放射性セシウムは食物網を介して魚類や爬虫類など高次生物へと取り込まれる可能性があり、その濃度を把握することは生態系におけるリスク評価のために重要である。本研究では、昆虫群集における個体レベルでの放射性セシウム濃度の変動や、生息場所と関連した放射性セシウム存在分布を把握することを目的とした。地表徘徊性昆虫、飛翔性昆虫、および水生昆虫を、ピットフォールトラップ、衝突板トラップ、およびサーバーネットを用いて採取し、オートラジオグラフィ法により高濃度放射性セシウム含有粒子が体内に含まれているか個体ごとに識別した。また、試料全体の放射能を測定し、昆虫群集における放射性セシウム分布を分析した。結果として、摂食による陸生昆虫への高濃度放射性セシウム含有粒子の取り込みとみられる事例が確認された。昆虫群集における放射性セシウム分布には個体ごとの食性の特徴が影響していると考えられた。

キーワード：放射性セシウム、高濃度放射性セシウム含有粒子、森林生態系、昆虫

P-35

Volume reduction of radionuclide-contaminated wastewater utilizing a charcoal-ceramic composite：Preliminary findings

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The efficient separation of radiocesium and radiostrontium from wastewater presents a critical challenge due to the environmental and health impacts of radioactive contamination, and it is vital for advancing sustainable nuclear energy practices. This study reports on the development and characterization of a novel charcoal-ceramic composite material designed for the treatment of radionuclide-contaminated wastewater. The composite is synthesized from Japanese domestic cedar and cypress sawdust, modified with ceramic materials, and features a unique double-layered structure that integrates the properties of both charcoal and ceramics. The composite's ability to retain cesium and strontium was thoroughly evaluated. Initial assessments indicated that the composite's retention performance improved significantly following pulverization and washing treatments. Subsequent characterization confirmed that these improvements were achieved without altering the material's morphology. Future work will focus on optimizing the sorption behavior of the composite under a range of operating conditions and exploring its practical application for treating real-world radionuclide-contaminated wastewater.

Keywords：charcoal-ceramic composite, radiocesium, radiostrontium, separation, wastewater

P -36

Influence of nutrient solution composition on cesium uptake by Japanese knotweed (*Fallopia japonica*) in hydroponic culture

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Plants exhibit considerable potential for the phytoremediation of radioisotopes from the soil, including the effective removal of key contaminants, such as radiocesium (r-Cs). This study investigated the efficacy of Japanese knotweed (*Fallopia japonica*) for cesium (Cs) uptake in a controlled hydroponic environment. A two-month hydroponic experiment was conducted within an illuminated incubator to cultivate *Fallopia japonica*. Plants were grown in two distinct nutrient solutions, characterized by differing potassium nitrate (KNO_3) concentrations: 1 mM and 3 mM. Three experimental treatments were established: (1) a control group without Cs^+, (2) a continuous Cs^+ treatment group grown in a nutrient solution containing stable Cs^+, and (3) a sequential treatment group initially exposed to Cs^+ and subsequently transferred to a nutrient solution containing Cs^+. Three concentrations of Cs^+ (5 mM, 0.5 mM, and 0.05 mM) were employed across the treatment groups. Results indicated that *Fallopia japonica* demonstrated the highest seed germination rate in the nutrient solution without Cs^+, moderate germination in the presence of Cs^+, and the lowest germination under control conditions. Elevated KNO_3 concentrations (3 mM) in the nutrient solution significantly enhanced both root and shoot growth, resulting in increased plant height. Root uptake exceeding 50% was observed at high and low Cs^+ concentrations. This was evidenced when plants, initially exposed to Cs^+, were subsequently transferred to a nutrient solution containing correspondingly high or low concentrations of KNO_3 and Cs^+. These findings suggest that *F. japonica* effectively compartmentalizes cesium within specific tissues, particularly the roots, thereby restricting its translocation to aerial parts.

Keywords：Japanese knotweed, nutrient solution, hydroponic, cesium, root uptake

P -37

Application of macrocyclic-based porous sorbent for selective removal of radiocesium and radiostrontium from contaminated water

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Radiocesium (r-Cs: ^{137}Cs; $t_{1/2}$, 30.2 yrs) and radiostrontium (r-Sr: ^{90}Sr; $t_{1/2}$, 28.8 yrs) pose significant challenges to public health and the environment, particularly in the aftermath of nuclear accidents such as those at Chornobyl and Fukushima. Consequently, the efficient removal of these radionuclides is of paramount importance for environmental remediation and monitoring. This research focuses on developing and applying a novel macrocyclic-based porous sorbent, DFDB18C6@SBA-NH_2, for the efficient and selective removal of r-Cs and r-Sr from contaminated water. The sorbent integrates a macrocyclic ligand (diformyldibenzo-18-crown-6-ether, DFDB18C6) with amino-functionalized mesoporous SBA-15 (Santa Barbara Amorphous-15). The sorbent's structure, thermal properties, and surface morphology were comprehensively characterized. The sorbent demonstrated remarkable performance, achieving approximately 85% removal of r-Cs using contaminated pond water from Fukushima, and approximately 99.67% removal of r-Sr using Chornobyl cooling pond water, even in the presence of competing matrix ions such as Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}. These results highlight the potential of DFDB18C6@SBA-NH_2 as an effective and selective porous sorbent for the decontamination of r-Cs and r-Sr in radioactive contaminated water.

Keywords：radiocesium, radiostrontium, removal, macrocyclic-based porous sorbent, contaminated water

P-38

Evaluation of temporal downward movement of ^{137}Cs in soil in the area surrounding the Fukushima Daiichi Nuclear Power Plant for soil erosion study

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After being released into the atmosphere, ^{137}Cs deposit onto the soil surface and gradually penetrate the soil, exhibiting a downward migration process over time. Among the calibration models that utilize ^{137}Cs for tracking soil particle redistribution, the Diffusion and Migration (DM) model stands out due to its capability to account for this temporal change of ^{137}Cs within soil profiles. While this model has demonstrated strong performance in areas affected by ^{137}Cs from global fallout and the Chornobyl disaster, its applicability in regions impacted by the ^{137}Cs released during the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident remains largely unknown. This study analyzed an extensive historical dataset of ^{137}Cs depth distributions in soil profiles within an 80 km radius of the FDNPP, collected annually using scraper plates since December 2011. We focused on three parameters of the DM model: (i) relaxation mass depth (H), (ii) diffusion coefficient (D), and (iii) migration rate (V), which represent the downward movement of ^{137}Cs in the soil over time. Our result indicated that the average values of D increased during the survey while the average values of V decreased, despite these values initially being considered constant in the DM model. Additionally, we found a negative correlation between H during the first sampling period in 2011 and the clay particle content of the soil ($n = 40$, $r = -0.52$, $p < 0.05$). Model simulations using the computed parameters suggested that revisions are necessary to improve the performance of the DM model in this region.

Keywords：soil erosion, cesium-137, downward movement, diffusion and migration model, Fukushima

P-39

Simulation of anthropogenic tritium discharge into the ocean from the Fukushima Daiichi Nuclear Power Plant

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Following the accident at the Fukushima Daiichi Nuclear Power Plant (FDNPP) in March 2011, large quantities of radioactive materials were released into the atmosphere and ocean. Since the FDNPP nuclear accident, Tokyo Electric Power Company (TEPCO) operators have been implementing measures to reduce groundwater inflow into the FDNPP damaged reactor buildings while pumping water to cool the nuclear reactors and fuel debris. The resulting huge water volume began the discharge into the ocean from August 2023, after being treated by an Advanced Liquid Processing System (ALPS) to remove radionuclides for acceptable discharge levels except tritium. Since then, tritium concentrations in seawater and aquatic ecosystems near the FDNPP site are continuously monitored and disseminated publicly. It is essential to assess the long-term safety threshold of ALPS-treated water discharge procedure in terms of tritium concentration in coastal areas of Japan and the Pacific Ocean. However, there is no global oceanic simulation with tritium concentration and, by extension, no projection of tritium concentration at Pacific Ocean scale.
In this study, we used the TEPCO ALPS treated water release plan as an input to the ocean general circulation model (OGCM) COCO4.9, which is the ocean component of the Model for Interdisciplinary Research on Climate, version 6 (MIROC6 [1]). This approach allowed us to simulate the anthropogenic tritium concentration in the ocean due to ALPS treated water release in the forthcoming decades. The spatial distribution and temporal evolution of the projected tritium concentrations in different parts of the Pacific Ocean, as well as the impact of global warming on them, were analyzed. Moreover, the anthropogenic tritium concentration following the FDNPP accident was modeled to evaluate how large the tritium concentrations due to current treated water release are compared to the accidental one in 2011. Finally, given that oceanic tritium concentrations are mainly controlled by ocean mixing, our study represents a valuable opportunity to evaluate the impact of the Kuroshio current representation in COCO4.9 on tritium concentrations at non-eddy-resolving and eddy-resolving horizontal resolutions.
[1] Tatebe et al., *Geosci. Model Dev.*, 12, 2727–2765, doi:10.5194/gmd-12-2727-2019, 2019.

Keywords： tritium, Fukushima, Pacific Ocean, Kuroshio current, COCO4.9, ocean general circulation model

P-40

Simulation of the impact assessment of the discharge of ALPS-treated water into the ocean

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As part of the decommissioning work at the Fukushima Daiichi Nuclear Power Plant, the discharge of ALPS-treated water began in August 2023. Prior to discharge, a radiation impact assessment was carried out by TEPCO. This assessment used a marine dispersion model that had been verified using observation results for Cs-137 that had leaked out as a result of the Fukushima Daiichi Nuclear Power Plant accident. The ocean dispersion model was a 1 km x 1 km ROMS model with a variable mesh that was refined to 200 m x 200 m in the vicinity. In this assessment, a H-3 concentration of 0.1 Bq/L was used as the background concentration from atmospheric nuclear testing. However, a concentration of 1 Bq/L of H-3 was observed even before the release, and this is thought to be due to the influence of the supply from the power plant site or surrounding areas, or from rivers. After taking into account the influence of these background concentrations, the results of the model simulations were verified against the results of the monitoring of H-3 concentrations. Because the rate of release of the ALPS processed water was small, the range of influence of the monitoring of H-3 concentrations was limited, but the verification results were consistent.

Keywords：Fukushima Daiichi Nuclear Power Plant, ALPS treated water, Regional Ocean Model

ALPS処理水の海洋放出時の影響評価のシミュレーション

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福島第一原子力発電所の廃炉作業の一環として、2023年８月よりALPS処理水の放出が開始された。放出の前に東京電力によって放射線影響評価が実施された。この評価には、福島第一原子力発電所事故によって漏洩したCs-137の観測結果によって検証された海洋分散モデルが用いられた。海洋分散モデルは、水平解像度１km x １kmのROMSに対して、可変メッシュを用いて近傍を200m x 200mに高解像度化した。日本の気象庁による気象再解析データによって駆動し、黒潮や中規模渦の再現のために海洋再解析データJCOPE２Mを用いたデータ同化を行った。この評価においては、0.1Bq/LのH-3濃度が大気圏核実験起源のバックグランド濃度としていた。しかし、放出前にも１Bq/LのH-3濃度が観測されており、発電所敷地もしくは周辺地域、または河川からの供給の影響と考えられる。これらのバックグランド濃度の影響を考慮した上で、H-3濃度のモニタリング結果に対するモデルシミュレーション結果の検証を行った。ALPS処理水の放出率が小さいため、H-3濃度のモニタリングによる影響範囲は限定的であるが、検証結果は整合的であった。今後のモニタリングの継続によってデータを蓄積し、平均的な分布を求める必要がある。

キーワード：福島第一原子力発電所、ALPS処理水、領域海洋モデル

P-41

Elucidation and modeling of the effects of forest management on air dose rates

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This study is based on the result that an increase in soil moisture content due to rainfall partially intercepts γ-rays from radiocesium in the soil, resulting in a temporary decrease in air dose rates. Although previous studies have shown that rainfall decreases air dose rates, modeling requires site-specific parameters and has not yet been generalized. Therefore, we examined how changes in rainfall on the soil surface during forest management by thinning affect air dose rates, and attempted to generalize the effects of rainfall on air dose rates. As study sites, we selected the Iitoi site and the Fuyuzumi site, which are located about 40 km northwest of the Fukushima Daiichi Nuclear Power Plant. At both study sites, row thinning was conducted from October to December 2022. The detailed installation of the rain gauges showed changes in rainfall in the forest due to canopy cover interception, and it was confirmed that rainfall in the forest increased in areas that were less affected by canopy cover interception. The Forestry Agency's report indicates that the change in rainfall to the soil surface due to canopy cover has affected soil moisture content and air dose rate. According to the Forestry Agency report, the average one-year soil moisture content before thinning was 33.1% in the thinned area and 28.6% in the control area, while the average one-year soil moisture content after thinning was 35.0% in the thinned area and 25.5% in the control area, indicating that thinning has increased soil moisture content in the thinned area. The air dose rate was 0.9 μSv/h in both the thinned and control areas before thinning, but 12 months after thinning, the dose rate in the thinned area decreased to 0.75 μSv/h, while that in the control area was 0.85 μSv/h. Thus, thinning has been shown to increase rainfall in the forest, which in turn increases the soil moisture content and decreases the air dose rate.
Based on the equation for estimating soil moisture content from rainfall and air dose rate from a previous study, we developed a model equation that can be used to estimate air dose rate over a longer period than in the previous study.

Keywords： forest management, air dose rates, soil moisture rates

森林管理が空間線量率に及ぼす影響の解明とモデル化

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本研究は、降雨による土壌含水率の上昇によって土壌中の放射性セシウムからのγ線が一部遮断され、空間線量率が一時的に減少するという結果に基づいている。先行研究では、降雨によって空間線量率が減少する事が判明したが、モデル化をするにあたって、それぞれのサイトに固有のパラメータが必要であり一般化には至っていない。そこで、間伐による森林管理での土壌面への雨量変化がどのように空間線量率に影響を与えるのかを考察し、この影響を一般化することを試した。調査地としては、福島第一原発より北西に40km程度離れた飯樋サイトと冬住サイトを選んだ。両調査地には2022年10月から12月にかけて列状間伐を実施し、2024年４月より雨量計、空間線量率計、土壌水分計を設置してモニタリングを開始した。林野庁の報告書より土壌含水率は、間伐前の一年間平均で間伐区が33.1%、対照区が28.6％であったが、間伐後の一年間平均で間伐区が35.0％、対照区25.5％となっており、間伐によって間伐区の土壌含水率が上昇していることが分かる。また、空間線量率においては間伐前に間伐区、対照区両者とも0.9μSv/hであったが、間伐後12ヶ月で、間伐区では0.75μSv/hまで下がっているのに対して、対照区では0.85μSv/hとなっていた。このように間伐によって、林内雨量の増加がもたらされ、その影響として、土壌含水率が上昇し、空間線量率が減少していることが分かっている。
先行研究より、雨量から土壌含水率を推定し、空間線量率を推定する式を基に先行研究よりもより長期間での推定を行えるモデル式を作成した。

キーワード：森林管理、空間線量率、土壌含水率

P-42

Modeling adsorption/desorption processes of Cesium-137 in river-bottom sediments in Fukushima

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The 2011 Fukushima Daiichi Nuclear Power Plant (FDNPP) accident released significant amounts of radioactive Cesium-137 (^{137}Cs). Both dissolved and suspended forms of ^{137}Cs contribute to river runoff. Although the Ministry of the Environment has monitored ^{137}Cs in Fukushima river-bottom sediments since 2011, identifying long-term trends is challenging. Existing adsorption/desorption models focus on ideal lab conditions and lack real-world field data. This study uses long-term monitoring data to examine changes in ^{137}Cs concentration in river sediments. Sediment samples were collected every four months, while river water and suspended sediment were sampled quarterly. The model simulates adsorption/desorption reactions between river water and sediments, incorporating fast and slow reaction sites. By adjusting reaction rates, measured and modeled ^{137}Cs concentrations were optimized. Results show ^{137}Cs concentrations in particle-size-corrected sediments aligned with suspended forms within a year. An increase in ^{137}Cs concentration at 45 sites was observed, a phenomenon not seen in dissolved or suspended forms. The distribution coefficient (Kd) of sediments fluctuated significantly in the first three years. Slow adsorption dominated ^{137}Cs accumulation within six months, while its effect on suspended concentrations was negligible. These findings highlight that slow adsorption/desorption processes are critical for the long-term behavior of ^{137}Cs in river-bottom sediments.

Keywords： ^{137}Cs, FDNPP, river-bottom sediment, suspended sediment, adsorption/desorption model, Kd

福島における河川底質中のセシウム137の吸脱着プロセスのモデル化

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2011年に発生した福島第一原子力発電所事故により、放射性セシウム137(^{137}Cs)が大量に放出された。^{137}Csは溶存態および懸濁態として河川流出に大きく寄与している。環境省は2011年から福島県内の河川底質中の^{137}Cs濃度をモニタリングしているが、長期的な傾向を把握することは困難である。これまでの吸脱着モデルは、理想的な実験室条件に基づくものであり、現場での長期データに基づく研究は乏しい。
本研究では、自然条件下における河川底質中の^{137}Cs濃度変化を対象とし、長期モニタリングデータを用いて分析を行った。底質試料は４か月ごとに、河川水および懸濁態試料はおおよそ３か月ごとに採取した。本モデルは、河川水と底質間の吸脱着反応を再現し、速い反応部位と遅い反応部位をそれぞれ考慮した２つの区画で構成される。反応速度を調整することで、観測値とモデル値の^{137}Cs濃度を最適化した。
その結果、粒径補正した底質中の^{137}Cs濃度は、１年以内に懸濁態の濃度と一致することが明らかになった。45地点において、^{137}Cs濃度が増加する現象が確認され、これは溶存態や懸濁態では見られないものであった。また、底質の分配係数(Kd)は、初期３年間で１～２桁の変動を示した。６か月以内に遅い吸着反応が底質中の^{137}Cs濃度を支配し、懸濁態濃度への影響はごく小さいことが判明した。これらの結果は、河川底質中の^{137}Cs濃度の長期的形成において、遅い吸脱着反応が主要なプロセスであることを示唆する。

キーワード： ^{137}Cs、福島第一原子力発電所、河川底質、懸濁態、吸脱着モデル、Kd

P-43

Application of ambient dose equivalent estimation models in remediated cedar forests of Kawauchi Village Japan

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Following the 2011 Fukushima Daiichi Nuclear Power Plant disaster, many regions contaminated by the release of radionuclides are still being investigated today. The mountainous forest areas surrounding Fukushima Prefecture were of the most affected by fallout radionuclides, primarily radiocesium (^{134}Cs and ^{137}Cs), and remain a focus area for remediation and scientific research. From this effort, several models have been developed to estimate ambient dose equivalent rates ($H^*(10)$) using data on the depth distribution of fallout radiocesium in the forest soils. This study applies several of these models to a research plot in Kawauchi Village Japan, where forestry remediation such as clear-cutting and litter removal has been conducted. Using soil sampling data for radiocesium at the Kawauchi test site, these models were used to estimate $H^*(10)$ and were compared to measurements taken using handheld instrumentation. The distribution of radiocesium in the soil for sampling locations at the test site were determined using an exponential expression of vertical distribution. These distribution values were then used in two different models, one estimating $H^*(10)$ using conversion coefficients from Bq/m^2 to μSv/hr, and the other model estimating $H^*(10)$ using a "field of view" approach, estimating a surrounding area's contribution to total $H^*(10)$ measured at a central point within the test area. The results from this comparison provide a real-world test into the effectiveness of these computer software derived models, which is a research area the current literature is deficient in.

Keywords：Kawauchi, radiocesium, $H^*(10)$, models, forest, remediation

P-44

Verification of atmospheric transport model using Rn-222

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The study of advection and dispersion of atmospheric contaminant and radioactive materials is important issue to solve global environmental problems. To solve these problems, Analysis by atmosphere transport model is effective, and it is necessary to verify the model. In this study, Rn-222, a chemically inert natural radionuclide and half-life of 3.82 days, is used as a tracer, calculated by atmospheric transport model, and compared with observed data. The model is SCALE-RM (Scalable Computing for Advanced Library and Environment-Regional Model), a regional atmospheric model developed at the RIKEN Center for Computational Science (RIKEN R-CCS). The calculation domain was 7,500 km × 6,000 km (a horizontal resolution of 30 km × 30 km, 250 ×200 grids, and 30 layers up to 20.3 km vertical with the lowest vertical layer at 40 m) centered at 130° E and 40° N. The NCEP-FNL from the National Centers for Environmental Prediction was used for initial and boundary values. The results of the comparison and the factors involved will be discussed in the poster.

Keywords： Rn-222, Atmospheric transport model

Rn-222を用いた大気輸送モデルの検証

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大気汚染物質や放射性物質の移流・拡散の研究は地球環境問題を解決する上で重要な課題である。課題解決には大気輸送モデルによる解析が有効であり、そのモデルを検証することが必要である。そこで本研究では半減期が3.82日で化学的に不活性である天然放射性核種のRn-222をトレーサーとして用い、大気輸送モデルで計算し、観測値との比較を行った。モデルは理化学研究所計算科学研究センター(RIKEN R-CCS)で開発された領域大気モデルのSCALE-RM (Scalable Computing for Advanced Library and Environment-Regional Model)を用いた。モデルの計算領域は東経130度、北緯40度を中心とした水平方向7,500 km×6,000 km(水平格子間隔30km四方、格子数250×200個、鉛直最下層を40mとした鉛直20.3kmまでの30層)の範囲で行った。初期値・境界値には米国環境予測センターのNCEP-FNLを用いた。比較した結果とその要因について報告する。

キーワード： Rn-222、大気輸送モデル


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